NOVEMBER 20, 1980

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Circle 2 on reader service card

Electronics

The International Magazine of Electronic Technology

Vol. 53, No. 25 • November 20, 1980

Electronics

Highlights

Model year 1981 marks a major step in the integration of microelectronics into cars. In the U. S., each of the Big Three will put more than 1 million microprocessors into their 1981 vehicles, primarily for engine control, and maintaining these systems will mean a new level of testing and diagnosis, as well. The next stage will concentrate on dashboard instrumentation and electronic options like keyless entry and speed and climate controls.

Cover photography by Ahlberg Photography.

In a positive shift for the Northeast, the Massachusetts Institute of Technology is becoming more involved with the needs of the region's electronics companies. Contributing to the change are the shortage of engineers and technicians in the area and the recent appointment of Paul E. Grey as MIT's new president.

A low-cost display processor for television sets controls complex color graphics in as many as 32 planes, creating the illusion of three-dimensionality. Requiring very few parts for implementation, it is compatible with most popular microprocessors.

This year's International Electron Devices Meeting, to be held next month in Washington, D. C., reveals that the main thrust in integrated circuits for the next year or two will be on improving conventional processing techniques and on increasing the gains from old and new materials alike. For microwave ICs and light-emitting-diode arrays, for example, compound semiconductors are the coming material. In the digital arena, attention is on finding ways to push the various aspects of processing to their limits.

Winchester drives may be more than a match for floppy disks in microcomputer systems, but they impose a heavy burden on the host processor that shows up as reduced system throughput. An input/output processor has been given the intelligence to take on the control of an entire Winchester drive, letting the host machine get on with its primary task.

And in the next issue . . .

Electronics executives look ahead to 1981 . . . the influence of Japanese "quality circles" on U. S. semiconductor firms . . . top-down design with Fortran . . . a three-article series on testers for random-access memory chips . . . Pascal for microprocessors.

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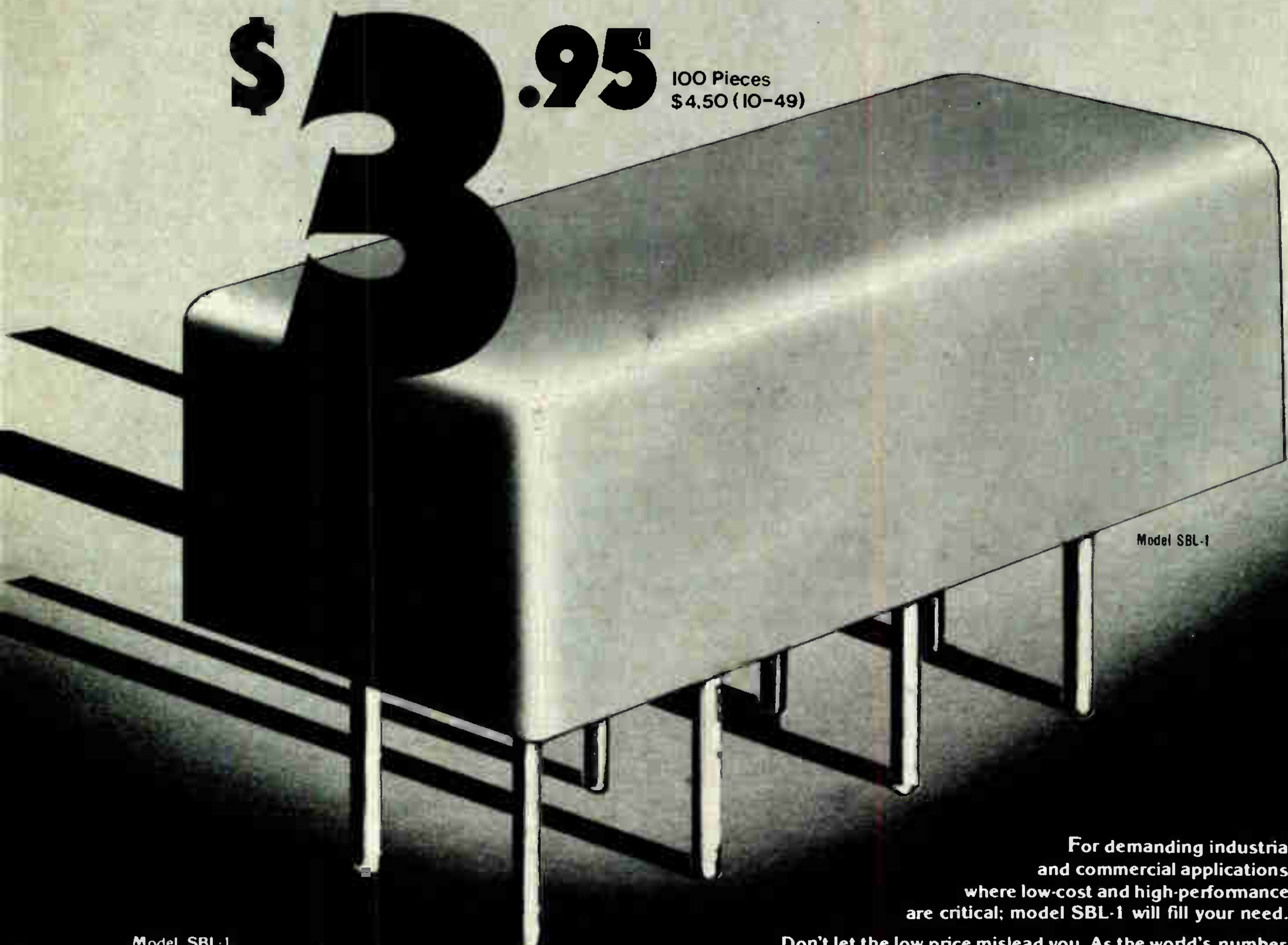

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21 Rev H

Circle 5 on reader service card

Publisher's letter

The trials and tribulations of putting electronically controlled seat-belt interlock systems into automobiles already seem light years away. Automotive electronics has come a long way in less than a decade.

With fear of the unknown put aside, Detroit's engineers today talk about how many microprocessors are going into automobiles. Rather than a necessary evil, electronics has become a selling point, a means of incorporating appealing new features.

As one automotive electronics engineering manager says proudly, "We are finally doing what we said we would do. This year we are going to ship 1 million microprocessors in the engine control systems. Microprocessors are here in big numbers."

The timing is just right for a special report on auto electronics (p. 113). This report, prepared by industrial/consumer editor Gil Bassak, follows the proliferation of microprocessors and related devices from engine controls to dash board. Just as semiconductors have had an impact on the auto industry, the car makers have had an impact on semiconductor producers. Gil points out that the semiconductor suppliers have had to achieve a 0.1%-per-thousand acceptable-quality level while under constant cost pressure.

"Quality and reliability are of major importance to the car makers," Gil reports. "Fault diagnostics, or self-test electronics, is therefore a vital concern."

Auto designers face a tradeoff in this area. Diagnostics could be built into the car. The advantage is that momentary problems that could cause later failures are trapped immediately and stored for analysis by a microprocessor. The disadvantage is that on-board diagnostics add to the cost of the car, something that Detroit is not anxious to do. So-called roll-up test gear—equipment used by the garage mechanics—spares adding costs to the car. But these instruments are also expensive and become obsolete.

At present, the auto companies are doing a bit of both. There are early warning tests displayed to the driver that a mechanic can follow up with a thorough examination.

"Automotive electronics will be something like the handheld calculator," Gil observes. "People will look back and wonder how they ever did without it. Cars will never be the same again, nor will the auto companies since the formation of engineering departments responsible for microelectronics."

Although the computer software called LISP has been around for some 25 years now, LISP is the future. That's West Coast computers and instruments editor Marty Marshall's conclusion after reporting on the commercial introduction of computers with instruction sets optimized for LISP (p. 89).

Machines that operate with LISP (for list-processing) language are of immediate interest to artificial intelligence researchers because it is a symbolic rather than a number-crunching language, Marty remarks. And because of the implications this type of machine has in data-base management, LISP has a definite stake in the future. On the horizon for future systems are very large-scale integrated LISP chips.

Marty has been interested in artificial intelligence for some time. Some of the projects using the LISP language can be intriguing. For example, one researcher is working on a system that traces the mind of a design engineer. Essentially, as LISP makes logic connections and stores relationships very much as the human brain does, it may be possible to develop a program that automatically takes in a design problem and then adds layers of complex decision making in order to solve the problem in much the same way as an engineer might go about the task. We're asking Marty to keep an eye out for an article on this program.

Readers' comments

Recognition first

To the Editor: In "Finding tomorrow's engineers today" [Aug. 14, p. 32], Andrew S. Grove eloquently addresses a serious situation. Our eroding technological leadership is blunting the edge of our most valuable tool to shape the environment in the decades ahead, as well as endangering our long-term survival.

I agree there will be a substantial shortage of engineers, both hardware and software; that "electronic technology is penetrating our society at an accelerating rate"; and that Government action is not desirable. But I see a different solution to the problem from Mr. Grove's.

What can be done to supply the number of engineers needed? First, as with any limited resource expected to be in short supply, conservation and efficiency are required. All too often, senior engineers must perform lower-level tasks, such as writing test specifications, and are discouraged from pursuing educational updating at company expense. In addition, we are confronted by management attitudes ranging from a rare benevolence, to indifference, to contempt. To add modest salary and the threat of an insecure future for the older engineer to this general attitude toward engineers is to belie the claim that we are a valuable resource to be cultivated. How many engineers have left the ranks for marketing, administration, law, even floorwaxing, because they were tired of "playing the game" and sought a more equitable income?

The answer does indeed lie with the students of today and tomorrow. Most of the high school students I have spoken to are aware of the predicted need for engineers. However, when presented with a more objective and factual critique of engineering, they are astonished and appalled. In overwhelming numbers, today's students consider the amount of money they can ultimately expect to make as extremely critical. The fact that I have fiscal restraints that appear not to apply to the businessmen, lawyers, doctors, salesmen, and so on in my neighborhood is significant to them. When confronted with

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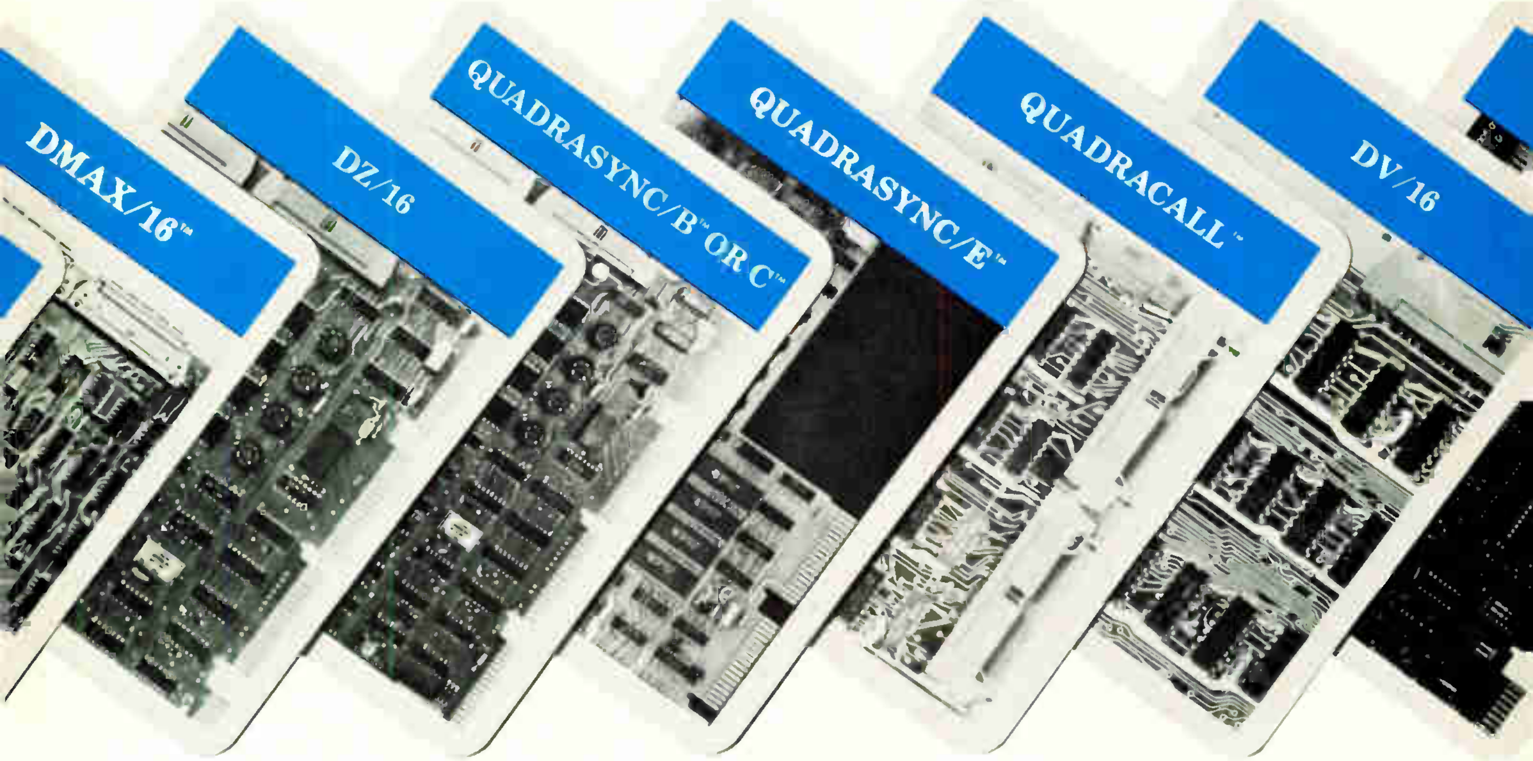

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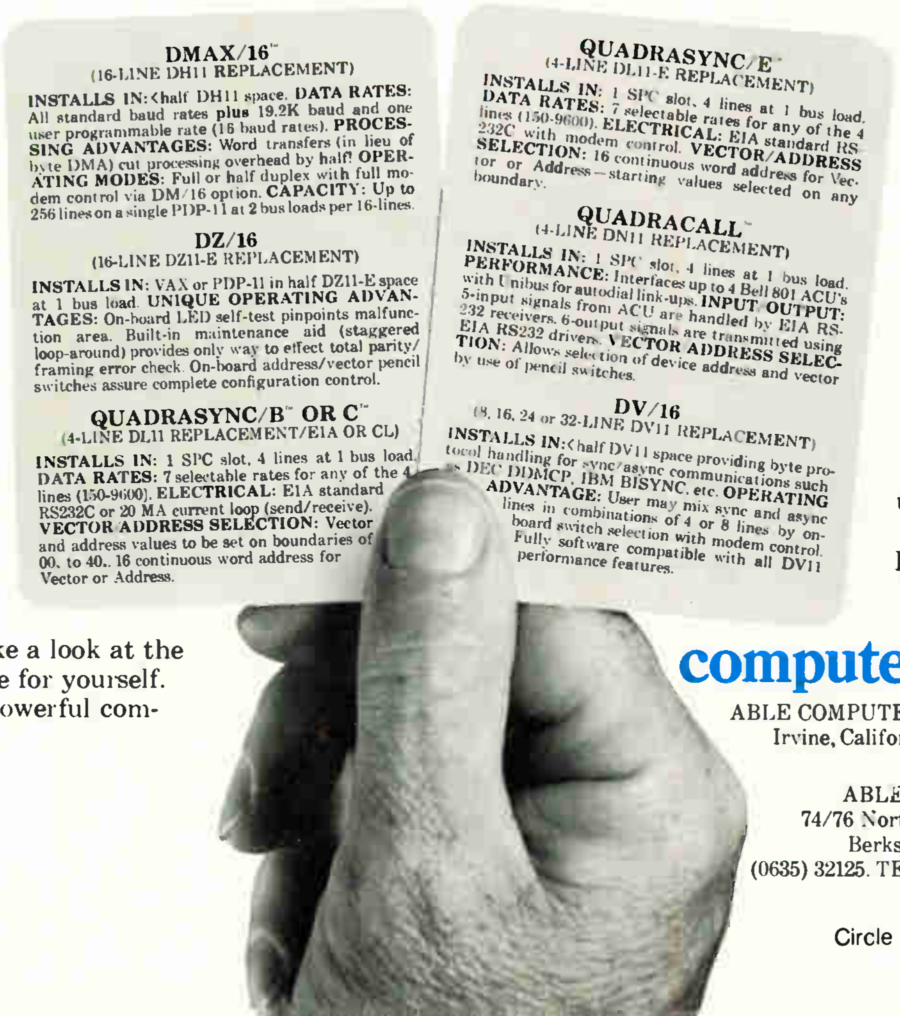

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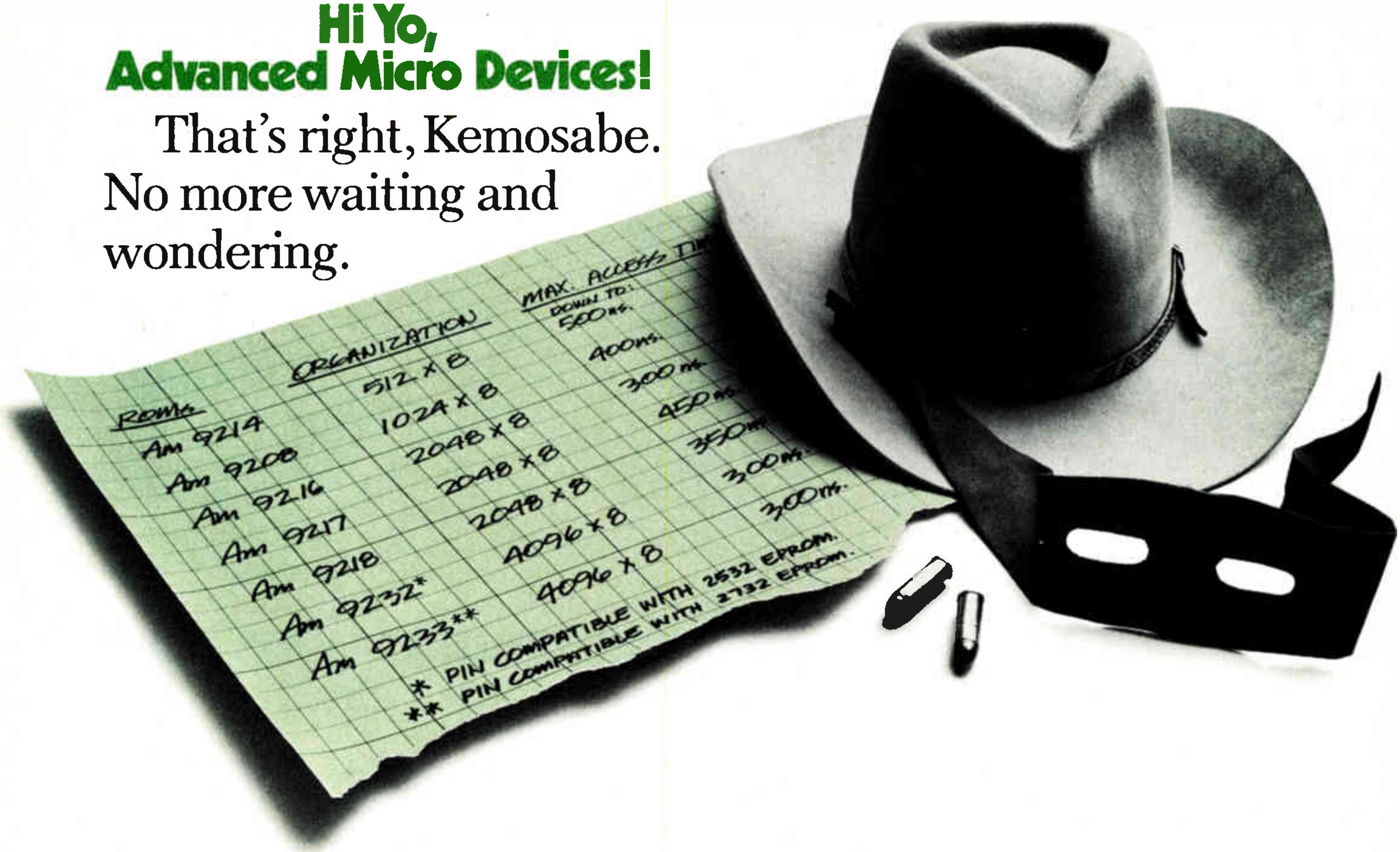

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Readers' comments

economic realities, most students choose today, and will choose tomorrow if no change is forthcoming, the better-compensated careers.

It is true that "no segment of society understands the problem better than we engineers or is better qualified to proselytize for the profession." But until we engineering "craftsmen," the day-to-day practitioners of the "art," are recognized for our substantial contributions to this country's productivity and accomplishments and until the present abuses are corrected, how can we, in fairness and good faith, seek converts to the cause? Without action by Mr. Grove and other corporate leaders to bring about change, his exhortations merely become more rhetoric proclaiming the eternal "engineering shortage" so as to maintain an adequate supply of cheaper labor. And without change that will bring "the very best into our field," we will indeed lose the "continued eminence and leadership of our American technological society."

Jay L. Richman
Montville, N. J.

Corrections

In "Three-level inverter conserves battery power" (Oct. 9, p. 163), the anodes of the MR751 diodes that connect to the MJE801 transistors should be brought to the emitter of Q_1 instead of to the negative terminal (ground) of the battery as shown. The cathodes of the lower 1N914 diodes in all the back-to-back 1N914 diode pairs should be connected to Q_1's collector instead of to ground. And the standard mains transformer should be specified as a 1:1:20 arrangement.

The resistance ranges of the Keithley 135 and Data Precision 255 digital multimeters were improperly specified in the Nov. 6 issue (p. 169). They are in fact 2 kilohms to 20 megohms, full scale. In the same story, Data Precision's CG-100A probe extends the 255's current-measuring range to 100 amperes, not to 1,000 A as written.

Also, Teledyne Philbrick's 4059 converter was described as an analog-to-digital unit (p. 225); it is rather a 16-bit digital-to-analog converter.

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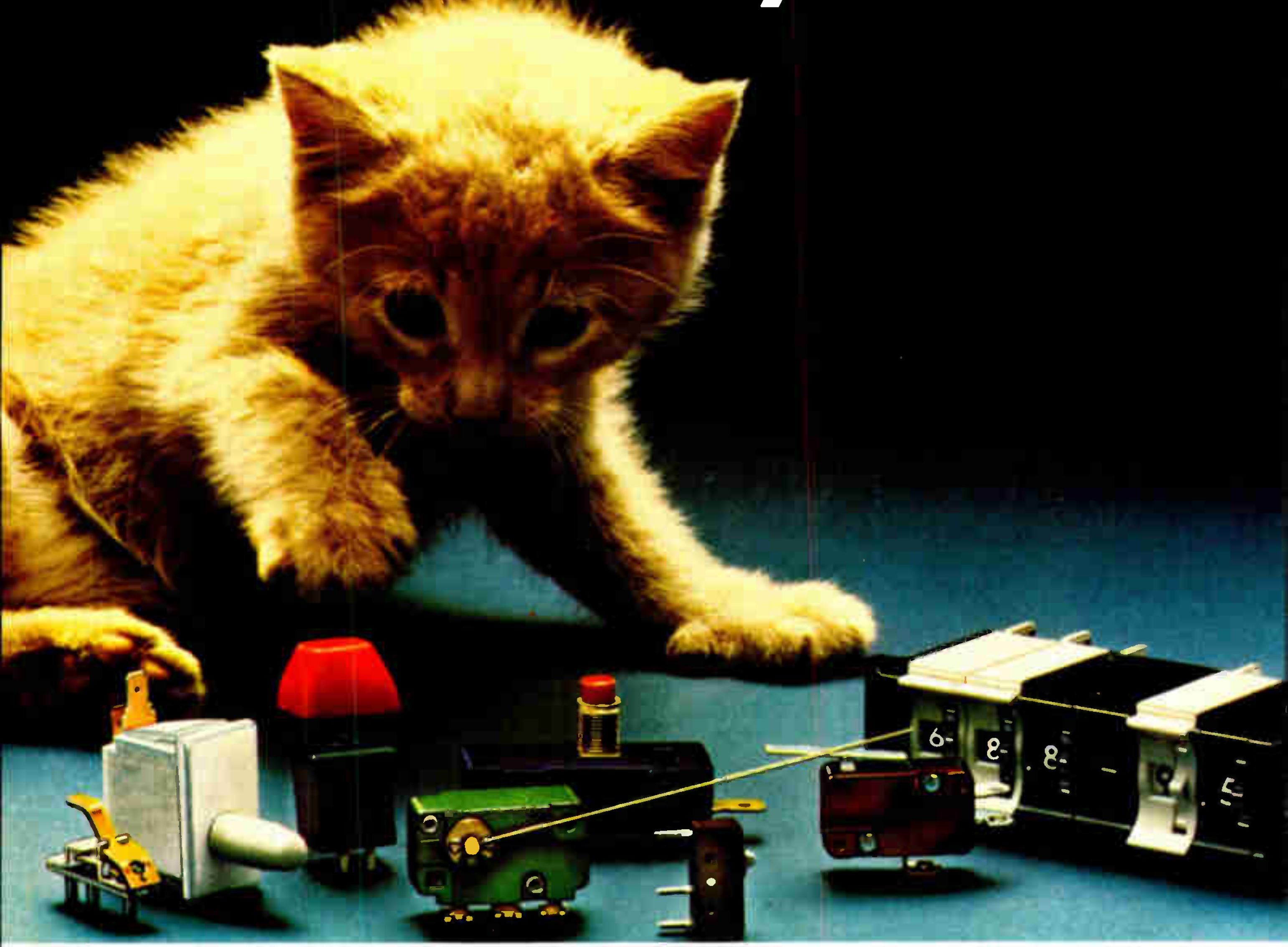

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People

Noorda finds smaller firm that he intends to make big

Latest challenge. Boschert's Noorda sees his job as putting firm back on growth curve.

"Most people like going to bigger and better things. I like going to smaller and worse things," says Raymond J. Noorda, new president and chief executive of Boschert Inc. But if history repeats itself, as Noorda intends it to, and small goes to big and worse to better, employees and customers of the Sunnyvale, Calif., switching-power-supply manufacturer won't mind his candor.

The 56-year-old Ogden, Utah, native thrives on challenges, as he demonstrated in 1970 by ending a 21-year management career with General Electric Co. to become president of General Automation Inc. in Anaheim, Calif. When Noorda arrived, sales at the computer maker were about $6 million; they grew nearly tenfold by the time he departed in 1975. Then, following some interim management with Systems Industries Inc. of Sunnyvale, Noorda officially joined it as president in 1977.

"I would have felt better if Boschert were even smaller," says Noorda. The company, which grew more than 50% in fiscal 1980, expects little growth this fiscal year, ending June 30. "Boschert was in a temporary slowdown. It was a good opportunity for me to come aboard and a good time to get back on our growth curve," states Noorda, who holds a bachelor of science in electrical engineering from the University of Utah in Salt Lake City.

Noorda views Boschert as a maker of high-quality custom and tailored supplies sold in small-to-medium quantities to original-equipment manufacturers. However, he wants it to become a "total power-supply company," producing low-quantity and high-cost switching supplies, as well as high-quantity and low-cost supplies made offshore. Also, he's looking to fill gaps between its traditional stronghold (devices handling 500 watts and less) and a new 1,500-W supply.

By implementing these plans, Noorda expects Boschert's growth to be as good as, if not better than, the 35% per year typically enjoyed by small business. "That alone should put us at around $55 million to $60 million in sales by 1985. But we're focusing on meeting the needs of European markets as well, and with an aggressive push in Europe we'd be able to achieve $65 million to $75 million by that time," he says.

Phillips sees GaAs growth passing silicon's by 1990

After a long countdown, gallium arsenide integrated-circuit technology is blasting off, thanks to proponents like D. Howard Phillips. With a style as fast-paced as the high-speed circuits he has been pushing for the past 16 years, the new director of Aerospace Corp.'s Electronics Research Laboratory in Los Angeles beams that "the growth rate for gallium arsenide ICs will exceed that for silicon by 1990."

Phillips does not mean to imply that the total available market for GaAs ICs will ever outdo that for silicon. "Gallium arsenide will not run silicon out of business the way silicon ran germanium out of business," says the 39-year-old Phillips. But needs in data- and signal-processing markets, where speed is critical, will help to fuel the emergence of commercial GaAs chips.

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These controllers provide you with added features such as automatic self-testing, onboard pack formatting, and programmable bandwidth control at no additional cost.

BROAD RANGE OF DEVICES SUPPORTED
It makes no difference which of the DEC PDP-11 or LSI-11 family you are using or which type of storage device is required for your application. We can support 59 different drives from 13 different manufacturers.

HIGHEST QUALITY AND SUPER RELIABILITY
You can be assured of the quality and reliability of these Tape and Disk Controllers because First Computer Corporation specializes in PDP-11 and LSI-11 computer systems, components, and peripherials. Over the years our reputation was built on the quality and reliability of the products we sell. We continue to protect this reputation by selling only the very best.

SUPER FAST SERVICE
Because we are the largest system integrator specializing in PDP-11 and LSI-11 systems, components, and peripherials, First Computer Corporation can satisfy most of your Tape and Disk Controller requirements directly from our stock.

GUARANTEED SATISFACTION
Your satisfaction is fully guaranteed by First Computer Corporation. We believe in every product we sell. If for any reason these Tape and Disk Controllers do not meet your expectations, simply return them freight prepaid and insured, within 10 days of receipt and we will refund your money in full. First Computer Corporation backs each of these products with a full one year warranty.

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People

Speed merchant. Fast GaAs IC devices will be on market in a few years, says Phillips.

ductor material is already vital for discrete devices like high-speed transistors and laser diodes, the fabrication of GaAs ICs has been beset with technical difficulties. Phillips has been instrumental in ironing out these problems so that the devices will be commercially produced "in a couple of years," he says.

An indicator of the tremendous growth awaiting large-scale GaAs ICs, says Phillips, is the sheer volume of papers on the subject at the GaAs IC Symposium held Nov. 4–6 in Las Vegas, Nev., where Phillips was chairman, as he was last year.

Phillips' expertise is not limited to GaAs—he is equally knowledgeable about silicon processing. Before heading south to Aerospace Corp., he put in three years as manager of Lockheed's Microelectronics Center in Sunnyvale, Calif., where he coordinated both GaAs and silicon-on-sapphire research efforts. At Aerospace, he will be able to pick up where he left off on these projects as the leader of 85 scientists, engineers, and technicians.

Phillips climbed the ladder to a doctoral degree on three campuses. After receiving a bachelor's degree in electrical engineering at Oklahoma State, he switched to the University of Oklahoma for a master's in nuclear engineering. His Ph. D. with honors in electrical engineering was conferred by the University of New Mexico in 1972. □

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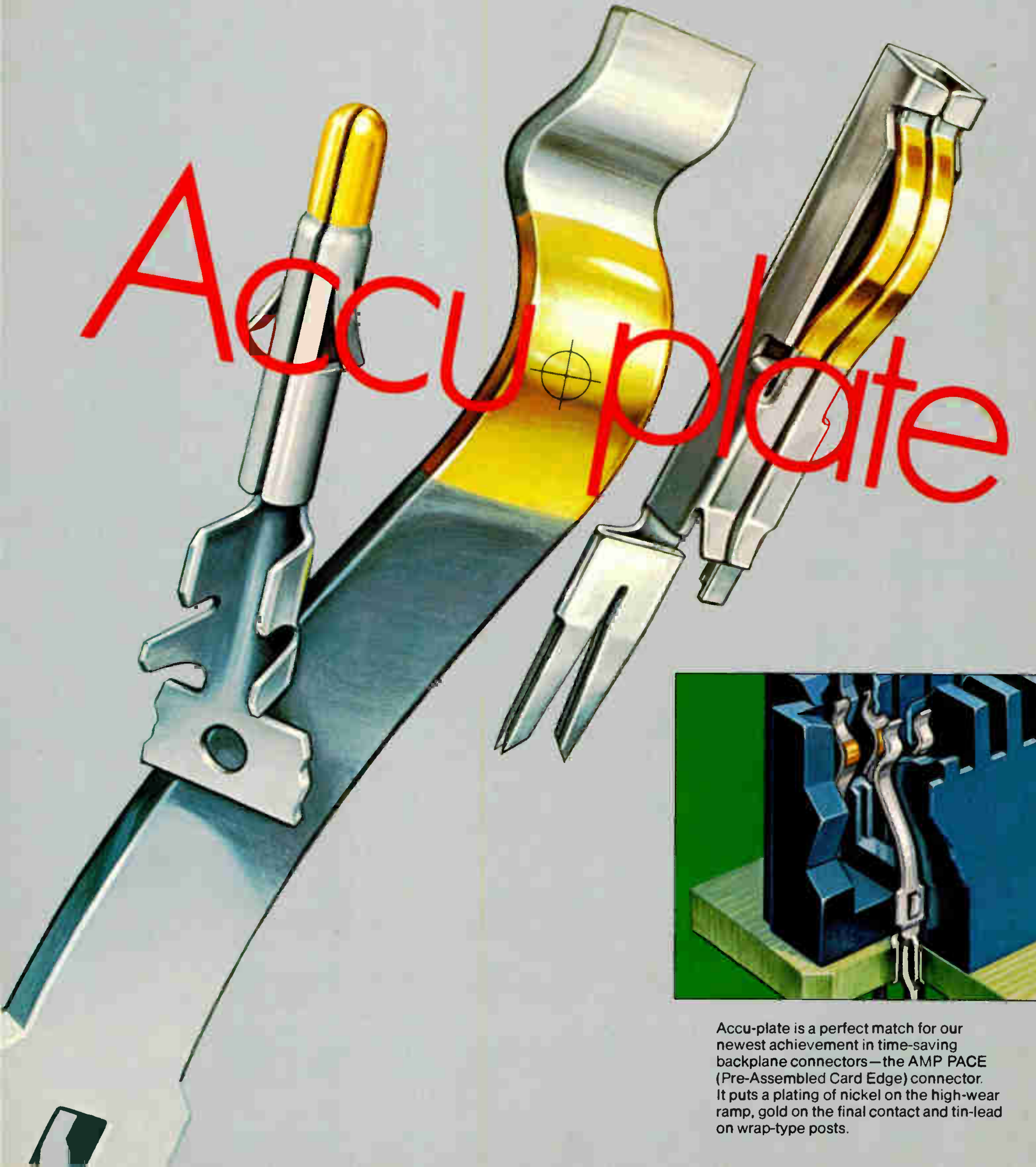
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Introducing Accu-plate—the precision plating that gives reliability you can afford.

You're looking at the latest advance in plating technology, Accu-plate. It's the cost-effective way to use gold, palladium and a lot of other plating materials—without compromising reliability or performance.

Accu-plate gives you precision never before obtainable. This precision even allows us to employ several platings on the same contact. We use gold precisely where other metals can't perform as well. We can use tin-lead for solderability and nickel in high-wear areas.

In other words, whichever plating performs best, Accu-plate enables us to put it in the right place. Nothing is wasted. You get a superior electrical contact at a price you can afford, and you are not faced with redesign costs.

Want to gain the benefits of the best plating without excessive expense? Investigate Accu-plate.

The Accu-plate plating line uses an advanced computer to precisely plate contacts on the surface area where it is actually needed.

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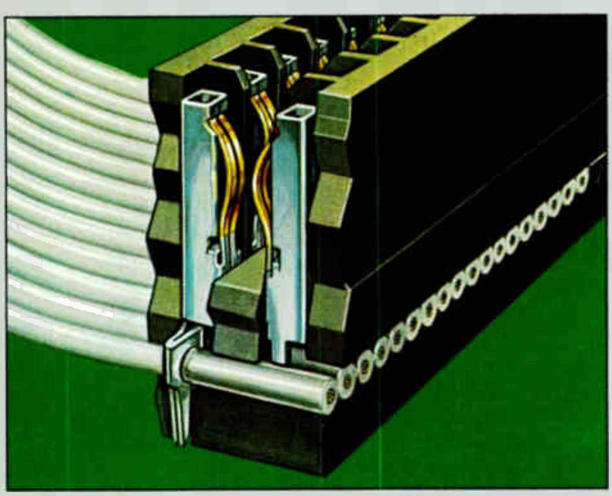
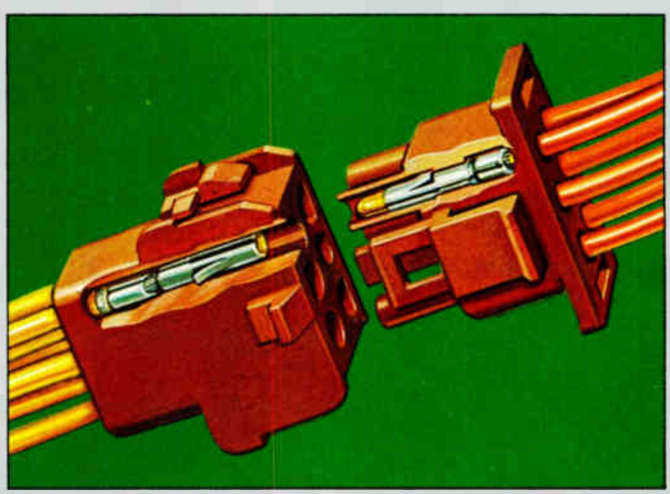
AMP means productivity.



Accu-plate puts a plus in AMP-Latch connectors for terminating ribbon cable and small-gauge discrete wires. It enables us to precisely plate the receptacle with gold and the insulation displacing V-slot area with tin-lead.



Accu-plate does well for commercial connectors, too. We prestripe gold over nickel on unformed stock for sockets and tip-plate pins. We apply nickel plate to the interior of the wire barrel for crimp performance and tin to the exterior to reduce applicator die wear.

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MICROPROCESSOR BUS
128 BYTES RAM
32 I/O LINES
ICE-51™ EMULATOR
INTELLEC® DEV. SYSTEM
MULTIPLY / DIVIDE
TWO 16-BIT COUNTERS
SERIAL UART
8051

Microcomputer Hero

Intel's new 8051 packs more processing ingredients onto a single chip than ever before. And serves it up with total development support.

Intel introduces its latest recipe for the highest performance single-chip microcomputer. Take an up to ten times functional/speed improvement, and add more program and data memory than you can find on any competitive single-chip micro. Garnish these with peripheral capabilities like 32 programmable I/O lines, a full-duplex UART, and two 16-bit timers/event counters. Top it all off with a unique Boolean processor, and serve it up on the industry's broadest development support base. That's the 8051, a veritable feast for product designers.

A new combination of ingredients

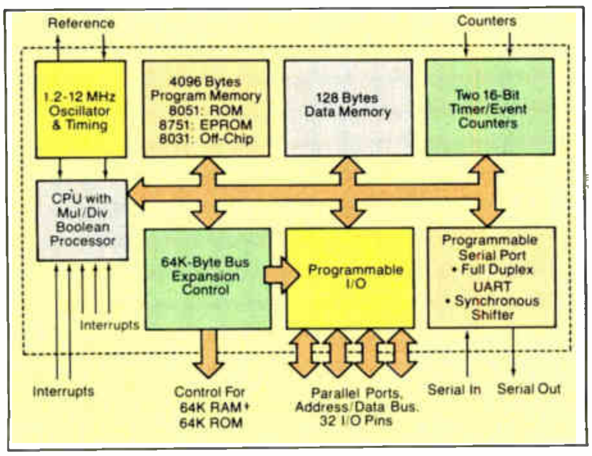
The 8051 family sets the standard for the next generation of single-chip microcomputers. And opens new application opportunities where a multiple-chip approach would have been necessary before.

For large program storage, there are 4K bytes of ROM/EPROM, 128 bytes of RAM for internal scratchpad, and 20 registers for controlling peripheral functions. Plus the memory space is expandable to 64K bytes each of RAM and ROM.

The 8051 also offers extended CPU processing capabilities, multiple addressing modes, and four 8-register banks. Furthermore, it's fast. Multiply and Divide execute in 4 µs. Over half of the remaining instructions execute in 1 µs; the rest in 2 µs.

Then there's the 8051's full duplex serial I/O port, which allows it to talk to peripherals—such as terminals and UARTs—at a much higher data rate than could be achieved using software alone. At rates, in fact, from 122 to 31,250 baud. This port can also link multiple 8051s to achieve transmission rates up to 187,500 baud using standard asynchronous protocols and an address-driven automatic wakeup.

Added to that is the 8051's sophisticated interrupt system, with five sources, two priority levels, and a nested structure which allows exceptionally efficient monitoring of internal and external alarms.



Boolean bit manipulation

In addition to handling 8-bit binary and BCD arithmetic, plus 8-bit logic operations, the 8051 family offers an exclusive feature: extensive Boolean bit-handling—especially important in controller applications.

An integral part of the CPU, the Boolean processor has its own set of 12 instructions, its own accumulator, and its own bit-addressable RAM and I/O. With these instructions, now you can do bit manipulation without extensive data movement, byte masking/shifting, or test-and-branch trees.

Full-course development support

With even the most versatile microcomputer, though, you need development support to get your product to market the fastest, lowest risk, least expensive way possible. Support such as only Intel delivers.

That means support from the Intellec® Microcomputer Development System, your own in-house digital design center. It also means software support, like the ASM 51 macroassembler, which provides tight, fast code and efficient access to the Boolean processor. Or the CONV 51 conversion program for upgrading your existing 8048 source code to operate on the 8051.

Intel support further includes the ICE-51™ in-circuit emulator, which lets you exercise your system at full processor speed with all of its I/O functions. So you can analyze test results quickly, even before your application system hardware is available. Or fully debug your system in logical segments before committing code to EPROMs or ROM. Thus getting a more reliable product to market faster.

Come and get it

A direct descendant of the industry-standard 8048, the 8051 family is the beginning of the new MCS-51™ series of high-performance devices. In addition to the ROM-based 8051, the other two members of the immediate family are the 8751 EPROM version, intended for prototyping and low volume production, and the 8031, which relies on external program memory.

For further details on the 8051 family and its development support, contact your local Intel sales office/distributor. Or write Intel Corporation, 3065 Bowers Avenue, Santa Clara, CA 95051. Telephone (408) 987-8080.

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Compare our data and time domain logic analyzer with the industry's leading data-domain-only unit.

For complete analysis, the K100-D outperforms H-P's 1610B!

Before you settle for the Hewlett-Packard 1610B data domain analyzer, compare it with the general purpose Biomation K100-D, our fastest-selling logic analyzer ever.

Compare depth of information.
A data domain (software) analyzer —even a unit as sophisticated as the H-P 1610B—simply does not give you all the information you need for debugging your mainframe, mini- and microprocessor-based systems. During the critical system-integration stage of a development cycle, a problem that looks like a software failure may turn out to be a not-too-obvious hardware malfunction. The K100-D's data/timing capability lets you analyze software/hardware relationships and find the problem, wherever it originates. You can display up to 16 channels of critical timing information about race conditions and phase relationships between signals.

So vital is this timing information to complete problem analysis that industry trends indicate logic analyzers of the future will have both data and timing analysis capabilities—like the K100-D has today!

Compare data domain range.
The high-speed K100-D gives you data domain capability to 70 MHz —as compared with the 1610B's 10 MHz rate—for use with faster multiplexed microprocessors, computers, and ECL bit-slice processors. At 12 to 70 MHz, the K100-D gives you 16 channels of data display, with 1024 words of memory.

Operating at 0 to 10 MHz, both units give you 32 channels of data domain information. But the K100-D's memory is 8 times as deep as the 1610B's—512 words versus 64. The 1610B's 7 levels of triggering exceed the needs of most users, and those who do need this capability can generally get it from their development system. With the K100-D, you don't sacrifice vital timing information for data domain capabilities you don't need.

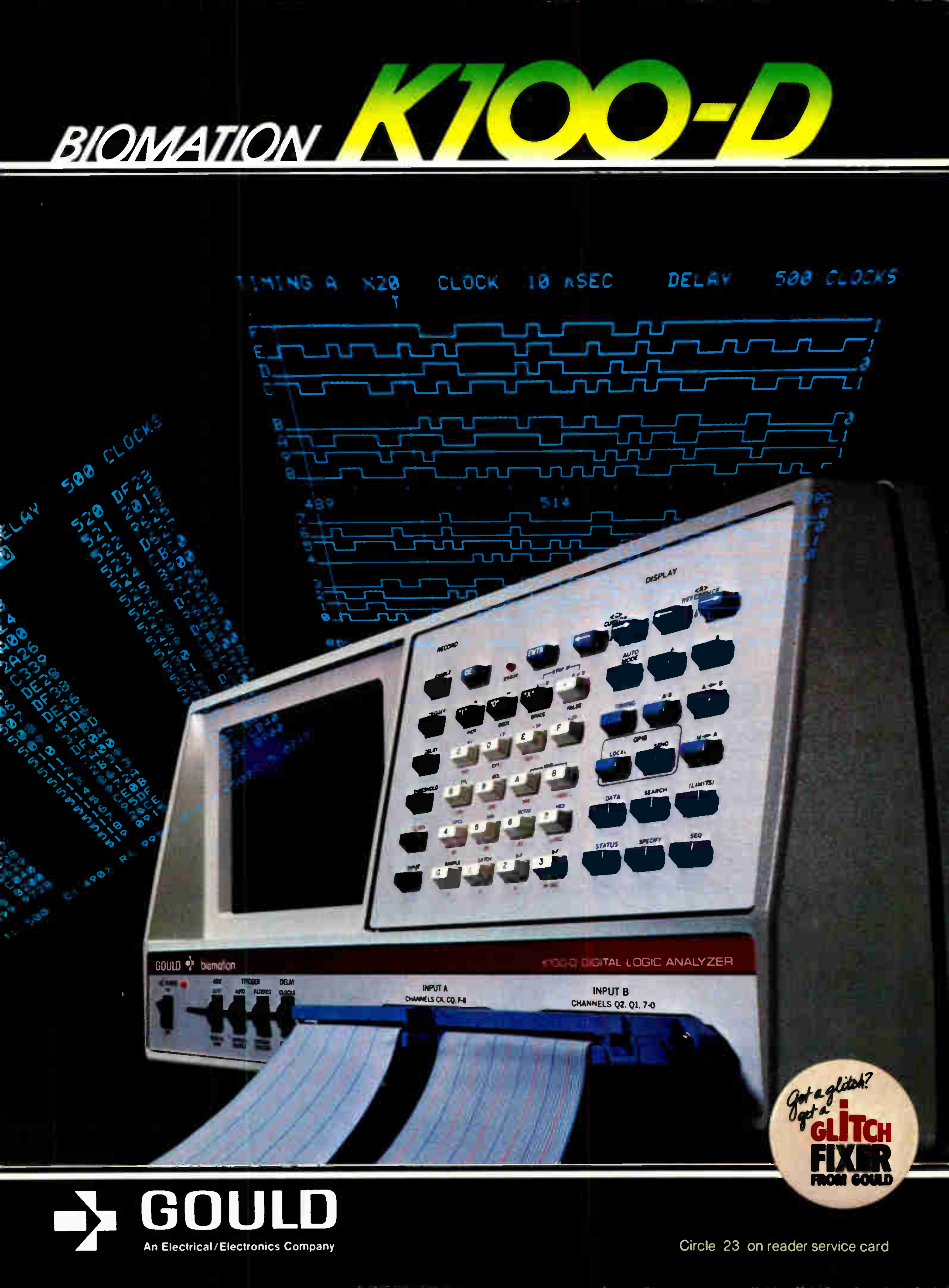
The final analysis.
To help you evaluate your needs before you buy, we've prepared a point-by-point competitive comparison of the Biomation K100-D and the H-P 1610B. (Incidentally, it also shows how the K100-D beats H-P's general purpose 1615A hands down.) To get your free copy, just use the reader service number or write Gould Inc., Instrument Division, 4600 Old Ironsides Drive, Santa Clara, CA 95050. For faster response, call 408-988-6800.

Hewlett-Packard 1610B
A sophisticated data-domain-only logic analyzer

Analysis: Software
Speed: to 10 MHz
Channels: 32 data
Memory: 64 words

Biomation K100-D
The industry's finest data/timing logic analyzer

Analysis: Software & Hardware
Speed: to 70 MHz data domain
to 100 MHz time domain
Channels: 32 data to 12 MHz,
16 data to 70 MHz
16 timing to 100 MHz
Memory: 1024 words @ 16 channels
512 words @ 32 channels


BIOMATION K100-D
TIMING A X20 CLOCK 10 nSEC DELAY 500 CLOCKS
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K100-D DIGITAL LOGIC ANALYZER
INPUT A
CHANNELS CK, CQ, F-8
INPUT B
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Editorial

A program for educating more engineers better . . .

The report issued by the Department of Education and the National Science Foundation last month failed to make specific recommendations on what might be done to combat what it admitted is a growing scientific and technological illiteracy rate in this country. Real problems need real solutions, and "Science and Engineering Education for the 1980s and Beyond" did not provide them.

But one engineering organization, at least—the American Association of Engineering Societies—has put forward the following three-point plan for getting engineering education up and on its feet again (see p. 182):

- A $20 million yearly grant program funded by the Federal government to sponsor 2,000 graduate students.
- A $100 million annual incentive program to equip American universities with laboratory equipment for research and teaching.
- A push at the Federal, state, and local government levels to give engineering education a national priority equal to that of medical education.

The first two points could easily be taken up by the 97th Congress when it convenes in January. It would be several years before direct results could be seen, but these actions would nevertheless be an immediate shot in the arm for engineering education.

The third point would be more difficult to implement, requiring revolutionary changes in the thinking about the value of engineers to national economic health and well-being. Engineers would need increased public recognition as professionals and would have to be valued consistently instead of being treated in a cyclical "now we need them, now we don't" manner.

Government and industry must be ready to share equally the cost as well as the benefit of technological preeminence.

. . . and an idea for Government recognition

It's clear from the concern education is causing in Washington that something has to be done to overhaul the system if America is to produce the high-level engineering talent needed in the next decades. The situation brings to mind Georges Clemençeau's observation, "War is much too serious a matter to be entrusted to the military." In this case, education is much too serious a matter to be entrusted to the academics.

Some insist that reform must be entrusted primarily to industry but that the Government, too, must play an important role. One place where it can help is with the third point in the American Association of Engineering Societies' proposal discussed above: improvement of both the public image of engineers and of their own self-esteem. And one way of achieving that was suggested by financial analyst Ben Rosen at the recent Midcon show in Dallas. He suggests that the President reestablish annual technology prizes.

The idea was initiated in 1973, but fell victim to the Watergate trauma. Essentially, this plan would involve a national recognition of the 5 or 10 most significant engineering achievements of the year as decided by the President's science and technology adviser. Such a prize would not only reward high-technology achievement but also make national heroes of the engineers so honored. They would be models for students and would encourage the belief that technology is a prestigious career path. We're all for the plan.

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With Pro-Log's powerful new M980 control unit and plug-in personality modules, you can program, copy and test most MOS and bipolar PROMs and logic devices.
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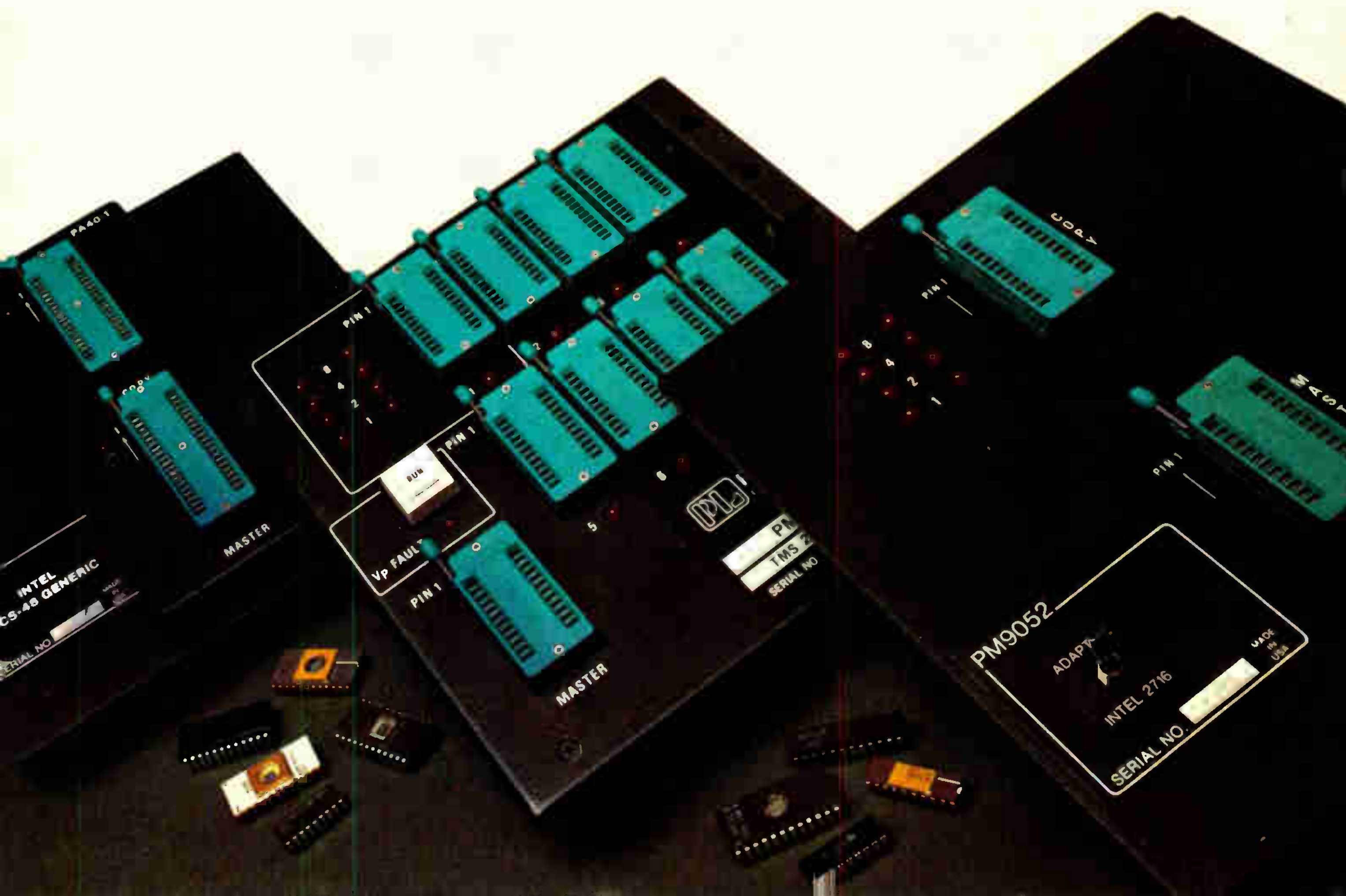

Meetings

Advanced Strategies in Data Processing and Communications, The Yankee Group (P. O. Box 43, Cambridge, Mass. 02138), Harvard Club, New York, Dec. 2–3; Hyatt Rickey's, Palo Alto, Calif., Dec. 9–10.

U. S./Southeast Asia Telecommunications Conference and Exhibit, EIA (2001 Eye St., N. W., Washington, D. C. 20006), Mandarin Hotel, Singapore, Dec. 3–5.

IEDM—1980 International Electron Devices Meeting, IEEE, Washington Hilton Hotel, Washington, D. C., Dec. 8–10.

PLANS 80—Position Location and Navigation Symposium, IEEE, Resorts International Hotel, Atlantic City, N. J., Dec. 8–11.

1980 Computer Networking Symposium, IEEE and NBS Institute for Computer Sciences and Technology (Washington, D. C. 20230), National Bureau of Standards, Gaithersburg, Md., Dec. 10.

19th IEEE Conference on Decision and Control, IEEE, Albuquerque Inn, Albuquerque, N. M., Dec. 10–12.

3rd Miami International Conference on Alternative Energy Sources, Clean Energy Research Institute, University of Miami (P. O. Box 248294, Coral Gables, Fla. 33124) *et al.*, Sheraton Bel Harbour, Bel Harbour, Fla., Dec. 15–17.

MIMI 81—International Symposium on Mini and Microcomputers, International Society for Mini and Microcomputers (Box 2481, Anaheim, Calif. 92804), Hotel del Coronado, San Diego, Jan. 7–9, 1981.

1981 International Consumer Electronics Show, EIA (CES, 2 Illinois Center, Suite 1607, 233 N. Michigan Ave., Chicago, Ill. 60601), Las Vegas Convention Center, Las Vegas, Jan. 8–11.

PTC '81—Pacific Telecommunications Conference, Pacific Telecommunications Council (PTC '81 Director, 2424 Maile Way, Rm. 704, Honolulu, Hawaii 96822), Ilikai Hotel, Honolulu, Hawaii, Jan. 12–14.

National Radio Science Meeting, IEEE and U. S. National Committee for the International Union of Radio Science (URSI), University of Colorado, Boulder, Jan. 12–15.

AVEC 81—Seventh International Audiovisual and Communications Salon, Société pour la Diffusion des Sciences et des Arts (20 rue Hamelin, 751 16 Paris, France), Palais des Congrès, Paris, Jan. 12–17.

High Speed Digital Technologies Conference, IEEE Electron Device Society and American Vacuum Society, San Diego Hilton Hotel, San Diego, Jan. 13–15.

Southcon/81 Show and Convention, IEEE, Georgia World Congress Center and Omni International Hotel, Atlanta, Jan. 13–15.

Automatic Test Equipment Seminar-Exhibit, Benwill Publishing Corp. (1050 Commonwealth Ave., Boston, Mass. 02215). Pasadena Center, Pasadena, Calif., Jan. 19–22.

Annual Reliability and Maintainability Symposium, IEEE *et al.*, Marriott Motor Hotel, Philadelphia, Jan. 27–29.

ASEE 81—Advanced Semiconductor Equipment Exposition, Electronic Representatives Association (Cartlidge and Associates, 491 Macara Ave., Suite 1014, Sunnyvale, Calif. 94086), San Jose Convention Center, San Jose, Calif., Jan. 27–29.

Second International Conference on Microprocessors in Automation and Communications, Institution of Electronics and Radio Engineers (99 Gower St., London WC1 6AZ, England), Penta Hotel, London, Jan. 27–30.

Power Engineering Society Winter Meeting, IEEE, Atlanta Hilton Hotel, Atlanta, Feb. 1–6.

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Third, commitment. Add up our product line as proof. More than 30 products, including CODECs, filters, pulse dialers, tone dialers,

How better numbers logically add up to a higher level of confidence.

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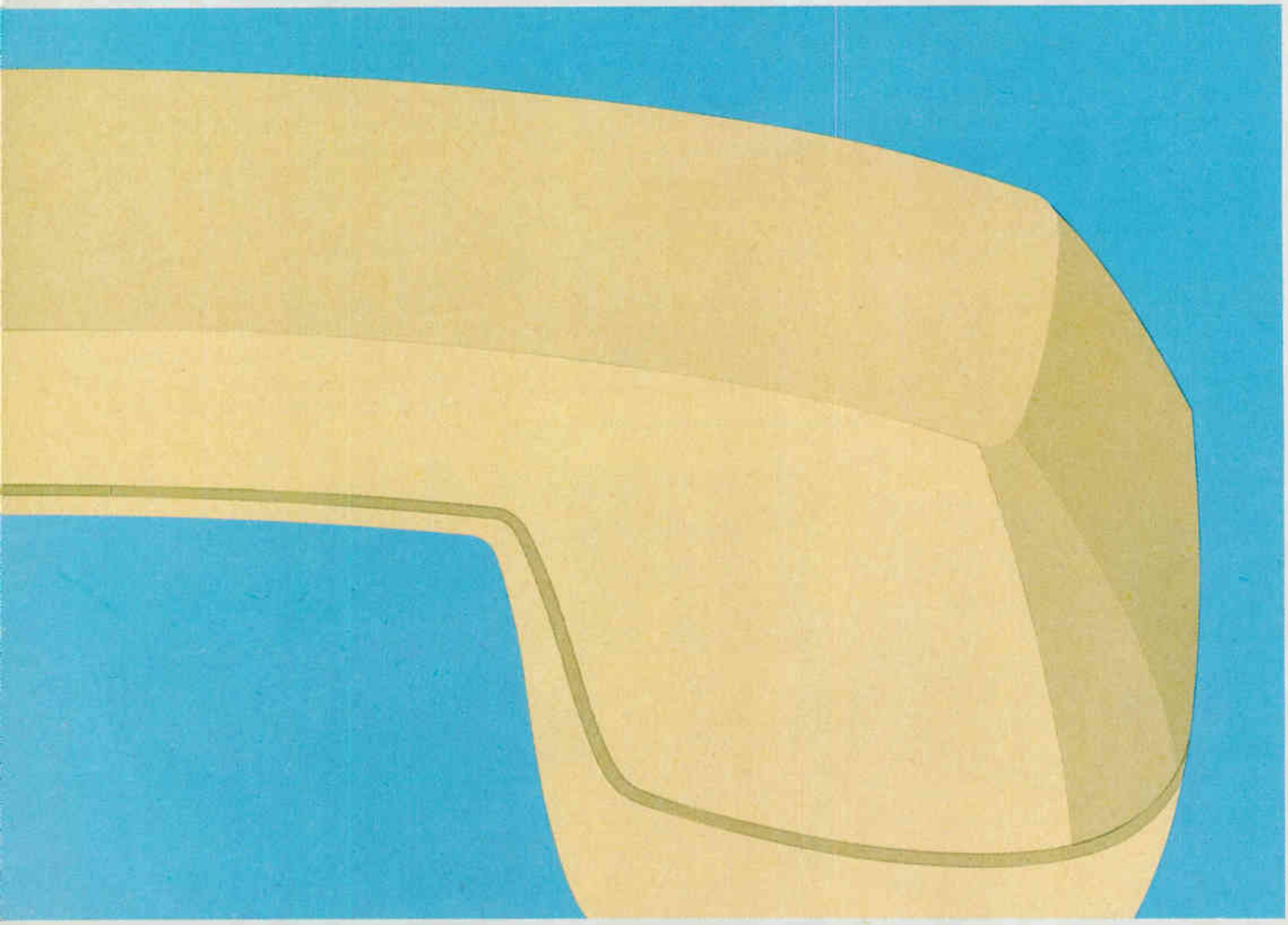
Fourth, growth. As a semiconductor manufacturer, ours is unparalleled. In telecommunications alone, for example, we have doubled in size every year for the past four. Stated another way, that totals up to more than 10 million telecom circuits shipped, more than all other IC manufacturers combined.

The advantages for you? In a word, confidence. Confidence that our expertise can position you at the leading edge of digital telecommunications. Confidence that our lower-power devices will make your system more cost-efficient. Confidence that you can specify a full line of those devices from a proven single source. And confidence that we have the demonstrated production capability to meet your high volume needs. Both today and tomorrow.

To find out more about what our numbers can do for you, contact: Mostek, 1215 West Crosby Road, Carrollton, Texas 75006 (214) 323-1000. In Europe, contact Mostek Brussels 660.69.24.



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Now CMOS cuts your design time.

Now there's another good reason to switch to CMOS.

COSMAC System IV: The complete 1802 hardware, software Microprocessor Development System.

Full-screen editing. The COSMAC System IV features an integral CRT display screen with built-in "true" full-screen editing.

Program entries and corrections appear instantly on the screen for fast, easy program editing.

The 12-inch integral CRT displays 80 characters per line and up to 24 lines. With attractive green phosphor for reduced eye fatigue.

New, high performance macroassembler. Our new ASM8, level II macroassembler provides much faster assembly time. We've added cross-reference listings and "verbal" error messages. Plus numerous other enhancements for fast, easy operation.

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Other on-board hardware includes: 60K bytes of user accessible CMOS RAM. Dual drive floppy disk. A built-in PROM programmer and line printer interface. And the RCA exclusive CDOS file-management operating system.

Go anywhere Micromonitor. Also included in the package is our widely acclaimed Micromonitor, the portable, in-circuit emulator. A complete diagnostic and design tool, capable of real-time, in-circuit hardware and software debugging. Plus our MOPS (Micromonitor OPerating System) software which allows complete software interrogation of the system under test.

Optional aids. For hard copy, add our 340 character-per-second, 132 column matrix printer, complete with built-in self test and diagnostics display.

Choose from three high-level languages: BASIC 1, BASIC 2, or PLM-1800.

If you already own our 005 or 007 system, move up to full-screen editing with our smart CRT terminal upgrade (CDP18S040).

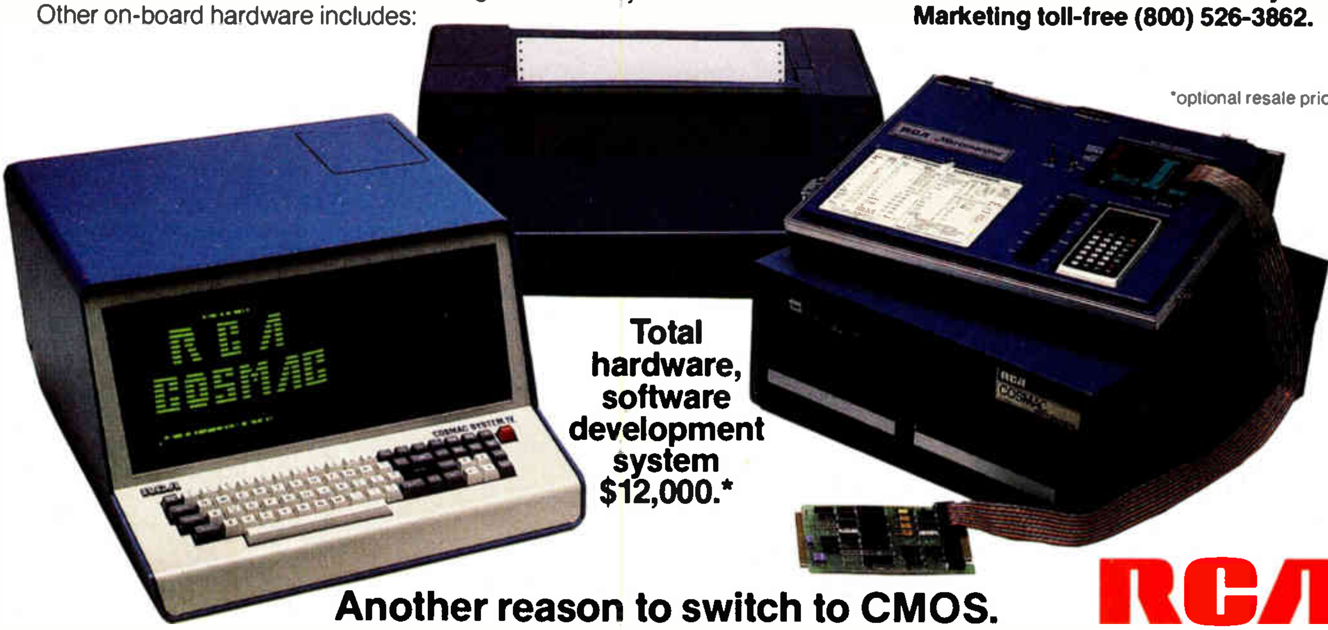
"Total design support" from the CMOS people.

The $12,000* total System IV price also includes total design support from the people who brought you the 1802.

Plus a copy of "Welcome to the World of RCA COSMAC," a demonstration diskette to introduce you to your new COSMAC System IV. And a free one-year subscription to the RCA software update service.

For more information or a System IV (CDP18S008) demonstration, contact your local RCA Solid State sales office or distributor. Or contact RCA Solid State Headquarters in Somerville, New Jersey. Brussels, Belgium. Hong Kong. Sao Paulo, Brazil. **Or call Microsystems Marketing toll-free (800) 526-3862.**

*optional resale price



Total hardware, software development system $12,000.*

Another reason to switch to CMOS.

RCA

Ion-beam annealing at IBM lab offers advantages over laser

IBM scientists are working on a new method of beam processing, ion-beam annealing, **that opens the possibility of self-annealing implantation with a pulsed beam of dopant ions.** The researchers, from International Business Machines Corp.'s Thomas J. Watson Research Center at Yorktown Heights, N. Y., described their work in a paper at the Materials Research Society's annual meeting in Boston on Nov. 19. The paper told how beams at a 300-keV energy level have already been used to produce ordered regrowth in virgin and implanted silicon.

The work is exciting the processing community because an intense pulsed ion beam has several advantages over a pulsed laser for annealing thin-film materials. Among them are a favorable energy loss distribution, the ability of ions to heat metallic and nonmetallic surfaces directly without reflection problems, and the availability of large-area and uniform ion beams.

Chip makers join programmable array logic competition

Ensuring industry acceptance of Monolithic Memories' programmable array logic family, Advanced Micro Devices and Texas Instruments will, by next year, join National Semiconductor and Raytheon as alternative sources for some members of MMI's PAL line. **But they will use oxide-isolated bipolar processes**—AMD its implanted micro-oxide, or IMOX, and TI its advanced low-power Schottky—for more speed to meet industry demands.

It is believed that Harris Semiconductor Products, too, will build PALs, possibly with a fuse-link complementary-MOS process. Even Intel may be eyeing PALs, though it is not known whether it will use its bipolar or its MOS electrically erasable read-only memory technologies. Meanwhile, MMI in Sunnyvale, Calif., is readying family members that will provide more inputs via 24-pin packages.

Intel adds polyimide, redundant elements to static, dynamic RAMs

Intel Corp.'s latest random-access memories will weather hard and soft errors better. A polyimide tape like the one Texas Instruments Inc. is using [*Electronics*, Oct. 23, p. 36] should hold alpha-particle failures below 0.1% and 0.01% per 1,000 hours for Intel's new 2164 64-K dynamic and 2167 16-K static RAMs, respectively. What's more, both chips have been modified to include redundant circuit elements—three rows in the 2167 and four rows, four columns, and decoders in the 2164—to improve wafer yields. In fact, the Santa Clara, Calif., company feels that redundancy will be a central issue in the 1980s, **and it intends to put spare elements on all future high-density memories,** including erasable programmable read-only and byte-organized types. To swap in the extra circuits, Intel blows polysilicon fuses like the ones it has been using in its bipolar PROMs.

Philips proposes standard bus for home electronics

In an attempt to simplify the operation of the proliferating consumer electronics gear—television sets, video cassette and disk players, stereo audio equipment, and the coming videotext options—NV Philips Gloeilampenfabrieken of Eindhoven, the Netherlands, has proposed a data-bus standard for home electronics. Its researchers maintain that a single-wire multimaster protocol would do the trick. **For example, if a video cassette recorder were turned on, the TV set would also be signaled on and tuned to the proper channel.** The protocol, dubbed by the company D^2B, for domestic digital bus, could use wire, optical fiber, or infrared beam. Philips described it last week at the Fall Conference on Consumer Electronics at Des Plaines, Ill.

Monolithic optical receiver performance matches hybrid versions

The prototype of a monolithic optical receiver with performance equal to that of hybrid designs has been built at the International Business Machines Corp.'s Thomas J. Watson Research Center by Dennis L. Rogers. He came up with the device in his hunt for a cost-effective optical-fiber link able to match computer data-transfer rates. Spokesmen at the Yorktown Heights, N. Y., research center say that the receiver, built from a bipolar master slice geared for emitter-coupled-logic circuits, **achieves both broad bandwidth and high sensitivity.**

Computer system using node approach coming from Apollo

A new data-processing system based on powerful, independent local computing nodes connected through an ultrafast network bows this week in Boston. From Apollo Computer Inc., the new approach combines 16-bit microprocessor-based computing nodes (MC68000s from Motorola) having full graphics and text-manipulation capabilities and 32-bit computing power, in a network allowing data, programs, costly peripherals, and controllers to be shared. Nodes could sell for as little as $25,000, and **a network of nine would offer three times the performance of a VAX-11/780,** according to the Billerica, Mass., firm. Since each added node would include its own processor, Apollo networks could expand without increased user latency time or loss of user available processing power—both problems of current timesharing computer systems.

National widens plans for new P²C-MOS process

National Semiconductor Corp. is applying its proprietary double-polysilicon complementary-MOS (P²C-MOS) process to a variety of microprocessor, memory, and telecommunications chips it will be unveiling in 1981. Among the first entries from the Santa Clara, Calif., firm will be the 80C48, **a low-power version of the industry-standard single-chip 8-bit microcontroller** that draws a mere 5 μA of standby current and 10 mA of supply current. Another newcomer is the NMC27C16 16-K erasable programmable read-only memory which has a 450-ns access time and draws essentially no dc power. Also fabricated in P²C-MOS is a one-chip codec, the TP3020/21, that might surface during the first half of 1981.

Datapoint quadruples memory capacity for new 16-bit machine

Datapoint Corp. of San Antonio, Texas, has taken the wraps off a 16-bit minicomputer that offers four times more main-memory capacity than previous Datapoint machines, as well as a new architecture that yields a 40% to 300% throughput improvement, depending on configuration and application, company officials say. **The 8800 series is also equipped with new operating system software** known as Resource Management System that is compatible with the company's Attached Resource Computer networking system. The 1-megabyte main-memory capacity should overcome objections by some critics that the 6640's maximum of 256-K bytes was too small [*Electronics*, Dec. 6, 1979, p. 44]. In addition, the use of built-in peripheral processors to handle input/output operations significantly increases throughput compared with Datapoint's previous top-of-the-line 6640 processors. The 8800 is Datapoint's first full-blown 16-bit machine, since the 6640 uses an 8-bit memory channel.

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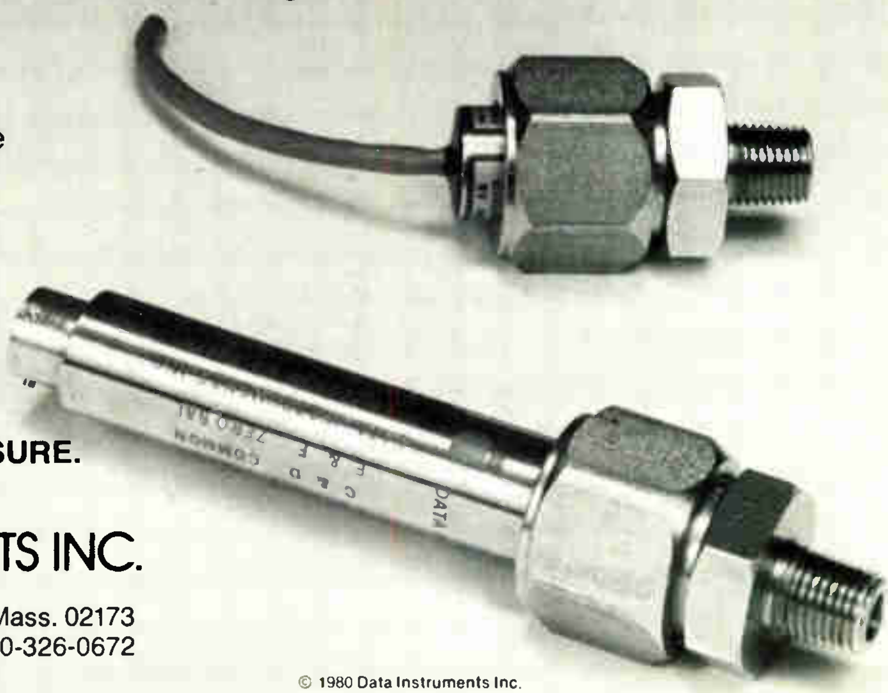

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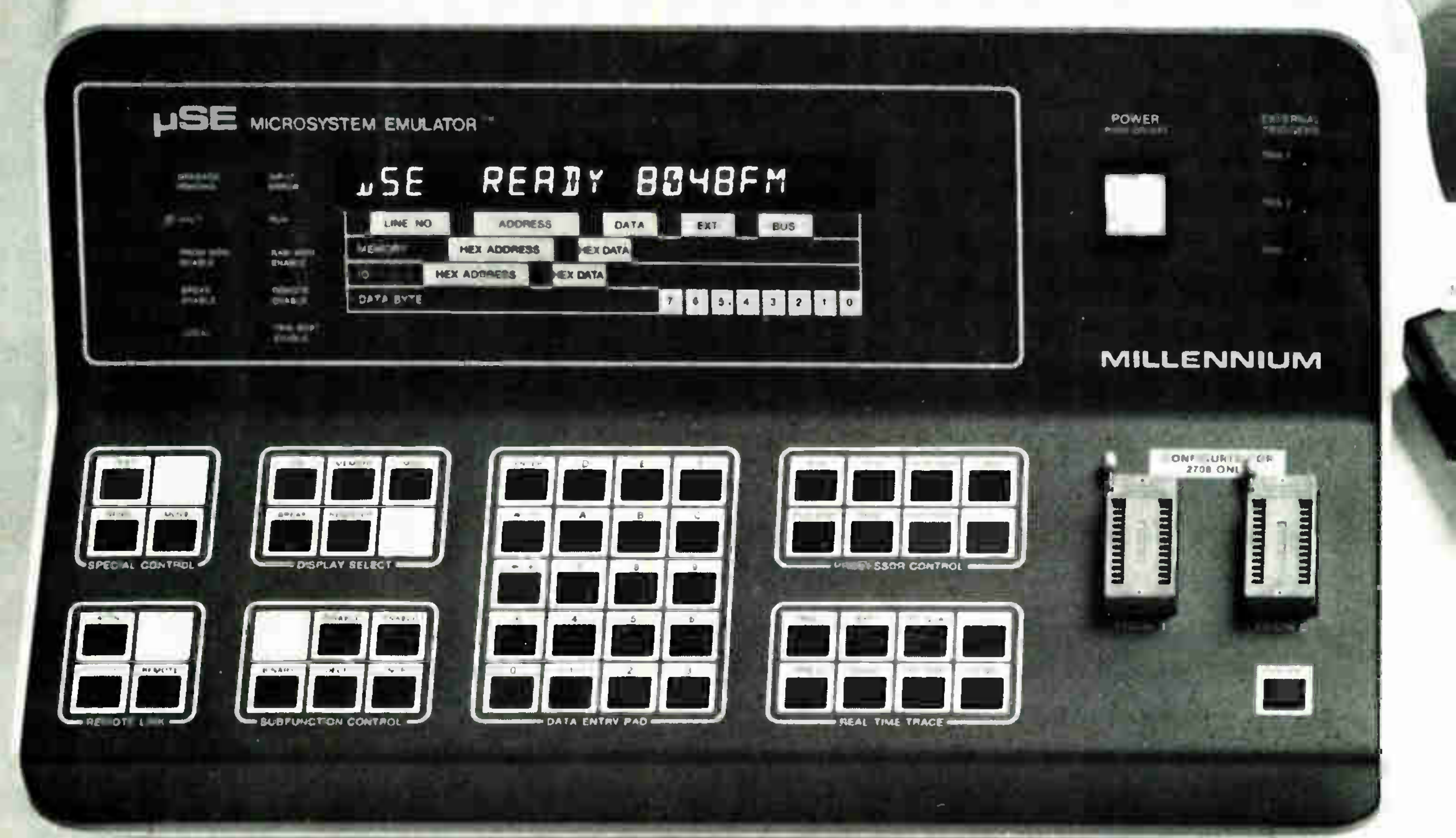

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GaAs LSI chips aim at supplanting fastest silicon ICs

by John G. Posa, Solid State Editor

Processors and RAMs on gallium arsenide material already are realities in laboratories around the world

Consistently uniform substrate materials and maturing processing and circuit techniques are swiftly elevating gallium arsenide chips from the discrete to the integrated level—even to large-scale densities, in some cases. Now on the horizon are parts like powerful data and signal processors with GaAs integrated circuits for core functions and extremely fast GaAs random-access memories.

The primary attraction of the compound III–V semiconductor is speed (see table). An electron mobility over five times higher than silicon's promises comparably quicker chips. There are secondary benefits, too, such as the potential for higher-temperature electronics and on-chip lasers and optical receivers.

Advances. The most recent advances in GaAs IC technology were reported at a symposium on the subject held by the Institute of Electrical and Electronics Engineers earlier this month in Las Vegas, Nev. Although exciting analog circuits like low-noise and power amplifiers, oscillators, mixers, and switches were discussed, the most sensational results are clearly in the digital area. The circuits described gave an indication of the types of high-speed digital GaAs components that will trickle into the market in the 1980s.

The memories and gate arrays slated for GaAs will boost computer performance by minimizing delays through speed-critical loops. Indeed, an impressive paper at the meeting disclosed a 4-bit arithmetic and logic unit implemented with a GaAs gate array by Fujitsu Ltd.'s Kawasaki, Japan, laboratories.

Over two metal levels, Fujitsu interconnected 629 metal-semiconductor GaAs field-effect transistors and 225 Schottky diodes for the ALU's 99 gates. With +3.5- and −2.5-volt power supplies and internal logic swings of 1 V, the chip consumes about a watt. Data-path delays are just over 2 nanoseconds.

Fujitsu interconnected multiple FETs in parallel for the current to drive the 50-ohm impedances of emitter-coupled logic. Obviously, then, the company intends to surround the extremely fast unit with ECL peripheral circuits.

By going from 2-micrometer to 1-μm channel lengths in a future ALU, "delay would be improved by a factor of two. Subnanosecond data delays will be possible," says K. Suyama of the Fujitsu labs.

Denser. To build the ALU, Fujitsu used buffered-FET logic, a form of depletion-mode, or normally on, logic pioneered by Hewlett-Packard Co. at its Solid State Research Laboratories in Palo Alto, Calif. But the highest densities for GaAs thus far are coming from Rockwell International Corp.'s Thousand Oaks, Calif., Electronics Research Center using another form of depletion-mode circuit, called Schottky-diode FET logic, or SDFL.

Using SDFL, Rockwell reported on

GALLIUM ARSENIDE VS SILICON

	1980		1985	
	Silicon	GaAs	Silicon	GaAs
Chip characteristics				
Feature size (μm)	2	1–1.5	0.5–1	0.25–1
Chip size (mil^2)	40,000	<6,000	>60,000	40,000
Integration level (devices)	2,000	200	10,000	2,000
Peak frequency (GHz)	1–2	5–10	3–4	15–20
Static random-access memory				
Access time (ns)	25	15	—	5
Density (bits)	4-K	16-K	—	8-K
Universal gate array				
Gate delay (ns)	0.6	0.5	—	0.3
Complexity (number of gates)	400	2,000	—	1,000
Phase-locked-loop frequency synthesizer				
Frequency (GHz)	1.5	2.5	3	10
Complexity (number of chips)	2	1	15	3

SOURCE: TRW INC.

a long-sought goal: an 8-by-8-bit parallel multiplier. More than 1,000 gates had to be crammed onto a substrate measuring nearly 10,000 square mils—gigantic for GaAs.

But then, "the goal of the program is to reach VLSI" with GaAs, states coauthor F. S. Lee, adding that "10,000 gates can be expected by 1983." The multiplier gives a product in 5.3 ns, compared with 45 ns for the fastest 8-bit silicon unit.

Some of the most useful GaAs circuits will use both depletion- and enhancement-mode, or normally off, FETs. Since this is the combination found in today's silicon MOS chips, existing circuit twists can be applied.

"There are all those silicon circuit designers out there who, with a one-week course, can be gallium arsenide designers," says D. Howard Phillips, the chairman of the conference. He is the new director of Los Angeles–based Aerospace Corp.'s electronics research lab (see p. 14).

RAMs. GaAs static RAMs were described in papers from the McDonnell Douglas Astronautics Co. of Huntington Beach, Calif., and from Lockheed Corp.'s Microelectronics Center in Sunnyvale, Calif. McDonnell Douglas has Department of Defense contracts to build a 900-picosecond, 600-milliwatt 1-K memory and a 6-ns, 100-mW 4-K RAM.

The 1-K part will be organized as 256 by 4 bits and will use depletion-mode load devices in the cell array. The 4,096-by-1-bit chip will employ doped GaAs load resistors for a 32-by-61-μm cell area—roughly half that of the 1-K device—and a cell power rating of just 2 microwatts.

Lockheed is also pursuing a 4-K static RAM, but with a 40-by-57-μm cell layout using depletion loads. Like Fujitsu, it is giving its chip ECL translators to talk with surrounding silicon circuits.

However, on an experimental 16-by-16-bit array, a sad truth became apparent: most of the memory's access time will be eaten up in the ECL level-shifting circuits. In fact, whereas address decoding and internal cell selecting each take only 600 ps, input buffering takes 1.2 ns and output buffering 1.6 ns.

Components

Discrete techniques beef up power ICs to boost current ratings as much as sixfold

A new linear integrated-circuit process that borrows a leaf from the book on discrete technology allows National Semiconductor Corp. to produce power ICs with as much as six times the current rating of the best of previous monolithic parts. The new bipolar process adds some steps found in the fabrication of high-power discrete transistors, and the result is to multiply the power output per unit area.

"The new process and structure enable more efficient utilization of silicon for gathering high currents," says Robert C. Dobkin, director of advanced linear circuit development for the Santa Clara, Calif., firm.

Because it gives a much bigger effective die area, the proprietary process is being called Moose. What's more, it simplifies fabrication of standard and power transistors on the same chip (see figure).

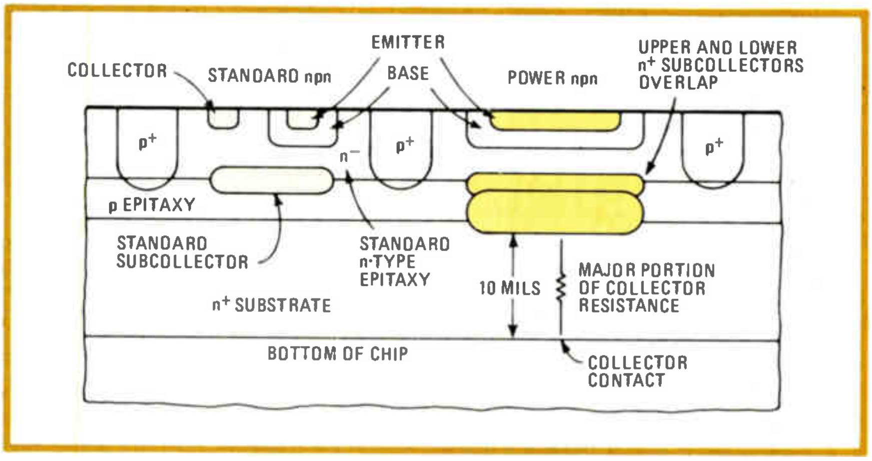
Standard linear processing cannot fabricate a single-chip voltage regulator with an output current greater than 5 amperes, Dobkin says. "The real limitation isn't the amount of silicon, but the fact that you can't put [a more powerful conventional regulator IC] in a regular package because of the large number of bonds required," he explains.

Also, conventional techniques for gathering power "are not compatible with IC processing," he adds. The etched aluminum wires carrying the current from the emitters to the bonds, where power is transferred off chip, must grow in diameter as the IC area and current produced grow. However, thicker wires are extremely difficult to etch, and the longer path between emitters and bonds boosts dissipation.

To overcome the packaging limitation, the Moose process moves the collector of the power transistors from the wafer's top to its bottom. The collector contacts therefore move to the bottom, where they are found in discrete npn transistors.

These moves eliminate the need for input bonds to the power transistors. With the collectors gone, moreover, a much larger emitter area can be fabricated.

Doped n⁺. National starts with a heavily doped n⁺ substrate, rather than the p substrate used to build standard power transistors. "This allows us to get lower resistivity—0.2 versus 2 ohms, typically—from the bottom of the die up to the power transistor," explains Carl Nelson, staff scientist and developer of the Moose process.



Power up. National's new Moose process, which can build power transistors that handle significantly more current, eases fabricating standard transistors on the same substrate.

Building two overlapping subcollectors rather than the conventional surface collector and single subcollector also allows for a lower bottom-to-top resistivity. More importantly, it removes the isolating p layer from the current path, Nelson notes.

The rest of the fabrication process is like that for conventional bipolar linear transistors. The first part using the Moose process will be the LM196 adjustable voltage regulator [*Electronics*, Nov. 6, p. 34], capable of supplying in excess of 10 A.

Wire-limited. "The process doesn't encounter standard limitations until we get up to devices with an output current in excess of 30 A," Dobkin claims. Then it is limited by the amount of silicon that a current-gathering wire can handle, he adds.

"The new regulators will be just as easy to use as standard voltage regulators; they just put out more power," he says. Now designers of systems requiring from 5 to 20 A will be able to make an entire system power supply with just one part rather than the several, each on a card, that has been the practice. **-Bruce LeBoss**

Solid state

IEDM late papers break new ground

The wealth of papers at next month's International Electron Devices Meeting in Washington, D. C., has long been in the planning, but as always, there are a few surprises. If the regular papers (p. 132) are not reason enough to attend, the late ones will add even more impetus. Among late-breaking developments:

A 70-volt power MOS field-effect transistor from Hitachi's Central Research Laboratories puts out 22 watts at 1.1 gigahertz with an 8.5-decibel gain.

A 4-K dynamic random-access memory, also from Hitachi's labs, uses an n-well complementary-MOS process to curb alpha-particle errors.

Bell Laboratories uses tantalum silicide to achieve order-of-magnitude decreases in polysilicon sheet resistance and RC delay in a 64-K dynamic RAM.

Silicides of tantalum and molybdenum are being exploited by RCA Corp.'s Solid State Technology Center to speed up silicon-on-sapphire circuits.

Polysilicon stripes on oxide and nitride insulators are being recrystallized by the Massachusetts Institute of Technology's Lincoln Laboratory using two carbon strip heaters.

With 1.25-micrometer rules, Honeywell Inc.'s Solid State Electronics Center is putting 10,000 subnanosecond bipolar gates on 160,000-square-mil chips.

Self-alignment of emitter-contact and polysilicon base regions by IBM Corp.'s Thomas J. Watson Research Center results in repeatable 0.25-μm base widths.

Like Texas Instruments Inc., the Research Laboratories of the Hughes Aircraft Co. ion-implant gallium arsenide for bipolar devices; gains of 16 are seen.

1-GHz GaAs charge-coupled devices from the Electronics Research Center of Rockwell International Corp. use buried channels and Schottky diodes.

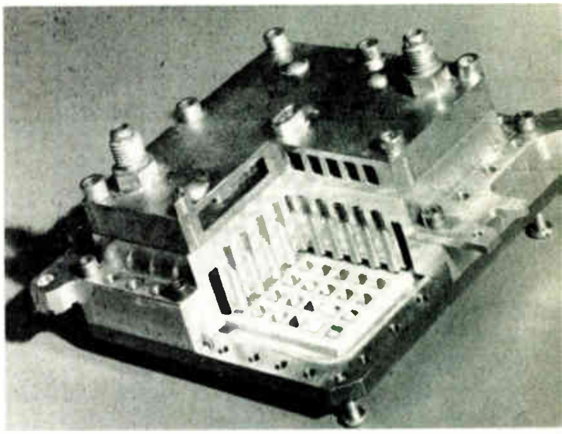
High-gain phototransistors and light-emitting diodes are being integrated by West Germany's Aachen University for optical circuits.

The Hughes' Research Laboratories builds the first integrated optical spectrum analyzer with CCD detectors and semiconductor lasers on a lithium niobium oxide integrated-circuit substrate. **-John G. Posa**

Computers

IBM's H series bows; packaging ups speed

Hitting a new performance level for general-purpose computers, International Business Machine Corp.'s long-awaited 3081 owes its speed hike primarily to a new, very dense circuit packaging scheme. Though the new machine, nicknamed the H series, should hit 10 million instructions a second—perhaps twice the top speed of other top-of-the-line mainframes—it does not up the ante in price-performance ratios as IBM's midrange 4300 series did.



Cooling. In IBM's IC-packed module, spring-loaded rods carry heat from the logic and memory chips (bottom) to a metal structure cooled by circulating chilled water.

The 3081 uses two central processing units that share execution of operations to give parallel processing. An IBM spokesman points out that this architecture differs from the multiprocessing setup available with the company's former top of the line, the 3033, in which CPUs are assigned different tasks.

Performance. The 3081 cycles in 38.5 nanoseconds and has 16, 24, or 32 megabytes of main memory; 16 or 24 data channels; and a maximum data transfer rate of 72 megabytes per second. A basic 16-megabyte configuration with 16 data channels will be available a year from now for some $4,050,000; peripherals and software will be extra.

"The 3081 is less aggressive in price-performance improvements than the 4300 series was," observes Robert T. Fertig, vice president of Advanced Computer Techniques Corp., a New York-based consulting firm. A 4341 model group 2 costs about $455,000 and hits 1.4 million instructions/s for a price-performance ratio of $325,000 per million instructions/s; the basic 3081 should be about $400,000 per million instructions/s.

With its aggressive price-performance ratio, the 4300 series sent shock waves through the mid-range plug-compatible industry. The new machine is unlikely to have that effect on the top-of-the-line plug-compatible makers. This week, in fact, Amdahl Corp. is slated to introduce its new top-of-the-line machine, offering speeds of 12 million instructions/s or better.

The 3081 may well mark the beginning of a line replacing the 3030 family later in the decade. However, there is still life in that line, with a new low-end 3033 that offers a price-performance ratio of about $500,000 per million instructions/s bowing last week.

Enhancing the reliability of the system are the 3081's two CPUs, working under a single operating system. Each processor has its own dedicated data channels, but they share main memory.

Water-cooled. Using bipolar gate-array logic chips similar to those in the 4300 and System/38 designs, IBM has chosen a new packaging scheme in which the integrated circuits are packed much more closely. The higher IC density contributes to speed; on the average two thirds of the signal delay within a CPU occurs between chips.

IBM fixes up to 118 logic and memory chips onto a 90-millimeter-square 33-layer ceramic carrier. It seals all of this into a helium-filled 5-by-5-by-2-inch module (see photograph, p. 41), which depends on a cooling system using chilled water.

The heat flows from the ICs through the helium and through metal rods running to a metal structure with water passages. The elaborate cooling system is necessary because the density increases heat, and it will require an extra investment on the part of 3081 users.

The circuit modules are mounted on specially developed multilayer circuit boards. Four of these boards—each about 2 feet square by 3 in. thick—contain about 750,000 ICs and make up the CPU. Industry observers note that design and production problems with this packaging scheme may have contributed significantly to the delay in IBM's introduction of the H series.

-Tom Manuel and Pamela Hamilton

Microsystems

16-bit Intel processor uses virtual memory

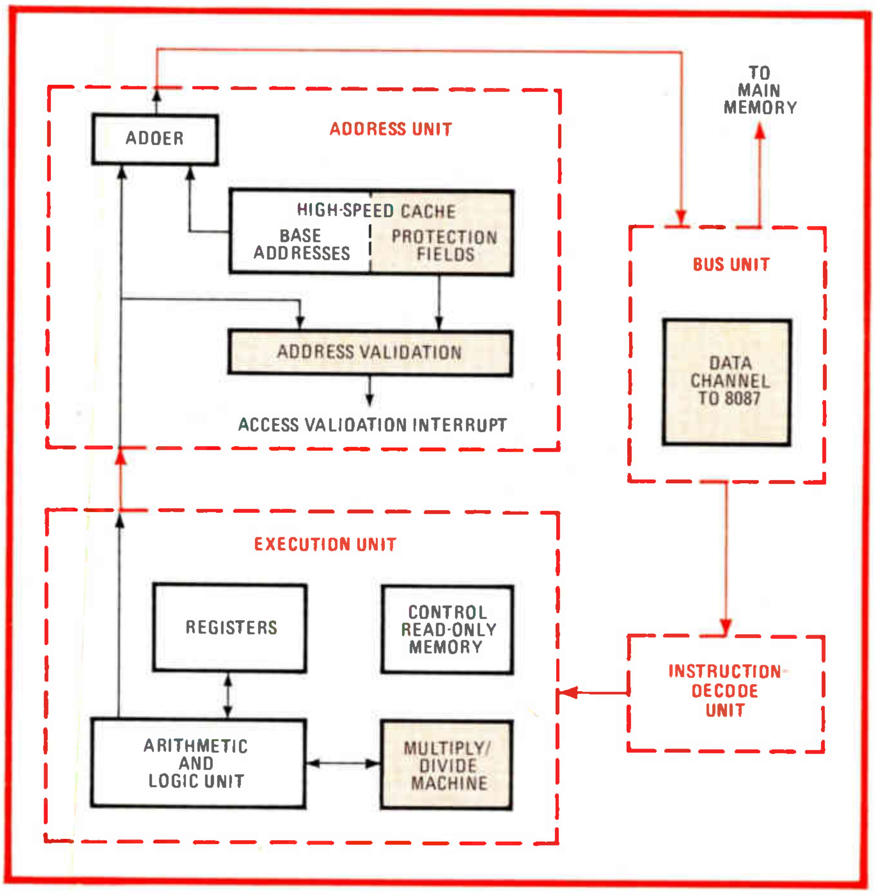
Just as Intel Corp. is incorporating mainframe features in its forthcoming 32-bit microprocessor chip set, it is promoting big computer techniques in the 16-bit field. Its iAPX-286 16-bit processor, to be introduced in late 1981, will feature a pipelined architecture and virtual memory management and protection on the chip.

At three invitation-only sessions, the Santa Clara, Calif., company is telling potential big users that the 286 will be software-compatible with the older 8086. In its capabilities, the new chip will fit between the 8086 and the coming iAPX-432 [*Electronics*, Nov. 6, p. 42].

Intel took a first step toward a pipelined architecture with the 8086, where it found that the division of labor into bus and instruction-execution units boosted throughput—one instruction can be executed while the next is being fetched. As the figure shows, the new setup permits parallel processing in four functional submodules: the bus unit, the instruction-decoding unit, the execution unit, and the address unit.

Virtual. It is in the address unit that virtual memory management and protection take place. Competitors in the 16-bit processor world have already said they will push virtual memory: Zilog, in a new memory management unit accompanying its planned Z8003, which it was calling the Z9000 [*Electronics*, Oct. 23, p. 41]; and National, in its 16000, which will appear next year along with the Intel and Zilog chips.

Virtual memory lets the computer treat every location in the system as if it were in main memory. Intel



Pipelining. Intel's new 16-bit microprocessor will be able to do parallel processing because it is divided into four functional units, including one that handles virtual memory.

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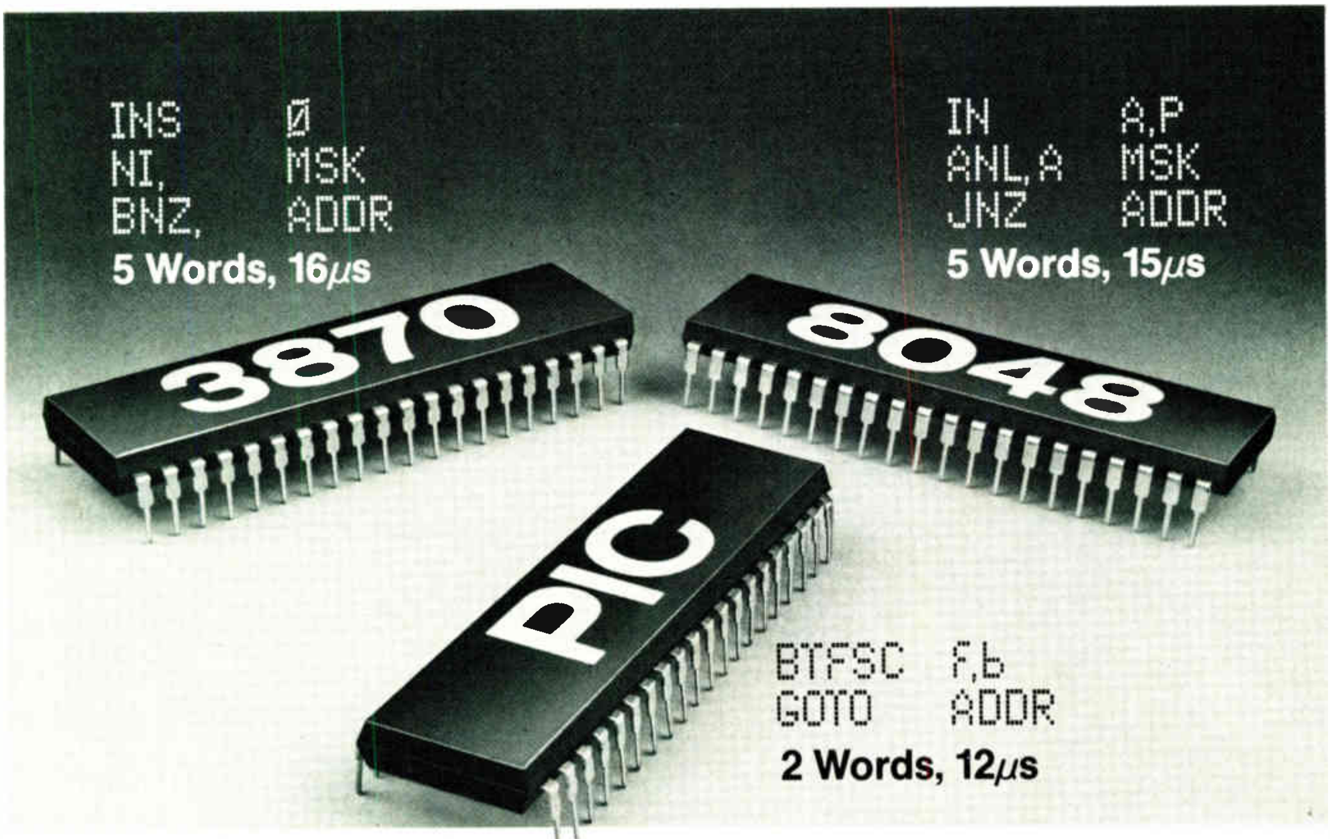

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maps a virtual address space of 1 gigabyte into a 16-megabyte main memory using a combination of hardware and software, whereas others use only hardware.

Using a standard mainframe approach, software pulls blocks of data (called pages or, by Intel, segments) from disks or tapes into main memory. However, handling these segments once they are in the main memory is accomplished solely with hardware in Intel's setup.

The programmer adds protection fields to the base address that specifies the main-memory location of a segment. This creates what is called a descriptor, which contains such information as the type of access permitted to the segment.

The iAPX-286 is not designed to routinely handle references to segments outside the main memory. The 16000 and the Z8003 permit such references with an instruction-abort pin, which backs up the processor one instruction while the missing segment is fetched.

Compiler. The competitive approach requires more on-chip logic than the Intel tack (which allows restart only of those instructions that load or store the descriptors). However, users of the 286 will have to write much more complex compilers, because Intel delegates to this software the responsibility for pulling the segments into main memory.

Intel says there is a programming bonus in its compiler-based memory management approach, as instructions that cannot call on the entire virtual memory space use shorter addresses. It claims that these shorter addresses can result in 40% shorter programs.

Nor are the novelties of the 286 contained only in the address unit. As well as prefetching and queuing instructions, the bus unit provides a direct data channel to the 8087 math coprocessor. Thus this powerful number cruncher can function as a direct extension of the 286, inserting its results directly into the instruction queue. Also, the execution unit has a multiplying and dividing machine six times faster than the 8086. **-R. Colin Johnson**

Instrumentation

Signature analysis tackles mixed logic

That increasingly popular field-service technique, signature analysis, is extending its reach. Its creator, Hewlett-Packard Co., is introducing a signature analyzer that works on a mix of high-speed logic and reads signatures more selectively.

The 5005A also combines signature analysis with commonly needed field tools. In fact, HP's Santa Clara (Calif.) division is calling its new offering a signature multimeter.

The unit is the second to combine signature analysis with other measurement functions. Last year, Sony and Tektronix introduced the model 308, which combined signature analysis with other types of logic analysis—timing, state, and serial. But HP has aimed at a wider field-service market by combining an easier-to-use signature analyzer with a voltmeter, ohmmeter, and counter.

"It incorporates everything that we wish we had thought of for the first generation of signature analyzers," says Ed White, manager of signature-analysis products. Apparently, it is just what the company's Loveland (Colo.) division wanted, too (see "Board tester adds signature analysis").

The unit adds to HP's first-generation 5004A a number of functional capabilities needed for signature analysis today. For one, it expands the applicability of signature analysis beyond the 5004A's TTL levels to emitter-coupled logic, complementary-MOS, or any other logic whose high and low thresholds fall in the ±12.5-volt range.

Mixed boards. It can be used with mixed-logic boards too, because logic thresholds can be set independently for each input line—clocking, start/stop, data, and the new clock-qualifier line. In contrast, the Sony/Tektronix 308's input lines cannot be set independently, so only one type of logic can be checked at a time. Further, setting thresholds with the 5005A is an easy, push-button operation, whereas with the 308 it requires a screwdriver and voltmeter.

The clock-qualifier feature, an idea borrowed from logic analysis, permits greater selectivity in getting a signature. It lets the analyzer clock data in only when a specified signal level (high or low) appears on the qualifier line and is particularly useful for finding faulty components in bused systems.

For instance, one might want to check the signature at the output pin of a read-only memory while the processor is performing a no-operation instruction, or no-op. But other parties to the bus—uninitialized random-access memories or analog-to-digital converters, say—can inter-

Board tester adds signature analysis

Hardware that is equivalent to the 5005A is in a new option that lets Hewlett-Packard Co.'s 3060A board test system do functional checks with signature analysis on digital logic boards with speeds as high as 10 megahertz. Thus the option 100 lets original-equipment manufacturers generate the reference data for comparison by the field-service man using the 5005A with the signatures from a malfunctioning piece of equipment.

Introduced last week at the annual Institute of Electrical and Electronics Engineers test conference in Philadelphia, the $12,000 option accepts test programs generated on a development system and loaded into read-only memories or—if the HP 6400 development system is used—directly downloaded to the tester. In testing the boards at the factory, the OEM can log the signatures, providing a fault tree that can be used in the field as well. Also, by introducing faults at the board level, signature-analysis test procedures can be generated automatically. The option's software includes an advanced troubleshooting concept that can functionally verify typical boards with just eight signatures. **-Richard Comerford**

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Theory may sharpen radar's eyes

Two scientists at the Naval Surface Weapons Center have developed a theoretical procedure for analyzing radar echos to determine the material composition and shape of an object causing an echo. If the procedure proves out, radar and sonar systems could supply precise identification of aircraft and submerged objects—down to the type of plane or submarine—a long-sought goal for military electronic identification systems.

The technique evolved by Guillermo C. Gaunaurd and Herbert Überall at the U. S. Navy unit in Silver Spring, Md., involves a mathematical analysis of each of the component waveforms in the radar return signal that an object generates. Certain resonances in these waveforms can be correlated with the shape and composition of the object itself. The method builds on previously known theory and on Gaunaurd and Überall's own recent theoretical development in the study of the diffraction of acoustic and surface waves. It is an example of the type of development that could outmode the Air Force's plans for a plane invisible to radar [*Electronics*, Sept. 11, p. 46].

The method should also be useful in seismic prospecting for minerals and oil and in tumor identification. But all applications await the refinement of the theory and the building of specially designed equipment, which would require substantial computer capability and fast-acting electronic gear that can resolve echo waveforms.

-Harvey J. Hindin

rupt at random, introducing false data and invalidating the signature. With the qualifier line tied to the ROM's chip-select pin, data will be gated to the analyzer only when that chip is on the bus, producing the signature information wanted.

Adding a counter-timer allows the 5005A to test asynchronous digital circuitry, an area off limits to previous signature analyzers. Even in the traditional voltmeter area, the instrument adds a new twist—a ΔV function, to display the voltage difference between two nodes.

All these additions beget one more. The price of the 5005A is \$2,500—\$1,500 more than that of the 5004A. **-Martin Marshall**

Speech synthesis

IC-based text reader 'speaks' ASCII code

With the cost benefits of solid-state integration pushing the spread of speech synthesis into new areas, chip makers are also expanding the availability of older applications. For example, speech-synthesis chip pioneer Texas Instruments is readying a low-cost text-to-speech conversion system with an unlimited vocabulary aimed for home use.

The new subsystem will first appear as an option for TI's 99/4 home computers. Its efficient conversion software, working from a program resident in the system microprocessor to convert typed-in spellings or serial data to natural-sounding speech, requires little or no additional hardware.

Difference. The TI reader cannot scan printed matter electronically as can much more costly text-to-speech machines. Rather, it transforms incoming ASCII-encoded characters into sounds called allophones—variants of phonemes, one family of basic human speech sounds.

The transformation is handled by an efficient set of software rules easily implemented by a microprocessor like the 16-bit 9900 in the 99/4. After producing the allophones, the processor joins the parameters needed to verbalize each one. The parameters are drawn from a library in a read-only memory using another fast and simple alogrithm.

TI derived these parameters with linear predictive coding, the same method used by the synthesis IC to simulate the human voice when the parameters are linked together. To smooth the allophone stringing, a 25-millisecond interpolation period appears between each parameter.

The allophones greatly relax memory requirements, thereby helping keep system cost low. An allophone acts like a phoneme, except that it takes into account the sound's relative position in a word or phrase, as well as adjoining sounds.

Library. There are 128 allophones whose parameters are stored in the ROM library, including long and short pauses. These take "only 3-K bytes of storage, which is much less than the storage required for the sound units in most of the text-to-speech systems today," avers Kun-Shan Lin, manager of speech research and development at TI's Lubbock, Texas, consumer products headquarters. The rules for joining allophones have been packed into a 7-K-byte lookup table.

The synthesizer used in the system is the TMS 5200, an improved version of the original talking IC introduced by TI over two years ago [*Electronics*, Aug. 31, 1978, p. 109]. The 5200, the heart of an already available voice option on the 99/4 home computer, gives the machine some ability to talk about its operations through a limited vocabulary of stored whole words. Now the 99/4 will be even more talkative.

Key hardware features of the 5200 will make TI's new text-speech subsystem a shoe-in. These features include circuits that allow sources other than a ROM to supply it with LPC codes and a 16-byte first-in, first-out buffer memory to store this external data.

The new synthesizer also includes a memory data-bus interface, which could be important in future applications. The interface can route speech data to the microprocessor for manipulation beyond the capabilities of the synthesizer.

Future. TI also is contemplating transferral of the allophone formation from the system microprocessor to a specialized logic chip. It would design that IC so that it would appear as a simple ROM to the synthesizer chip. Thus the assembled allophones could be treated by the synthesizer exactly as it treats the words stored in the existing ROM.

The 99/4 home computer's text-

"360 panels an hour outstrips any aqueous system we've ever used."

Dana Schofield, Plant Manager, Hadco Printed Circuits, Owego, NY

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Innovations for Electronics

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to-speech capability will be featured in Texnet, a home information and communications service that TI will introduce in the first half of 1981. The Texnet services, such as news, electronic mail, financial reporting, and consumer buying and travel information, all can be verbalized.

Source. The new network will be supplied by Source Telecomputing Co., the McLean, Va., pioneer in distributed data and communications services for the general public. Texnet will offer all of Source's information services, plus programs that can use the color graphics and music capabilities of the 99/4.

To further enhance the value and appeal of the year-old 99/4 computer (which has been a slow starter), TI has also announced a new software development program to convert existing Basic programs from various third-party software vendors into TI Basic.

-John G. Posa and Tom Manuel

Peripheral equipment

Low-cost Winchester boosts density

A new family of 8-inch Winchester disk drives offers two to three times the capacity of the best-selling Shugart Associates SA1000 line for about the same low price. An innovative head actuator and positioning system gives them a track density of 345 tracks per inch versus the others' 175 tracks/in. or so.

Designed to be compatible with the SA1000 units, the Q2000 family boasts a combination of a novel rotary moving-coil actuator and a unique temperature-compensation system that improves positioning. It comes from a new company, Quantum Corp. of San Jose, Calif.

In effect, Quantum will both second-source Shugart Associates and make it possible to upgrade to higher capacities. The company is betting that low-cost computers will continue their explosive annual sales growth of 35% to 50% and that individual systems will require more memory, further increasing demand.

Denser. The Quantum Q2000 8-in. Winchester drive uses a novel actuator design and temperature-compensation method to achieve high densities at low cost.

Quantum's actuator consists of a ring magnet, two flat-plate magnetic circuit elements, a single-plane moving coil, and two bearings. It is far less complex than the stepper motors normally used in low-cost Winchester drives. Because of its simplicity, it positions the arm holding the read/write heads with greater accuracy, and because of the low mass of the coil, it is slightly faster than the best stepper motor designs, attaining average access times of 50 to 60 milliseconds.

The more accurate the positioning of the arm, the closer together the tracks can be on the disk. Thus the Q2000's track density is double that of stepper-based models, but it is well under the 450 to 500 tracks/in. of the linear and rotary voice coil actuators found in high-cost Winchester drives. However, the simpler Quantum design costs significantly less to manufacture than these more accurate actuators.

Temperature. To get its high density, the Q2000 must compensate for the fluctuations in track positions due to temperature changes. With a stepper actuator, the less dense tracks are wide enough to make positioning accuracy less important. The more expensive drives use a full-track servomechanism in which temperature compensation is inherent in the track-reference method used.

In these drives, an entire disk side and its accompanying head provide the track reference information for all disks. This side contains only data that identifies the track locations, and, as the head positions itself on the desired track, the read/write heads attached to the same arm move to the same location on the other disks. When the track reference shifts due to temperature, so do the corresponding data tracks.

Compromise. The Quantum setup makes a nice compromise between devoting an entire disk side to track reference with inherent temperature compensation and the lower track density that needs no compensation. Like the stepper actuators, it has the track reference in the actuator mechanism, but unlike them, it also has a temperature-compensation servomechanism.

The track reference comes from an optical position encoder on the actuator. The encoder is built around a 3-inch-long glass rectangular plate engraved with a bar pattern whose positions refer to tracks on the disks.

The temperature-compensation servo reads a track location code written into the ordinarily blank index time space at the end of each

News briefs

Calma adds speech to CAD system
Voice recognition technology is appearing in the computer-aided design field in a system unveiled by Calma Co. The $12,000 option to the Sunnyvale, Calif., firm's vector memory display station recognizes over 50 of the operator's words or phrases of less than 1 second in duration. Later it will be expanded to include up to 100 words. The voice recognition hardware, produced by Interstate Electronics Inc., has been considerably modified by Calma. Although the company has no extensive study of productivity improvements from voice recognition, it says initial users have saved from 40 minutes to 2 hours and 10 minutes per 8-hour shift.

CAD firm turning out products as well as artwork
Branching out, Algorex Corp. is adding manufacturing work to its computer-aided design services. The Syosset, N. Y., company has specialized in CAD artwork for extremely large custom multilayer thick-film hybrid substrates and for printed-circuit boards. Now it is adding a production line for thick-film multilayer ceramic substrates. Thus its engineers can take a customer's design from the schematic to tested hardware.

Intel launches fast 16-K EE-PROM
A speedy 16-K nonvolatile memory, the 2816 electrically erasable programmable read-only memory is available in prototype quantities from Intel Corp.'s Special Products division. Priced at $120 each in 100-piece lots, the 2816 has a worst-case access time of 250 nanoseconds—at least 100 ns faster than Hitachi's recently introduced HN48016 16-K EE-PROM, which is selling for $70 in like quantities. The key to the 2816's performance is the Santa Clara, Calif., firm's new Flotox—floating-gate tunnel oxide—cell structure [*Electronics*, Oct. 23, p. 142]. To be available in production quantities in the first quarter of 1981, the 2816 dissipates 495 milliwatts from its single 5-volt power supply when active and 132 mW when on standby.

track. An Intel 8048 microcomputer uses the information once each revolution, or 50 times a second, to check and correct the heads' position.

The Q2000 is available initially in 10-, 20-, and 30-megabyte versions. The quantity prices of $1,200, $1,500, and $1,800, respectively, closely track those of the SA1000 and the Memorex model 101, except that these at present go only to 10 megabytes. -**Tom Manuel**

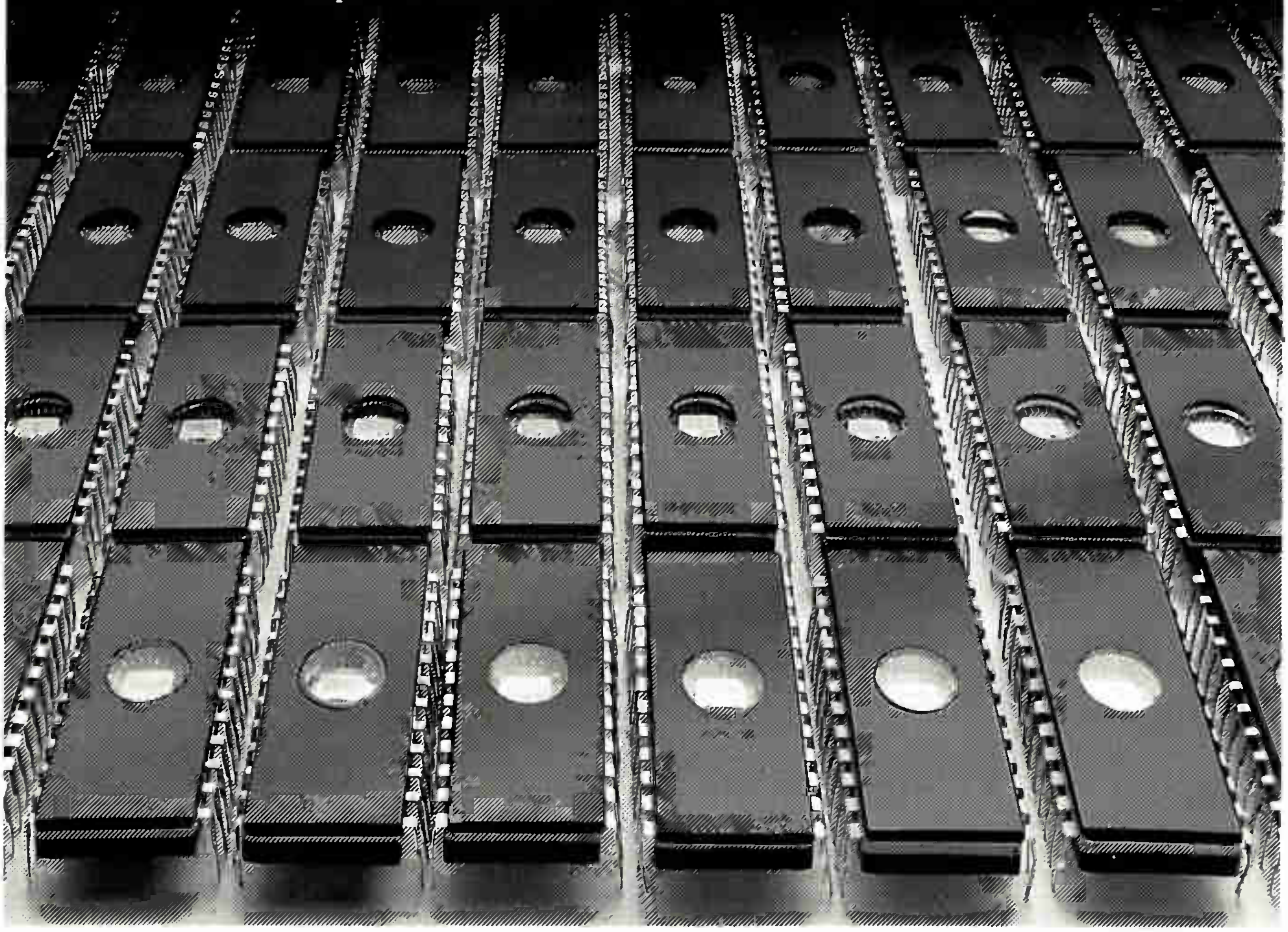
Production

Temporary electroplating bath speeds up checks of multilayer hybrid substrates

A new continuity tester for multilayer hybrid substrates uses an electroplating approach that promises to slash testing costs. The tester, based on developmental work at the Sperry division of Sperry Corp., can speed the checking process because it relies on simple visual inspections of as many as 10 2½-by-2½-inch substrates at once.

Because multilayer substrates can hold many integrated circuits, continuity testing is vital to reduce the chance of loading a faulty one with expensive chips and components. On the other hand, users can take a chance on a single-layer substrate being good and test it only when it is loaded.

Cost. "Continuity testing of a multilayer thick-film substrate's thousands of interconnections is an expensive process, requiring an up-to-$250,000 computerized continuity tester, plus a special $5,000-to-$15,000 custom probe interface for



each new substrate design," says Robert J. Ost, senior engineer at the Great Neck, N.Y., division and coauthor of a paper on the development presented at the recent ISHM '80 meeting of the International Society for Hybrid Microelectronics in New York.

Low cost. The new tester, which will be manufactured and sold by Integrity Systems of New York under a Sperry license, will cost around $10,000. Thus it can bring the advantages of automatic testing to manufacturers of small and medium-sized hybrids, for whom the computerized testers [*Electronics*, Aug. 7, 1975, p. 87] are too costly.

A master, or known good, substrate is placed under a magnifier dome, and the operator sets a special probe on one node of one network. By a pantographic arrangement, 10 probes move to the same nodes on the substrate under test.

When all 11 substrates are bathed in a proprietary electrolytic solution and the probes are energized with a test voltage, all the nodes in the networks under test—which are, in effect, temporarily plated—should darken, says senior engineer Robert F. Perry, co-inventor with Ost of the process. Pulsing the test voltage causes the nodes to "blink" as the plating waxes and wanes.

The network under test in each substrate should exhibit the same blinking pattern as the master substrate. Shorts would cause more nodes to blink on a substrate under test than on a master; opens would result in fewer nodes blinking.

Pinholes. The new equipment can also remove pinhole shorts between nodes. The operator puts a special probe on one of the shorted points, and a controlled current discharge passes between it and the test probe, burning out the short.

By picking up shorts and opens on substrates' inner layers, the new machine will cut some, but not all, of the requirements for visual inspection. Also, it makes it easy to evaluate screen-printed insulating materials by checking simple screened patterns on a test substrate of two conductive layers. **-Jerry Lyman**

Washington newsletter

Military readiness, savings gains seen from ATE policies

Readiness of U. S. weapons systems could be raised by 30% and life-cycle costs cut if the Defense Department and the military services "establish verifiable testability requirements for new prime weapon systems and for automatic test systems equipment." Moreover, potential savings of $100 million annually in support equipment system costs alone could be realized **if the Pentagon creates an integrated logistics development policy and enforces it at the service level.** These are 2 of the 11 summary recommendations in a new 228-page report on military automatic test equipment issued following a study by the joint services and five industry trade associations.

Conservatives to reshape FCC under Reagan . . .

A reshuffle of the Federal Communications Commission along more conservative lines is near the top of Republican priority lists after confirmation of President-elect Reagan's Cabinet appointments early next year. **Reagan will get to appoint at least three of the seven FCC commissioners, including a new chairman, and possibly a fourth.** By law, three of the seven must be Democrats, but, as one source noted, "there are lots of different kinds of Democrats." Chairman Charles D. Ferris must resign that post, and he is expected to resign his membership as well. Other expected departures: James H. Quello, Tyrone Brown, and Robert E. Lee. Conservative Lee, however, is considered a possible successor as chairman despite his age (nearly 69), as is Republican Commissioner Anne P. Jones. Key Reagan telecommunications advisers—former FCC Chairman Dean Burch and Richard L. Wiley—are also considered candidates.

. . . as G.O.P. gets stronger role in telecomm deregulation

Republicans also will hold key roles in any rewrite by the 97th Congress of the 1934 Communications Act to deregulate telecommunications. Among them are Oregon's Sen. Robert Packwood, who will become chairman of the Commerce, Science and Transportation Committee, and Arizona's Sen. Barry Goldwater, who is expected to take over the communications subcommittee. **Both have been active in supporting a rewrite, as has New Mexico's Harrison H. Schmitt,** former astronaut and expected chairman of the science and technology subcommittee. On the House side, Democrats retain control, but Lionel Van Deerlin (D., Calif.) was defeated; his successor as chairman of the House Interstate and Foreign Commerce committee's communications subcommittee is expected to be Timothy Wirth of Colorado, now senior Democrat.

Westinghouse wins Holland's order for F-16 countermeasures

In a big step toward equipment commonality among North Atlantic Treaty Organization forces, the Royal Netherlands Air Force has contracted with Westinghouse Electric Corp. to buy 75 AN/ALQ-131 electronics countermeasures pods for its General Dynamics F-16 fighter. **The plane is being coproduced by the Dutch and three other NATO partners—Belgium, Denmark, and Norway** [*Electronics*, Jan. 20, 1977, p. 79]. The Westinghouse Defense and Electronic Systems Center near Baltimore signed a $12 million agreement for the first 12 pods, spares, support, and training, says Westinghouse ECM marketing manager Kent E. Hutchinson. The company, which is already under contract to provide 288 systems to the U. S. Air Force, expects follow-up orders from the Dutch because they are committed to buy 102 F-16s and are negotiating for a second batch of 111 aircraft.

Washington commentary

The constraints on Reagan's defense budget boosts

Ronald Reagan's military spending advisers are advocating upwards of $25 billion in supplemental programs to the $157.8 billion ceiling approved by Congress for fiscal 1981, and the conservative Heritage Foundation is reporting to Reagan that increases should be $35 billion annually over the next five years. So why are the Electronic Industries Association and the Aerospace Industries Association holding to their respective forecasts of relatively slow growth in military electronics outlays and in aerospace engineering jobs next year?

Double-digit inflation is part of the answer, although so are an already tight market for engineers and technicians and the time needed for the military to gear up for new programs. Fiscal 1981 began in October, and as one Pentagon senior budget specialist points out, "we would have a hard time, realistically, trying to spend $500 million with industry this year to restart the B-1 bomber program or a like amount for an army ballistic missile defense system," as Reagan advisers propose.

Playing cool with Congress.

Although the Republicans will control the Senate for the first time in 26 years, with a majority of 53 of the 100 seats and with strong military advocates becoming chairmen of key committees—for example, Texan John G. Tower taking over Armed Services—the EIA holds to its forecast that the 1981 market growth will be constrained to 2% after inflation is discounted [*Electronics*, Oct. 9, p. 95]. The EIA, notes one official of its Government division, believes that President Reagan "will let Congress settle down a little" before proposing significant increases in defense spending.

Says another congressional specialist in the Office of Management and Budget, "The Republicans have been out of the saddle for a long time and will need some time to adjust, particularly since the House is still controlled by the Democrats. Sure, the Democrats' margin is much smaller [down by 33 seats], and many of them will be keeping a low profile as a result, but they are still in control. And Reagan and the Senate know that. They will be looking for some compromises."

Bigger military spending increases will more likely come after Jimmy Carter sends his final budget for fiscal 1982 to the Congress before Reagan's inauguration in January. Most industry officials agree that the largest share of Reagan's military supplemental increase will be sought in that budget. Sources agree that the revised fiscal 1982 budget will easily exceed $200 billion if military pay and benefits increases are included.

Nevertheless, the Aerospace Industries Association forecasts that 1981 jobs for engineers and scientists will rise only a bit more than 2% to 195,000 at year-end. That compares with the 1980 growth level of nearly 8% to 191,000 from the December 1979 total of 177,000. Similarly, the association's new estimate, which was drawn from a survey of 51 major companies accounting for two thirds of the aerospace output and from Bureau of Labor Statistics data, sees jobs for technicians rising by just 1,000 to 79,000 by the end of 1981.

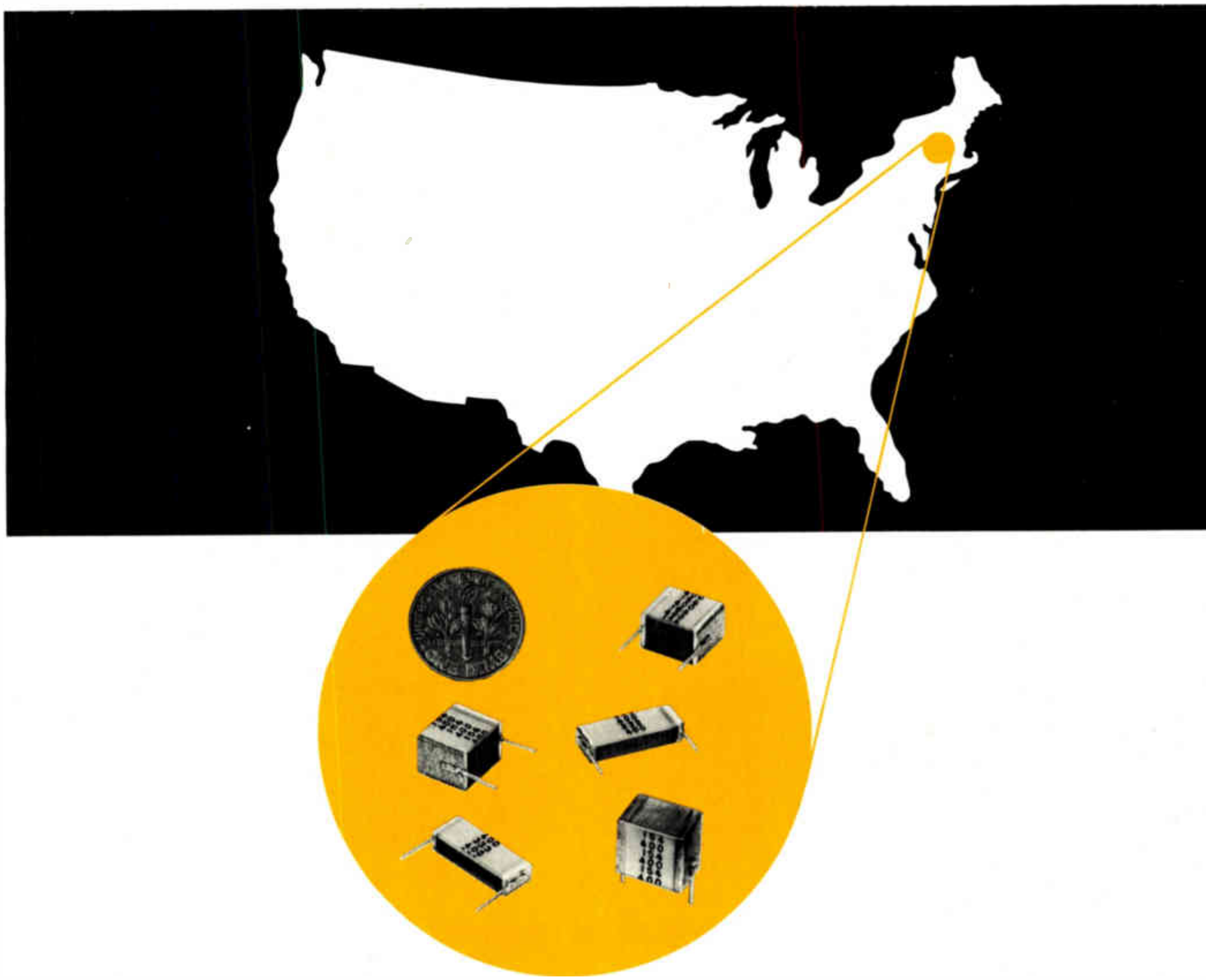
This year, 9,000 new jobs were added to the 1979 level of 69,000. That in turn means that jobs for engineers, scientists, and technicians in aerospace at the end of 1980 will stand at the highest level since 1969 but expand only slightly next year. Moreover, the steadiest growth, says the AIA, has already come in the missile and space side of the industry, as well as in avionics manufacturing, while jobs in manufacturing of commercial transports and helicopters remain flat in the face of rising foreign competition and increased airline operating costs.

Finding the engineers.

"What I would like to know," says one outgoing executive on the Carter military team, "is where all the engineers are going to come from" to make good on Reagan proposals to increase defense preparedness. "We simply do not have enough trained people," he points out, noting that most recently graduated electronics engineers are going into the commercial/industrial side of the industry because they see greater job stability in that sector than in the military electronics market. The documented shortage of EEs [*Electronics*, Nov. 6, p. 93] is, he argues, "a factor that Reagan's people have yet to come to grips with."

Reagan defense advisers say they are aware of the tight market for engineers, of course, and have difficulty specifying where prime contractors for new and expanded weapons programs will find the skilled personnel they need to deliver on defense budgets of more than $200 billion annually through 1985. But "I don't see manpower as a major problem," says one Reagan transition team staff member. "If Congress votes the money, industry will find the people."

That is easily said. But some priorities in the electronics industries may have to change before they can in fact be found. **-Ray Connolly**



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themselves are far faster and more versatile than they were a few years ago. We're delivering 2,000 gate-cells per chip now, looking at about 4,000 soon and forecasting nearly 10,000 in '82. Three years ago we were offering less than 500 gate-cells per chip.

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Orhan Tozun, Director of Engineering

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Our engineering department talks with your designer and evaluates your logic to make sure it's do-able on one of our many gate arrays. The next step is a firm quote to let you evaluate the economics of our solution. That includes both development and production costs. We can do it because our CAD system gives us consistency and our years of experience provide projectable yield information that lets us cost your job accurately in advance.

Then we send you our logic, right?

Right. We take it through a logic restructuring and minimization, block out the functions from our CAD library and lay out the interconnections between logic blocks. Then we check it. And re-check it. Only then do we commit to fabrication.

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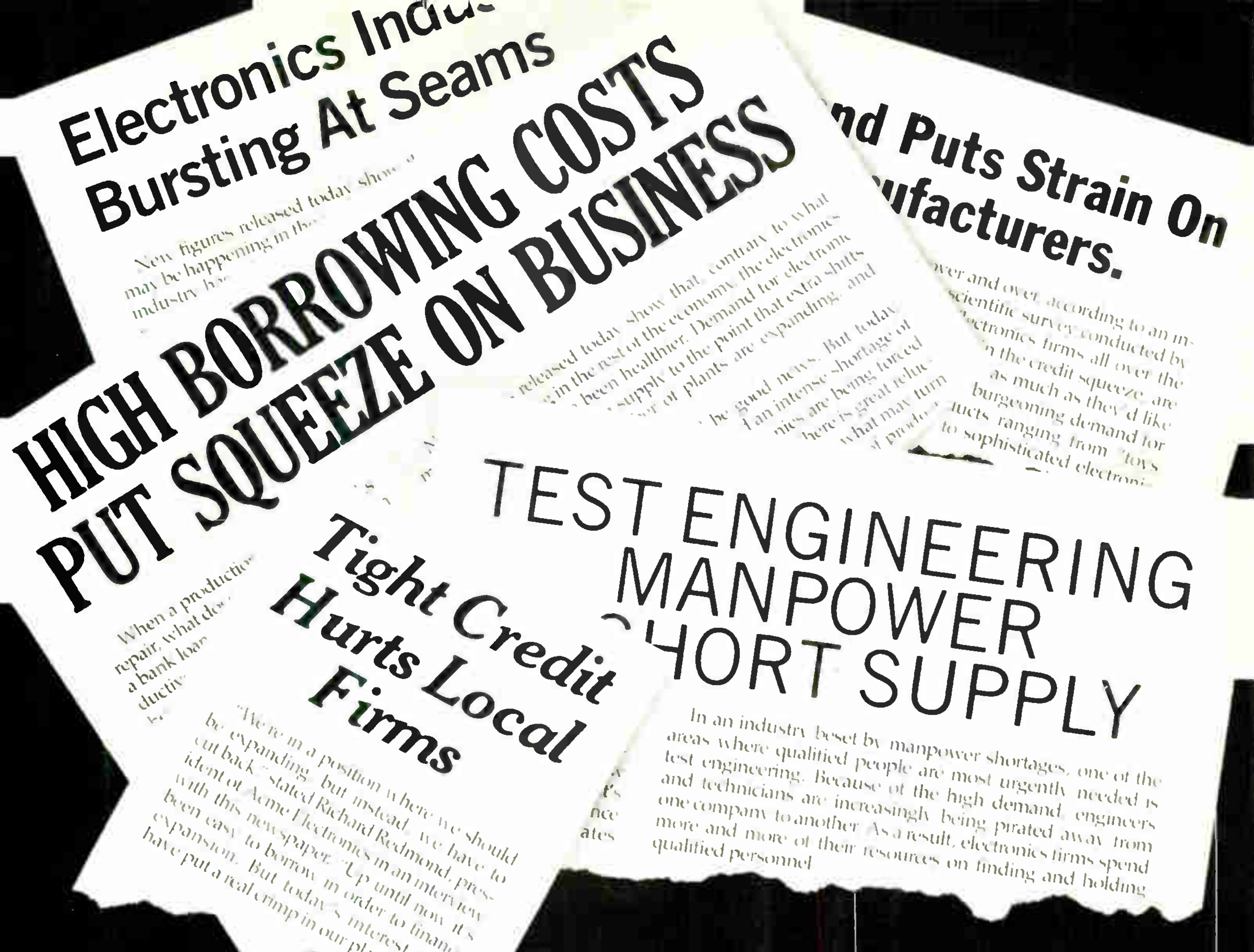

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International newsletter

Hitachi plunges deeper into wafer lithography market

Japan's newest manufacturer of wafer lithography equipment has now added pattern-generation and dry-etching equipment to its 10:1 optical projection unit [*Electronics*, June 5, p. 63]. Hitachi Ltd.'s HL-550 vector-scanning electron-beam system can pattern a 5-by-5-in. area with a minimum line width of 1 μm and a positioning accuracy to within 0.1 μm. **It takes an average of 1 hour to expose the pattern of a 64-K dynamic random-access memory** on a 4-in.-diameter substrate. A cassette holds 12 masks or wafers for increased throughput.

The HE-818 magneto-microwave plasma-etching system produces devices with a minimum line width of 0.2 μm. The extremely low pressure of 10^{-4} torr gives a low ion energy level of 20 to 30 eV, which will not melt even susceptible electron-beam resists, and also produces many fewer radicals than other dry-etching systems, effectively eliminating undercutting even of submicrometer line widths. A magnetron of the type used in home microwave ovens excites the plasma. The HL-550 and HE-818 will sell in Japan for $2.1 million and $235,000, respectively, and first deliveries will be next year.

Two data networks in West Germany and France to link up

After studying the technical prerequisites for across-the-border data-communications services, West Germany's Bundespost and France's postal and telecommunications authority have agreed to start data exchange next year between equipment hooked to a packet-switching network in each country. These networks, called Transpac in France and Datex-P in West Germany, allow transmissions of large amounts of data at speeds up to 9,600 b/s. **Trial services will get under way early in 1981** and regular services around mid-year. The coupling of the two networks, the Bundespost says, should benefit each country's economy, trade, and industry.

Racal cooperates with GI in C-MOS venture . . .

Racal Electronics Ltd. of Wokingham, Berks., and the United States' General Instrument Corp. are collaborating to provide a European source of high-density silicon-gate oxide-isolated complementary-MOS microcircuits. **A $20 million facility now being completed at GI's production unit in Glenrothes, Scotland, has the capacity for 3,000 wafer starts per week,** using a 5-μm C-MOS process developed with Racal funding at Leuven Research and Development, a commercial offshoot of Belgium's Leuven University. GI will provide all production investment, and Racal will continue to fund development at Leuven of a 3- to 5-μm second-generation process. First products from the new facility will be available next year. They will include C-MOS versions of GI's PIC 1650 8-bit microcomputer and SP-0256 speech-synthesis chip, as well as the C-MOS uncommitted logic arrays for use by Racal subsidiaries. The deal gives Racal an additional European source of supply and provides GI with an entree into the European C-MOS market.

. . . with Plessey wins contracts for Project Raven

After an earlier competitive target study for **the replacement of the Australian army's combat radio system,** Racal Electronics Ltd. and Plessey Avionics and Communications Ltd. of Ilford, Essex, have each landed a competitive second-stage project-definition contract for the new frequency-hopping electronic counter-countermeasures radio communication system. Ultimately the contract for Project Raven, as it is called, could be worth some $86 million. The 14-month $860,000 definition phase will be followed by equipment development and manufacture in Australia, where Plessey is already established and Racal is forming a new company, Racal-Milcom Pty, especially for the purpose. Plessey Co. recently landed the largest British military communication contract ever placed, the one for the Ptarmigan all-digital battlefield trunk communication system [*Electronics*, Nov. 6, p. 63].

ICL upgrades 2900 line of mainframes

Britain's International Computers Ltd. is giving its six-year-old 2900 series a shot in the arm with a package of over 30 new software and hardware developments. In particular, it has announced two new heavily microcoded mainframes: the 2955, which is 38% more powerful than the IBM 4331/2 and has a world price of $460,000, and the 2966, which is 11% more powerful than the IBM 4341/2 and has a $920,000 world price. Also, **in what it claims is a major breakthrough in microcoding technology,** ICL says that both machines can concurrently run application software in their native-mode VME (virtual machine environment) operating system and in their DME (direct machine environment) operating system, which emulates earlier-generation ICL 1900 machines, and also carry out VME program development. Communication is possible between VME and DME files. ICL engineers achieve simultaneous operation by time-slicing the central processing unit between operating systems, adjusting the processor time allocated to each to match the work load.

Austria seeking to limit imports of Japanese VCRs

Impending restrictions on imports of Japanese video cassette recorders into Austria **appear to mark the start of trade friction over an original Japanese product,** which the Japanese thought was immune to this type of problem because it does not affect an established operation. Industry sources report that Austria is striving to protect VCR maker Philips Austria by limiting Japanese imports to one third of the domestic demand. Direct exports to Austria during the first nine months of the year were less than 5,000, but private label units exported from Japan to European manufacturers account for much of the remainder of the country's yearly demand of 25,000. Since Austria produces about 300,000 VCRs a year, it is an exporter of VCRs.

Addenda

Market forecasts to the effect that the number of installations of viewdata-based TV receivers in West Germany will reach half a million, let alone 1 million, by the mid-1980s are unrealistic, believes Diebold Deutschland GmbH, the Frankfurt-based computer consultant affiliate of Diebold Inc. in New York. General manager Hans Jürgen Schwab notes that initially **viewdata communications, like personal computers, will be a service for commercial rather than private users.** . . . A technical exhibition celebrating Hitachi Ltd.'s seventieth anniversary includes items spanning the state of the art in electronics—an in-line three-gun color picture tube using magnetostatic instead of electrostatic focusing; a prototype microcassette speech-only recorder that records and plays back at a very slow 0.6 cm/s; and a prototype watch-radio combination **whose transparent piezoelectric cover for the display doubles as the radio speaker.**

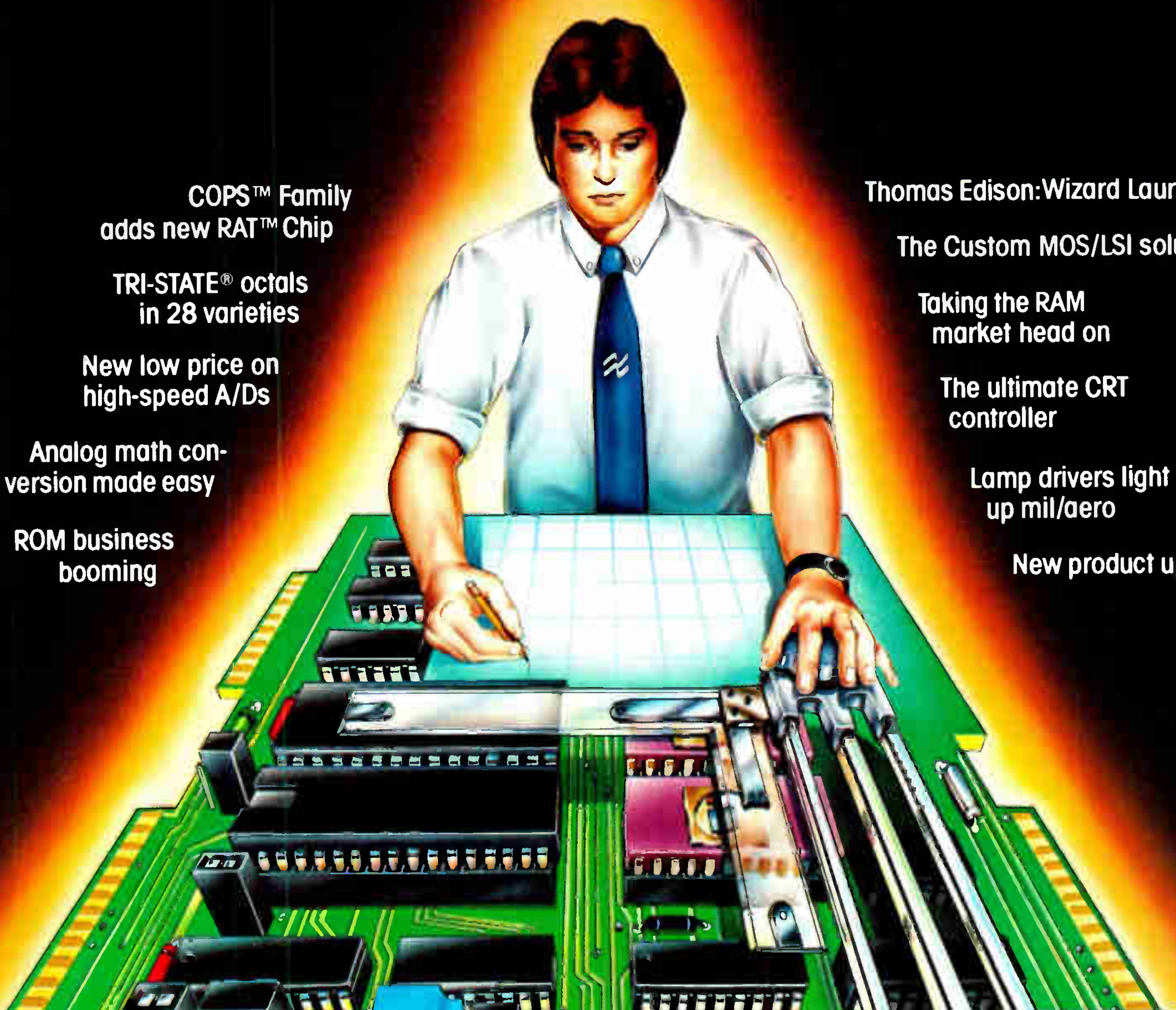
NO. 18

NATIONAL ANTHEM®

SEMICONDUCTOR NEWS FROM THE PRACTICAL WIZARDS OF SILICON VALLEY.

Quick new interfaces to the real world.

NATIONAL'S SERIES/80 PROCESS CONTROL BOARDS SIGNIFICANTLY REDUCE SYSTEM DEVELOPMENT COSTS.



COPS™ Family adds new RAT™ Chip

TRI-STATE® octals in 28 varieties

New low price on high-speed A/Ds

Analog math conversion made easy

ROM business booming

Thomas Edison: Wizard Laureate

The Custom MOS/LSI solution

Taking the RAM market head on

The ultimate CRT controller

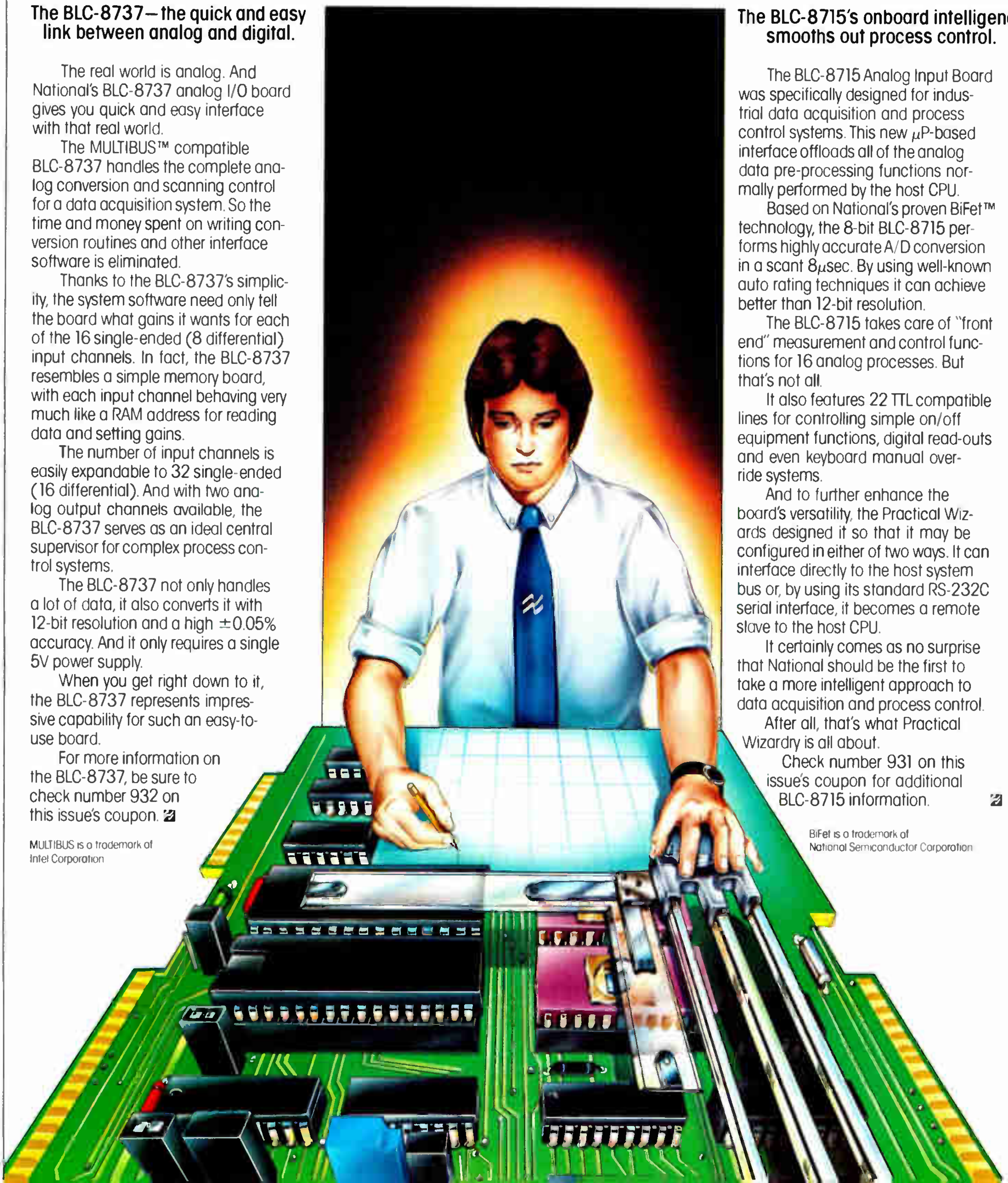
Lamp drivers light up mil/aero

New product update

Digitalker COPS Data Acquisition Logic Transistors Hybrids Linear Interface
Bubble Memory RAMs/ROMs/PROMs Transducers Displays Custom Circuits Optoelectronics
Memory Boards Microprocessors Development Systems Microcomputers Modules

NATIONAL ANTHEM

Practicality comes to process control.



The BLC-8737—the quick and easy link between analog and digital.

The real world is analog. And National's BLC-8737 analog I/O board gives you quick and easy interface with that real world.

The MULTIBUS™ compatible BLC-8737 handles the complete analog conversion and scanning control for a data acquisition system. So the time and money spent on writing conversion routines and other interface software is eliminated.

Thanks to the BLC-8737's simplicity, the system software need only tell the board what gains it wants for each of the 16 single-ended (8 differential) input channels. In fact, the BLC-8737 resembles a simple memory board, with each input channel behaving very much like a RAM address for reading data and setting gains.

The number of input channels is easily expandable to 32 single-ended (16 differential). And with two analog output channels available, the BLC-8737 serves as an ideal central supervisor for complex process control systems.

The BLC-8737 not only handles a lot of data, it also converts it with 12-bit resolution and a high ±0.05% accuracy. And it only requires a single 5V power supply.

When you get right down to it, the BLC-8737 represents impressive capability for such an easy-to-use board.

For more information on the BLC-8737, be sure to check number 932 on this issue's coupon.

MULTIBUS is a trademark of Intel Corporation

The BLC-8715's onboard intelligence smooths out process control.

The BLC-8715 Analog Input Board was specifically designed for industrial data acquisition and process control systems. This new μP-based interface offloads all of the analog data pre-processing functions normally performed by the host CPU.

Based on National's proven BiFet™ technology, the 8-bit BLC-8715 performs highly accurate A/D conversion in a scant 8μsec. By using well-known auto rating techniques it can achieve better than 12-bit resolution.

The BLC-8715 takes care of "front end" measurement and control functions for 16 analog processes. But that's not all.

It also features 22 TTL compatible lines for controlling simple on/off equipment functions, digital read-outs and even keyboard manual override systems.

And to further enhance the board's versatility, the Practical Wizards designed it so that it may be configured in either of two ways. It can interface directly to the host system bus or, by using its standard RS-232C serial interface, it becomes a remote slave to the host CPU.

It certainly comes as no surprise that National should be the first to take a more intelligent approach to data acquisition and process control.

After all, that's what Practical Wizardry is all about.

Check number 931 on this issue's coupon for additional BLC-8715 information.

BiFet is a trademark of National Semiconductor Corporation

"National Custom MOS/LSI came through with the most advanced keyboard encoder chip of its time."

"As a leading supplier of solid state keyboard units, Cortron first found a need for sophisticated signal encoder electronics way back in 1972. But at the time, the semiconductor industry had no standard offerings that satisfied our cost/performance requirements.

"So we turned to National's Custom MOS/LSI group for a solution – and found one. National's solution was to design and build the most advanced chip of its kind: a signal encoder that greatly enhanced the flexibility of our keyboards while reducing their dependence on the host processor.

"National Custom MOS/LSI clearly has the technical and production expertise to develop such sophisticated solutions. But more than that, they're extremely easy to do business with. They worked very closely with our own engineers and kept us fully informed every step of the way.

"So far, Cortron has gone to National for four Custom MOS/LSI components. And in every case, National came through with highly advanced cost-effective solutions backed by good solid service."

Keith Engstrom
Engineering Manager CORTRON
A Division of Illinois Tool Works, Inc.

Analog math converter adds up to total simplicity.

The LH0094 real-time analog converter solves linear design problems simply and inexpensively.

Once again, the Practical Wizards come to the aid of the analog designer.

Their versatile yet low-cost LH0094 analog math converter eliminates the need for digital intelligence in applications that require dedicated real-time computations. So the design's overall component count is reduced while maintaining a very high level of accuracy (0.05%).

The LH0094 contains an internal matched resistor pair for establishing square or square root functions. All other arithmetic, trigonometric or logarithmic conversions are defined by an external resistor network.

The linear leaders also offer LH0094s that meet MIL. STD. 883 level B specs. The multiple testing and REL processing performed on these devices complement the inherent quality of every linear part that National produces.

For further information, check number 906 on this issue's National Archive coupon.

Acquire the lowest cost high-performance A/Ds.

National now offers their high-speed 8-bit A/D converters for 40% less than ever before.

National, the leader in innovative, cost-effective data acquisition products, now offers the industry's best price/performance on high-speed A/D converters.

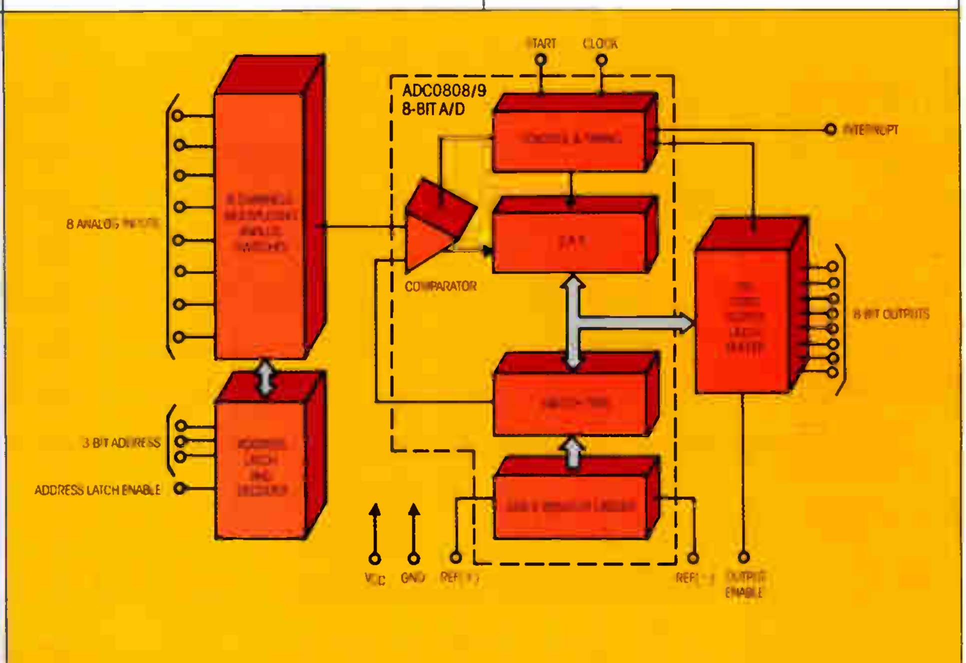
Their line of 100μsec A/Ds eliminates the need for external zero- and full-scale adjustments and delivers absolute accuracies as good as 1/4 Least Significant Bit (see the Price/Performance chart below).

National's μP-compatible converters operate off of a single 5V supply, so they're both versatile and straightforward in design. And now they're priced lower than ever before. For more information, enter number 924 on the coupon.

Practicality strikes again – all the way down to the bottom line.

P/N	ANALOG INPUT	ACCURACY	100 UNIT PRICE*
ADC0801	SINGLE DIFFERENTIAL	1/4 LSB	12.25
ADC0802	SINGLE DIFFERENTIAL	1/2 LSB	8.10
ADC0803	SINGLE DIFFERENTIAL	1/2 LSB	4.80
ADC0804	SINGLE DIFFERENTIAL	1 LSB	2.95
ADC0808	8-CHANNEL MUX	1/2 LSB	9.95
ADC0809	8-CHANNEL MUX	1 LSB	3.60
ADC0816	16-CHANNEL MUX	1/2 LSB	12.95
ADC0817	16-CHANNEL MUX	1 LSB	7.95

*Prices shown are U.S. prices only



NATIONAL ANTHEM

TRI-STATE® octals in 28 varieties.

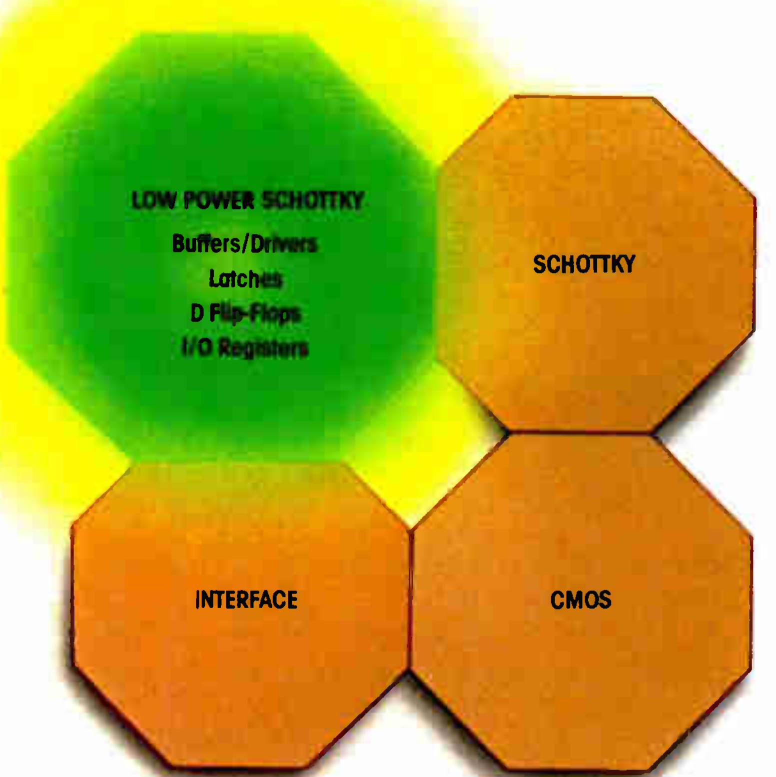
National carries the industry's broadest line of 20-pin LS, S, CMOS and Interface octals.

National Semiconductor is doing more for 8-bit designs than anyone else. In fact, they're currently offering no less than 28 different TRI-STATE octal devices.

So now the designer can select his 8-bit building blocks from the industry's largest assortment of 20-pin Low Power Schottky, Schottky, CMOS and Interface products. Everything from buffers/drivers, latches and D flip-flops to I/O registers and transceivers.

LOW POWER SCHOTTKY OCTALS

Device Type	Part Number Commercial	Part Number Military
Buffers/Drivers	DM74LS240	DM54LS240
	DM74LS241	DM54LS241
	DM74LS244	DM54LS244
	DM81LS95	DM71LS95
	DM81LS96	DM71LS96
	DM81LS97	DM71LS97
	DM81LS98	DM71LS98
Latches	DM74LS373	DM54LS373
D Flip-Flops	DM74LS374	DM54LS374
I/O Registers	DM74LS952	DM54LS952
	DM74LS962	DM54LS962



TRI-STATE is a registered trademark of National Semiconductor Corporation

National takes the RAM market head on.

Only National has the technical expertise and manufacturing muscle to produce the industry's most popular high performance RAMs.

It takes a great deal of manufacturing and technical know-how to satisfy the ever-increasing demand for static and dynamic RAMs. And National Semiconductor has a lot of both.

In fact, National offers the most popular line of high performance MOS RAMs in the business.

Having just stepped up their production capacity even further, National is able to ship more parts in one month than most suppliers can ship in six. At volumes like these, you can be sure that their prices are competitive.

Vastly superior test facilities. Between the production and shipment of each RAM order come National's high-caliber test procedures.

In addition to their use of conventional component level electrical testing from wafers to tested packages, many dynamic RAM customers request National's unique MST™ (Memory Systems Test) program.*

MST eliminates or greatly reduces your own requirements for internal testing. So your incoming test, board test, and system rework costs are substantially reduced. Because MST parts have already been debugged in a 9 megabyte memory system.

The future looks even brighter. In the months to come, National's MOS RAM product line will grow even broader. They will soon add new low-power XMOS™ static RAMs and new dynamic RAMs incorporating their exclusive polysilicon capacitors.

The new dynamic RAMs will feature (among other things) improved refresh characteristics and a high immunity to soft errors.

To find out just how competitive National really is, contact your local distributor or NSC sales rep or enter number 940 on this issue's coupon.

*Pat. Pending

Between their technical expertise, their high volume production capacity and their high-quality RAMs, it's easy to see that the Practical Wizards are taking the RAM market head on.

RAM SUMMARY TABLE

STATIC RAMs

Part Number	T_{AA} (ns)	Organization
MM2114	200-450	1K x 4
MM5257	250-450	4K x 1
NMC2114A†	120-250	1K x 4
NMC5257A†	120-250	4K x 1
NMC2141	120-250	4K x 1
NMC2142†	120-250	1K x 4
NMC2147	45-70	4K x 1
NMC2147H†	35	4K x 1
NMC2148	55-70	1K x 4

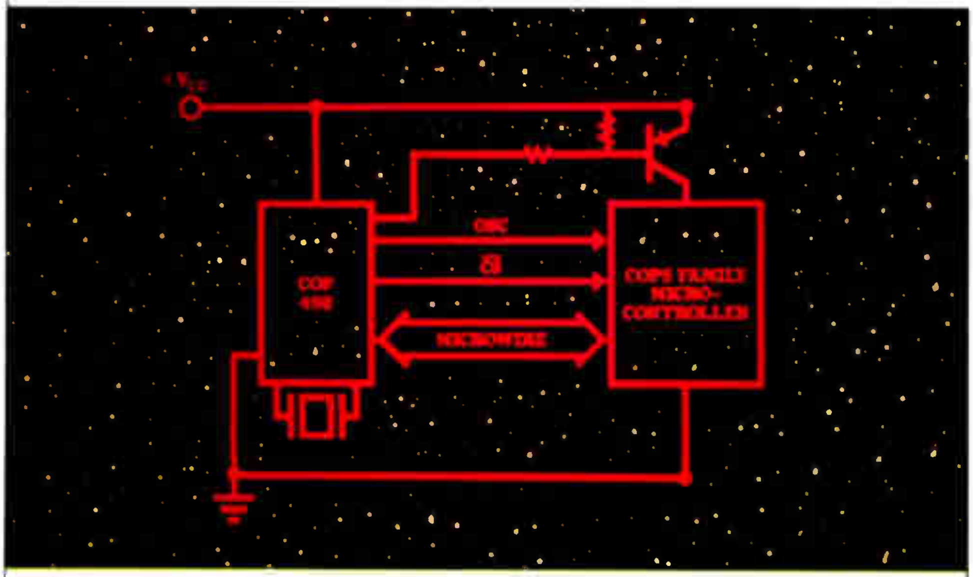
DYNAMIC RAMs

Part Number	T_{AA} (ns)	Organization
MM5280	200-270	4K x 1
MM5298	150-250	8K x 1
MM5290	120-250	16K x 1
NMC5295†	80-150	16K x 1
NMC4164††	120-250	64K x 1

†Production in 2-4 months
††Production in 1981

MST and XMOS are trademarks of National Semiconductor Corporation.

The RAT™ Chip–CMOS power at NMOS cost.



COPS, RAT Chip and MICROWIRE are trademarks of National Semiconductor Corporation

The new low-cost COPS™ Family RAM/Timer chip trims an NMOS processor's power consumption down to nearly CMOS levels.

National's COPS Family of microcontrollers welcomes a powerful new peripheral member: the COP498 RAM/Timer.

In addition to its 64 x 4 RAM, the 14-pin CMOX RAT Chip carries a crystal-based timer. When used with any of the COPS microcontrollers (or any National μP), it allows the processor to go to sleep (power off) and wake up (power on) under software control.

As an extra measure of design versatility, the engineer can choose between a 2.097152MHz or a 32.768KHz timer. In operation, the processor can specify either a 6ms, 1Hz or 16Hz wake-up signal from the RAT Chip. An external override capability allows for immediate processor wake-up whenever necessary.

The RAT Chip thereby reduces an NMOS processor's overall power consumption to nearly CMOS levels, yet it costs significantly less than CMOS components.

The distribution of intelligence. The COPS Family represents a unique approach to microcontroller applications.

Every COPS device – processors and peripherals alike – has enough intelligence designed into it to execute its own instruction set. By distributing the processing workload to each device on the MICROWIRE,™ every COPS system is optimized for efficiency.

The benefits of this family approach are felt throughout the development phase as well. The entire family is supported by a single development system (the COP400-PDS). The high-efficiency COPS instruction set consists of simple task-oriented instructions that not only take up less memory space, they also accomplish each task in less time than other single-chip microcontrollers.

So it's easy to see why the COPS Family provides the lowest cost solution to application problems. For complete information on the COP498 RAT Chip and the entire COPS Family, enter number 938 on this issue's National Archives coupon.

Lamp drivers shine in mil/aero applications.

Hi-Rel incandescent lamp drivers now available in TO-5 packages.

National takes aim at the mil/aero marketplace with their DH0006 and DH0008 high voltage, high current drivers.

Both of these self-contained devices accept standard DTL or TTL logic levels and operate from a single continuous +10V to +45V supply. The DH0006 drives loads of up to 400mA at 28V and is capable of driving 1.5 amps pulsed. The DH0008, on the other hand, provides pulsed loading of up to 3 amps.

And inputs for both the DH0006 and the DH0008 include an expander connection should additional gating be required.

Versions of both parts are available that meet MIL. STD. 883 level B specifications. So engineers designing for mil/aero applications are getting the most reliable incandescent lamp driver around.

For additional information, enter number 906 on this issue's coupon.

Thomas A. Edison: Wizard Laureate.

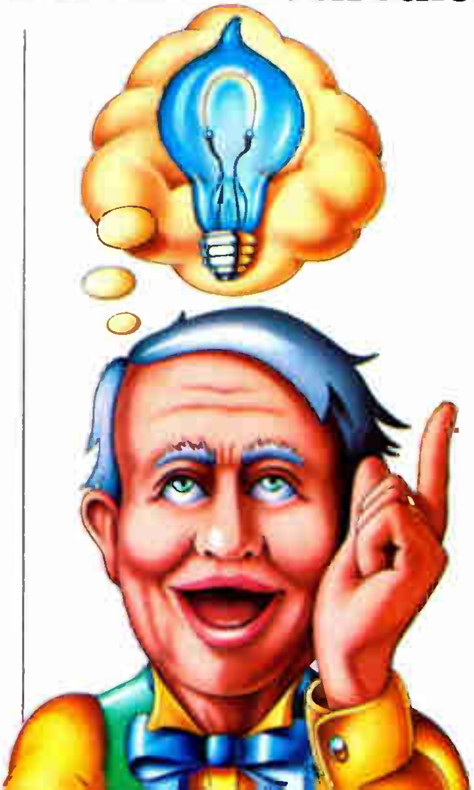
Thomas Alva Edison never liked to think of himself as a theoretician. Nor did he have any illusions of being privy to secret wisdom, like the wizards of olde.

On the contrary, the Wizard of Menlo Park thought himself a disciple of common sense and a seeker of practicality. It was his life's intention to bring imaginative insight to bear upon the practical problems of everyday life.

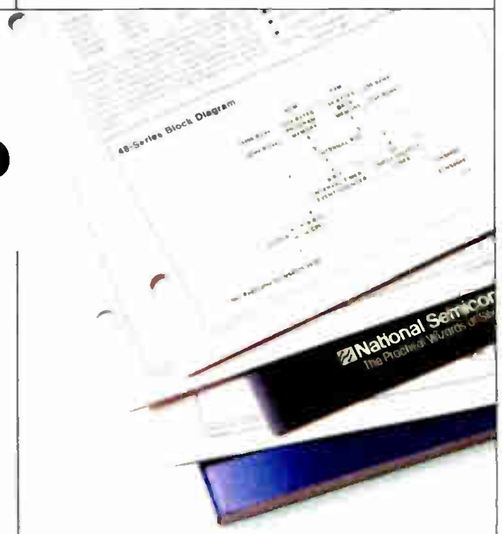
Hardworking, innovative and daring. These are some of the characteristics that exemplified the work of Thomas Edison. Ones that made him truly a practical wizard.

It is these same characteristics that the Practical Wizards at National bring with them when they come to work each day. The uncommon common sense of Edison is the secret behind our modern wizardry.

Taking Edison as a model is certainly not an exercise in mere sentimentality. Rather, it's National's way of honoring a great American tradition.



What's new from the National Archives?



Over the past 12 months, National has offered a wide variety of product literature through their National Archives. Here, they recap the year's offerings for those who may have missed them originally.

To order literature, simply indicate any desired selection numbers on the Archives coupon on the bottom of the following page. A legible coupon will speed things up.

All literature is free of charge except where noted. All prices shown are U.S. prices only. California residents please add 6% sales tax, 6½% in BART counties.

Bipolar

901 ☐ **PAL Brochure.** Complete description of National's family of Programmable Array Logic devices.

902 ☐ **1980 Interface Data Book ($6.00).** Contains complete information on all of National's Interface products, i.e., special ICs used in conjunction with standard logic or μP functions. Included are transmission line drivers/receivers, bus transceivers, peripheral/power drivers, level translators/buffers, display drivers, MOS memory interface circuits, μP support circuits and applicable TTL, ECL and CMOS logic circuits.

Discrete Components

903 ☐ **TO-220 Darlington Transistors.** Free data sheets and application notes on the PNP 2N6040 through 2N6042 transistors and the NPN 2N6043 through 2N6045 transistors.

904 ☐ **TO-237 (92 Plus Series) Transistors.** Free data sheets and application notes on the 2N6705 through 2N6735 transistors housed on National's patented Epoxy B plastic.

905 ☐ **D42-D45 Series Transistors.** Data sheets on the D42-D45 Series silicon power transistors.

Hybrid/Transducers

906 ☐ **1980 Special Functions Data Book ($6.00).** Contains detailed information on all of National's hybrid products, including op amps, buffers, instrumentation amps, S&H amps, comparators, non-linear functions, precision voltage regulators and references, analog switches, MOS clock drivers, digital drivers, A/Ds and D/As, data acquisition cards, active filters and telecomm products, and precision networks.

907 ☐ **LH0002/33/63 Buffer Amps.** Application notes for these popular high-speed buffer amps. Detailed information is contained in the 1980 Special Functions Data Book.

908 ☐ **LH0024 and LH0032 Op Amps.** Data sheets and application notes on the LH0024 and LH0032 high-speed op amps (also included in the Special Functions Data Book).

909 ☐ **LH0038 Precision Instrumentation Amp.** Data sheet and additional information on the versatile LH0038 (also included in the Special Functions Data Book).

910 ☐ **LH0082 Fiber Optic Receiver Amp.** Data sheet on this high-speed general purpose receiver amp for fiber optic applications.

911 ☐ **LH0084 Instrumentation Amp.** Free data sheet and additional information on the LH0084 programmable gain instrumentation amp (also included in the Special Functions Data Book).

912 ☐ **1980 Pressure Transducer Handbook ($3.00).** Conveniently summarizes National's broad line of absolute, gage, backward gage and differential IC pressure transducers. Also includes comprehensive application information.

Linear/Data Acquisition

913 ☐ **1980 Linear Data Book ($9.00).** Includes voltage regulators, voltage references, op amps/buffers, instrumentation amps, voltage comparators, analog switches, sample & holds, A/Ds and D/As, industrial/automotive/functional blocks/telecomm, audio, radio and TV circuits, and transistor/diode arrays.

914 ☐ **New 1980 Data Conversion/Acquisition Handbook ($7.00).** Covers A/Ds and D/As, data acquisition systems, voltage references, analog switches/multiplexers, sample and holds, amplifiers, resistor arrays, active filters, successive approximation registers and functional blocks.

915 ☐ **1980 Voltage Regulator Handbook ($7.00).** This handy reference covers power supply and regulator design all the way from the transformer to the heat sinks.

916 ☐ **1980 Audio Handbook ($5.00).** This volume presents real-world design approaches plus the more exotic audio subjects such as pick-ups, phase splitters, fuzz, reverb, etc.

917 ☐ **LM11 Precision DC Amplifier.** Free data sheet and application notes on this precedent-setting bipolar op amp (also included in the 1980 Linear Data Book).

918 ☐ **LF151, 151A, 153 Op Amps.** Get all the technical information on these single and dual wide bandwidth JFET input op amps (also included in the 1980 Linear Data Book).

919 ☐ **M159/359 Norton Amplifiers.** Data sheets on these dual high-speed programmable current mode amplifiers (also included in the 1980 Linear Data Book).

920 ☐ **LM185/285/385 Voltage Reference Diodes.** Complete information on the LM185/285/385 micropower two-terminal bandgap voltage reference diodes (also included in the 1980 Linear Data Book).

921 ☐ **LM135/235/335 Precision Temperature Sensors.** Data sheets on these directly calibrated sensors (also included in the 1980 Linear Data Book).

922 ☐ **LF351A-1/351B-1/353A-1 Op Amps.** Free data sheets on these wide bandwidth JFET input op amps.

923 ☐ **DAC 1000 Series D/A Converters.** Fully detailed information on the MICRO-DAC™ Family of μP-compatible 10-, 9- and 8-bit accurate multiplying D/As (also included in the Data Acquisition Handbook).

924 ☐ **ADC0801-4/ADC0808-9/ADC0816-17 A/D Converters.** Data sheets available on these 8-bit μP-compatible A/D converters with 8 or 16 channel multiplexers on chip (also included in the Data Conversion/Acquisition Handbook).

More from the National Archives.

Microcomputer Products

925 ☐ **STARPLEX™ Development System with ISE™** Brochure and technical information on the STARPLEX µP software development system with In System Emulation (ISE).

926 ☐ **STARPLEX INS8080 ISE Package.** Information on the STARPLEX In System Emulator package for the INS8080 µP family.

927 ☐ **STARPLEX INS8048 ISE Package.** Information on the STARPLEX In System Emulator package for the INS8048 µP family.

928 ☐ **STARPLEX INS8070 ISE Package.** Information on the STARPLEX In System Emulator package for the INS8070 µP family.

929 ☐ **BLC-80/316 Z-80*/16K CPU Board.** Detailed information concerning this advanced Series/80 Board Level Computer product.

930 ☐ **BLC-8222 Double Density Floppy Disk Controller.** Free data sheet on this Series/80 board level floppy disk controller.

931 ☐ **Series/80 BLC-8715 Analog Input Board.** This high-speed intelligent I/O board offloads analog preprocessing functions from the data acquisition system CPU.

932 ☐ **BLC-8737 Analog I/O Board.** The Series/80 BLC-8737, with up to 32 input lines, serves as a quick and easy interface between the digital and analog halves of a data acquisition or process control system.

933 ☐ **RMC-655.** Data sheet on this four-slot RMC (with no CPU).

Microprocessors

934 ☐ **INS8048 Family.** Complete information on the entire INS8048 Family, including the INS8048 (64 x 8 RAM; 1K x 8 ROM), INS8049 (128 x 8 RAM; 2K x 8 ROM), the INS8050 (256 x 8 RAM; 4K x 8 ROM) plus ROM-less versions of each.

Module Products

935 ☐ **MA1026 Digital LED Alarm Clock/Thermometer Module.** Check coupon for free data sheet.

936 ☐ **MA1032 Digital LCD Clock Module.** Get the data sheet with full details on the LCD clock module.

937 ☐ **MA5036 Digital LED Clock/Timer Module.** Check the coupon for a free data sheet on this low-cost LED clock/timer module.

MOS/LSI

938 ☐ **1980 MOS Data Book ($6.00).** Contains comprehensive descriptions of National's broad MOS/LSI product line. Includes COPS™ Family devices and application information, MAXI-ROMs,™ DIGITALKER™ speech synthesis, standard and custom MOS/LSI.

939 ☐ **DIGITALKER Digital Speech Synthesis.** National's hot new speech synthesis chip set produces totally natural sounding speech in any spoken voice or language (also included in the 1980 MOS Data Book).

MOS Memory

940 ☐ **1980 Memory Data Book ($6.00).** Contains all technical data on National's NMOS, CMOS and bipolar RAMs, magnetic bubble memories, MOS EPROMs, bipolar PROMs, MOS ROMs, character generators and memory support circuits.

941 ☐ **MM2147L RAM.** Data sheet on this 4096-word by 1-bit static RAM fabricated using N-channel silicon gate technology (also included in the 1980 Memory Data Book).

942 ☐ **MM2716M EPROM.** Free data sheet on this high-speed 16K UV erasable and electrically reprogrammable EPROM.

943 ☐ **DP8350 CRT Controller.** Free technical information on the DP8350 Family of CRT controllers.

Optoelectronics

944 ☐ **Optoelectronics Handbook ($3.00).** Complete information on all of National's optoelectronic products.

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NA 18

Fiber optics adopts superheterodyne principles

by Harvey J. Hindin, Communications Editor, and Charles Cohen, Tokyo bureau manager

By reworking classic rf design, Japanese team enhances a fiber-optic receiver's selectivity and sensitivity

The 50-year-old concepts underlying Edwin H. Armstrong's rf superheterodyne receiver are being applied in Japan to that most modern gadget of communications technology, the fiber-optic receiver. The result is what Shigeru Saito, Yoshihisa Yamamoto, and Tatsuya Kimura of Nippon Telegraph & Telephone Public Corp.'s Musashino Laboratories claim is the world's first fiber-optic laser-driven superheterodyne receiver. They have tested their prototype both as a 300-megahertz analog device and as a 100-megabit-per-second digital device.

Discriminating. Unlike p-i-n diode or avalanche photodiode receivers [*Electronics*, Oct. 9, 1980, p. 155], optical superheterodyne systems (see figure) can select carriers spaced only a few megahertz apart and thus fully exploit the fiber's bandwidth of hundreds, if not thousands, of megahertz. This unprecedented degree of selectivity will in particular enhance the upcoming second generation of very wide-bandwidth optical-fiber communications systems, which operate in the low-attenuation window at 1.3 micrometers.

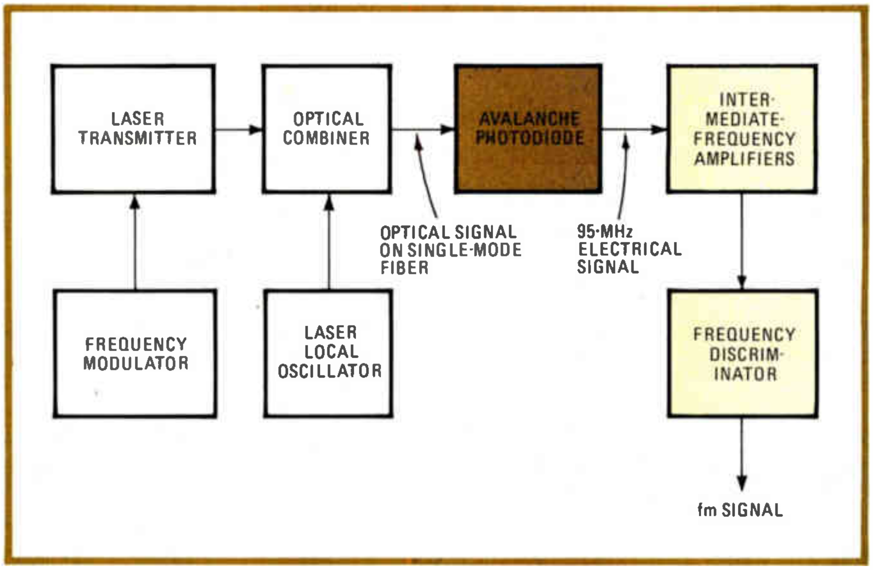
Though imperfect, the Japanese system is good enough to show the advantages of frequency-modulation superheterodyne circuitry for fiber-optic receivers. It enhances sensitivity, as well as selectivity. According to Kimura, the sensitivity of the fm system should be 10 decibels better than present baseband systems. Precise sensitivity measurements have not yet been made.

The detector, an avalanche photodiode, converts low-power optical signals into an electrical intermediate frequency of 950 MHz that is easily amplified. Such sensitivity cannot be directly achieved at optical frequencies, since gain is far easier to achieve electrically at 950 MHz than optically at the 0.82-micrometer wavelength of the laser transmitter used.

Demodulation. In the system designed by the Tokyo-based scientists, the superheterodyne approach permits the laser to be frequency-modulated. Unlike the amplitude modulation previously used, fm "opens the way to multilevel coding schemes," says Kimura. The light output from the free-running aluminum gallium arsenide double-heterostructure laser is sent down a single-mode fiber along with a local oscillator frequency from another laser operating 950 MHz away.

It is this 950-MHz difference frequency that is generated by the avalanche photodiode when the two laser light signals impinge on it. The diode is electrically biased to act much like a standard electrical mixing diode. Its gain at 950 MHz is almost the same as the baseband gain.

The 950-MHz signal—which has by now become a conventional electrical superheterodyne intermediate frequency—carries the original modulation fed into the laser transmitter diode. It enters an i-f amplifier and then an rf discriminator implemented as a doubly balanced mixer. The mixer output is the desired fm modulation with residual amplitude



Electrifying. Fiber-optic receiver uses avalanche photodiode to transform optical into electrical signals that make it possible to select carriers only a few megahertz apart.

modulation that is easily suppressed by an i-f limiting amplifier.

As noted, the system is still at the prototype stage. For one thing, according to its developers, the intermediate frequency is not yet stable enough, but work is in progress on frequency-stabilization feedback schemes. In the latest experiments, a form of automatic wavelength control of the local oscillator has been applied that decreases the drift to ±1 MHz. The researchers also want to explore higher intermediate frequencies, so that systems may be built for up to 200-Mb/s rates.

Great Britain

SAW, semiconductor technologies combine on zinc oxide layer

Integrated circuit functions and surface-acoustic-wave signal processing techniques are combined on a single gallium arsenide substrate in a new class of electronic component from Britain's Standard Telecommunication Laboratories Ltd. The Harlow, Essex-based group, headed by David J. Jackson, has fabricated a convolver and a programmable correlator in the new technology, both of which can be used in high-performance radar systems to recover an echo signal in the presence of high background noise. Other possible applications include use in the front-end section of a receiver for the Navstar satellite navigation system.

In search of ever higher performance, other teams besides STL are working to combine semiconductor and SAW technologies. In the U. S., Stanford University produced the first acoustoelectric device on a silicon substrate, and Westinghouse Electric Corp. has a contract to develop GaAs-based SAW devices. But the problem with both substrate materials is that they are not natural piezoelectric materials.

Surface acoustic waves are normally launched into substrates of quartz or lithium niobate by surface electrodes that produce compressions and rarefactions in the material. STL researchers achieve the same end by sputtering a 3.2-micrometer-thick zinc oxide layer onto the GaAs substrate. Zinc oxide is a better piezoelectric material than quartz, though it is not as good as lithium niobate is.

To evaluate its performance, the STL team used the process to fabricate a 6-microsecond delay line operating at a 57-megahertz center frequency. They achieved coupling factors so high that at a near theoretical tuned bandwidth of 8.8% centered at 57 MHz, insertion loss was a mere 10 decibels—the lowest yet reported for a monolithic SAW semiconductor device. These properties were preserved in the more complex devices they developed subsequently.

Complex. The correlator, by far the most complex device the Harlow group has developed to date, comprises a launching electrode and plate electrode formed on top of the zinc oxide layer. In the GaAs substrate beneath the plate electrode there is a diode array that serves as the correlator memory.

To fabricate this structure, STL researchers harness a battery of relatively new production techniques. The zinc oxide layer, for example, is grown in a planar magnetron system employing dc rather than rf fields. According to a report given at the Institute of Electrical and Electronics Engineers' Ultrasonics Symposium, held in Boston earlier this month, the technique results in an excellent film quality and uniform thickness.

To form the diode elements, an n-type epitaxial layer is first grown upon the n^+ GaAs substrate. GaAs Schottky diode arrays are created on a base epitaxial surface by titanium evaporation followed by photolithographic pattern definition. Proton bombardment—a relatively new technique STL employs extensively in its GaAs IC program—is used to create high-resistivity isolating regions around the diodes. The process, says STL, is convenient and flexible and preserves the essentially planar nature of the substrate. With its aid, charge leakage is contained and storage times up to 200 milliseconds have been achieved.

One use. The correlator could find its first application in a high-performance radar system. In operation, the transmitted pulse is applied to the correlator and an image stored in the diode matrix. "The diodes are continuously sampling the field," explains Jackson, "and you can store an image of the wave when the plate is pulsed. This forward-biases the diodes and then turns them off again, trapping charge in each diode." When the echo pulse is received, a correlation function is performed between the stored and applied waveforms, using the diode's nonlinear multiplier characteristic, and a correlation signal is generated at the plate electrodes.

According to Garry R. Adams, a team member, the device demonstrates a useful efficiency and storage capacity, but other aspects of its performance such as its dynamic range—currently 20 dB—and bandwidth as well as high-frequency performance remain to be developed. For example, the aim is to reach 400 MHz and eventually 1 GHz, frequencies at which SAW devices are commonly used in radar and communications systems. STL's acoustoelectric program was funded by Britain's Ministry of Defence. **-Kevin Smith**

Japan

GaAlAs LEDs shine brightest red of all

Red light-emitting diodes are about to become an order of magnitude brighter, now that Matsushita Electronics Corp., a subsidiary of Matsushita Electric Industrial Co., has chosen to make them from a popular laser material, gallium aluminum arsenide. Gallium phosphide LEDs

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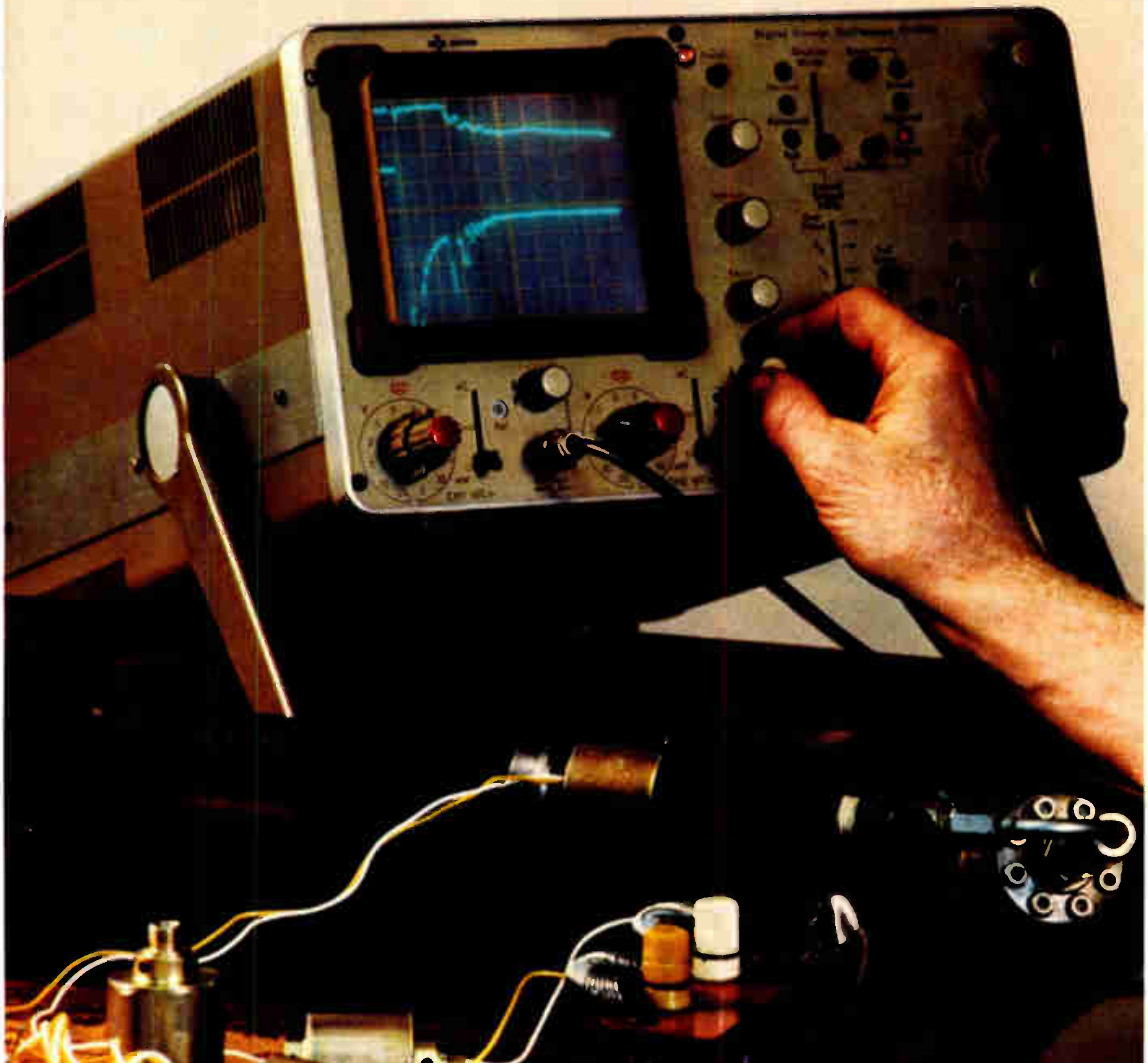


have till now been the most efficient at emitting visible red light.

Furthermore, yields promise to be high. A specially developed liquid epitaxial process makes it unnecessary to wipe the wafer surface during LED fabrication, thus eliminating the risk of scratches.

Volume production. The Japanese company has already started supplying samples and will begin shipping production devices in March. It expects prices to quickly fall to less than twice that of its present red GaP LEDs, which sell for an average of 7 cents apiece.

The new LEDs deploy two epitaxial GaAlAs layers in a heterojunction structure that increases both electron injection into the active, light-generating layer and the transparency of the overlying, inactive layer. As a result, they are capable of extracting an output of 200 millicandelas from a current of only 20 milliamperes.

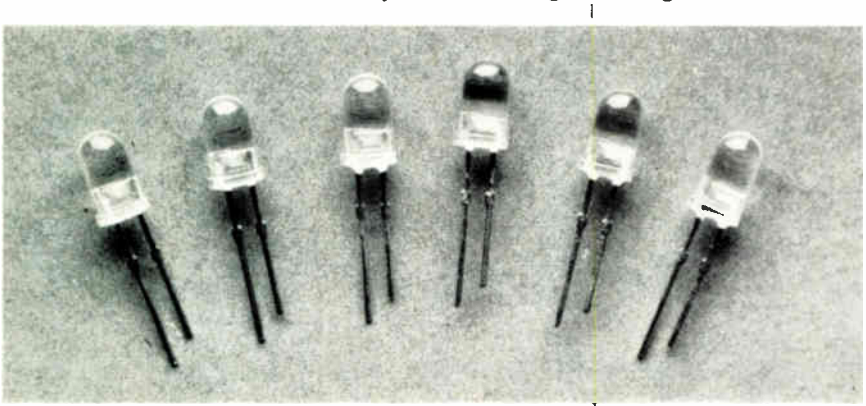
That level of brightness makes the LEDs attractive for use as pilot lights, in optoelectronic isolators, and as stereo record turntable strobes. The devices should also turn up in applications like the low-cost transmission of information through plastic fiber-optic cable and even optically biasing TV camera tubes to reduce image persistence.

New direction. The Matsushita engineers say that they switched to GaAlAs because they have given up hope of squeezing higher brightness out of GaP devices, which they produce at a rate of about 30 million a month. Above a certain level of input current, the brightness of GaP devices increases in ever smaller increments for equal increments of current. In contrast, the GaAlAs devices both are brighter at low currents and increase linearly in brightness with increased current for current 10 times as great.

The new fabrication method resembles vapor-phase epitaxial and diffusion approaches in simultaneously processing a batch of 50 or more wafers arranged at a slight angle from the vertical. The wafers sit in a boat that slides beneath a series of reservoirs containing the GaAlAs melts and above a series of sinks into which the previous melt is dumped. In the usual setup, horizontal wafers are wiped and may be scratched between melts, and productivity is lower because the boat accommodates either one or at most two wafers.

Layered. Zinc doping is used in the p epitaxial layer, grown directly on the substrate to a thickness of about 20 micrometers. Some 32% of the gallium is replaced by aluminum, making for a bandgap of 1.85 electronvolts. Tellurium doping is used in the overlying n epitaxial layer, which is only 10 μm thick. About 70% of the gallium is replaced by aluminum, making for a bandgap of 2 ev. The difference in bandgaps encourages the injection of many more electrons into the light-emitting layer than into the n layer, and it also turns the n layer into an almost lossless window.

The diode output increases at increasing wavelengths. But in relation to the response curves of the eye, the optimum wavelength is a deep red with a peak at 660 nanometers. The LED has a relatively narrow spectrum of about 20 nm at half power. Sample chips measure 0.35 millimeters square and are mounted in a clear plastic package whose end acts as a lens. The terminal voltage for a current of 20 mA is 1.7 volts, which is somewhat lower than that of the GaP diodes. Thus the improvement in efficiency is even greater than that indicated by the higher light output per unit of current. -Charles Cohen



Red lights. Clear plastic packages house samples of gallium aluminum arsenide light-emitting diodes that are more than 10 times brighter than gallium phosphide LEDs.

West Germany

Portable case holds cryptographic unit

AEG-Telefunken hopes the small size and low price of its new electronic cryptographic system will make it a hit with industrial and military users when it goes to market this month. The Telekrypt-Mini fits snugly into a slim attaché case and will sell for less than $7,300 in West Germany.

Into that attaché case go not only the basic unit, complete with keyboard, display, and power supply, but also peripherals such as adapters and a printer. No equally powerful cryptographic system is as small, according to Helmut Böttcher, head of the Telekrypt project at AEG-Telefunken's facilities in Backnang, near Stuttgart.

The Telekrypt-Mini achieves its small size by extensive use of microelectronics and the miniaturization of other components, says Böttcher. Also, the software is written to occupy relatively little memory, reducing the parts count as well as system cost, he notes.

Operating the Telekrypt-Mini is simple. First, the user enters his message on its miniature typewriter keyboard. Then the system microprocessor, using Mekdal (for message-key–dependent algorithm) principles, enciphers the text character by character and files the result in a semiconductor memory. This text

memory stores the data for up to 2,000 characters, which corresponds to about one typewritten page. The system then sends the message over either telephone lines or radio links to its destination, where a similar system deciphers the text.

Crucial to the enciphering operation is the 21-character basic key. Typed into the system before the message is entered, this key provides for more than 10^{30} different character combinations. Only someone who knows the key's character sequence can encipher the information and have it printed out on the system's printer or shown on its 16-digit light-emitting-diode display.

Central. The heart of the system is a complementary-MOS microprocessor, a type 1802 from RCA. It is built up with two memory blocks, one containing the control software for the keyboard, the display, and the circuitry interfacing with the peripherals, and the other containing the enciphering and deciphering program. Because the two blocks are designed largely with low-power C-MOS components, the system can be operated not only off line power but also off batteries.

In the actual enciphering process a quasi-randomly generated sequence of more than 10^{39} bits is used. From this sequence, the microprocessor picks out the required number of bits and assigns 5 of them to each character. The time at which enciphering starts within the sequence is determined by the data in the basic key. To avoid the possibility that a number of messages are enciphered with the same bit sequence, the system generates 1 billion different bit sequences from which it automatically fetches a different one for each new message.

Synchronized. A special synchronization program ensures that the receiving end uses the same bit sequence for deciphering as the sending end did for enciphering. The enciphered text is put out in the form of groups of 5 characters. Preceding the encoded message are 12 characters denoting the synchronization program, 3 characters permitting the deciphering circuitry at the receiving end to test itself, and 5 characters for correcting errors in the synchronization program.

The Telekrypt-Mini can be used either off or on line. In the off-line mode, the equipment's printer produces a copy of the enciphered contents of the text memory.

In the on-line mode, a telephone adapter with a modem couples the system to the telephone network over which the enciphered message is transmitted at 20 bits per second. Also possible is on-line operation over radio links. Here, an adapter couples the system to a radio transmitter that sends out the message at user-selectable speeds of 20 to 200 b/s. Modes of radio transmission can be selective-call or all-call, both carried out in the high-frequency, very high-frequency, or ultrahigh-frequency ranges.

At the receiving end adapters couple the radio- or telephone-transmitted text to similar systems. The message is entered into the text memory, deciphered, and displayed or printed out or both. Text printout with the electrosensitive printer is at 16 characters per line on narrow metalized paper.

To enable the Telekrypt-Mini to stand up to rough environments, particularly in military applications, its electronics-packed basic unit comes in a dustproof and watertight housing. **-John Gosch**

France

Chip automatically switches TV plug-ins

One current belief in France is that home television sets one day reasonably soon will serve as display screens for all sorts of peripheral equipment, starting with video cassette recorders and games and eventually getting into services like viewdata. So strong is this belief that the set makers' trade association, the Syndicat des Constructeurs d'Appareils Radiorécepteurs et Téléviseurs (Scart), has added this year a video and sound connector to its

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specifications for new set designs.

The requirement poses no significant problem for set designers, for a little more than a dollar's worth of discrete components will add a connector interface to a set. The parts cost, though, jumps to around $5 for a quality interface with automatic switching from the set's own video and sound intermediate frequency to outside inputs. At that level, since the potential market is millions of chips, the interface becomes a tempting proposition for an integrated-circuit house.

Inevitably tempted, Thomson-CSF's Semiconductor division developed a dedicated bipolar interface chip and now is supplying samples of it to set makers. "We will be in full production in about six months," reports Jean-Pierre Lusinchi, product line manager for consumer linear circuits. Lusinchi still has not set a price for the 3.5-square-millimeter chip, which is designated the TEA 1014. But he insists it, in turn, will be tempting to set makers.

Essentially, the chip has integrated on it a pair of buffer amplifiers for video inputs, a second pair for audio inputs, and control logic to switch them appropriately to the chip's output amplifiers, which drive the set's video-processing circuits and sound channel.

The control logic is set up so that the outside inputs from a video cassette recorder, say, can be switched to the output by a command signal from the recorder, from an audio-visual push button on the TV set, or by a channel-selection push button (for recorders with modulators). Also, the audio-visual button activates an open-collector circuit that switches the time constant for the set's horizontal sweep circuit, thus compensating for the absence of interlacing between lines in successive fields in the VCR image.

Low power. The electronic switch controlled by the chip's logic is based on differential transistor switching circuits. But, Lusinchi points out, they have been designed for very low power consumption. "The chip consumes less than 450 milliwatts," he explains.

At Thomson-CSF's semiconductor plant in the Grenoble suburb of St. Egrève, where the chip was developed and will be produced, the mainstay technology is linear bipolar. But that is not the only reason the company uses a 20-volt bipolar process for the chip. "The rejection is much higher than the 40 decibels possible with C-MOS," says Lusinchi. Thus the specifications for the TEA 1014 list 55 dB as the minimum separation between the two video outputs and 60 dB between the audio and video outputs. Typical distortion is 2% for linearity and 5% in the intermodulation between luminance and chrominance signals. —**Arthur Erikson**

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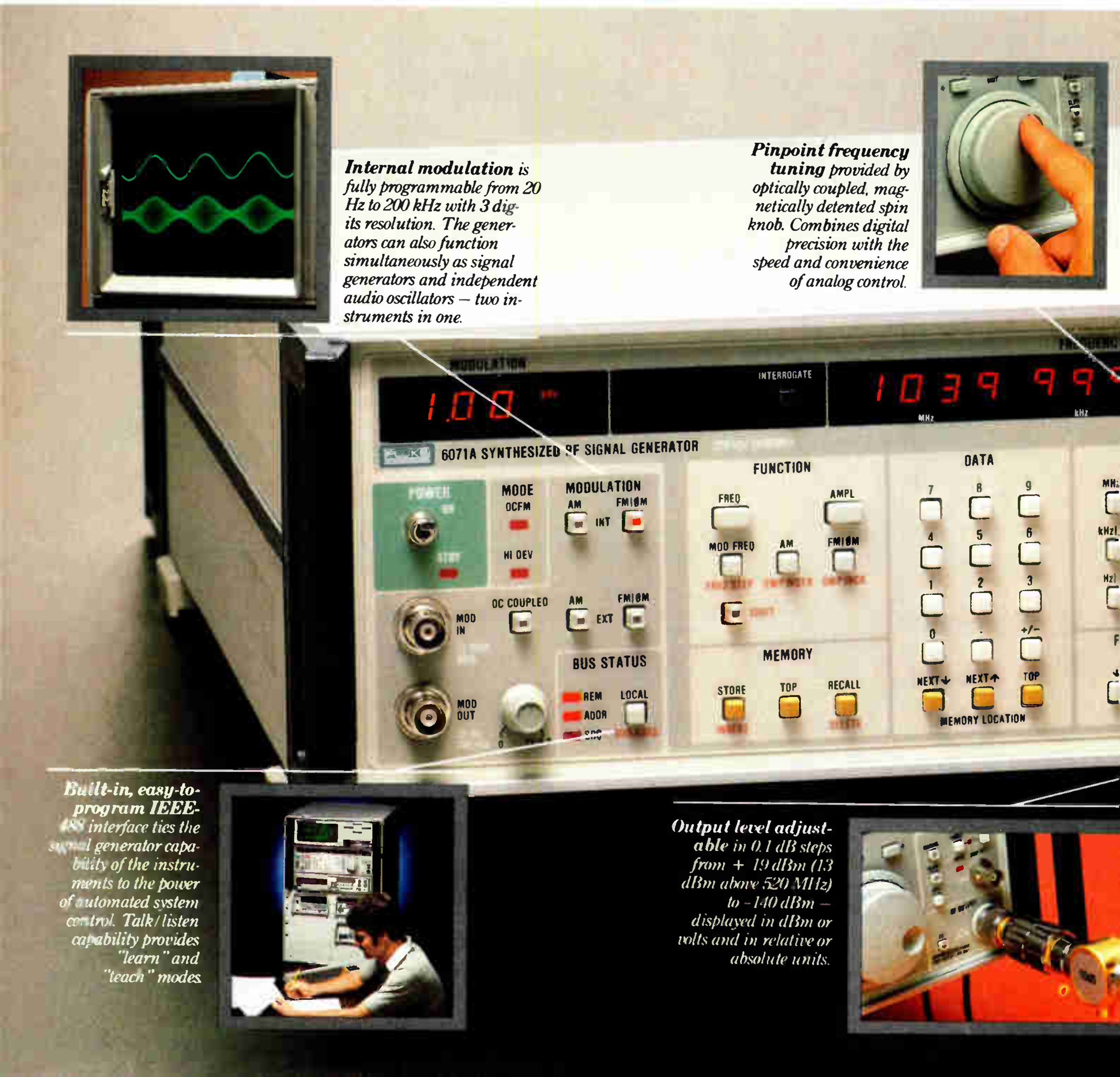

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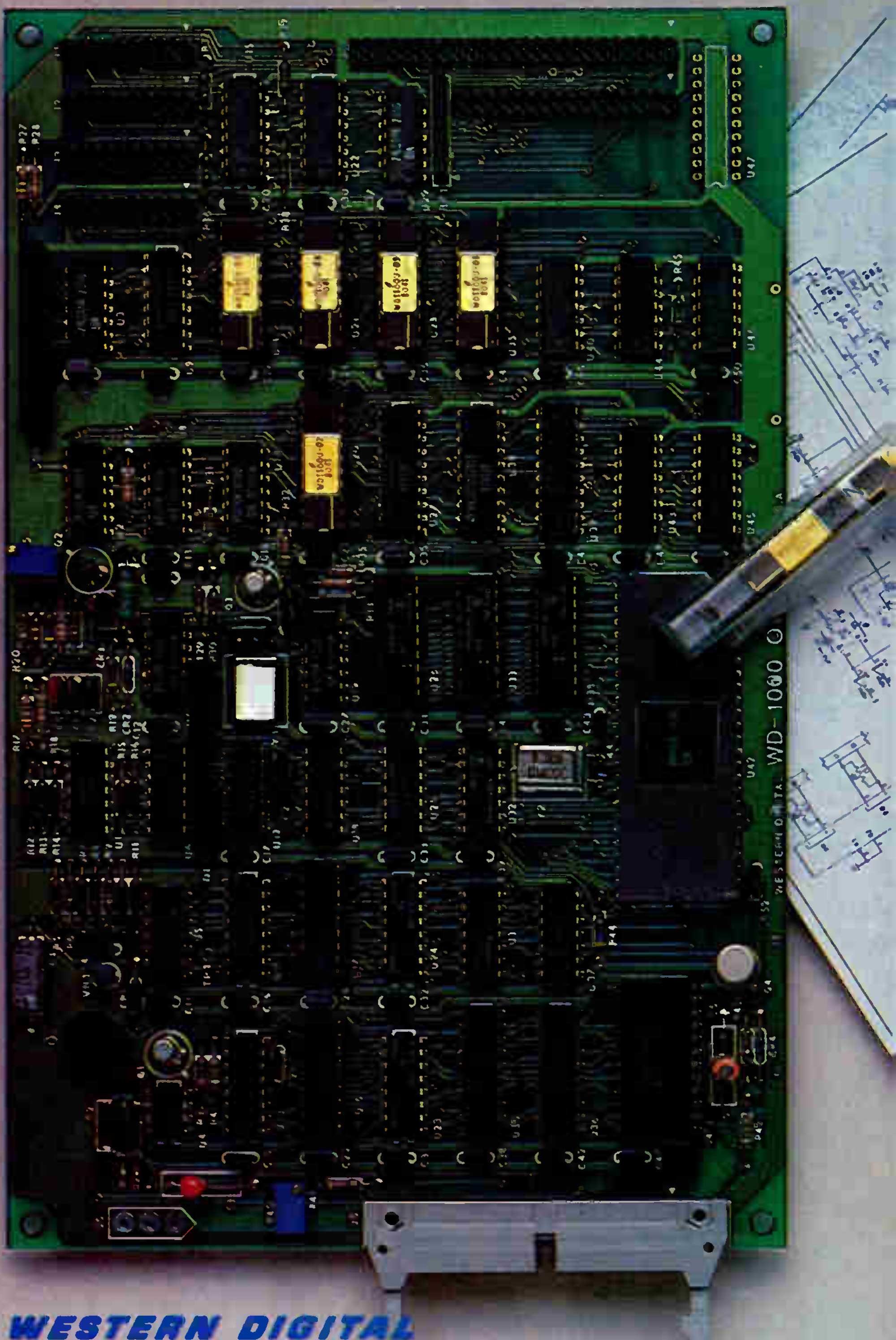

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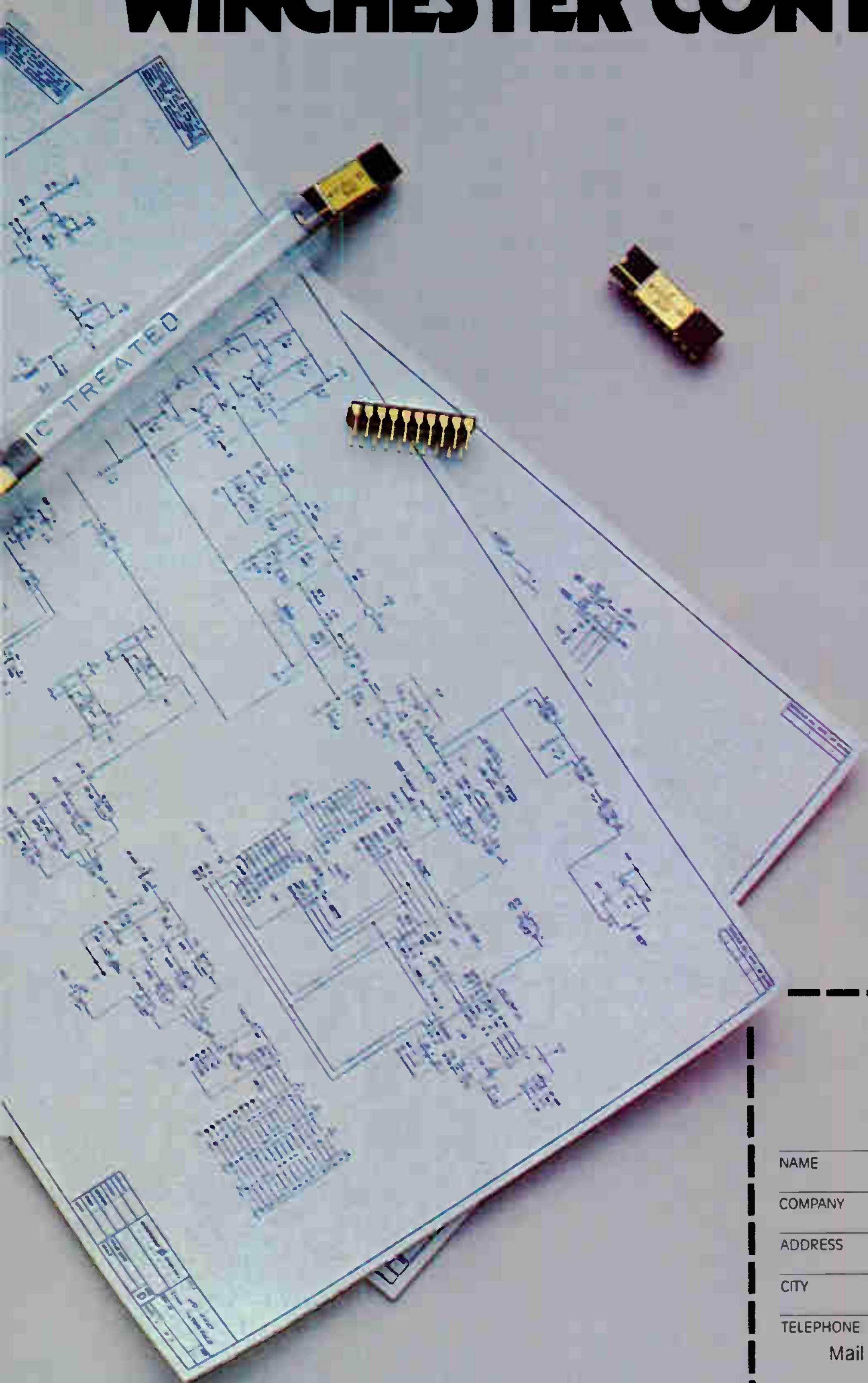

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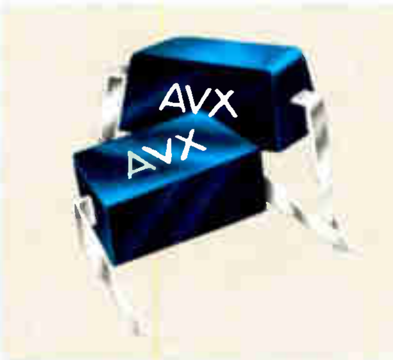

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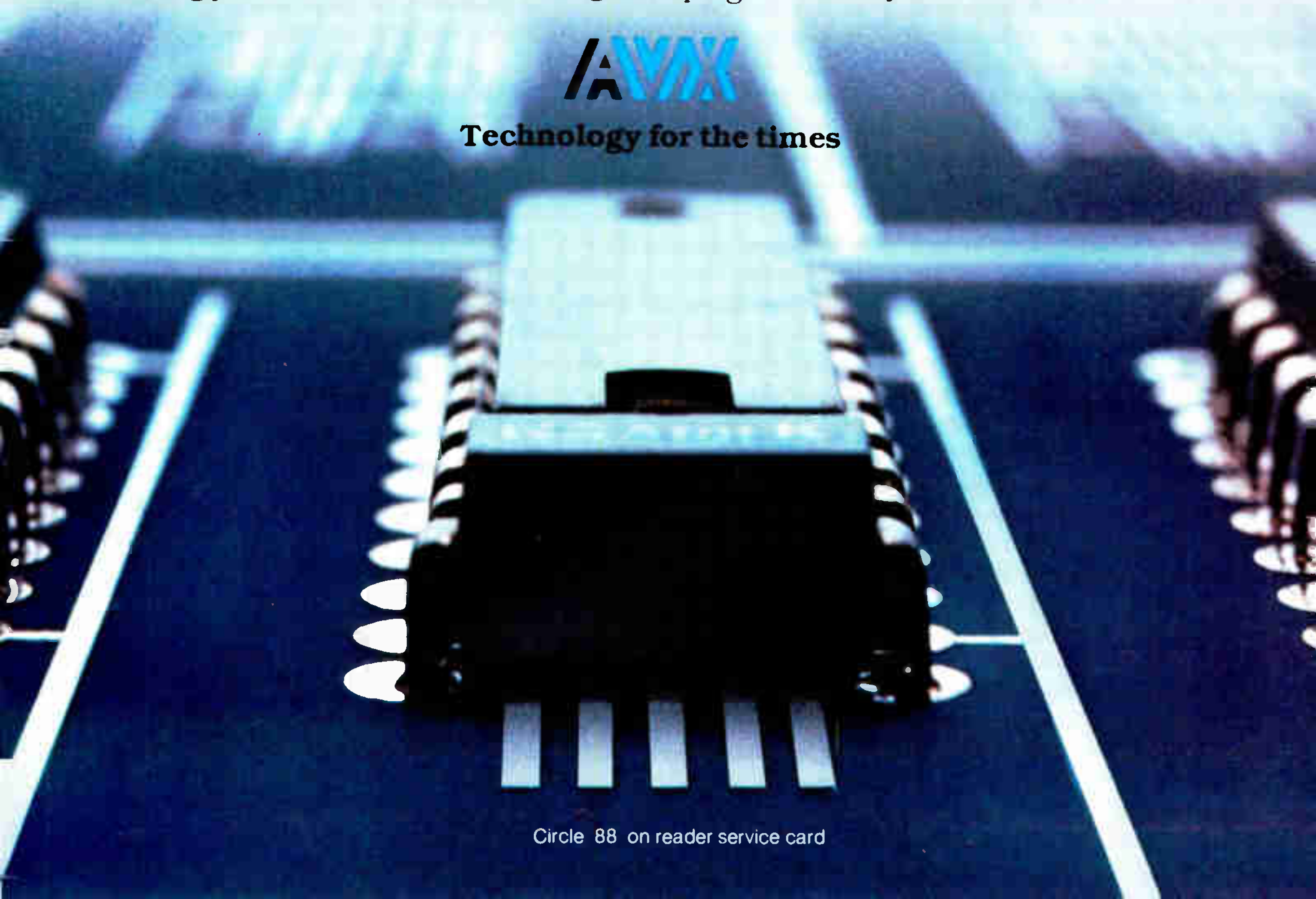


LISP computers go commercial

New companies are forming to build machines incorporating symbolic programming used for artificial intelligence

by Martin Marshall, West Coast Computers & Instruments Editor

LISP, for list-processing language, has become the *de facto* programming language of the artificial intelligence community and promises to become important to other emerging technologies, such as genetic engineering and computer-aided design. It has done so despite the fact that the only machines tailored to this kind of processing are experimental models recently completed in Cambridge, Mass., at the Massachusetts Institute of Technology's Artificial Intelligence Laboratory.

The advantage seen in LISP is that it is a "cleaner" language more suited to the building of complex logical structures. It eliminates the burden of data-typing declarations in the program because the data is recorded with a 5-bit "pointer" tag indicating data type. It also automatically checks for data-type matches upon every memory reference. This makes LISP programs considerably more reliable and easier to debug than conventional ones.

Now, MIT's second-generation LISP machine, the CADR (for contents of the address/decrement register, a holdover from the early days of LISP programs running on IBM 704 computers), is about to be commercially produced. The resulting availability of these machines promises to be a great boon to both artificial intelligence and other research-oriented processing.

"Fifteen years from now, one half of the computers being sold will be symbolic processors rather than von Neuman machines," predicts Robert Adams, president of Symbolics Inc. of Santa Monica, Calif., one of the first companies to market the CADR machine.

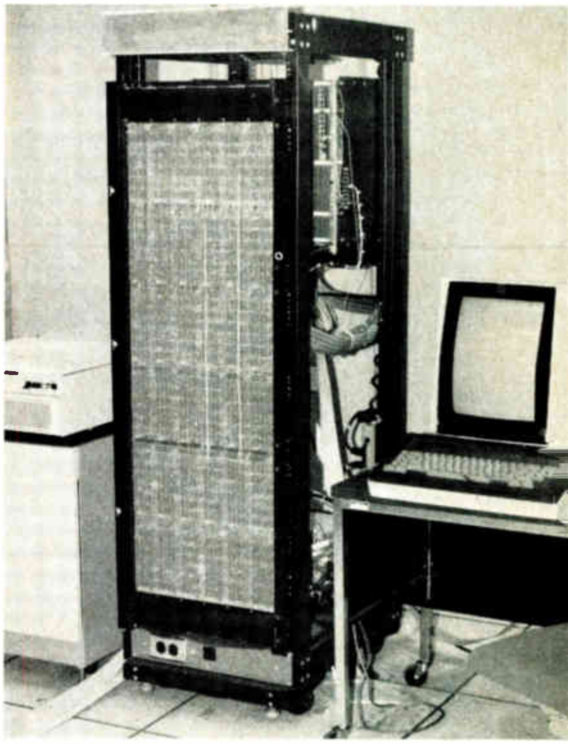
The concept of symbolic processing as exemplified by LISP has been around for nearly 25 years, but only recently has the movement grown in strength. This is attributable to a number of factors: first, the artificial intelligence field itself has only recently begun to mature [*Electronics*, Sept. 11, p. 83]. Secondly, a LISP machine requires a significant amount of memory, and only recently has the cost of memory dropped enough to make such a machine more affordable. Third, the software to support LISP had to go through enough development to offer a sophisticated, turnkey machine. And fourth, the instruction set of the LISP language needed to be microcoded directly into the central processing unit.

In the strictest sense, a LISP machine is still a von Neumann computer, because it processes one instruction at a time. Still, it diverges from the classic von Neumann computer in that it introduces "tagged" data into the run-time environment. Other types of programming have compilation-time data typing, which is lost to the program in run time.

Same tools. As noted by Richard Greenblatt, the MIT Artificial Intelligence Laboratory's group leader for the CADR project, "There is an additional benefit in that the various software features are either in microcode or in LISP. The editor, compiler, monitor, scheduler, window-system, and network routines are all in LISP, so that the same tools can be used to inspect any level of the system."

On a more qualitative level, the classic computer focuses upon the addressing of data and the movement of that data from one location to another to perform numerical calculations. The focus of the LISP instruction set is not upon the movement of data, but upon the logical connections between cells of data resident in the memory. The stack pointer, which controls the allocation of these connections, then becomes the main object of manipulation.

Users of LISP programs also access data differently. In an ordinary computer, the data is accessed by location; in a LISP program, the links to the cells in computer memory are



The machine. LISP, with its symbolic programming, is favored by artificial intelligence community for its ease of use and reliability.

accessed. This type of manipulation is well suited to building complex relationships, such as those in English language understanding, relational data bases, molecule building, design of very large-scale integrated circuits, and knowledge-based system responses. With this list of hot technologies on its side, there is little wonder that some companies have become interested in commercialization of a LISP machine.

New firms. The first two out of the starting blocks are LISP Machines Inc. of Los Angeles, Calif., and Adams' Symbolics. LMI's version is closest to the MIT CADR machine in construction. It maintains the entire CPU in one large, six-sectioned board. "Our philosophy in going with this version is that there is a history of about 20 machines produced by MIT to look back upon," notes Stephen Wyle, president of LMI. "We figured that was more important than making minor changes." Symbolics' CADR machine, the LM-2, breaks up the CPU onto six separate boards to improve maintenance.

LMI was formed by Wyle and Greenblatt. It already has orders for four machines, two from Control Data Corp. and two from Texas Instruments Inc., and it will be the first to deliver a commercial LISP machine, in early 1981. This will have a basic price of about $80,000 and sell only in units of two or more. "We want people to have at least two of them because, if one of them goes down, there is a great deal of troubleshooting the other machine can do," observes Greenblatt. "One machine can take over the other and act as a sophisticated console. The troubleshooter can also swap boards between the two machines to narrow down the problem."

The LMI machine will include 128 kilowords of 32-bit–word main storage, with 12,000 48-bit words of writable control storage, an 80-megabyte disk, a black and white monitor, a "mouse" pointing device, and the MIT Chaosnet local networking software. In contrast, the Symbolics LM-2, which will see first deliveries in May, includes 256-K by 32 bits of main memory, a 12,000-by-48-bit writable control store, an 80-megabyte disk, a black and white display, and software.

Both companies use MIT's Chaosnet as a local networking format. But each also points to the fact that the Xerox Palo Alto (Calif.) Research Center (Parc) has interfaced its two CADR machines, obtained from MIT, with Ethernet.

Though the initial battle for commercialized LISP may be fought between Symbolics and LMI, others have been quietly building LISP machines of their own. Xerox, for example, has developed two 16-bit machines, the Dorado and the Dolphin, which support a full implementation of Interlisp-D. "These machines were built solely for our inhouse research purposes," explains W. R. Sutherland, staff member to the corporate research vice president at Xerox Parc. "We believe that artificial intelligence technology will have applications in office systems. The AI community works in LISP, one uses LISP to be a part of that community."

Looking ahead. Robert Adams, president of Symbolics Inc., predicts that in 15 years half of computers sold will be of LISP type.

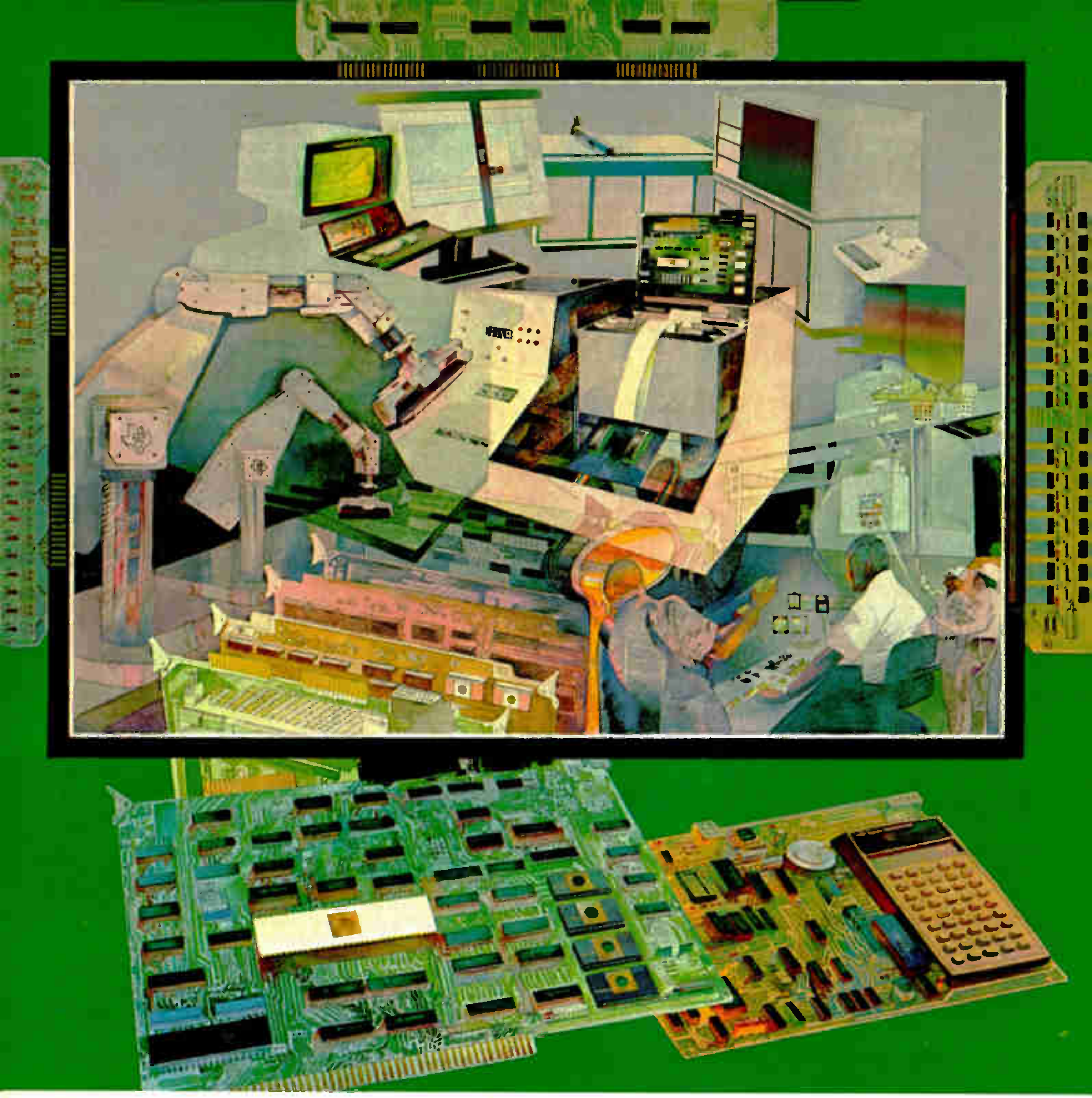
Both Dolphin and Dorado have a 24-bit address space and microcoded instructions that support LISP, but they can also support Small Talk and Mesa, structured high-level languages that were developed inside Xerox. "We found that the 18-bit addressing of the PDP-10 simply wasn't enough," recalls staff researcher Beau Sheil. "Our large programs are already filling up around 22 bits of address space, and I suspect that in a couple of years we may want even more than the 24 bits." Both Dolphin and Dorado have main memories of about a half million 16-bit words, with hardware support for both virtual memory management and instruction decoding. Dorado is more powerful, comparable to a DEC KL-10, while the Dolphin is more comparable to a DEC KA-10 in performance.

Head start. Another company that could not wait for a commercial LISP machine was Bolt, Beranek and Newman Inc. of Cambridge, Mass. It has developed a CADR-like machine known internally as Jericho to satisfy its own research needs. "We are currently deciding whether to go commercial with it," notes senior scientist Norton Greenfeld. "If we do, it should cost significantly less than either the Symbolics or LMI machines."

Greenfeld notes that Jericho is aiming for a different tradeoff from that of LMI or Symbolics, giving up some computational power to achieve a lower-cost, simpler machine. "Our primary focus in building Jericho was to develop high-bandwidth, high-resolution color graphics," adds Greenfeld.

Yet another researcher is focusing upon the absolute bottom end of the LISP spectrum. John R. Allen of Los Gatos, Calif., has developed software that will enable a Z80-based microcomputer to support LISP. His target is the educational market, specifically for LISP programming.

"We are going to need a lot more LISP programmers, and somehow they have to be trained on an affordable machine," observes Allen. He is selling his software package for $150 and using it in classes he teaches at Santa Clara University. "It adds the programming environment to the kernel of the language," he notes. "It gives display-based editing and a debugging package, and it runs on the 64-kilobyte address space of a Z80." Admittedly, it will not allow for the large programs that make LISP a truly useful language, but he points out that it will give students valuable hands-on experience with the language. □



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Careers

MIT maps manpower dialogue

Institute extends contacts with industry beyond R&D, sets up monthly meetings with executives

by Linda Lowe, Boston bureau

The shortage of engineering and other technical talent in the Northeast, now regarded by regional companies as a full-blown crisis, is one factor encouraging a closer, more mutually supportive relationship between the Massachusetts Institute of Technology and local electronics firms. The other factor is Paul E. Grey, who in September succeeded Jerome B. Wiesner as MIT's president and who appears to be accessible and sympathetic to industry's problems.

"He's a good and sensitive listener," says Ray Stata of Grey. Stata is president and chairman of Analog Devices Inc. in Norwood, Mass., and helped found the Massachusetts High Technology Council three years ago to lobby for legislative and educational actions to increase the state's pool of technical talent [*Electronics*, June 19, p. 102]. He sees in Grey a firm ally in efforts to redirect MIT's traditional "teacher-of-teachers" orientation toward one that will produce more career engineers.

"A breath of fresh air," seconds Alexander V. d'Arbeloff, president and chairman of Teradyne Inc. in Boston and current president of the MHTC. "He's very receptive to industry's concerns and willing to talk."

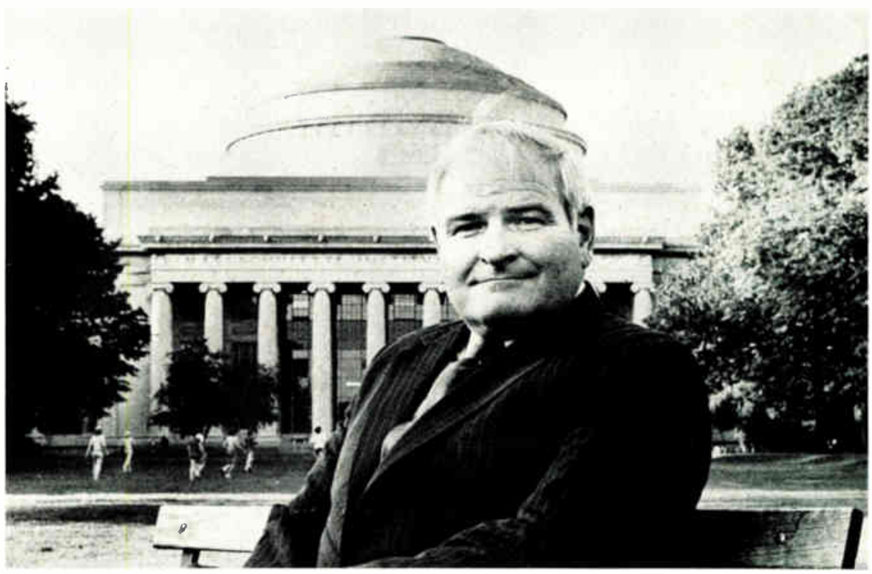
At Grey's direction, MIT's Industrial Liaison Office is recruiting a 10- to 12-member group of local industry leaders to meet monthly with Grey and other MIT officials through mid-1981. Their agenda will focus on manpower development issues, and the debate could become lively.

Such a debate may be music to industry ears. MIT, secure in its stature as a world-class educational center, traditionally has confined its dialogue with private firms to research and development issues and gone its own way in curriculum and training matters. But the new administration is looking now for more input—and assistance—from industry in charting its academic course, says James D. Bruce, director of the industrial liaison program. "This is an experimental period for us, and MIT will be taking a more active role in approaching industry for its suggestions."

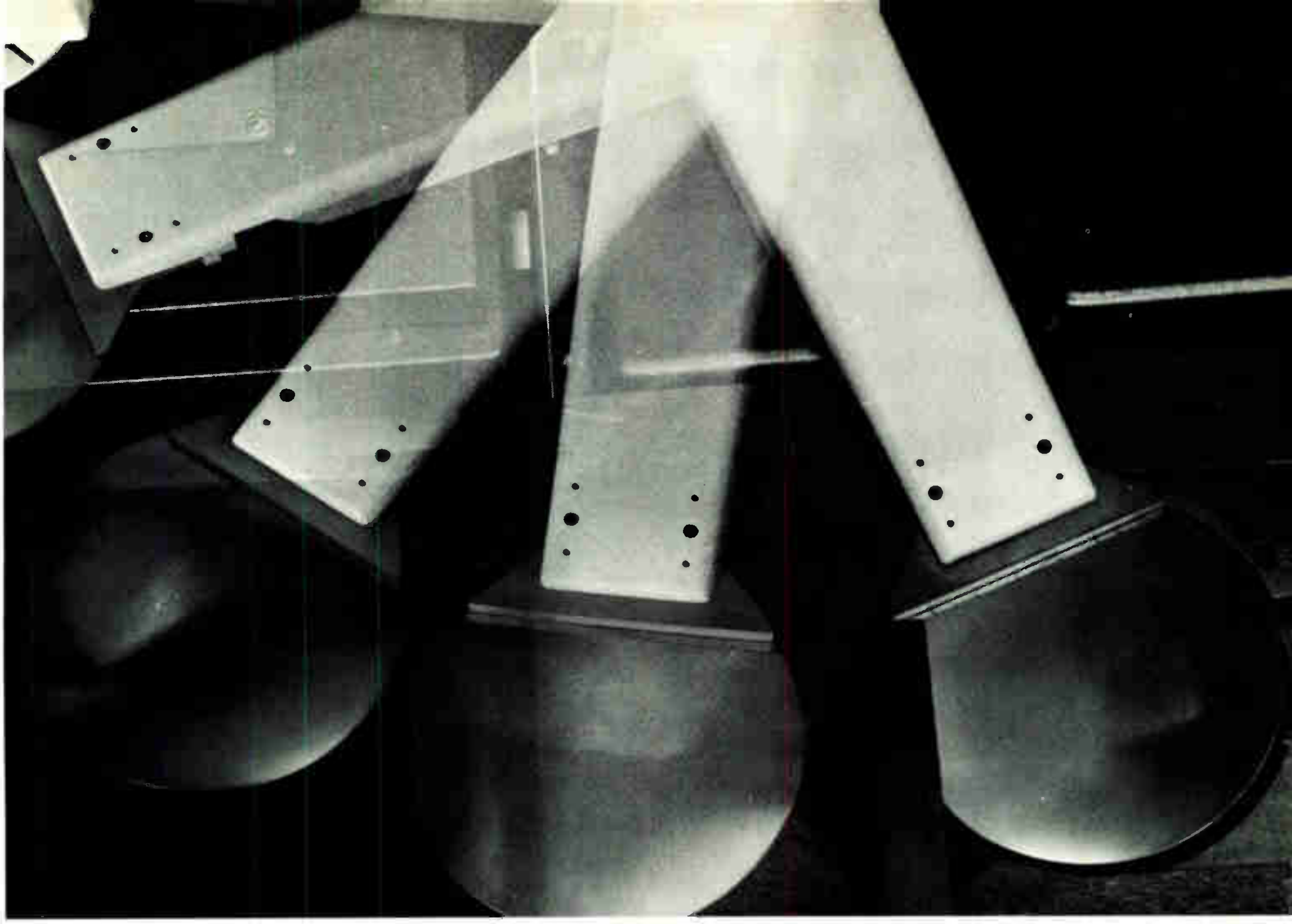
Industry interests want to see MIT increase its output of engineers, particularly at the graduate level, and particularly through the establishment of part-time, off-campus degree programs for working engineers. Other regional engineering schools are struggling hard to expand their graduate programs, points out Stata, "whereas the public universities are completely misaligned in terms of responding to market demand." MIT's prestige as an educational resource prompts high expectations for its role in helping ease the engineering crunch, Stata adds.

Not drastic. But changes will not be wholesale. For example, Grey says bluntly that MIT's graduate programs will not significantly increase in scale in coming years. He cites "the enormous costs of expansion," MIT's commitment to close student-professor interaction as part of the educational process, and the sharply declining number of college-age persons with adequate grounding to pursue engineering studies.

He notes also that MIT, whose student population currently numbers about 9,000, has doubled its production of graduates since the early 1970s. Grey also is quick to remind local industry that its demands for



Getting involved. MIT's new president, Paul E. Grey, plans to lead the institute toward a closer relationship with industry in the region.



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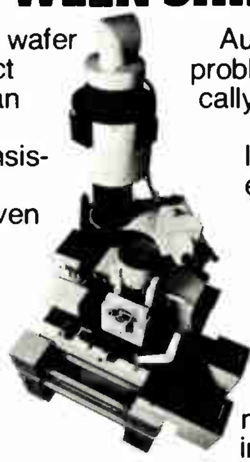

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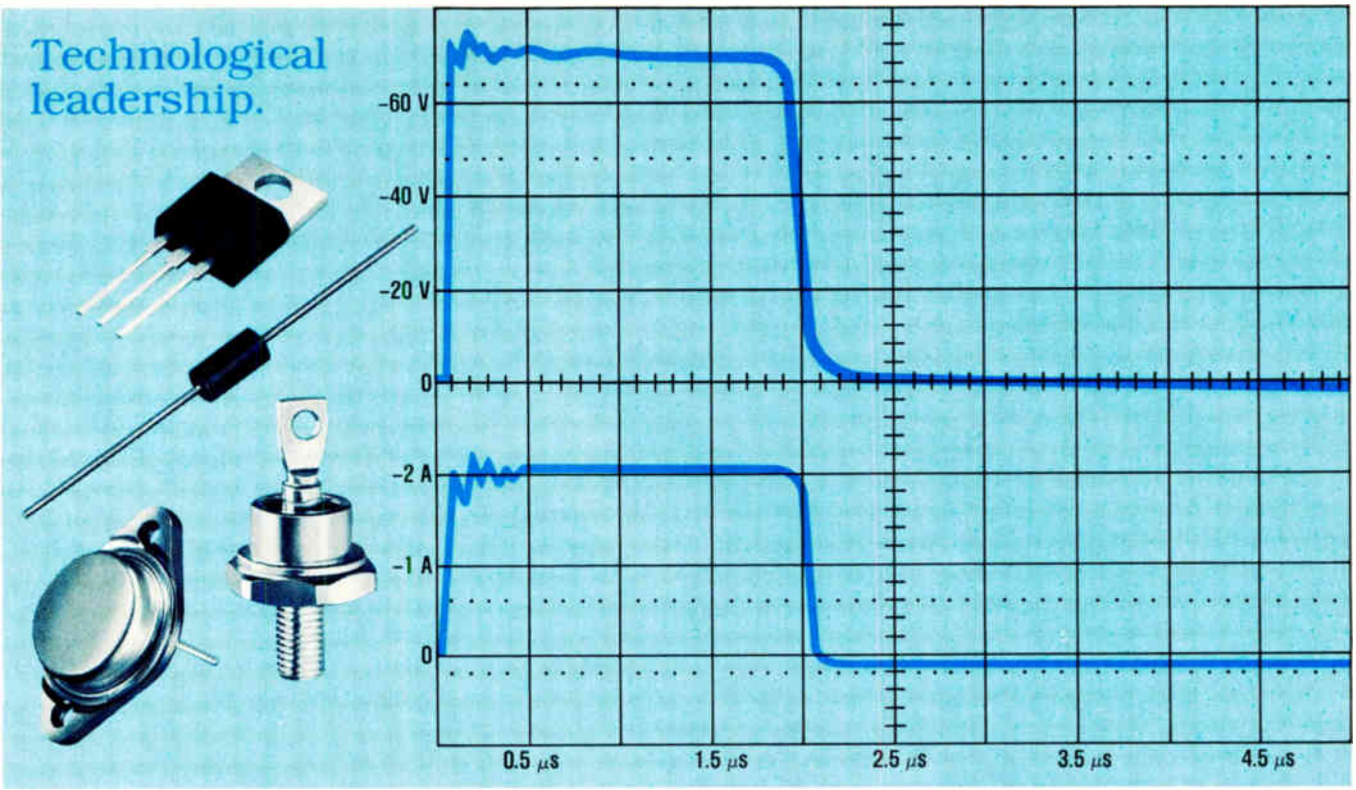
more MIT graduates are considerably out of proportion to the financial support it has given the institute in the past.

One of Grey's more positive responses is to list among priorities for MIT-industry cooperative efforts "extending the earlier work initiated by the MHTC, which focused on regional supply and demand for technical people." This may include continuation of studies by the MHTC and MIT's Center for Policy Alternatives on engineers' migrations into and out of New England and on companies' recruiting practices in the region.

Strong inducement. Many MHTC members point to the recruiting issue to explain their wish to have an off-campus MIT graduate program that they can offer to prospective engineering job candidates. They note the powerful recruiting advantage enjoyed by companies clustered around Stanford University in Palo Alto, Calif. Stanford broadcasts graduate-level course lectures to local subscriber companies over closed-circuit television, assigns coursework, and administers tests for working engineers. Studying part-time, an engineer can get a master's degree in electrical engineering or computer science on the job. No thesis is required.

"The chance to get a Stanford degree while pulling down a regular salary and being reimbursed by the company is the deciding factor for many engineers who come to work for us," comments Marialis Seehorn, corporate honors co-op coordinator at Hewlett-Packard Co. in Palo Alto. Though she confirms the arguments of the Massachusetts executives, she adds that the Stanford program is not without its limitations, such as Stanford's high admission standards and the high tuition.

No dilution. MIT offers off-campus videotape courses, but not for credit, and the institute seems unlikely to follow the Stanford model. Grey reflects the attitude of many MIT faculty members in his assertion that "the educational encounter occurs, for the most part, between individuals, not en masse." Nor will MIT



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State ____________________ ZIP ____________ dispense with its thesis requirements, he adds. The issue for MIT is safeguarding its reputation.

"Yes, we could trade in our prestige and make an MIT degree easier and more convenient to get, but I don't happen to think that producing a large army of mediocre engineers will win the technology war," says Myron Tribus, director of MIT's Center for Advanced Engineering Studies. Answering for many industry leaders is William R. Thurston, president and chief executive officer of GenRad Inc. in Concord, Mass., who replies, "Quantity is just as critical a measurement of prestige as quality. Quality times quantity equals real prestige."

But MIT and industry are not throwing up barricades around their respective points of view yet. Grey's point about MIT's limited resources and its need for local companies' financial support is well taken, Thurston believes. Analog Devices' Stata agrees that local firms must match their new interest in MIT's contribution to their manpower needs with material contributions of their own and says the issue of industry support will be a major topic of the upcoming series of meetings.

New programs. Grey, for his part, points to several new or incipient MIT programs that should please industry—particularly if they grow a bit faster than Grey currently predicts. For example, a master's program that allows one semester of part-time study and completion of a master's thesis off campus is a partial concession to the needs of the career engineer. But Grey anticipates only six students will participate in the program when it starts next fall; in the next two or three years, he hopes to see that number rise to 25, eventually to about 50.

That is painfully slow progress, though small, tentative beginnings may be the only way Grey can win faculty support for change, thinks Teradyne's d'Arbeloff. "He's got a big constituency to please, but maybe if some of these programs show initial success, he'll be able to move them along much faster. It's all going to take a lot of patience." □

Data communications

SBS lofts its package

Now, Satellite Business Systems hopes, companies of all sizes will sign up for its communications services

by Harvey J. Hindin, Communications & Microwave Editor

Satellite Business Systems Corp.'s scheduled launch last week of a communications satellite is the culmination of five years of effort and the expenditure of $375 million. The result: an all-digital bird with a 14-gigahertz uplink and a 12-GHz downlink that provides a unique combination of data-communication operating modes and services that the company hopes will be irresistible to cost-conscious customers.

Some of the services offered by SBS have been available in various forms through other satellite communications companies that have been in business for years. But the McLean, Va., company puts all of them into one package, adds new ones, and perhaps most important, has paid for the development of ancillary products that users need to make a completely cost-effective, high-speed data-communications system.

These products fit right in with SBS's basic offering, the Communications Network Service, or CNS. An all-digital, high-speed, high-capacity system, CNS is designed to provide large organizations having widely dispersed facilities with a private satellite-based data network. Fully dedicated earth stations are on these firms' premises.

In the CNS approach, customer telephone lines and computer circuits go straight into the earth station where their traffic, whether voice, data, or image, is digitized and encoded for the appropriate earth station destination. All of this is done at speeds up to 48 million bits per second—the limit of the satellite transponder.

For all of this high-speed equipment to operate successfully, SBS decided early in the game that compatible equipment had to be available for the user to connect to the earth station, whether that user owned or shared it. SBS had no desire to be in this equipment business but decided to let contracts for prototypes to be developed for sale by other communications companies. In this way, both terminal devices and local loops were addressed.

Other products. One result of this effort is a communicating copier produced by A-M International of Los Angeles that can send thousands of pages an hour to other communicating copiers. SBS's goal in this project was to make the sending of documents among multiple sites around the country no more time-consuming than single-location distribution. Another piece of hardware, developed in cooperation with E-Systems Inc. of Dallas and other vendors, was a teleconferencing system. For its part, the Bunker Ramo Corp. of Oak Brook, Ill., developed a device known as a satellite data-exchange controller (S-DEC). It handles data transfers at speeds of up to 6.3 megabits per second, either switched or nonswitched and either point to point or point to multipoint. Designed to adapt to a wide variety of data-processing equipment, S-DEC is at present compatible only with IBM System/360 and /370 gear. But Honeywell, Sperry Univac, Control Data, and Digital Equipment computers will soon be served by the device.

Error-rate control is a prime consideration in the S-DEC design and its accuracy is to within better than 1 part in 10 trillion. This means it can transmit the contents of millions of standard disk packs without an undetected error getting through. Both Bunker Ramo and SBS are proud of the fact that this feat does not require special host software. Because of the high speed and simultaneous low error rate, SBS says the device has made it feasible, for the first time, to transmit the contents of a large data file electronically (see figure).

Local loops. SBS also found it necessary to push the state of the art in high-speed local data distribution in big cities. Here, SBS worked with Tymnet and the Local Digital Distribution Co. to set up a terminal equipment experiment in

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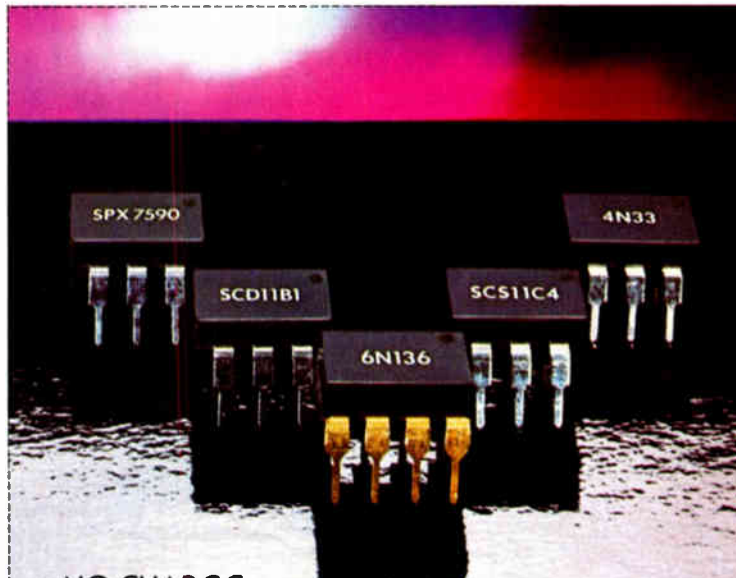

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Probing the news

New York and San Francisco. In New York, already-in-place cable television coaxial cable distributes data between the service's users and an SBS earth station.

The SBS satellite link connects New York with San Francisco where SBS is looking into cellular radio [*Electronics*, May 24, 1979, p. 158] as well as coaxial cable for local distribution. The SBS cellular radio scheme requires construction of a local microwave antenna at each data site. Each of these points to a central distributing antenna at a "node" in the geographic center of a "cell."

In the cellular approach, a number of 56-kilobit-per-second channels will be available for "relatively small users" who have "smaller traffic requirements but are numerically much larger than the candidates for CNS," an SBS spokesman says. In contrast to this relatively slow service, SBS is also looking into accommodating customers who want to distribute data at up to 50 million bits per second. For this SBS has decided to utilize the Hyperchannel system.

Hyperchannel, a 5,000-foot-long local network, is the brainchild of Network Systems Corp. of Minneapolis. It provides multidrop capabilities and—like Net/One developed by Ungermann-Bass Inc. of Santa Clara, Calif. [*Electronics*, Sept. 25, p. 114]—allows for network interconnection of terminals or computers of different vendors.

Hyperchannel-to-SBS connections will require the use of devices called satellite link adapters and maintenance adapters. Network Systems has been given a contract by SBS to deliver prototypes of these products for testing during the third quarter of 1981. The adapter will massage the data for proper transmission and reception from the satellite, while the maintenance device will be concerned with error detection and correction.

Why satellite data communications? What drives their customers, SBS has decided, is cost. In fact, in one study of several large corporations, SBS concluded that in what it terms hard displaceables, or directly measurable benefits, the cost of data processing, voice networks, data lines, mail, travel, and all associated hardware averages $85 million per year. SBS calculated that SBS-type solutions could save such companies from $2 million to $20 million per year. Of course, just what actually will be achieved will not be known for some years. Yet not only is SBS confident that its case is strong, but it also says that the "soft displaceables," or intangible benefits, from electronics mail, video teleconferencing, and the like will be significant.

SBS says that its cost-saving power is derived the "grand union of cheap chips and cheap bits." And this, in turn, is due to "the amazing improvements in the price-performance characteristics of semiconductor products." Add to this "the convergence of computer and communi-

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cation technologies and the suitable adjustments in the legal and regulatory environments," and the entry of SBS into a "previously closed industry" has become possible.

Need questioned. But all is not yet clear sailing for the company, which is sensitive both about its relationship with IBM Corp. and about being called an IBM spinoff. Comsat Corp., IBM, and Aetna Life and Casualty Co. are SBS's founders. According to SBS, customers for various forms of data services include Aetna and IBM, plus Allstate Insurance, Boeing Computer Services, Insurance Systems of America, the Travelers Corp., and Westinghouse Electric. However, because not every organization that might benefit from its services is a corporate giant, SBS also provides earth stations and other network access facilities that may be shared by two or more users.

SBS's C. Thomas Rush, assistant director of marketing, marketing requirements, and development, says that the company "has always intended to provide these shared services" and that its doing so is in no way an indication that the big targets have been less than enthusiastic in spending the money needed to set up a dedicated earth station and its associated communications links. In fact, Rush says there is no shortage of customers and the company is staffing up in an orderly manner to handle an orderly growth of the customer base.

Unneeded, say critics. Critics of the SBS approach counter with claims that many SBS services can be provided by RCA Americom, American Satellite, Western Union, and others without the capital expenditures that SBS requires. These critics further maintain that SBS was forced to lower its sights to establish a customer base in the present troubled economy and that its costs are too high for companies without massive data-handling requirements like the four insurance companies already signed up. As one data-communications user who prefers to remain anonymous puts it, "There is a lot of 56-kb/s traffic out there that doesn't require an SBS to do the job." □

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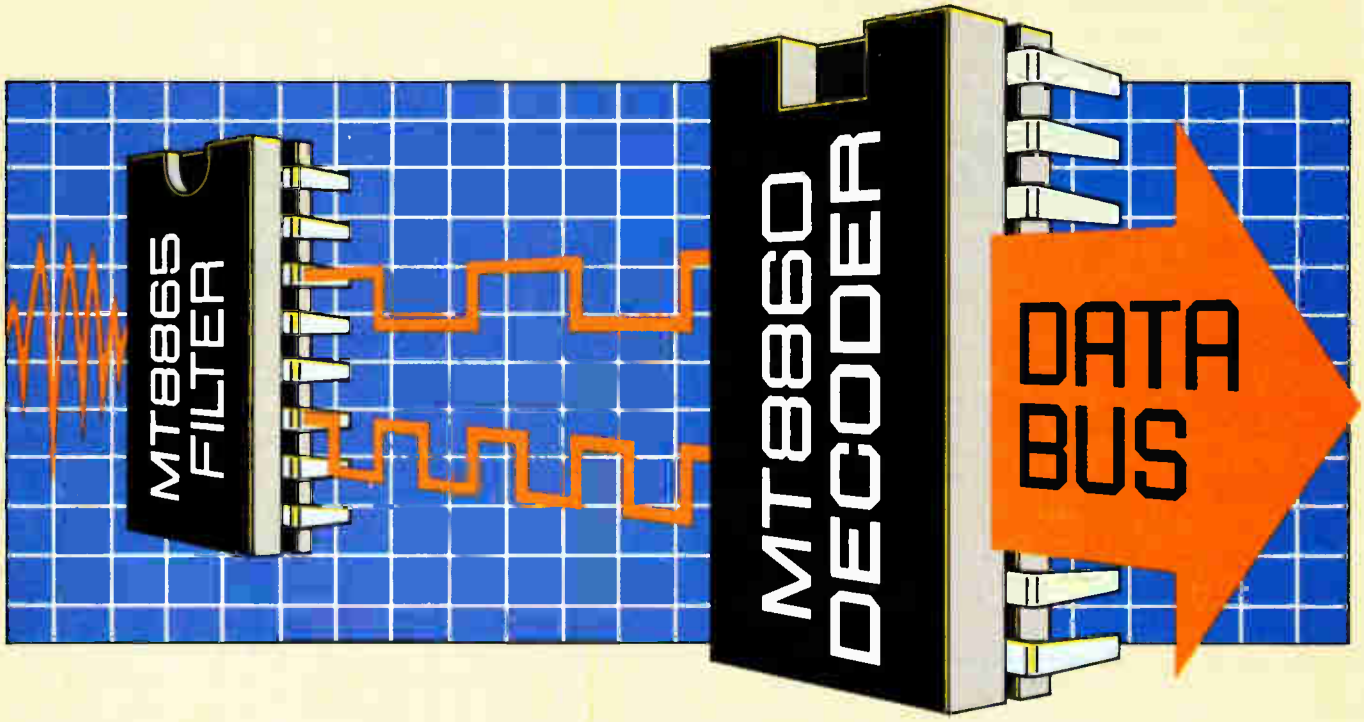

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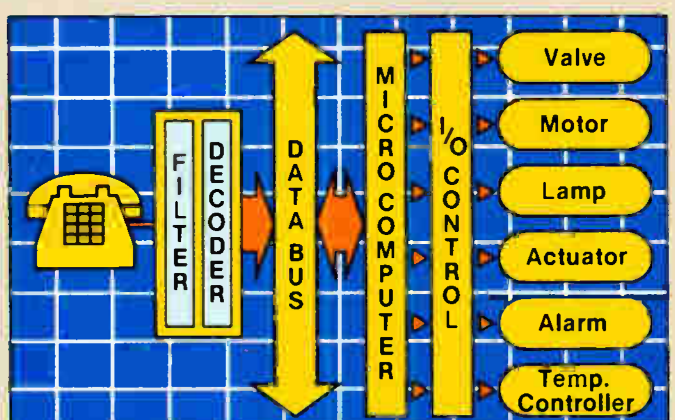

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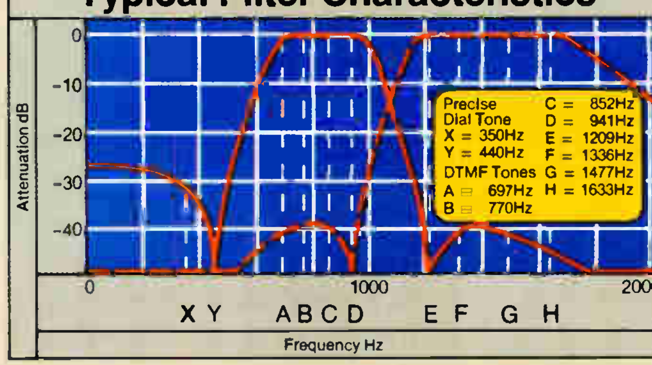

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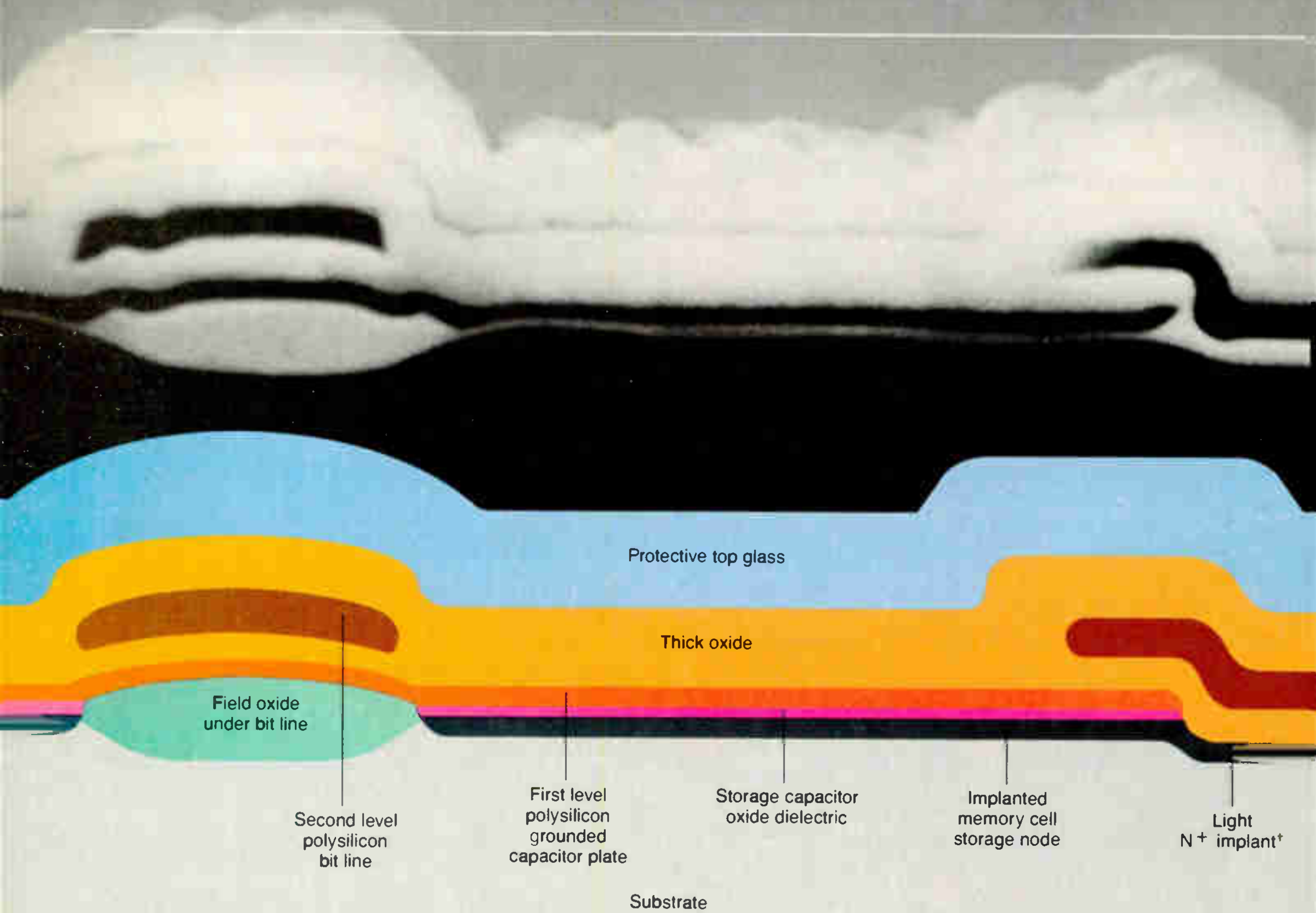
THE BUSINESS OF DESIGN



By now, you're probably aware that no less than 18 manufacturers have or will introduce their own version of a 64K RAM. And that each version will be at least a slightly different design. So how will you choose one intelligently? How will you base your decision knowing that each manufacturer feels strongly justified in choosing the architecture and manufacturing process it will use?

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How to choose a 64K RAM wisely after examining the specs.

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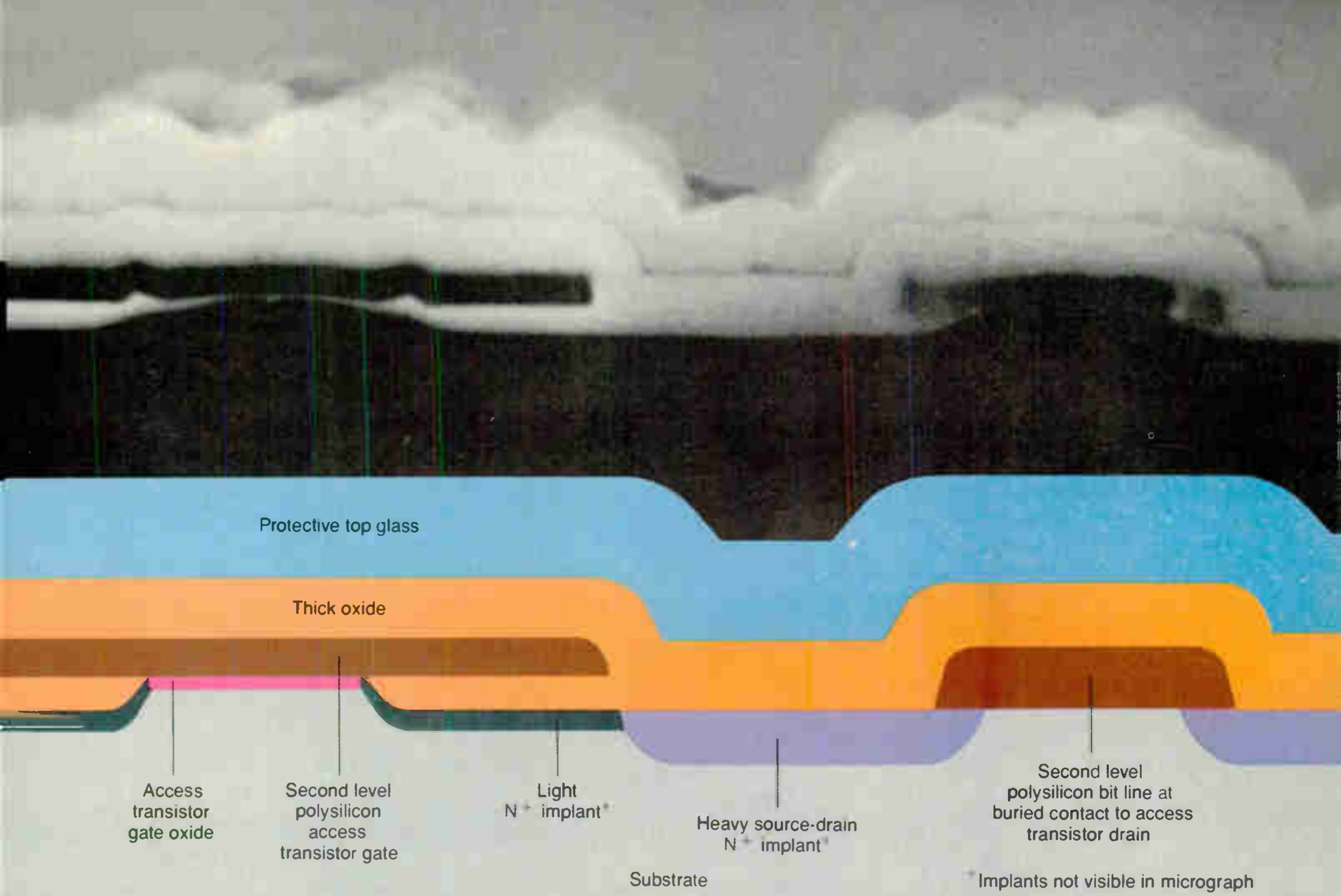

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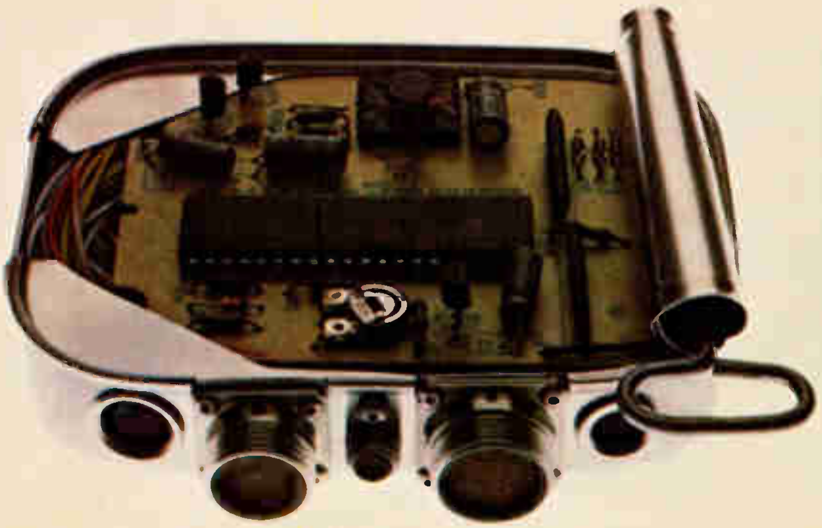
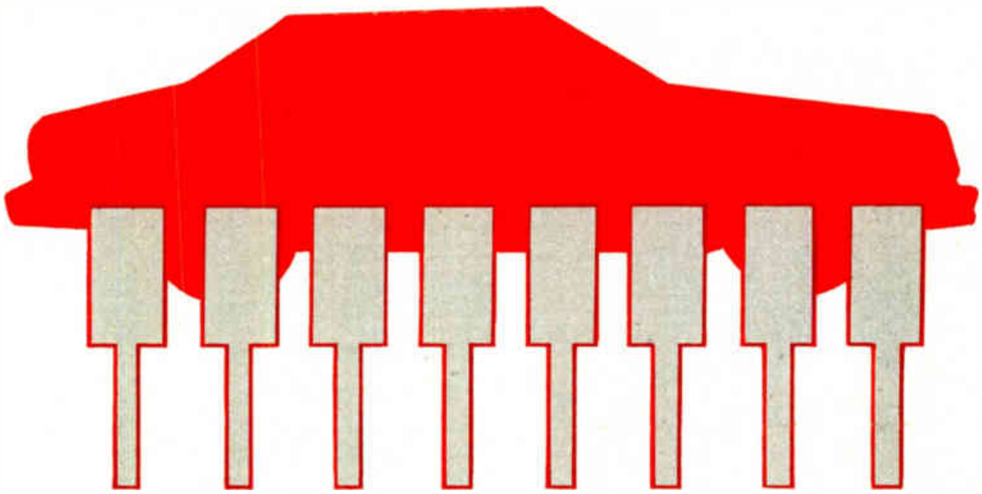




Microelectronics takes to the road in a big way: a special report

With electronic engine controls set for 1981, auto makers are turning their attention to electronic options

by Gil Bassak, *Industrial/Consumer Editor*

☐ Detroit, it could easily be said, is microprocessor-happy. Each of the Big Three automobile manufacturers will put more than a million such devices into their 1981-model cars, and the number will continue to grow. Microprocessors, microcomputers, and other large-scale integrated circuits are being used both in engine controls, where they help Detroit meet emission and fuel economy standards legislated by the Federal government, and in the passenger compartment. What's more, microelectronics for the transmission and the suspension system are in the works as well.

Car makers are aggressively using their new education in electronics to adorn auto interiors with striking instrument clusters and optional electronic features that they hope will attract buyers. In fact, most observers believe that the growth area for automotive electronics is now in what the industry calls "feature electronics." This category covers the instrumentation package, plus such features as keyless entry, speed and climate controls, and safety enhancements.

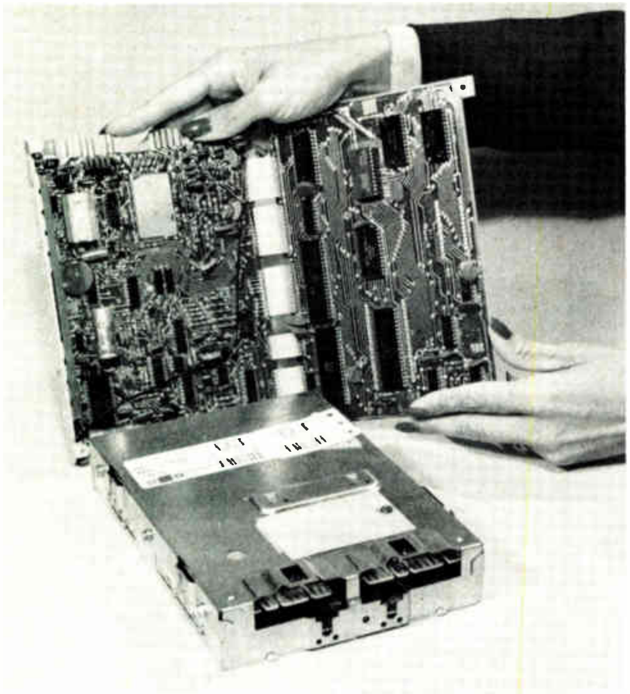
Moreover, testing and diagnosing breakdowns in the electronic systems will be taking on entirely new proportions in 1981. Some systems will be able to pinpoint their own faults; others, in contrast, will be tested by specially designed consoles rolled up to the vehicle.

A plateau of sorts has been reached in the microprocessor-driven engine controls themselves. The basic systems in place will meet Government requirements specified through 1985. Their programmability—made possible by changing the coding in a read-only memory—will enable them to be modified to meet evolving auto requirements. Thus auto makers will now be able to pay more attention to reducing costs, primarily by reducing the number of parts by using custom components, and designing in as much reliability as possible.

Reliable supplies

Also, in terms of parts, the auto industry found that, despite fears of a shortage, it could rely on the semiconductor industry to meet its needs. Capacity had been increased to satisfy other demands, so that the shortages feared several years ago, when auto makers began planning their requirements, just did not materialize.

As for European and Japanese car manufacturers, they are behind the Big Three in applying on-board electronics. Their smaller and more fuel-economical



1. **On the road.** The electronic control module for GM's Computer Command Control is separated into boards for digital processing (right) and input/output signal processing (left). This unit is the center of GM's engine control system, for its line of gas engine cars.

vehicles have generally been able to meet U. S. standards without centralized microprocessor-driven engine controls. However, they are making strides in digital instrumentation, and as feature electronics increasingly becomes a selling point, the competition from Europe and Japan can be expected to rise.

The first auto maker to go virtually across the board with electronic engine controls is General Motors Corp., the biggest of Detroit's Big Three but actually headquartered in New York. Almost all of its 5 million or so 1981-model gasoline-powered cars will sport what the company calls Computer Command Control (Fig. 1), designed by its Delco Electronics division, Kokomo, Ind. The first version was introduced in 1979. Based on a 6802 8-bit off-the-shelf microprocessor from Motorola Inc.'s MOS IC division in Austin, Texas, it will be in most of the 1981 model cars that GM ships. A second system, a faster, more powerful version of the first, contains a custom chip set developed in cooperation with Motorola and is called the GMCM, for General Motors Custom Microcomputer.

The GMCM chip set will appear in all of the company's model year 1982 passenger cars. It has fewer components than its predecessor, relying more heavily on custom LSI. At its core is a 6802 modified for engine control tasks with a powerful input/output section and mathematical and self-testing capabilities.

However, the Computer Command Control is used differently by each of GM's car divisions. For example, the Cadillac alone features the Modulated Displacement System, which saves fuel by varying the number of operating cylinders among eight, six, and four, depending on the load and speed of the vehicle, as well as the driver's demands. The common engine control unit is tailored to each car division's needs by dropping in one of about 82 different programmable read-only memories.

The GMCM comprises five bus-compatible large-scale integrated circuits. They are the microprocessor, plus engine control logic, memory, an analog-to-digital converter, and a power-conditioning unit, configured as shown in Fig. 2.

Customized for speed

The microprocessor, a 40-pin device, adds 10 instructions to the standard 6800 instruction set, including an 8-bit multiplication and double-precision (16-bit) addition, subtraction, stacking, and accumulator instructions. In addition, the execution time of 32 selected instructions has been reduced so that the processor can perform more engine control functions in less time.

The engine control unit is a microprogrammed controller, preprocessing input and output signals and thus offloading the microprocessor. Most activators on the car that are not simple on/off devices are driven by a pulse-width-modulated signal. Also, many transducer outputs are pulse trains that require pulse counting or time-interval measurements. As a result, to match these I/O characteristics, the chip provides eight PWM outputs for actuator control, as well as six pulse accumulators for transferring sensor data to the processor.

Since the ability to detect system malfunctions takes a high priority, the chip has built-in testing capability and can provide a signal to be used by the processor to initiate a failure mode of operation. It allows the design engineer to provide contingency hardware and software with which to avoid catastrophic malfunctions.

The memory combination unit holds the system software. It contains 4-K bytes of read-only memory and 128 bytes of random-access memory, 64 bytes of which is nonvolatile, plus eight programmable I/O ports.

The a-d converter is a C-MOS chip housed in a 40-pin package. By providing 16 channels that convert in 300 microseconds, it frees the microprocessor for other tasks.

Finally, the power-conditioning unit has transistor-transistor, emitter-coupled, and integrated injection logic combined in a single device. It provides the system clock, power regulation, backup circuits, and reset timing. It also serves as an integral part of the system's overall fail-safe mechanism. Typical system specifications include a temperature range of $-40°$ to $+85°C$ and a power dissipation of about 2.5 watts at 5 volts dc.

The approach at Ford Motor Co. differs from that of GM's across-the-board sweep toward electronic engine controls. Ford's management proceeded more cautiously and found, according to Jack Paskus, manager of the electronic engine components department in Dearborn, Mich., that "as we developed engine controls, we also were learning more about the mechanical design of the engine—and how to improve it." Consequently, in model year 1981 only about 20% of Ford's passenger cars will contain electronic engine controls of any kind, and most of them will be the company's Microprocessor Control Unit, which performs only closed-loop carburetor control and limited spark advance.

The EEC-III, Ford's latest engine control system in production, is being used mostly in the Lincoln and Mark VI Continental. The reason is that Ford engineers were able to back off from "very good results" using electronics to "acceptable results" with less expensive mechanical solutions, Paskus points out. "What we found was that we could develop mechanical systems which simulated the electronic system, and the mechanical system was cheaper."

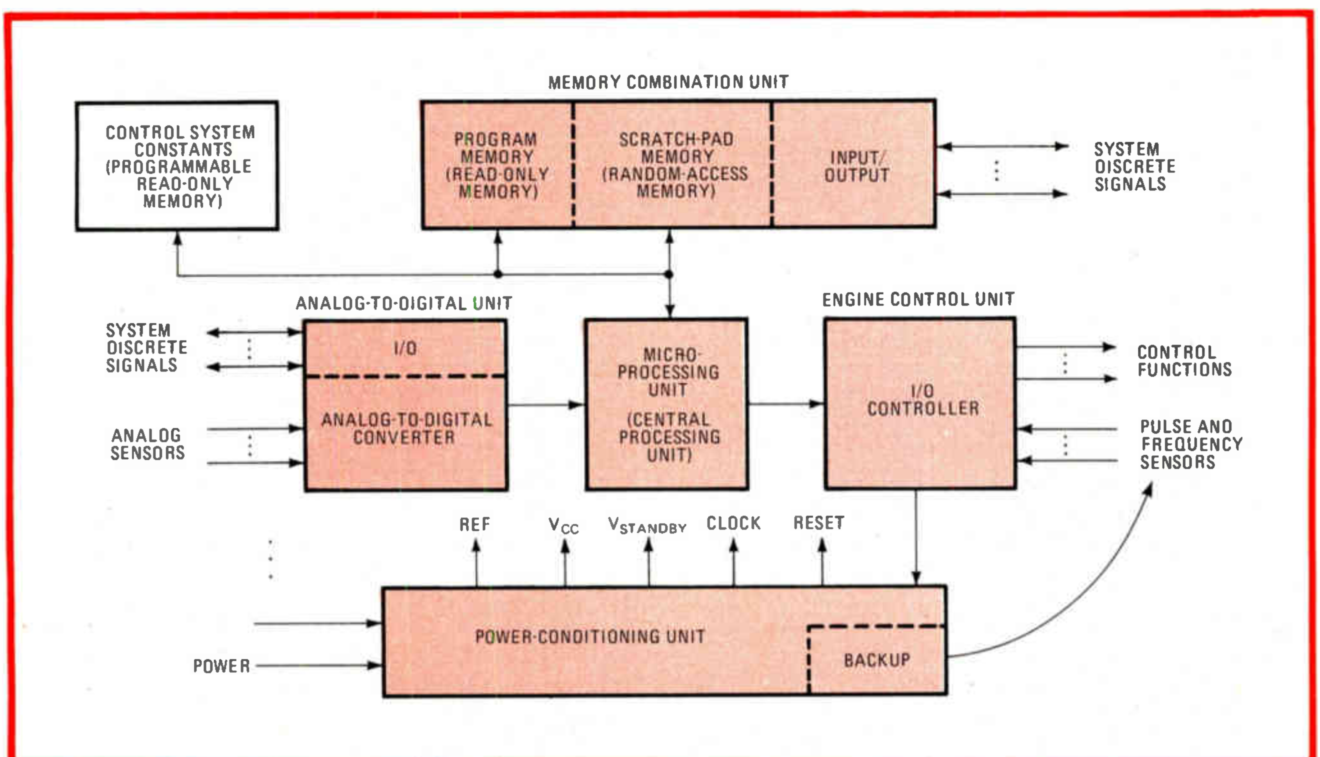
Paskus concedes that he will not be so lucky in the future, with stricter emission and mileage requirements in the offing. Ford intends to meet them with its newest engine control system, EEC-IV. Development of the microcomputer chip set for the system, which is scheduled for model year 1984, was announced recently by Intel Corp., Santa Clara, Calif.

Ford's electronic control system has evolved since 1978 from the first-generation EEC-I, which governed spark timing and exhaust gas recirculation, to the 1980 EEC-III, capable of performing all critical engine control functions, including closed-loop carburetor control, central (also called throttle-body) fuel injection, and—though not implemented on current models—torque converter clutch control.

EEC-II, which replaced EEC-I during model year 1979, added closed-loop carburetor control. It was based on a 12-bit microprocessor system developed by Japan's Toshiba Corp., with five LSI circuits—the microprocessor, plus four memory chips. Those producing the system included Toshiba; Texas Instruments Inc., Dallas; and Ford's own Electrical and Electronics division (EED) in Ypsilanti, Mich.

Meanwhile, a design competition raged among the Essex Group Inc. of Fort Wayne, Ind., Toshiba, Motorola, and Ford's EED over how to accomplish the third generation, which was introduced on some cars in model year 1980 and completely replaced the EEC-II in 1981 cars. Motorola's Automotive Products division, Schaumburg, Ill., won the contest with the company's 67000 custom microprocessor. EEC-III now is the basic system for Ford cars and will be for several years, with a fourth generation to bow in 1984.

The evolution of EEC-III is indicative of the auto makers' desire to reduce the cost of using electronics by reducing the number of components. By going to large-scale integration around a custom-designed Motorola processor, Ford enhanced the performance of its system



2. Custom crew. The General Motors Custom Microcomputer (GMCM) uses a modified Motorola 6802 microcomputer and four other custom components all designed specifically for engine control tasks. The PROM tailors the system to a particular car and engine.

and reduced the chip count. The EEC-III has only five LSI chips yet outperforms the EEC-II with its seven, working faster and adding fuel injection control.

Although Ford is reluctant to discuss specifics of the EEC-III engine computer, the major LSI component, Motorola's custom 67002, is an n-MOS chip that handles 8-bit data and executes 10-bit instructions. It was specifically designed to multiply and divide in hardware.

For 1984

Ford's EEC-IV, for model year 1984, will use Intel's recently announced 8061 and 8361 custom ICs, which were designed exclusively for the auto maker. The 8061 is a 16-bit processor, needed to handle the wide dynamic range of the engine variables being sensed. Ford hopes to implement its complete engine strategy using just the single 8061, its companion 8361 ROM, and a minimum of interface components. Both the 8061 and 8361 are n-channel high-performance MOS (H-MOS) parts requiring a single 5-V dc source.

General Motors and Ford have made a fundamental decision in going with H-MOS technology. They would like to put the engine control electronics under the hood, but because of the high temperatures, components that would logically belong near the engine must be located in the passenger compartment. The cost of installing the system there is higher, since bulkhead connectors and wiring to the controls are needed between the engine and passenger compartments. However, the advantages of using n-MOS are substantial, because greater integration, and hence more functions per chip, are possible.

Chrysler takes the high road

Chrysler Corp., however, has gone another route. The Highland Park, Mich.–based car maker has picked a C-MOS microprocessor, the Cosmac 1802 from RCA Corp.'s Solid State division, Somerville, N. J., for its engine control system. The higher operating temperature of C-MOS allows the processor to be mounted in the engine compartment, closer to the sensors and actuators connected to it, thereby reducing the overall cost.

Chrysler's Spark Control Computer will appear in about 70% of the company's passenger cars for model year 1981. The least complicated and having the lowest

Meeting the environmental standards

Striving to clean up emissions and reduce fuel consumption, Detroit has produced a whole raft of emission control and fuel economy techniques and then enhanced and coordinated them with the precision of computer control. Here is a summary of these techniques.

Choke control. Almost 70% of a car's hydrocarbon and 60% of its carbon monoxide emissions are produced during warmup. A rich fuel mixture, although necessary for smooth starting, is largely responsible. Computerizing the choke control to hold the richness to a minimum reduces these emissions.

Closed-loop (feedback) carburetor. By sensing the oxygen level at the exhaust, the air/fuel mass ratio at the carburetor is adjusted to maintain stoichiometry, the point at which the auto's three-way catalytic converter performs at maximum efficiency. The stoichiometric ratio of air to fuel is 14.7:1.

Controlled canister purge. Evaporating fuel from the carburetor and fuel tank, a potential source of pollution, is fed into a charcoal canister whose vapors must be periodically purged into the intake manifold—but only when the vapors will not adversely affect the combustion emissions.

Exhaust gas recirculation (EGR). Cycling some of the exhaust gas back to the intake manifold cools combustion and reduces emissions of oxides of nitrogen (NO_x).

Fuel injection. Fuel and air are precisely measured and injected either from above the intake manifold (at the throttle body) or directly into each cylinder.

Idle-speed control. The engine speed of a car at rest is automatically adjusted to compensate for changes in engine load, caused by devices like the air-conditioning compressor or rear window defroster.

Knock limiting. One way to optimize spark control is to adjust the timing to the optimal point, which is just short of the pinging, or "knocking," of the engine. Detectors sense this knocking and retard the spark advance so as to restore the optimum timing.

Modulated displacement. The number of active cylinders is varied according to engine load, vehicle speed, and demands by the driver, minimizing fuel consumption.

Secondary air management. Air can help the catalytic converter operate more effectively. At startup, secondary air management pipes air into the two catalytic chambers (oxidizing and reducing). As the engine warms, air is needed only to assist in oxidation. During extended idles and high engine temperatures, the extra air is "dumped overboard" to prevent overheating the converter.

Spark control. Spark control has two aspects: electronic ignition and spark advance. Spark advance adjusts the timing of the ignition for highest torque, based on the engine's load and speed. Electronic advance replaces the vacuum system with a more accurate, continuous adjustment. Electronic ignition, around for several years, replaces the mechanical breaker points used to generate the spark.

Three-way catalytic converter. When the air/fuel ratio is maintained at stoichiometry, the converter affects three types of emissions. It reduces the nitrogen oxides and oxidizes the carbon monoxide and hydrocarbons, using two different catalyst beds. Too rich or too lean a gas mixture cuts the converter's efficiency.

Transmission controls. An automatic transmission wastes fuel because of slippage in the fluid link between input and output shafts. At the proper time, however, transmission controls trigger a clutch to engage the engine solidly to the drive shaft, eliminating slip-induced losses.

cost per function of the Big Three systems, it controls spark advance, a closed-loop carburetor, and exhaust gas recirculation (EGR).

Chrysler must squeeze the engine functions out of the 1802 while operating it at only 5 V, down at the low end of its approximately 4-to-10.5-V range. The reason for this low-voltage operation is that the engine control software is stored in a fusable-link bipolar PROM that requires 5 V. To keep the power requirements simple, Chrysler opted to use the same low voltage for the processor at the cost of the speed at which it will run.

RCA has begun supplying samples of a faster chip, the 1804, which Chrysler intends to use to implement other emission control and fuel economy functions in the future. Asked about whether it has any plans to switch from C-MOS to n-MOS for its processor, John L. Webster, manager of engine controls for Chrysler's Electronics division, Huntsville, Ala., says, "We will use the 1802 through 1985. We keep looking at n-channel, but we haven't gotten to the point where we'd make an n-channel commitment."

Coming from behind

Without the imperatives of governmental antipollution legislation, European and Japanese auto manufacturers can wait and evaluate microprocessor-based electronic engine control schemes on strictly economic terms such as improved gas mileage. Moreover, for the U. S. market, the small foreign cars can meet Federal gas mileage and pollution standards with relatively simple analog electronic systems.

Most electronics in European cars is in larger, top-of-the-line models like British Leyland's 12-cylinder Jaguar, in which fuel injectors squirt precisely metered fuel into each cylinder under control of a digital regulator. Developed by Lucas Industries Ltd., Birmingham, several years ago, the controller uses a custom chip from Ferranti Electronics Ltd., Chadderton, Oldham. This controller is now also being fitted to six-cylinder Jaguar engines.

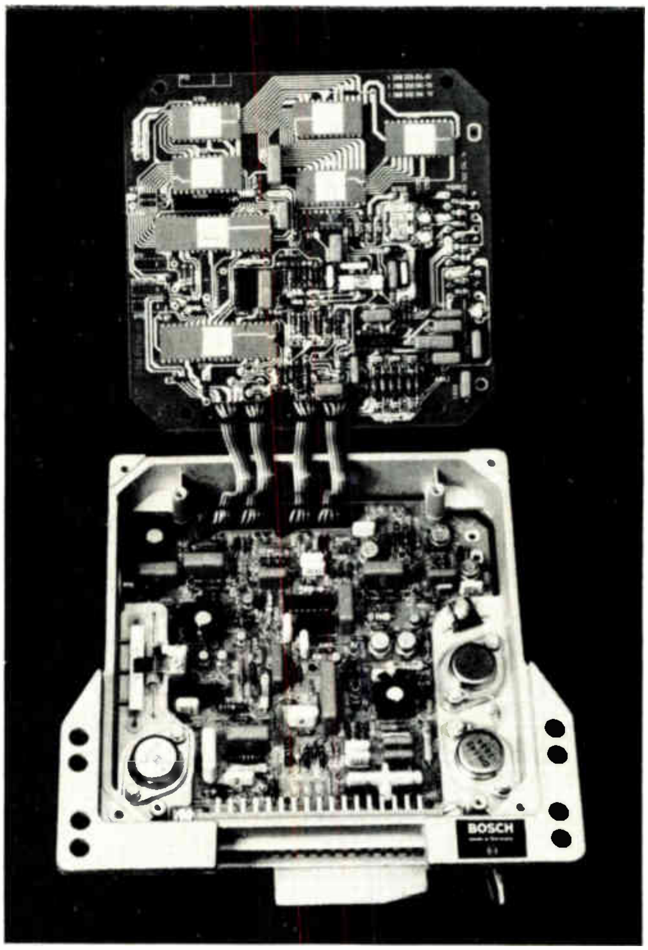
One of the most progressive users of electronic systems in Europe is Bayrische Motoren Werke AG, maker of the stylish—and expensive—BMW cars. BMW introduced a digital electronic system that integrates the circuitry for controlling both the fuel injection and the ignition in one of its 1980 model cars and is applying it to three 1981 models. Called the Motronic system (Fig. 3), it is a joint development with Robert Bosch GmbH of Stuttgart [*Electronics*, Aug. 2, 1979, p. 69].

Also built around RCA's 1802 C-MOS microprocessor, Motronic picks up information on engine speed, intake-air flow, crankshaft position, and engine and intake-air temperature. Data on engine speed and gas pedal position, for example, are stored in ROM, with each memory location containing a data combination for these two parameters. Each combination corresponds to a particular ignition and fuel injection time. The computer calculates the injection and ignition timing and the optimum amount of fuel to be injected for a certain rpm value and gas pedal position.

The Motronic system saves fuel, facilitates starting in cold weather, makes for smoother engine operation, and requires virtually no maintenance, according to H. D. Fournell, head of predevelopment of electronic and electrical systems for Munich-based BMW.

In France, Paris-based Automobiles Citroën (part of the PSA-Peugeot-Citroën group) is putting an integrated digital electronic ignition system (furnished by both Thomson-CSF, also based in Paris, and Motorola) into its four-cylinder-engine LNA and Visa models. The latest version includes a semiconductor memory that stores the ignition advance curve.

Also moving ahead with microprocessor-based electronics is Renix SA, a joint venture created two years ago by La Régie Renault and Bendix Corp. Renix, in Toulouse, offers an electronic speed regulator, called Normalu, based on an Intel 8022 microprocessor. Introduced



3. Integrated controls. Bosch and BMW have integrated fuel injection and spark control in this RCA 1802-based system called Motronic. In general, foreign auto makers use less electronics, however, since their cars often meet Federal standards without it.

4. New look. Chrysler's new instrument cluster with electronic odometer is a standard feature on all 1981 Imperials. Vehicle speed, fuel supply, and even the gear selection indicator have gone to vacuum fluorescent blue displays for added appeal.

recently as an option for some Renault models, Normalu permits the driver to choose a maximum speed and to automatically return to that speed even though he has depressed the brake pedal to slow down.

In Japan, microprocessor-based engine control is proceeding at a very slow pace. Nissan Motor Corp., the industry leader, is installing such controls on some top-of-the-line car models with six-cylinder in-line engines. But it has yet to install them on four-cylinder engines, which are the lion's share of the cars it manufactures.

Heading East

Nissan calls its engine controller ECCS, for Electronic Concentrated Engine Control System, and uses microprocessor and peripheral chips from Hitachi Ltd. It is built around a 6802-type microprocessor, two 4-K-byte ROMs, a 128-byte RAM, and an LSI custom I/O chip. The custom chip includes the normal peripheral interface adapter functions, a 10-bit and an 8-bit a-d converter, and an 8-by-8-bit hardware multiplier.

Two other Japanese companies are starting to use microprocessor engine control. They are Mitsubishi Motors Corp., which uses chips fabricated by sister firm Mitsubishi Electric Corp., and Toyota Motor Co. using devices from Toshiba and systems from Nippondenso Co. (which makes its own semiconductors).

Avoiding pit stops

Since GM has chosen to go all out with a computer-controlled engine, serviceability is a must to prevent "walk-home" failures. Indeed the complexity of the system demands self-testing and fault-tolerance—requiring a careful balance between the necessity of avoiding catastrophic failures and the cost of implementation.

GM has used three techniques—redundant hardware, self-test hardware, and self-test software—to keep the driver on the road. Even failures that may go unnoticed by the driver yet adversely affect the car's emissions or fuel economy are signaled by an instrument panel light.

Of the three, redundant hardware is the most expensive route to system reliability. It is therefore reserved for critical engine functions only—namely, the fuel- and spark-control loops.

The second technique, self-test hardware, serves a watchdog function, monitoring for deviations in the normal program flow. To ensure that the engine control software is operating, a self-test instruction is placed in the software loop that carries out the engine control program. The instruction toggles a circuit that sets a 12-millisecond timer. In most cases, if the software malfunctions, the self-test instruction will not be executed, and after 12 ms the timer will generate an error flag. A sequence is then started that switches control to redundant hardware in the spark- and fuel-control loops, sets the loop outputs to nominal levels, and reinitializes the software. Reinitializing allows the resumption of computer control if the failure is transient. Hard failures, however, sustain the failure mode of operation, which uses backup hardware.

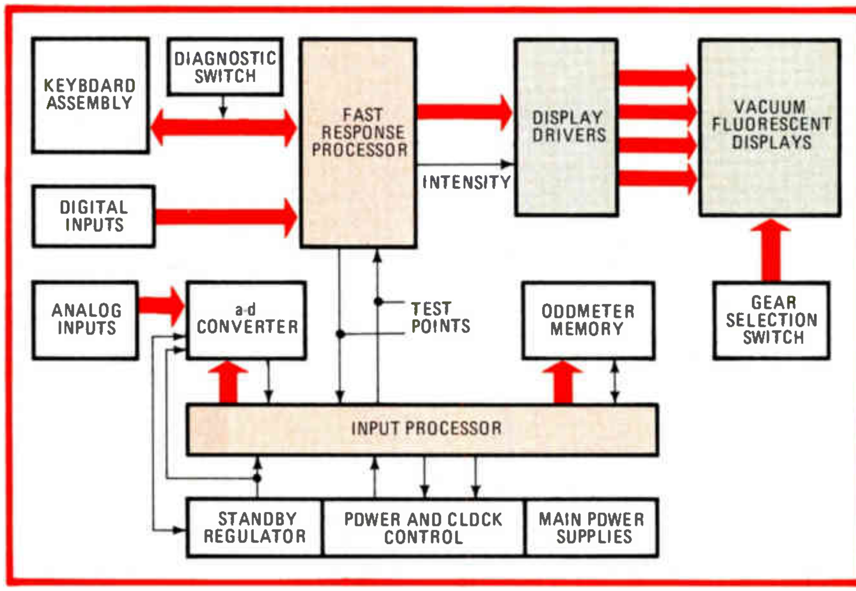
The third technique, self-test software, also corrects for malfunctioning components in the system. When a component fails, the software detects the failure and average operating values are substituted for the part's input. For example, if a coolant temperature sensor fails, warm engine temperature values are assumed by the computer. An instrument panel "check engine" light also comes on, indicating a problem to the driver, who would then bring the car in for service.

Meanwhile, the software automatically enters a code number for the failure in a continuously powered memory. When the car is brought in, the mechanic queries the system by grounding a test point located under the instrument panel. The system replies in the form of a code flashed by a light-emitting diode. For example, two flashes followed by a pause and then three flashes is code number 23—a failure in the carburetor mixture-control solenoid circuit. The mechanic then refers to a troubleshooting guide, supplied by GM, which leads him or her through a series of test and result sequences so that the failed component can be identified.

Producing a high level of diagnostic capability for each car has cost GM a bundle. Not including the engineering development time, the additional memory and related hardware expense (about $2 to $5 per car) is multiplied by the more than 5 million vehicles into which they will go.

An alternative approach is to use test equipment that interfaces with the car's microprocessor and performs the diagnostics "off board." This approach cuts the auto makers' costs but requires dealers to invest considerable money in test equipment that must not be made obsolete when next year's cars are introduced.

The latter is the direction Chrysler has taken in introducing its Electronic Engine Performance Analyzer (EEPA), a $16,500 unit resembling the car diagnostic consoles with oscilloscopes and meters that have been offered for some time. But the EEPA, which is far more



5. Distributed dashboard. A pair of Motorola 6801 microcomputers orchestrates the multiple functions of Chrysler's newest digital instrument cluster. The fast-response processor monitors the keyboard and refreshes the display while the input processor updates the information.

advanced, uses test procedures stored in its memory and accessed by a microprocessor. It relieves the mechanic of the troubleshooting burden by performing step-by-step diagnostic tests, analyzing the data, and displaying both the test instructions and the results on a neon plasma display. A printer provides diagnostic messages, as well as a hard-copy summary of test results and critical measurements like battery voltage and alternator output.

However, Chrysler concedes that the apparent simplicity of GM's on-board diagnostics has merit and that it, too, will need to include more on-board self-tests as its engine systems grow in complexity. One reason is the on-board systems' ability to capture transient faults. As John E. Call, manager of engineering at Chrysler's Electronics division, Huntsville, Ala., explains, "The biggest problem of electronics is the transient problem. The dealer's serviceman can't make it happen. We need a system that will trap transitory states."

Dashing-looking dashboards

In the passenger compartment, the dashboard is getting a new, more aesthetic look, made possible by microprocessor-driven blue-green vacuum fluorescent displays. Top-of-the-line cars and even lower-priced models are offering what the auto makers are referring to as electronic instrument clusters. Digital readouts, message displays, and bar graphs are replacing the alternator voltage and oil pressure "idiot lights" and analog fuel gages used for so many years.

One of the more elaborate types of alphanumeric displays was introduced for model year 1980 in Ford's luxury cars. Its vacuum fluorescent message center contains 20 14-segment display characters, each a quarter inch high, arranged in two rows.

Thirty-six messages relating to 11 vehicle functions, including trip information, may be displayed. The functions are divided into three priority levels. Critical warnings appear at 4-second intervals and include things like a loss of brake or oil pressure or low alternator output. Secondary warnings refer to items like doors being unlatched and distance to empty; they are repeated every 16 seconds. The third, or auxiliary, warning level indicates when the washer fluid is low or if a light is out on the car; they appear when the condition is detected and subsequently when the engine is started. Moreover, each critical and secondary warning is accompanied by an audible tone to alert the driver. A separate set of buttons may be used to get trip information like distance traveled, elapsed time, distance to destination, and instantaneous fuel economy.

For model year 1981 Chrysler introduced the first truly electronic odometer, as part of the instrument panel on the 1981 Chrysler Imperial (Fig. 4). Two 6801 microcomputers from Motorola and a custom display driver chip make up the electronics package (Fig. 5).

The panel's electronic clock displays more than just time, showing the driver the month, day, and elapsed time. The vehicle's speed is displayed in 0.6-in.-high numerals and even the familiar P-R-N-D-2-1 gear indicator is in the instrument cluster's vacuum fluorescent blue. The gear selected is indicated by a moving square that frames the appropriate letter.

The fuel level is indicated by FULL when there is at least 14 gallons in the tank. Below that, the number of gallons (or liters, if the metric mode is picked) is shown, and a flashing blue LOW confronts the driver when the fuel level falls below 2 gallons. A photodetector monitors the ambient lighting and adjusts the display brightness.

The instrument panel also contains a built-in diagnostic test that performs checks of the microcomputers, interprocessor communications, and memory. The results of these checks show up on the odometer display as

Transducers for the road

Among every auto manufacturer's wish list of items is an array of simple, rugged, low-cost engine transducers and actuators. Sensors for temperature, position, pressure, oxygen content, and fuel flow all have applications today in the car [*Electronics*, Nov. 6, 1980, p. 113]. Still plagued by the relative expense of these units, each car maker has sought a balance among accuracy, reliability, and cost.

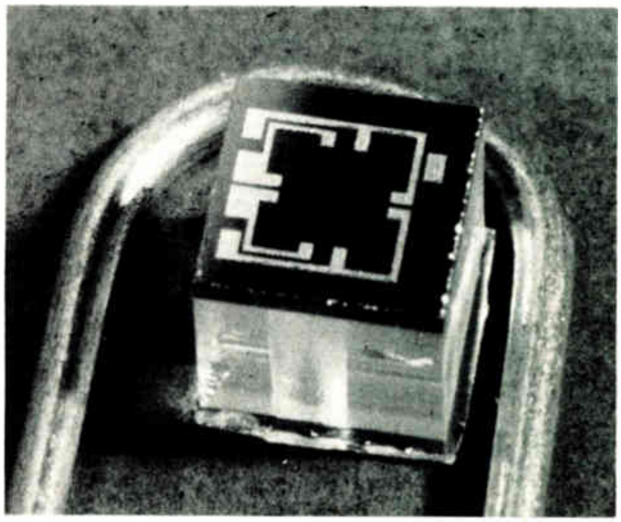
As one example, Chrysler Corp. announced that as part of its electronic fuel injection system for 1981 it had developed a unique air flow sensor using a thermistor. In a feedback loop, the thermistor is sensitive enough to detect oscillations in a vortex of air, from which the rate of air mass flow is calculated.

Chrysler also devised its own transducer to measure fuel flow. A ball spinning in a circular track in the fuel flow interrupts the path between a light source and a photodetector. The fuel flow rate is then a function of the pulse rate out of the detector. Not an exotic device, it does meet the auto maker's specifications. As Bernard F. Heinrich, Chrysler's chief engineer for feature product engineering at its Huntsville, Ala., Electronics division, puts it, "It's simple and it works."

Detroit's ability to mass-produce the feedback carburetor system is primarily due to the development of a low-cost oxygen sensor by West Germany's Robert Bosch GmbH. The zirconium dioxide sensor exhibits a steep drop in voltage at the stoichiometric air/fuel ratio, the ratio at which the catalytic converter is most efficient. The sensor monitors the oxygen content of the exhaust gas and feeds back information to a microcomputer, which then adjusts the air/fuel ratio at the carburetor.

Other engine controls like spark advance and exhaust gas recirculation require accurate manifold and absolute pressure readings. Sensors for this purpose have been produced in several configurations, including solid-state strain gages and capacitive devices. General Motors Corp. makes its own monolithic pressure transducer, which uses a thin-film strain gage on a silicon membrane (see figure), at its Delco Electronics plant in Kokomo, Ind., and is working on making other low-cost sensors and actuators at its AC Spark Plug division in Flint, Mich.

Motorola Inc.'s Semiconductor Group in Phoenix, Ariz., just entered the transducer market with its line of X-ducer solid-state pressure sensors [*Electronics*, Sept. 25, 1980, p. 44], using a piezoresistive strain gage and available either as the basic transducer or in a module containing the electronics for interfacing with a microprocessor.



the words PASS or FAIL, followed by the test numbers

Meanwhile, in Europe, with compact cars looking ever more alike, automotive engineers there also are eyeing the dashboard as the place where sales can be won or lost. They, too, are developing trip computers, as are the Japanese. Working with Siemens AG of Munich, BMW, for example, has developed a system that performs 15 functions related to driving and car-related conditions. Nissan has a digital clock system and a pair of trip computers of differing complexity that it is installing on cars sold only in its domestic market.

Creating diversions?

SGS-ATES Componenti Elettronici SpA, based in Agrate Brianza, near Milan, and already a factor in supplying chips to the auto industry, is making a single-chip 3870 microcomputer for a trip computer that should be in volume production next year (but it will not reveal for whom). In addition, the company has a technology for combining nonvolatile memory and digital circuitry on the same chip that it expects will turn up in custom designs before the mid-1980s.

For its part, Volkswagenwerk AG believes most existing trip computers require too much of the driver's attention. "The need to push those closely spaced buttons and to read off the results can divert the driver's attention and put him into a potentially dangerous traffic situation," says Karsten Ehlers, head of automotive electronic systems development at the Wolfsburg, West Germany–based company. For that reason, VW is developing a simple trip computer that the driver need only glance down at to read. It will go into 1982 VW cars.

Another VW-designed electronic system is an "upshift" indicator, now being installed in 1981 economy VW models. Using manifold pressure and engine-speed information, the system determines the optimum time for the driver to shift into the next higher gear and indicates that moment with an LED.

Electronic innovations in the passenger compartment do not end with trip computers and electronic displays. As cars are made smaller, the auto makers are adding electronic "feature products" to enhance the value of their cars and attract consumer interest. It is this road that auto makers will embark on in the near future. Says Bernard F. Heinrich, chief engineer of feature products at Chrysler's Electronics division, "The growth area is in feature products."

For example, in 1980 Ford introduced a keyless door-entry system and a microprocessor-based citizens' band radio. Electronic load leveling, which was offered for the first time in 1979 as standard equipment on GM luxury front-wheel-drive cars, is also likely to become a more common option. Furthermore, market tests are being conducted to determine how best to use synthesized speech in the passenger compartment. A voice to warn, advise, or inform the driver will be almost commonplace in a few years, according to those working on speech chips. Other features, like electronic transmission controls, will be less obvious to the buyer.

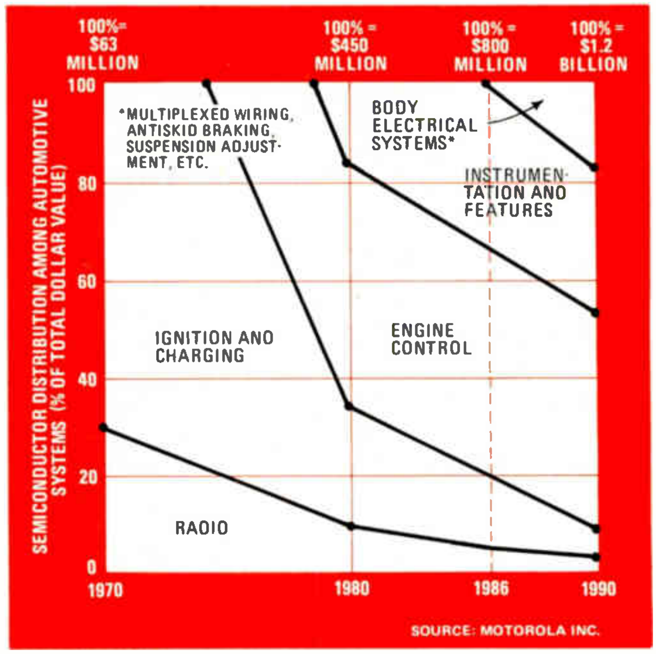
Shifting electronically

The Europeans are pushing ahead with the development of electronically controlled transmissions. Ultimately, they are striving for continuously variable drives that boost fuel economy by transmitting engine torque at the optimum engine speed.

Italy's Fiat SpA in Turin, for example, has started trials of a continuously variable transmission jointly developed with Van Doorne-Transmissie BV of Tilburg, the Netherlands. Their Transmatic gearbox may cost no more than a conventional one yet could cut fuel consumption 8% below that of a normal automatic's. The transmission comprises a rubber loop reinforced with concentric steel bands onto which are fitted hardened steel blocks. The belt runs in two V pulleys whose diameter is varied by an electronic system—the flange pieces move axially—that responds to the engine speed, throttle setting, and vehicle speed.

Renault, too, is working on such transmissions. It hopes to introduce one with a very high gear ratio in about 1985. The transmission control will be linked to other parameters to choose an optimum combination of gear ratio, engine speed, and carburetor mixture. "It will be necessary to decouple the accelerator pedal from the carburetor throttle," explains Pierre Bouthors, director of general advanced studies service for Renault in the Paris suburb of Boulogne-Billancourt. "The electronic control system will not only select the most efficient gear ratio, but will also examine such parameters as the speed at which the vehicle is traveling, the engine speed, and the position of the accelerator pedal."

Still another electronic system, this one by VW, is also intended to reduce fuel consumption. The start/stop system works this way: a driver coming to a red traffic light pushes a small button at the tip of the windshield wiper lever, shutting off the engine. When the traffic light turns green, the driver simply steps on the gas pedal and the engine starts up again. The system is being installed in some of the company's 1981 models.



6. Features flourish. Electronic features will be an important part of the perceived value of a car, according to car makers. Thus, although the greatest dollar value of semiconductors will continue to be in engine controls, feature and instrumentation growth will be higher.

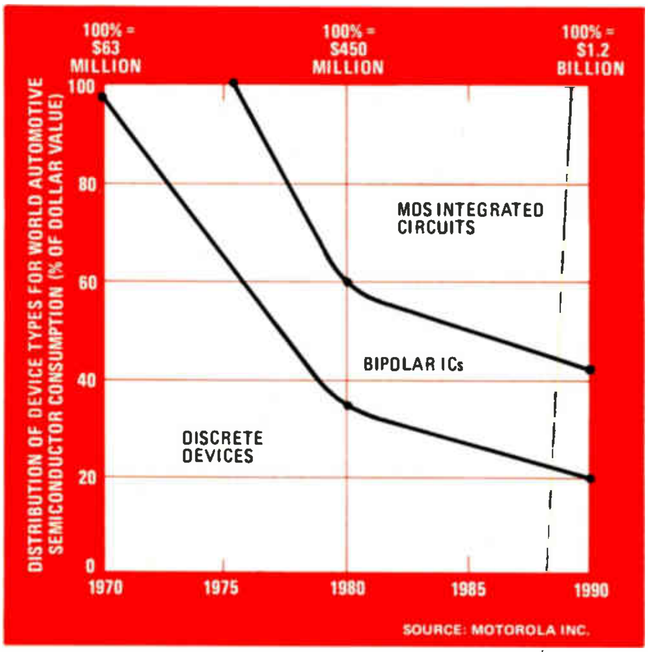
That the rise in demand for semiconductors by the auto industry has not led to the crippling shortages some predicted is due to several factors. For one, there was a slump in sales by the American auto companies, and for another, the slump coincided with a rapid growth in U. S. semiconductor capacity to counter Japanese competition in a soaring market.

What shortages?

"The so-called shortage" that was expected "was a realistic appraisal, based on booking rates of the last quarter of 1979 and those of early 1980," says John S. Richardson, vice president for central marketing at American Microsystems Inc., Santa Clara, Calif. Then, at a time when yields were improving and "a whole lot of physical capacity was put on stream," he continues, "demands from the auto industry dropped like a rock—by at least 30% to 50%."

However, the slump did not hurt semiconductor makers. For Texas Instruments, for example, it has meant that the company achieved only "super growth instead of phenomenal growth" in automotive semiconductors, says Eugene R. McFarland, assistant vice president and manager of the automotive sales segment in Dallas. Sales doubled from model year 1980 to 1981, but that growth rate should decrease to about 20% to 25% annually beginning next year, he says.

The past year did see spot problems involving specific device types. Bipolar PROMs were tight, and so were low-power Schottky TTL chips, says Terry Malarkey,



7. Gathering MOS. Economic pressures compel the auto maker to reduce the parts count of electronic systems wherever possible. This push toward integration will result in increased consumption of MOS circuits by the car manufacturers through 1990.

who manages automotive strategic marketing for Motorola's Semiconductor Group in Phoenix. The 8-K PROM is virtually a universal part, serving all types of needs, he points out. However, the production capacity crunch for this device is expected to end this year. Meanwhile, the supply is particularly tight for General Motors, which has a 1-K-by-8-bit PROM in every car.

But though the automotive portion of the semiconductor business is one of the fastest growing, it is not so overwhelming in the context of the entire market, points out TI's McFarland. Total worldwide sales of semiconductors (that is, excluding the Soviet Union, China, and their allies) is pegged at some $13 billion, according to Dataquest Inc., the Cupertino, Calif., market research firm. But Motorola, the leader in semiconductor sales to the auto industry, estimates that such sales will total only about $450 million in 1980 (roughly 3.5% of the semiconductor market). That puts automotive applications in sixth place, well behind the leader, consumer electronics, which accounts for about 25% of the total, according to Motorola.

The bulk of automotive semiconductor sales—55%—goes into engine control (Figs. 6 and 7). By 1986, Motorola sees the auto market at $800 million yearly. Engine control will still dominate, with 47%, but instrumentation and feature electronics is expected to be a healthy second with 32.5%.

More optimistic is Dataquest, which by 1985 expects automotive consumption of semiconductors to have reached $1.3 billion (from $450 million in 1980). However, it puts the total market at $29.9 billion, so that the automotive percentage is still small—4.3%.

As for the total market for electronics, Trevor O. Jones, vice president of engineering at TRW Inc., Cleveland, and a noted auto industry figure, places it at $1.53 billion in 1980, or $45 per vehicle. By 1985, he expects the value to rise to $240 per vehicle, or a total of more than $100 billion for an estimated 42 million cars and light trucks.

There has been much discussion in the past, sometimes heated, between automobile and semiconductor manufacturers on the issues of quality and reliability. With regard to quality, the semiconductor makers have been successful in meeting Detroit's quality standard of 1 failure per 1,000 parts (0.1%). However, still unanswered is the reliability question, which refers to long-term failure rates—the far end of the familiar bathtub curve characterizing semiconductor failures.

Frank E. Jaumot Jr., director of advanced engineering at GM's Delco Electronics division, has said that his goal is an average failure rate of 0.002% per 1,000 operating hours, or about 1 failure per billion miles driven.

Many parts, especially custom components, have not been in place long enough to indicate whether that kind of reliability exists, although the auto makers so far seem confident in the devices in the field. Accelerated life cycle testing is done, but it is the actual field performance that everyone is ultimately interested in.

One way to achieve high reliability and low cost, especially with very large-scale integration on the way, has been suggested by Robert N. Noyce, vice chairman of Intel. His idea is standardization: semiconductor makers will design parts with the needs of the auto industry so firmly in mind that the auto makers will find them suitable for most, if not all, tasks; consequently, they will accept them as standard. The benefits, he points out, would be software portability; the establishment of a known, mature technology; superior quality and reliability; and uniformity in test and field-support equipment and in maintenance procedures.

At General Instrument Corp.'s Microelectronics division, Andrew R. Sass disagrees. Citing as the reason the fact that there is always the concern among semiconductor houses that standardization of a part means that the first one to manufacture it will get all the business, he says that "the semiconductor industry is not receptive to standardization." He also feels that the car manufacturers would have to get solidly behind any attempt to choose a standard configuration for any processor. Group director for business and technical research for the Hicksville, N. Y., division, Sass considers the chances of the auto makers' aligning on a given part to be small and believes that "we won't see a level of standardization beyond what there is now—that is, second sourcing." □

Video display processor simulates three dimensions

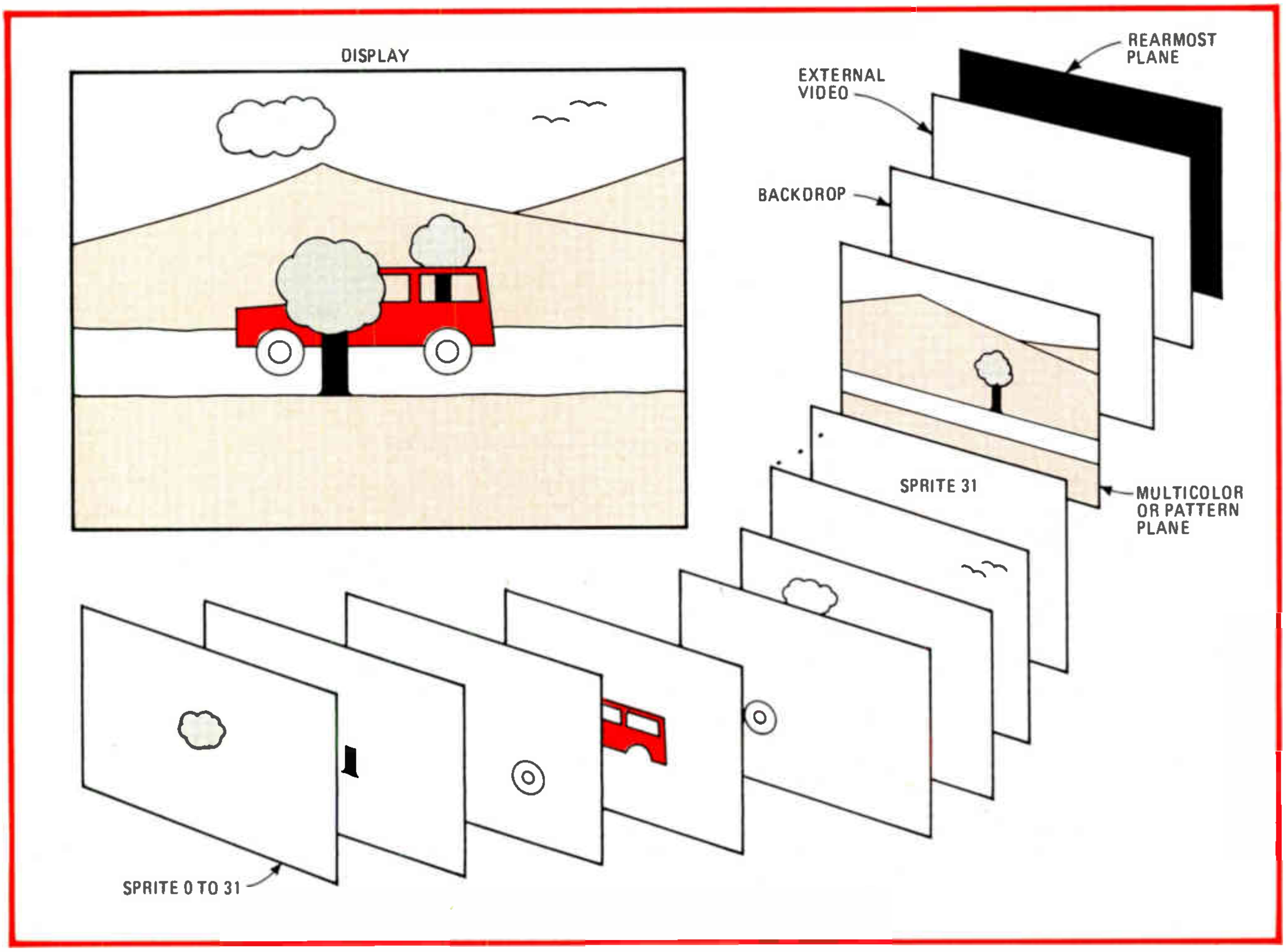
Low-cost interface manages complex color graphics display, with objects shown separately and simultaneously at apparently different depths

by Karl Guttag and John Hayn, *Texas Instruments Inc., Dallas, Texas*

☐ As home computing systems come into their own in the 1980s, they are creating a demand for improved interfacing between computers and ordinary television receivers. Up to now, home video display systems have required many small- and medium-scale integrated circuits even to achieve a resolution sufficient for relatively simple video games.

The TMS 9918A video display processor represents a new generation of interface that makes possible a low-cost display of 15 colors with complex overlaid graphics and higher resolution. One of the most complex large-scale integrated chips to date from TI, the VDP is designed for data processing and display of educational material and for home entertainment. It contains a memory-mapped computer interface compatible with most popular microprocessors. And since the VDP refreshes the display memory automatically and interfaces directly with standard video monitors, very few other parts are needed to implement a system.

The VDP's object-oriented format offers a novel



1. Flatland in 3-D. The 9918 offers a total of 36 video image planes in strict depth priority to produce the illusion of three-dimensionality. Thirty-two planes containing objects, called sprites, combine with transparent areas that let the background show through.

approach to graphics display: images of objects can be defined and then quickly and smoothly moved about the screen by respecifying only their coordinates instead of redefining the entire screen. Those seemingly in the foreground appear to pass over those behind, for a three-dimensional effect. The high-resolution display is organized into 256 by 192 picture elements or pixels—the smallest controllable elements on the display. As little as 4-K bytes of external dynamic random-access memory control the 49,052 pixels.

In addition to the 15 standard colors possible, there is a transparency option; an external video signal can also be mixed in. Four operating modes are available: two different graphics modes, which allow the display with the highest resolution of user-definable multicolor eight-by-eight-pixel cells; the multicolor mode, with a full-color memory-image display but with lower resolution; and a text mode for display of standard alphanumeric characters.

Flat, yet three-dimensional

The display presents a set of images, each of which is specified for a different "depth" and is best thought of as existing on an independent geometric plane (Fig. 1). These separate flat images are stacked or sandwiched onto the picture tube in such a way that whenever one moving object comes in contact with another, it progressively blots it out and creates the illusion of passing over it. Each plane is strictly prioritized and since there is only one object per plane, the manipulation of images is easily programmed.

The transparency option lets those planes that are behind show through, to depict, for instance, a structure with a window. The rearmost plane is pure black, so that when the other planes are set to transparent and external video is not used, the screen appears to be black.

External video can be displayed on this rearmost plane. The next closest plane, the backdrop, is solid-colored and slightly larger than the other planes so that it forms a rectangular rim around the video display elements. Then comes the multicolor pattern plane, over which objects on the remaining planes pass. These planes contain what are called sprites—object-oriented graphic characters in a transparent surrounding. The 32 sprite planes can hold that same number of objects or, since each sprite is a single color, several adjacent planes can be used to make up a multicolored object.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0
0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	0
0	0	0	1	0	1	1	1	1	0	1	0	0	0	0	0
0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0
0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

2. Object formation. Sprites ordinarily represent video images of objects and are defined by a bit pattern in memory. A normal sprite consists of 64 bits in which 1s represent color and 0s transparency. The larger sprite shown above requires 256 bits to define its shape.

Sprites represent objects

The normal sprite is specified by an 8-by-8-bit pattern kept in memory. Each is a single color wherever the bit pattern contains a 1; 0s designate transparency. A larger sprite can be obtained either by using a 16-by-16-bit pattern (Fig. 2) or by magnifying the existing sprite by a factor of four. Or both techniques together can create a sprite 16 times as large as the normal one. These functions are controlled by 2 bits in a control register, and it should be noted that the magnifying function increases size at the expense of resolution, but with smaller memory requirements.

Each sprite is independently movable and is described by four attributes (Fig. 3). Of the 4 bytes in memory that describe a sprite, the first 2 specify its vertical and horizontal position; the third points to its bit pattern and is called its name; and the fourth utilizes its last 4 bits to specify the sprite's color. A unique feature allows a bit contained in the fourth byte to shift the sprite 32 pixels to the left, so objects may gradually appear from off that side of the screen.

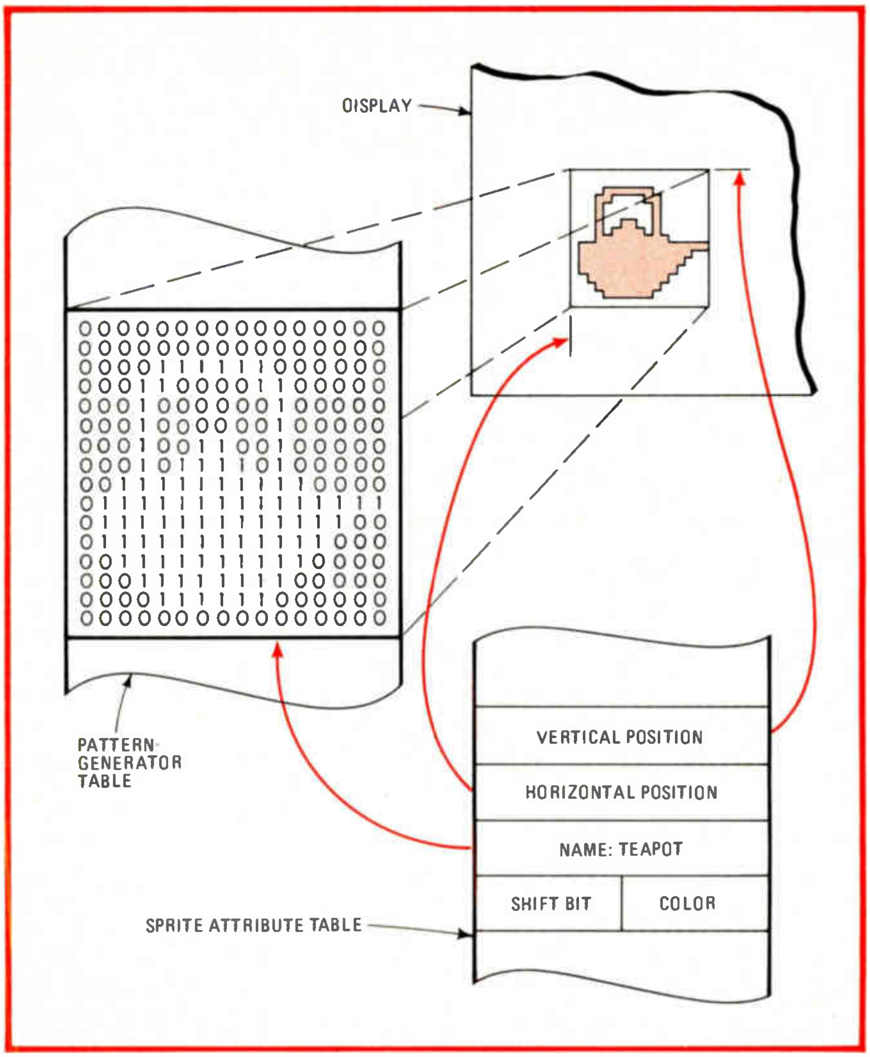
Sprites are the active constituents of the display. They can be easily moved about the screen by merely changing their position indicators. Depictions of secondary motion—like the turning wheels of a moving car—can be made by naming several similar sprites in different states of, in this case, rotation, and then swapping their names in the attribute table.

Patterns are graphic

The multicolor or pattern plane is commonly used as an environment for the moving sprites. For instance, it might be a multicolored nebula behind spaceships of several shapes and sizes. When any object comes in contact with another, a flag is set in an internal register that can be read by the host processor so that the collision may be handled.

The graphics modes generate 32 columns by 24 rows of eight-by-eight-pixel cells. Each of the 768 cells is mapped into by way of a pattern name table in memory. Each table entry is a name that is used to point to entries in the pattern generator table (Fig. 4). Since the pattern entries are 8 bytes long, like the sprite tables, a maximum 6,144 bytes are required for this table. Each entry in the generator table defines a cell, but for graphics 1s represent one color and 0s a second color that is not necessarily transparent.

The two graphics modes differ in two respects—in the number of unique cells that may appear on the display



3. Sprite location. Sprites are located and moved about according to their vertical and horizontal coordinates stored in memory. The sprite attribute table also defines color and contains a bit that shifts them to the left so objects may appear from off screen.

and in the color makeup of each cell. In the more sophisticated graphics mode, each cell is unique, requiring 6,144 bytes of memory. The other graphics mode allows only 256 unique cells to be defined but at a significant savings in memory, since it requires only 2,048 bytes.

Color tradeoffs

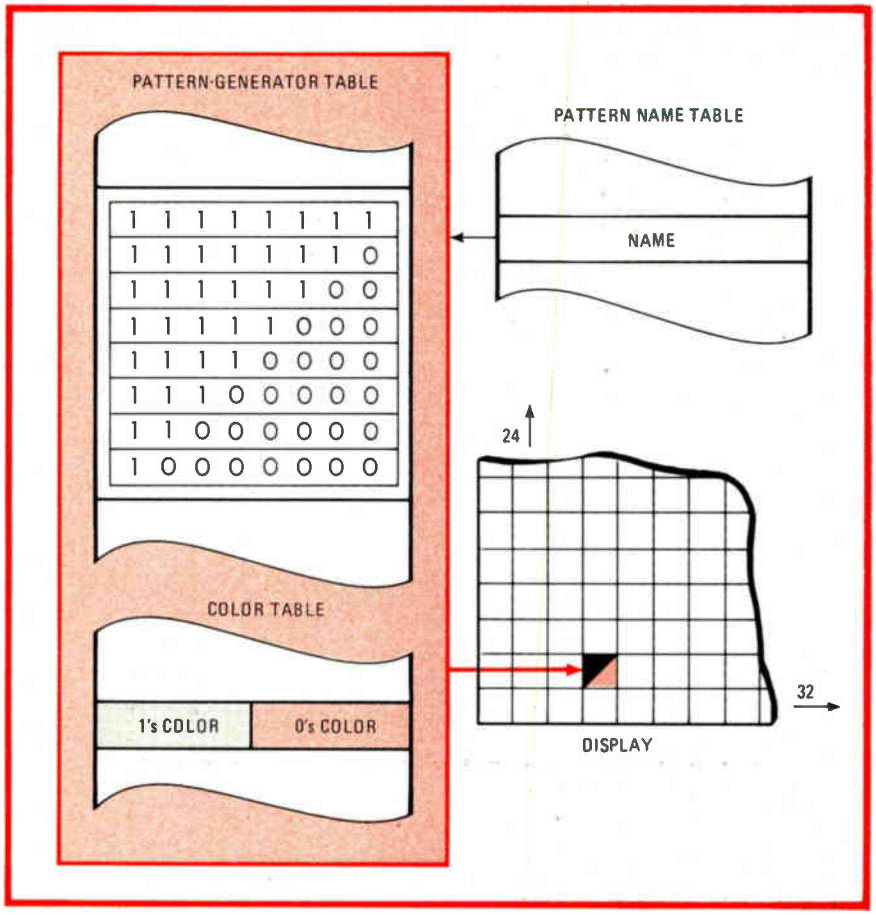
The color options for each cell also involve a tradeoff between memory requirements and versatility. The simpler graphics mode allows only two different colors for each block of eight cells, whereas the more sophisticated option allows each row within each cell to use two unique colors. The first option utilizes only 32 bytes of memory, whereas the second needs an additional 6,144 bytes, since each of the 8 rows per cell requires a byte in the color table. In either case the first 4 bits of a color table entry represent the 1's color and the least significant the 0's color. Figure 4 illustrates the memory utilization of the simpler graphics option.

The VDP has base address registers for the various tables, so they can be stored in memory and switched to by varying the base address; in this way an entire screen can be changed instantaneously by writing into a single register.

A more conventional alternative to the pattern-graphics mode is the multicolor mode. It consists of 3,072 color squares, each a solid color (or transparent) and measuring four pixels on a side. The squares are organized into a grid of 64 by 48, with the color of each indicated in a name table in memory. The names are mapped onto the screen according to their position in the table; hence, this mode is a true memory-mapped configuration similar to that of other manufacturers like Motorola's 6847. This mode trades off lower resolution for color memory-mapping capability, but the high-resolution sprites are still available.

Alphanumeric displays

The text mode is intended primarily for standard alphanumeric applications; it uses, unlike the others, a single plane. This mode organizes the screen into 24 rows of 40 character cells, each cell comprising six by eight pixels. That allows 40 five-by-seven ASCII characters to be displayed on a single line with two pixel spaces between characters and lines. Only two colors are allowed in this mode and the sprites are automatically disabled. The pattern generator becomes, in this mode, the character generator of conventional systems. However, here the character generator is stored in random-



4. Background patterns. The pattern-graphic mode achieves background with the highest resolution. The name of each of the 768 cells that compose the display points not only to a pattern but also to a color table defining the colors assigned to 1s and 0s.

access memory so that special symbols are simple to generate.

The video display processor was designed to interface easily with external components, ensuring a minimum chip count. It has an internal summing network and gating control to selectively enable external video information. A synchronization input is provided to give the external source control over its horizontal line time, as well as over the number of vertical lines. A 3.58-megahertz clock output is provided as well, so that color phase-locking can be controlled by an external source. This arrangement allows for both noninterlaced and interlaced external sources.

One application for external video might be providing subtitles for the deaf, where, since the text is applied locally with the information sent during retrace, it need not distract others who do not request the service. In educational applications, answers can be masked on the screen until a correct response is received, and visual congratulations on right answers can be added. Also, multiple VDPs can be chained together to create more spectacular video effects.

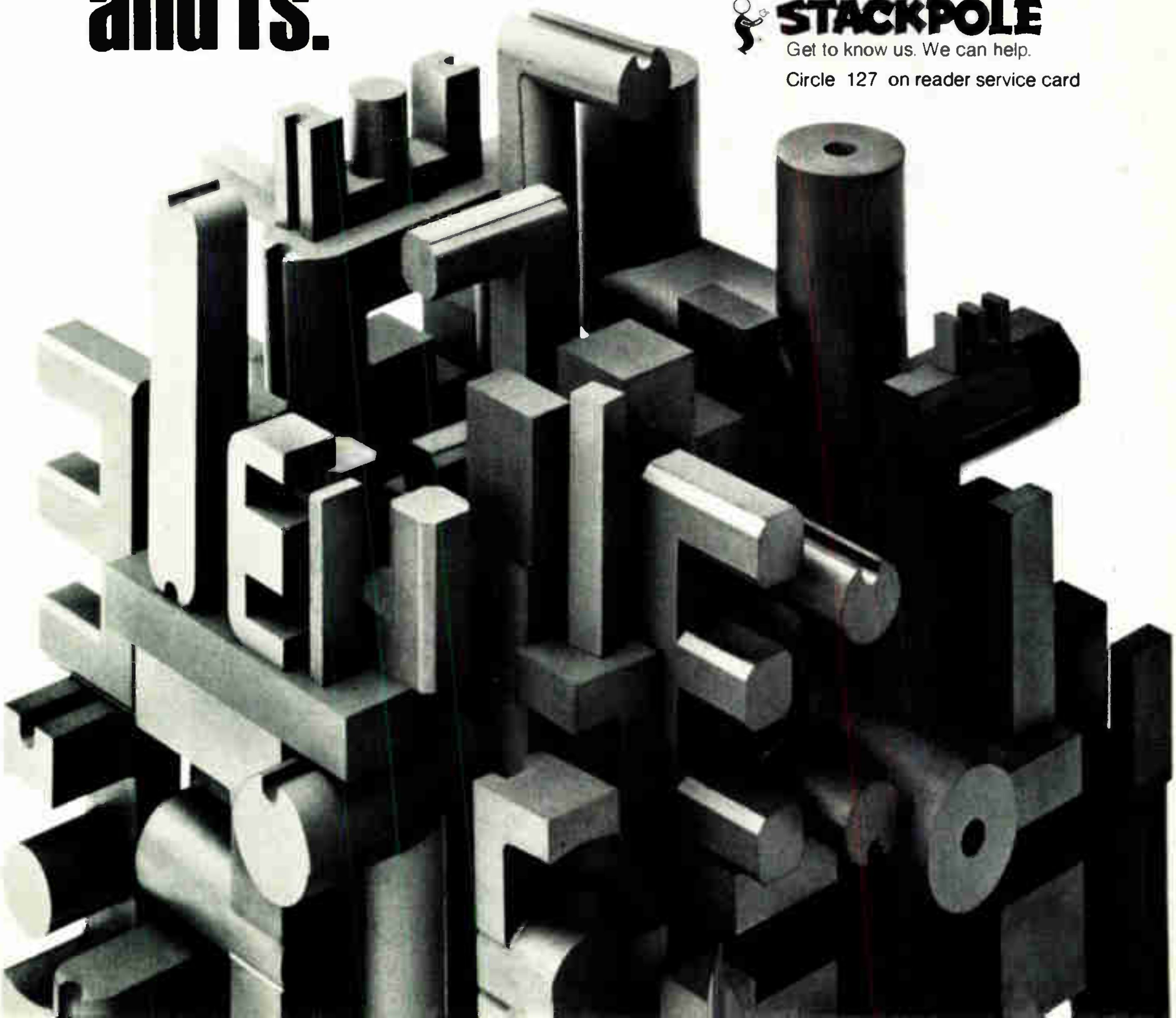
Display memory

The VDP was designed for simple, direct connection to low-cost dynamic RAMs. It generates the necessary row and column addresses for either 4-K or 16-K devices as well as refreshing them automatically. It is in this RAM that all of the tables mentioned above reside; the base addresses of the tables are determined by a set of registers internal to the VDP itself. Since a complete screen of information may use 4-K bytes of memory, a system with 16-K bytes would allow the programmer to store four unique screens that can be alternated by merely altering the base registers by the host processor. It uses 8-bit-wide data paths to and from memory and acts as the interface between the host processor and the memories. Thus no special external circuitry is needed to resolve contention between host and video processor accesses to memory.

Host processor interface

The host processor interface uses a general-purpose 8-bit data bus with three control signals that have timing compatible with the popular microprocessors, making it usable with a minimal amount of interface hardware by most systems. This interface is used to load data- and table-base addresses, to read status, and to transfer display and other data to and from the display memory. It includes a 14-bit auto-incrementing register that is initially loaded by the host for addressing up to 16-K bytes of video display memory. The auto-incrementing feature speeds up the host's memory accesses to and from display tables.

The video display processor provides standard color composite video containing all burst, blanking, sync, and color signals for a noninterlaced image. Only an external pull-down resistor and a radio-frequency modulator are required to connect the video display processor to a normal television. □



Simplified multiplier improves standard shaft encoder

by Michael M. Butler
Minneapolis, Minn.

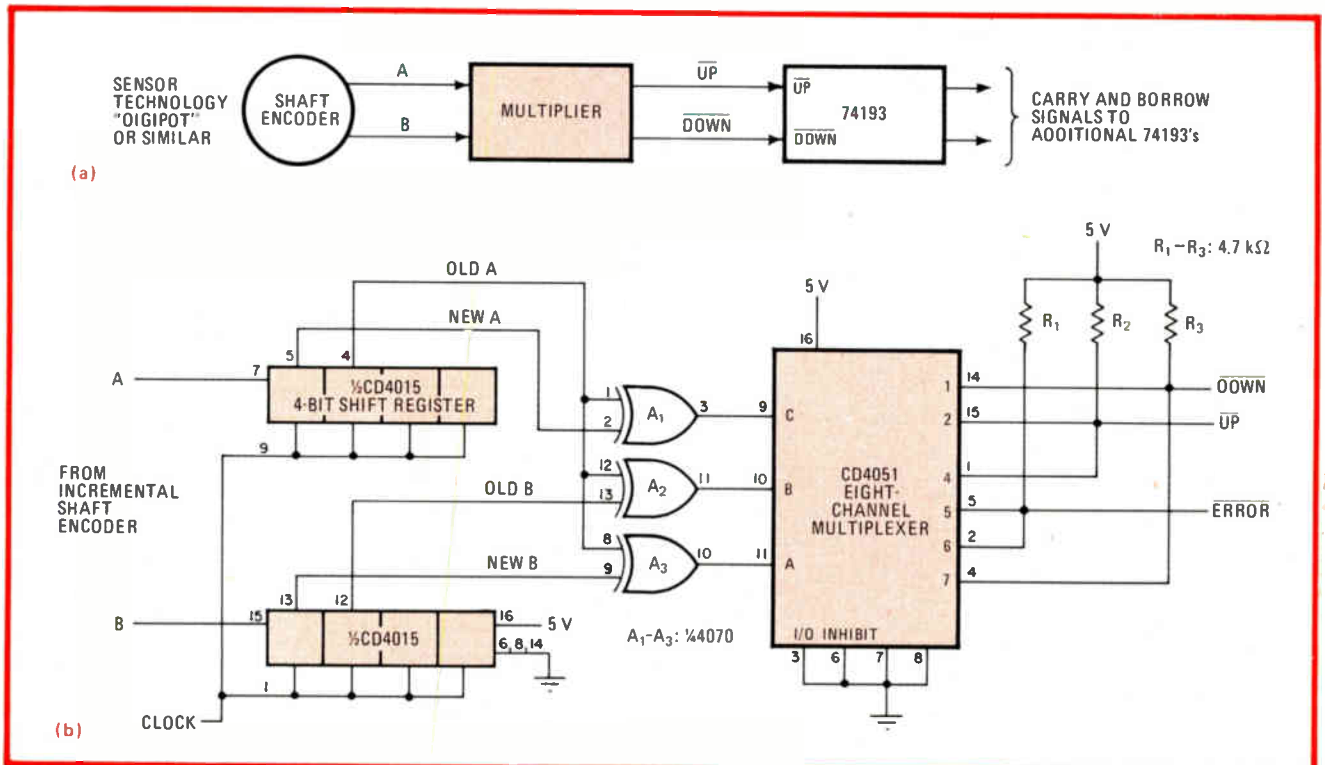
The pulse multiplier proposed by Amthor [*Electronics*, Sept. 11, p. 139] for increasing the resolution of a standard shaft encoder may be simplified, and improved as well, with this low-power circuit. Using only three complementary-MOS chips to derive a proportionally greater number of pulses from the encoder's output for a positioning up/down counter, it is relatively insensitive to encoder phase errors, uses no temperamental one-shots, and can detect the occurrence of illegal transition states generated by the encoder or circuit. It will serve well in electrically noisy industrial environments.

As in Amthor's circuit, the multiplier (a) used to drive the counter produces four pulses for each square-wave input of the two-phase encoder, whose outputs are displaced 90° with respect to one another. In this circuit, however, two 4-bit shift registers, three exclusive-OR gates, and an eight-channel multiplexer (b) derive the pulses. Previously four one-shots and 16 logic gates were required for the same task.

As seen, the clocked shift registers generate a 4-bit code to the multiplexer for each clock cycle. To ensure that no shaft-encoder transitions are missed, the clock frequency should be at least 8 NS, where N is the number of pulses produced by the encoder for each shaft revolution and S is the maximum speed, in revolutions per second, to be expected. A clock frequency of 1

MULTIPLIER LOGIC

A	B	Multiplexer code: Old A	New A	Old B	New B	Count
0	0	0	0	0	0	no change
0	↑	0	0	0	1	down
0	↓	0	0	1	0	up
0	1	0	0	1	1	no change
↑	0	0	1	0	0	up
↑	↑	0	1	0	1	error
↑	↓	0	1	1	0	error
↑	1	0	1	1	1	down
↓	0	1	0	0	0	down
↓	↑	1	0	0	1	error
↓	↓	1	0	1	0	error
↓	1	1	0	1	1	up
1	0	1	1	0	0	no change
1	↑	1	1	0	1	up
1	↓	1	1	1	0	down
1	1	1	1	1	1	no change



Accretion. Requiring only three chips, pulse multiplier gives better resolution to optical positioning systems that are driven by a shaft encoder. Low-power circuit is relatively insensitive to encoder phase errors. Stability is high because no one-shot multivibrators are used.

megahertz or less is recommended for optimum circuit operation.

The code is symmetrical, and so only three exclusive-OR gates are required to fold the data into 3 bits. These bits are then applied to the control ports of the three-input multiplexer, which will generate the truth table shown opposite. □

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.

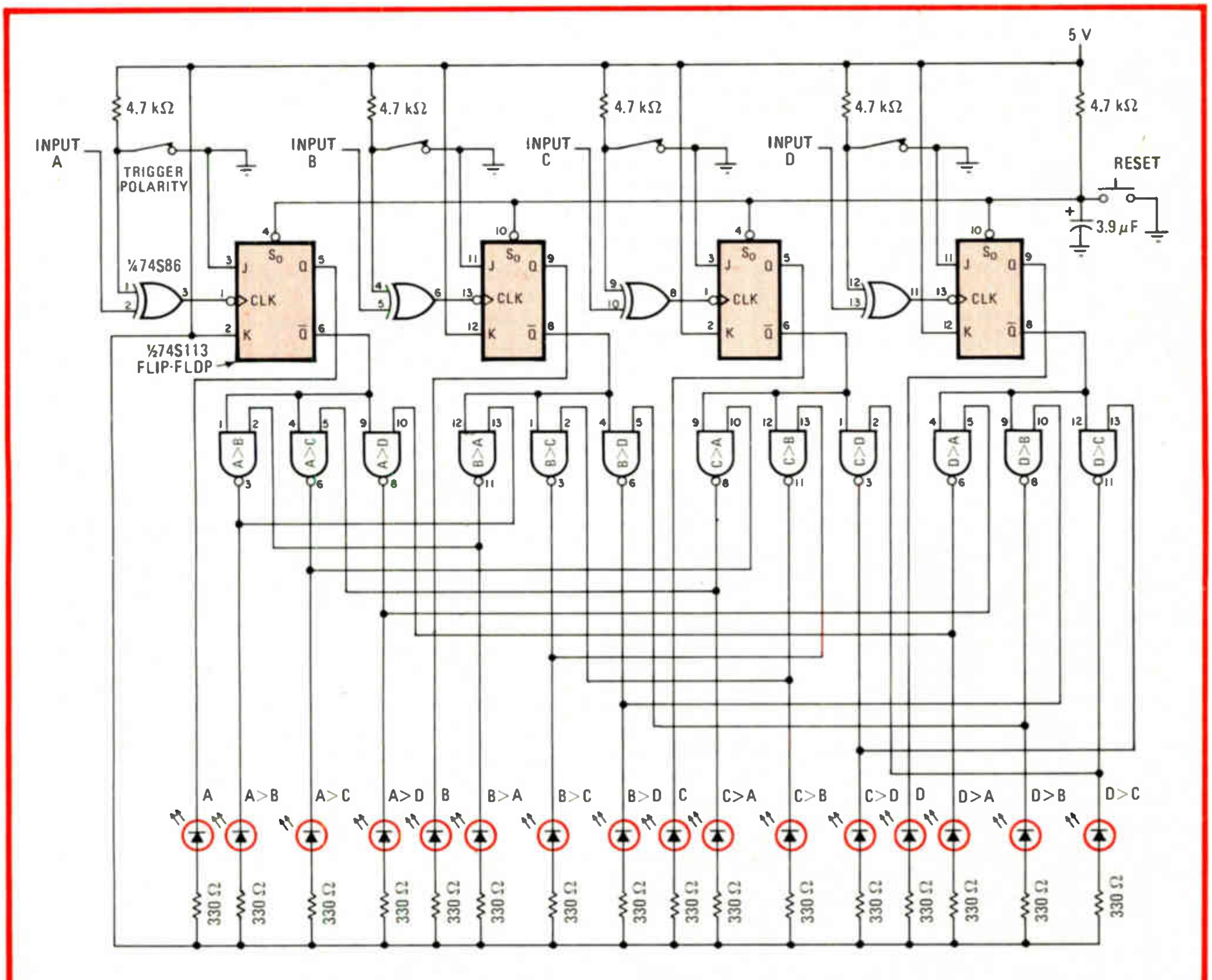
Decoder logs signals' order of arrival

by Claude Haridge
Ottawa, Ontario, Canada

This decoder indicates the sequence of arrival of up to four digital input signals and therefore serves as an excellent priority encoder. Alternatively, it can aid the technician in troubleshooting high-speed circuits. Using Schottky TTL devices to minimize propagation delays, the decoder can resolve two signals only 30 nanoseconds apart.

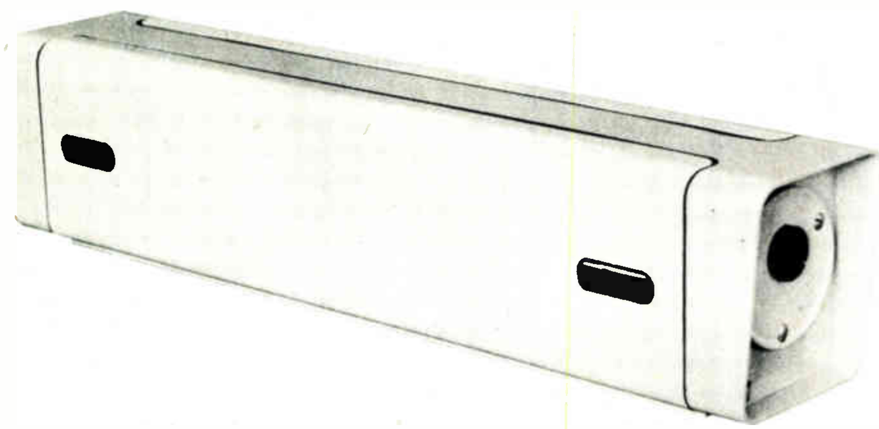
As shown, one flip-flop, three NAND gates, and four light-emitting diodes per input are needed to capture the corresponding signals and compare their arrival times. There are four such sections. In order to perform the time-difference checks accurately, the gates of each section are cross-coupled as shown in the figure, so that they provide an effective signal-lockout function. Polarity switches at each input enable the user to designate either the rising or falling edge of a signal as a valid gating stimulus.

A system reset brings the Q output of each flip-flop low. At this time, all the LED indicators are off. A valid



Signal sequence. Circuit indicates relative arrival times of four digital signal inputs. Using Schottky TTL, unit resolves any two signals separated by as little as 30 ns. Polarity switches at each input enable detection of signal's rising or falling edges.

LTI-501



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trigger input sets its corresponding flip-flop, which then turns on its indicator—LED A, B, C, or D. Simultaneously, the gates leading to the remaining three LEDs of the activated section are enabled. These three LEDs are used to indicate the relative arrival of succeeding pulses.

Thus, the lighting of LED A, followed by the LED associated with the A>C output, indicates that a signal at input A arrived before a pulse at input C. In this case, note that the LEDs connected to the C>A, B>A, and D>A ports are inhibited from turning on until the next system reset. Succeeding pulses reaching the B, C, and D inputs in any order enable the corresponding outputs and lock out the appropriate LEDs until all four inputs have been detected. □

Sync clock, counter improve programmable-width generator

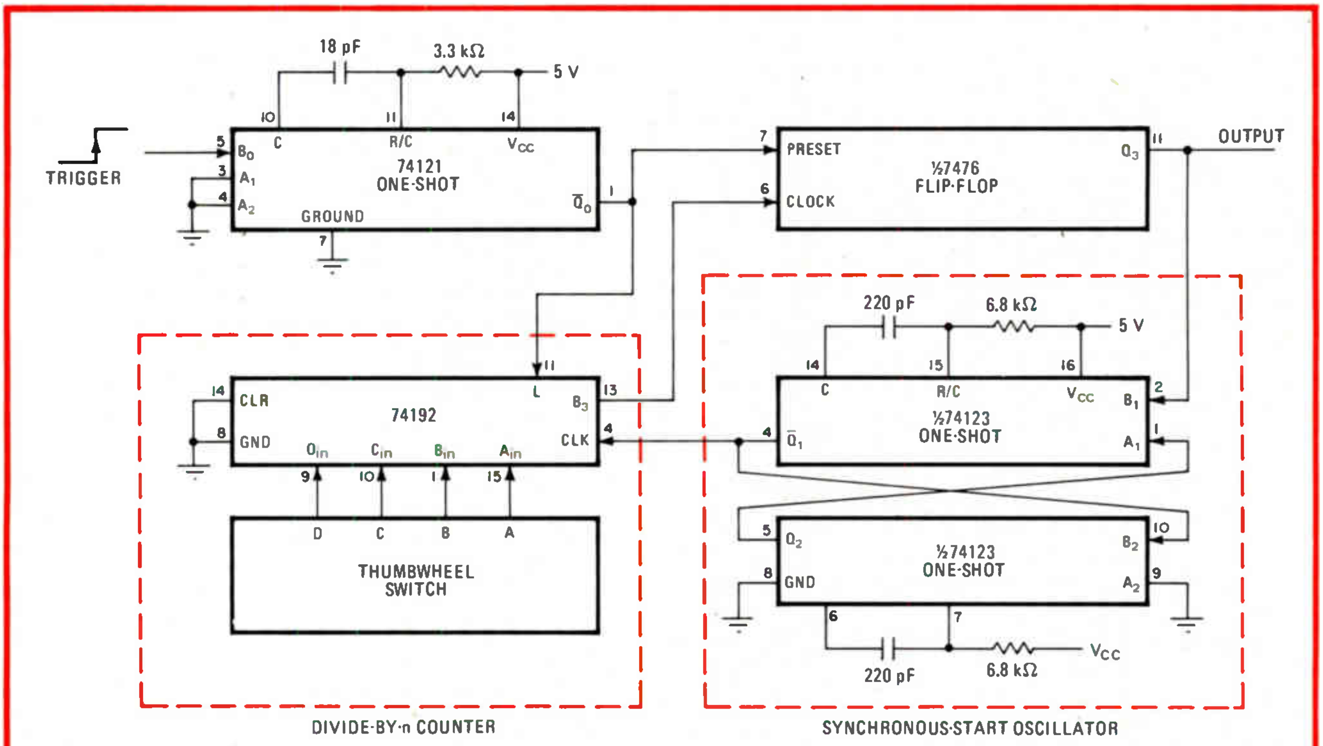
by M. V. Subba Rao and V. L. Patil
Central Electronics Engineering Research Institute, Pilani, India

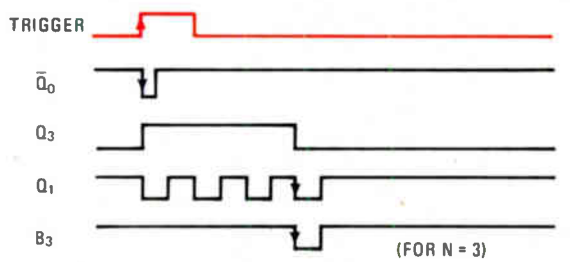
The typical programmable pulse-width generator either has limited programming capability or creates an initial timing error because of the asynchronism between an input trigger and the system's internal clock. Employing a binary-coded-decimal–programmable divide-by-n counter and a synchronous-start oscillator in a basic circuit overcomes these drawbacks, as shown here.

A trigger to the B_o input of the 74121 monostable multivibrator generates a pulse that presets the 7476 flip-flop and also loads a preset number into the 74192 divide-by-n counter. The flip-flop then initiates pulse generation in the 74123 oscillator, whose output is counted down by the 74192 until zero is reached.

At this time, its borrow output, B_3, clears the flip-flop and the oscillator is disabled. The pulse width of the waveform at Q_3 is thus proportional to the number of clock pulses counted.

For the component values specified in the figure, the clock period is 1 microsecond. Thus, the circuit will generate pulses of from 1 to 9 μs, in steps of 1 μs. The 74192s can be cascaded to yield larger pulse widths. □



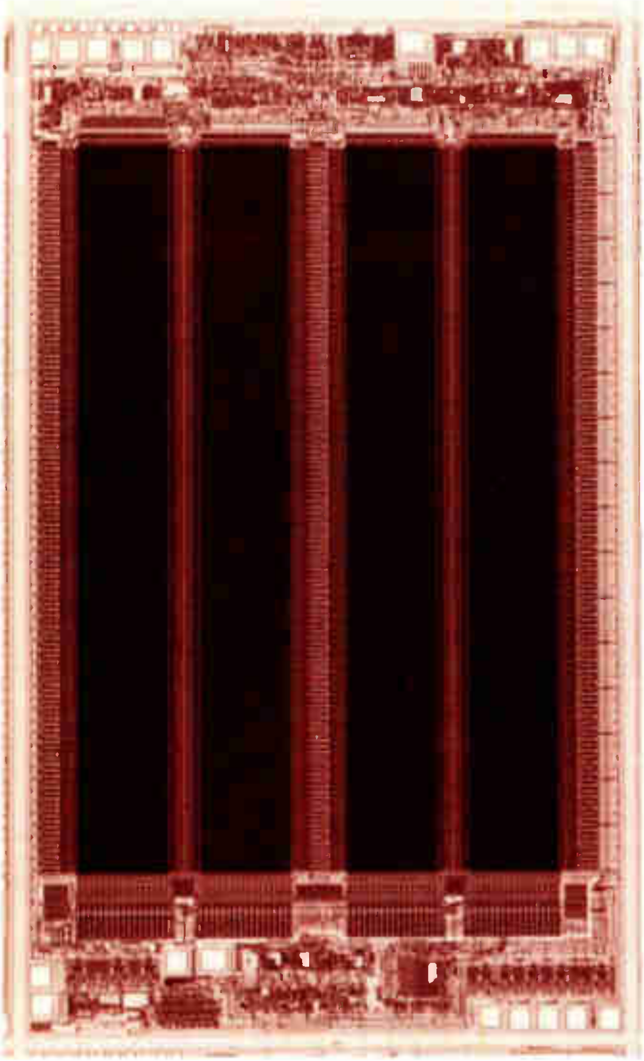


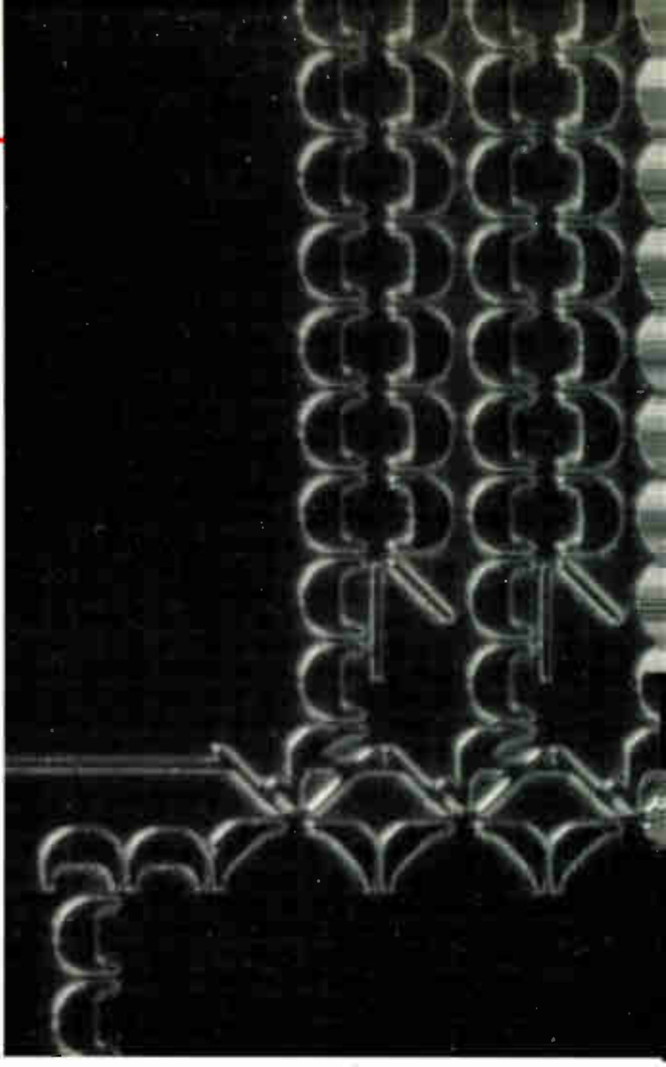
Precisely programmable. Divide-by-n counter and synchronous-start oscillator combine to expand range of pulse-width programmable one-shot and to eliminate initial timing errors due to asynchronous triggers. Pulse widths of from 1 to 9 μs can be selected, in 1-μs steps. The 74192s can be cascaded for larger widths.

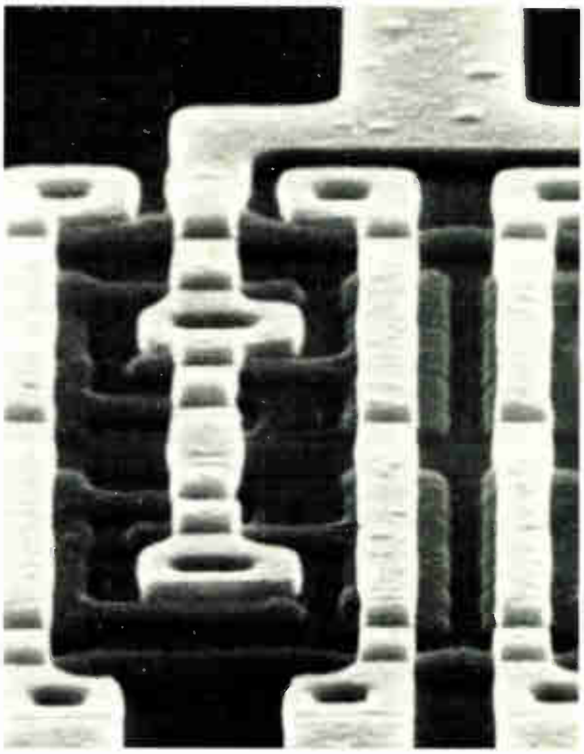
IEDM

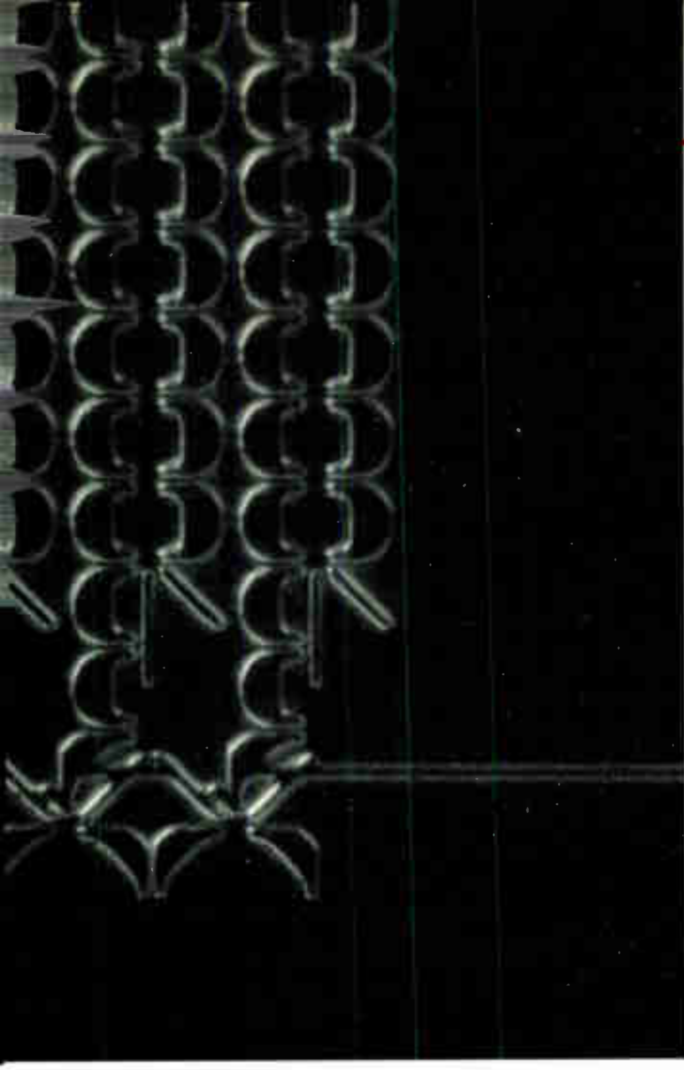
Raising device performance with standard processes

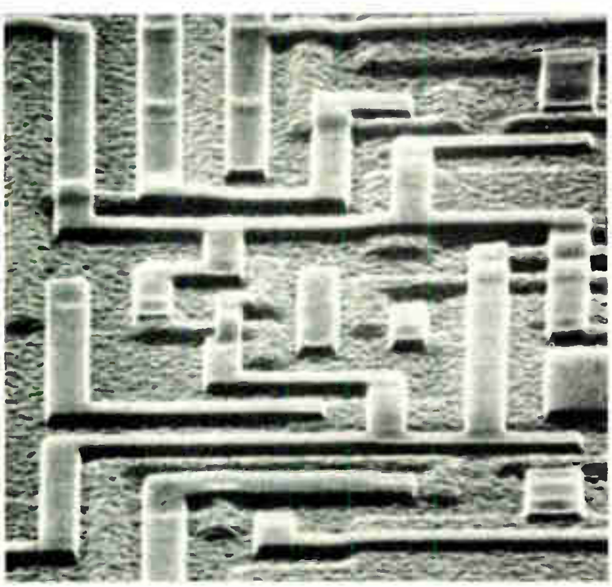
by John G. Posa, *Solid State Editor*
and Roger Allan, *Components Editor*











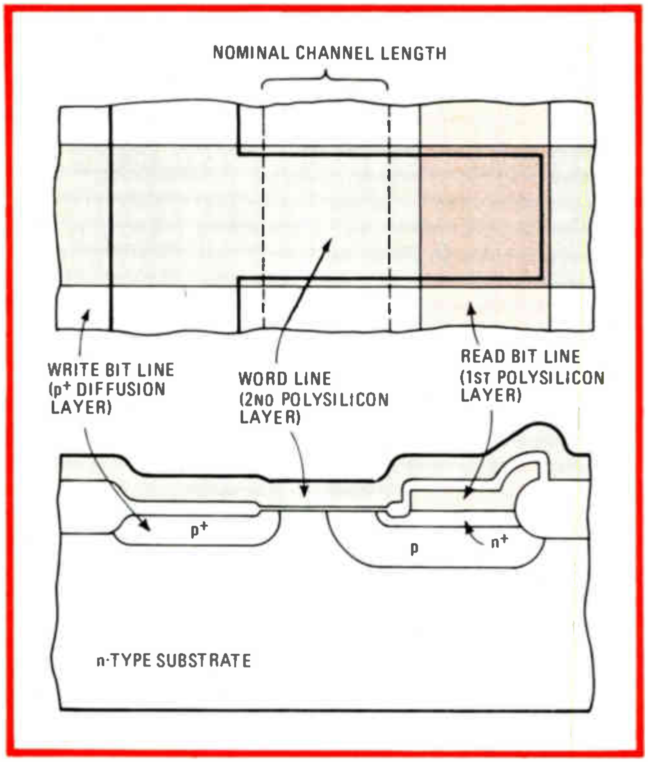
Newcomers. Shown counterclockwise from above right are: Rockwell's totally self-aligned transistor for VLSI; a bubble memory pattern made by IBM with X-ray lithography; Mitsubishi's 64-K dynamic RAM, which uses Hi-C cell; 1-μm lines produced by Siemens' 10:1 projection lithography; and an example of direct writing by electron beam for VLSI from NTT.

The International Electron Devices Meeting will highlight gains in every area from memory chips to thyristors

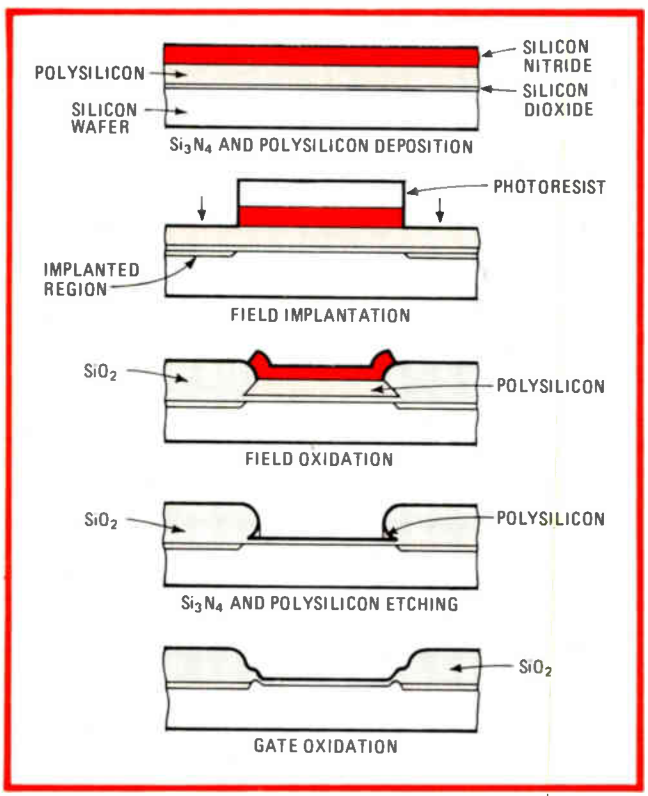
☐ To judge by this year's International Electron Devices Meeting, extracting the utmost from conventional chip-processing techniques is the wave of the immediate future. Although some papers on ultrafine features fashioned by electron beams and X rays will be heard at the Washington, D. C., Hilton on Dec. 3–5, many more will describe how new and old materials in combination with current tools can take up the slack in chip real estate.

MOS and bipolar technologies are being mixed in digital integrated circuits and also in discrete power devices for high-wattage switches like thyristors. Layered structures are making possible complex sensors like hybrid focal-plane imager arrays. Compound semiconductors are responsible for cooler, quicker microwave ICs as well as brighter, more efficient charge-coupled or charge-injection diode arrays.

With digital chips, where density has always been the watchword, the designers are teaching new tricks to the raw materials oxide, nitride, and polysilicon.



1. New RAM cell. This dynamic random-access memory cell from NEC uses diffused MOS, or D-MOS, plus three-way self-alignment for half the area of a conventional double-polysilicon layout. Using 4-micrometer rules, it consumes an area of 189 μm^2.



2. Beak eater. Selective oxidation often leaves a thick dielectric that tapers into a sharp point. As this so-called bird's beak can collect electric charge and cause problems, Toshiba limits its length by oxidizing polysilicon using the process sequence above.

Ingenious methods of self-alignment, masking for doping, and directional etching are squeezing every last micrometer out of memory cells and logic gates alike.

For dynamic random-access memories, Nippon Electric Co.'s Basic Technology Research Laboratories in Kawasaki uses diffused MOS and three-way self-alignment to create a cell with half the area of conventional double-polysilicon cells. Diffused MOS, or D-MOS, is a method of fixing channel length through lateral diffusion rather than tight lithography that has been investigated in the U. S. but applied more in Japan [*Electronics*, May 24, 1979, p. 87].

Reduction details

As shown in Fig. 1, NEC lines up a p-type boron implant, an n^+ arsenic implant, and an oxide etch in its n-channel D-MOS field-effect transistor for a 9-by-21-micrometer cell using 4-μm rules. Charge stored in the floating p-type region alters the threshold of the n-channel FET. This threshold shift is sensed by a word-line voltage that sends a constant current through the device to the substrate.

NEC says that since the two threshold levels are nondestructively detected, the structure can be scaled down unchanged. It is not clear when or where NEC will first apply this cell, since its 64- and 256-K RAMs use fairly conventional double-polysilicon cells.

In a new 64-K RAM design, Mitsubishi Electric Corp. of Japan is using the Hi-C cell with polysilicon bit lines to increase charge storage capacity by 30% while decreasing soft errors induced by alpha particles by a factor of 72. The high-capacity, or Hi-C, cells pioneered by Texas Instruments dramatically raise the depletion-region component of a cell capacitor through ion implantation [*Electronics*, May 22, 1980, p. 127].

But the Hi-C cell is controversial, too, as some say that if these implants are not exactly aligned, a potential barrier may arise that prevents sensing. So Mitsubishi biases its first-level polysilicon upper–capacitor-plate lines to a high voltage level generated on chip. This voltage, which equals V_{DD} plus two threshold drops, adjusts cell potentials so as to make alignment less critical.

Toshiba Corp. is oxidizing polysilicon for local dielectric isolation. It has applied the technique to otherwise standard MOS processing to eliminate the so-called bird's beak effect that shows up in selective oxidation processes. This effect, characterized by sharp oxide edges near the substrate surface that encroach on active device regions, can limit density. Toshiba's process sequence, shown in Fig. 2, limits the length of the beaks to 0.15 μm. It also forgoes a planar surface.

A nonvolatile PLA

This year's meeting will also learn of some important electrically alterable memories. International Business Machines Corp.'s Kingston, N. Y., facility will introduce the concept of an electrically alterable programmable logic array, or Eapla (Fig. 3), and Mostek Corp. of Carrollton, Texas, has added a third polysilicon level for an electrically erasable programmable read-only memory in which one transistor per bit suffices.

Fujitsu Ltd.'s Kawasaki Laboratories has lowered the programming voltage of an EE-PROM with a graded energy insulator, and Hitachi Ltd. will show off an EE-PROM with a 50-ns write-erase time, qualifying it as a true nonvolatile RAM. Hitachi builds this memory with an improved version of its floating–silicon-gate channel-corner–avalanche-transition, or FCAT, technology described at the 1978 IEDM.

Mostek essentially adds a third polysilicon layer over an ultraviolet-light–erasable PROM cell for its single-device-per-bit EE-PROM. A positive potential on this added electrode attracts electrons, which tunnel to it from the second-level polysilicon floating gate. Field emission is enhanced by the rough edge of the floating gate, so that 10 to 20 volts can erase a cell.

In fact, erasure is so efficient that it runs the risk of pushing Mostek's cell into a depletion mode. Since depletion would forestall a conventional EE-PROM cell-selection scheme, it is prevented by an adaptive erase mechanism, which keeps the internal erase voltage slightly more negative than the potential during erasure. An advantage of Mostek's idea is compatibility with its very dense E-PROM or ROM layout based upon X-shaped cells; a disadvantage, at present, is a lack of byte erasure.

With Fujitsu's graded insulator, the potential barrier seen from the substrate during programming of the EE-PROM is much less than the potential barrier seen from the opposite direction. The upshot is a cell that can be programmed with less than 12 V and still exhibit acceptable retention.

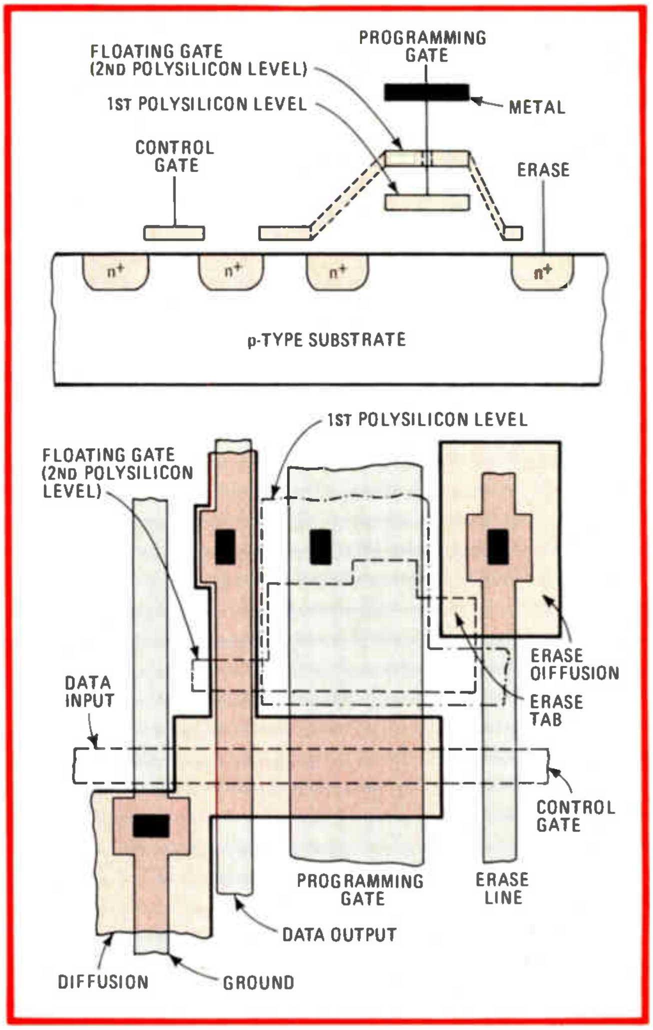
The 100-angstrom-thick insulating layer is obtained by thermally oxidizing a thin silicon nitride film grown previously by direct nitridation of the silicon substrate. Pure silicon nitride remains only at the substrate interface as the insulator gradually turns into silicon dioxide.

The Lincoln Laboratory of the Massachusetts Institute of Technology in Lexington, Mass., will explain how it goes the other way and converts silicon dioxide into nitride. The goal is an insulator thin enough for very large-scale integration yet with the integrity for substantial yields. Pure thermal nitride gates thick enough for submicrometer MOS have been difficult to grow and oxides thinner than 200 Å are defect-prone. The lab's 100-to-150-Å oxynitride dielectrics are reproducible while exhibiting acceptable breakdown voltages.

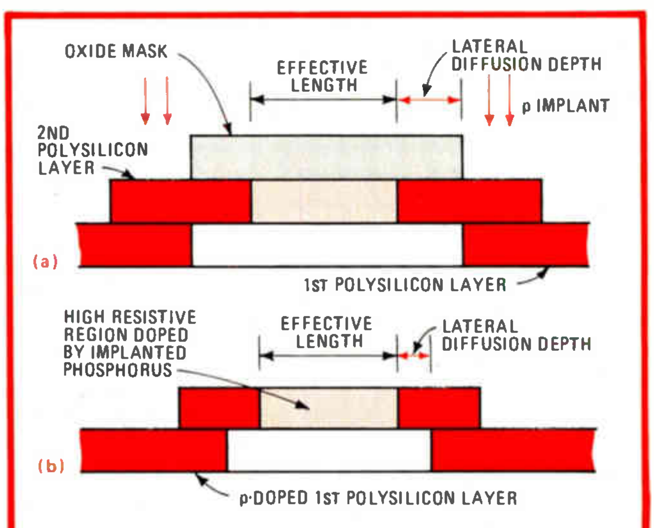
Self-alignment refinements

Members of Rockwell International Corp.'s Electronics Research Center in Anaheim, Calif., are working on a monolithic 1-megabit ROM based upon 2-μm design rules and a planar totally self-aligned MOS structure. They expect a cell size of 24 μm^2 and an estimated die size of 200 by 260 mils. Such self-alignment would be very successful, in view of the fact that NEC has recently used finer geometries to produce a ROM with twice the area and half the capacity.

Self-alignment combined with over-diffusing or over-etching often produces features finer than the lithography equipment on hand allows. At Texas Instruments, for instance, an oxide layer sandwiched between two nitride layers is over-etched and then used as a mask for fashioning extremely short MOS channels. TI's MOS FET



3. Eapla from IBM. For quick turnaround on logic circuits, IBM uses standard n-channel processing for an electrically alterable programmable logic array. In each cell, the metal layer and the first polysilicon layer are connected for better coupling to the floating gate.



4. Doped up. In a 2-kilobyte static MOS random-access memory to be described by Toshiba, contacts are made to lightly doped polysilicon resistors, not by ion implantation (a), but by getting impurities to diffuse up from the highly doped first polysilicon layer (b).

has a 0.35-μm channel, but the same technique has yielded 0.1-μm channels—the shortest yet reported.

Apart from doping, self-alignment also minimizes the area occupied by buried and metal contacts. A new process from NEC lines up a third level of polysilicon with a diffused region to improve MOS device packing density up to 30%. In particular, the Japanese company applies the technique to a single-transistor dynamic RAM cell for a 75% to 80% area reduction without sacrificing cell capacitance.

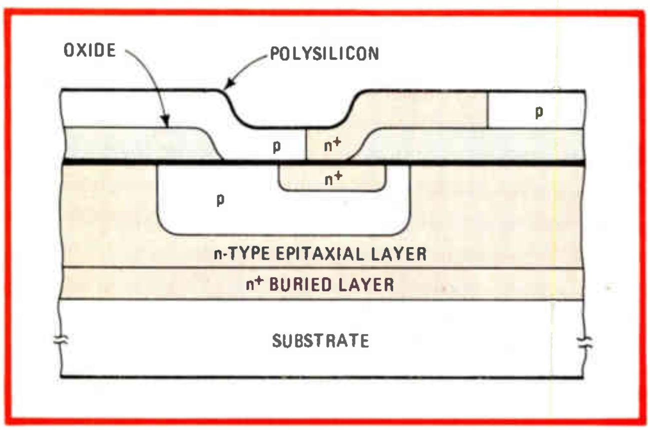
Burying the channel

As FETs are scaled down, carrier mobility may be slowed down by the increased surface fields. One way out is to bury the channel beneath the substrate surface, but a paper co-authored by researchers from Hewlett-Packard Co. of Palo Alto, Calif., and the University of Dortmund in West Germany argues that buried-channel FETs seldom optimize transconductance, the parameter that really needs improvement. So they use $n^-p\,p^-$ layers under the gate to subdue high fields while maintaining surface conduction. The structure, dubbed junction MOS, or J-MOS, increases carrier mobility in bulk silicon by 20% to 40% and in silicon on sapphire by 50% to 70%.

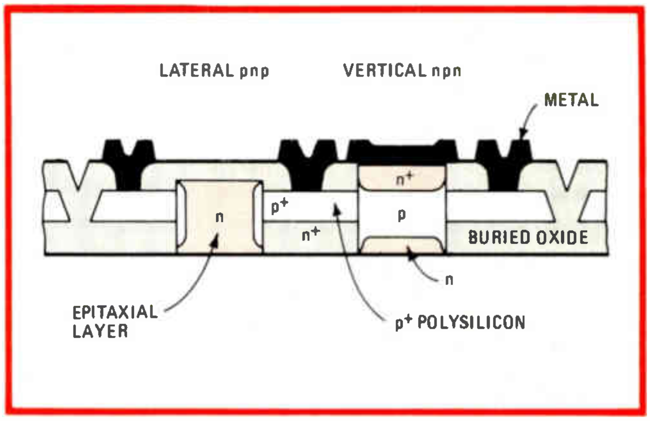
The Musashino Electrical Communication Laboratory of Japan's Nippon Telegraph and Telephone Public Corp. has combined buried-channel MOS FETs with dielectric isolation, using what it calls separation by implanted oxygen, or Simox technology. The implanted oxygen forms a buried silicon dioxide layer, leaving a thin layer of single-crystal silicon at the surface. On this is grown an epitaxial layer for device fabrication.

Of course, a more straightforward route to an insulating substrate is simply to switch from bulk silicon to sapphire—or maybe to laser-recrystallized polysilicon on oxide, an approach TI seems increasingly fond of. It will present two papers regarding laser-annealed silicon-on-insulator, or SOI, MOS FETs. Recently, using local oxide isolation around annealed islands, it has achieved mobilities nearing 700 square centimeters per volt-second—higher than those so far possible with silicon on sapphire.

The Tokyo Institute of Technology has been stressing and perfecting amorphous silicon circuitry, and its latest



5. Bipolar poly. Bipolar technology is finding new uses for polysilicon, a material largely responsible for the speed and density of MOS. The Philips Research Laboratories at Eindhoven is using doped polysilicon for resistors, diodes, and transistors like this npn device.



6. Symmetrical. Due to area and impurity differences in base and collector, standard bipolar processing yields unidirectional transistors. By doping polysilicon above the substrate surface, IBM has built npn and pnp transistors with symmetrical characteristics.

success is a unique inverter based upon a single FET used both as an n-channel driver and as a p-channel enhancement-mode load. The driver has an $n^+n^-n^+$ structure and the p-channel pull-up has a metal-n^--metal configuration, so that only aluminum and n-type dopants are needed for its manufacture.

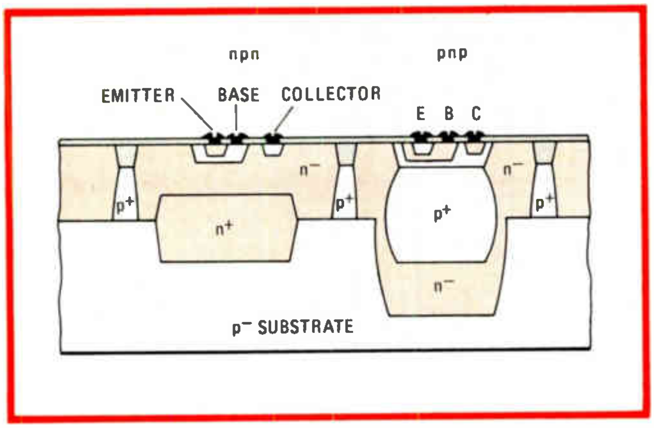
Sapphire pros and cons

Successes with noncrystalline substrates keep sapphire's justification subject to heated debate. Rockwell's Anaheim, Calif., Electronics Research Center and NEC's Basic Technology Research Labs in Kawasaki have confirmed 1-GHz frequencies for C-MOS on sapphire. But a division of the Canadian company Mitel Corp., Mitel Semiconductor in Bromont, Quebec, will conclude in another paper that the advantage of a sapphire substrate over bulk silicon for C-MOS remains a theoretical one. Bell Laboratories, Murray Hill, N. J., has been stalking bulk C-MOS's latch-up problem, and it will propose solutions at 7.5-, 5-, and 3.5-μm geometries. These include fabrication in an n-type epitaxial layer on an n^+ substrate and high-impurity regions like guard rings.

In the area of static RAMs, Toshiba Corp. will present a 2-K-by-8-bit n-MOS memory that has an unusual way of achieving smaller polysilicon loads. As shown in Fig. 4, dopants for the ends of the resistors diffuse up from the first layer of polysilicon rather than from another implant. Thus, lateral encroachment can be held to 1.5 μm. Cell size in this device is 1.44 mil^2.

Lightly doped polysilicon is also being fully exploited in bipolar processes for similar speed and circuit packing improvements. Two Toshiba papers and a third from NV Philips Gloeilampenfabrieken's Research Laboratories in Eindhoven, the Netherlands, and in Sunnyvale, Calif., will describe in detail the use of polysilicon load resistors in bipolar ICs.

One of Toshiba's papers will describe a 4.6-ns 256-bit emitter-coupled-logic RAM based on 9.8-kilohm doped polysilicon loads. With 3-μm features, the resistors measure 3 by 22 μm^2 (2,612 mil^2) and the chip, 2 by 2.3 mm (7,130 mil^2). Its other paper will introduce collector function logic, or CFL, which uses 30% less area than ECL through self-alignment, two-level metalization, and



7. Complementary. With conventional bipolar processing, the gain of npn and pnp transistors is usually not matched. But some linear applications could benefit from complementary structures. NEC has made some using the n⁺ and p⁺ buried layers shown above.

multiple collectors pulled up with polysilicon resistors that are implanted simultaneously with base regions. Toshiba has already pushed its CFL to 1-GHz speeds.

In addition to resistors, Philips is using polysilicon for diodes and transistors like the vertical poly/mono device—as the company calls it—shown in Fig. 5. The polysilicon makes contact with the substrate through an oxide window. With 6-μm–diameter windows, which Philips has etched, bipolar memory cells as small as 2 mil^2 will be possible, it says.

Since standard bipolar processing favors lateral bipolar npn transistors, pnp devices are inherently poorer in quality. Also, since emitter and collector areas and their respective impurity concentrations do not ordinarily coincide, bilateral operation is generally not possible. Solutions to both shortcomings are on the way, however, since NEC's Kawasaki Semiconductor division is integrating complementary npn and pnp transistors and IBM Corp.'s Thomas J. Watson Research Center in Yorktown Heights, N. Y., will present npn and pnp bipolar devices with symmetrical characteristics. Interestingly, IBM dopes polysilicon above the substrate (Fig. 6), whereas NEC's construction zone is below the surface (Fig. 7).

Texas Instruments will prove that bipolar technology is not limited to silicon circuitry. Although bipolar gallium arsenide devices were attempted in the 1960s, the results were discouraging because diffusion was the only doping method around. TI is reviving bipolar GaAs with accurate ion implantation. It hopes to fashion circuits like those used in integrated injection logic, replacing a common injector rail with implanted resistors feeding each gate.

No lithography lethargy

In addition to the papers regarding individual device technology, about every aspect of lithography and wafer processing will be covered at the meeting. For instance, NTT's Musashino Labs will give an overview of the dry etching technology and the electron-beam direct-writing system that it used to process a 256-K RAM [*Electronics*, Feb. 14, 1980, p. 140] with 1-μm minimum features and 1- to 2-μm alignment accuracies.

IBM's Watson Research Center will review X-ray lithography and reactive-ion etching. Of all known X-ray sources, it recommends the electron storage ring for reasons of accuracy. Optimum throughput will come with automatic step-and-repeat alignment, says IBM. However, assembling all of these components into a practical system will not only be a formidable task, but could also have the price tag of $10 million.

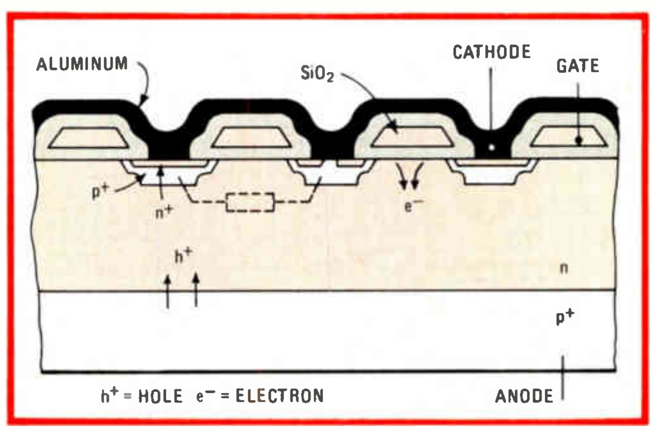
Refractory metal silicides are becoming increasingly attractive for shortening nonmetal-interconnection delays in very large-scale integrated circuits. The two most promising candidates are molybdenum and tungsten silicide. IBM's paper on dry etching will look at fashioning micrometer features in WSi_2, and a manuscript accepted from Fujitsu's Kawasaki Labs will focus on phosphorus doping of $MoSi_2$. Fujitsu has found that the dopant will diffuse through the silicide, facilitating buried contacts. It also found that phosphorus-doped gates promote stable thresholds.

The more unusual papers about device processing include "Aluminum Patterning by Ion Implantation," authored by RCA Corp.'s laboratories in Princeton, N. J., and "Laser-programmed Vias for Restructurable VLSI," from MIT's Lincoln Lab.

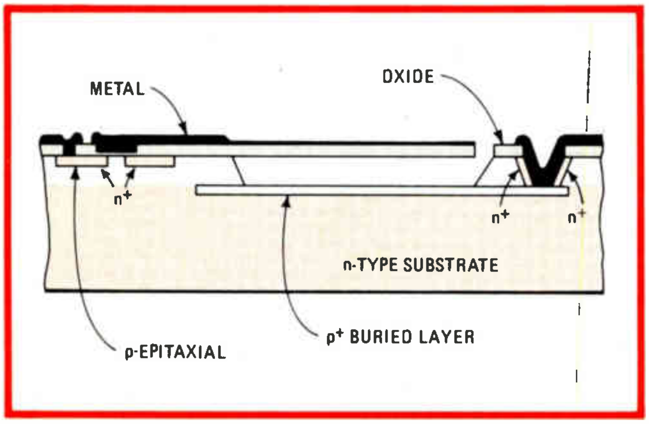
RCA has discovered that when an aluminum film is bombarded with ions or electrons, it is less affected later by chemical etchants. Besides the obvious application of this discovery to metal interconnection patterning, RCA anticipates that aluminum etched in this way will also be useful as a mask for intermediate implantations and for laser annealing since the metallic surface will reflect radiation.

Perhaps RCA's idea can be used for the laser-programmed vias under investigation at the Lincoln Lab. The researchers there are able not only to fuse two levels of aluminum wiring on an IC but also to break connections by severing them on only one plane. Uses include the activation of redundant on-chip circuit elements and user customization. MIT is now looking into lower-power, longer-lasting pulses and the applicability of the approach to C-MOS.

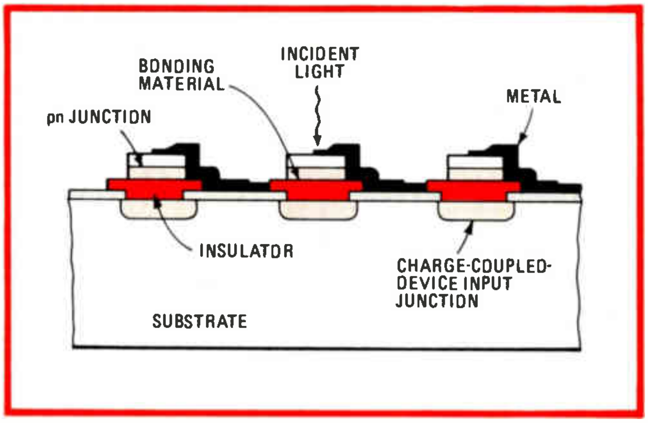
Power semiconductors are pushing their limits all around the world. In France, for instance, RTC-La



8. Mixed. Siemens' Sipmos technology puts a vertical MOS field-effect transistor together with a bipolar structure on the same chip. One result is this thyristor, which combines high input sensitivity and high dV/dt immunity with excellent di/dt characteristics.



9. Altogether. This integrated silicon accelerometer includes on-the-chip detection circuitry. The metal-coated silicon dioxide cantilever-beam sensing element is anisotropically etched. Suspended over a shallow well, the element measures 105 by 25 by 0.5 μm.



10. Hybrid. In its hybrid focal-plane imaging arrays, Thomson-CSF uses an "island" technology to overcome the difference in thermal expansion between the silicon of the CCDs and the lead-tin-tellurium alloy of the infrared-light detectors to which the CCDs are linked.

Radiotechnique Compélec of Caen has developed a mixed bipolar and MOS power transistor in which the MOS device provides the drive signal and the bipolar device handles the high power levels.

In Munich, West Germany, Siemens AG's Components division has also integrated bipolar and MOS elements (Fig. 8), using its Sipmos (for Siemens power MOS) technology. It has produced vertical-FET–controlled and lateral optically coupled MOS FET thyristors.

Thyristor developments abound, in fact. Among them are optically coupled devices from AEG-Telefunken in Frankfurt, West Germany; Brown Boveri Research Center in Baden, Switzerland; and Hitachi Ltd.'s Research Laboratory in Ibaraki, Japan. Hitachi uses optical triggering to handle 6,000 V and 1,500 amperes.

Yet another power device is the Resurf junction FET, a lateral device from Philips' Research Laboratories in Eindhoven, the Netherlands. Its developers will claim that it can handle higher currents and voltages than conventional JFETs, because its drain-source breakdown voltage depends on the doping concentration in the FET's substrate instead of on the epitaxial layer for conventional JFETs.

Finally, the Soviet Union's Physics Technologic Institute in Leningrad has found a way to switch currents up to 40 A at voltages more than 2 kilovolts in less than 0.2 ns. A study of the avalanche-breakdown characteristics of silicon diodes led to this development.

Sensor developments on the rise

The need for silicon sensors of all types has never been greater now that the microprocessor has become an inexpensive mass-producible item. A silicon microtransducer from the Delft University of Technology in the Netherlands has been developed to fulfill such a need. Capable of measuring the magnitude and direction of a magnetic-field vector, the position sensor is made by a standard bipolar technology. Its four-collector npn transistor output provides signals that are a linear function of the two components of an in-plane magnetic field.

From IBM's Research Laboratory in San Jose, Calif., comes a truly tiny silicon accelerometer with detection circuitry on the chip. Its dimensions of a mere 4.9 mils to a side make it at least two orders of magnitude smaller than other solid-state analog accelerometers (Fig. 9). The cantilever-beam sensing element produces capacitance variations in response to acceleration forces (40 attofarads/gravity). These variations are detected by an on-chip MOS detector.

Even moisture can now be measured within electronic packages thanks to the availability of silicon moisture-sensing chips. One such chip design is reported by students from MIT. The device measures another chip's moisture content through the second chip's surface-impedance changes. Finally, University of Michigan researchers have integrated on a silicon chip a thermopile detector consisting of 60 thermocouples in series. They used 10-μm lithography on a die 3.5 mm to a side.

Sensing arrays advance

Charge-coupled and charge-injection diode arrays are making impressive advances in performance, particularly the charge-coupled-device arrays from Japan. At Sharp Corp.'s Central Research Laboratories, Nara, Japan, a simplified 488-by-385-element CCD imager has been fabricated using only two levels of polysilicon instead of the conventional three. The interline-transfer device has floating photodiodes fabricated by ion implantation. Quantum efficiencies of 20% at the 400-nanometer light wavelength were obtained.

Another advanced CCD imager is a nondestructive one from Tohoku University, Sendai, Japan. Made up of an optical transistor with a floating n^+p contact and a readout transistor, the device continuously stores light information, even during readout, independently of floating-contact storage and bit-line capacitances.

In yet another Japanese CCD imager development, the Toshiba Research and Development Center in Kawasaki has designed and fabricated a complex interline-transfer CCD imager for a ⅔-inch color-TV camera. The imager has 492 by 400 picture elements and is manufactured using double-polysilicon electrodes for high yields. An aperture ratio of 35% for incident light is achieved by minimizing the physical size of the vertical CCD register. Dimensions for each imaging cell are 13 μm horizontally by 22 μm vertically.

Hybrid focal-plane arrays, in which infrared sensing elements are coupled to CCDs, are gaining in popularity as high-performance yet cost-effective imagers. Two such developments are from Rockwell International's facility in Downey, Calif., and Thomson-CSF's Electron Tube division, Boulogne-Billancourt, France. In the Rockwell device, an extrinsic indium-doped silicon detector array is interconnected to a 32-by-32-element direct-injection CCD multiplexer, with resulting interconnection yields as high as 99.6%.

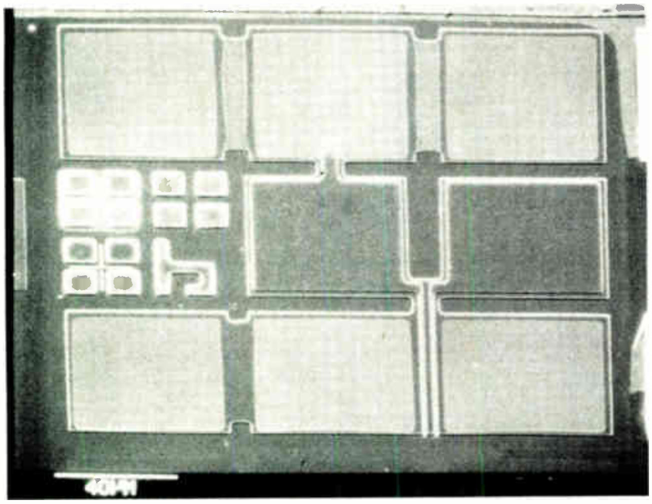
Thomson-CSF's array consists of lead-tin-tellurium detectors with a cutoff wavelength of 10.6 μm, directly injected into a 10-by-10-element CCD array. Designed to operate in the 9-to-12-μm range, the device is batch-processed to obtain "island" hybrid structures (Fig. 10). Such an approach is said not to be limited by mismatching between detector and CCD materials due to the different thermal expansions of metal and silicon, although it does suffer from a lower packing density.

Compound devices for higher frequencies

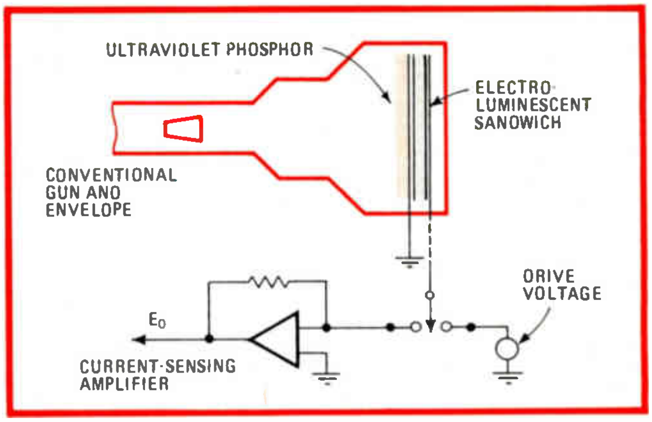
As operating frequencies get higher, conventional semiconductor devices become limited in performance and give way to compound semiconductor devices.

At Cornell University, Ithaca, N. Y., molecular-beam epitaxy (MBE) is used to make metal-semiconductor FETs with active channels of gallium indium arsenide grown on indium phosphide substrates. The MES FETs' 0.6-μm-long aluminum gates are separated from the active channels by thin layers of MBE-grown aluminum indium arsenide. The latter compound is also used to separate the active channels from the substrate. The Cornell researchers have fabricated an integrated photoreceiver made up of a dual-gate double-heterojunction GaInAs MES FET and two photoconductive detectors (Fig. 11).

Working in conjunction with the U. S. Army Electronics Technology Devices Laboratory, Fort Monmouth, N. J., and Britain's University of Wales in Swansea, the Cornell researchers have also used MBE to make



11. **MES FET.** Cornell's integrated metal-semiconductor FET photoreceiver uses double-heterojunction gallium-indium-arsenide devices and is made with molecular-beam-epitaxial techniques. The photograph was taken by a scanning electron-beam microscope.



12. **Electroluminescent.** Tektronix has made an experimental storage cathode-ray tube using the thin-film electroluminescent materials more commonly found in flat-panel displays. It could offer substantial performance advantages over conventional storage CRTs.

GaAs planar-doped rectifiers. When viewed with respect to their current-voltage curves, such devices' barrier heights and asymmetry can be continuously and independently controlled for a constant capacitance.

The use of GaAs insulated-gate FETs in high-speed digital ICs will be described in a paper from the Avionics Laboratory of the Wright-Patterson Air Force Base, Dayton, Ohio. Till now, interface states in the GaAs Igfets have hindered the use of the devices at high frequencies. But new techniques developed at the Avionics Lab allow the devices to operate in the enhancement mode, making possible GaAs Igfet ring oscillator circuits of 9 and 13 stages, with typical gate delays of 180 picoseconds. Also successfully demonstrated were GaAs Igfet divide-by-two circuits using NAND and NOR gates, with lower cut-off frequencies under 1 kilohertz.

Electroluminescent CRTs

Thin-film electroluminescent materials have been used for flat-panel displays. But in a new twist, Tektronix Inc. of Beaverton, Ore., has used the material to make a storage cathode-ray tube (Fig. 12). According to Tektronix, no fundamental barriers exist to prohibit the use of electroluminescent display technology in a storage CRT. However, problems relating to display stability, reliability, size and writing speed in a storage CRT largely remain to be solved.

At Fujitsu Laboratories Ltd., Kobe, Japan, a host material has been developed that gives ac electroluminescent panels both high brightness levels and low operating voltages, a combination hitherto difficult to achieve. Fujitsu researchers use zinc sulfide-selenide, a solid solution obtained by evaporating zinc sulfide and zinc selenide together. Sandwiched between insulating layers of yttrium oxide, the material emits more than 100 foot-lamberts of brightness at 1 kHz while excited by 120 V. Upward voltage shift during aging is 10 V.

A green thin-film ac electroluminescent material with 700-ft-L of brightness (at about 180 V) has been developed at Rockwell's Electronics Research Center, Thousand Oaks, Calif. The researchers there used terbium fluoride as the activator material (instead of the conventional manganese), doped into zinc sulfide. □

Very smart hard-disk controller offloads host microcomputer

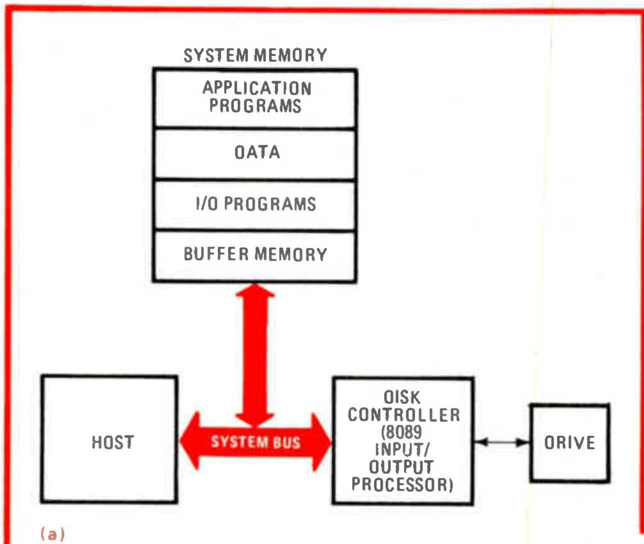
A 16-bit machine capable of addressing an entire Winchester disk needs an I/O-processor–based controller to prevent crippling bottlenecks

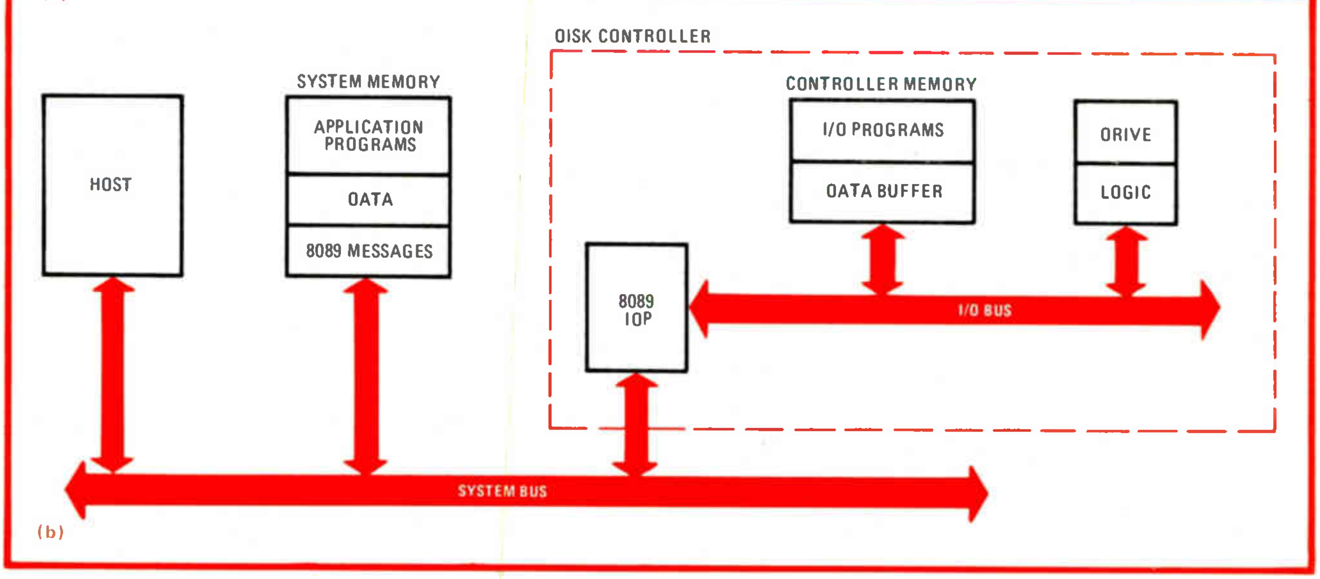
by Hal Kop, *Intel Corp., Santa Clara, Calif.*

☐ The most important new trend in mass storage for microcomputers is the use of Winchester-technology drives. Far superior to floppy disks in both performance and capacity, they will upgrade existing floppy-disk–based systems and make a better match for the speed and megabyte-memory–addressing capabilities of third-generation microcomputers. But if the new drives are accessed by conventional controllers, the microcomputer will be distracted from its proper job—the execution of application programs.

Even the better of today's command-level controllers, such as those built around bit-slice processors, leave most of the work to the host processor. At Winchester drive speeds, that burden cuts heavily into system throughput. But the whole problem can be avoided by offloading the work onto a very intelligent controller built around the Intel 8089 input/output processor (see "The 8089 third-generation I/O interface," p. 141).

With its two high-performance I/O channels, the 8089 IOP is a large-scale integrated version of the intelligent I/O channels used to unburden mainframes. In effect, the host computer has only to tell the IOP what records it desires. It can simply assemble disk-access parameters as a background operation while executing a related application program, dispatch a few setup signals to the channels, and return to executing the main program





1. Configurations. Conventionally the host processor and the disk controller share the system bus and memory (a), minimizing the parts count but lowering throughput. The disk controller with its own memory and processor (b) is cost-effective for a fast disk because it maximizes throughput by adding a few parts.

The 8089 third-generation I/O interface

Since 1971, microcomputer peripheral controllers have progressed from TTL logic coupled to simple input/output ports, through single-chip programmable interfaces and controllers, to the specialized I/O microprocessor of today, such as Intel's 8089.

In the early designs, a host computer could handle only a few slow peripherals because it had to cope with input/output transfers at the bit level. The second-generation controllers allow data to be transferred in bytes or even blocks. However, the host is often interrupted for each byte transferred or has to halt while a block is transferred.

Intel's 8089 I/O processor raises I/O control to the next level. A member of Intel's iAPX 86 and iAPX 88 families of H-MOS microprocessors, the 8089 is normally used to execute the I/O programs of several peripherals for the host microcomputer.

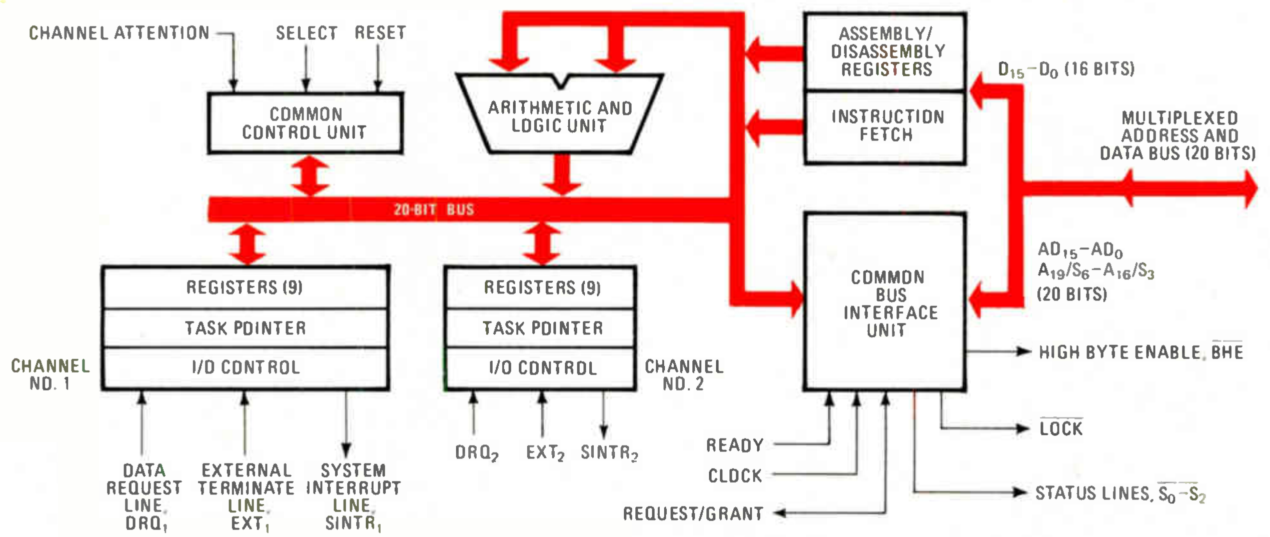
Essentially, the host builds a message in memory to describe the I/O function to be performed and the 8089 IOP interprets the message and assumes all the device controller overhead required to make the transfer.

The two channels on the chip are designed to make direct-memory-access (DMA) transfers at high speed and also to manipulate and process data being transferred. These operations can all take place while the host is attending to other tasks. Transfers to and from system memory can also be made invisible to the host. As a result, the peripherals appear to transmit and receive whole blocks of data, instead of bits or bytes.

Each channel contains nine registers. They share a common arithmetic and logic unit, a common control unit, a common bus interface unit, and other logic on the 40-pin chip. With such an architecture the two channels may either execute entire I/O programs independently or execute individual I/O program tasks in a time-multiplexed manner—that is, concurrently or alternately, according to current priorities. If priorities are equal, executions are interleaved. There is no switching overhead, so different tasks can be performed in rapid succession.

The 8089 IOP has some 50 instructions. In addition to I/O operations, the set includes arithmetic, jump and call, logical, and other operations. The instructions most often used in the disk control applications are MOV and XFER.

The 8089 can be used in either of two modes: a local mode or a remote mode. In the local mode, a channel executing a task gains control of a local bus through the request/grant line on the bus interface unit. In the remote mode, an external Intel 8289 bus arbiter is needed to award control of the system bus according to system priorities. The lock line allows a channel task to retain possession of a system bus during an entire DMA block transfer. Each channel also has an I/O control section with DMA request, external termination, and system interrupt lines (DRQ, EXT and SINTR).



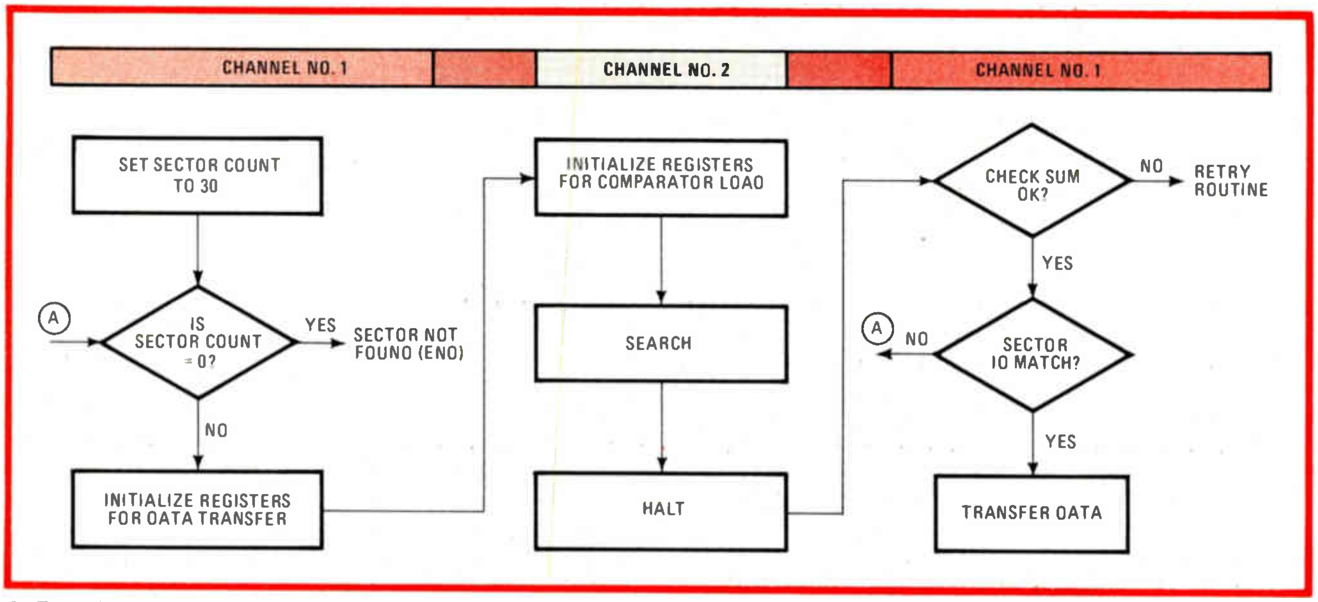
while the IOP finds the parameter information in system memory and handles all the disk-access details.

Such a hard-disk controller is also compact and flexible. The IOP replaces some two thirds of the components and occupies about a third the area ordinarily required when a bit-slice processor is used. Hardware and software can be fully modular and may be changed with little impact on the host processor design. Moreover, since only a fraction of the controller's I/O bus is needed for hard-disk control, the designer is free to add other control functions in hardware and software.

This 8089-based controller design was developed for systems using Intel's third-generation iAPX 86 and iAPX 88 processor families (based on 8086 and 8088 devices, respectively), but it is not restricted to them. The Multibus interface control signals and timing employed are also compatible with those used by the single-board Intel computers based on the 8080, 8085, and iAPX 86 and with equipment from other makers, since the Multibus is a *de facto* industry standard.

The 8089 IOP could be connected directly to an 8086 or 8088's address and data bus, as in the traditional configuration, so as to save system bus interface parts (Fig. 1a). For most disk-control applications, however, a remote configuration (Fig. 1b) is much more cost-effective since it maximizes system throughput at the cost of only a small number of additional parts.

With a conventional controller, the host microcomput-



2. Two-channel operation. Control switches between the two channels of the 8089 during the search and transfer operation. Channel No. 1 initializes registers for the transfer, No. 2 performs the search, and then No. 1 checks the comparator and completes the transfer.

er executes I/O programs stored in system memory through the system bus. The host and its bus are engaged in detailed disk-handling operations a large percentage of the time during an access. This situation can create not only a lot of overhead but also bus bottlenecks, especially during periods of heavy I/O traffic.

The remote configuration fully resolves both difficulties. Since all the unchanging parts of I/O programs can be stored in erasable programmable read-only memory on the remote I/O bus, only the parameters of a disk access have to be obtained from system memory. These parameters are few—cylinder, head, and sector desired and memory address to start storing or reading the data. To obtain them, only a few system memory accesses are needed, and they can be made when the host microcomputer is not using the system bus.

Since data can also be stored in local buffer memory and transferred only when the host computer does not need the system bus, the host will have use of the system bus most of the time. As a result, it can execute application programs in parallel with the controller's execution of disk I/O programs.

Disk control requirements

To minimize the host's overhead, an intelligent controller should be able to perform all the basic disk control functions—formatting, seek, search, error-checking, buffering, and read/write transfer operations as a basis for randomly accessing files (see "Glossary of basic disk control terms," p. 145). More advanced capabilities, such as handling multiple drives, error-recovery operations, and data searches, would also utilize these basic control operations.

The drive type, of course, establishes specific requirements for the controller. If the controller cannot keep up with the transfer rate during search and data transfer or buffering operations, both performance and storage density will suffer.

However, speed during data transfers is not the only requirement. A microprocessor is designed to execute programs in sequence and must initialize registers at transition points between programs. But, while the microprocessor pauses to "change gears," the disk keeps turning. Since the microprocessor cannot control the reading or writing of data during these intervals, formatting gaps must be inserted within the sectors of data into which the disk track is divided—specifically a gap must be inserted between the header, or sector identification (ID), and the data block of each sector.

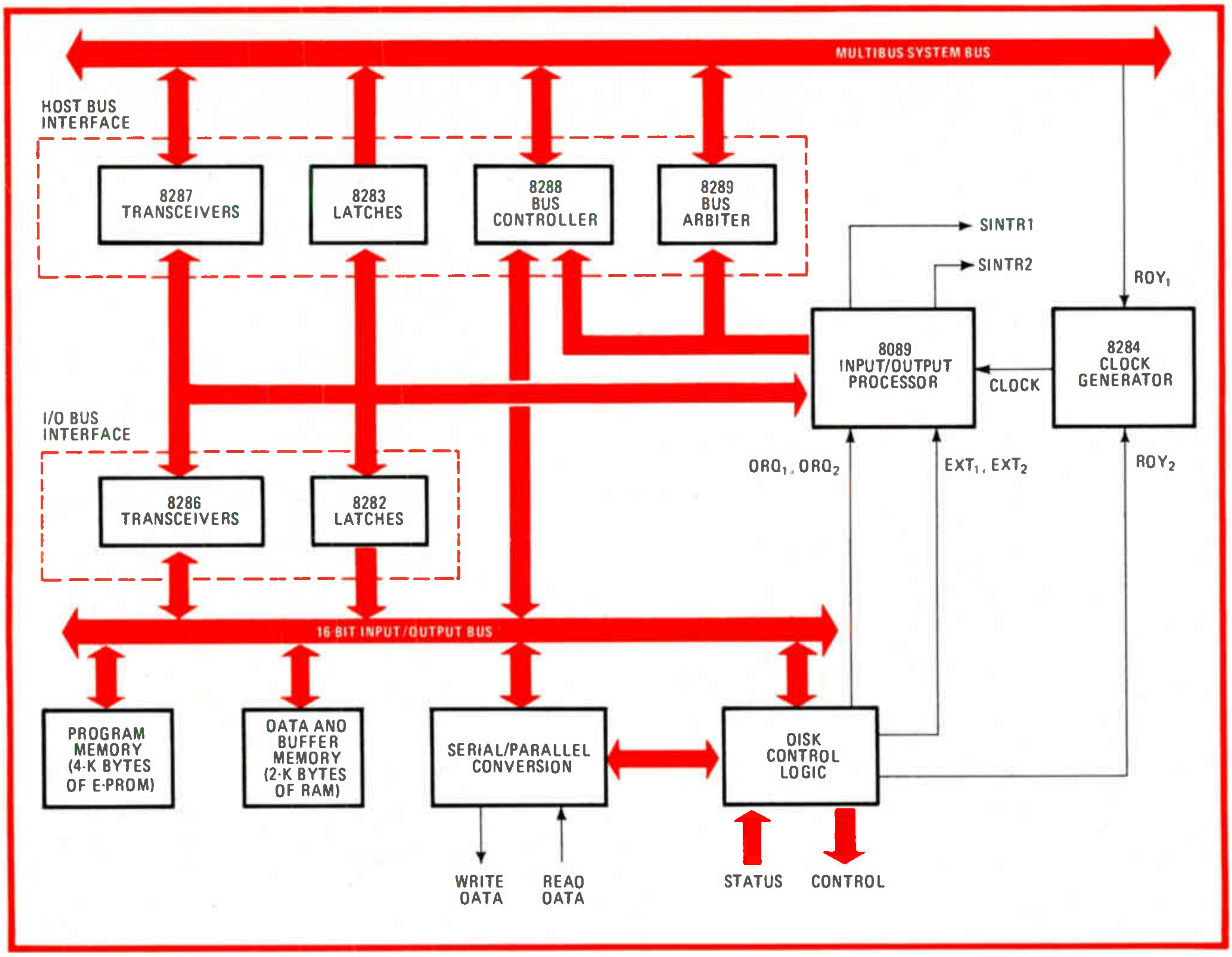
This gap has the job of providing time to enable or disable the drive's read-gate and write-gate signals. It also gives the controller time to tell from the header if this is the sector it wants before the data starts passing under the read/write head so that it can catch the sector on this revolution. In order to make the best use of the packing density of the disk, the controller must work very fast so that this gap can be kept short.

The amount of logic in a disk controller depends largely on how this problem is solved. In the 8089-based controller both I/O channels are used in an alternating mode to achieve speed while minimizing external logic.

The 8089 IOP's two channels effectively hide the time needed for register setup. They execute channel I/O programs independently or concurrently, handing control back and forth. One channel initializes registers for high-priority task, such as a DMA transfer, and then passes control to the other channel, which is programmed to do another part of the task.

Two-channel search

Figure 2 shows the two-channel flow of control during the sector-search and data-transfer part of the operation. At this point the seek operation has been completed and the read/write head is over the desired track. Channel No. 1 sets a sector counter register to 30, the number of sectors on the track. It checks the sector count and, if the count is not equal to zero, starts the search at the next sector to pass under the head. It does not have to wait to



3. Controller hardware. Besides the 8089 input/output processor, the controller board contains its own I/O bus with program memory, data memory, serial/parallel conversion and disk control logic, and the components of the I/O bus and host bus interfaces.

start at the first sector on a track—it just counts off 30 sectors from wherever it happens to start.

The first channel does not actually make a data transfer at the beginning. Instead, it sets up its registers for the transfer and passes control to the second channel by sending it a channel-attention signal.

When channel No. 2 receives the CA signal, it wakes up, initializes registers for the comparator loading operation, searches for the next sector ID, and then halts. Next, with its registers already set up for a DMA transfer between the controller's local buffer memory and the disk, the first channel can immediately begin transferring data if the cyclic redundancy checksum of the sector ID is correct and the sector ID is the one desired.

If there is no header ID match, the sector count is decremented and the search operation is repeated on the next sector. There is now plenty of time for the channels to initialize their registers again because this is done while the unwanted sector data begins passing under the read/write head.

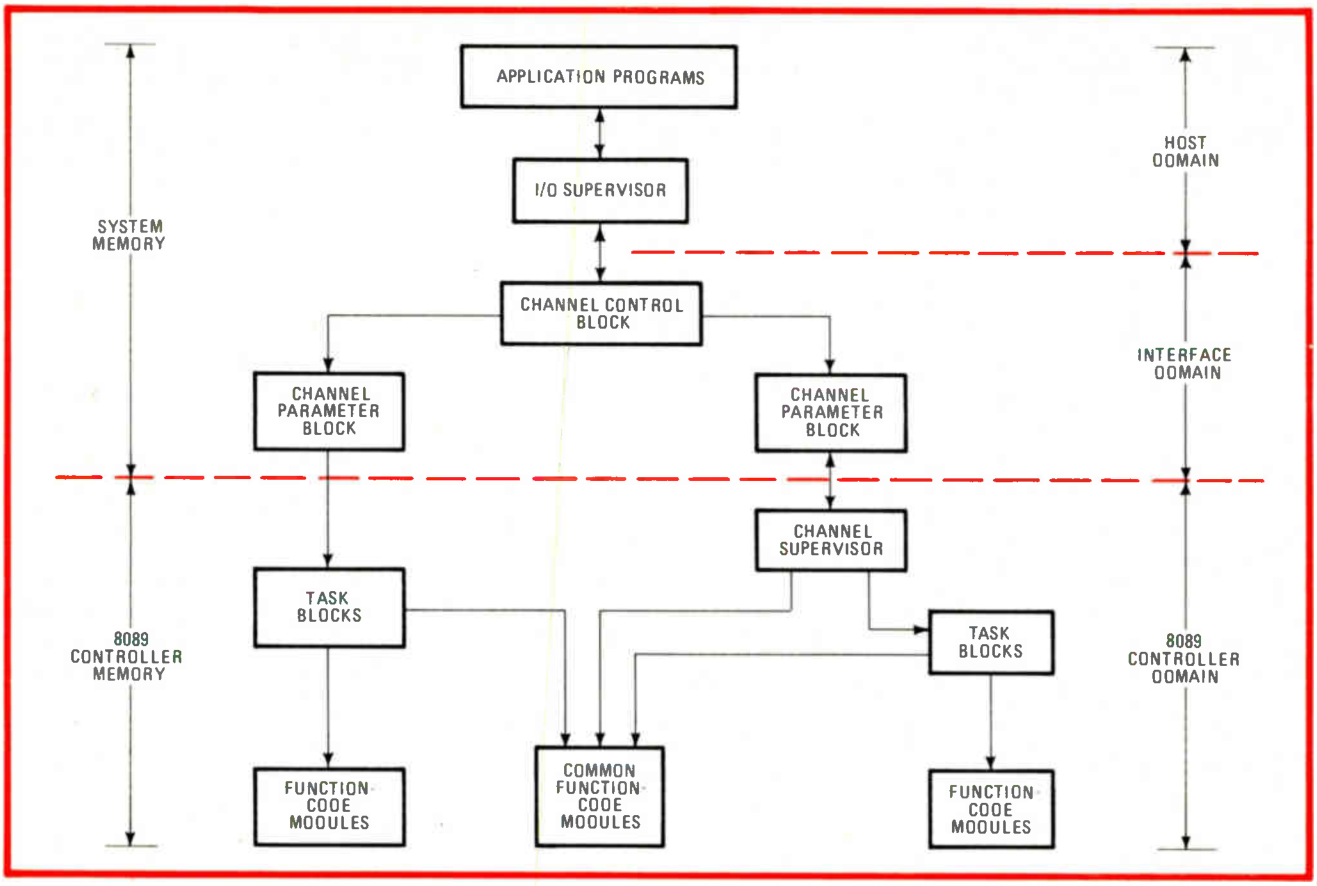
The program branches in Fig. 2 can be used to start a retry routine or other error-recovery processes. Since the 8089 IOP has the intelligence of a microcomputer, the system designer could implement more sophisticated error-checking and error-recovery techniques.

As an example, an 8089-based controller was designed for the Shugart Associates SA4008 drive, selected because it is typical of Winchester drives now being used in microcomputer systems. This drive has 1,616 tracks, four surfaces on 14-inch disks, and two heads per surface. Each track stores 18 kilobytes of unformatted data for a total of 29 megabytes.

With a high-density format such as 256 bytes per sector at 60 sectors per track, the formatted capacity is 15.4 kilobytes per track and 24.8 megabytes per drive. This controller design searches 30-sector tracks at 512 bytes per sector. Other formats would require only minor changes in software.

The drive has an average seek time of 65 milliseconds and revolves in about 20 ms, resulting in an average latency of 10.1 ms and a data-transfer rate of 889 kilobytes per second. Either I/O channel of the 8089 IOP can make DMA transfers at up to 1.25 megabytes per second at the standard clock rate of 5 MHz—more than fast enough for this disk.

The controller hardware configuration is shown in Fig. 3. During an access, the 8089 IOP interacts with two logic subassemblies on the I/O bus—specifically, the



4. Software organization. Software for detailed control of the disk is in the controller's local memory. The host system software and controller-resident software communicate only in the interface domain, through the channel control block and the parameter blocks that are located in system memory. With a channel supervisor in use, one parameter block access is capable of starting multiple tasks.

disk-control logic and serial-parallel conversion logic.

The major components of the control logic section are the 16-bit comparator for the sector search operation and an 8253 programmable interval timer. The comparator is implemented with four 4-bit TTL comparators. The 8253 chip provides three software-configurable counter/timers used to synchronize cyclic redundancy check operations and to generate strobes.

The serial-parallel converter is implemented with two 8-bit TTL shift registers. Associated with the converter (but not shown) is a 9401 TTL CRC checker/generator device. The CRC chip adds CRC checksums to the header ID and to the data during writes, checks ID CRC checksums during read and write sector searches, and checks data CRCs during a read access.

Following a search operation, the controller transfers data between logical sectors and buffer memory. To write data, sectors are transferred to the track specified by the seek parameters, beginning with the specified logical sector. The data words are serialized and delivered to the drive. To read, serial data from the drive is converted into parallel and stored in random-access memory until the CRC check is completed.

During reads and writes, the data is double-buffered. For example, during a read, when 16 bits are received from the drive, the word is shifted into a 16-bit buffer, which is read by the 8089 IOP as a DMA operation.

A byte count terminates DMA when the entire block of 512 bytes of data has been transferred. The transfers to and from the disk are synchronized by means of the 8089's ready signal. If the CRC device detects an error, the controller retries the operation the number of times specified. Retries allow recovery from soft errors before the data block is transferred to system memory.

Like all controllers, this one requires a bus interface to the host microcomputer. The 8287 transceivers transmit and receive data information, and the 8283 chips latch address information. An 8288 bus controller and an 8289 bus arbiter coordinate Multibus access and protocol. The board also provides 4-K bytes of program storage space in the form of 2716 16-K E-PROMs, 2-K bytes of buffering and data storage in 2142 4-K static RAMs, and the interface to its own I/O bus.

The entire controller assembly fits on a 6½-by-12-inch prototyping board with wrapped-wire connections. This is about one third the size of a typical command-level controller built around a bipolar bit-slice processor.

All program and data communications take place via system memory. The only direct communications between the 8089 IOP and the host processor in a system are the control signals: channel attention (CA), select (SEL), and reset connected to the common control unit. The CA and SEL signals tell a specific channel to execute an I/O program, and, with RAM on the controller board, it is a simple matter to design the I/O programs to minimize system memory accesses.

Glossary of basic disk control terms

Buffering: Storing data between transfer operations. Data read from disk is buffered before transfer to system memory and data to be written is buffered after transfer from system memory.
Cyclic redundancy check: Comparison of the checksum derived from data as it was originally written into storage with the checksum derived from the same data as it is being read out of storage. The first checksum is appended to the data as it enters storage. After reading this data, the controller computes a new checksum from it and compares the two. If the checksums match, the data is correct. A checksum error may indicate a damaged area on the disk, data that has changed since written, or erroneous reading of correct data where a retry may work.
Direct memory access: The technique generally used to transfer blocks of data between a peripheral and random-access memory. It is called direct because the host does not handle the data during the transfer operation.
Formatting: The division of tracks into sections to make it easier to retrieve and update data. In each sector, the block of data is preceded by an identifying header. Gaps are inserted between sectors and between the header and data block within each sector to allow time for control logic functions.
Retry: Repetition of search or read/write operations to recover from "soft" (correctable) errors.
Search: Reading headers on the track passing under a read/write head so as to locate the desired sector. The controller compares each identification (ID) read from the track with the ID of the desired sector.
Seek: Moving a set of read/write heads so that one of them is over the desired track.

There can be considerable variation in the software organization used for these communications. An example of a software hierarchy is shown in Fig. 4. Only the format of the channel control block is fixed, and one control block must be shared by both channels of the IOP. There must also be at least one parameter block for each channel. For instance, in a multiperipheral application, separate parameter blocks may be used for each peripheral so that the host only has to update parameters and not repeatedly assemble the blocks.

Three modules

Three types of software modules may be used in I/O programs for the controller:
- Task blocks for handling such tasks as seek, search, and data transfer.
- Function-code modules for such detailed functions as write, read, and retry (function-code modules may be designed to be called by one task block or to be shared by two or more task blocks).
- Channel supervisors that can be used to supervise multiple tasks without requiring the host's intervention.

The parameter block always starts with the address of the task block that starts the I/O program—such as the program for a seek—followed by function codes and variables for that operation. There are two ways the host can specify a continuing series of operations. It can extend the parameter block to provide a series of task block addresses and parameter sets, and the channel can then be programmed to execute the tasks in linked sequence. Alternatively, it may provide a task block address and multiple function codes and parameter sets. The task block can then be programmed to call the function code modules in turn. Likewise, a channel supervisor can be addressed to call task blocks.

After effects

These techniques allow the host to set up any number or variety of accesses as a background or low-priority housekeeping operation, dispatch the channels with a simple startup procedure, and return to main program execution. In effect, the host just requests the 8089 I/O processor to read file X or write file Y.

The host starts up the IOP by sending CA and SEL signals to the channels. The channels read the command words, store the parameter block and task block addresses in their registers, and set the busy flags in the control block.

The host has three ways of determining the progress of disk accesses: it can poll the busy flags to see whether either channel is still active; it can read a status word written in the parameter block; or it can receive an interrupt from the channel completing the operation.

For this example, the 8089 IOP has only been programmed to illustrate the two-channel technique in straightforward read and write operations. But as a general-purpose device, it can handle many other storage operations. For instance, it could be programmed to manage the backup and recovery of data on backup peripherals such as floppy disks, tape cartridges, start-stop tape drives, and streaming-tape drives.

Input/output spooling is another possibility. Data from relatively slow I/O devices such as terminals could be read by the IOP and placed on disk or in local memory until the transmissions are finished. The IOP could then transfer the data at high speed when an application program needs the data. Conversely, data to be sent to slow devices such as printers could be assembled in system memory, transferred to disk, and then sent. Such operations could be handled as low-priority background tasks by the host microcomputer and the I/O programs.

Thirdly, the IOP could be programmed to implement high-level file systems that appear to application programs to be simple commands, such as open a file, read, or write. The IOP could search and update disk directories and maintain free-space maps. It could also implement hierarchical memory systems using high-speed and low-speed drives based on frequency of use, as for main storage and backup storage of critical data.

Finally, the IOP could increase the throughput of a multitasking operating system dramatically. The operating system could dispatch I/O tasks to the IOP, and the channels could be programmed to handle the highest-priority task automatically. □

8X300 microcontroller performs fast 8-by-8-bit multiplication

by Sam Mallicoat
Tektronix Inc., Beaverton, Ore.

Although it is not geared to number crunching, the Signetics 8X300 bipolar microprocessor can execute its compact control-oriented instruction set rapidly and excels at bit testing and manipulation—qualities which make it easy to implement this high-speed algorithm for multiplying two 8-bit words. The multiplication routine can be performed in as little as 19 microseconds and in 24 microseconds in the worst-case situation.

Conventional routines perform an add and/or shift operation for each bit of the multiplier word to achieve fixed-point multiplication. This program, based on a technique described in detail by MacSorley,[1] halves the number of operations, and thus the execution time, by examining the multiplier's bits in groups. Depending on the group value, the multiplier is added to or subtracted from the previous partial product, either once or twice.

With the multiplicand and multiplier placed in registers R_3 and R_4, respectively, the 16-bit product appears at registers R_1 (high-order byte) and R_2 (low-order byte). All numbers are expressed in 2's complement format. □

References
1. O. L. MacSorley, "High-Speed Arithmetic in Binary Computers," Proceedings of the IRE, Jan. 1961, pp. 67–91.

MULTIPLICATION ROUTINE FOR 8X300 MICROCOMPUTER

Label	Source statement	Comment
	XMIT 0, R1	clear product high byte
	XMIT 0, R2	clear product low byte
	XMIT 377, AUX	place 2's complement of
	XOR R3, R5	multiplicand in R5
	XMIT 1, AUX	
	ADD R5, R5	
	AND R3(7), AUX	test the sign of multiplicand
	XEC AUX, TAB1	
	XMITO, R11	prepare multiplier
	MOV R4(7), R4	mask for first pass
	XMIT 6, AUX	
	JMP ENT	
LOOP:	MOV R4(2), R4	rotate multiplier right twice
	XMIT 7, AUX	
ENT:	AND R4, AUX	mask lower 3 bits
	XEC AUX, TAB2	eight-way conditional branch
SUM:	ADD R1, R1	
SHIFT:	XMIT 77, AUX	shift low product byte
	AND R2(2), R2	right twice
	XMIT 300, AUX	
	ADD R6, R6	increment loop counter
	AND R11, R11	
	AND R1(2), AUX	shift 2 least significant bits of high
	XOR R2, R2	product byte to low product
	XMIT 77, AUX	shift high product byte
	AND R1(2), AUX	right twice
	XOR R11, R1	correct for product sign
	NZT OVF, LOOP	test for done
	JMP EXIT	exit routine
TAB1:	XMIT 363, R6	
	XMIT 374, R6	
TAB2:	JMP SHIFT	
	JMP P1	
	JMP P1	
	JMP P2	
	JMP M2	
	JMP M1	
	JMP M1	
	JMP SHIFT	
P1:	MOV R6(4), R11	add multiplicand once
	MOV R3, AUX	
	JMP SUM	
P2:	MOV R6(4), R11	add multiplicand twice
	MOV R3, AUX	
	ADD R1,R1	
	JMP SUM	
M2:	MOV R6(2), R11	subtract multiplicand twice
	MOV R5, AUX	
	ADD R1, R1	
	JMP SUM	
M1:	MOV R6(2), R11	subtract multiplicand once
	MOV R5, AUX	
	JMP SUM	

Meter measures coatings magnetically

by Jules Schlesinger
UPA Technology Inc., Syosset, N. Y.

Utilizing the principle of reluctance to measure the thickness of nonmagnetic coatings (such as paint, rubber and metal plating) on a magnetic substrate, this meter will provide precise and stable readings over the range of 0 to 19.99 mils. The measurements are accurate to within ±1 microinch, which is adequate for most industrial requirements.

The heart of the instrument is its sensor, which is

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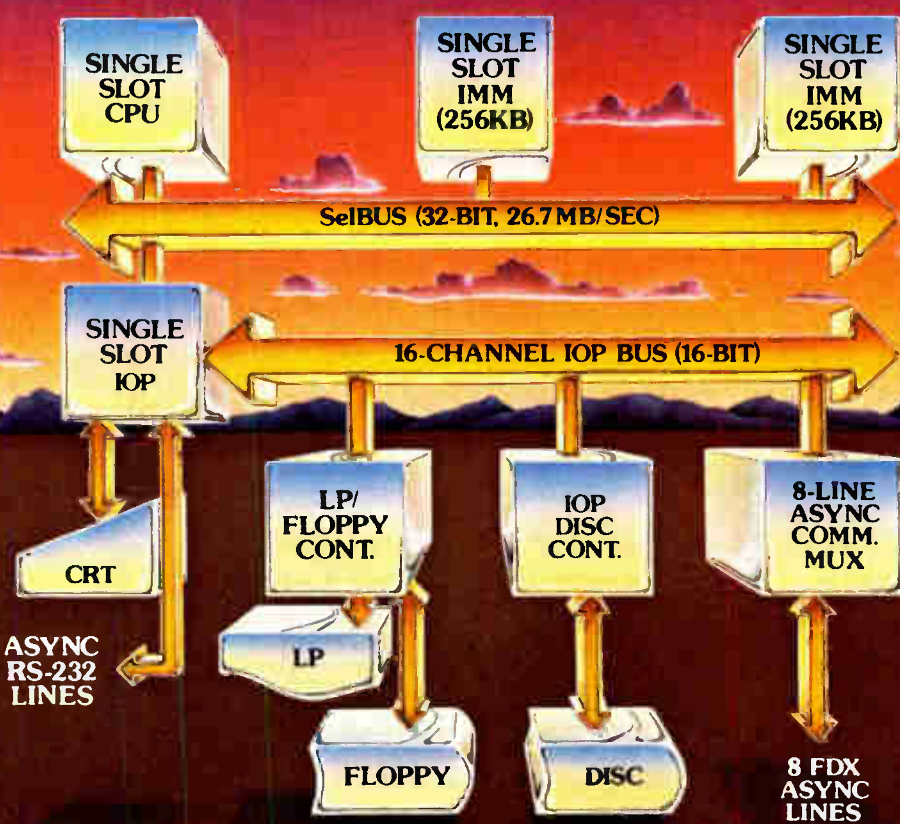

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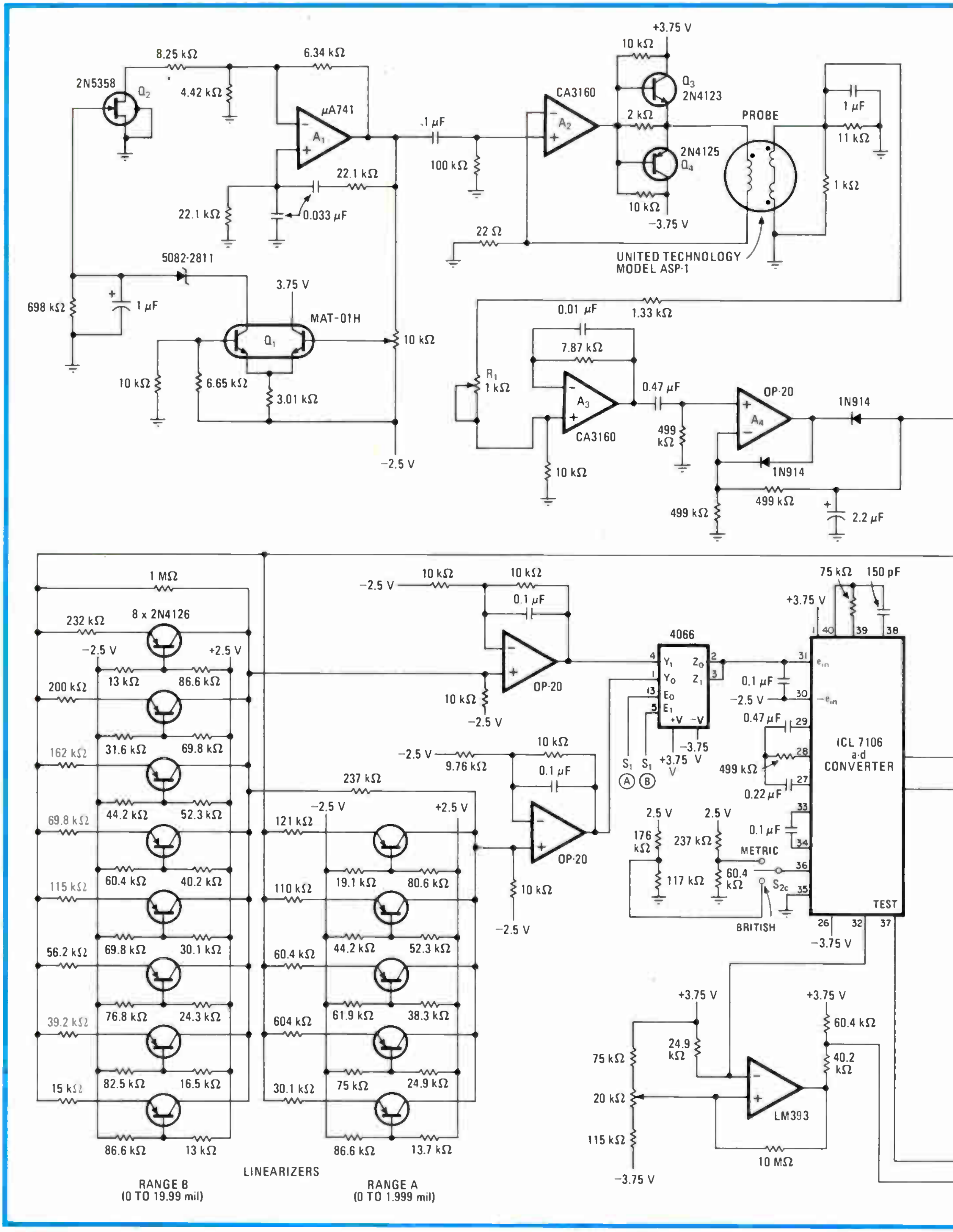

2N5358
Q_2
8.25 kΩ
4.42 kΩ
6.34 kΩ
μA741
A_1
22.1 kΩ
22.1 kΩ
0.033 μF
.1 μF
100 kΩ
CA3160
A_2
+3.75 V
10 kΩ
Q_3
2N4123
2 kΩ
2N4125
Q_4
10 kΩ
−3.75 V
PROBE
1 μF
11 kΩ
1 kΩ
22 Ω
UNITED TECHNOLOGY
MODEL ASP-1
5082-2811
698 kΩ
1 μF
3.75 V
MAT-01H
Q_1
10 kΩ
10 kΩ
6.65 kΩ
3.01 kΩ
−2.5 V
0.01 μF
1.33 kΩ
7.87 kΩ
R_1
1 kΩ
A_3
CA3160
0.47 μF
499 kΩ
OP-20
A_4
1N914
1N914
10 kΩ
499 kΩ
499 kΩ
2.2 μF
1 MΩ
8 x 2N4126
232 kΩ
−2.5 V
+2.5 V
200 kΩ
13 kΩ
86.6 kΩ
162 kΩ
31.6 kΩ
69.8 kΩ
69.8 kΩ
44.2 kΩ
52.3 kΩ
115 kΩ
60.4 kΩ
40.2 kΩ
56.2 kΩ
69.8 kΩ
30.1 kΩ
39.2 kΩ
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OP-20
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0.1 μF
237 kΩ
−2.5 V
+2.5 V
121 kΩ
110 kΩ
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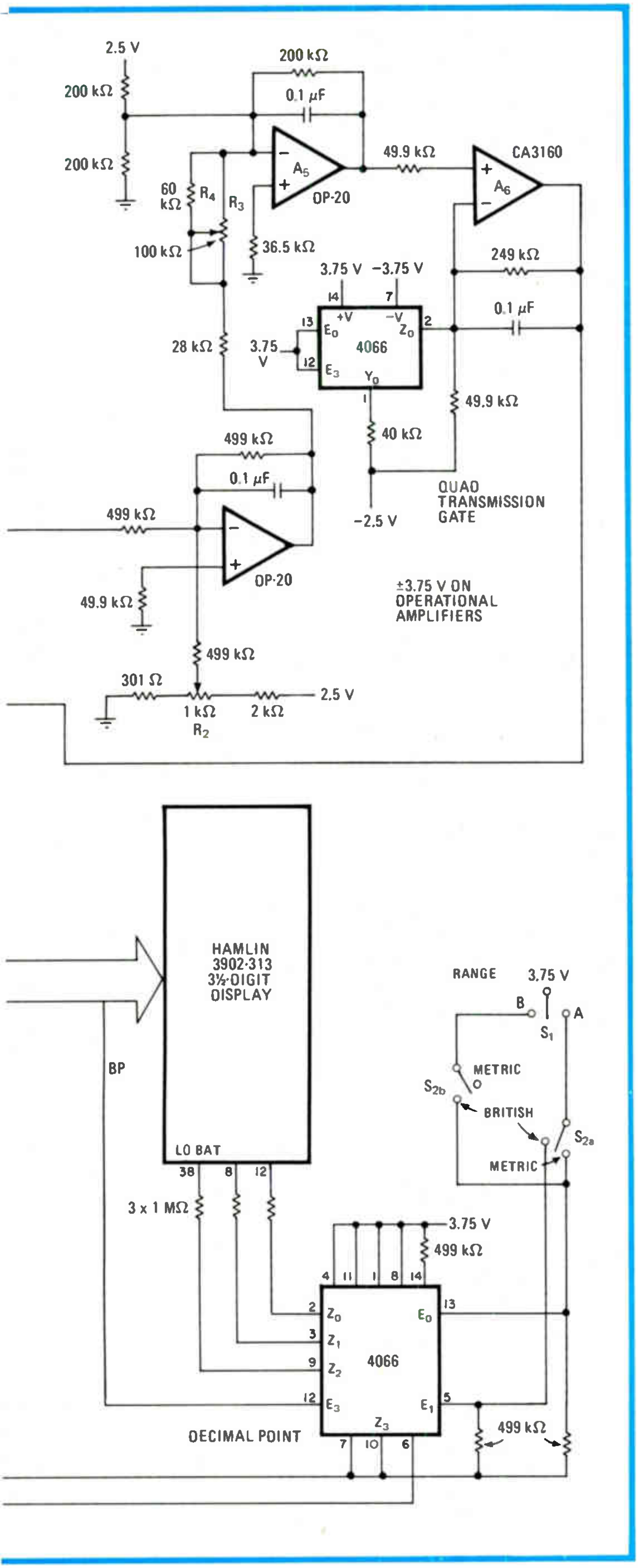
80.6 kΩ
60.4 kΩ
44.2 kΩ
52.3 kΩ
604 kΩ
61.9 kΩ
38.3 kΩ
30.1 kΩ
75 kΩ
24.9 kΩ
86.6 kΩ
13.7 kΩ
OP-20
10 kΩ
−2.5 V
4066
Y_1 Y_0 E_0 E_1 +V −V Z_0 Z_1
S_1 S_1
A B
+3.75 V
−3.75 V
75 kΩ
150 pF
+3.75 V
0.1 μF
−2.5 V
0.47 μF
499 kΩ
0.22 μF
ICL 7106
a-d
CONVERTER
e_{in}
$-e_{in}$
2.5 V
2.5 V
176 kΩ
237 kΩ
0.1 μF
METRIC
117 kΩ
60.4 kΩ
S_{2c}
BRITISH
TEST
−3.75 V
+3.75 V
+3.75 V
24.9 kΩ
60.4 kΩ
40.2 kΩ
75 kΩ
20 kΩ
115 kΩ
LM393
10 MΩ
−3.75 V
LINEARIZERS
RANGE B
(0 TO 19.99 mil)
RANGE A
(0 TO 1.999 mil)



Field distance. Micrometer determines thickness of nonmagnetic coatings on magnetic material from difference in flux generated by series-opposing windings of output transformer, which constitutes the meter's probe. Unit's measurements are precise over the range of 0 to 19.99 mils and accurate to within ±1 microinch. At the flip of a switch, meter will display readings in micrometers.

basically a transformer having one primary and two secondary series-opposing coils and wound on a solid magnetic core. One end of the core protrudes from the sensor proper, becoming the probe that measures the contact surface. So, for the free-space condition, the output taken across the probe's secondary coils will cancel when it is excited by a low-frequency signal (below about 300 hertz to avoid generating eddy currents). Cancelation occurs because the output across one secondary coil is equal in amplitude and opposite in phase with the other. Otherwise, the output from the secondary coil closest to the contact surface will generate a voltage exceeding the potential produced by the other secondary winding. The magnitude of the root-mean-square difference will be a nonlinear function of the thickness of the magnetic substrate's coating.

In general operation, A_1 serves as the active element of a Wein-bridge oscillator for driving the probe. Q_1 and Q_2 in the feedback network provide automatic level control for stabilizing the oscillator's output. In addition, A_2, Q_3, and Q_4 provide constant-current drive for the meter's probe.

The output signal is fed to amplifier A_3 and ac-to-dc converter A_4 through potentiometer R_1, which is used to normalize, or zero, the probe for a steel contact surface. The signal is then passed through a chain of additional amplifiers, which provide a convenient means of setting system offset (R_2), the system gain for a known thickness (R_3 and range amplifiers A_5 and A_6), and system sensitivity (R_4).

A_6's output is then introduced into one of two transistor current switches, which provides a piecewise-linear fit for the probe's nonlinear output. After buffering and further amplification, the signal is presented to the 7106 a-d converter and its associated liquid-crystal display. Note that the reference voltage at pin 36 of the 7106 is selectable, so that the readings can be displayed either in British or metric units (that is, micrometers). The 4066 transmission gate and switches S_1 and S_2 are used to set the position of the decimal point. S_1 places the meter in the low-scale (0–1.999 mils, or 0–19.9 μm) or high-scale (0–19.99 mils, or 0–199 μm) positions. Switch S_2 selects the display mode—either British or metric. In terms of metric units, the meter's measurement resolution is ±0.1 μm.

Power for the equipment may be supplied by either eight nickel-cadmium batteries or an ac-line adapter/charger. In the latter case, it is suggested that integrated-circuit regulators be employed to provide stable ±3.75- and ±2.5-volt sources. Special attention should be paid to maximizing the suppression of line glitches and other transients. □

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.

Engineer's newsletter

LSI-11/23's hidden address pins call on additional memory

Although Digital Equipment Corp. of Maynard, Mass., has not made much mention of it, recent versions of its LSI-11/23 microcomputer are **capable of 22-bit addressing, for a total of 4 megabytes of memory—16 times larger than the 18-bit address space (256-K bytes) that is specified** for the system. But Stewart Dole of Dole and Farmer, a software consulting outfit located in Petaluma, Calif., says expanded addressing power can be achieved if the additional four pins on the machine's central-processing-unit card are simply hardwired to the system's peripheral board. The minor system modifications also required will be easy for anyone familiar with the RSX-11 operating system, according to Dole.

DEC does not offer any 22-bit peripherals for the LSI-11/23, but others, like Motorola, Texas Instruments, and Peritek Corp., have memory and peripheral cards designed to interface with a modified system. For consultations, contact Dole at (707) 763-2800.

Ion implantation increases ceramic's photosensitivity

Scientists at Sandia National Laboratories have recently shown that ion implantation, ordinarily associated with the fabrication of integrated circuits and solar cells, sharply increases the photosensitivity of a transparent lead-lanthanum-zirconate-titanate (PLZT) ceramic device. The photoferroelectric image-storage device has potential for nonvolatile but erasable photographic storage and image contrast enhancement. Implanting hydrogen, helium, or argon ions or co-implanting argon and neon ions increases the photosensitivity of the ceramic and thus **cuts by as much as 10,000 times the exposure energy required to store an image.** For additional information, write the labs at Box 5800, Albuquerque, N. M. 87185.

U. S. government adopts ANSI standard for labeling magnetic tapes

A magnetic-tape–labeling standard designed to provide improved capability for Federal bureaus that interchange data via computer was recently approved by the Secretary of Commerce and will become effective Oct. 17, 1981. The new Federal information-processing standard, FIPS 79, **establishes four levels of labeling, in addition to label formats, blocking structure, and tape-mark relationships.** It is virtually identical to American National Standard X3.27–1978, which aims at reducing the difficulties associated with the exchange of data on nine-track magnetic tape.

By arrangement with the American National Standards Institute (ANSI), FIPS PUB 79 can be ordered at $8.00 per copy from the National Technical Information Service, U. S. Department of Commerce, Springfield, Va. 22161. Further details may be obtained from Joseph C. Collica, Institute of Computer Sciences and Technology, National Bureau of Standards, Washington, D. C. 20234.

Read about the future, technical and economic, of local networks

With distributed data processing and office automation taking off in the marketplace, you may want to see a 124-page report on the local networks that are expected to handle the growing volume of high-speed data in these applications. Prepared by International Resource Development Inc., the seven-section overview, entitled "Local Networks and Short-Range Communications," includes **a discussion of technical considerations, the structure of the industry, highlights of companies actively engaged in standardization and design efforts, the areas in which local networks are likely to find use, and market forecasts.** The report, costing $985, is available from IRD, 30 High St., Norwalk, Conn. 06851. **-Vincent Biancomano**

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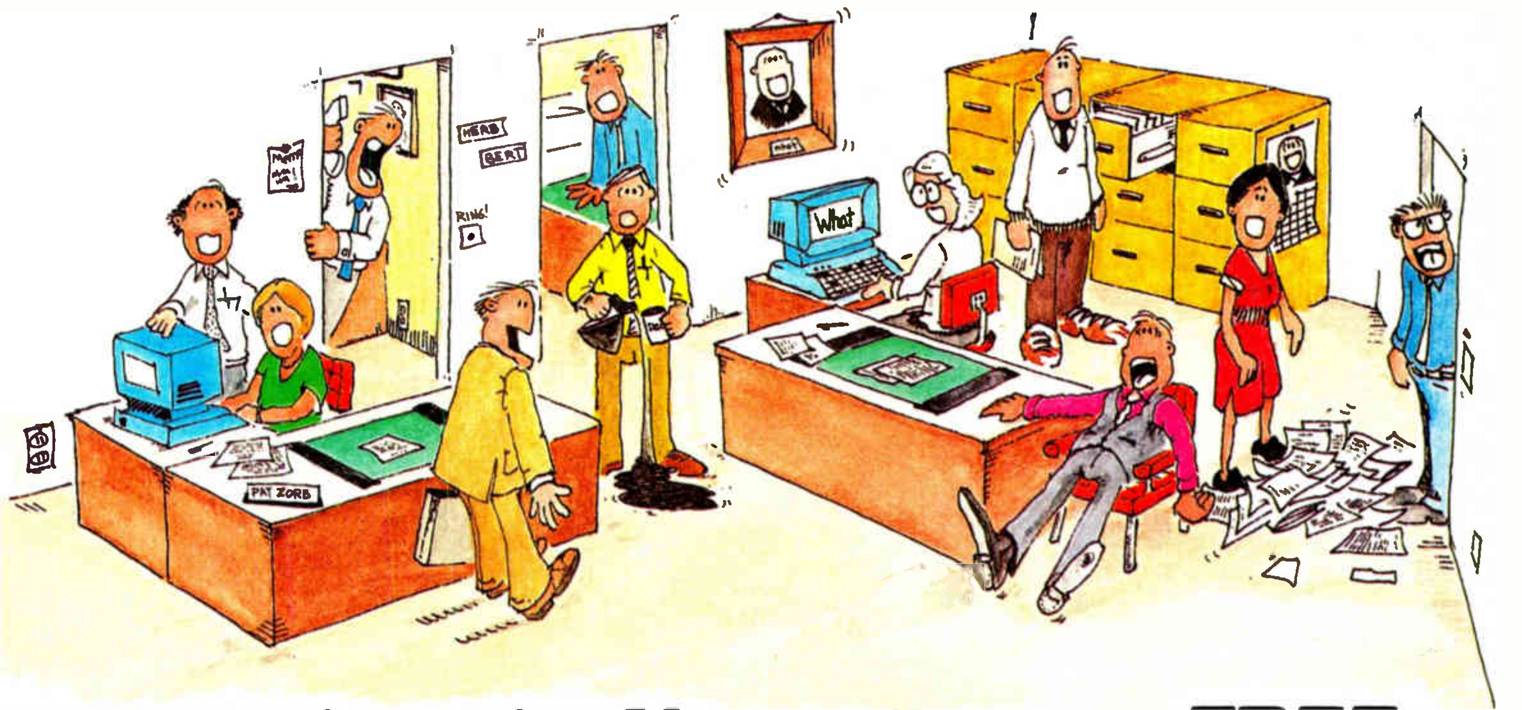

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Short-run fiber-optic link costs $55

5-meter, 10-Mb/s system uses photodiode integrated with TTL-level amplifier and simple plastic connection scheme

by Bruce LeBoss, San Francisco regional bureau manager

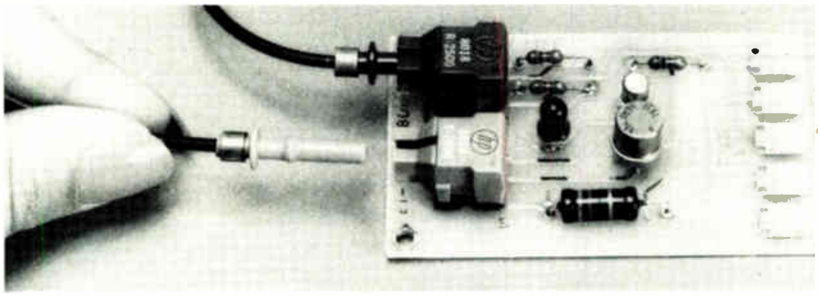
Fiber optics offers systems designers the ability to reduce radio-frequency and electromagnetic noise susceptibility, solve high-voltage isolation problems, and provide secure data communications, among other things. But exploitation of the technology has been limited by the cost and implementation complexity of fiber-optic subsystems. A low-cost short-distance digital data-transmission link promises to go a long way toward opening up the fiber optics market to high-volume applications.

The system, which Hewlett-Packard calls a snap-in fiber-optic link, combines a novel connector with optocoupler and integrated optics technology developed at the company's Optoelectronics division. When used over 5 meters or less, the link has a dc-to-10-Mb/s data rate. "It is intended for low-cost, short intra- or inter-system data links, or to solve difficult high-voltage or low input/output coupling requirements that elude conventional optocouplers and transformers," states product marketing manager Gary LaBelle.

Kit. Priced at $55 in quantities of from 1 to 99, the system is available from stock to four weeks after receipt of order as the HFBR-0500 evaluation kit. It includes fully characterized and specified transmitter and TTL-compatible receiver modules that are guaranteed to operate with the 5 m of 1-mm plastic cable that comes in the kit with connectors already fitted. Two connectors with crimp rings, a polishing kit, and technical literature are also covered by the $55. The kit, name notwithstanding, is intended for more than evaluation: it is designed for easy use in a production environment.

The transmitter module, HFBR-1501, contains a 665-nm gallium arsenide phosphide (GaAsP) light-emitting diode. The LED is die-attached to a copper-alloy lead-frame, LaBelle notes, to "minimize LED junction temperature." The module also contains a small lens to improve light coupling into the fiber.

Integration. The HFBR-2500 receiver module contains an integrated circuit that combines a photodiode and a TTL-compatible amplifier on the same chip. In addition, the IC has an optically transparent, electrically conductive shield over the photodiode and the first few sensitive gain stages to shunt any induced rf interference to ground. "Monolithic construction of the detector, plus this shield, results in a receiver that can withstand fields on the order of 8,000 V/m," LaBelle states, "good enough for most industrial control applications."



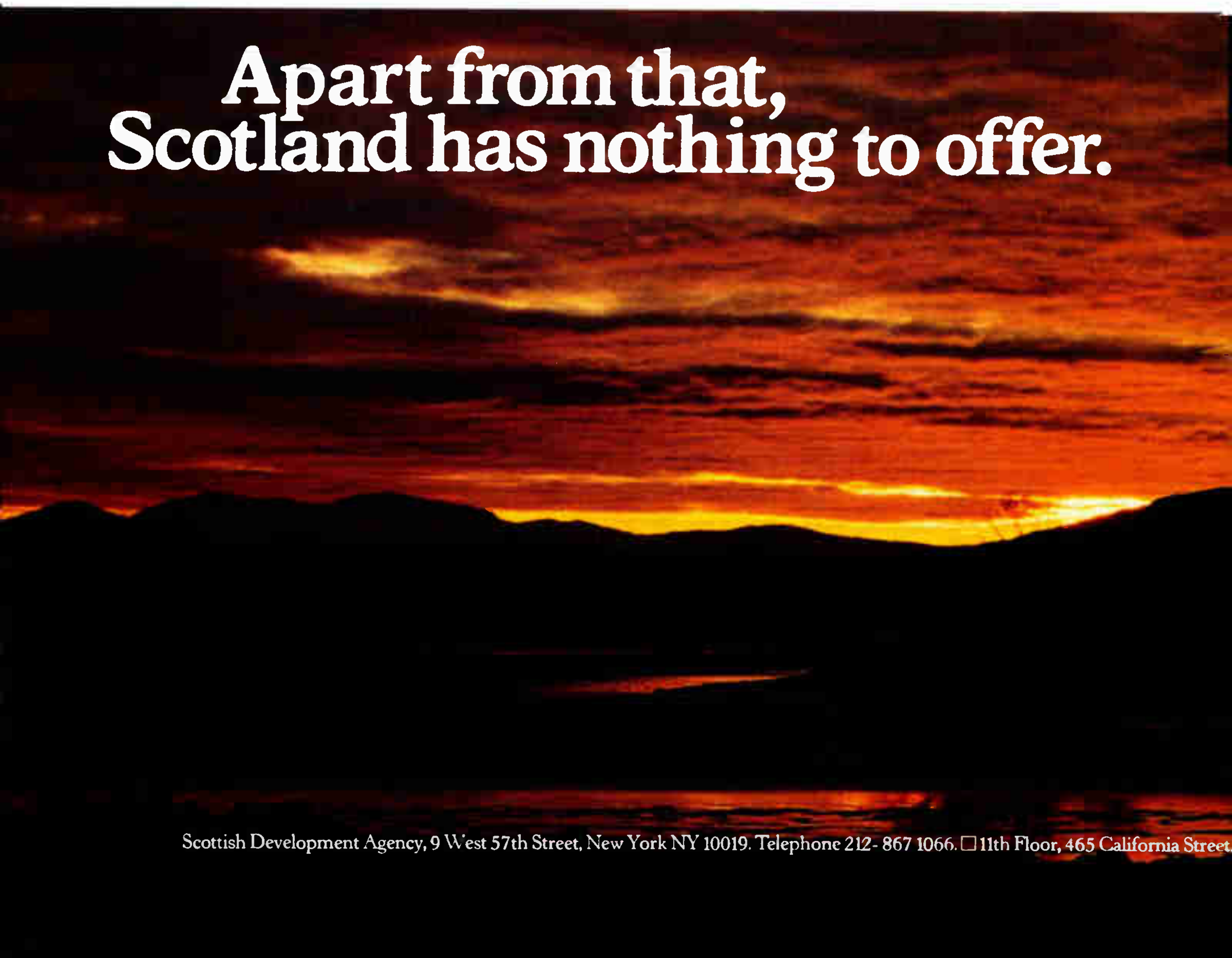
The data link makes use of a snap-in connector that HP designed for easy and fast mounting and connection. The plastic connector was developed specifically for the plastic dual in-line package that houses either the transmitter or the receiver module. Each module has jaws that grip the cable connectors.

Whereas most field termination of fiber-optic cables can be a "time-consuming and frustrating experience for inexperienced users," LaBelle continues, the new connector "was designed for quick installation with a minimum of tools and does not require adhesives."

The fiber-optic link can be used far beyond the 5-m worst-case operation guaranteed. The length is "limited by the dynamic range of the receiver, which is sensitive to being overdriven," LaBelle notes. Lowering the data rate from 10 Mb/s to less than 1 Mb/s extends the length limit to about 20 m. Other approaches, such as temperature compensation and an increase in the fall time of the optical flux input to the receiver, he adds, "allow lengths to be extended several-fold."

The receiver module uses a +5-V power supply, which makes it compatible with the popular TTL families. The propagation delay, both from low to high output levels and vice versa, is 75 ns typically and 140 ns maximum. The operating temperature range of the link is from 0° to 70°C; the storage temperature is from −40° to +75°C.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. [338]



D-a converter chip is linear to 14 bits

Monolithic multiplying digital-to-analog unit costs $33, is monotonic and linear to its full 14-bit resolution

by James B. Brinton, Boston bureau manager

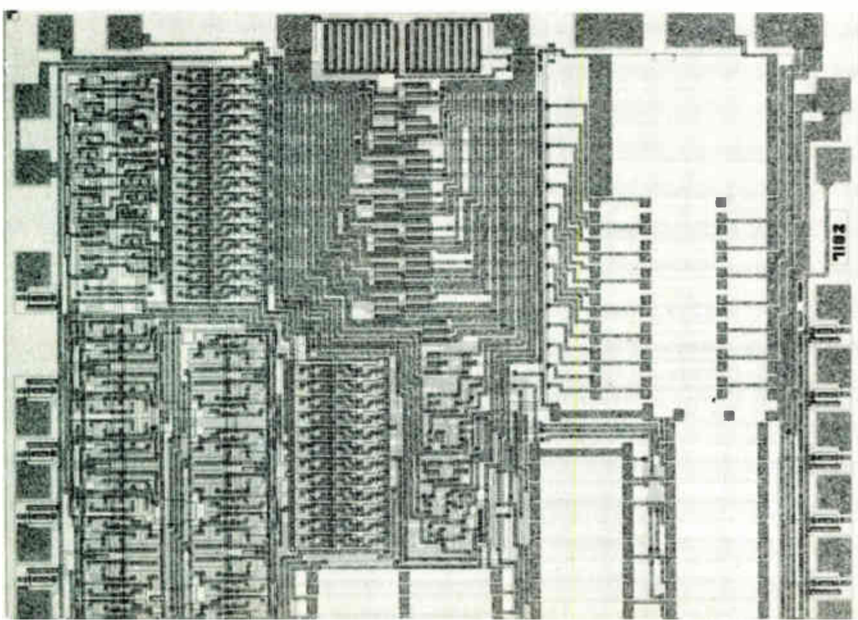
Hybrid Systems' HS3140 has not only raised the technological ante in its market, but also lowered the cost of 14-bit performance. First shown this month at Electronica in Munich, it is said to be the only 14-bit monolithic digital-to-analog converter on the market except for one or two either dedicated to specific applications or still in the laboratory.

A d-a converter's resolution is often greater than its linearity, but the parallel-input HS3140 has 14-bit integral and differential linearity and 14-bit monotonicity. It also costs less than its counterparts—typically hybrid circuits or modules. The HS3140C-4, operable over a commercial temperature range, sells for $39 each, or about 40% less than the going rate for other 14-bit d-a converters. In 100-unit lots, its price falls to $33. Three other HS3140s are available with different linearity and temperature characteristics.

The unit is only the firm's second monolithic offering; its most noteworthy products have been hybrids. But the company has used its in-house monolithic design capability to create the parts for its 12-, 16-, and 18-bit hybrid converters [*Electronics*, Oct. 9, p. 228].

Hybrid Systems got a 14-bit converter onto a single chip by adapting a bit-decoding scheme used in its 16- and 18-bit d-a converters [*Electronics*, June 5, p. 128]. The converter's transfer function is divided into 16 segments, determined by the 4 most significant bits of the word to be decoded. Each segment consists of 1,024 possible voltage levels, which are determined by the 10 least significant bits. The 4 MSBs are digitally decoded to drive 15 matched current sources. Because the current sources are matched, the accuracy requirements of the complementary-MOS switches and the resistor network are relaxed.

A multiplying converter, the HS3140 accepts either ac or dc voltage references over a ±25-V range, multiplies in all four quadrants and has latch-up protection. Its input bias current is less than 1 μA, and its input impedance is 5 kΩ. Scale factor is 200 μA per reference volt; scale factor accuracy is to within better than 1%, worst case. Output leakage over either of the units' two temperature ranges is less than 200 μA maximum. Settling time for a full-scale transition is only 2 μs for the current-output device, and its linearity specifications are conservative.

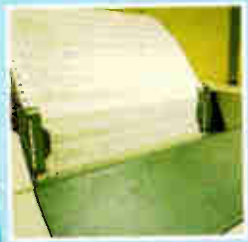


Performer. The HS3140-3 has the same performance for differential as for integral linearity at ±0.006% of full-scale range, typical, and ±0.012% maximum. The HS3140-4 has ±0.004% typical integral linearity and ±0.003% typical differential linearity, with 0.006% of full scale the maximum figure for both parameters. The temperature coefficient of linearity is typically 0.5 ppm/°C and 1 ppm/°C maximum; power supply voltage is +15 V ±5%, but the unit will operate over a +11-to-+18-V supply range. The current requirement is about 2 mA.

The converter is offered in temperature ranges for commercial and military use as the HS3140C and -B, respectively. The firm will bin the parts so that users who need less than 14-bit linearity will be able to buy the HS3140-3 at reduced cost—for example, a unit with 13-bit linearity for the commercial temperature range is $35, $29 in 100-unit lots. The HS3140B-4, with 14-bit linearity, built in conformance with MIL STD 883B and operable over the full military temperature range, costs $108 each and $79 in lots of 100. Housed in a 20-lead ceramic dual in-line package, the HS3140 is available from stock.

Hybrid Systems Corp., Crosby Drive, Bedford Research Park, Bedford, Mass. 01730. Phone (617) 275-1570 [339]

A new measure of protection from AIRPAX



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Semiconductors

$15 chip controls CRT displays

IC uses system memory for screen refreshing without resorting to DMA

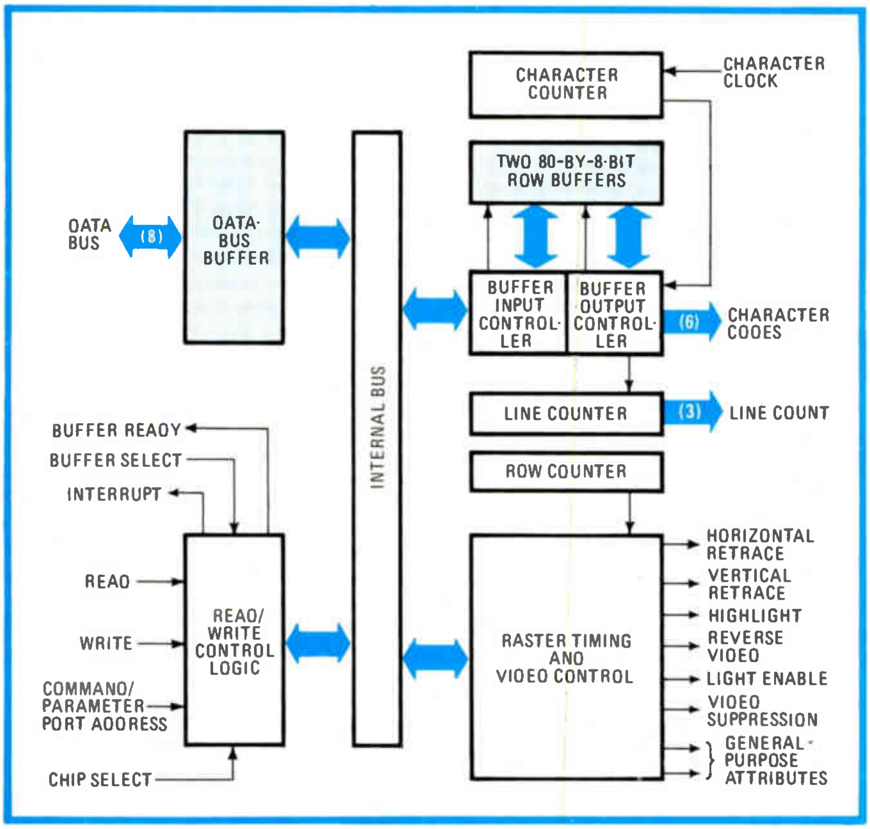
Targeted for cost-sensitive small-system applications such as dumb terminals, the 8276 is designed to interface raster-scan cathode-ray-tube displays with Intel microcomputer systems. The controller chip is priced at $15 in lots of 100 or more, about half as much as the same company's 8275 CRT controller.

The 8275 avoids the need for dedicated screen-refreshing memory with a direct-memory-access facility; the new 8276 omits the DMA feature, as well as others, such as light-pen capability. Instead, the new controller from the company's microprocessor and peripherals operation connects directly to the host system's data bus.

To load screen-refreshing data into the 8276, the system's central processing unit need only read screen data held in system memory and does not have to execute a write command. Thus the 8276 also uses system memory—rather than the dedicated memory most CRT controllers require—for refreshing.

Its dual-buffer architecture "ensures that CRT display throughput remains high without resorting to DMA procedures," according to Donald C. Phillips, manager for peripherals marketing. "Designers can dispense with the DMA circuitry and reduce their chip count."

The dual-buffer scheme allows the next row of characters to be filling one buffer while the other buffer is being used to display the previous row. The resulting rapid transfer of data from memory to the screen helps keep the system bus free for screen editing, keyboard scanning, serial data handling, and other terminal functions.



CRT control. To avoid using either dedicated memory or direct memory access for screen refreshing, the 8276 CRT controller connects to an Intel microcomputer's data bus.

The controller has fully programmable screen and character formats and generates six independent visual field attributes. The six are text underlining, reverse video, highlighted and blinking characters, and two general-purpose, independently programmable field attributes.

The 8276 can program up to 80 characters per row and up to 64 rows per frame. The number of lines occupied by each row of characters, the underline positions, and top and bottom line blanking all are user-programmable, as are the cursor location and format. "This lets users design a large variety of screen and character formats using just the 8276," states Phillips.

Efficient codes. Furthermore, special control codes reduce processor overhead, he claims. For example, an end-of-screen character permits blanking to the end of the screen without modifying memory. Similarly, an end-of-row code activates video suppression and holds it to the end of the line. Two other special codes available are end of row, stop buffer loading; and end of screen, stop buffer loading.

According to Philips, by teaming the 8276 with the 8051, a single-chip 8-bit microcomputer with an on-board Boolean arithmetic processor, designers can reduce the parts count for a CRT display subsystem to about 10 chips. Other Intel microprocessors, such as the 8085A, the 8088 microcomputer, and the 16-bit iAPX 86 "micromidi" system, are fully compatible with the 8276. The controller works particularly well with the 8088, whose string manipulation capabilities can be used to fill an entire row with characters with a single instruction.

Operating from a single +5-V power supply, the 8276 dissipates a maximum of 1 W. The voltage on any pin, with respect to ground, may range from −0.5 to +7 V. Under bias, its ambient temperature range is 0° to 70°C; its storage temperature range is −65° to +150°C. Samples housed in 40-pin dual in-line plastic

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Circle 159 on reader service card

packages are available now. Production quantities will be available in February 1981.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. Phone (408) 987-8080 [411]

DMM chip has reference, digital autozero function

The model ZN450 digital-multimeter integrated circuit requires only eight external passive components for operation. It uses a delta-sigma modulation technique that ensures high linearity and permits zero reading for 0-V input. The autozero function is completely digital. A 3½-digit liquid-crystal display allows full-scale readings to 199.9. The DMM also has an on-chip clock and a precision reference.

In sample quantities, the ZN450 is priced at less than $10 and is available from stock. Volume orders of the chip are available for delivery in 8 to 12 weeks.

Ferranti Electric Inc., Semiconductor Products, 87 Modular Ave., Commack, N. Y 11725. Phone (516) 543-0200 [413]

Subscriber loop interface IC needs no hybrid transformer

The MC3419 is a bipolar, laser-trimmed integrated circuit designed to perform subscriber-loop interface circuit (SLIC) functions in digital telephone switching systems. The SLIC system offers basic functions like battery-line feed and overvoltage and line-fault protection, but unlike traditional SLICs, the unit does not use a hybrid transformer.

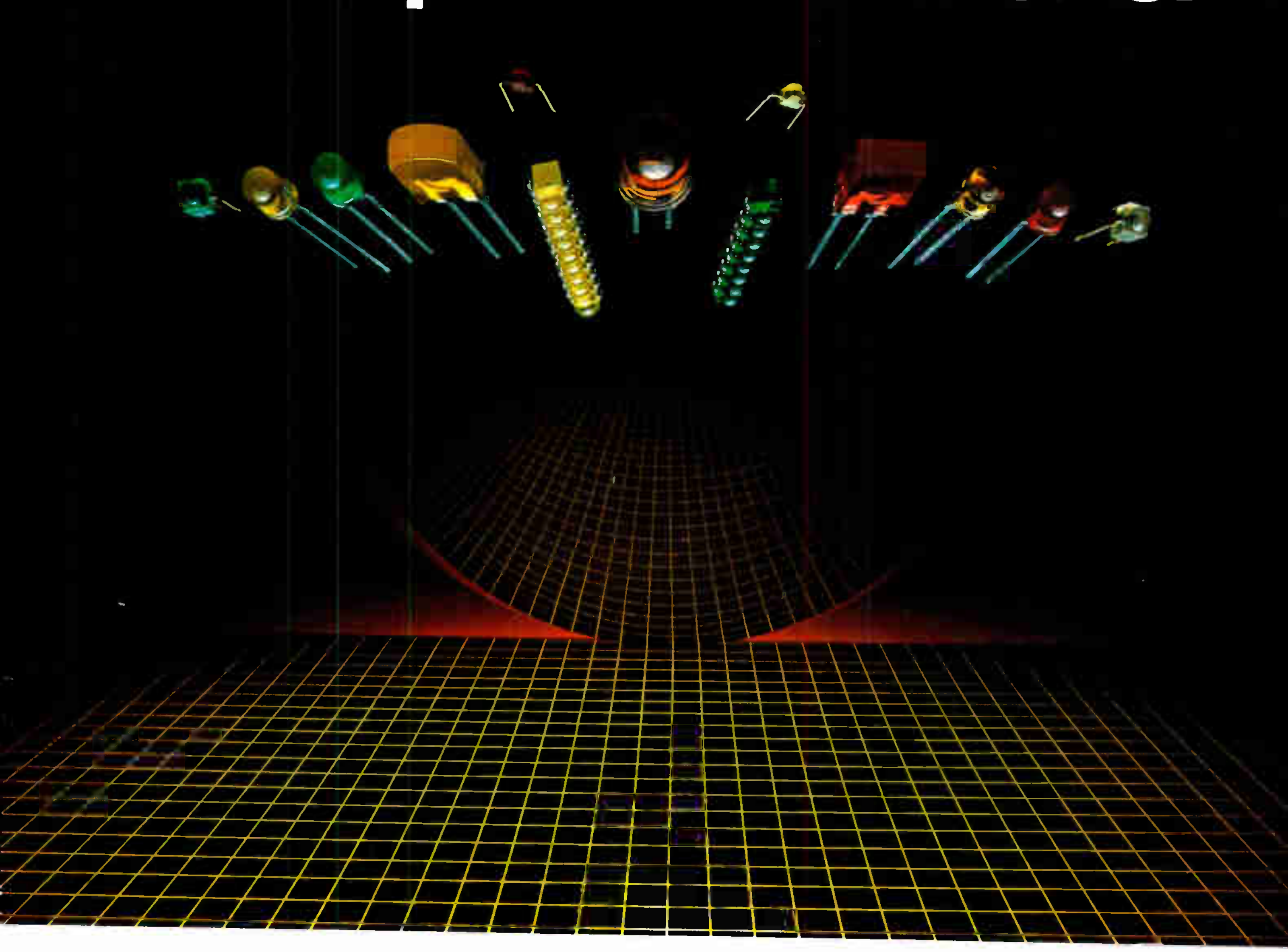
Designed for use in 48-V systems with a maximum operating voltage of 56 V, the MC3419 provides two-wire differential to four-wire, single-ended signal conversion and suppresses longitudinal signals at the two-wire input. The device consumes less than 5 mW in the idle state.

In large quantities, prices range from $3.15 to $8.05.

Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Ariz. [415]

Litronix + Siemens =

A lamp for all reasons.



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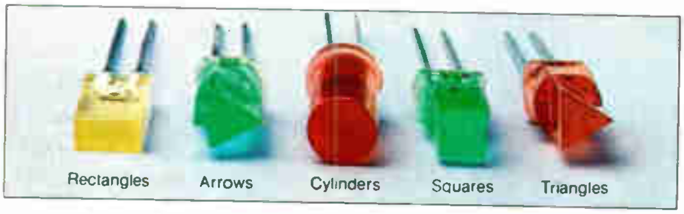

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The Lights Fantastic. Litronix, 19000 Homestead Road, Cupertino, CA 95014. (408) 257-7910.

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Circle 161 on reader service card

New products

Instruments

275-MHz storage scope costs $7,200

Variable-persistence unit writes at 2,000 cm/μs, has fast-repeating sweep

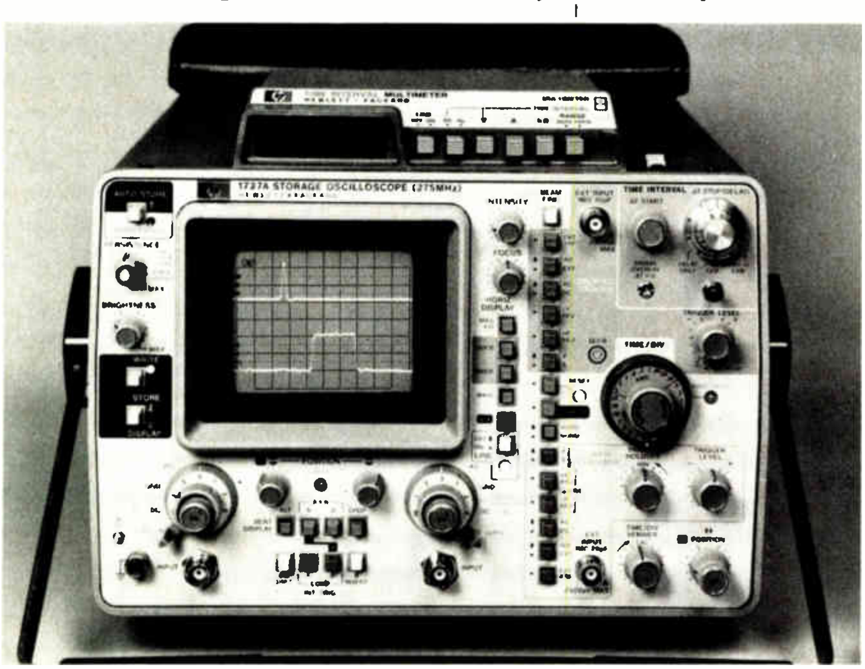
Hewlett-Packard has followed Tektronix across the 100-MHz barrier in pursuit of the market for very high-bandwidth storage oscilloscopes. Its entry is the 275-MHz 1727A, which has a 2,000-cm/μs writing rate, variable persistence, delta time measurement, and an optional digital multimeter. The 1727A joins the only other fast storage scope, the 400-MHz Tektronix 7834, as a much less expensive alternative of monolithic construction.

"A customer should get about the same stored bandwidth performance out of either scope," explains Jim Egbert, product manager for the 1727A at HP's Colorado Springs division. "The specified 400-MHz bandwidth of the 7834 would only be useful when operating in a nonstore mode. The real limiting factor is its 2,500-cm/μs writing rate."

After bandwidth, price must be considered. The $7,200 for the 1727A with probes falls significantly below that of the fully configured Tektronix 7834 with 7A24, 7B85, and 7B80 plug-ins—about $15,000. The 1727A has bistable storage and the flexibility of the plug-ins of the Tek 7000 series line.

The real-time portion of the 1727A is similar to that of HP's 275-MHz 1725A nonstorage scope, but HP designed a new cathode-ray tube to provide storage capability. The deflection plates were made in such a way that the voltage on them varies with the distance traveled by the beam. "Essentially, we turned the deflection plate into a sequence of delay lines, with the delay-line length over each plate section matched to the time of flight of the electrons over that section," notes Egbert. "The linear plates are good up to about 100 MHz, then one has to go to a technology such as this."

The dual-trace 1727A has selectable impedances of either 50 Ω or 1 MΩ. It has a rise time of 1.27 ns and both main and delayed sweeps with ranges from 1 ns/division to 20 ms/division. The unit's dual markers can be used in conjunction with its time-interval measurement function to digitally display intervals with an accuracy of ±0.5%, plus 0.05% of full scale. Though the scope's vertical accuracy is ±3%, the inclusion of a three-digit DMM increases that accuracy to ±0.5% of reading plus 0.05% of full scale.



Unlike the Tektronix 7834, the 1727A does not go to a reduced scan mode in order to obtain its fastest writing rate. The 7834's CRT is a little larger, however, with 0.9-cm divisions, compared to 0.72-cm divisions for the 1727A.

Automated. The 1727A has automatic store, erase, and intensity features. The auto-store mode is used for single-shot events. It automatically sets the persistence control for maximum retention time and selects the normal triggering mode; then, after the event is captured, it automatically switches to the store mode for maximum storage time.

The auto-erase is a repetitive single-shot mode that gives the user an easy means of setting focus, intensity, and trace positioning in preparation for single-shot events. The view time between erase cycles can be adjusted from 1 to 13 seconds to provide a series of stop-action snapshots of trace activity.

The scope's variable persistence gives it the ability to write traces repetitively at the input-signal repetition rate or the time-base duty-cycle rate, whichever is slower. This means that in scanning repetitive signals for spurious signals, the 1727A misses fewer cycles. In the transfer-storage technique used on the Tek 7834, it takes about 1 second to bring a sweep from the fast mesh to the longer-persistence mesh, so more sweep repetitions are missed between cycles. The 1727A uses only one mesh, so the delay associated with transfer storage is eliminated.

Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, Calif., 94304 [351]

Universal programmer takes on 240 memories

The Smarty II universal programmer for erasable programmable read-only memories can program 240 E-PROMs at once. It does that by

Choose from TI's line of A/D converters to meet your cost/performance goals.

TI's line of A/D converters offers you a simple, versatile and cost-effective design solution. A solution for use with discrete logic or microprocessors. A solution to help you meet the demands of even your most demanding applications.

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ADC0808/09/16/17 Series

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TL507 Converter

At $0.66* it's our lowest cost converter. Single-slope for use with TI's TMS1000 and virtually all microprocessors. I²L technology makes it possible to offer this monolithic chip at such low cost, and in a small 8-pin DIP. 7-bit resolution, 1-ms conversion speed, single supply operation and 25-mW (typ) power consumption at 5 V are more good reasons to design in TL507.

TL500 Series

Converter systems consisting of analog and digital processors, as follows:

- TL500/TL501 analog processors . . . TL500 is a high-performance converter for high accuracy applications with features such as:
  - full 4½-digit accuracy
  - 0.005% linearity
  - automatic zero and polarity
  - high input impedance — 10^9 Ohms (typ)
  - use with TL502 for complete 4½-digit system

TL501 is a low-cost converter with all the features of TL500 except accuracy is 3½ digits, linearity 0.02%.

- TL502/TL503 digital processors . . . TL502 logic control interface is designed for use with TL500, TL501 or TL505 converters and drives common anode 7-segment displays such as TIL321. Single 5-V supply, 20-mA digit-base drive outputs and 100-mA internal segment drivers round out a long list of features and functions. TL503 controller shares TL502 features, except TL503 offers BCD outputs.

TL505 Converter

A low-cost, dual-slope converter for high volume applications, TL505 is ideally suited for use with TMS1000 and most microprocessors, and/or TL502/TL503 digital processors, 3-digit (0.1%) accuracy, high impedance MOS input, automatic zero and single supply operation — and more.

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slaving up to 15 gang-programming units, each of which handles 16 memories, to its personality module. The $2,995 unit can also be used in a single-socket, stand-alone mode in the engineering lab. It can program 28-pin devices and single- or triple-voltage 24-pin memories, including PROMs, E-PROMs, electrically erasable PROMs, field-programmable logic and gate arrays, programmable array logic chips, programmable multiplexers, and microprocessors with on-board PROM, like those of the 8748 family. It can program a wide variety of different memory types, including the 2704, 2708, 2758, 2716, TMS 2716, 2732, 2732A, Intel's and Mostek's 2764, Motorola's MCM68764, and TI's 2564.

The Smarty II comes with a 64-K random-access memory for data, formatted as 8-K by 8 bits and extendable to 56-K by 8 bits. It also has a built-in 8-K-by-8 ROM/PROM simulator. The unit can be controlled either by two-keystroke commands from its own 20-key keyboard or by three-keystroke commands from a dumb terminal or computer. It can be interfaced through a 20-mA current loop or parallel, RS-232, or paper-tape interfaces. Transmission rates are switch-selectable from 50 to 9,600 b/s.

A Braemar microcassette tape drive, at $695, is optional. It will record up to 16 programs, each containing 2-K by 8 bits and recorded with a four-character code name for separate accessing.

The Smarty II also includes a full RAM editor, which allows the user to list, insert, replace, and move data; find its complement; perform nibble shifts; and check sums. Six-digit checksums can be displayed, as can six-digit hexadecimal inputs.

Sunrise Electronics Inc., 524 S. Vermont Ave., Glendora, Calif. 91740 [352]

Analyzer checks compliance with FCC emi regulations

In response to the rapidly growing need for instruments that measure electromagnetic interference, Penril has designed the model CPR-25 interference analyzer for determining compliance with the newly proposed standards of the Federal Communications Commission (Docket 20780). The CPR-25 also includes all instrumentation characteristics for emi measurements as specified by the Comité International Spécial des Perturbations Radioélectriques (CISPR) and the Verband Deutscher Elektrotechniker (VDE) and for quasi-peak measurements as specified by the American National Standards Institute (ANSI). The latter capability helps detect emi due to digital pulse trains.

Liquid-crystal-display digital readouts show attentuation setting and tuned frequency to an accuracy of ±0.1% over the instrument's entire range of 10 kHz to 1 GHz. Circuits detect peak, average, and root-mean-square levels and ratios for display on the 80-dB front-panel meter or for single- or dual-pen X-Y plotting. Video response over each octave can be presented on any conventional or storage oscilloscope to create a tuned front-end spectrum analyzer. The CPR-25 will be available for delivery in 90 to 120 days at a price of $27,900.

Electro-Metrics Division, Penril Corp., 100 Church St., Amsterdam, N. Y. 12010. Phone (518) 843-2600 [353]

16-channel filter can be programmed via a GPIB

The system 716 programmable multichannel Brickwall filter is a low- and high-pass filter that links with the General-Purpose Interface Bus (IEEE-488). Its 16 channels exhibit nearly flat passband responses, yet each provides a rolloff of better than 115 dB per octave. The member of the Brickwall family, first introduced at Electro in 1979 [*Electronics*, April 12, 1979, p. 182], has cutoff frequencies varying between 1 Hz and 100 kHz. The filter's channels can be used independently or in series. Its memory stores 16 groups of cutoff frequencies and gain settings. In addition, the instrument has overload protection, two-digit resolution, and a dynamic range of 80 dB.

A system 716 mainframe costs $5,000, and cards sell for $1,400 apiece. Deliveries take 16 weeks.

Wavetek Rockland Inc., Rockleigh Industrial Park, Rockleigh, N. J. 07647 [355]

Radio-frequency voltmeter is controlled by microprocessor

The model 9200 rf millivoltmeter is controlled by a microprocessor for automatic zeroing and ranging. The instrument's voltage sensors have a sensitivity of from 200 μV to 3 V over the frequency range of 1 kHz to 1.2 GHz. The rf voltage can be displayed in millivolts, dBV, dBmV, dB relative to any arbitrary reference, or dB relative to 1 mW across any impedance between 50 and 600 Ω.

An IEEE-488 bus option can be installed in the field for $375. With one voltage probe, the 9200 costs $1,900. A second channel with an additional probe is $500, and a rechargeable battery is available for $495. Delivery takes 12 weeks.

Boonton Electronics Corp., Parsippany, N. J. 07054. Phone Wallace White at (201) 887-5110 [356]

"Circle number 165 for literature"
"Circle number 141 to have a representative call"

Data acquisition

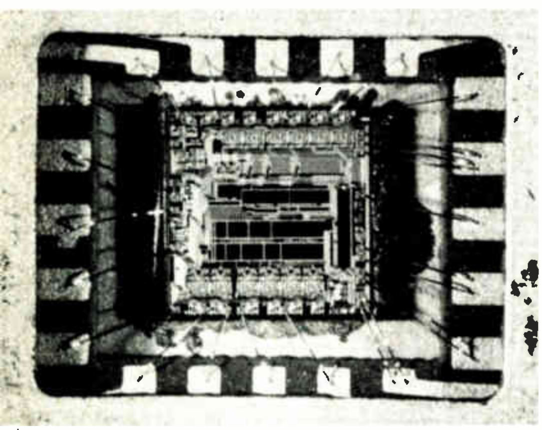
8-, 12-bit d-a chips dissipate 20 mW

C-MOS d-a converters have double-buffered 8-bit inputs for easier system updating

More often than not, system designers are willing to pay a premium for complementary-MOS devices that consume less than one tenth the power of their bipolar counterparts. Three series of C-MOS digital-to-analog converters from National Semiconductor consume a mere 20 mW, typically. They are easier to interface with microprocessors at a much lower cost than similar bipolar devices, claim their developers.

Fabricated using a proprietary silicon-chromium C-MOS technology, the new monolithic multiplying d-a converters are designed for direct interfacing with the 8080, 8048, 8085, Z80, and other popular microprocessors. They "particularly satisfy the need for low-cost microprocessor-compatible d-a converters in high-volume, cost-sensitive applications" such as servo controls, programmable gain amplifiers, and synchro-to-digital converters, states product marketing manager David Whetstone.

The DAC0830 series of 8-bit devices is available with 8- (0832), 9- (0831), and 10-bit (0830) linearity options guaranteed from 0° to 70°C and are priced at $4.50, $6, and $7.50, respectively, in 100-piece quantities. A higher-precision 12-bit DAC1230 series, available with 12- (1230), 11- (1231), and 10-bit (1232) linearity options, is priced at $15.75, $12.95, and $11.75, respectively, in like quantities.



Input lines. The 1230 series can be used with an 8-bit data bus directly, as it has eight input lines and puts the 12-bit word together internally. A second 12-bit family, the DAC1208 series, has 12 input lines to allow single buffering and maximum throughput when used with 16-bit processors. At the 100-piece level the 1208 (12-bit linearity), 1209 (11-bit), and 1210 (10-bit) converters are priced at $17.75, $15.75, and $14.75 each, respectively. All the 12-bit converters are specified for operation from −40° to 85°C.

Unlike most competitive single-buffered units, says Whetstone, all the new d-a converters are double-buffered and load in 8-bit bytes. This allows them to put out a voltage corresponding to one word while holding the next word, thus "permitting the simultaneous updating of any number" of converters, he says.

National's Micro-DACs, as they are called, are guaranteed to be monotonic—that is, there will be no decrease in output voltage for an increasing digital input command. Monotonicity is offered by other suppliers only on premium parts, says Whetstone, but "we're offering it on all parts, and specified over the full temperature range."

The converters all have a guaranteed differential nonlinearity specification of ±½ least significant bit. Linearity is specified with the only adjustments left for the user those for the zero and full-scale points. This is in contrast with most—if not all—other linearity specs, which "are based on 'best-fit' straight lines," according to Whetstone. End-point linearity-error specification, as the National approach is called, "simplifies the adjustment procedure that the customer must do in a production environment to attain the specified linearity."

Designed to operate from a single +5 to +15-V power supply, the d-a converters have logic inputs that are TTL-compatible over the full temperature range. This compatibility, Whetstone points out, is "achieved through use of special on-chip biasing circuitry that makes use of the parasitic npn bipolar transistors inherent in the C-MOS structure."

The converter family's interchangeability allows system designers to go easily from 8- to 12-bit chips without any board or microprocessor-programming changes. For example, the 8-bit 8030 and 12-bit 1230 series both fit in a standard 20-pin (0.3-in.) package and use the same pinouts. "This leaves an easy way to make running changes in converter specifications and performance as a new system is being developed," Whetstone says, "and supports performance options in the customer's system." By contrast, the 1208 series, which is tailored for applications using 16-bit buses, is housed in a larger (0.6-in.) 24-pin package. All are available from stock to 30 days after receipt of order.

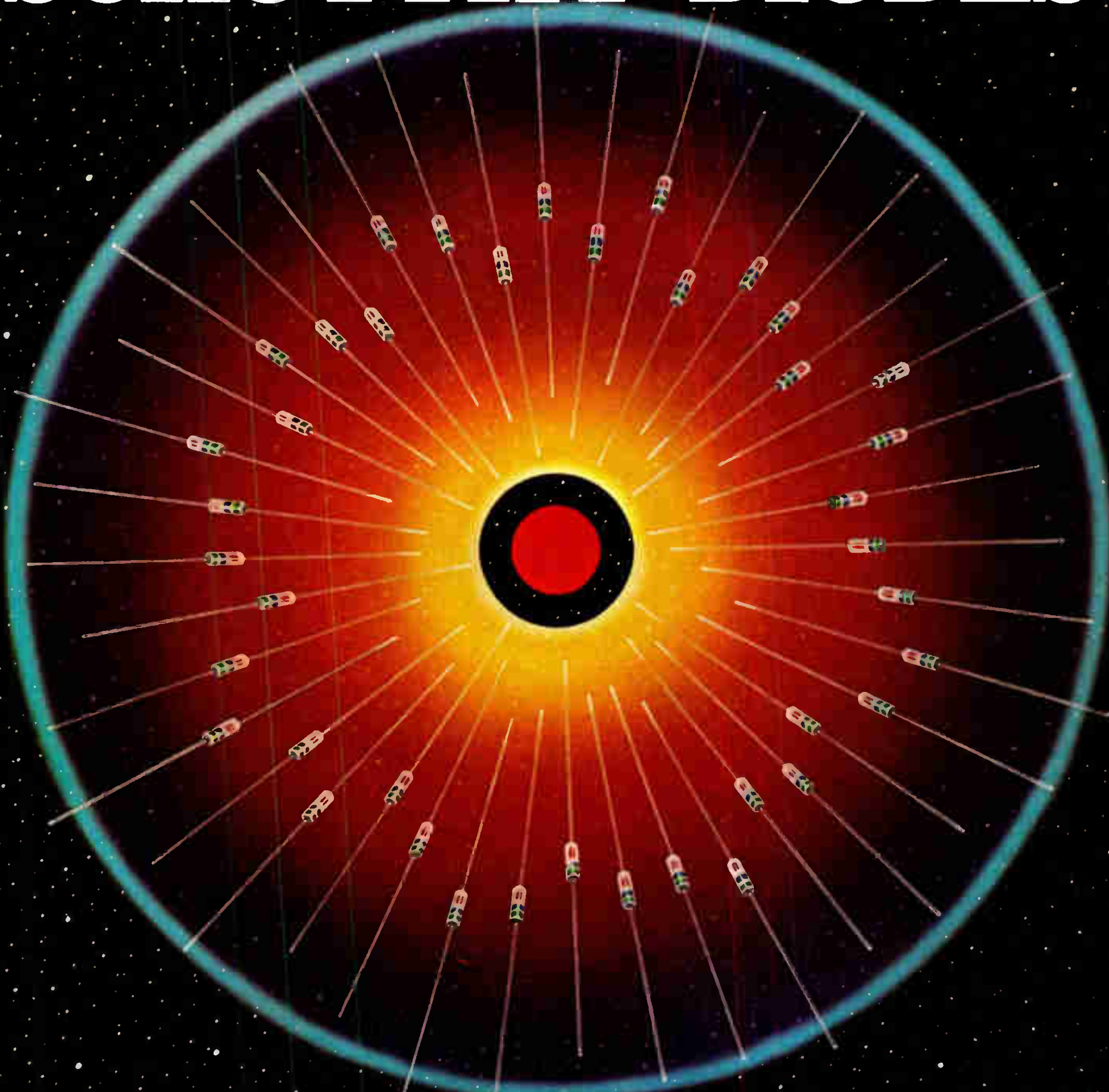
National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif., 95051. Phone (408) 737-5000 [381]

10-bit d-a converter settles typically in 200 ns

The DAC-101 monolithic 10-bit digital-to-analog converter has a typical settling time of 200 ns. The device consumes 200 mW typically, operating over a supply range of ±6 to ±18 V. It directly accepts diode-transistor-logic and TTL inputs and may be easily adapted to accept complementary-MOS logic.

The converter comes in three linearity grades that are priced accordingly. The DAC-101EQ with a maximum nonlinearity of 0.1% of full scale is $12, the FQ version with a 0.2% nonlinearity is $7.50, and the GQ with a 0.3% rating is $6. All models are available from stock.

Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, Calif. 95050. Phone Bill Pascoe at (408) 246-9222 [385]



Industrial

Transmitters hold error to ±0.1%

Current-loop transmitters adjusted for thermocouples can be easily recalibrated

Two flexible, low-cost thermocouple temperature transmitters convert 5-to-100-mA inputs from industry-standard J-, K-, or T-type thermocouples into a 4-to-20-mA output for standard current loops. These two-wire devices can be field-calibrated for the various thermocouple types and for temperature measurement that ranges from −100° to +1,000°C, depending on type.

The 2B52A uses transformer coupling to maintain input-to-output isolation of 600 V. Common-mode rejection is 160 dB at 60 Hz. The 2B52A costs $160 in lots of 100, while the functionally equivalent but nonisolated 2B53A is $114 in 100s. These prices undercut those of competitive devices by about 25% to 30%, figures Janusz S. Kobel, marketing manager for signal-conditioning products at Analog Devices.

Both transmitters have internal filtering circuitry to minimize the effects of radio-frequency and other electromagnetic interference. Both also feature internal cold-junction compensation, sensing temperature at their input terminals and so eliminating errors due to temperature gradients between these terminals and internal circuitry.

Stability. Total output error, including the effects of transmitter repeatability, hysteresis, and linearity, is to within ±0.1% of the transmitters' 16-mA current-output span over the full operating temperature range of −30° to 85°C. Stability of zero, depending on operating temperature, is to within between ±0.015 and ±0.06°/°C; stability of the current-output span is to within ±0.005%/°C.

Response time to 90% of output span is 0.3 second in the 2B52A and 0.1 second in the 2B53A. Both operate with unregulated power supplies ranging from +12 to +60 V dc and use the same wiring for both power and output. They send current signals over conventional copper wire to remote receivers, eliminating the need for long runs of ultralow-resistance thermocouple wire. Further, users can bypass the devices' cold-junction compensation circuitry in applications such as strain-gage measurement that require direct millivolt readings.

One board. Analog Devices will calibrate both transmitters for common J-, K-, and T-type transducer measurement ranges, but users can recalibrate the units in the field. Kobel expects the price of the 2B52A and 2B53A, along with their easy recalibration for differing inputs, to make them attractive to original-equipment manufacturers of monitoring and process-control systems. Their low cost and reliable performance, he adds, come in part from their single-circuit–board design; most competing products use twin-board construction.

The 2B52A and 2B53A come in protective metal cases measuring 4 by 3.26 by 1.26 in. and have screw-terminal input and output connections. They can be either surface-mounted or mounted on standard relay racks. Evaluation samples are available from stock. Delivery times for large orders are quoted on an individual basis.

Analog Devices Inc., Route One Industrial Park, P. O. Box 280, Norwood, Mass. 02062. Phone (617) 329-4700 [361]

Digital panel meter doubles as industrial controller

Inside the IMC 85-910 intelligent meter is an 8085A microprocessor, so when the digital panel meter is supplied with an optional keyboard it becomes a complete interactive industrial control and display station. System software is the 8085A instruction set; support packages and custom programming are available.

The memory consists of an 8-K-by-8-bit erasable programmable read-only memory, a 1-K-by-8-bit complementary-MOS random-access memory with a 10-year battery, and an additional 512-by-8-bit RAM. Two programmable counter-timers and four interrupts allow the control and monitoring of high-speed events in real time. The unit also includes a digital tachometer interface, a serial communication channel, and 40 buffered input/output lines that include 14 optically isolated inputs. It also has an eight-character, 0.54-in.-high alphanumeric display. The optional keyboard has 32 keys and eight status light-emitting diodes.

A basic 85-910, without options, sells for $795 in quantities of one to nine and $635 in quantities of 25 to 99. Small quantities can be delivered off the shelf.

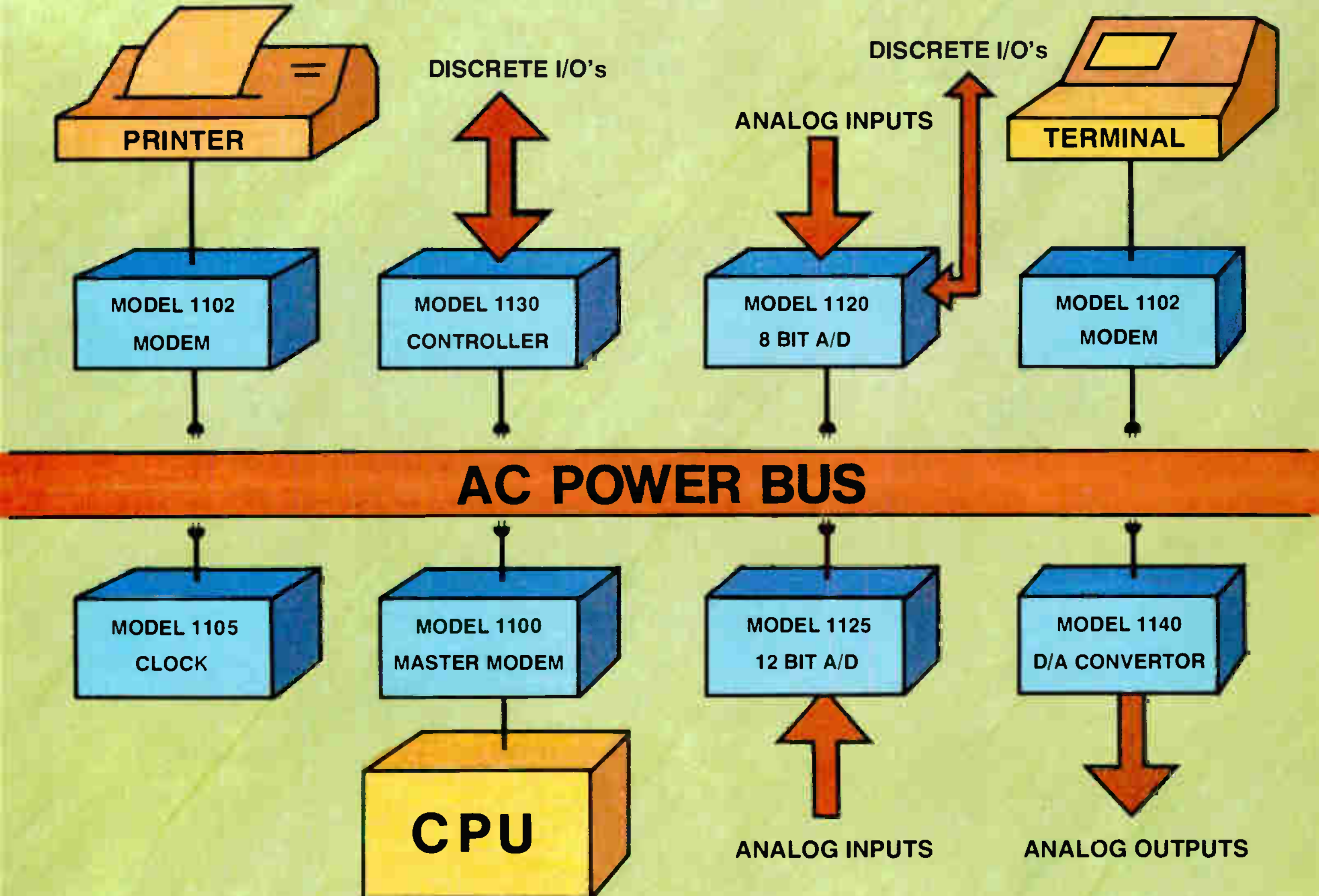
Comptrol Inc., 9505 Midwest Ave., Cleveland, Ohio 44125. Phone (216) 587-5212 [363]

Digital process monitor needs no terminals, programs

The series 079 digital process monitor can process a variety of inputs, perform mathematical operations, make logical decisions, and then provide output signals for display, alarm, and control of industrial processes, so that no cathode-ray-tube or teletypewriter terminals are needed. Each monitor is configured to user specifications at the factory and requires no programming by the user. Its output can be in the form of light-emitting-diode readouts, relays, status LEDs, analog signals, or communications links to other computers. The monitor accepts analog inputs and those from tachometers, accumulators, thumbwheel switches, and switches housed in dual in-line packages.

The 079 consists of a front panel with displays and switches, an Intel MCS-48–based processing section, and any number of input/output cards. Currently available are: a four-channel tachometer card, a two-channel tachometer card, an

POWER MODEM™ series 1100
data acquisition and control made easy



- Multipoint network capability.
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Model 1100 Master/Slave $139.00
Model 1102 Addressable Slave $199.00
Model 1120 Addressable 6 Channel A/D $199.00
For prices and availability on other models contact BTA.

Circle 169 on reader service card

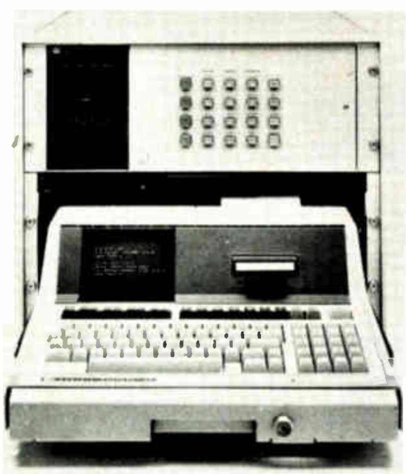
BAY TECHNICAL ASSOCIATES, inc.
HWY. 603, P.O. BOX 387
BAY ST. LOUIS, MISSISSIPPI 39520
(601) 467-8231

accumulator card, an analog card, a relay card, a communications card (RS-232), and a DIP switch card. Since the monitor is customized for the user, prices vary according to configuration and may range from $3,000 to $10,000.

Airpax, North American Philips Controls Corp., Fort Lauderdale Division, 6801 W. Sunrise Blvd., Fort Lauderdale, Fla. 33313. Phone (305) 587-1100 [364]

Data logger measures, computes, and analyzes

The model 3054DL data logger not only measures accurately for data logging but also has full computational and analysis capabilities. The unit consists of a 5½-digit scanning digital voltmeter, a low thermal scanner (multiplexer), an ohmmeter, a current course, a real-time clock,



and an IEEE-488 interface. All this is packed into a 16-in.-high cabinet that has a sliding drawer to accommodate an HP 85F computer. The 3054DL uses the computer to control the data logging, but the 85F can also be used as a separate computer when it is not logging.

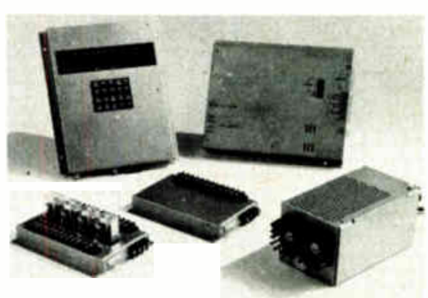
The autoranging voltmeter in the 3054DL makes precision low-level measurements in the presence of noise. Resolution is 10 ppm, accuracy is to within $\pm 0.007\% + 1$ count, and sensitivity is 1 μV. Resistance resolution is 1 mΩ, and temperature resolution is 0.1°C. Noise rejection is greater than 150 dB for common-mode rejection and greater than 60 dB for normal-mode rejection. Up to 100 analog channels (20 per card) or up to 80 digital input/output slots (16 channels per slot) are available with plug-in assemblies. There are three levels of data-logging software: a menu-driven entry level; line-entry instructions to test for limits, print data, and close relays when limits are exceeded; and operator-written computer programs.

The U. S. price starts at $8,455 depending on the number of options selected. Deliveries will begin in January 1981.

Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, Calif. 94304 [365]

Control system can be configured for under $200

With the 800 series family of electronic control modules, an original-equipment manufacturer can configure a complete automation and machine-control system for less than $200. The modules have been designed as direct replacements for electromechanical devices like cam programmers, stepping switches, and drum timers. The family includes a control module that is capable of driving eight output devices; these are expandable to 40. An array of output modules drives a wide variety of ac and dc devices. A time module synchronizes system operations to time of day and a power module provides power for the entire system.



Delivery is from stock.

Control Technology Corp., 82 Turnpike Rd., Westboro, Mass 01581. Phone (617) 366-9668 [366]

Components

On-resistance of power FETs drops

Increased die area gives improved ratings to Hexfets in 150- to 500-V range

Sixteen power MOS field-effect transistors, some of them with very low on-state drain-source resistances, are being added to International Rectifier's line. Six of the devices are rated at 500 V, six at 450 V, and two each at 200 and 150 V. They are listed in four series of four sequentially numbered units each, the first of which are designated IRF250, -420, -450, and -820.

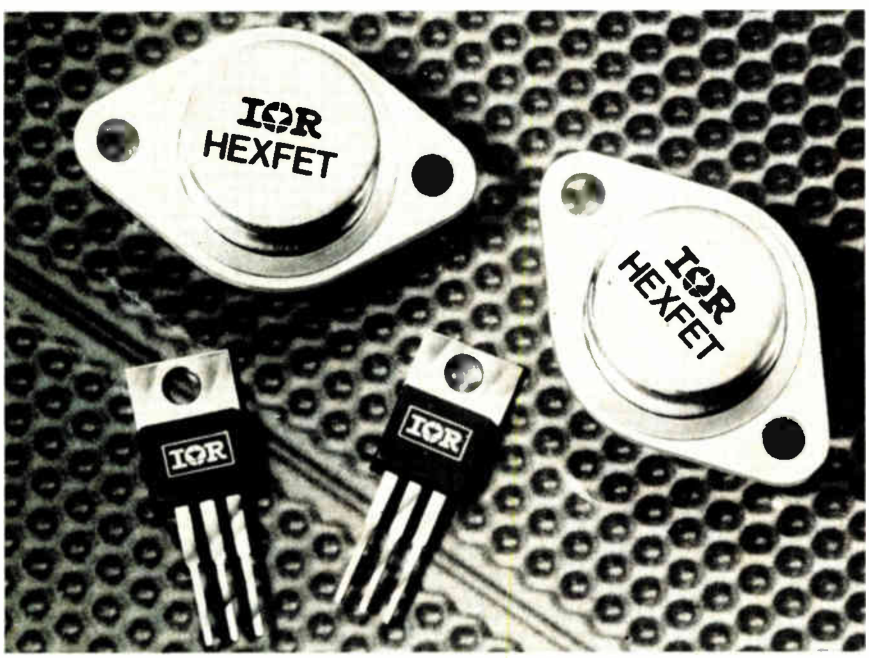
Claimed by the firm to have the lowest on-resistance of any 500-V MOS FET available is the 0.4-Ω IRF450, rated at 10 A and costing $75.24 in 100-unit lots. This performance is a result of further work with the company's Hexfet manufacturing process, which uses many hexagonal source-cell structures (500,000/in.^{2}) along with double-diffused silicon-gate technology and began yielding 500-V MOS FETs in volume just under a year ago [*Electronics*, Dec. 20, 1979, p. 126].

To obtain lower on-resistance ratings, the firm has increased die sizes: the IRF450 chip is 250 mils on each side. This is about four times the area of earlier 500-V devices, which were fabricated on 100-by-180-mil chips.

Standouts. The 16 devices include a number of standouts: a 200-V, 20-A FET with 0.085-Ω on-resistance priced at $57.80 in 100-piece lots (IRF250); a 3.0-Ω, 2.0-A, 500-V unit in a TO-3 package for $13.38 in 100s (IRF420); and a 3.0-Ω, 1.5-A, 500-V transistor in a TO-220 package for $11.16 (IRF820).

International Rectifier expects the 500-V devices to be of particular interest to designers of power supplies for European operation from 220-V power lines, since they can safely replace the 800-V bipolar transistors often used in these supplies. Parts with 450-V ratings can give switching power supplies and motor controls an increased voltage margin in noisy electrical environments, the company says. Audio amplifiers are a major application for 200-V devices.

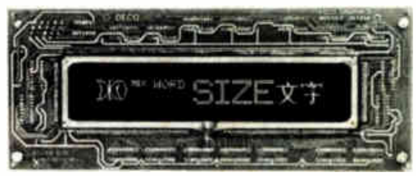
The 16 new FETs, which are available now, bring the line of n-channel power MOS FETs to a total of 80 (p-channel units are also available). Hexfet devices with higher ratings are under development.



International Rectifier Corp., Semiconductor Division, 233 Kansas St., El Segundo, Calif. 90245. Phone (213) 772-2000 [341]

Vacuum fluorescent display creates custom characters

The M26x256 graphics display module can vary alphanumeric characters to create custom sets of characters (including Arabic), symbols, graphics, and waveforms when operated under software control. The vacuum-fluorescent unit is capable of turning on or off any single dot in



the entire matrix, which is 26 dots high by 256 wide. Each byte address can be randomly accessed in less than 10 µs, and the entire screen updated in about 10 ms. Left-to-right and right-to-left scrolling are hardware-controlled, and vertical scrolling can be performed under user software control.

Measuring 11.9 by 4.7 by 2.4 in., the module contains all necessary drive, refresh, buffer memory, and interface electronics and requires only +5 V dc at 1.5 to 2.0 A. It is priced at $520 in quantities of 100, and has a 60-day delivery schedule, starting in December.

Chemetrics Corp., Digital Electronics Division, 197 Airport Blvd., Burlingame, Calif. 94010. Phone Robert F. Wallock at (415) 342-8333 [343]

Aluminum vies with tantalum in electrolytic capacitors

Designed to compete both in size and performance with tantalum capacitors, the US-A series of radial-lead miniature aluminum electrolytic capacitors offers low leakage and a

Test drive our high performance compact.

Over 20 million Aromat NF relays in use... built for high performance, with a low profile that's perfectly suited for the busy traffic patterns of today's high density PC boards.

Responsive handling is the key to the NFEB's reliability, with shock absorbing construction to assure smooth long lasting performance.

Aromat was the pioneer in plastic sealed relays over 10 years ago, and is now producing the NFEB in the U.S. Extensive test data, gathered here and abroad, prove the dependability of these relays.

NFEB Amber Relay

SPECIFICATIONS

Contacts
Arrangement 2, 4C
Rating resistive load
  Max. switching power 60W 100VA
  Max. voltage .... 220V AC/DC
  Max. current 2A
UL rating .... 0.5A 125V AC, 2A 30V DC
VDE rating .... 1A 65V AC, 2A 30V DC
Expected life, min. operations
  Mechanical .... NF2/3 x 10^8, NF4/10^8
  Electrical (2A 30V DC Resistive) .... 10^6
  (1A 30V DC Resistive) .... 5 x 10^6
Initial contact pressure .... approx. 8.5g (0.3 oz)
Contact bounce .... approx. 1.5 msec.
Contact material
  Movable contact .... Gold-clad silver
  Stationary contact .... Gold-clad silver
  For telephone circuit applications gold-clad silver-palladium type is available rated 0.1A 50V DC 10 x 10^6 operations
Initial contact resistance
  Maximum .... 50 mΩ
  Typical .... 25 mΩ

Coil
Min. operating power (at 25°C) .... approx. NF2/150mW, NF4/240mW
Nominal operating power (at 25°C) .... approx. NF2/300mW, NF4/480mW
Max. operating power for continuous duty .... approx. 1W at 40°C 104°F

Characteristics (at 25°C, 50% R.H. sea level)
Max. operating speed .... 50 cps
Operate time .... approx. 10 msec.
Release time .... approx. 5 msec.
Electro static capacitance
  Contact/Contact .... approx. 4 pF
  Contact/Coil .... approx. 7 pF
  Contact/Ground .... approx. 6 pF
Breakdown voltage
  Between open contacts 750Vrms
  Between contact sets 750Vrms
  Between live parts and ground 1,000Vrms
  Between contacts and coil 1,000Vrms
Initial insulation resistance .... 1,000MΩ at 500VDC
Ambient temperature .... −40 to +65°C, −40 to +149°F
Shock/Vibration resistance
  Deenergized condition .... 8G/8G 55 cps.
  Energized condition .... 20G/20G 55 cps.
Unit weight .... approx. NF2/14g (0.5 oz.) NF4/16g (0.6 oz.)

Specifications for MBB contact types
Expected life, min. operations
  Electrical (1A 30V DC Resistive) .... 10^6
Breakdown voltage
  Between open contacts 200Vrms
All other characteristics are the same as those of standard types.

Over 20 million Aromat NF Relays in use

Free Samples. Write to Aromat or your regional distributor today, and get a free sample and test data on the NFEB relay. Once you've driven this engineering marvel, you'll never turn back!

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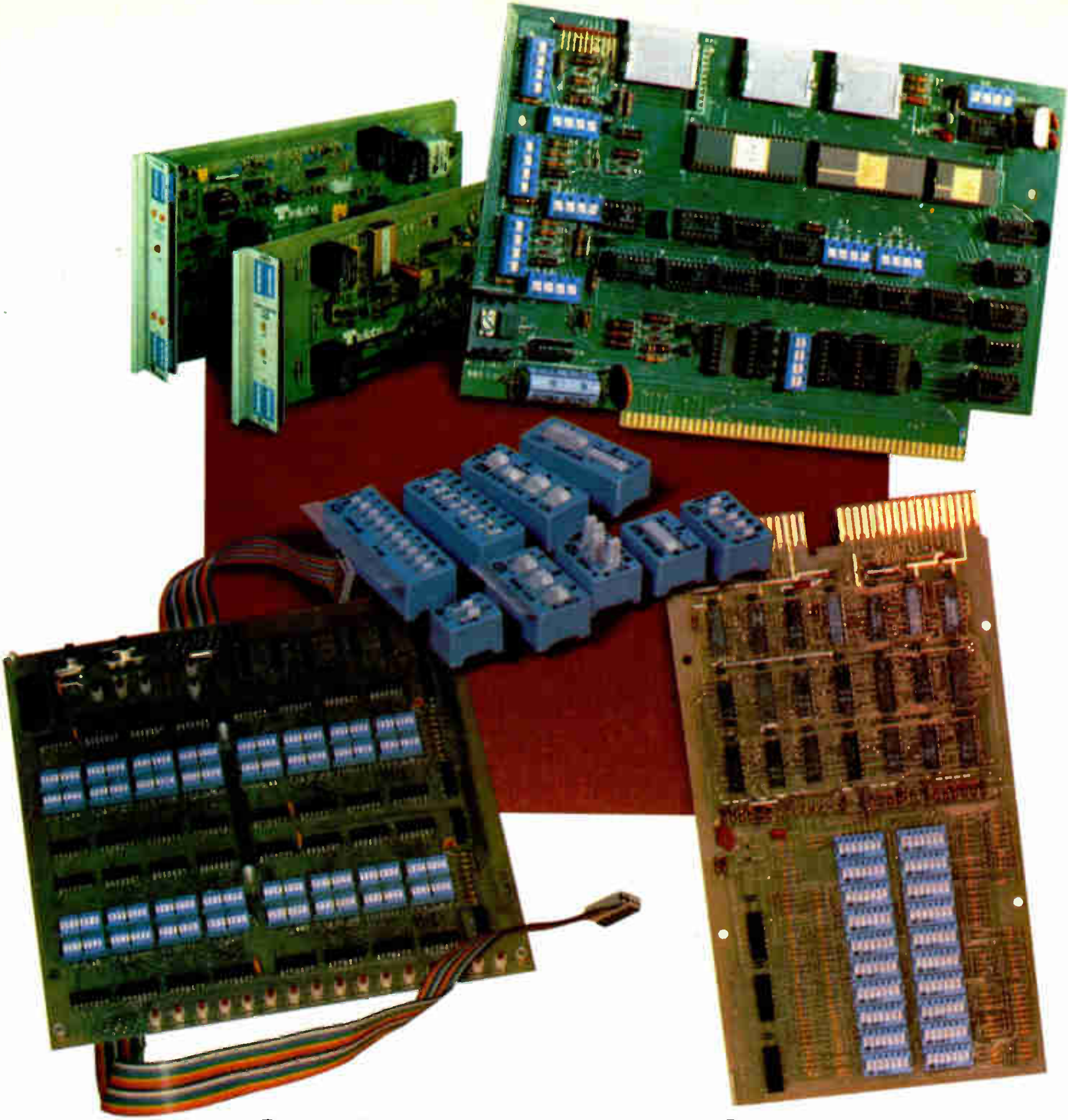
Western Office:
10400 North Tantau Avenue
Cupertino, CA 95014
(408) 446-5000



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7-mm maximum case height.

The series covers a range from 0.1 to 100 μF, with a standard capacitance tolerance of ±20%. They are available with voltage ratings from 6.3 to 63 V dc and surge voltage ratings from 8 to 79 V dc. Maximum leakage current does not exceed 0.01 coulomb or 3 μA, whichever is greater, over the capacitors' temperature range from −40° through +85°C.

The capacitors are priced at about $80 per thousand in 10,000-piece orders and are available in standard bulk packaging or on tape for automatic insertion.

Nichicon America Corp., 927 E. State Parkway, Schaumburg, Ill. 60195. Phone Richard Aldana at (312) 843-7500 [345]

Injection-laser ICs offer 820- or 1,300-nm outputs

Two solid-state continuous-wave injection lasers from RCA offer outputs at wavelengths of either 820 or 1,300 nm. The model C86014E gallium-aluminum-arsenide (GaAlAs) laser operates in a single spatial mode and provides a 820-nm output that matches the wavelength of silicon photodiodes and most available fiber-optic materials, says RCA. It is available with its own fiber-optic cable and connector.

The C86022E unit employs an indium-gallium-arsenide-phosphide (InGaAsP) pellet to extend spectral emission to 1,300 nm, which approximates the wavelength of near-maximum response for germanium photodiodes. It is constructed with a 1-m-long fiber-optic cable coupled to the emitting region of the chip and terminated with a Siecor T11 connector. The device is also available in a geometrically centered coaxial stud package with a removable cap.

In quantities of 1 to 9, the C86014E GaAlAs injection laser is priced at $1,885, and the C86022E InGaAsP laser is $1,725. Delivery of either product takes 30 days after the receipt of an order.

RCA Electro-Optics and Devices, Lancaster, Pa. 17604. Phone (717) 397-7661, ext. 2377 [346]

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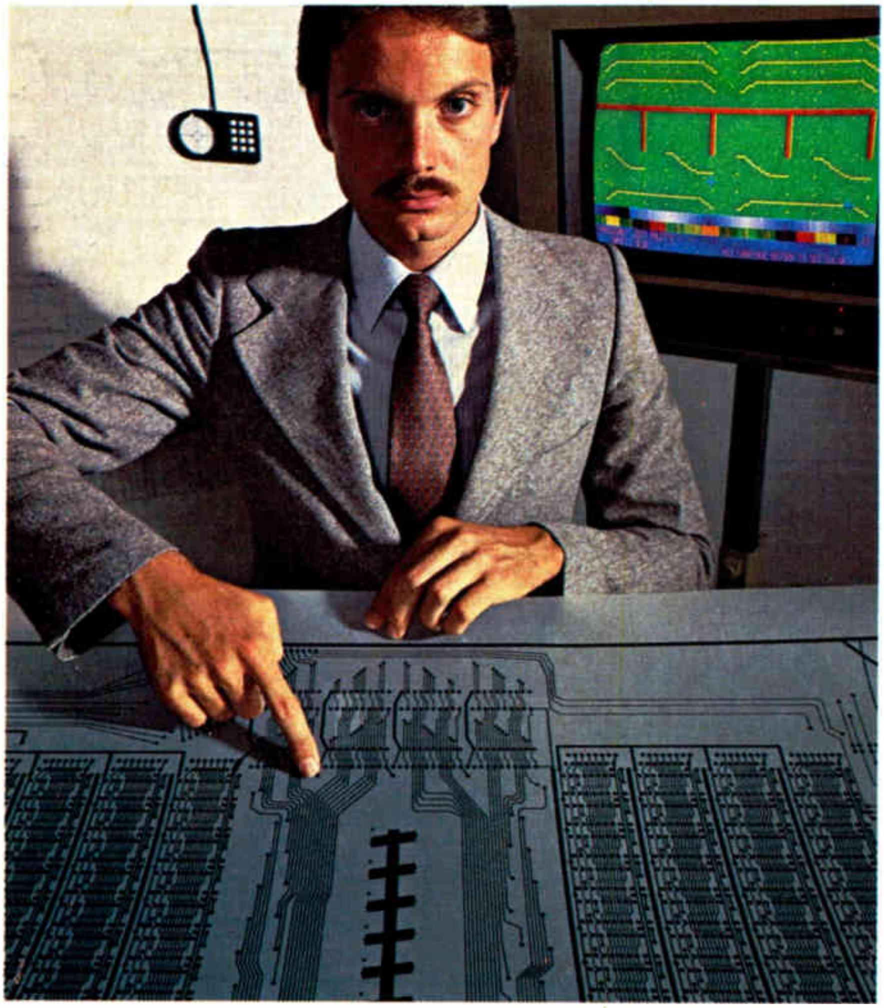

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New literature

Peripheral controllers. Hardware, software, and system configurations for connecting disk and tape storage subsystems to Digital Equipment Corp. computers is discussed in "Peripheral Controller Handbook." This guidebook, which includes many photos, illustrations, and tables, contains detailed information on disk drives, disk subsystem characteristics, hardware design and microcode implementations of disk controllers, software, tape controllers, DEC tape subsystems, and Emulex tape controllers. The publication suggests features users should consider when buying tape subsystem components. For a copy of the handbook write to Handbook, Emulex Corp., 2001 East Deere Ave., Santa Ana, Calif. 92705. Circle reader service number 421.

Semiconductor memories. MOS static and dynamic random-access memories, MOS erasable programmable read-only memories, and bipolar emitter-coupled-logic– and TTL–compatible RAMs made by Hitachi are described in "IC Memories." The 180-page catalog contains special sections on packaging, reliability data, handling precautions, testing procedures, E-PROM programming and erasing, and symbols and terms for integrated-circuit memories. Individual data sheets with tables, block diagrams, and graphs covering such characteristics as access times, voltage requirements, and read and write cycles give information on each memory; there is also a cross-reference section. For a copy of catalog number HLN100, write to Electronic Devices Sales and Service Division of Hitachi America Ltd., 1800 Bering Dr., San Jose, Calif. 95112 [422]

Rotating components. Eighty-one synchro-servo and stepper-motor rotor and stator laminations are described in "Precision Rotating Components." The nine-page catalog discusses the materials used for these rotors and stators and includes graphs for impedance permeability and core loss. The brochure contains a postcard for ordering a compre-

New literature

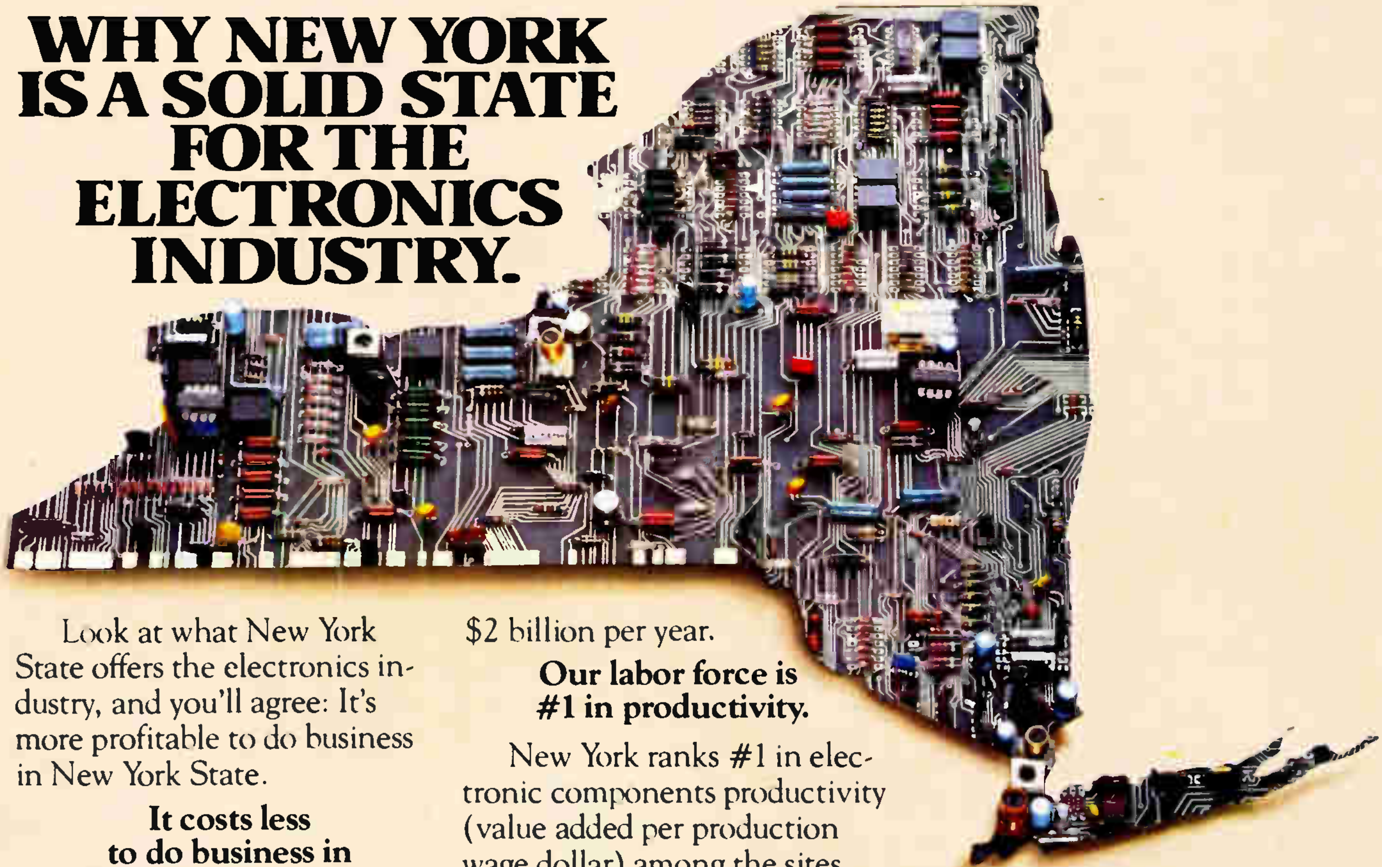
hensive binder that includes drawings of each standard component. Magnetic Metals Corp., 21st Street, P. O. Box 351, Camden, N. J. 08101 [423]

Liquid-crystal displays. A 20-page catalog discusses the product line of General Electric Co.'s Liquid Xtal Displays operation. Included in the catalog are fluid performance specifications, liquid-crystal fluid characteristics, and driving techniques. The

catalog explains seven-segment, clock, alphanumeric, bar graph, and multiplexed displays; illustrates font styles for custom displays; and has an index by GE-LXD part number. For more information or for a copy of the catalog, contact General Electric Liquid Xtal Displays Operation, 24500 Highpoint Rd., Cleveland, Ohio 44122 [424]

Computer vendor list. Information covering over 40 vendors of network components and systems, including transceivers, modems, and communication software, are contained in 3Com Corp.'s Local Computer Network Vendor List. The vendors include Amdax, Datapoint, Digital Equipment Corp., General Electric, Hewlett-Packard, Intel, Interactive Systems/3M, Nestar, Sytek, Ungermann-Bass, Xerox, and Zilog. The name, address, and telephone number of a key person available for additional information are listed for each. Over 100 pages long, the listing provides brief product descriptions, technical data, prices when available, delivery schedules, and notices of events in the local computer networking field. 3Com Corp., 300 Sand Hill Rd. #1, Menlo Park, Calif. 94025 [426]

WHY NEW YORK IS A SOLID STATE FOR THE ELECTRONICS INDUSTRY.



Look at what New York State offers the electronics industry, and you'll agree: It's more profitable to do business in New York State.

It costs less to do business in New York State sites than in San Jose, California. And we can prove it.

An independent study analyzed the four critical costs of taxes, wages, power and construction for a model new electronics firm. It showed that New York State offers sites where these costs are less than they are for choice electronics industry sites around the country.

For example, these costs would total $7.6 million annually in San Jose, versus only $6.4 million in, say, Brookhaven, New York.

New York has the best business advantages in America.

Our costs are lower because we have the best tax incentives and credits. We have on-the-job training and job incentive programs. Long-term, low-cost financing. And, we've cut personal and business taxes by $2 billion per year.

Our labor force is #1 in productivity.

New York ranks #1 in electronic components productivity (value added per production wage dollar) among the sites analyzed. And in the past five years, New York's number of idle man-days due to work stoppages was half that of the national average.

We graduate more electronics engineers than any other state.

Thanks to universities like RPI and Cornell – and dozens of other fine colleges – more electronics engineers are graduated each year in New York State than any other state including California or Massachusetts. And since many of the largest electronics firms are already doing business here – GE, IBM, to name only a couple – our graduates are quickly turned into seasoned professionals.

When you look into New York, you'll love New York.

We have an abundance of electric power. Lots of affordable housing for your employees. And our 30 million acres include thousands of available plant sites. Not to mention some of the most magnificent outdoors and year-round recreation on the American continent.

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8-7-9C

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Circle 180 on reader service card

Products Newsletter

E-PROM programmer and memory packed onto S-100 board

SSM Micro-Computer Products Inc. in San Jose, Calif., has combined **an E-PROM programmer and 18-K bytes of memory** on a single S-100–compatible board. With programming voltage generated on board and all programming sockets addressable to any 4-K boundary, the model PBI can program the single-supply 5-V versions of the popular 2708 and 2716 erasable programmable read-only memories. The $500 board contains software for copying from random-access memory to PROM. A later board will handle 32-K E-PROMs.

Intel readies new E-PROM microcomputer

Intel Corp.'s microcontroller operation in Phoenix, Ariz., is busy readying a holiday season present for the industry. Expected to be available as samples by year-end is the 8749, **an erasable programmable read-only memory version of the single-chip 8049 8-bit microcomputer.** It will have 2-K bytes of ROM and 128 bytes of random-access memory on board. Production quantities are expected to be available in the first quarter of 1981.

Linear ICs fit into microminiaturized plastic packages

In December, Motorola Semiconductor Products Inc., Mesa, Ariz., will join Signetics in supplying **linear integrated circuits in SO-8, SO-14, and SO-16 microminiaturized plastic packages.** The packages resemble miniature dual in-line packages (a 16-pin unit is 0.155 by 0.390 by 0.50 in.) and have preshaped leads on 50-mil centers designed for reflow soldering to ceramic substrates for manufacturing hybrids. They will be priced at between $1 and $2.50 in 100-unit quantities.

Power switchers are 80% efficient

Watch for Power General Corp., Canton, Mass., to announce an ultra-high-efficiency miniature switching power supply. To be offered in **four models with outputs of 5 to 15 V dc, the series 125 supplies achieve a guaranteed efficiency of 80%.** Built to military specifications, they have an estimated mean time before failure of 45,000 hours. Their single-unit price will be $69.

General Instrument adds 64-K ROM to silicon-gate line

Adding to its line of silicon gate read-only memories, General Instrument Corp.'s Microelectronics division, Hicksville, N. Y., is now offering a 64-K ROM. Organized as 8,192 8-bit words, the RO-3-9364B can operate from a single +5-V power supply, **accesses in a maximum of 300 ns, and dissipates 50 mA when active.** It is priced at $26.50 each in 250-unit volumes and is available in 10 to 12 weeks.

11- and 12-bit C-MOS d-a converters hold errors to ±½ LSB

National Semiconductor Corp., Santa Clara, Calif., will extend its line of unbuffered complementary-MOS digital-to-analog converters with two new units, the DAC1218 and DAC1219. They are **guaranteed to have, respectively, 12- and 11-bit linearity, to have a maximum differential linearity error of ±½ least significant bit, and to be monotonic.** In orders of 100 or more, the 1218 and 1219 will sell for $10.75 and $9.75 apiece, respectively. They are pin-for-pin–compatible with Analog Device's AD7541 series, which offers ±1.0 LSB error and sells for twice the price.

Career outlook

Ph.D. slump creates fears

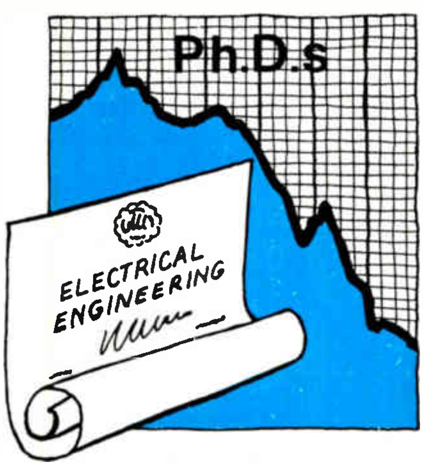
■ Electrical engineering is picking up popularity on college campuses, but only below the doctoral level, according to a recent study by the American Association of Engineering Societies. The figures published in "Engineering and Technology Degrees—1980" reflect a national trend toward fewer doctoral candidates, which may seriously inhibit the growth of technology in the U. S. into the 1990s. The association does propose some solutions to this shortage, however.

Conducted by the Engineering Manpower Commission for the AAES, the study reports that 13,745 bachelor's degrees in electrical engineering were awarded in 1980—an increase of 12.5% over 1979. The survey, which was conducted at 296 U. S. colleges and universities, also notes that 23% of all engineering degrees awarded at the bachelor's level were in electrical engineering.

Master's degrees are also on the upswing—12.1% more were awarded in 1980 than in 1979. The 3,740 MSEE diplomas represent 21.7% of all engineering master's degrees given in 1980.

At the doctoral level, only 523 Ph.D. degrees were awarded in electrical engineering in 1980, down from 545 in 1979—a net loss of 4%. Doctoral degrees in electrical engineering represented 19% of all engineering Ph.D.s in 1980.

Complicating the picture are the figures for foreign nationals receiving degrees. At the bachelor's level, 1,095 non-U. S. citizens received an EE degree—not quite 8% of the total number of undergraduate electrical engineering degrees awarded. At the master's level, that percentage climbs to 23.5%—881 out of the total 3,740 MSEE degree recipients. The percentage is highest at the doctoral level, where 171, or 32.6%, of the degrees went to foreign nationals.



Solutions. Noting these trends, the association is concerned that the recent report to the President from the National Science Foundation and the Department of Education, "Science and Engineering Education for the 1980s and Beyond," does not go far enough or set firm enough guidelines for strengthening the U. S. commitment to technical education [*Electronics*, Nov. 6, p. 93].

According to Donald E. Marlowe, executive director of the American Society for Engineering Education, a member society of the association, three steps must be taken to ensure an adequate science and engineering education into the 1990s. The first would be to reinstitute Government-supported graduate fellowships in engineering. The solution the association wants the Federal government to adopt would be a program whereby 2,000 awards of approximately $10,000 would be made each year to support graduate students.

The second approach would be more costly—about $100 million per year—and would involve the upgrading of laboratory equipment for teaching and research. This would be in the form of partial Government support and additional tax credits to industry for the donation of older gear, as well as state-of-the-art equipment.

The third solution, which Marlowe sees being implemented in the next five or six years at the earliest, is an increase in engineering faculty salaries. "This is the toughest problem," he admits. "It means changing the national mental set so that engineering education becomes as important as medical education. The latter involves people's health and the former involves the national economic health." **-Pamela Hamilton**

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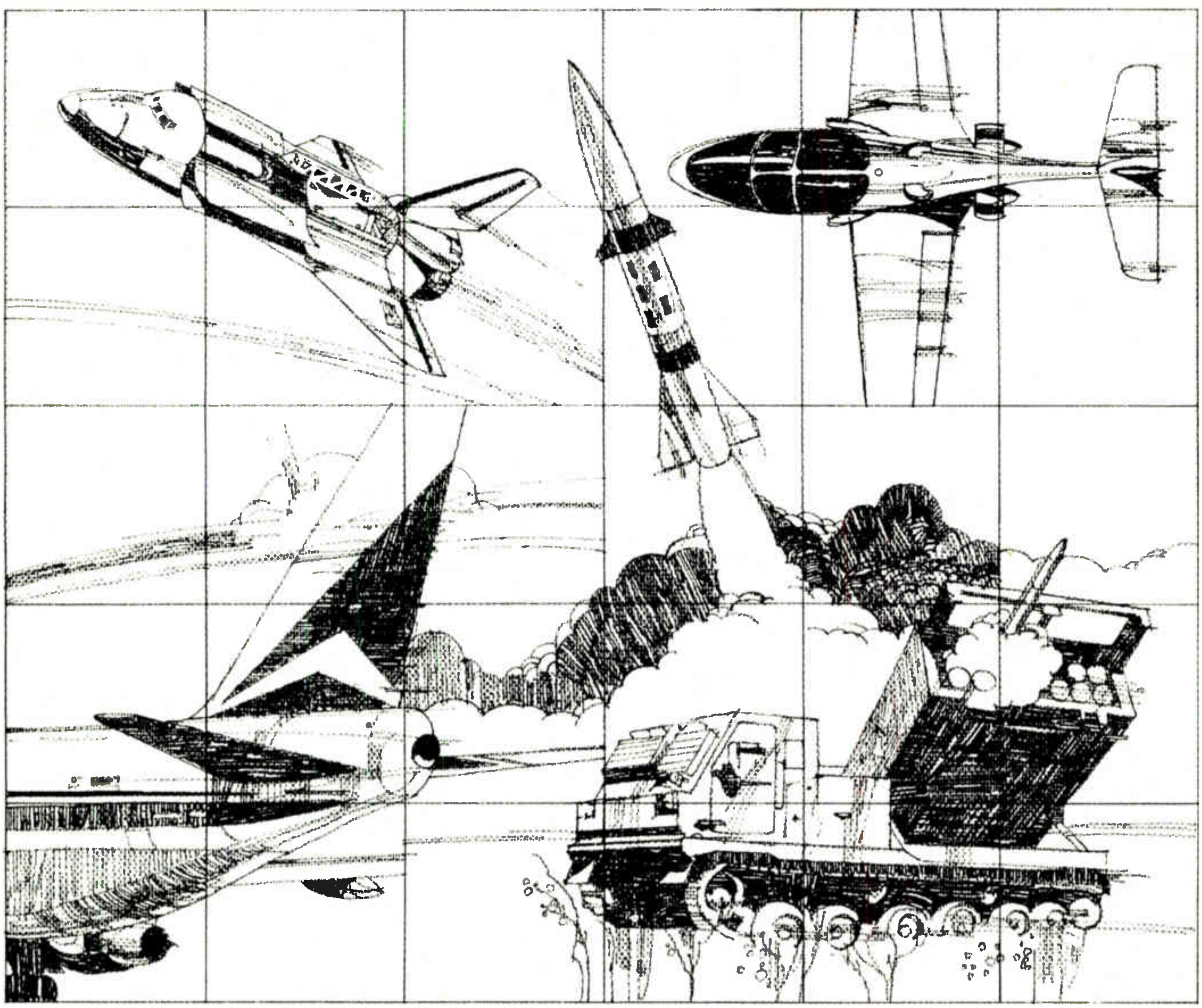

The State That Offers Engineers the Good Life

Florida is noted as the Sunshine State. It enjoys a favored geographic location in the United States and is world-famous for its living conditions, its climate, and its outdoor recreation facilities.

But Florida also has another dimension. It has become a state of high technology that wants and seeks engineers from entry-level to those with experience to help its growing companies meet the increasing technological demands of the 1980s and beyond.

Florida companies seek engineers in the following disciplines: avionics/aerospace, electrical/electronics, computer science, and data processing.

In addition to the demand for engineers the opportunities for them are great. Florida's governor, Bob Graham, says, "One of the misconceptions about Florida is that it is nothing more than a sandy beach resort appended to the Southeast corner of the United States. Nothing could be further from the truth. Our economy is growing and becoming more diversified daily.

"Construction has traditionally been one of our primary industries, and our department of commerce has been doing an exceptional job during the past several years in attracting high technology industry to our state, particularly in the areas of defense, electronics, and aviation. Part of our commitment to these new industries is to provide the talented and skilled professionals industry needs. The consensus, however, is that our own schools are not keeping up with the growing demand brought about by newly arrived or expanding companies. In short, the professional climate for engineers in Florida can be summed up in one word: opportunity".

Electronics is the field that generated Florida's rapid growth as a major technological state. It began in the mid-60s, surged again in the '70s, and continued into the 1980s. Today Florida has more than 275 electronic companies that utilize the talents of more than 56,000 persons.

Both large and small firms are located throughout the state. The hot spots, however, are located in the metropolitan areas such as central Florida in Brevard County, on the Gulf Coast, Hillsborough/Pinellas, and the southeastern coastal strip where the majority of the electronic companies are located.

Central Florida is noted for its manufacturers of telecommunications equipment, with employment rosters ranging from 140 to more than 1,800 employees. The city of Longwood is the heart of the telecommunications manufacturers.

The largest employer in the state, with more than 7,000 employees, is situated in the Melbourne area. It is a company that designs and produces high technology communications and information processing equipment and systems projects. The company expects strong growth and forecasts that it will have more than 10,000 employees by the mid-1980s.

Avionics firms are located in the Saint Petersburg-Clearwater area of the Gulf Coast. Another major electronics concentration runs from Fort Pierce to Miami on the east coast. Boca Raton is a growing telecommunications region, and Fort Lauderdale's companies are involved in the design and manufacture of high technology communications products and systems.

As you can see, Florida has much to offer the engineer seeking a career in the high technology disciplines. But there are several other advantages Florida offers engineers. Education is one example. The state has 1,996 elementary and secondary schools, 219 adult education centers, 45 vocational-technical centers (with two more currently being constructed), 28 community colleges, 9 state universities, and approximately 200 state-licensed vocational and technical schools.

Engineers who want to work for an advanced degree have a number of schools they can attend. The University of Florida in Gainesville, for example, and the University of Florida in Tampa, offer PhD programs. There are also a number of colleges offering degrees through MSEE, including an optional program in computer engineering.

Electronic technology programs and a degree program leading to the Associate in Science degree in electronics engineering technology are some of the many courses available to engineers.

Another advantage for new residents is the cost of living. According to the Bureau of Labor Statistics, "Indexes of Comparative Living Costs," show that the total family budget for residents in Orlando, for example, is only 88% of the U.S. urban average. Food costs 11% less, transportation is 4% less costly, housing is 14% cheaper, and personal income taxes are 39% below the national average. The stability of the work force in a region is reflected in the number of people who own homes. Florida is one of the leaders in the southeast in this category and has the 15th highest percentage in the United States.

Bob Graham, Governor of Florida, says the climate for engineers can be summed up in one word: "Opportunity."

There are no personal income taxes in Florida, and the property taxes are low with homestead exemptions for all taxpayers, and sales tax exemptions on groceries, medicines, household fuels, and most services. In short, a Florida engineer keeps more of what he or she earns.

Culturally, Florida is a haven for both the visual and performing arts. Every major metropolitan area contains museums which feature collections ranging from Baroque, Renaissance and Flemish artworks, to Chinese and Meissen porcelains, to pre-Columbian artifacts, to modern French and American Paintings.

There are a half dozen major symphony orchestras in the state and a number of local and community university symphonies to satisfy lovers of good music.

Florida boasts a mild semitropical climate and a relatively pollution-free environment. Winter temperatures range from an average of 54° F in Pensacola to 67° F along the southern Atlantic coast. Average summer temperatures are remarkably uniform throughout the state, ranging from 80° F to 83° F. Precipitation averages about 50 inches annually, with most of the rain falling during the summer months.

The year-round semitropical climate, moderate rainfall, and abundant sunshine, fresh and sea waters, and freedom from heavy frosts, snow and ice make Florida an attractive and appealing place to live and work.

When it comes to recreation, Florida leads all other southeastern states. The Florida sporting scene, for example, includes both professional and leisure-time activities for both doers and watchers. The professional sport enthusiast can watch the Miami Dolphins and Tampa Bay Buccaneers football teams. Soccer aficionados can enjoy the fancy footwork of the Fort Lauderdale Strikers and the Tampa Bay Rowdies.

Moreover, numerous golf and tennis tournaments are held throughout the state, and the many universities offer a variety of intercollegiate athletics. Florida's well-known horse races, dog races, and Jai-Alai give Sunshine State residents the chance to make a sporting wager if they so desire.

Residents also have at their disposal an extensive system of first-class harbors and numerous marinas and other docking facilities for deep-sea fishing and boating.

Freshwater boating and fishing addicts can enjoy the state's more than 7,700 inland lakes, and numerous rivers and streams.

In addition, Florida has 5,620 designated public recreation sites at the federal, state, county, and municipal levels. These sites are used for camping, hiking, canoeing, birdwatching, sailing, surfing, skindiving, and swimming.

Then there are 48 professionally supervised wildlife management areas in Florida that offer 5.2 million acres for hunting deer, small game, and even wild boar.

Florida is also the home of world-famous Disney World, Cypress Gardens, The Everglades, Cape Kennedy, Key West, and many other major attractions that provide a pleasant escape from everyday living.

To sum up, Florida offers engineers the good life in both careers and lifestyle. If you would like to pursue a long term and profitable career in this vacation state, closely examine the following Career Opportunities section to acquaint yourself with the many top-notch companies that are interested in you and your talents.

—John Brand

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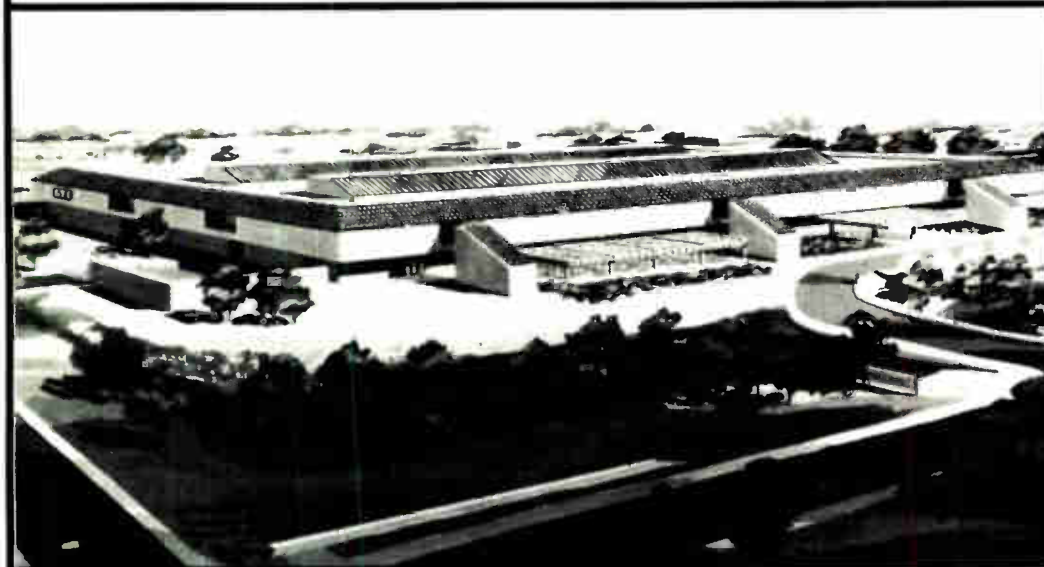

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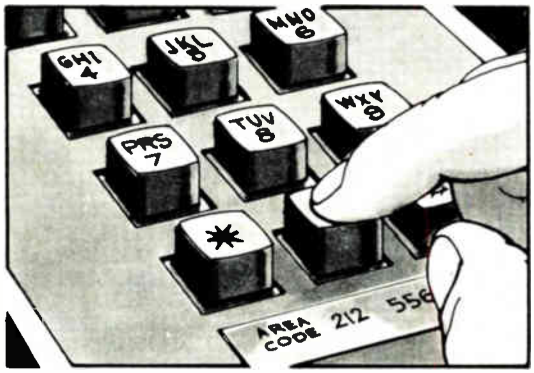

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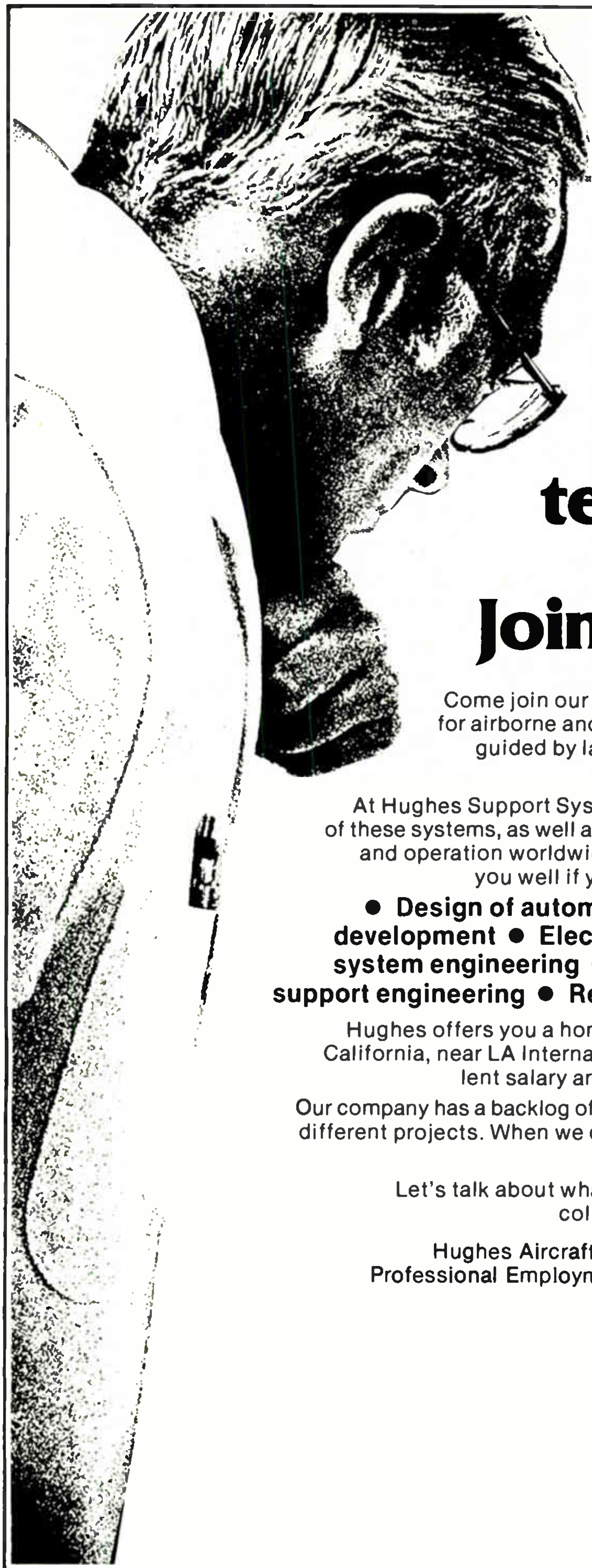

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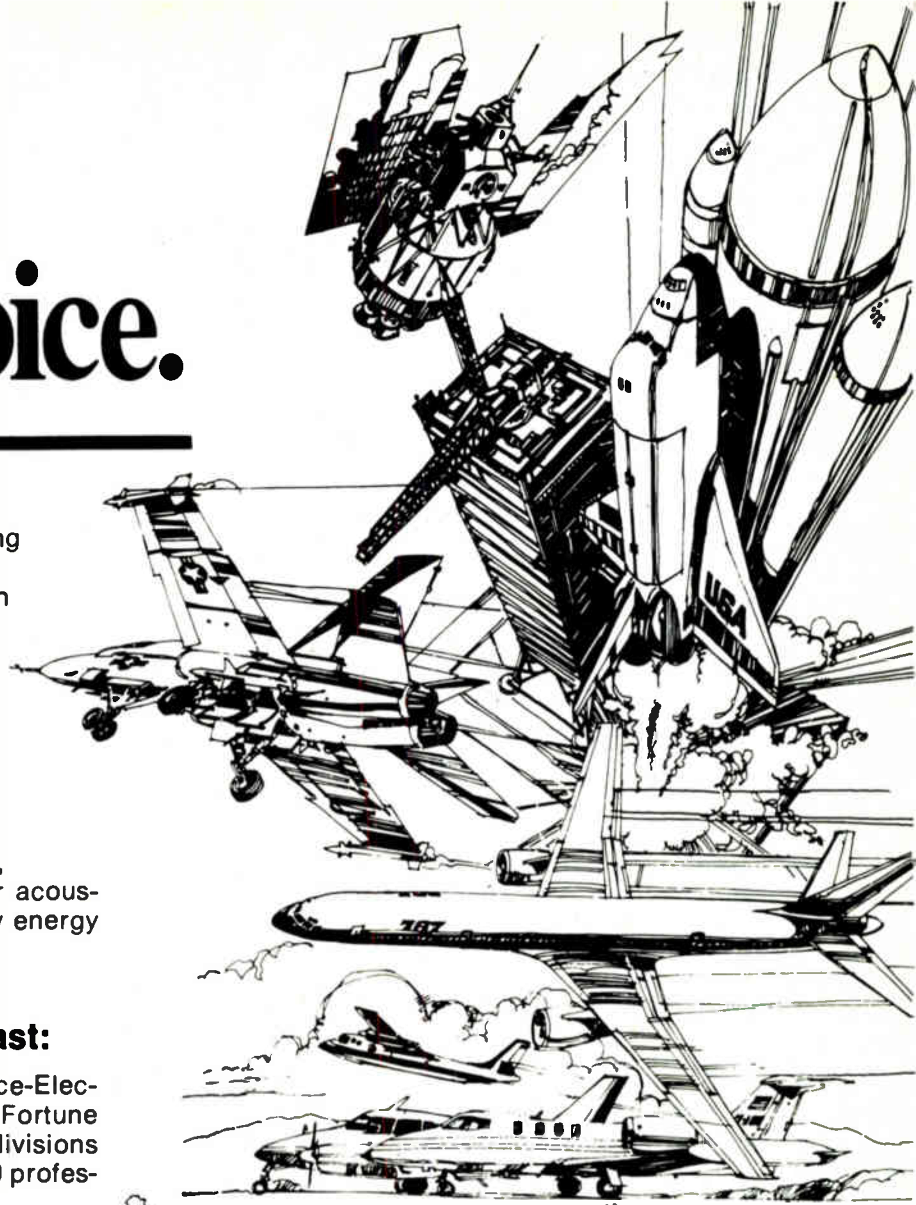

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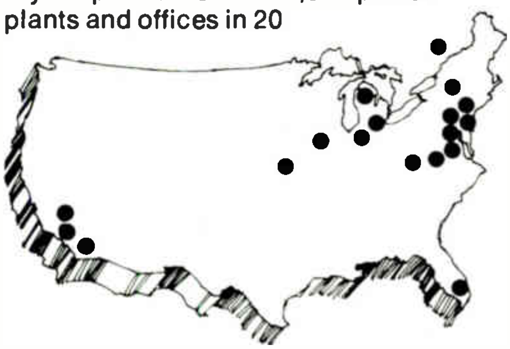

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