NOVEMBER 6, 1980

SURVEY REVEALS EEs' CAREER CONCERNS/134

N-well C-MOS process yields 64-K static RAM/ 145

Microprocessor pushes a-d converter to 20-bit precision/ 151

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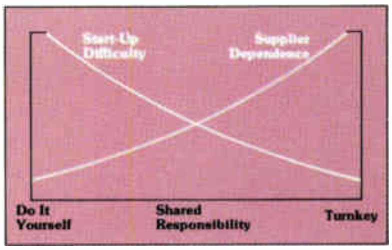

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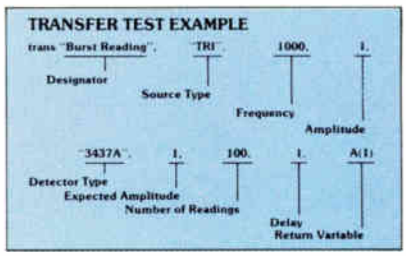

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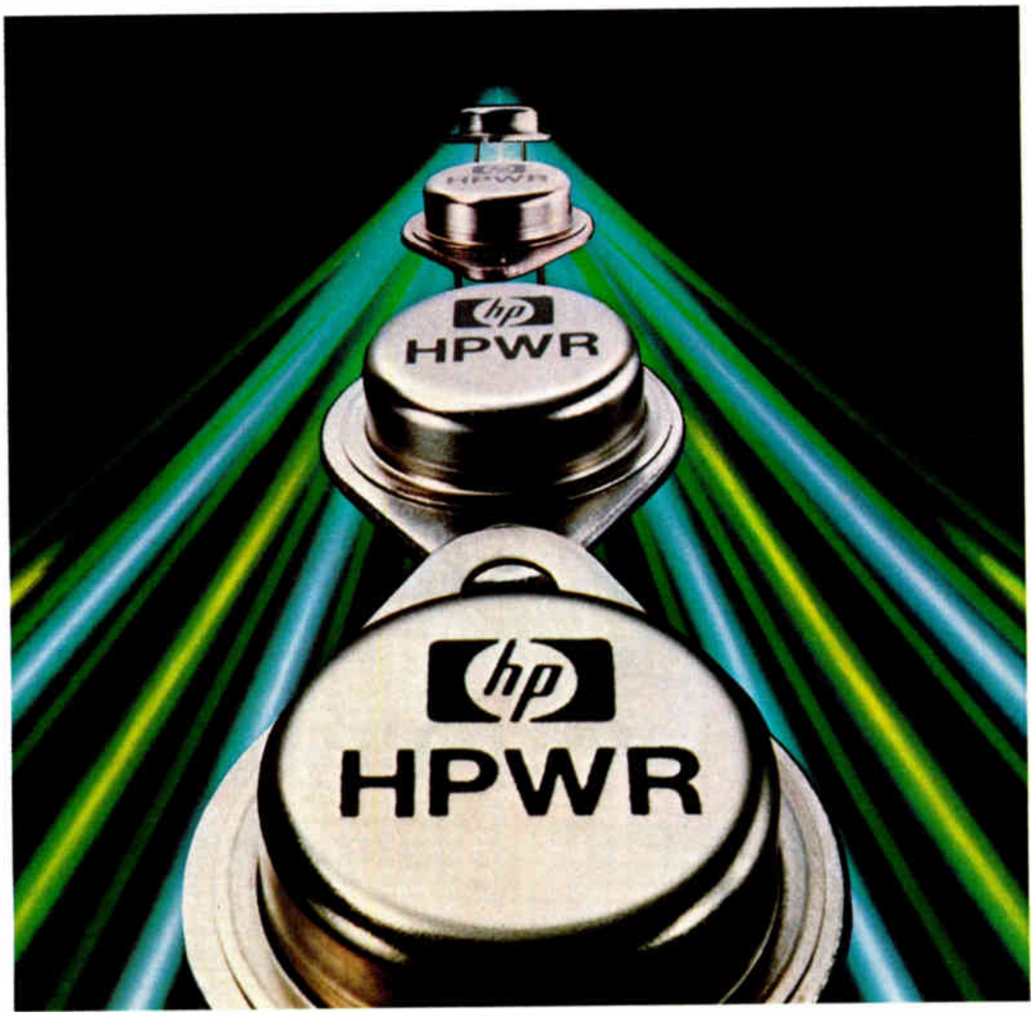

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Highlights

Cover: Silicon sensors face up to reality, 113

One notable aspect of the microelectronics revolution is that silicon sensors are increasingly getting the call to team up with microprocessors. Though silicon has many advantages in this role, it is only recently that demand and technical advances have brought its costs down to practical levels—and these developments are just in their early stages, promising both a huge market and new types of solid-state sensors, says this special report.

Cover illustration is by Solid State Editor John G. Posa.

Tek unveils development system plans, 98

In a departure from past practice, Tektronix Inc., the instrument maker, has announced an entire new family of microcomputer development systems, although only the first member is ready. The reason: Tek wants to give potential users the "full picture," letting them know that they will be able to shift to different design environments without undue expense and hence revealing the "real value" of its single-user system.

EEs say the future looks bright, 134

Five years of record well-being for the electronics industries has given electronics engineers an optimistic view of their future, according to this special report based on a survey of *Electronics* subscribers. Still, the memory of past recessions lingers, so that they are pressing for increased professional recognition.

64-K static RAM boasts the best of two worlds, 145

To build the largest-capacity static random-access memory so far, Japan's Matsushita Electric Industrial Co. went with an n-channel memory-cell array and complementary-MOS peripheral circuitry. Thus it achieved high density without the usual power consumption penalty. What's more, it opted for n-type wells, instead of the common p-type, because of the predominance of n-channel devices.

Single-slope a-d converter bounces back with 20-bit linearity, 151

Passed over for some time now, the single-slope analog-to-digital converter has come back with the aid of the microprocesor. In a prototype, the two together deliver a linearity of 20 bits and an absolute accuracy that depends primarily on the voltage reference used.

And in the next issue . . .

Automotive electronics: a special report . . . a comprehensive preview of December's International Electron Devices Meeting . . . upgrading Fortran for modular programming . . . a video display processor for home use . . . a Winchester disk drive controller for microprocessors.

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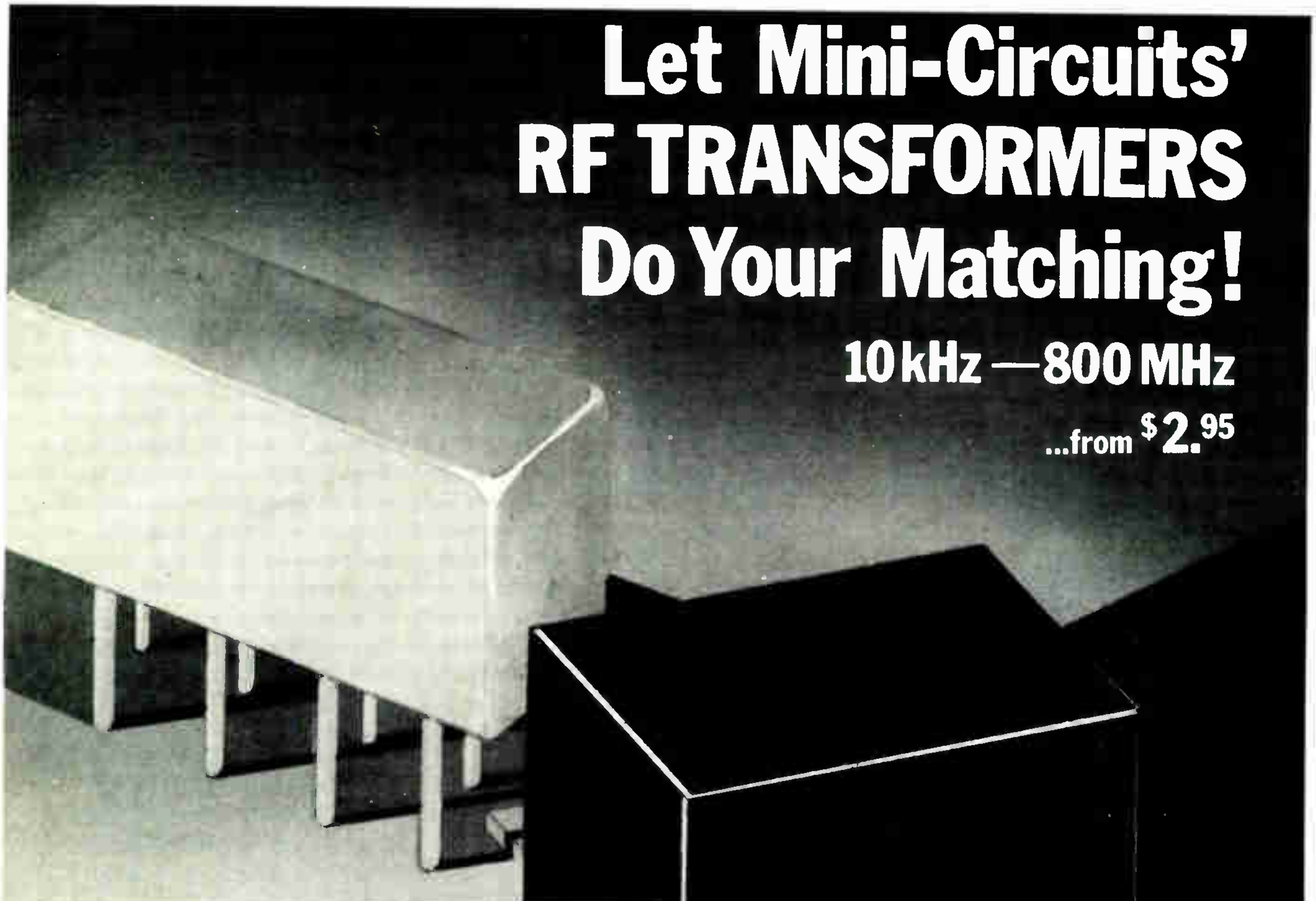

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TMO4-1	4	.2-350	$4.95
● T4-1H	4	8-350	$4.95
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T4-2	4	.2-600	$3.45
TMO4-2	4	.2-600	$5.95
T8-1	8	.15-250	$3.45
TMO8-1	3	.15-250	$5.95
T14-1	14	.2-150	$4.25
TMO14-1	14	.2-150	$6.75

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42/Rev/B

The world may be turning digital, thanks to the growth of microprocessors, but the missing integrated link between the digital processors and the real, analog world is the sensor. So the time is right for an overview of solid-state sensors.

"With so many microprocessors coming into use, especially low-cost devices, the push is on sensors," says components editor Roger Allan. Finding that the small companies that have been selling solid-state sensors are being joined by large companies looking for big sales in consumer and industrial markets, Roger concluded that a survey of the situation would be welcome at this time. The result is the special report that starts on page 113.

The potential applications for solid-state sensors in home appliances, automobiles, and process controls are enormous, he explains. As a result, a raft of devices has been coming on the market, from the popular pressure and temperature sensors to those for position, acceleration, and liquid and gas flow.

A dramatic illustration of the trend, a single-chip gas sensor developed by Stanford University is replacing an instrument normally the size of a desk top. The gas sensor designed at Stanford, as small as a cigarette pack, can be carried in a shirt pocket. Another plus—solid-state sensors are inherently more reliable than the instruments or electromechanical devices they replace.

Comments Roger, "The big breakthrough has been universal sensing chips made possible with packaging improvements that make the device more mass-producible and more mass-usable."

Like most people, engineers like to compare their careers with those of others in the same profession. We have provided that opportunity with the report on an exclusive survey conducted for *Electronics* by the McGraw-Hill Publications Co.'s research department.

Making this project still more interesting was comparing the results with those of a similar questionnaire done three years ago. In fact, the first survey, also done by the research department, formed the basis for this year's effort.

Armed with the tabulated results, compiled by Ann Graham Hannon and Jeffrey Wolf of the research department, careers editor Pam Hamilton prepared the report (p. 134). "I hope that this survey starts a dialog among engineers and between readers and us," Pam remarks. "The salary statistics alone should generate lots of discussion."

Another informative aspect of the survey was the opportunity for writing in comments, which gave insight into the mood of the respondents. "We could tell that on some topics, like job frustrations, feelings are running high," Pam declares.

What were the findings? They are detailed in the report, but it is interesting to note that the majority of respondents in the wake of extended good times are satisfied with the EE career. In addition, most respondents are confident that they can follow engineering as a lifelong career, in contrast with 1977, when a smaller number thought so.

A striking comparison with the 1977 survey is the increased impact of microprocessors and software on EEs. In 1977 a little over half of the respondents said they had to learn microprocessor technology. In 1980 that fraction has jumped to over three quarters. In addition, over 68% of the respondents in 1980 report they spend some time programming. This figure compares with a little over 47% back in 1977.

New to this year's questionnaire was the topic of personal computers. Based on this survey, personal computers will be big business with EEs. About one third already own and use such equipment. And of those who do not have one, over half intend to buy a personal computer in the next two years.

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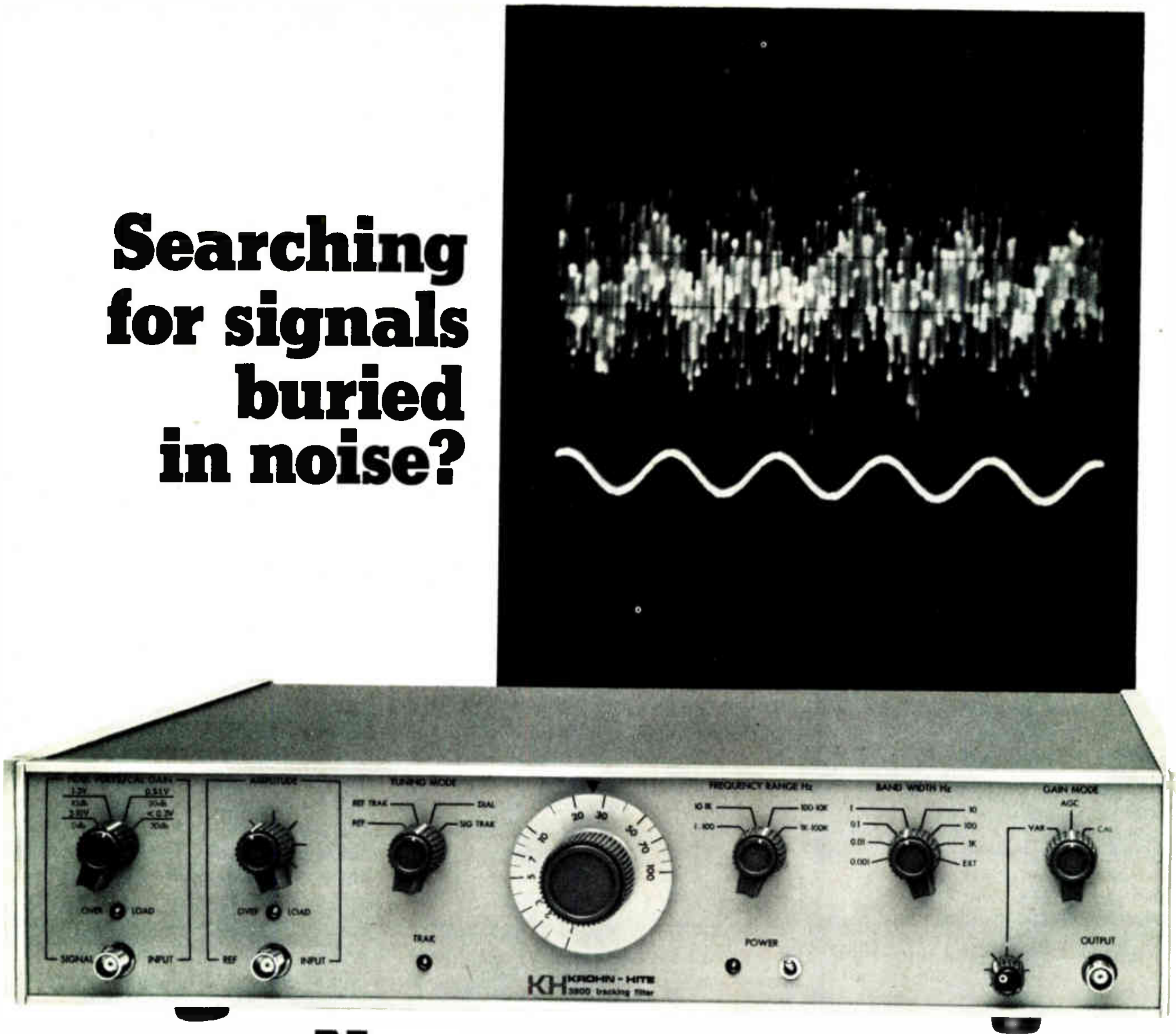

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Circle 7 on reader service card

Readers' comments

Take care of triboelectricity

To the Editor: The article on static discharge by Yennis and Huntsman ["Guarding ICs against static discharge," July 17, p. 115] is an excellent example of the type of work needed to make a true science out of investigations in this area. However, one additional test might be useful.

The authors demonstrate the relative merits of plain plastic, antistatic carbon-loaded plastic, and metal DIP tubes with regard to electrostatic discharge shielding, but they do not consider the effect of triboelectric charge generation.

Clearly, the sliding motion of integrated circuits contained in half-loaded DIP tubes is significant and potentially capable of generating a triboelectric charge. An investigation of this condition would be a welcome addition to the study.

Mark H. Polczynski
Engineer–Quality Control
Count Central/Systems Division
Eaton Corp.
Watertown, Wis.

Problems of Academe

To the Editor: I agree wholeheartedly that good teachers are being sucked out of the universities by industry [Editorial, July 3, p. 24]. Inadequate financial compensation by the universities does play a large part in this drain. But it would be wrong to conclude that better pay or shinier equipment would reverse this drain.

The university as a separate, tax-exempt institution is obsolete in today's fast-changing technical world. An intensive, four-year university education no longer lasts a lifetime. "Batch-process education" is giving way to "continuous education," which integrates work and learning so that engineers do not become quickly outmoded.

Yet the universities are not even very good at this "batch processing." For example, if engineering students were simply given a microcomputer of their own, rather than forced to take an irrelevant beginning programming course using the campus dinosaur, they would learn far more—and use less teaching labor.

The universities have none of the standard incentives to increase productivity through capital spending. Since they are tax-exempt, depreciation and investment tax credits mean nothing. Having "free labor" in the form of students skews labor-capital analyses toward labor. And the professor's own low salary is used to show that capital expense to save his labor is not justified!

Doing applied technical research at a university is also a bad idea. At least half of all grant money is skimmed off the top for "administrative overhead," adding only red tape.

Further, government research money, the lifeblood of university research, comes with strings like equal opportunity and time cards to keep track of time spent on each project. (I'm not against equal opportunity, just the red tape it creates.) This money also flows more freely if one is after a better bomb instead of a better refrigerator.

Business money for research is not available in any quantity because businessmen justifiably want to see a return on their investment, and tax-exempt universities cannot accept money under those conditions. This arm's-length relationship hampers cooperation from both sides, creates conflicts of interest for the faculty, and seriously impedes the transfer of university technology to the marketplace (for example, UCSD Pascal).

A better approach to the teaching problem would be the accreditation of technical teaching and research institutions that are profit-making. They could have much closer ties with other businesses and could commercialize their own research, if necessary. A tax-deductible tuition (through depreciation), even for degree programs, would more than offset the higher tuition fees required.

Henry G. Baker Jr.
Rochester, N. Y.

Correction

The microprocessor in the lead photograph in the Microsystems & software Technology Update (Oct. 23, p. 151) should have been identified as Motorola's complementary-MOS 146805E2.

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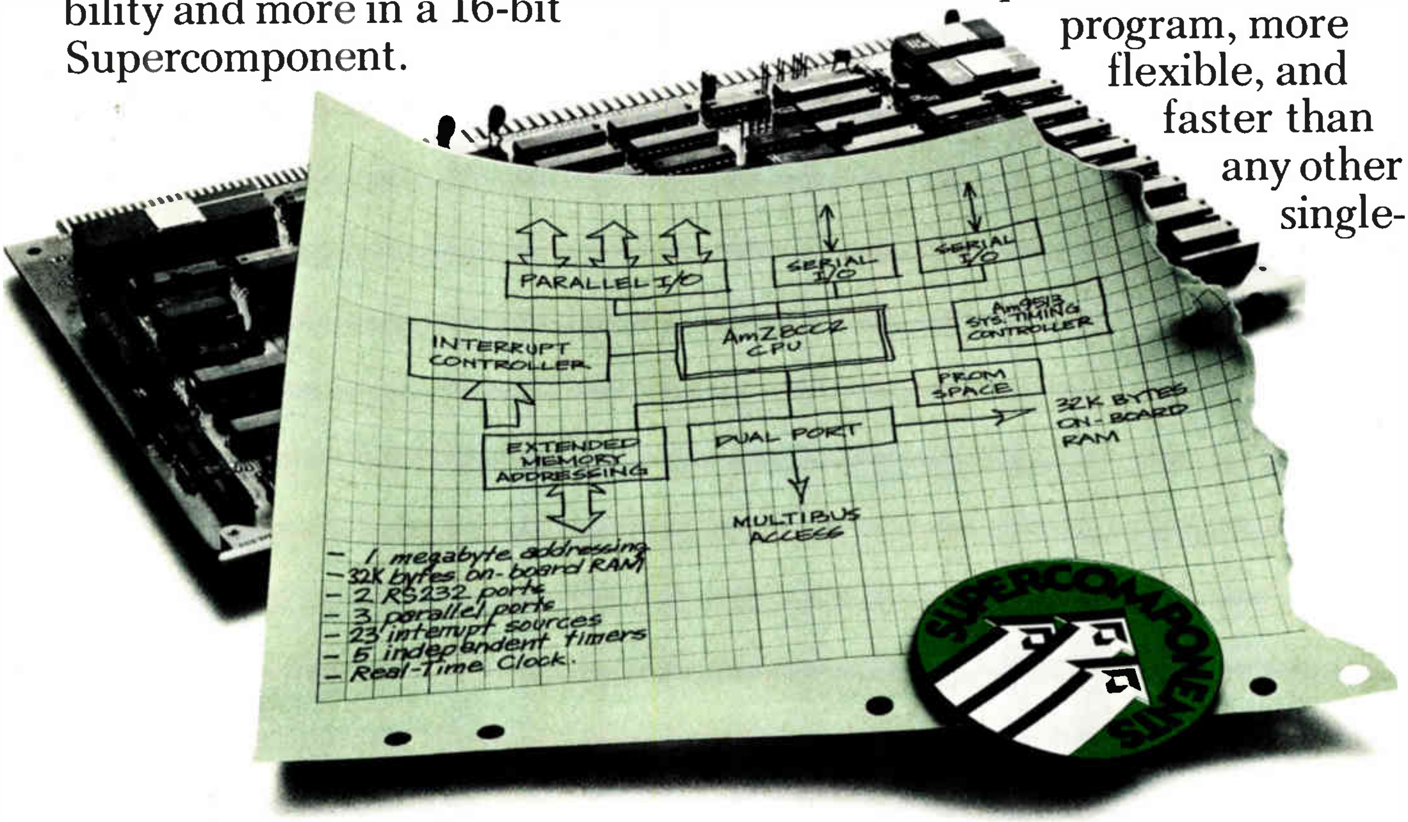

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News update

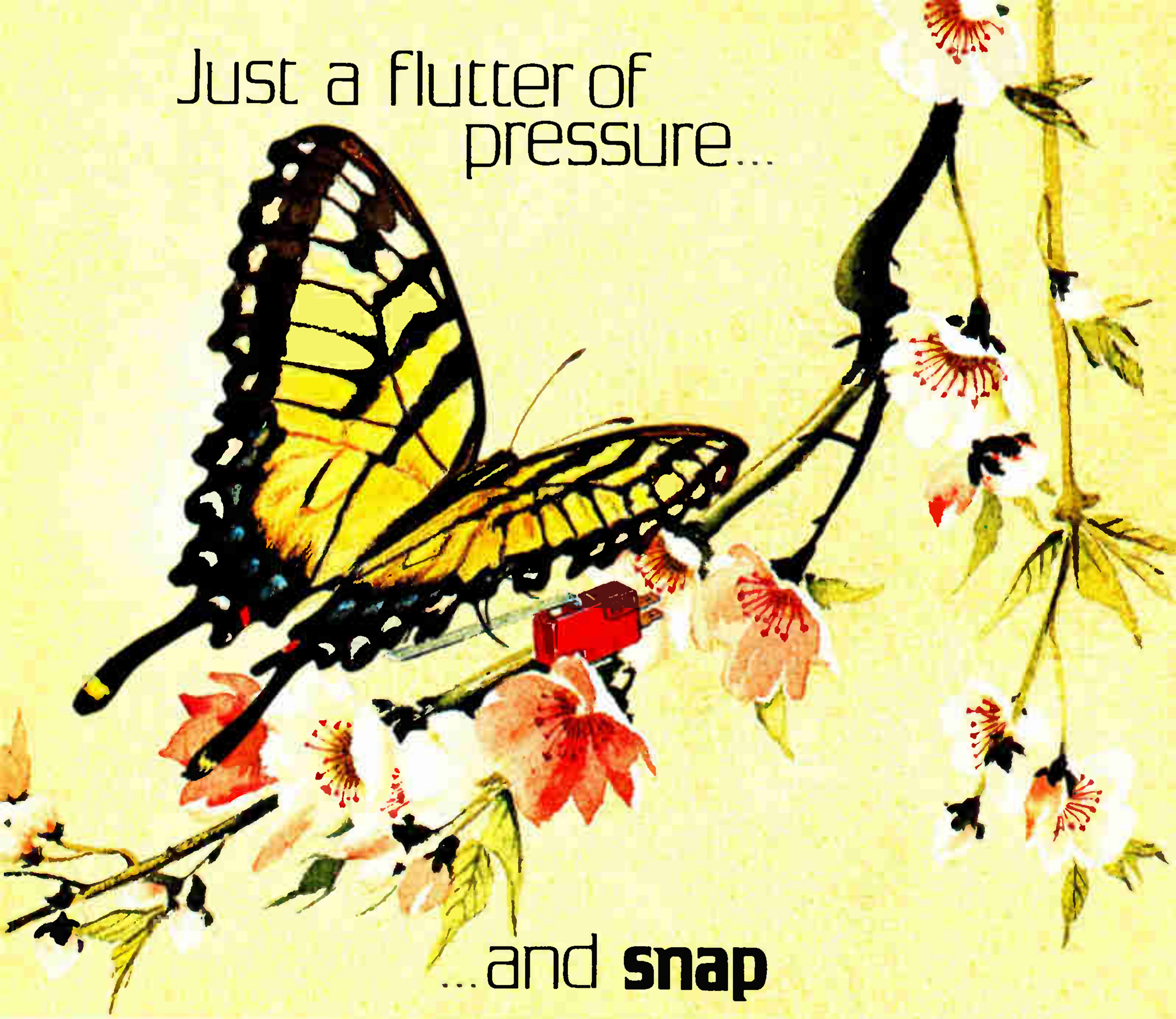
■ The recession is all washed up, and now begins the gradual return to normality: by the second half of 1981 it will be business as usual for most electronic firms. So conclude five top executives representing a cross section of New England's high-technology industries. The panel discussion of the five is a follow-up of one last year also sponsored by the American Electronics Association's New England chapter to get a reading of the state of the electronics economy in New England [*Electronics*, Oct. 25, 1979, p. 24].

Healthy. William R. Thurston, president and chief executive officer of GenRad Inc., who last year predicted that the proliferation of electronics in consumer and industrial products would blunt the effects of a recession, affirmed that 1980 represented "but a temporary slowdown in a healthy long-term uptrend." He expects his segment of the industry—test and measurement—to grow about 18% in 1981, compared with 1980's 15%.

Ray Stata, chairman and president of Analog Devices Inc., believes that U. S. reindustrialization, requiring modernization and automation of production, is one of the major noncyclical demand factors that will fuel a 18.5% compounded annual growth in semiconductor consumption through 1984. He warns that rebounding demand could once again outstrip the supply, extending delivery times.

More growth. Codex Corp. president Arthur Carr foresees a 20% overall growth in telecommunications next year, with such segments as data communications pushing ahead by 30% to 35%. Andrew C. Knowles, vice president of Digital Equipment Corp.'s technical group, also is very optimistic, predicting a 35% growth rate for computers and peripherals in 1981.

Increased defense spending will have an impact in the region, says Robert L. Seaman, vice president of planning for Raytheon Co. He believes that U. S. uneasiness over the end of detente with the USSR will spur spending for electronic warfare equipment. **-Linda Lowe**



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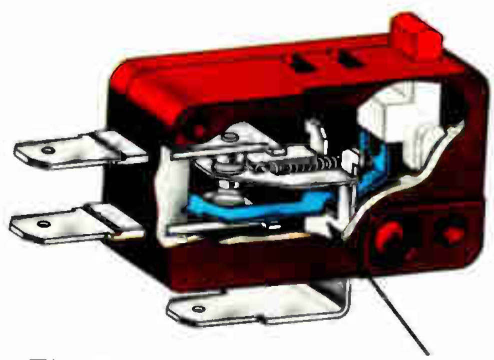

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Circle 13 on reader service card

People

ITT's Micic to emphasize service to the customer

His big frame and square shoulders make Ljubomir Micic look like an American football player. But the outside interest of the recently appointed managing director of the ITT Semiconductors Group in Freiburg, West Germany, is philosophy, not sports.

More important to Micic (pronounced Mit-chitch) right now than the teaching of the ancient and modern thinkers, however, is the philosophy he wants to pursue as head of the 3,400-employee group, with its production facilities in England, France, the U. S., and West Germany. And one aspect of that is what he calls quality of sales.

"In the semiconductor business it is not always profitable to think of profits alone," says the 50-year-old Yugoslav-born executive, who has a master's degree in telecommunications from the University of Belgrade. To ensure a customer's loyalty, "one must invest in advance service by working with him to help solve the problems he may have with applications." Such assistance and after-sales service tend to keep customers loyal.

Now the group has tightened its product spectrum, and Micic wants "to penetrate deeper into our established markets—the consumer, communications, and data-processing sectors—with narrow-line, high-volume integrated circuits and discrete components." In this effort, the lead that the group has in automated and mechanized production techniques should be a valuable asset, he declares. "And customers should benefit from the prices that such techniques make possible."

At the same time, Micic will emphasize microcomputers (where a second-source agreement with Texas Instruments Inc. should help) as well as memories. ITT Semiconductors will announce a concept of signal-processor/memory combinations next year, the first producer in Europe to do so, as well as a 64-K random-access memory.

Digging. ITT Semiconductors' Micic aims to penetrate his markets more deeply.

Micic is convinced that with this strategy his group will sustain the above-average growth it has enjoyed in the past. The target for 1985 is worldwide sales of $500 million, twice the expected total for this year.

Past technology inspires Williams with new ideas

History is a great teacher, agrees Jim Williams of National Semiconductor Corp., Santa Clara, Calif., and author of the article on an analog-to-digital converter with 20-bit linearity that starts on page 151. "Much of today's innovation is nothing more than a refinement of techniques worked out hundreds of years ago," he observes.

One of that rare breed who see art in science and engineering, he points proudly to his collection of very early scientific equipment and apparatus, which he studies carefully for insights into solving modern circuit problems. Among the instruments are 150-year-old chronometers, one of the original Crookes tubes, an early electrometer built by Lord Kelvin, microscopes that date back to the late 1700s and early 1800s, some of the first Weston ac voltage and current meters, and nearly every conceivable type of beam balance.

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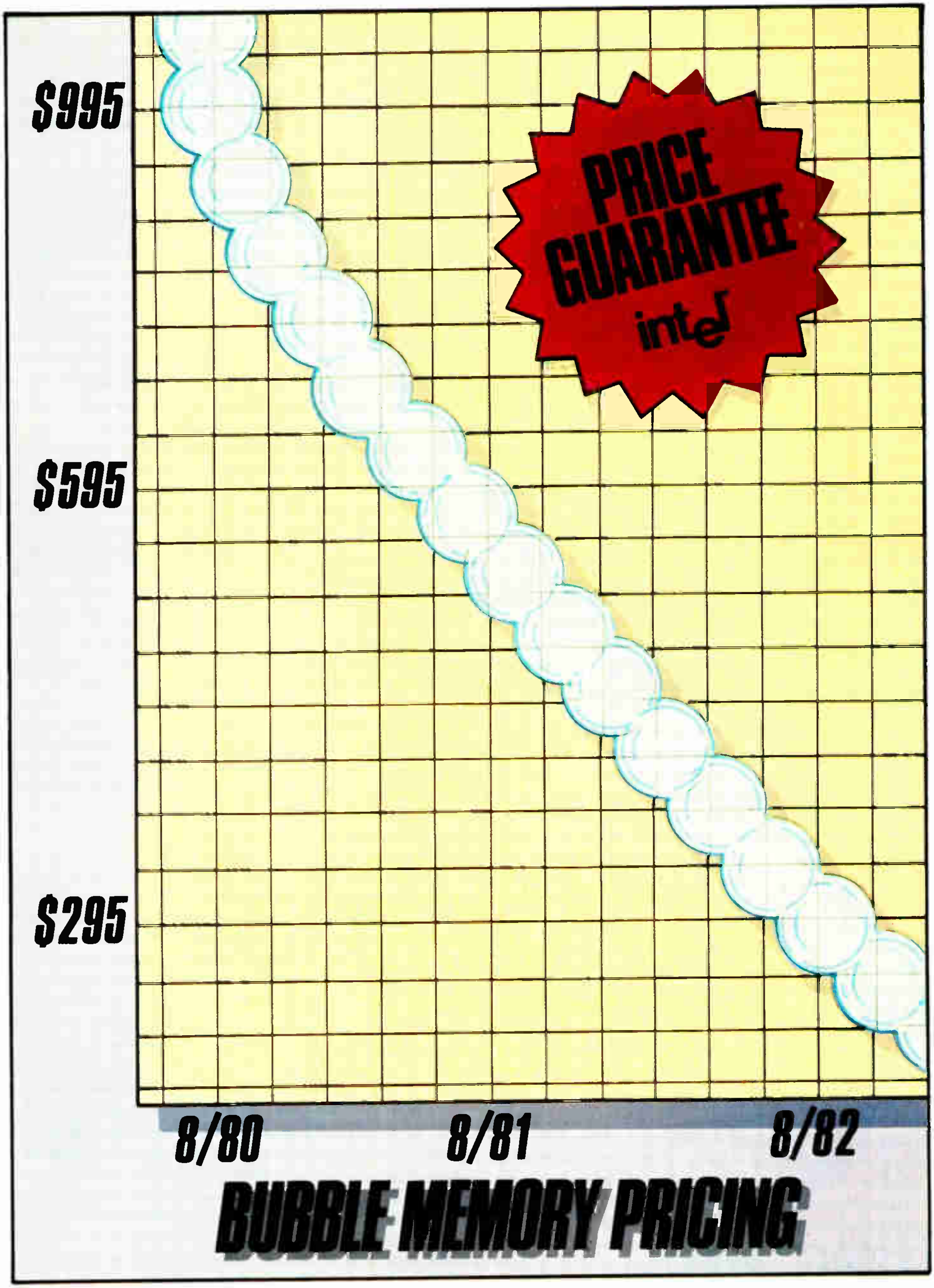
Looking back. Jim Williams says his collection of old instruments inspires him.

and scientific principles," he says. "They can tell us where technology has come from and assist us immensely in solving problems. For example, a beam balance is a perfect analog of an op amp."

Though he has taught at Massachusetts Institute of Technology, Williams is a self-taught man who never obtained a college degree—he left Detroit's Wayne State University in 1968 in his sophomore year. Then, in 1969, following a nine-month, 20,000-mile cross-country motorcycle vacation, he found himself at MIT in Cambridge, Mass., and at the start of his electronics career.

Persuasive teacher. It took him six months to persuade MIT officials to give him a job there with some biochemists who were designing instrumentation for measuring and automating fermentation processes. He stayed for eight years, teaching and supervising bachelor's and master's thesis programs, all the while working as an independent consultant. In 1977, he joined Arthur D. Little Inc. in Cambridge as a consultant and a year later formed his own consulting firm, Consultek Inc., in nearby Wellesley.

His employment at National began last year. In this, too, Williams showed a characteristic unconventionality. "I actually spent about a year investigating about 30 potential employers before I settled on National," he explains.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The Tektronix 4054 Desktop Computer

(Below) Using the 4054's Dynamic Graphics option, design symbols can be selected from a menu, dragged into position in refresh mode, then transferred to storage mode at the push of a button.

(Above) The 4054 screen's 13 million addressable points let designers work with whole circuit board layouts without sacrificing clarity of detail.

Editorial

The threat of technological illiteracy

"Where will the teachers come from?" That's what we asked last summer [*Electronics*, July 3, p. 24] and that's what the Government is beginning to wonder. Warning that the U. S. is heading toward virtual scientific and technological illiteracy, an eagerly awaited 230-page report from the Department of Education and the National Science Foundation views with alarm the accelerating shortage of faculty members, not to mention up-to-date equipment, in computer science and most engineering disciplines at the college and university level.

The report—"Science and Engineering Education for the 1980s" (see p. 93)—even looks at the relatively recent competition from foreign companies when it says that "we fear a loss of competitive edge" as the Soviet Union, Japan, and West Germany outdistance the U. S. in elementary school science and mathematics programs. In case there is any doubt of this country's falling educational standards, take a look at a neighborhood high school's mathematics department and see how many trigonometry courses it offers. Or try to find a high school student who has progressed in math beyond algebra and geometry.

Educational shortcomings strike at the very heart of U. S. technological leadership. Movers and shakers in the electronics industries, among others, have been trying to draw attention to the trend for some time. Indeed, who knows better than they that the pipeline leading to the advanced technology of tomorrow is the new engineering talent of today? Electronics leaders, in taking the long view of the manpower shortage of today, see no cause for optimism. Take, for example, Andrew S. Grove, president of Intel Corp. When he commented recently on the shortage of electronics engineers and software people, he called the situation a "catastrophe." He maintains that technical departments of colleges and universities are simply not getting their rightful and needed share of funds, compared with their liberal arts brethren, and concludes that things will probably get worse before they get better.

The NSF-DOE report calls for new programs lest the impetus to scientific and technological education provided in 1957 by the Soviets' launching of Sputnik be lost altogether. As industry has suggested, a major part of any new effort should be inducing newly minted engineers to stay in school beyond their bachelor's degrees so that they may eventually teach the next generation of engineers and scientists. But few of them are taking that course, and lack of money is the root of the problem. For it is understandable when a young engineer chooses the $18,000 or $20,000 starting salary being waved at him by a semiconductor, aerospace, or computer company over the sometimes threadbare life of a graduate student, leading finally to the dubious financial rewards of professorship. Teaching is, to be sure, satisfying. But, as a sage once observed, it is difficult to feed satisfaction to your children.

The Government can perhaps be forgiven for ignoring the pleas of the industry types who have been saying all along what this report enunciates on a broader scale and in more depth. But the danger is that—as is so often the case in Washington—the report will be filed and forgotten while the situation worsens, until another Sputnik-like crisis awakens offical attention. It is evident that action must be taken now.

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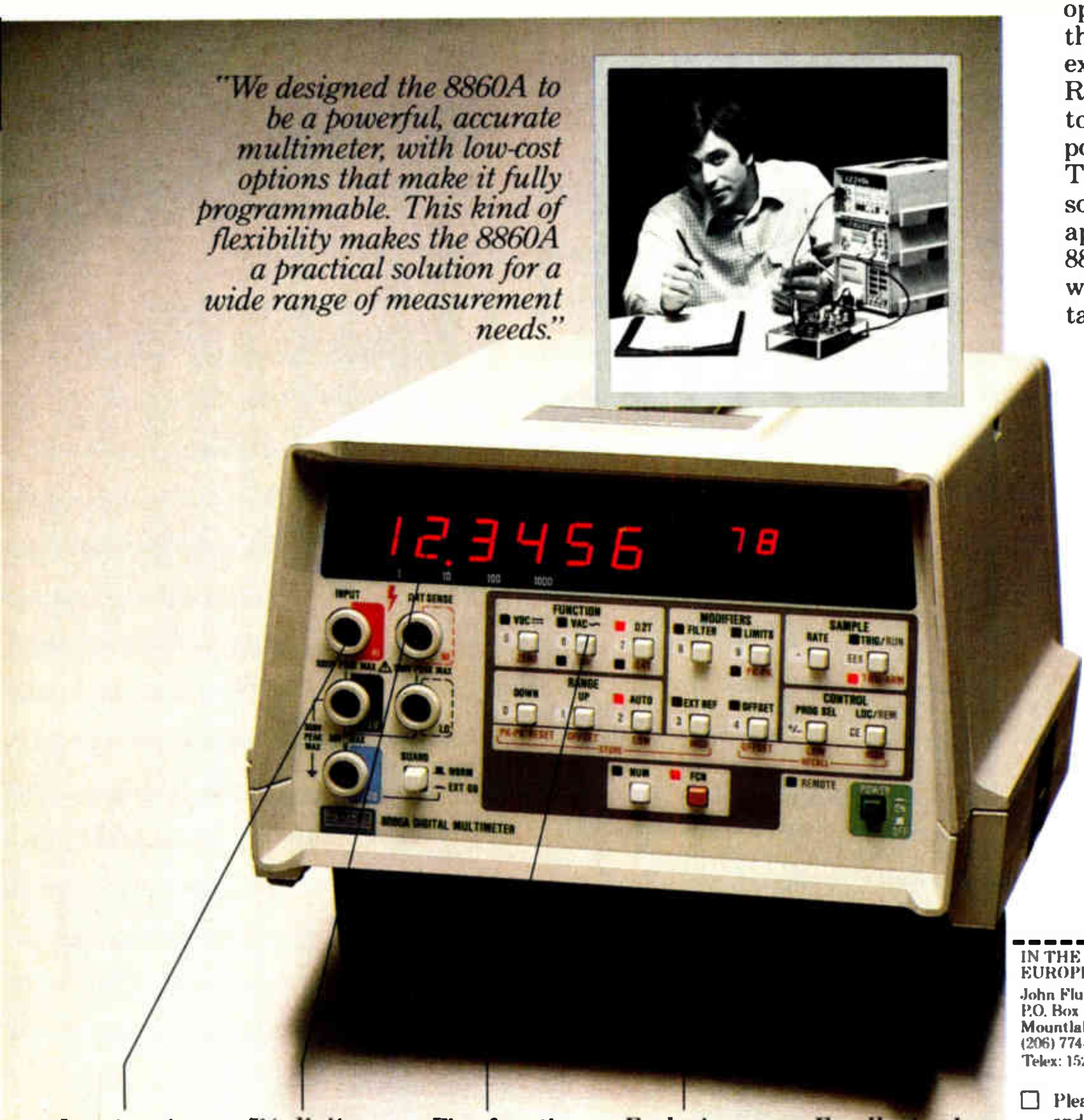

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For technical data circle no. 25

Meetings

Gomac-80—Government Microcircuit Applications Conference, Department of Defense *et al.* (Gomac Secretariat, 201 Varick St., New York, N. Y. 10014), Shamrock Hilton Hotel, Houston, Texas, Nov. 19–21.

International Conference on New Systems and Services in Telecommunications, Université de Liège (Prof. G. Cantraine, Institut d'Electricité Montéfiore, Sart Tilman, B. 28, B 4000 Liège, Belgium), Palais des Congrès, Liège, Nov. 24–26.

13th Annual Workshop on Microprogramming, Association for Computing Machinery and IEEE (Micro-13, Engineering Science Department, Colorado State University, Fort Collins, Colo. 80523), Broadmoor Hotel, Colorado Springs, Colo., Nov. 30–Dec. 3.

Fifth International Conference on Pattern Recognition, IEEE and International Association on Pattern Recognition (5th ICPR, P. O. Box 639, Silver Spring, Md. 20901), Konover Hotel, Miami Beach, Fla., Dec. 1–4.

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—14th International Symposium on Mini and Microcomputers, International Society for Mini and Microcomputers (P. O. 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.

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.

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

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For technical data circle no. 27

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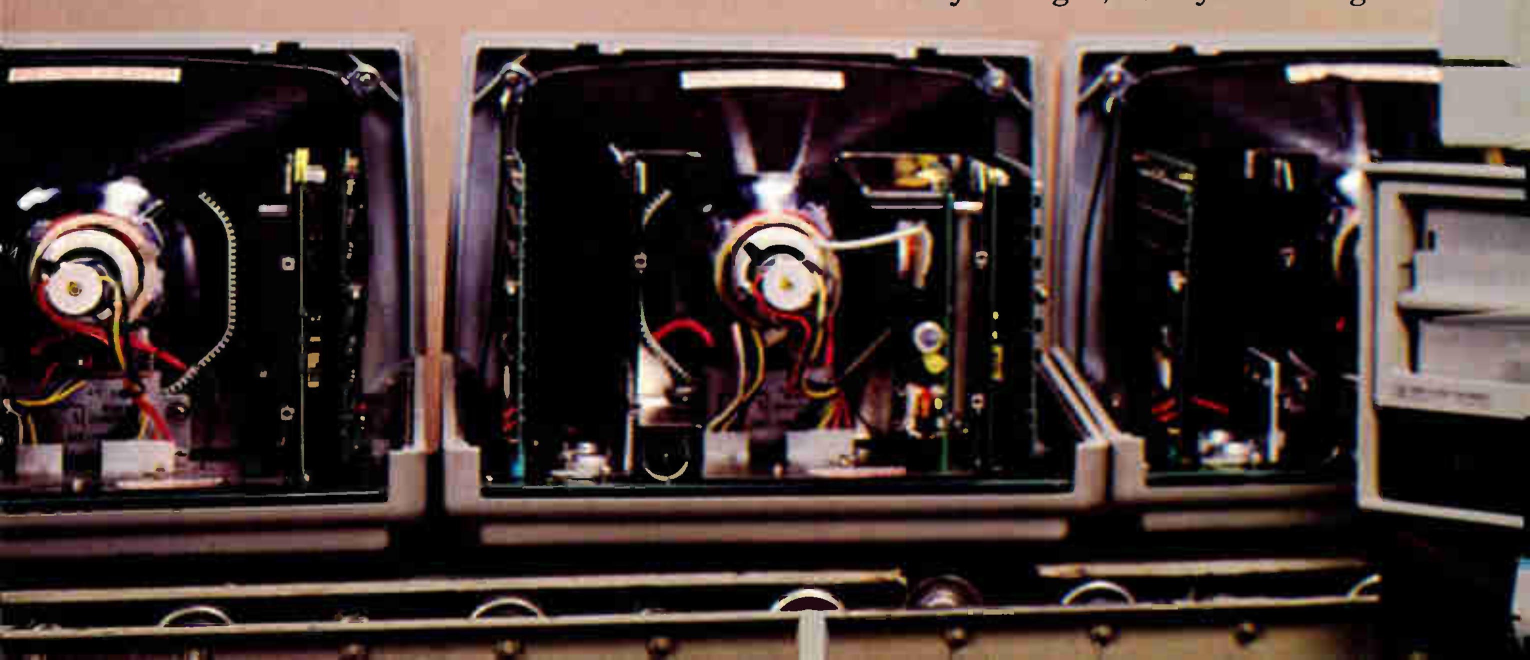

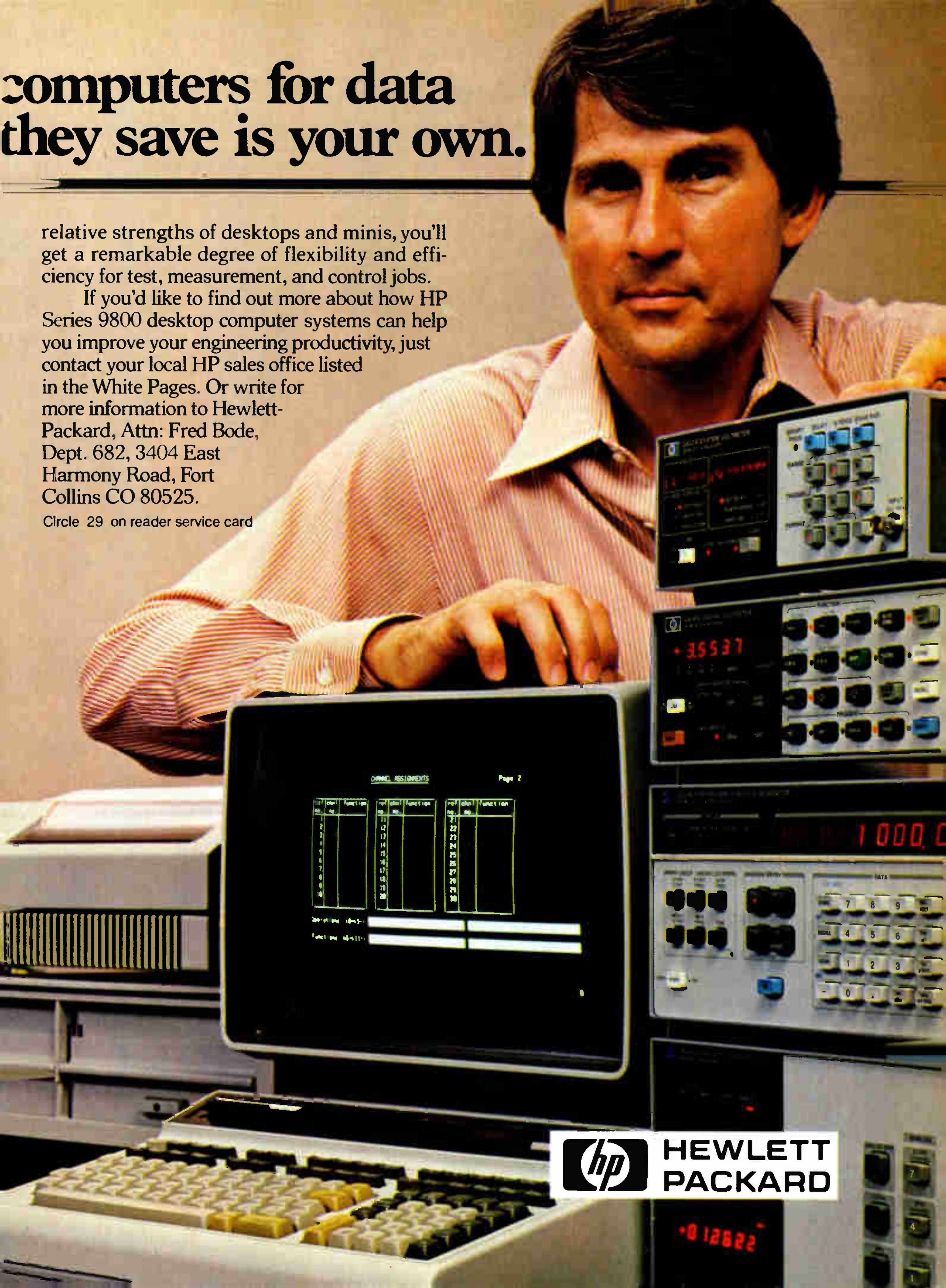
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The high-speed K100-D gives you data domain capability to 70 MHz —as compared with the 1610B's 10 MHz rate—for use with faster multiplexed microprocessors, computers, and ECL bit-slice processors. At 12 to 70 MHz, the K100-D gives you 16 channels of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

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Analysis: Software
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Biomation K100-D
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Analysis: Software & Hardware
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Memory: 1024 words @ 16 channels
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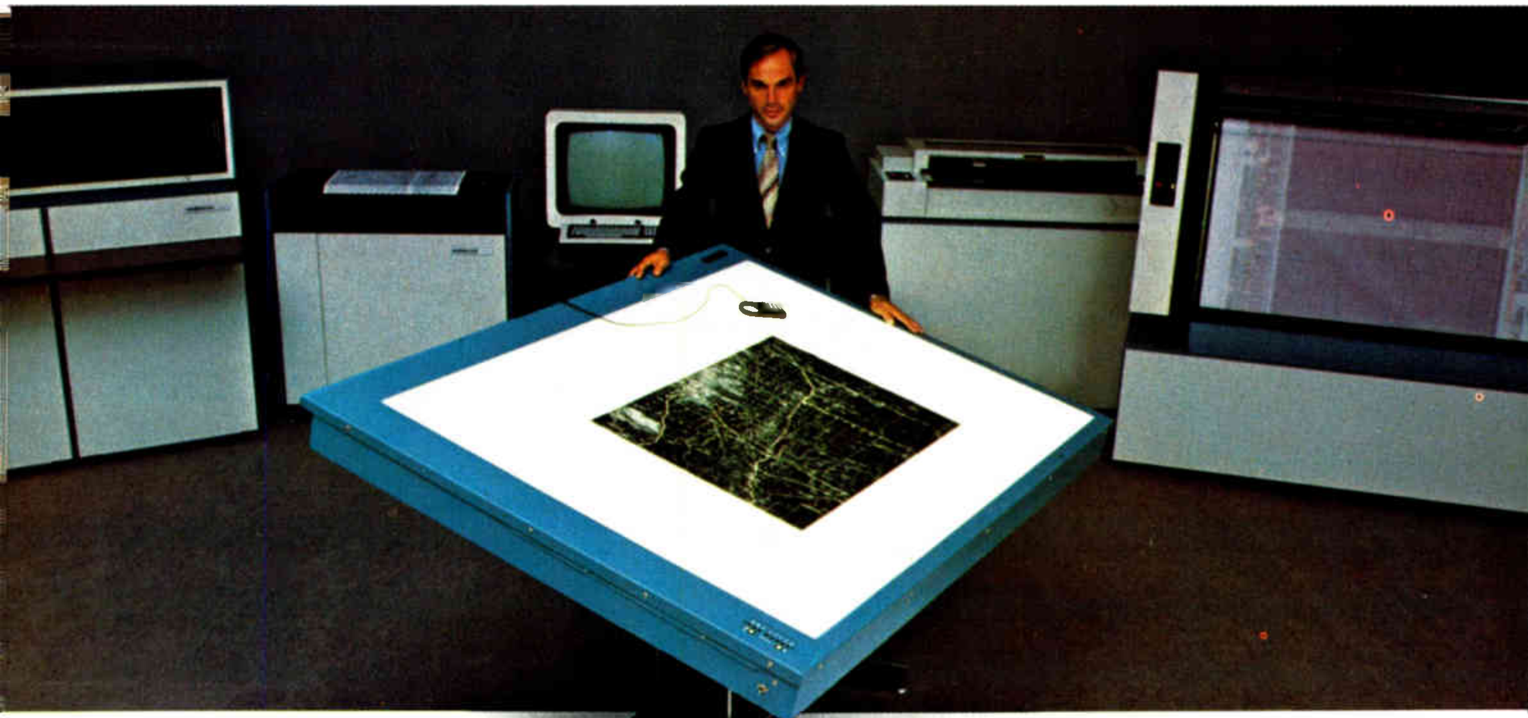

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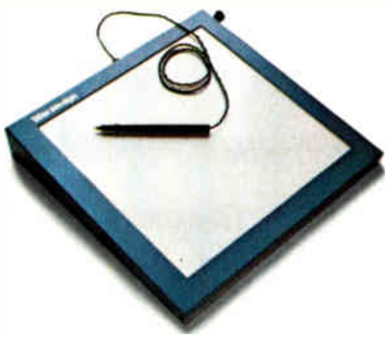

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Circle 32 on reader service card

Electronics newsletter

Book-to-bill ratio for semiconductors down in third quarter

According to the closely watched book-to-bill ratio, the semiconductor industry's third quarter of 1980 turned out to be the weakest such period since the 1974–75 recession. As computed by consultants Integrated Circuit Engineering Corp. of Scottsdale, Ariz., from figures compiled by the Semiconductor Industry Association, **the key ratio stood at 0.77 for September.** However, an SIA spokesman cautions that this figure represents an average for the three months and points out that September actually improved over July and August.

What drives this ratio lower, of course, is new orders not keeping pace with billings; for instance, September shipments of $515 million were estimated at a 34% higher rate than those for the same month of 1979. On the other hand, September bookings of about $358 million are down sharply, says ICE, from a peak of about $583 million in March. Both ICE and SIA forecast 1981 growth at about 15% over this year, which itself looks to be up 28% from 1979. SIA also foresees a 1:1 ratio by Jan. 1.

HP to offer new top-end business computer

Within a month or so, Hewlett-Packard Co.'s Computer Systems division in Cupertino, Calif., will unveil the series 44, a new top of the line for its 3000 family of 16-bit business computers. Code-named Grizzly, the system reportedly offers **1.7 times the throughput of the current top machine, the HP 3000 series III, but costs less than $6,000 (or 5%) more.** Unlike prior family members using a processor based on silicon-on-sapphire technology, the series 44's processor opts for standard Schottky TTL technology and pushes it to the limit.

Tymnet seeks to link office PBXs with X.25

A new way to deal with the problems of interoffice communications in the office of the future is being advanced by Tymnet Inc. of Cupertino, Calif. The concept is based on the use of a very intelligent private branch exchange, rather than a network processor or computer, to tie together word processors, facsimile machines, and other data terminals. To enable such PBXs to talk to each other, Tymnet proposes packet switching using the X.25 protocol. Mark W. Radwin, a consultant to Tymnet, says **the company is "well past the discussion stage" with several manufacturers of data or data and voice PBXs** to see how its public packet network could be meshed with those inherently internal digital PBX devices.

Hybrid Systems shows 14-bit converter in monolithic form

Hybrid Systems Inc. is upping the ante in the converter market by introducing what it says is the first monolithic 14-bit digital-to-analog converter. Until now, say spokesmen for the Bedford, Mass., firm, commercial monolithic technology reached 12-bit resolution. Not only does the new unit offer 14-bit resolution, **but it has 14-bit linearity and monotonicity as well.** Priced at $39 singly and $33 in hundreds, this is the first commercial monolithic converter from a hybrid house.

New Two Pi CPU to be twice as fast as company's V/32

Two Pi Corp., Santa Clara, Calif., developer of the V/32, which is recognized as the first 32-bit minicomputer compatible with IBM 370 software, has a new family of high-performance central processing units in engineering. The initial member of the new family, all of which will be field-upgradable from a basic V/32, is slated for introduction next spring. Called the V/33 inside the company, it will execute 500,000 instructions per second, which is **nearly twice the performance of its predecessor and equivalent to an IBM 370/148 or the more recent IBM 4331 group 2 processors** with cache memory [*Electronics*, May 22, p. 48]. Other members of the family, all based on standard and advanced Schottky TTL technology, are projected to perform up to 1 million instructions per second, and possibly more.

C-MOS RAM design survives 5×10^5 rads of nuclear radiation

Computer simulations have researchers at Harris Corp.'s Semiconductor Products division confident that they may soon deliver a super-hardened complementary-MOS random-access memory. **An extra photomasking level, special processing steps, and a Harris-developed silicon substrate** in combination allow a standard Harris HM650 4-K static RAM to operate without derating in the presence of up to 5×10^5 radiation-absorbed doses, or rads (100 rads is lethal to humans). Present devices resist 2×10^4 rads. Jointly funded by the Jet Propulsion Laboratory, the Naval Research Laboratory, and Applied Technology Inc., the Harris project currently is in final layout, and the Melbourne, Fla., division could be delivering prototypes by next summer.

TI system to convert text into speech

Texas Instruments, Dallas, plans to describe a text-to-speech system at the Fall Conference on Consumer Electronics, to be held Nov. 10–11 in Chicago. **The system converts incoming ASCII characters into natural-sounding speech by joining allophones,** which are variants of phonemes, the basic units of human speech. Besides having an unlimited vocabulary, the voice-response unit will be inexpensive and will interface easily with microprocessors and minicomputers. It is based on a microcontroller and TI's TMS5200 synthesizer chip, which uses linear predictive coding for reduced memory requirements.

National's Moose yields highest output current

National Semiconductor Corp. has developed a bipolar linear process, called Moose, based on a new integrated-circuit fabrication structure that allows the Santa Clara, Calif., firm to make high-current transistors on half the die area of standard processing. The first device to be built with the process is a single-chip adjustable voltage regulator, soon to be introduced, able to supply in excess of 10 A and to operate at power levels of up to 70 W, **or twice that of the present highest-output-current IC regulator available, National's own LM138.** The new device, called LM196, is to be available the first quarter of 1981.

Telic terminal to be marketed for consumer use

The Telic terminal, developed in France to replace the telephone book via access to the French videotext system, will soon have a modified American cousin. The as yet unnamed American version will be distributed by Source Telecomputing Corp. of McLean, Va., which will package the terminal with a subscription to its data base and sell it for from $500 to $600. Calling it the ideal consumer terminal, Source has signed an agreement with the designers of the American version, Reliable Communication Products Inc. of Franklin Lakes, Ill., **to market at least 250,000 terminals over the next three years.** The American version includes a 9-in. screen, an integrated 300-baud modem, and a keyboard, but not the integrated handset that the Telic terminal has.

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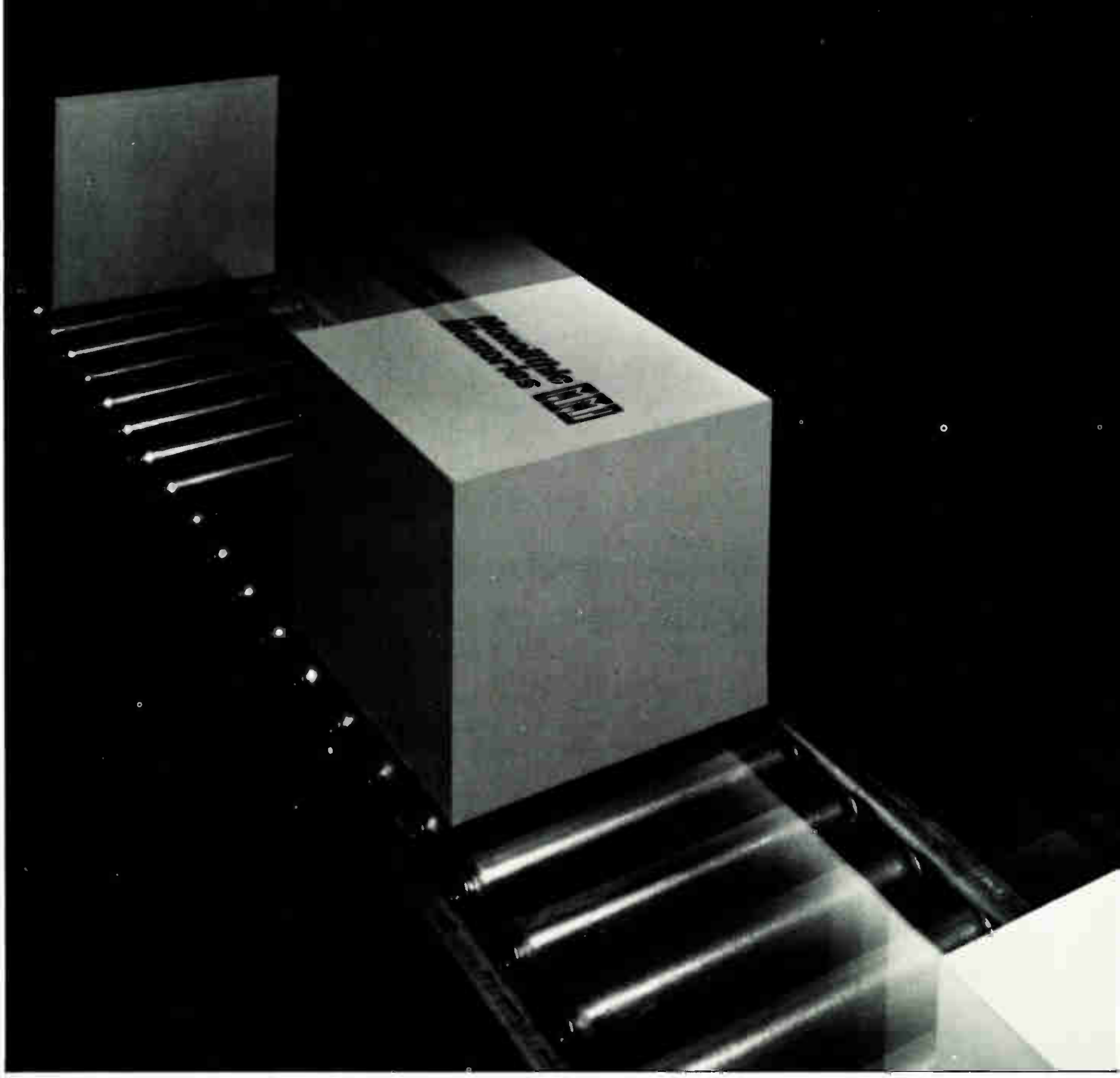

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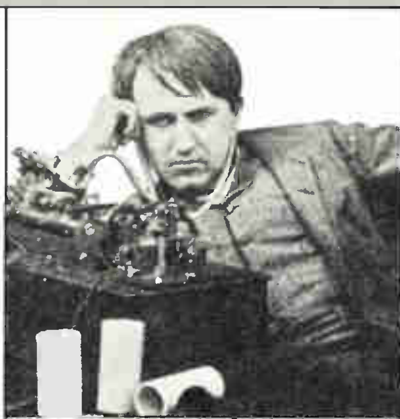

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Which will in turn make it as popular as the lightbulb. Because now, you and your software can stay with the XENIX OS, even after moving to new 16-bit hardware.

Very ingenious.

Solid support from the experts.

Best of all, the XENIX OS is brought to you by Microsoft, the leading innovator in quality system software. We believe in full support for our customers, no matter how much perspiration we expend in the process.

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MICROSOFT

TI airs details of low-cost solar collector

by John G. Posa, Solid State Editor

Novel photovoltaic design uses silicon spheres; conversion efficiency is 13%, cost is projected at 4¢/kW-h

The revolutionary solar energy system from Texas Instruments Inc. is ready for public airing. With a novel storage concept and a competitive conversion efficiency of around 13%, TI's design dramatically slashes the cost and energy required to build a collector—considerations of increasing importance in figuring a system's overall cost-effectiveness.

Because the design allows storage of energy, the Dallas company is confident its system can replace—rather than just supplement—existing electrical utilities. In fact, TI says, extensive cost studies and computer models have already shown that the system should produce more than 90% of a typical home's power at 4¢ per kilowatt-hour—the present cost of electrical power and well below the national goals for solar-energy systems.

Development. The system has been known to be in development for some time, with partial funding from the U. S. Department of Energy [*Electronics*, June 7, 1979, p. 55]. Co-inventor is Jack Kilby, the TI semiconductor pioneer often credited with originating the concept of the integrated circuit. Now that patent issues have been resolved, TI is ready to go public with its development.

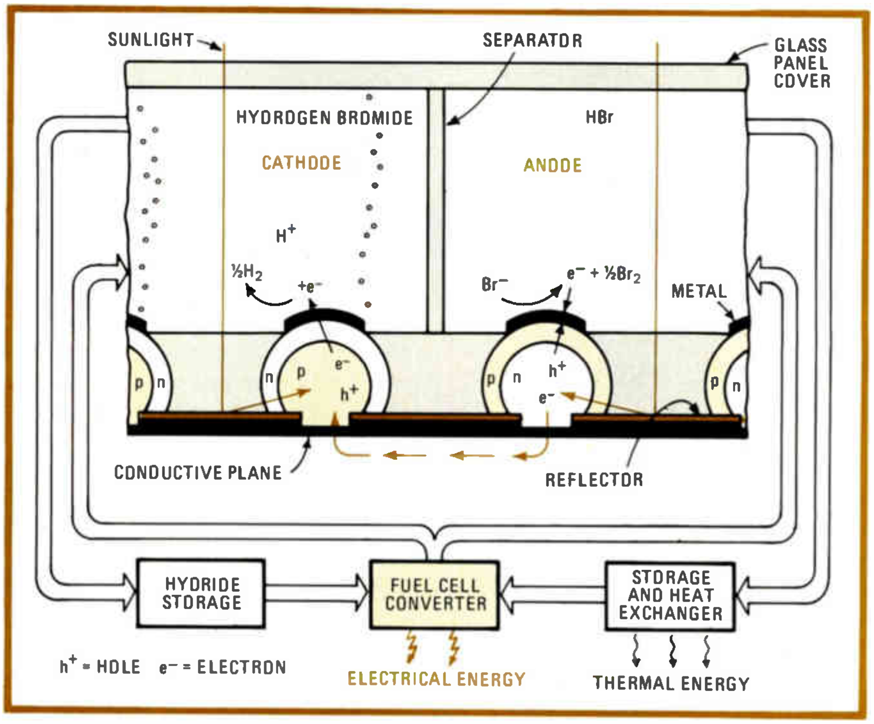
The collector contains an array of small silicon spheres—with either n centers and p coatings or p centers and n coatings—having metal electrodes that form anodes and cathodes, respectively (see diagram). These force a trickle current through a hydrobromic acid electrolyte, separating it into its constituent parts, liquid bromide and hydrogen gas, which are stored separately and recombined in a fuel cell to generate electricity on demand, as well as reconstituted electrolyte.

In this closed-loop system, the collector fluid is also warmed by the sun, so it is cooled by being passed through a conventional heat exchanger. "The only input is solar radiation, and the output is electrical and thermal energy," remarks project manager E. L. "Pete" Johnson.

Other photovoltaic collectors demand banks of batteries that are expensive, bulky, and difficult to maintain. The bromide in TI's system, in the form of tribromide ions in solution, is easily stored.

Though the storage of a large volume of hydrogen gas can be tricky because of its bulk and volatility, new methods are gaining prominence. One is to force the hydrogen atoms into the interstices of a metal alloy, forming a hydride compound.

Savings. At least as impressive as the storage concept is the ingenious design that lends itself to radically cheaper production. Conventional photovoltaic panels require large amounts of costly single-crystal or polycrystalline silicon. There, round



Light to power. TI's solar-cell-plus-electrolyte system, using spherical silicon collectors and a glass matrix exploits a reversible reaction: $2HBr + H_2O + \text{electricity} \rightleftharpoons H_2 + Br_2 + H_2O$.

ingots waste collector area and silicon, and ribbon-growing or casting methods so far deliver only moderate efficiencies for the expense of the procedures that shape them.

In contrast, TI's little silicon balls are made like lead shot; molten silicon is forced through an orifice, solidifying into crystalline beads. "No silicon is wasted," Johnson says.

Arrays. Since solar cells are low-voltage devices, they must be interconnected for kilowatt capacities. With ordinary systems, interconnection is labor-intensive and flaws in or excessive leakage from a single cell can seriously degrade performance.

But TI's silicon spheres are inexpensively cast into a glass matrix and automatically interconnected with a conductive backing layer. Thus, complete silicon coverage of the collector area is unnecessary, no electrical connections to the collector need be made, and open or shorted cells are tolerable. Johnson says sheets as large as 4 by 8 feet may be practical.

Though TI will not give a timetable on commercial introduction of its system, it does say that residential installations are its primary target. Home use "represents one of the few [markets] large enough to justify the costs of full-scale development," Johnson says.

He will describe the system at the Government Microcircuit Applications Conference—Gomac-80—to be held at Houston's Shamrock Hilton Nov. 19–21. More than 100 papers will address the general theme—signal processing—and a long list of other application areas.

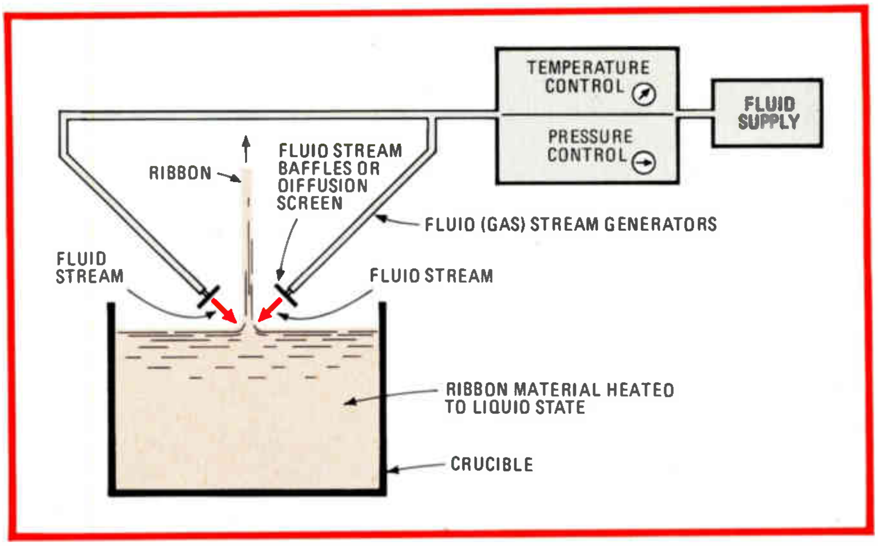
Gas jets shape silicon ribbon

Like the developers of Texas Instruments' new solar energy system, many researchers are pursuing the goal of high-efficiency solar cells produced cost-effectively. One promising technique receiving attention is fabrication of the silicon substrates in ribbons rather than ingots, and two Boston researchers report experimental processes they say sidestep yield problems hobbling other ribbon approaches.

In one process, developed by Welville B. Nowak, a mechanical engineering professor at Northeastern University, gas jets shape a silicon ribbon as it emerges from the melt. Patents are pending on the other approach, developed by Emanuel Sachs, an engineer at the Massachusetts Institute of Technology's mechanical engineering deparment in Cambridge, so he and his sponsor will not discuss the process's key mechanism, only its results.

Improving. Nowak says his method improves on current ribbon processes, such as those employed by Westinghouse Electric Co., and Mobil Tyco Solar Energy Corp. [*Electronics*, July 19, 1979, p. 110]. As in the ingot-producing Czochralski method, a silicon-crystal seed lowered into molten silicon starts the process; as the seed is withdrawn, it brings with it a column of single-crystal silicon from the melt.

Surface tension produces cylindrically shaped ingots in the Czochralski method, but Nowak's uses jets of inert gas or, since the crucible environment is inert, hydrogen. Applied to the column, they flatten it into a ribbon as it rises from the melt (see figure). Varying the temperature, pressure, angle, and number of gas jets configures the silicon to a desired width and thickness.



Gas shaping. In an experimental method, silicon ribbon for photovoltaic cells is shaped as it comes from the melt by carefully controlled jets of hydrogen or an inert gas.

This method eliminates the use of dendrites and special dies to shape the silicon into ribbons. The dendritic method used at Westinghouse, Nowak notes, produces ribbons with irregular edges and suffers from a high incidence of crystal deformities. Dies used in Mobil Tyco's edge-defined film-fed growth process dissolve on contact with the silicon melt, introducing impurities.

Control. A crucial factor with Nowak's method is the need for precise regulation of the gas jets. But he believes that sophisticated equipment available to industry will circumvent this difficulty.

The initial performance of the Sachs' ribbon-production method looks good. Of this approach, the developers will say only that it also works without dendrites or dies to shape silicon drawn from a melt. It has produced good-quality polysilicon ribbons with uniform 1-inch widths, manufacturing them at up to 6 in. per minute, they claim. Nowak, whose lab equipment limits him to 1-centimeter ribbons, sees no width limitations in his process.

Sachs' method allows the temperature of the molten silicon to vary 10°C or more, whereas current methods may need to keep variations to within 0.1° to ensure high-quality results. (Production of polysilicon ribbons, rather than the single-crystal ribbons he is producing, allows greater leeway in temperature control, Nowak comments).

Potential ribbon width with this method is about 4 in., figures Edward J. Cook, a physicist with Arthur D. Little Enterprises, sponsor of Sachs' work. He claims that ribbons with crystals several centimeters square have been achieved and that the photovoltaic properties of the ribbons compare well with those produced by present processes. He says Sachs' technique is relatively simple, allowing continuous operation when monitored by even an unskilled operator. **-Linda Lowe**

Speech synthesis

Speech processor on single chip talks at low bit rate with novel coding technique

The latest entry in the voice synthesis sweepstakes is a complete speech processor on a chip from General Instrument Corp., and it is the kind of offering that will boost talking integrated circuits into the realm of commodity products. Potential users of the growing number of speech-synthesis ICs have been looking for a low-cost, single-chip solution, and GI aims to make just that available in quantities in early 1981.

The SP-0256 can produce human-like speech at a surprisingly low bit rate because of its novel speech-encoding techniques. This efficient processing contributes to the competitive size of the IC: at 45,000 square mils, it is about the same size as the synthesizer IC alone in Texas Instruments Inc.'s three-chip set and three fourths the size of Matsushita's single-chip speech processor.

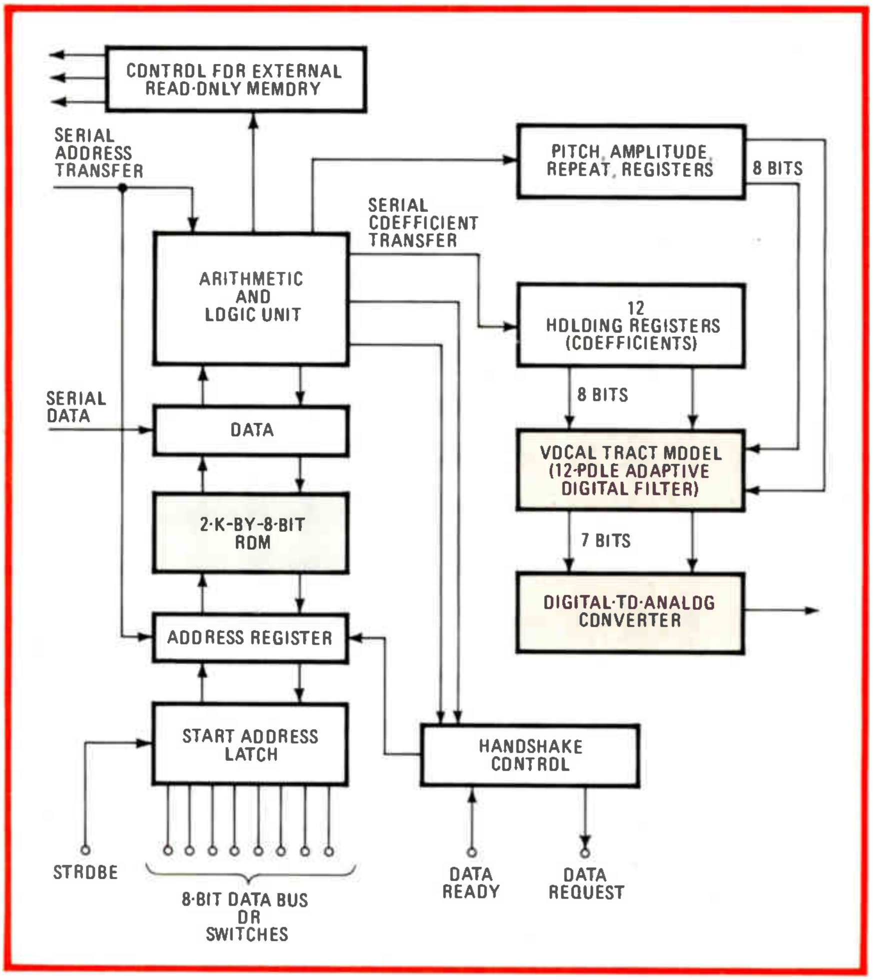
Complete. The n-channel MOS chip from GI's Hicksville, N. Y., Microelectronics division holds the synthesizer (the two solid-color blocks in the figure), a mask-programmable read-only memory, and a 4-bit microcontroller. Its 16-K ROM stores all data and instructions to produce 256 discrete sound sequences; for more words or higher quality sound, as much as 512 K of external ROM may be added.

The drive to produce ICs that can speak [*Electronics*, May 22, p. 95] is taking several routes. The chip duo from National Semiconductor Corp. uses waveform digitization; the chips from TI and others like Telesensory Systems Inc. use linear predictive coding, which models the vocal tract with a multiple-stage lattice filter; boards—and now chips—from the Votrax division of Federal Screw Works use formant coding, which combines frequency components (formants) into words.

In effect, GI combines linear predictive and formant coding, deriving the coefficients for an LPC algorithm from the frequency domain, rather than from the time domain, as in other LPC systems. This allows the extraction of redundant information to reduce bit rates.

Furthermore, the lattice filter is adaptive to accept changed coefficients, allowing GI greater programming flexibility than with time-based LPC systems. Thus the SP0256 can be programmed across a range from high-quality human speech, at the rate of one word for every 1,000 bits, to robotic speech, at one word for every 500 bits.

Using the frequency domain lets GI cut the amount of data necessary to reproduce words. "LPC is a mathematical procedure, but with [time-based approaches] you can't identify what information is redundant in



Talkative. GI's single-chip speech processor can hold as many as 32 words and associated instructions in its programmable ROM; adding more memory gives a bigger vocabulary.

speech because you can't identify what is important," says Stephen G. T. Maine, group director of advanced products. "With our algorithm, redundant information may be extracted."

Formants. GI will start with a tape of the sounds the customer wants. "We will do straight synthesis of that voice," Maine says. "We can model the voice using six formants. But we can throw away three of those formants and still reproduce the voice. We can reduce the data needed to be stored by up to 60%."

Thus the single chip can completely process speech for applications that need a few dozen words, like clocks, calculators, and instruments. In fact, GI sees the SP-0256 as another in its long line of commodity parts—and it plans to be shipping production quantities in 1981's first quarter priced at $10 to $12 in 25,000-unit volumes.

Moreover, the company is ready to quote a price for quarter-million-unit lots: $5 each. Also coming soon are 64- and 128-K add-on ROMs and development and prototyping support systems. "There are a lot of applications," Maine says. "With 32 words on a chip, you can do quite a bit."

-Pamela Hamilton

Microsystems

Intel's 32-bit three-chip set promises software-transparent multiprocessing systems

At three invitation-only sessions, Intel Corp. is disclosing key details of its forthcoming 32-bit microprocessor, the iAPX-432, to potential major customers. Details on these sessions are scant, but what is surfacing gives the picture of a system whose processing power can be incremented solely by plugging in additional units, without affecting the software. In other words, 432-based multiprocessing systems are software-transparent.

The three-chip minimum configuration [*Electronics*, May 22, p. 39] is the equivalent of a mainframe computer, and Intel is not shy about comparing anticipated systems with minicomputers and mainframes (see figure). When the set becomes available next year, it will cost about $3,000, but the Santa Clara, Calif., company expects the price will fall to about $200 by 1984.

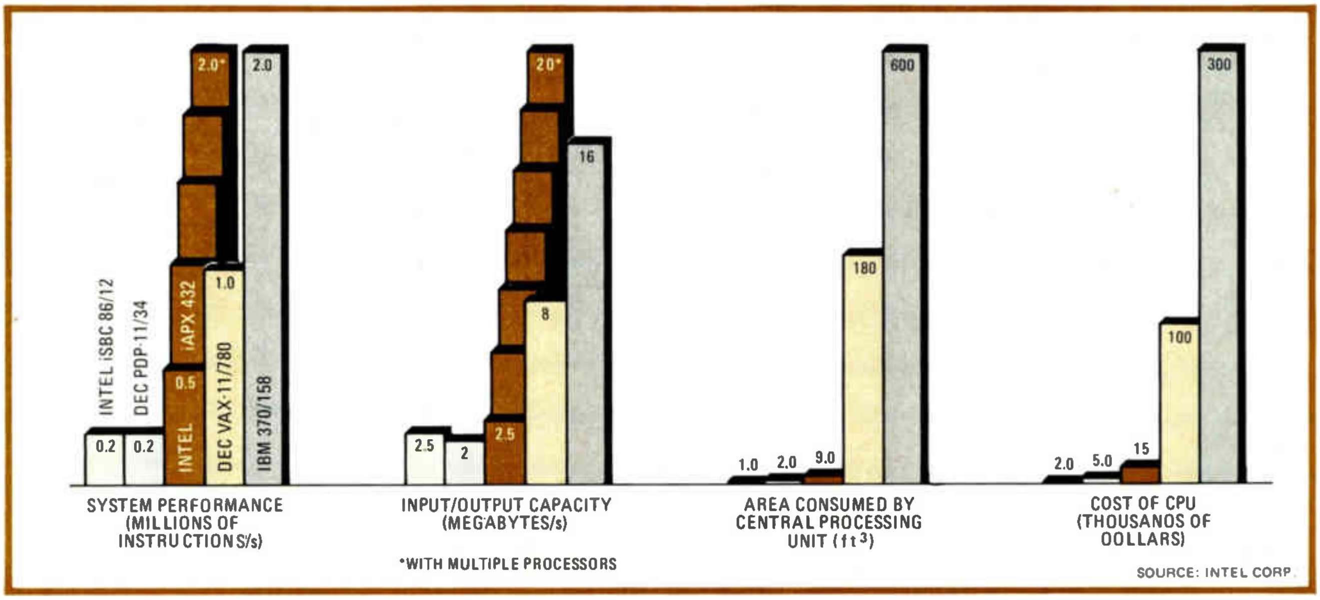
The three chips are the 43201 instruction-decode unit, the 43202 instruction-execution unit, and the 43203 input/output interface. However, Intel clearly sees these very large-scale integrated circuits as basic building blocks for high-performance machines.

Automatic. To this end, the processing units in a multiprocessor system are self-dispatching: each recognizes the instructions it is to execute and pulls them out of the instruction stream. This capability is achieved in part by integrating on the silicon many operating-system functions that have been software-based.

The hardware can schedule and dispatch concurrent processes to execution units. Interprocessor communication and memory management are handled similarly, including the mapping of a virtual memory space of 2^{40} bytes maximum into the physical space of 2^{24} bytes.

Hardware implementation of these functions is possible because of the 432's VLSI level of density: six times that of the 16-bit 8086. There are more than 200,000 devices in the three-chip set.

Just as in mainframes, hardware implementation of software functions contributes to an extremely



Stacking up. Intel expects systems based on its forthcoming 32-bit microprocessor, the iAPX 432, to excel small minicomputer by a wide margin. In fact, it does not hesitate to stack the new offering up against mainframes and high-performance minicomputers.

Buying a pre-owned instrument can help maximize your cash flow.
With today's ballooning interest rates, tight money and soaring inflation, it's tougher than ever to justify large cash outlays for new equipment. A pre-owned instrument from USIR can save you up to 40% over a new one, and you don't have to sacrifice quality.

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high throughput. Intel also is specifying 0.4 and 5 microseconds for 32-bit addition and multiplication, respectively, and only 27 μs for 80-bit floating-point multiplication.

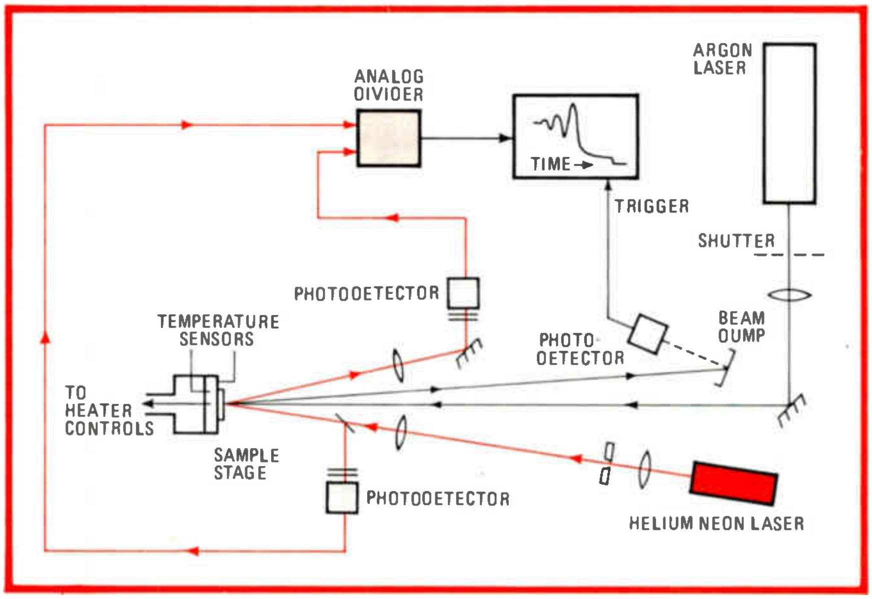
Language. To circumvent the tedium of low-level assembly-language programming, Intel mapped the features of a modular high-level language—the Department of Defense's Ada—directly into the hardware, making it the computer's native tongue. Then, to standardize the manipulation of all of Ada's varied constructs, which range from simple to complex data types and from nested tasks running on one processor to messages among the various processors, Intel adopted the notion of an object.

An object is simply a standardized format for a set of operations or data that can be referenced by a program. The format subsumes Ada's constructs in a way that unifies the 432's software and hardware operations into a consistent picture for the programmer.

Emulating mainframes, the 432 offloads I/O interrupt management into front-end processors, functions that Intel's Multibus line and the forthcoming iAPX-286 single-chip processor can serve. The 16-bit 286, featuring memory management and protection in silicon, also was discussed in detail at the invitation-only session. **-R. Colin Johnson**

Solid state

Laser monitor aids single-crystal growth



Precise growth. In Hughes Labs' experimental setup, HeNe laser monitors the crystal-growing activity of an argon laser, permitting fine-tuning of the growth.

Coming over the semiconductor-processing horizon is what looks to be a key use of the laser: a real-time tool to measure precisely—and therefore control—growth of silicon single crystals. Hughes Research Laboratories has rigged up a laser duo, with a helium-neon unit monitoring crystal growth rates that result from the heating of amorphous silicon by an argon continuous-wave laser.

The results of the HeNe laser's monitoring are used to fine-tune the action of the argon laser, already a precise and flexible tool for crystal growth. Though the initial work in the year-old project is with amorphous silicon, the jackpot is likely to be hit with polysilicon, from which prized large crystals can be grown.

Payoff. If these crystals are large enough, entire devices or circuits can be fabricated in them. The payoff is true three-dimensional micro-electronics, because devices can be stacked in successively grown layers.

Industry experiments have been limited to growing crystals with diameters of 20 micrometers. But Hughes says it already can do better than that, although efforts are only getting started with polysilicon and silicon dioxide layers.

Purely as a research tool, Hughes' laser-based annealing and monitoring technique shows such potential that "it is bound to stir intense interest," predicts LaVerne D. Hess, head of the laser chemistry section in the chemical physics department at the Malibu, Calif., labs. "Clearly, there are important advantages in the Hughes technique," says Walter L. Brown, head of the radiation physics department at Bell Laboratories, Murray Hill, N. J., which was a pioneer in laser application to semiconductor processing [*Electronics*, March 1, 1979, p. 88].

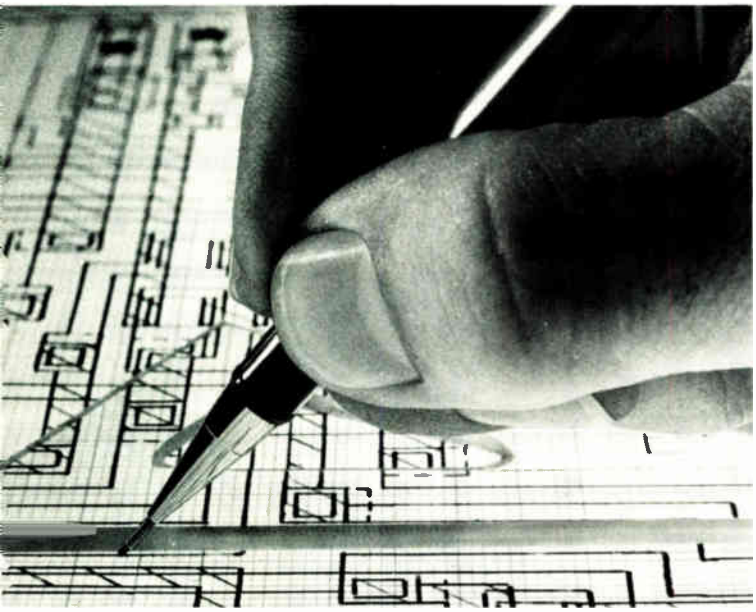
Brown is especially intrigued with the "feedback scheme of the Hughes work, which is very plausible," since it adds flexibility to control of the heat laser. He says Bell has worked with a second laser as a measurement tool but did not take the real-time feedback route.

Even more useful would be putting the whole setup under minicomputer control, something Hess says Hughes is already pursuing. Currently, the argon laser is adjusted by a researcher after seeing a readout of the test results.

Operation. The Hughes experimental gear is configured so the probe beam focuses to about 10 μm within the 30-μm spot of the argon laser annealing beam. Photodetectors sample the ingoing beam's intensity as well as the filtered, reflected intensities (see figure) and display the results on a chart recorder or oscilliscope.

Hess says the precise measurement of crystal growth is an order of magnitude better than those of conventional furnace-firing techniques, which have resolutions of only 300 angstroms or so. The measurements come from monitoring optional interference effects, which occur when the heating laser causes the thin film to crystallize. The heating unit uses from 5 to 20 watts; the helium-neon

"Every time we ask a MOS/LSI company about their custom experience, they change the subject."



That's no surprise. Most MOS/LSI companies take on custom work only when market conditions force them to. And, no matter how big they may seem, they're usually only willing to handle a few limited jobs. So they really don't have much custom experience worth talking about.

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"The single crystal grows out from the amorphous/crystal interface toward the surface," Hess explains. Actual growth rate is calculated from the variation in intensity of the reflected probe beam hitting both the material surface and the advancing crystal. Time-dependent changes in reflectivity make possible continuous measurement.

When perfected, the entire process will take only a fraction of a second, compared with 15 minutes or more for a furnace growth and up to a day to measure it, says Hess. He expects the first implementations of the technique to follow quickly, because laser annealing equipment, which Hughes uses, is available already at most sites involved in this kind of advanced materials research. Within a year or two, experimental devices will probably be fabricated with the technique. **-Larry Waller**

Memories

U. S. reject rate still trails Japanese

U. S. semiconductor makers are significantly improving the quality of their parts in an effort to regain market share, but their Japanese competitors still best them, says a prominent user of semiconductor memories, Hewlett-Packard Co. "It's my assessment that the Japanese semiconductor industry is ahead of the U. S. on MOS memory," states Richard W. Anderson, general manager of HP's Cupertino, Calif., Computer Systems division.

With much skepticism, the division began buying 16-K random-access memories from Japan when the supply from U. S. vendors started to dwindle several years ago. As Anderson told a seminar in Washington, D. C., last spring [*Electronics*, April 10, p. 81], not only was the quality good, it was superior to that of U. S. RAMs.

Range. "It appeared we were finding failure rates from U. S. products five to six times as great as from the Japanese. We and others, since, have seen an improvement in American products," he now says. HP saw the improvement in functional and parametric tests performed after simulated life tests conducted from January through August on 16-K RAMs from five Japanese and four American vendors (see table).

"There is still a large offset in favor of the Japanese," Anderson says. "The best U. S. performance is still worse than the worst Japanese." Although U. S. performance is about twice as good as in his earlier report, he notes, "the Japanese still show about a 3:1 superiority."

HP has only begun to qualify 64-K RAMs, and the only supplier it has accepted so far is Japanese. "We believe there are three Japanese vendors and three Americans who will qualify," Anderson says.

Concern. The Japanese are now "a little ahead on the 64-K RAM. Worse, they are at least at parity on emitter-coupled gate-array logic. Since this is what high-performance computers are going to be built of, this should greatly concern not only U. S. semiconductor manufacturers but also U. S. computer manufacturers. It certainly concerns us."

At least one U. S. semiconductor maker vigorously rebuts Anderson's conclusions, citing present failure rates close to the best of the Japanese. Arguing that the U. S. industry leads in productivity and quality, Charles E. Sporck, president of National Semiconductor Corp., told a Dataquest Inc. conference of semiconductor executives in Scottsdale, Ariz., late last month that the quality of American firms' parts "has been improving at an outstanding rate."

Push. Sporck says his Santa Clara, Calif., firm has improved its rejection rate in customers' tests from as high as 0.85% in fiscal 1979 to 0.1% by the end of fiscal 1980. For the current fiscal year, ending May 31, 1981, the goal is a reject rate of 0.05%. These figures are representative of U. S. semiconductor manufacturers, he believes.

Another major semiconductor producer, Advanced Micro Devices Inc., is aiming at a rejection rate of 0.1% for MOS read-only memories and RAMs, 0.2% for bipolar linear, logic, and interface chips, and 0.3% for large-scale integrated MOS logic and bipolar memory chips. These levels will be guaranteed to customers by April 1981, says W. J. Sanders III, president of the Sunnyvale, Calif., firm. AMD, in fact, has always manufactured all its chips to pass the performance tests in MIL STD 883. **-Bruce LeBoss**

COMPARING 16-K RAM FAILURE RATES AFTER BURN-IN

Japanese vendor	Failure rate	American vendor	Failure rate
Ja	0.05%	Aa	0.60%
Jb	0.10%	Ab	0.50%
Jc	0.12%	Ac	1.20%
Jd	0.35%	Ad	0.70%
Je	0.25%		

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Software

C, UNIX system takes on all sizes of CPU

After 10 years of wide use within the Bell system and at universities, the UNIX operating system and its companion programming language, C, are spreading to many more processors, from Z80s to Amdahl 470 V/8s. Bolstering this trend, the new C/70 mid-range minicomputer is billed by its builder, BBN Computer Corp., Cambridge, Mass., as a software development system optimized for C.

The UNIX software was developed at Bell Laboratories, as was C, in which it was written, and C/70 uses an enhanced version of the operating

Electronic mail goes independent

Electronic mail software that is independent of the user's central processing unit and therefore more cost-effective will emerge by early 1981 from the BBN Information Management Corp. To achieve this feat, the company is writing the package in Ratfor, for rational Fortran, which is a structured version of the high-level language. The absence of unstructured looping, as with GO TO statements, means that the program is easier to develop, read, and debug. To adapt the package to a particular CPU, the company translates Ratfor in a preprocessor into Fortran, which the user converts into the object code for his particular network.

The parent company, Bolt Beranek & Newman Inc., Cambridge, Mass., already offers electronic mail software, but each package must be written from the ground up for the particular application. BBN Information Management, also in Cambridge, has set up the software based on modules for ease of alteration as applications requirements and computer communications change. The modules handle communications, terminals, data-base management, electronic mail commands, and protocols separately. Like other electronic mail software, the package will act as a mailbox and a store-and-forward message system, and it will call up files for individual users and permit information exchange among terminals. "We intend to make this package available on most of the popular CPUs, as users requested," says John M. McQuillan, vice president of the subsidiary. **-Harvey J. Hindin**

system licensed from Western Electric. The combination should aid programming because the high-level language runs nearly as efficiently as machine language.

In fact, the UNIX/C combination is both efficient and portable, whereas Pascal, the other burgeoning structured high-level language, is only portable, says Bill Plauger, president of Whitesmiths Ltd., New York, one of several firms that offer software based on the UNIX/C duo. He estimates there are more than 1,000 installations outside the Bell System now and says the number is growing rapidly.

Trio. Contributing to its growing popularity are all three parts of the typical software system: the UNIX kernel, which takes up only 25- to 100-K bytes of memory; the C programming language, which occupies a small memory space and has good structuring facilities and compact notation; and a complete set of development tools and utilities for running a multiuser system.

Allowing structured programming, C encourages designing software in small modules, typically one-page functions. Thus programs can be built up easily, and the army of programmers experienced with high-level languages find it easy to use.

Since the UNIX system and the language make extremely economical use of memory, they are naturals for minicomputer and microprocessor systems. Their modularity gives easy adaptation to different computers that is quickly realized with the development tools, so that the combination is highly portable.

Development tool. The C/70 also includes a network-control program compatible with Arpanet and Telenet, electronic mail facilities, and word-processing capabilities. Its builder is a recently established subsidiary of Bolt Berenak & Newman Inc., also in Cambridge, the developers of Arpanet and Telenet packet-switched data networks.

BBN Computer Corp. already offers processors that function as packet-switching controllers. Though the C/70 is in effect a general-purpose minicomputer, its builder is pushing it as a software development tool because it thinks the users of many other machines will seek such a system as their interest in the UNIX operating system rises.

The C/70 is a microprogrammable 20-bit computer with a 32-K-to-1-megabyte main memory, an instruction mapper, a memory management unit, both source and destination buses, and error-detection

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For programming. Executing the C language and UNIX operating system, BBN Computer's C/70 is a minicomputer billed as a software development system.

and -correction capabilities.

The machine implements many of the C instructions in microcode for fast, efficient processing. These instructions take up 5-K bytes of the 32-bit-wide micromemory, leaving 3-K bytes for the user.

Offerings. Right now BBN and Amdahl are the only computer companies offering complete UNIX hardware and software systems. Amdahl's package, to be available next year, will run on all its machines; in fact it will run on any computer that uses IBM 370 code, because its compiler produces 370 object code. Amdahl says its software development group wanted the package, and enough customers—including American Telephone & Telegraph Co. operating companies—asked for it to suggest there is a significant market.

Certainly the most common machine operating with the UNIX software is Digital Equipment Corp.'s PDP-11, because AT&T makes heavy use of this minicomputer. However, DEC does not yet offer it, although Whitesmiths has just introduced Idris, a UNIX-based operating system for the PDP-11. Whitesmiths also offers a package for Z80s.

Other UNIX-based offerings include the just-introduced Xenix operating system [*Electronics*, Oct. 23, p. 310] from Microsoft for 16-bit microprocessors. 3Com Corp., Menlo Park, Calif., licenses a communications package for systems with UNIX software. -Tom Manuel

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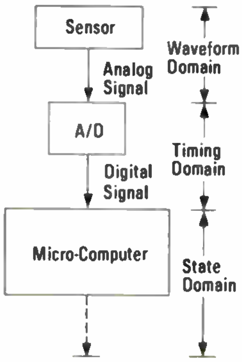

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GTE may compete directly in new markets, FCC rules

General Telephone & Electronics Corp., the nation's second largest telephone company, will be exempt from the requirement imposed on the American Telephone & Telegraph Co. to offer deregulated data-processing equipment and services through a fully separated subsidiary, the Federal Communications Commission says. Also in its 4-to-2 vote at the end of October reaffirming most of its landmark April ruling in the Second Computer Inquiry [*Electronics*, April 24, p. 104], **the FCC relaxed the requirement that AT&T separate by March 1982 the cost of all terminal equipment—an estimated $10 billion—from the cost of service.** The deadline will now apply only to new installations after that date. Meanwhile the FCC will begin a new inquiry by year-end on how to deregulate terminals already installed.

IBM, Sperry Univac win parallel awards for Navy's NECS

Two new Navy shipboard computer systems to begin 1984 production under the Naval Embedded Computer System (NECS) **will feature throughputs up to 4.5 times greater than those of existing systems,** according to parallel competitive development contracts awarded to International Business Machines Corp. and Sperry Univac. Under the three-year awards by the Naval Sea Systems Command, IBM's Federal Systems division got $20.2 million and Univac Defense Systems $15.8 million to develop the AN/UYK-43 large-scale shipboard computer. It will be able to directly address 4 billion words of memory with a throughput of 2.3 million instructions per second when using cache memory. The system will replace the AN/UYK-7 first produced by Sperry Univac in 1969. At the same time, IBM and Sperry Univac received parallel awards for $12.1 million and $10 million, respectively, in a separate set of three-year contracts to develop the AN/UYK-44. It is a micromilitarized reconfigurable processor for small-ship installations to replace the Univac AN/UYK-20. Three configurations of the new system will be developed.

Comsat General enters manufacturing for two markets

Comsat General Corp., the domestic-satellite subsidiary of Communications Satellite Corp., says it will design, develop, and manufacture equipment for two new markets—**computer-aided design and computer-aided manufacturing (CAD and CAM) systems, and high-technology communications hardware.** The Washington, D. C.–based company's CAD/CAM unit in Palo Alto, Calif., Comsat General Integrated Systems Inc., will initially develop an integrated design, manufacturing, and test system for microwave integrated circuits. The communications equipment operation, Comsat General Telesystems Inc., is in Maryfield, Va.

Makers of EFT systems to get first market index

Producers of equipment for electronic funds transfer (EFT) systems will get their "first systematic measurements of the growth and use" of their technology with the unveiling later this month of EMI—the Electronic Money Index—by the Electronic Money Council at its national financial conference in the capital. The council, an association of equipment manufacturers, data-processing firms, banks, and other financial institutions, says it has been developing the index for a year and will publish it quarterly. The first index to be put out on the first day of the Nov. 10–11 meeting at the Four Seasons Hotel **will include data for the base year of 1979 and the first three quarters of 1980** based on reports from 140 selected financial institutions in 35 states and the District of Columbia.

Stimulating long-range growth

Are American government and industry at last beginning to work in concert to meet global competition in high technology? The answer may be yes if last month's meeting of the Computer and Business Equipment Manufacturers Association (CBEMA) is any example. For it was there that two men of vastly dissimilar backgrounds—one a captain of the computer industry, the other a senior Government regulator—expressed strikingly similar views on how the nation's industries can most effectively compete in the world's markets. The speakers addressing separate CBEMA sessions were NCR Corp. chairman William S. Anderson and the Federal Trade Commission's Albert A. Foer, an assistant director of the Bureau of Competition.

Both men agree, for example, that the "reindustrialization" of America is more a popular national buzzword than a workable short-term solution for the national economy. They also agree that industrial tax codes need revision to stimulate innovation. Moreover, both see a need for the country's corporate leaders to take a longer view of the future.

On the last point, Anderson addressed his CBEMA peers with remarkable candor. "In contrast with some of our international competitors," he observed, "we have frequently subordinated long-range planning to short-range expediency. We have too often been interested in where our companies will be next year than in where they could be 5 or 10 years from now. We have also devoted too much time and too many resources to shoring up eroding markets and too little time and too few resources to penetrating emerging new markets. We've preached about the need to keep the spirit of enterprise alive, but too often when it came time to put our chips on the board, we've been excessively cautious."

The FTC's Foer was no less straightforward than Anderson: "I see managerial failure as a major problem. We need to structure more of our companies to encourage risk, innovation, and long-term payout. Short-term concern for the bottom line is an attitudinal problem of national dimension. Investment in our future managers and innovators should be a high national priority. For example, a greater effort must be made to get state-of-the-art, high-technology equipment into our engineering schools. Reindustrialization must be viewed as a long-term process, intimately related to our educational base."

Anderson also addressed conventional attitudes toward reindustrialization: "One panacea, currently a popular one in some Government circles, is based on the premise that the economy can be revitalized, and America's foreign trade interests advanced, by establishing a kind of economic supreme court. Presumably, such a group—comprising government, business, and labor representatives—will study the problems, weigh the alternatives, and then develop a master economic plan for the 1980s."

To suggest that such central economic planning—which the chairman points out has already failed in the United Kingdom and elsewhere—"could anticipate ever-changing market conditions or correctly determine which industries should or should not receive help flies in the face of all logic and experience."

Foer argues the same issue from the standpoint of a political realist. "What can we expect if Government picks winners and losers [among industries] on a national level? Suppose, in our mutual desire to promote American winners on the world market, the investment tax credit were denied to dogs and given to stars. A Government agency would have to define the dog industries. But who would willingly be classified as anything but a star? Can you imagine how the dogs would bark and how the Congress would bite! How the appeals would drag on! It couldn't possibly work."

Rx for progress

What both men made clear is that America's adoption of an economic model made in Japan—or worse, the UK—would be a catastrophic mistake. Rather than a crash program to turn the national economy around immediately, the nation needs rational revisions of tax laws that will stimulate innovation with credits for increased research and development, accelerate depreciation rates so they will be in step with technology's rapid advances, and encourage capital investment in high-risk technologies.

Finally, there is an urgent need for America's corporate leaders and their Government counterparts to learn to communicate without suspicion and distrust. "We seem to have lost the capacity for forthright talk, when that is the only kind of talk that will be understood," says NCR's Anderson. "How often have we seen the spectacle of business leaders who, appointed to high positions in Government, grow suddenly mute when the business viewpoint cries to be heard? How many of these industrial 'statesmen' have been willing to say, when the occasion demanded it, 'Mr. President, with all due respect to you and your office—you are wrong'?"

-Ray Connolly

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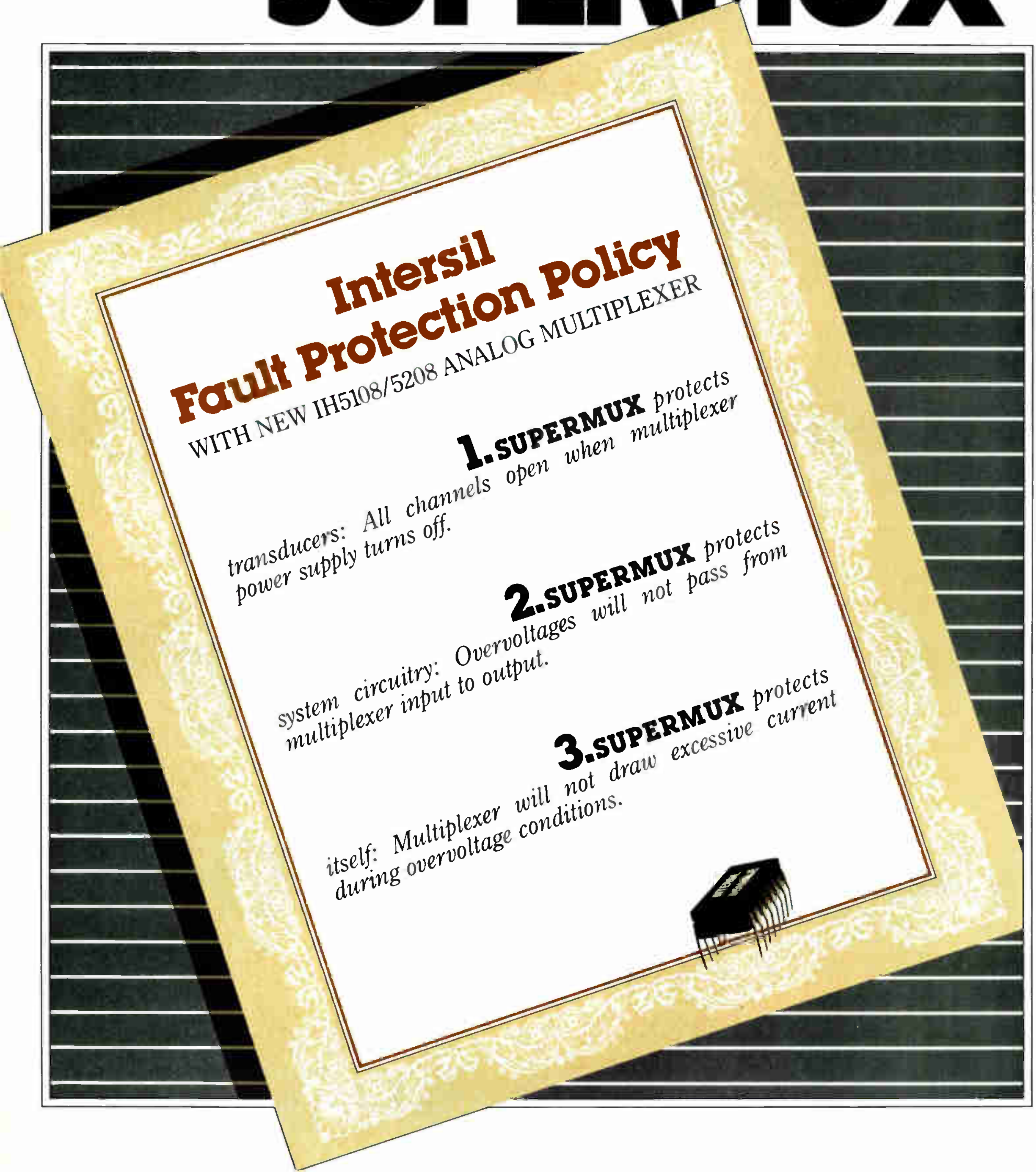

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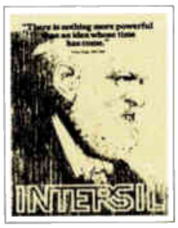
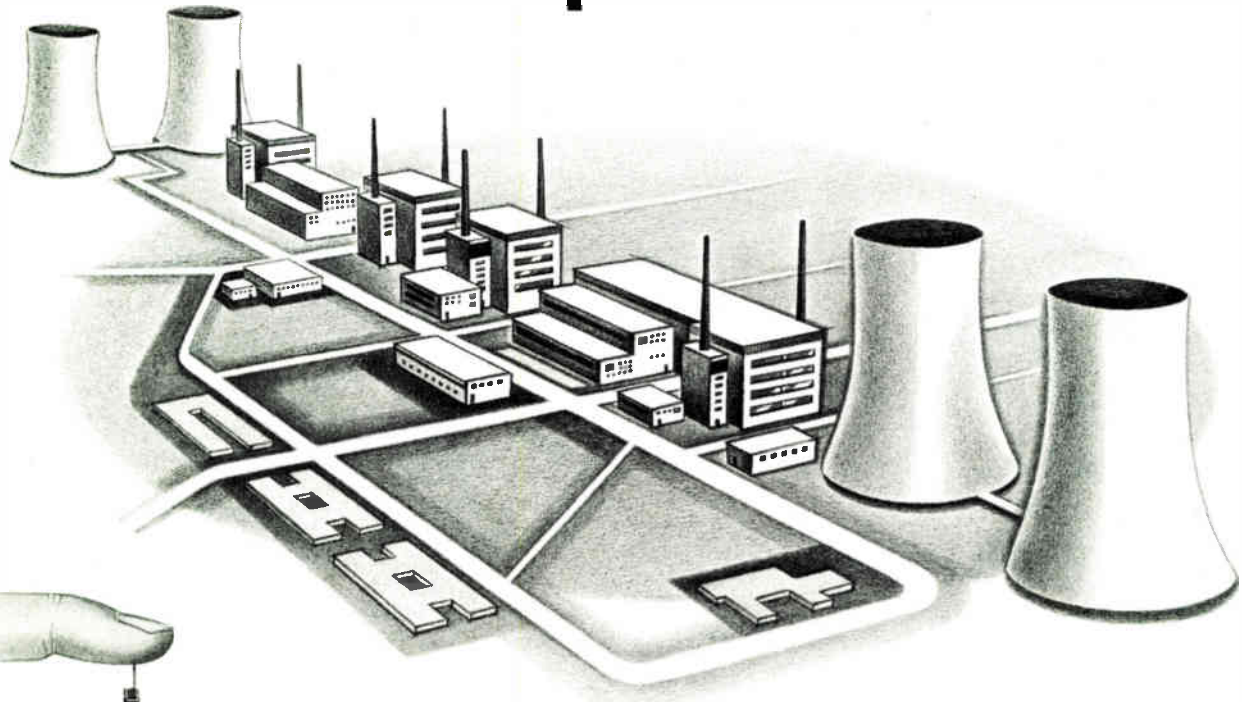
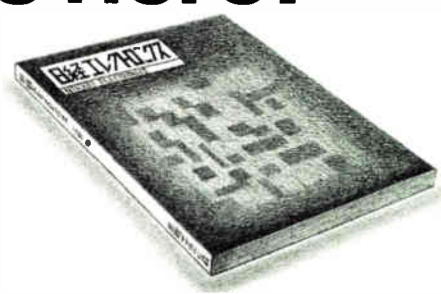


E11680

Giant nuclear power station...



...or compact solar cell, the key to successful sales in Japan lies here:



Energy is one of the many growth fields of the Japanese economy today. And attracted by the market potential, foreign corporations engaged in this and other electronics-related fields are entering the Japanese market in increasing numbers.

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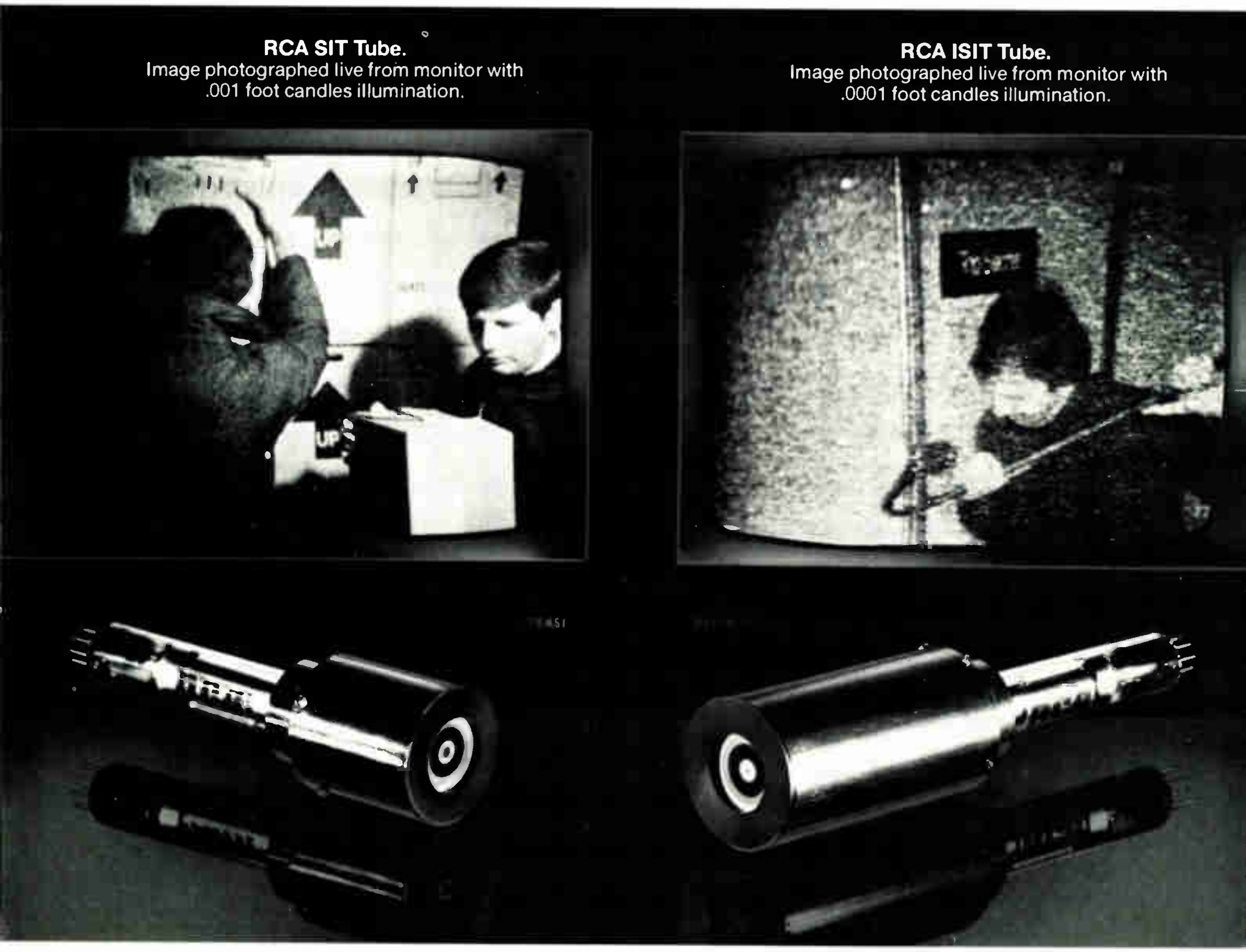
The night has no secrets from these RCA camera tubes.



RCA SIT Tube.
Image photographed live from monitor with .001 foot candles illumination.

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Image photographed live from monitor with .0001 foot candles illumination.

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The ISIT produces usable pictures down to .0001 foot candles, and even lower.

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ISIT offers the same low lag, minimal "comet-tailing," and low bloom performance as the SIT.

Plus 40 times as much sensitivity.

For complete technical data on RCA low light camera tubes, contact RCA Electro Optics and Devices, New Holland Avenue, Lancaster, PA 17604. Phone: (717) 397-7661. Or contact RCA, Buenos Aires, Argentina. Brussels, Belgium. Sao Paulo, Brazil. Sunbury-on-Thames, Middlesex, England. Paris, France. Stuttgart, West Germany. Mexico 16 D.F., Mexico.

RCA

Electron-beam imager rivals both optical and X-ray systems

Philips Research Laboratories in Redhill, Surrey, England, has scaled up its electron image projector [*Electronics*, Nov. 9, 1978, p. 63] to process 4-in. instead of 2-in. wafers **with a resolution of 0.25 μm and a throughput of 25 wafers per hour.** This rate could be increased to 60 per hour in a carousel-loading production version, which would therefore afford significantly lower manufacturing costs than the best optical systems. Moreover, the imager rivals X-ray systems for submicrometer lithography, since, unlike the usual electron-beam approach, it uses a 4-in.-diameter flood electron beam to expose an entire wafer in 30 seconds. The new projector incorporates both an automatic X-ray alignment system that positions masks to within 0.1 μm and an electrostatic chuck that flattens bowed wafers. **A decision on whether to market the system is likely within 12 months.** Significantly, Philips and Electron Beam Microfabrication Corp. of San Diego, Calif., at one time the approach's sole backers, have been joined by Japan's Toshiba Corp. and others in developing such imagers.

USSR models net that switches both packets and circuits

Data-communications networks, because of the great variety of terminals and user needs, should be capable of handling both circuit switching and packet switching, according to Stanislav I. Samoylenko, deputy chairman of the Council for Cybernetics of the USSR Academy of Sciences. Speaking at the International Conference on Computer Communications in Atlanta, Ga., last week, Samoylenko described an adaptive switching system, currently at the experimental stage, that under computer control dynamically reassigns channel capacity as needed from circuits to packets and vice versa and also **automatically fills idle periods in intermittent circuit transmissions with packets.** The new method complies with X.25 and other standard protocols.

Intermetall chip processes digital signals in real time

Intermetall GmbH, the lead house of the ITT Semiconductors Group, is currently developing what it claims is the first digital signal processor chip to come from a Europe-based company. Releasing preliminary details on its MAA 1000 at the Nov. 6–12 Electronica components show in Munich, the Freiburg, West Germany–based company says the device features very fast multiplier hardware that allows complex real-time signal processing. **The basic arithmetic operation, the multiplier and accumulator function, is executed in 250 ns.** The clock frequency checks in at 20 MHz. Using 3-μm MOS technology, the chip is about 30 mm^2 (46,500 mil^2) in area and has an internal word length of 24 bits. The device is programmable for linear, nonlinear, and logic operations. Changes in the stored program can be made via an asynchronous serial interface—a feature that Intermetall says facilitates the design of adaptive systems.

Britain's Ptarmigan is production-bound

Under a mammoth modernization program involving the largest military communications contract ever placed in Britain, the British Rhine Army is to be equipped with a new all-digital battlefield trunk communication system called Ptarmigan [*Electronics*, Aug. 19, 1976, p. 73]. Equivalent systems are under development in France and West Germany and should be able to work together, but **an initial-phase four-year contract worth $357 million** makes Ptarmigan one of the first to enter production.

International newsletter

West German post office to link videotext systems

The usual interactive videotext services have access only to their own data bases, but in the view of West Germany's Deutsche Bundespost, access to external data bases also is essential if such services are to be cost-effective, says Jens Otto, in charge of data- and text-communication terminals for the post office. In recent tests in West Germany, in which **computers controlling different data bases communicated successfully with one another,** "the user gained access to data bases of private organizations such as mail-order houses, publishers, banks, and insurance companies," Otto told the International Conference on Computer Communications in Atlanta, Ga., last week. He says a fully operational system can be expected by 1982 with dozens, if not hundreds, of organizations belonging.

British Telecom makes first move to electronic mail

In a first move toward electronic mail, British Telecom, part of the British Post Office, has placed a $48,000 contract with computer and communications consultants Logica Ltd., London, to define a specification for an interface device code-named Albert. **Albert's job would be to enable many different kinds of text-handling machines,** such as a Telex, facsimile, word processor, cathode-ray-tube display, teletypewriter, or Prestel set, to communicate with each other directly or over telephone, Telex, or packet-switched networks. If the nine-month study is successful, contracts to industry will follow for prototype devices to be used in a small market trial. A final production version would be highly modular and also likely adopt a multimicroprocessor configuration.

Japan likely to accept more data lines from abroad

Japan's international telecommunications monopoly—Kokusai Denshin Denwa Co.—has announced it will apply next month for postal ministry approval to ease its regulations on international data-transmission lines. The new policy, deemed certain of approval, is good news for such U. S. data-service companies as Control Data Corp., which have been allowed to link only one U. S. computer center to data-transmission lines entering Japan. The ability to link whole networks of computers to such lines will **vastly expand the number of services that U. S. firms will be able to offer Japanese customers.**

Addenda

Thomson-CSF will get **roughly one third of the $3.25 billion military naval contract signed in mid-October between Saudi Arabia** and the French Ministry of Defense. The Paris-based electronics group is to supply a wide variety of radar, navigation, fire-control, and missile systems for the four frigates ordered by the Saudis. . . . Munich-based Siemens AG is **expanding its tube factory in West Berlin** with a new 60,000-ft^2 building at a cost of about $8 million. The West Berlin facility produces, in addition to voltage-surge protectors, some 15,000 transmitting tubes and 10,000 vacuum switching tubes a year. The new building is to add production capacity for such devices. . . . In a one-year technology transfer agreement with France's Centre National d'Etudes des Télécommunications, Eurotechnique SA, a new joint venture of National Semiconductor Corp., Santa Clara, Calif., and the Saint-Gobain-Pont-à-Mousson industrial group, will **be training French government engineers in n-MOS technology.**

RAPID START IN HIGH-SPEED G3 FACSIMILES

NEC is supplying domestic and overseas customers with high-speed facsimile equipment that meets newly established international standards (G3).

The first overseas user of NEC's G3 equipment is a major broadcasting network in the United States. The equipment has been specially designed for the American market and is sold under the brand name NEFAX 180.

In Japan and other countries, NEC's G3 facsimiles are called NEFAX-6200. The first domestic units were delivered to a Tokyo whisky distilling company in February 1980.

High-speed facsimile equipment has a great potential for intra-country or international communications because it offers higher efficiency than medium or low-speed products. However, incompatibility between the models of different manufacturers was a problem until the CCITT set international standards last November.

Since the G3 standard was adopted, manufacturers have been racing to market equipment that meets it. By taking the lead in this race, NEC has proved that its facsimile equipment is one crucial step ahead in a highly competitive market.

NUMBER 114

ADVANCED RADAR SYSTEM FOR SINGAPORE

Singapore's new Changi Airport is putting safety first with an advanced approach control radar (ACR) system to control taking-off and landing. The NEC system consists of primary surveillance radar (PSR) with a range of 64 nautical miles, and secondary surveillance radar (SSR) with a coverage of 128 nautical miles. The system can display aircraft at altitudes up to 40,000 feet.

The new ACR system features special bright displays with digital scan-converters to reduce eyestrain for air controllers. Conventional displays are operated in a darkened room. NEC display screens can be easily observed even in a bright room because they are ten times brighter than conventional equipment.

Another significant feature of the system is its ability to track and display aircraft positions using alpha-numeric symbols on a large (40 cm) flat display screen. Better tracking and less eyestrain add up to an extra margin of airport safety.

The ACR system is integrated with the airport's long range radar and display system to improve the flexibility and efficiency of air traffic control.

Circle 40 on reader service card

MNC-80A PORTABLE CAMERA FOR ACTION TV.

TV audiences are demanding more dynamic and varied programs. This, in turn, creates a need for versatile, high-performance cameras that can be used with equal ease in the studio or out on location. NEC has been responding to this need with a growing line-up of advanced television cameras.

The latest offering is the MNC-80A series fully self-contained portable color camera. Light enough for hand-held operation, it is engineered for maximum stability and reliability both in the studio or out in the open air.

The MNC-80A weighs only 4.5 kg and measures 260mm (h) x 100mm (w) x 293 mm (d). Yet it produces pictures of astounding clarity, and because its circuitry is based on extensive use of LSIs, the MNC-80A consumes significantly less power than comparable cameras. In fact, it runs on a mere 24 watts.

The MNC-80A series comes with a wide range of accessories; models are available for NTSC, PAL, PAL-M and SECAM standards.

Circle 69 on reader service card

INDIA SWITCHES TO SPC PHONE SYSTEM

In a determined move to improve both domestic and international telephone services, India is introducing its first electronic switching systems.

NEC will manufacture and supply four ND 10 toll switching systems for the Posts and Telegraphs Department. In addition, NEC will supply three NXE 20 international switching systems to the Overseas Communications Service. Both ND 10 and NXE 20 are space-division, fully-stored-program controlled electronic switching systems.

The four ND 10 systems will be installed in New Delhi, Bombay, Calcutta and Madras. They will open a total of 15,000 circuits. The ND 10 is capable of accommodating up to 160,000 local or 64,000 trunk lines.

The three NXE 20 systems will be installed in Bombay, New Delhi and Madras. Accommodating a total of 925 international circuits, they will improve telephone services and traffic to and from India. The NXE 20 system has the capacity to handle up to 4,000 terminals.

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- **Synch output**—Recorders can be slaved together by synchronizing chart speeds using this TTL pulse output.
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Single-channel repeater cancels out problems

by Kevin Smith, London bureau manager

British company reveals the circuit techniques that prevent outgoing signals from swamping incoming ones

Hilly terrain can play havoc with mobile communications systems, blotting out voice communication when near line-of-sight contact is lost. But two years ago Plessey Avionics and Communications Ltd. came up with a solution called Groundsat, a small portable repeater that could be perched atop high ground and used to keep base station and front line groups in direct communication with each other on a single operational frequency [*Electronics*, Oct. 12, 1978, p. 70]. Other such operator-manned repeaters need at least two channels and careful operational planning.

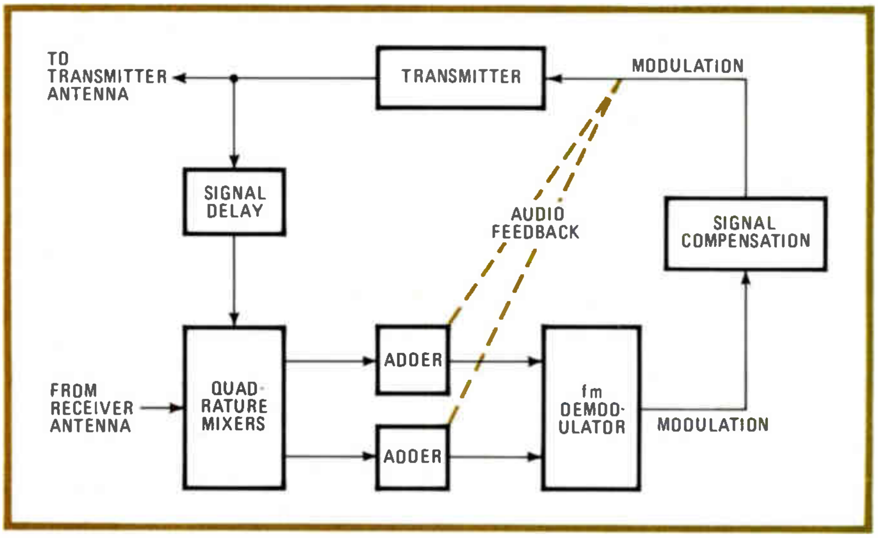
Groundsat's simplicity both impressed and puzzled observers, who wondered how transmitter and receiver could be operated in such close proximity on the same frequency without the rebroadcast signal swamping the incoming one. But last week, at a meeting of the Institution of Electrical Engineers attended mainly by competitors, Chris Richardson of Plessey Electronic Systems Research Laboratory, Roke Manor, Romsey, Hants., gave a first description of the techniques employed and wrote another chapter in the communications text books.

The secret. Groundsat, he explained, was designed to receive a weak signal, amplify it by at least 100 decibels, and retransmit it simultaneously on the same channel. It is also designed to operate anywhere in the military tactical band of 30 to 76 megahertz without special setup procedures and to work with standard equipment—for instance, it uses conventional omnidirectional whip antennas that need be separated by only 20 meters.

Several techniques have been tried to cancel a swamping rebroadcast signal but with limited success. Groundsat, says Richardson, wins out by employing a direct-conversion receiver—a well-known though little used technique. In such a receiver the local oscillator operates at nominally the same frequency as the distant transmitter, so by beating the incoming signal with the local oscillator signal, a difference frequency representing the wanted modulation is formed directly before final detection. In a superheterodyne receiver, in contrast, an intermediate frequency is formed first.

Richardson realized that by operating the local detector oscillator at the same frequency as the rebroadcast transmitter, a single device could be made to serve both functions, thereby eliminating at a stroke many of the problems of achieving a perfect rebroadcast cancellation.

The difference. In Groundsat the modulated output from the local oscillator is fed both to the rebroadcast antenna and to the incoming detector mixer via a delay line element. The receiver antenna picks up a rebroadcast signal and applies it to the other side of the mixer simultaneously with the internally applied oscillator signal. Since the mixer generates only the difference frequency between these two signals, its net output from them is a slowly varying dc level, and the dc element is effectively blocked by ac coupling into the first amplifier stage. The low-level incoming signal, however,



Coming and going. Repeater feeds high-level rebroadcast signal to receiver for removal from latter's input. From the low-level frequency left, the system derives an audio signal.

is demodulated conventionally.

To compensate for transmission delays in the transmitter and receiver antenna feeds, an equivalent 2-meter length of coaxial cable is inserted between the Groundsat oscillator and mixer stage. The rebroadcast signal traveling in a direct path from transmitter to receiver antennas is effectively canceled, but distant reflections cannot be entirely compensated for. The unwanted residual signal is almost phase-coherent with the modulation waveform and therefore can largely be removed by combining a small proportion of the modulated signal 180° out of phase with the unwanted signal at the mixer output.

Real life. Though the cancellation technique is simple in concept, additional engineering refinements have to be built into a practical system. Since the polarity of the instantaneous frequency deviation from nominal is lost in a single mixer, for example, a quadrature two-path receiver is employed. This detects whether the instantaneous received signal frequency is above or below the oscillator frequency as a 180° phase change of one quadrature signal relative to the other.

The demodulator, too, poses novel problems, since its output is unrecognizable as speech, being a constant-amplitude audio signal whose frequency varies as the amplitude of the modulation voltage at the distant transmitter. Richardson recovers the original audio signal by a processing technique in which the quadrature components I and Q are differentiated and cross-multiplied to yield $(I\,dQ/dt - Q\,dI/dt)$, which result is divided by (I^2+Q^2).

Lastly, the rebroadcast loop has to be stabilized. In the final system, however, duplex rebroadcast operation was achieved on a single frequency with a dynamic range of at least 130 dB.

West Germany

Latest 64-K dynamic RAM outdoes its two predecessors in flexibility

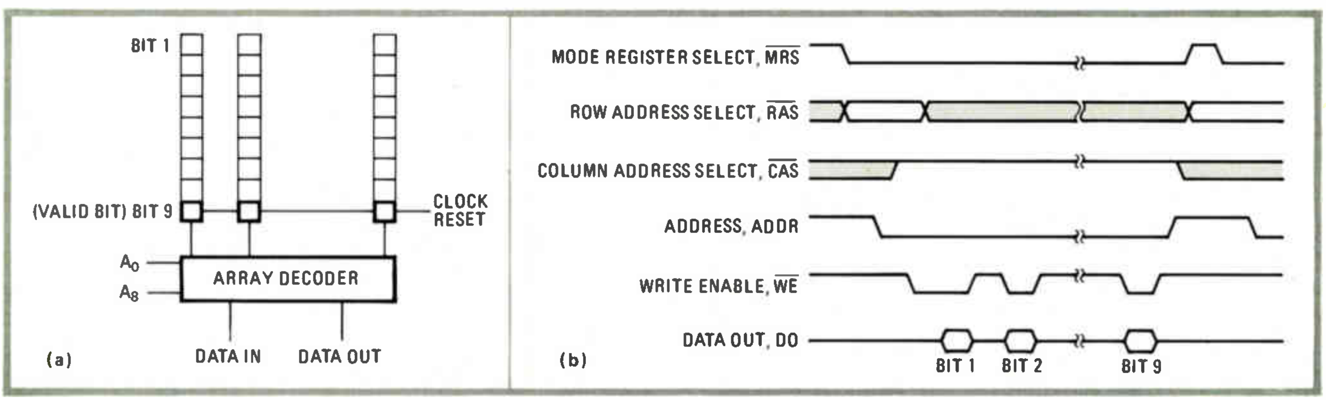
Munich's Siemens AG has become the third semiconductor manufacturer in the world to describe a quarter-megabit dynamic MOS random-access memory. But a unique mode register that raises both its yield and its throughput sets the West German device apart from its two 256-K dynamic RAM predecessors from Japan and also from all 64-K devices.

The mode register allows the user, and not just the manufacturer, to replace bad memory bits with good ones from a redundant group of 5,120 cells. It can improve throughput by such options as allowing a serial stream of data to pass through an input or output port during one cycle. In contrast, the 256-K RAMs from Nippon Electric Co. and National Telegraph and Telephone Public Corp.'s Musashino Laboratory appear much more like multiples of 64-K RAMs and do not offer the throughput-enhancing features.

According to Hans J. Penzel of Siemens' Data Systems group, who described the part at the First International Conference on Circuits and Computers held last month in Portchester, N. Y., his company feels that the flexibility added to the RAM by the mode register will be necessary at the 256-K density level for low cost per bit. That could well be the case, for although 16-K RAMs borrowed heavily from 4-K chips, MOS producers are finding that circuit design and processing improvements are needed to go from 16- to 64-K RAMs. Likewise, quarter-megabit chips will demand another set of inventive new design techniques.

Mode. The 256-K RAM's mode register will consist of from 100 to 400 static RAM cells, arranged in an array of 9-bit words, with the ninth bit for parity. It must be accessed through a special select pin, but addresses and data intended for the register could use existing interface lines. The register plus the other throughput-enhancing features and the redundancy should use up only 3% of the total die area, according to its designer.

Although in most redundancy schemes the manufacturer hardwires in good circuit elements for defective areas, Siemens hopes to let the user



Mode register. Key to the user's ability to enhance throughput and yield of Siemens' 256-K RAM is this mode register (a), consisting of arrays of nine cells for address, code, and parity information. A mode-register select line triggers it for reading (b) and writing.

do the substituting in its RAM via the mode register. Quality and reliability would then be in users' hands.

To ease mapping of good and bad areas, the company plans to partition the device into eight 32-K sectors, each with redundant bits. With such an architecture, if a sector could not be repaired, it could simply be dropped. Indeed, one of the options will be a 64-K RAM look-alike, obtained by choosing two sectors.

Throughput. The mode register will also command the throughput-enhancing options. For example, the number of bits to be read or written during a data-streaming operation—2, 4, or 8—would be loaded into the mode register as control information.

Then the data, synchronized with column-address strobe pulses, would be accepted by a data-in pin or emerge from a data-out pin with an effective cycle time of from 40 to 80 nanoseconds. An on-chip shift register will perform all serial-to-parallel conversions.

An 18-pin dual in-line package will house the part, with 16 pins having industry-standard assignments, 1 pin acting as the mode-register select, and the last pin left unconnected for address expansion to the 1-megabit level. Alternatively, the chip could be put into a 16-pin DIP if the user did not care to have the special options.

Siemens also plans to offer a pin-swapping mode on its 256-K memory. In this configuration, address lines will be expanded into bidirectional interface pins, allowing 8-bit data transfers, 1 bit to or from each of the eight sectors. One big drawback with this mode, admits Siemens, is elevated power dissipation resulting from the concurrent activation of all the sectors. **-John G. Posa**

Japan

Reactive-ion etching goes commercial, promising to boost LSI and VLSI yields

Semiconductor manufacturers on both sides of the Pacific will soon be able to share the benefits of a reactive-ion etching system designed for mass production of both large- and very large-scale integrated circuits. Toshiba Corp. is now using prototype models on its production lines of high-density 64-K n-channel MOS dynamic random-access memories and 16-K static RAMs fabricated using both n-channel and complementary-MOS technology. The yield is said to as much as double that of conventional dry etching. Toshiba is also using the same systems in its effort to develop a still denser, 256-K dynamic RAM.

Perpendicular. The great beauty of the reactive-ion etching system is that it etches anisotropically. Specifically, etching proceeds selectively in the direction perpendicular to the plane of the device, essentially eliminating undercutting of the masked pattern (see photograph).

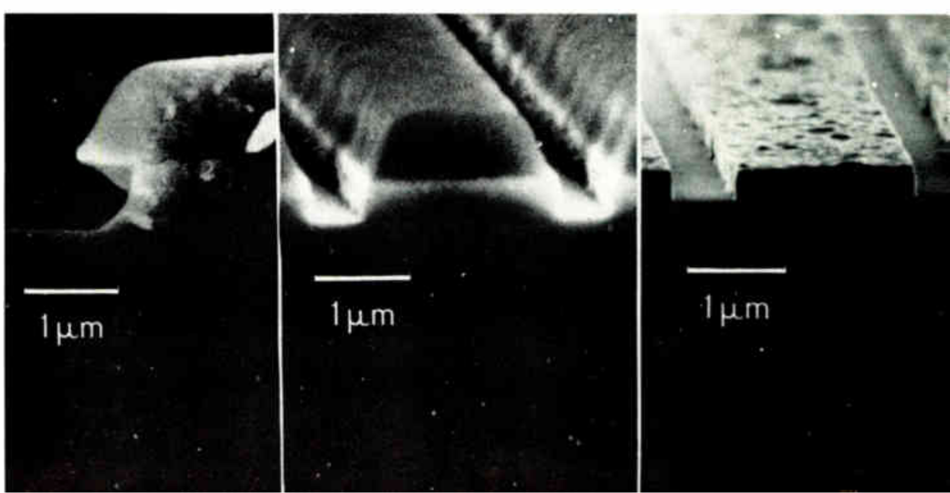
This feature becomes especially important as mask rules fall below 2 micrometers, because etching through a polysilicon layer 1 μm thick with an isotropic etching system would reduce line width to zero. Thus conventional plasma-etching systems—the so-called chemical dry etch—which Toshiba developed earlier, cannot be used.

Toshiba's subsidiary, Tokuta Seisakusho Ltd., expects to be able to ship 30 of the new systems during the 12-month period starting in November. And to make sure that its potential customers are aware of the system, Tokuta will feature it at Semicon in Tokyo in November, at Semicon West in May, and at Semicon East in September. In the U. S., in-house reactive-ion etching systems have been in use for the past two years both at International Business Machines Corp. and at Bell Laboratories.

In Toshiba's system, the wafers are processed in a cavity between two parallel plates 30 to 80 millimeters apart. High-frequency energy at 13.56 megahertz turns the gas into a plasma. Because the side of the cavity on which the wafers are mounted is smaller than the opposite side, geometrical effects cause it to develop a self-bias that makes it several hundred volts negative. Positively charged ions in the plasma are therefore accelerated onto the wafers and react at the point they strike, thus eliminating undercutting.

For highest throughput the system has separate evacuated loading and unloading chambers into which cassettes holding up to 25 wafers can be loaded. During processing the wafers are mounted on a turntable, a section of which actually forms the smaller side of the gas-filled cavity, and this arrangement helps maintain the advertised etching uniformity of 5%—on each wafer, between all the wafers in a batch, and among the different batches.

Efficient. The system can handle up to six 3- or 4-inch wafers or five 5-inch wafers simultaneously, with five etching cycles for an entire lot. Typically it will take 40 minutes for



Straight up. The undercutting of chemical dry etching (left) is eliminated by Toshiba's reactive-ion etching, which gave the results shown with (center) and without resist.

Electronics international

a lot in which polysilicon 4,000 angstroms thick must be etched—to define a gate, for example. The materials for which the system is suitable include all forms of silicon, aluminum, and silicon dioxide.

Automated. As befits a production machine, this system is fully automated. The loading, unloading, and transport of the wafers through the system are controlled by microcomputer, as is the adjustment of the high-frequency power for the best etching conditions. Also automatic is the control of six varieties of gas, either singly or as mixtures: a mass controller admits gas to the reaction region at a constant rate, while a variable-conductance aperture adjusts the exhaust to maintain a constant pressure in the region. Furthermore, if the plasma fails to start during low-pressure operation, the control gets it going by injecting thermal ions into the gas from an auxiliary filament. If desired, the automatic controls provide conventional chemical dry etching as well as reactive-ion etching.

The loading chamber isolates the reaction cavity from the atmosphere, ensuring reproducible results. Water cooling keeps wafer temperature low to prevent the photoresist from melting. And to minimize the requirements for valuable clean-room space, the system is compact, measuring 1.75 m (69 inches) wide by 1.66 m (65 in.) deep by 1.84 m (72.4 in.) high.

The price of the system in Japan is $215,000. **-Charles Cohen**

The Netherlands

Fast on-chip serial I/O distinguishes Philips' family of five microcomputers

So far, West European semiconductor houses have restricted their microcomputer endeavors mainly to copying the readily available U.S. designs and at best to modifying them for particular applications. But a recent transatlantic urge to become self-sufficient in all advanced devices has spurred NV Philips Gloeilampenfabrieken to come out with its own family of one-chip microcomputers.

The n-channel MOS 8-bit 8400 family has been closely tailored to customers' requirements, says the Dutch electronics giant. The first five members, varying in memory capacity, will be introduced in the course of next year. To be announced at the Nov. 6–12 Electronica components show in Munich, they were developed in West Germany at Hamburg-based Valvo, an affiliate of Philips' Electronic Components and Materials division in Eindhoven, the Netherlands, and will be manufactured at Valvo's Lokstedt plant, where the 8048 family started production earlier this year [*Electronics*, May 22, p. 70].

The 8400's principal feature, one that Elcoma says sets it apart from other designs, is the high speed of up to 100 kilobits per second of its on-chip serial input/output interface. In a system of several microcomputers, this interface conveniently implements distributed processing, providing the advantages of fewer connections and low overall system cost, points out Theo Akkermans, strategic planning manager for MOS microcomputers at Elcoma. In a TV set, for example, an 8400 might control a lot of equipment ranging from video games and recorders to teletext decoders.

Alike. In other respects, the 8400 chips have a lot in common with members of the Intel 8048 family, particularly the 8021. Their central processing unit includes an interrupt facility but otherwise is based on the 8021 type of CPU. (Compared with the 8048 CPU, with its more parallel setup, the 8021 CPU occupies less chip area.) Their instruction set resembles the 8048's with a few modifications.

The new family's first member is

designed for microcomputer systems prototyping and testing. Designated 8400 like the whole family, it is a piggy-back version with 128 bytes of random-access memory for data storage but without a read-only memory. Instead, a 4- or 8-K-byte erasable programmable ROM can be plugged into a socket on top of the 8400.

The other four devices, for more complex applications, come with mask-programmable ROMs for program storage and differently sized RAMs for data storage. The 8405 has 0.5-K byte of ROM and 32 bytes of RAM. For the 8410 it is 1-K byte of ROM and 64 bytes of RAM. The 8420 checks in with 2-K bytes of ROM and also 64 bytes of RAM. And the 8440 sports 4-K of ROM along with 128 bytes of RAM.

The instruction cycle time for the family is 6.77 microseconds. Of the 28 pins of each device, 22 serve the input or output lines. Of these, 20 are for bidirectional I/O ports and the other 2 for direct program scanning and external interrupts. Timing pulses are derived from a 4.43-megahertz external crystal, a type of crystal often used in consumer equipment like TV sets. Only one supply of 5 volts ±10% is needed.

To extend the family's potential applications, Elcoma will have 8400 microcomputers in two temperature ranges: from −10° to +70°C and from −25° to +85°C. Furthermore, the division plans to supply the single-chip devices not only in n-channel but eventually also in complementary-MOS technology.

Flat packs, too. On top of that, Elcoma will not confine itself to using only the standard 28-pin dual in-line package. With an eye on personal data-processing equipment, it also plans to make the 8400 available in a 28-pin flat pack, only slightly more than 2.5 millimeters high and just under 18 mm long.

Design support for the 8400 is available in the form of software for program development and hardware tools for emulation. Every system currently supporting an 8048 can easily be adapted to support the devices in the 8400 family, Akkermans says. **-John Gosch**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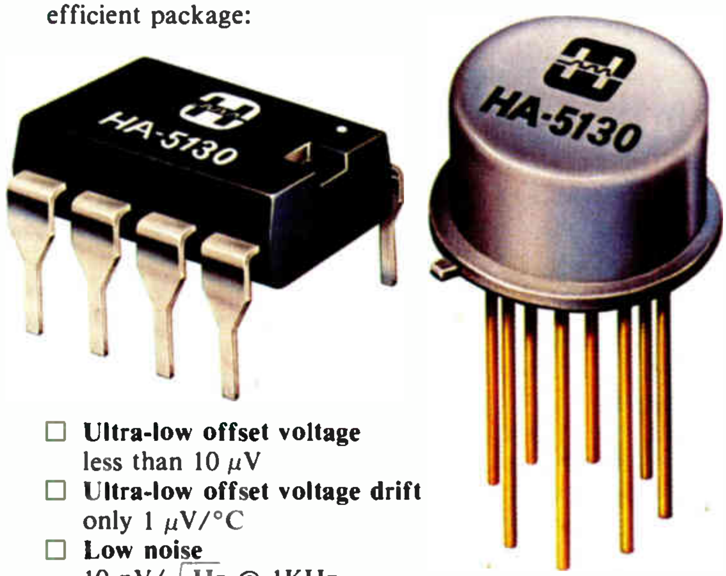

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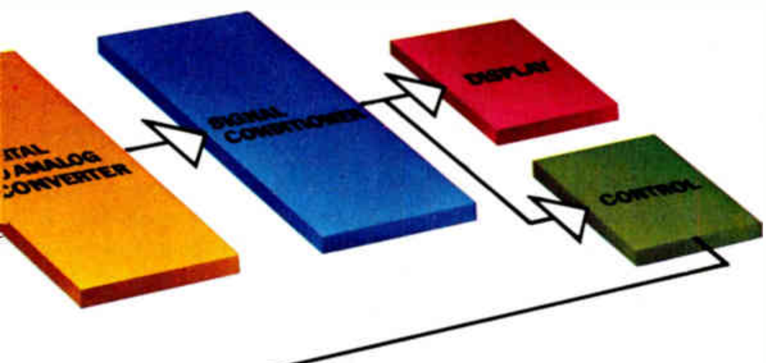

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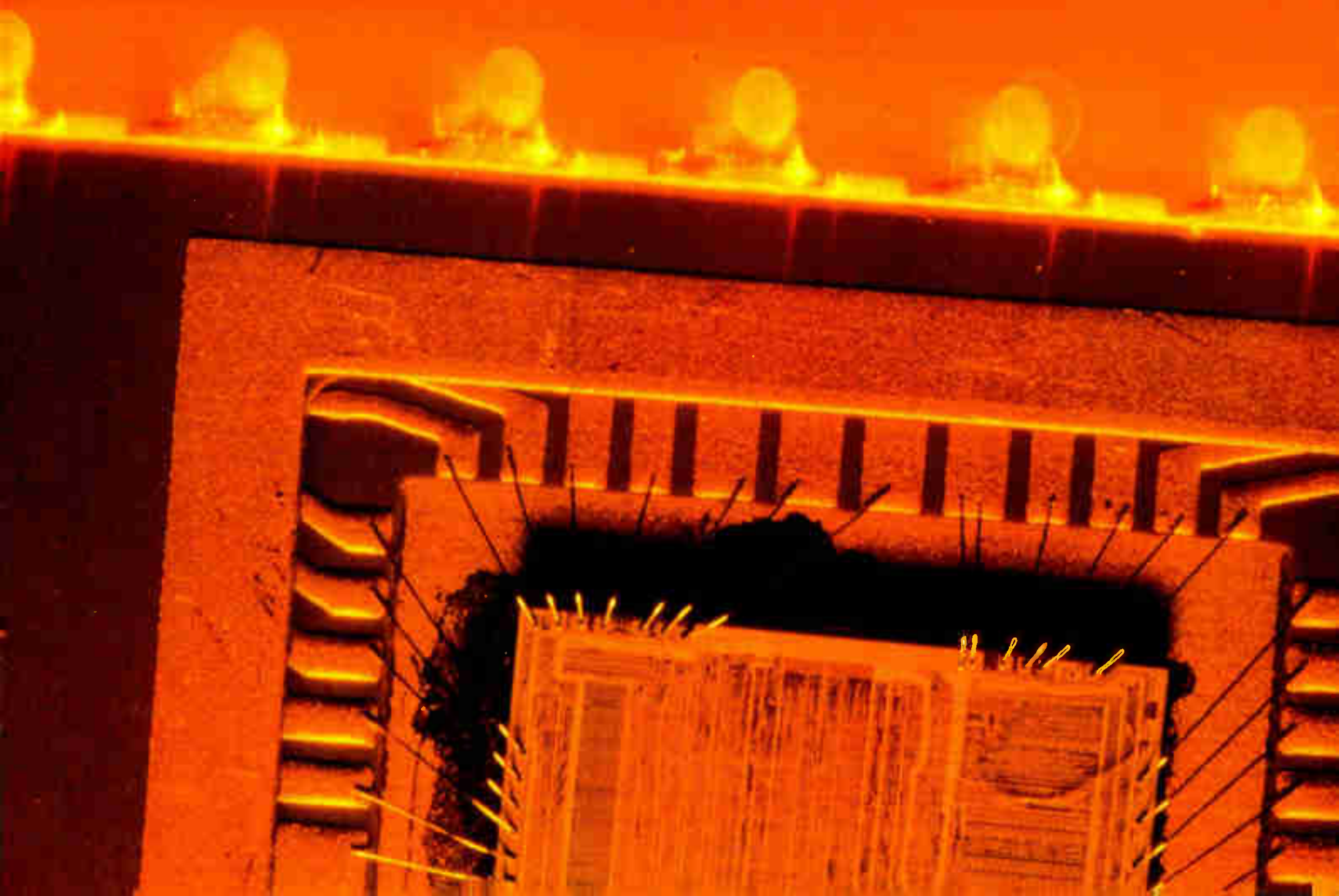


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Slew rates are typically 0.6 V/µS, bandwidths are 1 MHz open-loop and a typical noise of 34 nV/$\sqrt{\text{Hz}}$ at 1 kHz.

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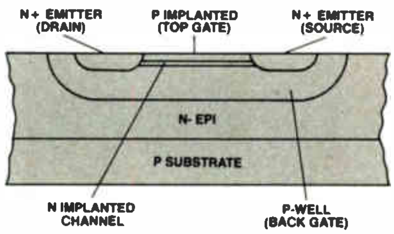
NFET technology... a capsule summary



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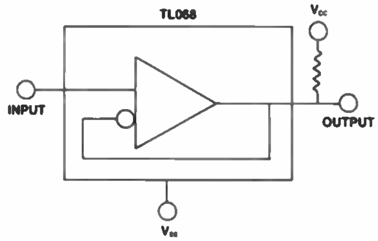
TL068 BIFET buffer



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Testers rise to VLSI challenge

Makers of automatic equipment to show new systems in Philadelphia featuring trend toward more pins and autoprogramming

by Martin Marshall, West Coast Computers & Instruments Editor

With growing excitement about meeting the challenge posed by very large-scale integrated circuits with higher pin counts, greater accuracy and flexibility, and autoprogramming, makers of automatic test equipment are preparing to go to Philadelphia for their Annual Test Conference, Nov. 11–13.

Not only will technical sessions describe the latest techniques [*Electronics*, Oct. 23, p. 91], but such ATE manufacturers as Teradyne, Fairchild, Eaton's Macrodata division, Tektronix, Hewlett-Packard, Zehntel, Lomac, and Accutest will also show up with new offerings that cover the spectrum of testing requirements.

Among the highlights are products from the Fairchild Test Systems group of Fairchild Camera and Instrument Corp. in San Jose, Calif. A perennial power in the ATE systems business, Fairchild has been losing its market share in recent years, but is hoping to bounce back with a series of introductions. The first is the series 80 analog test system, intended for design characterization as well as production testing of analog and mixed-signal integrated circuits such as coder/decoders, data converters, operational amplifiers, filters, and receivers.

Fairchild is also introducing model 5588, a 25-megahertz memory test system that is a second-generation enhancement of its 5582 tester. It has a new host computer and a new test head with 72 channels. The channel capacity of the Sentry series will also be increased with introduction of the Sentry series 20, a 20-MHz system with a new 120-pin test head. The Sentinel line will also be expandable to 120 pins and improved by the addition of a 16-phase multiple timing module and a pattern processor module.

Work together. Eaton Corp.'s Macrodata division, Woodland Hills, Calif., will introduce its Detective series. Despite the new name, they are compatible with previous systems, and some models represent enhancements of earlier systems. For example, the Detective 001 (starting at $137,000) is really an enhancement of the M-1 25-MHz memory test system, with the addition of a topological display and an optional data image simulator.

The Detective 002, however, is totally new. Whereas the 001 is intended as both an engineering and a production test system, the 002 is a low-cost production-only system. Its price starts at $100,000 for static or dynamic random-access memory versions. It is software-compatible with the production test-oriented instructions of the Detective 001 and M-1, and it can be interfaced with a wafer prober or chip handler.

In the memory-board tester area, the Detective series includes the new 10-MHz MD-300 ($93,800) and MD-301 ($69,500) test systems. The MD-300 is an upgraded version of

Versatile. Tektronix' new 3275 can be interfaced with any large computer. Its 2952 pattern processor will handle 16 clock phases for better data-stream pipelining.

the MD-207/11, but has added a guided probe feature, fault isolation in one-pass testing, signature analysis, and transition counting.

The MD-301, like the Detective 002, is meant for production testing. It does not have the shmoo plots and engineering graphics of the MD-300, but it does have the 96-channel capacity of the MD-300, with 16 megabits of memory behind each channel. In both systems there is a real-time failure record provided for each pin.

Some queries. The MD-300 and MD-301 also make use of an interactive program generator, which forms the test program after asking the programmer a series of questions such as whether the board is synchronous or asynchronous, what its refresh cycle is, what its maximum number of words and data bits are, and what its clock timing is. This information is used by the system's program to access its own data base of subroutines and link them to create a workable program.

A similar technique for automatic program generation appears in the Producer, a software package developed by Plantronics/Zehntel Inc., Walnut Creek, Calif., for its Troubleshooter 800 test system. The Producer is aimed at simplification of the system's input list creation, program generation, and library maintenance, and it contains subroutines that cover the verification of fixture and node wiring, the documentation of the fixture, input list preparation, cathode-ray-tube–prompted probing, syntax error detection and correction, and user-controlled format and sequencing.

The Producer software also helps the IC-probing portion of the board-test program by generating a network analysis tnat extends three levels away from the probed IC. The program automatically adjusts to voltage and current levels to compensate for network effects on the voltage and current of the probed pin, and it decides where to put grounding guards to avoid stray current.

For the people at Tektronix Inc., Beaverton, Ore., the star is the new model 3275 test system. It is similar to the previous 3270, but has a new pattern processor, clock generator, pin electronics cards, and a networking option. The networking option allows the 3275 to be interfaced with any large computer.

The primary hardware improvement is in the model 2952 pattern processor, which now can handle 16 clock phases for better pipelining of the data stream. It supplies full functional data, including force, compare, inhibit, and mask signals, to all 128 pins at the tester's 20-MHz maximum test speed. Moreover, it combines the functions of stored-table pattern sequencing with algorithmic (or formula-driven) pattern generation. Addresses can then be scrambled by a topological memory, an integral part of the pattern processor. The memory itself is set up as 4 kilowords by 12 bits.

The clock generator includes several improvements other than the 16 clock phases, including a phase-edge resolution of 125 picoseconds and skew of less than 1 nanosecond with calibration. The clock can operate in a free-running mode, be synchronized to the test device, or be switched on a cycle-by-cycle basis.

The new system also features revised software that has a real-time debugging feature and true foreground-background operation. Called Tektest III, Version IV, the software enhancement requires a minimum memory configuration of 42,000 words, memory management, and a floating-point processor. The 3275, which has a median price of $675,000, will not be available until October of next year.

HP represented. Hewlett-Packard Co.'s Loveland Instruments division of Loveland, Colo., is also planning to introduce a test system that will test large boards with 200 or more digital ICs on them. Users will be able to troubleshoot beyond the node, and the tester will provide the high-speed clock and test signals needed to exercise large-scale and very large-scale integrated circuits. The system will make use of signature analysis and will also ease transition from the design state to production.

Other, smaller vendors will also be polishing up new entries in the ATE race, including a new general-purpose memory test system, the model 7800, from Accutest Corp. of Sunnyvale, Calif., and the Zip board option from Lomac Corp. of San Jose, Calif. The Zip board ($3,750) is an intelligent serial interface that can be used with Lomac's line of electrical wafer parametric test systems. It is both pin- and software-compatible with the standard Lomac single-channel serial interface board, and it provides for the spooling of data to be printed out during production testing and engineering evaluation. The board has its own Z80A-based processor and 4 kilobytes of RAM to relieve the burden of printer and host computer input/output operation from the test system's central processor. The result is a two- to five-fold increase in throughput. □

An invisible presence

The latest and greatest test systems have traditionally made their debut around the time of the "Cherry Hill"—now Philadelphia—Test Conference. Based on that, buyers start making room in the next year's budgets. GenRad Semiconductor Test Inc., however, believes it has a general-purpose test system worth waiting for. So the Santa Clara, Calif., firm will begin a campaign at conference time asking those prospective purchasers not to make any commitments until it is ready to unveil its first product in January.

According to industry sources, the system, for testing very large-scale integrated circuits, will have less than half the 100-megahertz capability previously announced by Takeda-Riken of Japan—the highest tester frequency yet claimed. Still, since the system, to be called the model 16, will be modular from the card level up, expansion should not be a problem.

The tester, which will be expandable from about 50 to 100 pins, will feature self-diagnostics, complete auto-calibration, parallel test operation, and multiuser capability. It will also handle chips with the latest on-chip test facilities, as well as custom logic such as gate arrays. The basic configuration should come in for under $500,000. **-Richard W. Comerford**

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Re-programming Time	11ms	<500ns	15 mins	secs	μs	ms
Radiation Hardness	good	poor	poor	good	good	good
Temp Range	−55°C to +125°C	ltd. by battery	−55°C to +125°C	limited	limited	limited

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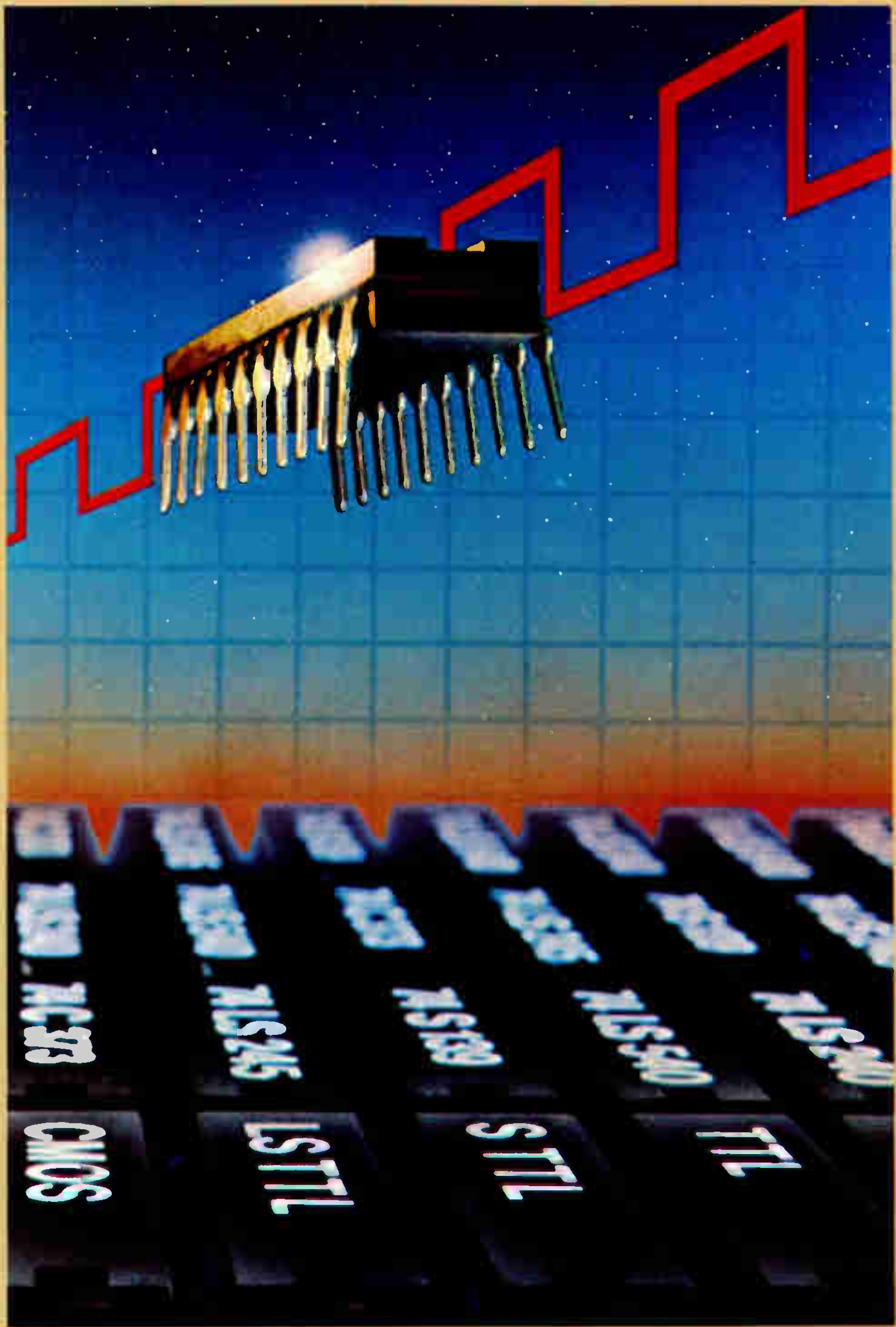

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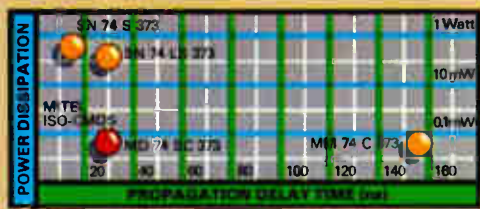

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MD 74 SC 239	Dual 1 of 4 Decoder
MD 74 SC 240	Octal Inverting Buffer
MD 74 SC 241	Octal Buffer
MD 74 SC 244	Octal Buffer
MD 74 SC 245	Octal Transceiver
MD 74 SC 373	Octal Transparent Latch
MD 74 SC 374	Octal D Type Flip Flop
MD 74 SC 533	Octal Inverted Output, Transparent Latch
MD 74 SC 534	Octal Inverted Output, D Type Flip Flop
MD 74 SC 540	Octal Buffer
MD 74 SC 541	Octal Buffer
MD 74 SC 563	Octal Inverted Output, Transparent Latch
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Circle 92 on reader service card

Careers

Government report hits education gap

Study says U. S. neglect of engineering training could cost it ground in world computer competition

by Ray Connolly, Washington bureau manager

The United States, creator of the Computer Age, is running short of electronics engineers—particularly computer specialists—just as it confronts increased world competition and bigger markets, the White House has been warned. Moreover, "the current shortage of trained computer professionals is expected to persist beyond 1990" despite recently rising enrollments in college and university electrical engineering departments, says a new study by the National Science Foundation and the Department of Education.

Demand for technicians in all engineering disciplines is also outpacing supply in a tight market, according to the study, as a result of an uncoordinated effort to meet the demand that "has largely been a haphazard enterprise, . . . a combination of on-the-job training, a few technical institutes, and vocational training in secondary schools." It is an effort that compares unfavorably with those of West Germany, Japan, and the Soviet Union, which, the report notes, "place heavy emphasis on training technicians in special vocational schools" that lead to "not only good jobs but considerable social status as well."

Entitled "Science and Engineering Education for the 1980s and Beyond," the 230-page report ordered by President Carter last February foresees no shortage of trained scientists for U. S. industry in the coming decade except for "current spot shortages" in subfields on which the electronics and energy industries draw heavily. These include solid-state physics, plasma physics, optics, polymer and analytical chemistry, and toxicology.

Engineering and how it is taught represent a serious problem, however, according to the report. It attributes existing and predicted shortages to "a shrinking of our national commitment to excellence and international primacy in science, mathematics, and technology" over the past 15 years. That decline was highlighted early in the last decade by the de-emphasis in secondary schools of mathematics and science that has led to the point where, the study points out, "only about one-sixth of all secondary-school students take junior- and senior-year courses" in those fields.

National educational emphasis focused instead on social goals of "providing equal access at all levels to the disadvantaged and underrepresented—minorities and women, and, later, the physically handicapped." For technologies like electronics, there is "an undesirable 'either/or' choice and change of direction that compares poorly with other nations' goals," says one NSF contributor to the study (see "The U. S. decline: compared with what?").

The period of rapid expansion of college and university engineering and science departments came to an end in the late 1960s as enrollments declined, followed by cuts in "real-dollar Federal investments" in

The U. S. decline: compared with what?

An examination of the long-term outlook for U. S. technological leadership is grim if the nation's secondary school system is any example. The situation is worse than that when the decline is measured against the systems in Japan and West Germany, with which America competes, according to an assessment jointly prepared for the President by the National Science Foundation and the Department of Education.

Whereas one third of U.S. school districts today require more than one year in mathematics or science for high school graduation, three fourths require more than one year of social studies. Japan and West Germany, on the other hand, continue to stress mathematics and science at the secondary level—with West Germany beginning chemistry and physics as laboratory courses in the fifth grade, following biology in the third. Algebra begins in the seventh grade, and students are introduced to a new mathematics and science subject each year through the tenth grade. Then those with an average of B or B+ go to upper secondary schools through grade 13; the rest go on to vocational schools or work.

Although the education system in Japan is structured differently, the approach is similar to West Germany's, with Japan requiring about 25% of the time in grades seven through nine to be spent on math and science. The number of engineering degrees granted in Japan has recently "surpassed the number granted in the U. S., though its population base is roughly one half of ours," the U. S. study says. Unchanging numbers over the past decade show that 20% of all baccalaureate and about 40% of all master's degrees are granted to engineers in Japan, compared with about 5% at each degree level for the U. S.

-R. C.

Probing the news

science education as costs of the war in Vietnam escalated. Despite an upturn in Federal research and development investments in 1975, many schools were using obsolescent laboratory equipment.

Teachers, gear. Compounding their problems was an "erosion" of technical faculties as teachers dropped out, rejecting obsolete equipment and overcrowded classes in favor of industry jobs paying up to 25% more and offering, at least in major corporations, state-of-the-art R&D facilities that few schools can match in an era of rapid technological change and rising equipment costs. By one estimate college laboratories have a shortage of an estimated $750 million in equipment.

Supply and demand laws took hold as the U. S. registered a 25% decline in the award of engineering doctorates in all fields between 1973 and 1979, dropping from 3,338 to 2,494. The decline since last year is more severe than even those numbers show; the study notes that "about one third of the new Ph. D.'s were non-immigrant foreign nationals," up to half of whom were expected to return to their homelands. The price paid in academia has been "severe difficulty" in recruiting doctoral faculty, while industry salaries for baccalaureate computer professionals and electrical, mechanical, and chemical engineers rose from 53% to 58% between 1974 and 1979. In contrast, increases for holders of bachelor's degrees in business and the humanities amounted to 37% and 42%, respectively.

Though the report projects that the supply of BSEEs between 1978 and 1990 should be "adequate" to fill U. S. demand except for academia and the computer industry, even that forecast — 172,000 degrees awarded to fill about 121,000 job openings — is sharply qualified by some contributors to the NSF-DOE survey. They note that factors like increased defense spending and the severe strain on teaching facilities could keep the market tight.

Computer makers and users have sought to cope with their shortages

by getting graduates in other disciplines to switch fields. At the doctoral level, for example, the largest exodus occurred in physics and astronomy, producing in 1979 about 3.5 times as many Ph.D.s working with computers as ever earned degrees in the field. Similarly, there were 2.7 times as many 1977 baccalaureates working in computer jobs in 1979 as had earned degrees two years earlier.

Weak on solutions. The NSF-DOE report sharply defines the problems of U. S. science and engineering education in strong language, but its recommendations are generally regarded as weak. They consist in large part of calls for collection of more data, broader surveys, greater spending for college and university laboratory equipment by industry and mission-oriented government agencies, and a presidentially convened national conference on the subject involving leaders in education, business, the media, private interest groups, and foundations.

The report's stronger recommendations propose that advanced-degree study in fields where shortages exist might be modeled on the work-study medical traineeship program of the National Institutes of Health. Also suggested is that the NSF, working with the Pentagon and other agencies with personnel shortages, aid colleges and universities in structuring one- and two-year programs that would allow science and engineering undergraduates to transfer to related fields of study where shortages exist and that industry be urged to form consortiums to support university research groups or offer money, equipment, and personnel in exchange for research.

"This is a statement of the problem for the President's and public's information. Admittedly, we do not have all the answers," explains one top lieutenant in the office of Frank Press, science and technology adviser to the President, in defense of the study. "We spoke with many people and many groups and collected and analyzed a great deal of data. The solutions must be proposed by the President and enacted by the Congress." □

Microsystems & software

Tek's new system means new tack

Instrument maker departs from cautious approach by announcing whole development system family a year in advance to help users plan

by Bruce LeBoss, San Francisco regional bureau manager

In its 34-year history, Tektronix Inc. has earned the reputation of being a very precise and conservative company. Thus, it is most unlike the Beaverton, Ore.–based producer of instruments and information display equipment to announce products that will not be available for a year. Yet that is what it did earlier this month when it unveiled the first member in a new family of microcomputer development systems. A closer look at the present and future offerings reveals why.

Designated the 8500 modular MDL series, the family is to provide design, debugging, and integration tools for the development of microcomputer-based products in three design environments. Unlike the multiuser system with which rival Hewlett-Packard Co. entered the development system business last year [*Electronics*, Sept. 13, 1979, p. 41], the initial family member, the 8550 microcomputer development lab, is a single-user system [*Electronics*, Sept. 25, 1980, p. 33]. However, it will be joined within the next 12 months by both a multiuser system (the 8560) and a host-computer system (the 8540).

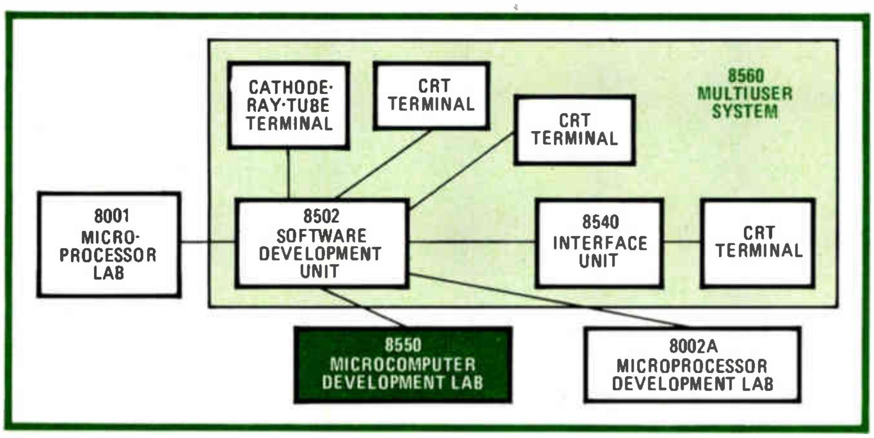
Considering the huge capital investment a potential user must make in a microcomputer development system and the rapid increases in the complexity of chip architecture and in performance, as well as a growing trend among designers to use microcomputers from many vendors, it is easy to understand why Tektronix is tipping its hand. "By giving only part of the story and cutting it off there, we wouldn't be giving users the full picture they need to make a decision," says Mike Maerz, business unit general manager of microcomputer development products. "We would be telling them only one tenth of the real value of the system they're buying," he says.

The basic 8550, priced at $14,300, consists of two major components: the 8301, a development unit that houses the operating system software, 32-K bytes of static program memory, a like amount of static user memory, a language processor, and an emulator controller; and the 8501 data-management unit, which handles files and auxiliary input/output for the operating system and manages the movement of user files between its dual-sided, double-density flexible disks and the 8501.

Of major significance, Tektronix is providing to users a "graceful migration path from one environment to another," Maerz explains, so that "they can minimize their capital investment in software and hardware tools. Also, if the user has to learn how to use a system only once, he can protect his source code, among other things, and maintain his productivity."

For example, the 8550 can be directly integrated into the upcoming 8560 multiuser system, itself an LSI-11/23–powered microcomputer development system for up to eight work stations. Similarly, the 8540, a self-contained peripheral station that integrates hardware and software in conjunction with a host computer, can be used as an integration work station in the multiuser environment. What's more, Tektronix' existing base, users of its 8001 and 8002A Universal Development Systems, can link these single-user systems into the multiuser environment, Maerz points out.

This compatibility between 8500 family members includes software support packages Tektronix already offers, so that present users of the 8001 and 8002A will find emulators already available from Tektronix to be upwardly compatible with the 8500 series. Such support currently includes 23 8-bit chips, among them 10 mem-



Family portrait. Tektronix will initially unveil the 8550 to be followed within a year by the 8560 and the 8540. System will be compatible with the older 8001 and 8002A.

bers of Intel's MCS-48 and MCS-80/85 families and three members of Motorola's 6800 family, as well as members of Texas Instruments' 16-bit 9900 series. Tektronix plans to offer full support soon, including emulation for more advanced 16-bit microcomputers, such as Intel's 8086, Zilog's Z8000, and Motorola's 68000.

Perhaps equally significant, Tektronix' strategy calls for it to take advantage of what Maerz calls "the power of modular architectures, so as to provide users with the flexibility" to configure their systems with any mix of software and hardware-software integration stations, each tailored to a specific task.

Semiconductor manufacturers, such as Intel and Motorola, "have as their end goal in this business the sale of chips and boards," Maerz states, "and the objective of some instrument manufacturers in the field may include the sale of computer systems. We don't have either of those biases. We have to live by the tools themselves."

Whole job. Thus, with the 8550 single-user station or any other RS-232-C–compatible cathode-ray-tube terminal in an 8560 multiuser environment, a user can generate, edit, and debug software programs. The next step—taking the software, putting it into a prototype system, and handling hardware-software integration—is basically what an emulator does. "And that's the role of the 8540," Maerz notes. "The person doing hardware-software integration needs a full emulation capability. On the other hand, we felt it was important for the software designer to have only what he needs."

Tektronix plans to increase the flexibility of its development system offerings with several hardware and software additions over the coming year. One of these will be the 8502, an advanced version of the 8501 data-management unit that will be the core of the 8560 multiuser system. Furthermore, it plans to offer within the next six to nine months an enhanced version of the real-time prototype analyzer (RTPA) it is offering initially as an option for the 8550. The RTPA permits the location of critical timing problems and hardware-software sequence problems in the prototype, and the enhanced version, called the Trigger Trace Analyzer (TTA), "will expand integration beyond just the CPU," Maerz states. It is expected to be of particular value in emulating 16-bit one-chip central processing units.

Shift seen. According to Maerz, Tektronix is banking its investment in the development system business on what it believes is a major shift from dedicated systems, used to support chips from a single vendor, to universal systems that support microcomputers from multiple vendors.

"What before was a marketplace dominated by one vendor, Intel, is now a three- or four-company [Motorola, Zilog, TI] marketplace," Maerz maintains. "Over 40% of our customers responding to a market research inquiry are currently using chips from more than one vendor. One third said they are adding another vendor or changing vendors when going to their next design."

Chuck Taylor, senior analyst for instrumentation industry service at market researcher Dataquest Inc. in Cupertino, Calif., agrees that such a shift is occurring, although not quite as rapidly as Tektronix believes. According to Taylor, the dedicated (single-vendor) portion of the microcomputer development system market accounted for 96% of a $48 million total worldwide market in 1976. Last year, when the total market reached $235 million, the universal (multivendor) portion increased its share of market to 14%. Dataquest forecasts that the market will reach $475 million in 1982, with dedicated systems accounting for 72%, universal ones for 28%.

Meanwhile, Intel, the principal supplier in the development system business, sees itself addressing the universal system market, as well. "When you consider that our systems support more chips [all of Intel's] than are available from our competitors, they can be viewed as universal too," states Tal Hurant, development systems product manager for Intel's Microcomputer Systems division in Santa Clara, Calif. "It all depends on what your definition of the universe is," he says. □

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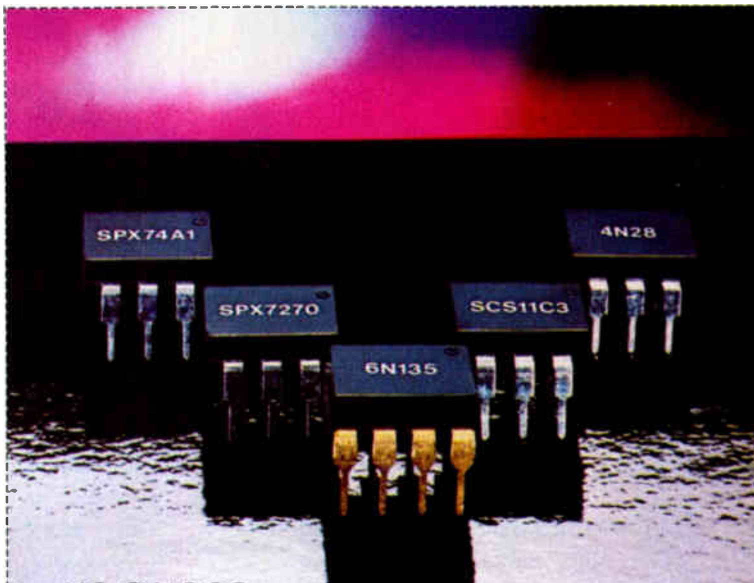

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Letter from Long Island

'The Island' gets high-tech push

Industry, government, and universities pitch new business with Long Island's technological strengths and stable work force

by Pamela Hamilton, New York bureau manager

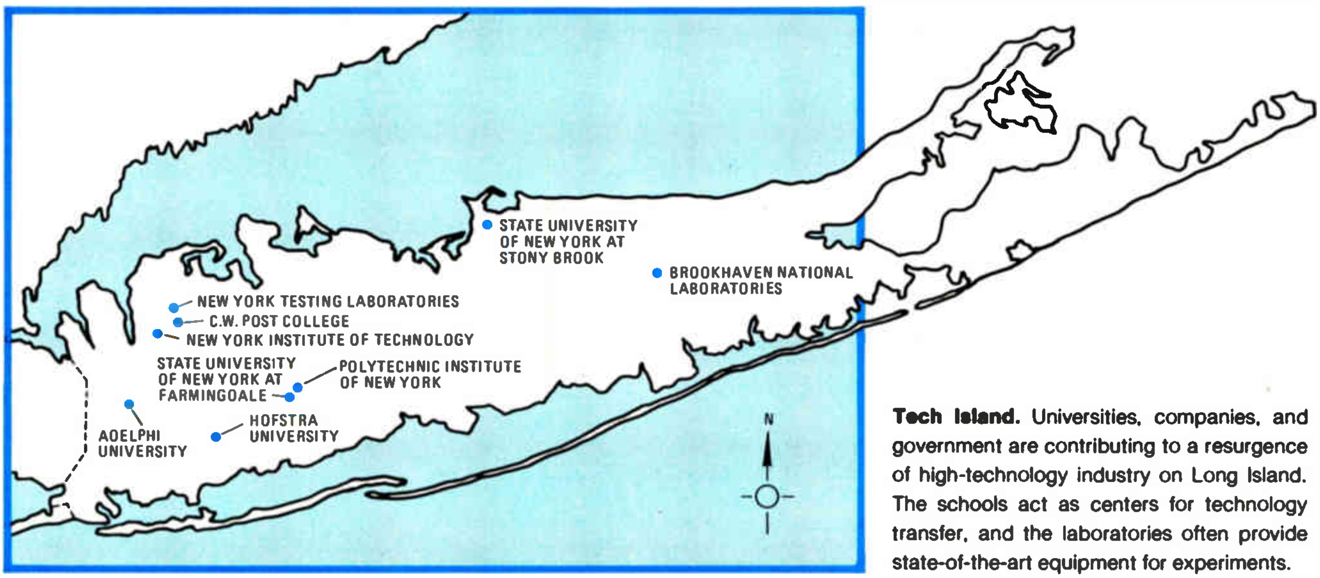
Long a bastion of Government and military electronics companies, New York's Long Island had been left on the sidelines in recent years with the growth of Silicon Valley in California and Route 128 in Boston as electronics centers. Now, a movement is afoot to push the Island—as its residents call it—back into the electronics limelight. Involved are high-technology companies, universities, government, financial institutions, real-estate developers, and research laboratories, with university representatives, company executives, and government officials joining to reinvigorate high-technology growth.

There are three main groups working toward this goal in the two counties—Nassau and Suffolk—that, along with New York City's boroughs of Brooklyn and Queens, form the Island. The Long Island Association of Commerce and Industry, which acts much like an enlarged Chamber of Commerce, consists of many businesses, both high-technology and otherwise. The Long Island Forum for Technology was started about 10 years ago and is in existence basically to provide seminars on high technology on the Island. From these two grew the Action Committee for Long Island Inc., a prime mover and shaker over the last two years for renewed interest in the growth of high-technology industries.

"What we're interested in doing on the Action Committee is promoting the Long Island economy via technology," observes Thomas J. Kelly, acting chairman of the committee's task force on high technology and economic development. Kelly, as vice president of engineering for Grumman Aerospace Corp., has a deep commitment to the growth of the industry as well as the labor force and support facilities on the Island.

His task force has succeeded in generating interest and cooperation in several areas in the last year. Among the projects that have been undertaken are:

- The creation of an Innovation Center in cooperation with the Long Island congressional delegation and the National Science Foundation. The center—which will be at both the State University of New York at Stony Brook and the Polytechnic Institute of New York—will resemble those already in place at the Massachusetts Institute of Technology and at the Universities of Utah, Wisconsin, and San Antonio (Texas). They aid entrepreneurs by finding companies to manufacture products or by helping set them up in their own businesses.
- The development of legislation at the state level to foster the growth of high technology throughout the state, especially on Long Island. This has taken the form of trying to reconstitute the New York State



Tech Island. Universities, companies, and government are contributing to a resurgence of high-technology industry on Long Island. The schools act as centers for technology transfer, and the laboratories often provide state-of-the-art equipment for experiments.

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Science and Technology Foundation—an agency that could find ways around the roadblocks hindering development—as well as attempting to open up the state universities' policies on patents and equipment use for commerical research.

■ The establishment of a clearing house for information on Federal government grants for research and development. Sponsored by the congressional delegation and the Action Committee, the clearing house should substantially aid in increasing the flow of R&D dollars to Long Island companies.

Federal nod. Perhaps most encouraging is a new status designation for the area. "One of the biggest hurdles we've gotten over is that we've now received status as a Federal economic development district [for Nassau and Suffolk counties]," observes Robert M. Schiffer, vice president of the Action Committee. "We're the first suburban area to receive Federal support for transportation, waste treatment, and other projects," he points out.

There are close to 285 firms on the Island in high-technology businesses. There is a work force of 164,000 technical persons, the second largest of any such region in the nation after Boston. With 20 colleges close at hand, companies have no trouble finding qualified people to work in their plants, nor do professional workers have trouble finding a choice of courses and degrees.

"We're increasing our engineering management ranks from people here on the Island," says Edgar A. Sack, senior vice president for General Instrument Corp.'s Microelectronics division in Hicksville, N. Y. "We're building our own society, as it were, our own technical infrastructure." He notes that, unlike that of the West Coast, Long Island's turnover rate reaches about 4%. "In my view, one of the biggest assets of being here is the stability of the work force," he says. Sack believes much of the growth will come from European and Japanese firms. One of the first to locate there may be Leader Instruments Corp., a Japanese maker of oscilloscopes. □

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- Lowest price of any 8-bit MPU with high-performance claims.

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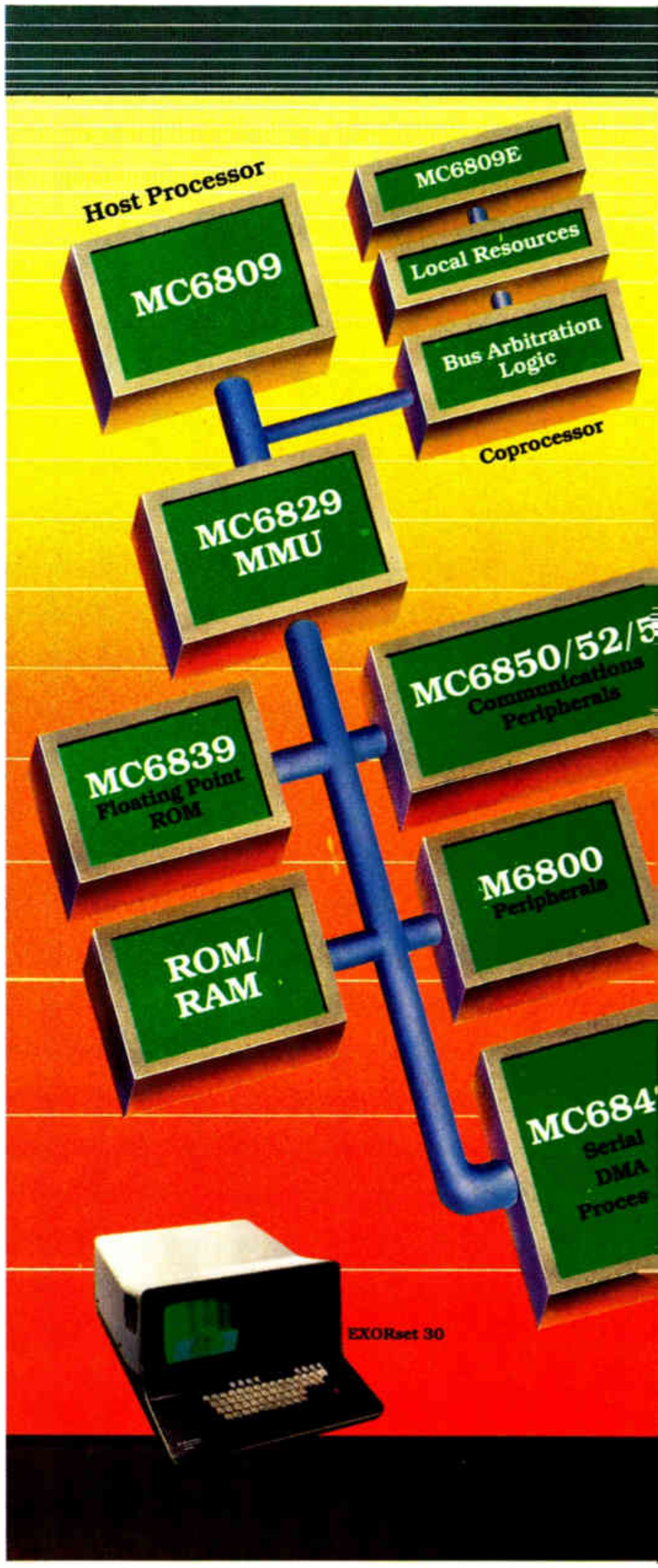
Helping keep software costs down must be counted as one of the MC6809's greatest assets. Its software-oriented architecture permits programmers to spend less time learning, more time programming. High-level languages like Pascal help keep costs down, too. And with the position independent addressing modes of the MC6809, standard "Software on Silicon" modules can be created to eliminate countless rewritings of commonly used codes.

Architectural advantages, beyond 16-bit registers and modern programming techniques, add to the versatility and cost-effectiveness of the MC6809. Auto-increment and auto-decrement addressing modes improve the efficiency of block moves and string handling, and extensive stack manipulation capabilities make block-structured high-level languages a natural.

The M6809 Family plan for advanced systems.

A whole new family of VLSI peripherals has been designed to take advantage of the many powerful features of the MC6809, and in turn, to help users obtain its full potential in flexible, high-performance 8-bit and pseudo 16-bit systems.

System support for the MC6809 is still supplied by the entire complement of M6800 Family peripherals, and several of the high-performance VLSI peripherals of the 16-bit M68000 Family also are directly compatible.



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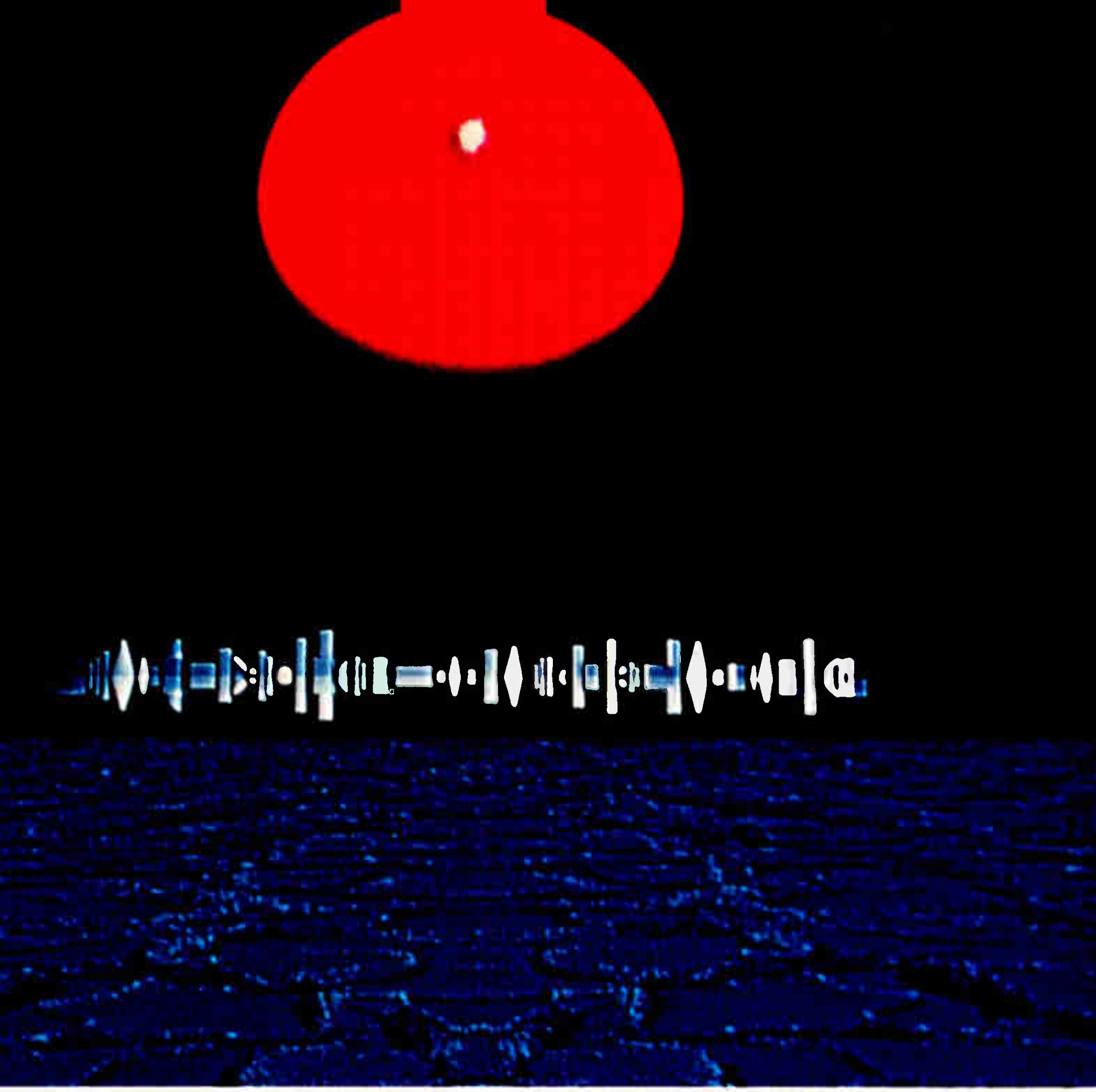

PMI Serves Up A New Data Conversion Plum Cake

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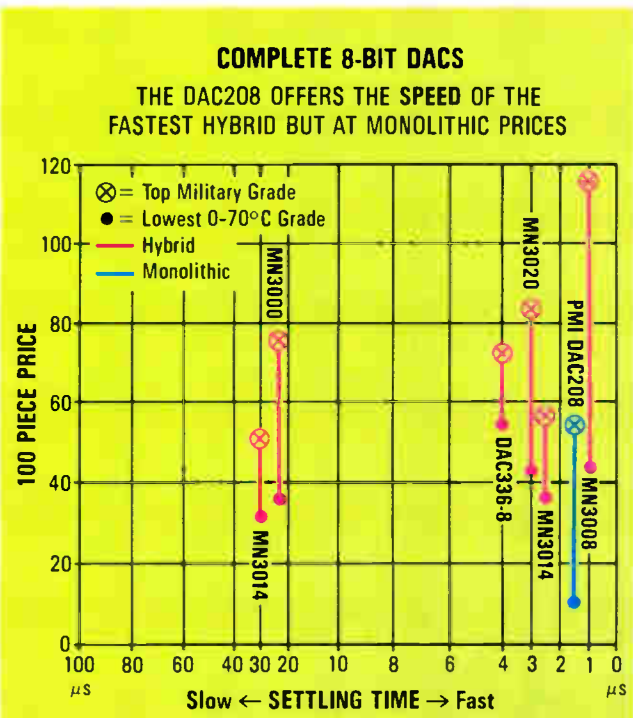
"The Lion and the Unicorn were fighting for the crown:
The Lion beat the Unicorn all around the town.
Some gave them white bread, some gave them brown:
Some gave them plum-cake and drummed them out of town."

Linear Wonderland has been a bloody battleground, with everyone fighting for the DAC Crown, ever since PMI introduced the *first* monolithic Digital-to-Analog Converter back in 1969. The battlefield has been crowded, like the one Alice observed in *Through the Looking Glass,* and the challengers have often been just as ineffective.

> "She thought that in all her life she had never seen soldiers so uncertain on their feet: they were always tripping over something or other and whenever one went down, several more always fell over him."

What they are fighting for in Linear Wonderland is PMI's DAC crown. Now—just when the Lion and the Unicorn thought one of them was about to win it away—PMI gives them something new to trip over: from the original source of the world-famous DAC-08 comes the complete 8-bit DAC-208, plus two more—the 6-bit DAC-206 and the 10-bit DAC-210—to create a *truly monolithic* new DAC family, with all components on a single chip, including an internal reference and output Amp.

Just look what's in our new Data Conversion Plum-Cake: the DAC-206 (a complete 6-bit D/A system); the DAC-208 (8 bits plus Sign); and the DAC-210 (10 bits plus Sign). All are the fastest in their class, with a maximum of μs settling time and a typical of 1.5μs, and after all, what most DAC users want is *speed.* All have guaranteed monotonicity. And all are priced lower than comparable hybrids and have no monolithic counterparts. And they offer the greater convenience and reliability of PMI's famous monolithic construction, plus our exclusive Sign-Magnitude Coding format, and Triple Passivation, of course.



For any data conversion application you have in mind, there's now a PMI DAC to fit the bill at prices ranging from $55 at the top of the line to $9.50 at the lower end. They also come at all commercial and military temperature ranges, including 883B versions.

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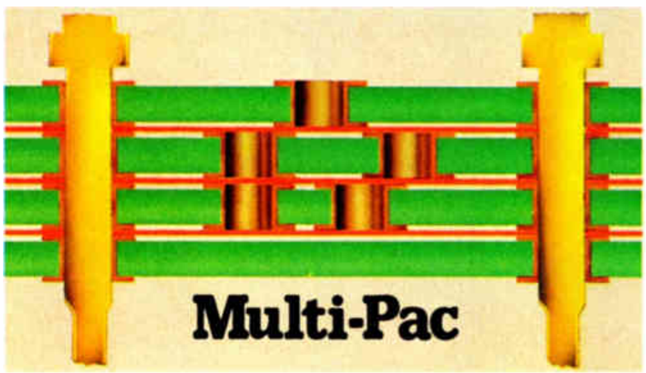

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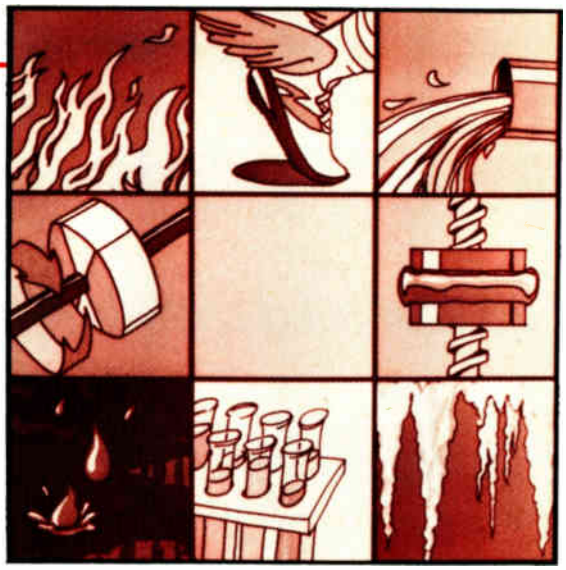


New applications open up for silicon sensors: a special report

The push to interface microprocessors with the real world will create a huge demand for monolithic sensing devices

by Roger Allan, *Components Editor*

☐ The lure of silicon for making small and highly accurate sensors has always been great, thanks to the material's high sensitivity to a wide variety of phenomena, its near-perfect freedom from mechanical hysteresis and creepage, its stability, and its ruggedness. But silicon sensors have not been inexpensive, despite their cost advantages over competing technologies.

Now, however, with microprocessors proliferating and coming down in price to a few dollars each, there is a growing demand for small, low-cost devices capable of interfacing this semiconductor intelligence with events in the analog world. What's more, the new surge of interest is promising rapid advances in silicon sensor technology, particularly in the area of pressure sensing, and opening up altogether new markets to microprocessor-based systems. Packaging, too, is improving. As a result, the silicon pressure sensor that three or four years ago sold in large quantities for $50 apiece is now being mass-produced for $5 and less.

Things are also changing for the traditional small makers of solid-state sensors. For years, they have supplied specific markets like aerospace, medical equipment, and process control with high-performance silicon devices, often because no other transduction method was satisfactory. Today, the potentially massive new markets, to which even knowledgeable observers find it hard to attach a dollar value, are attracting a number of larger integrated-circuit manufacturers into the field and are thus creating more business opportunities for them.

Perhaps the most rapidly growing market is in automotive applications. Certainly the most exciting is in biomedical uses. In between fall the industrial and machinery testing markets. Temperature sensors crop up in all of these areas.

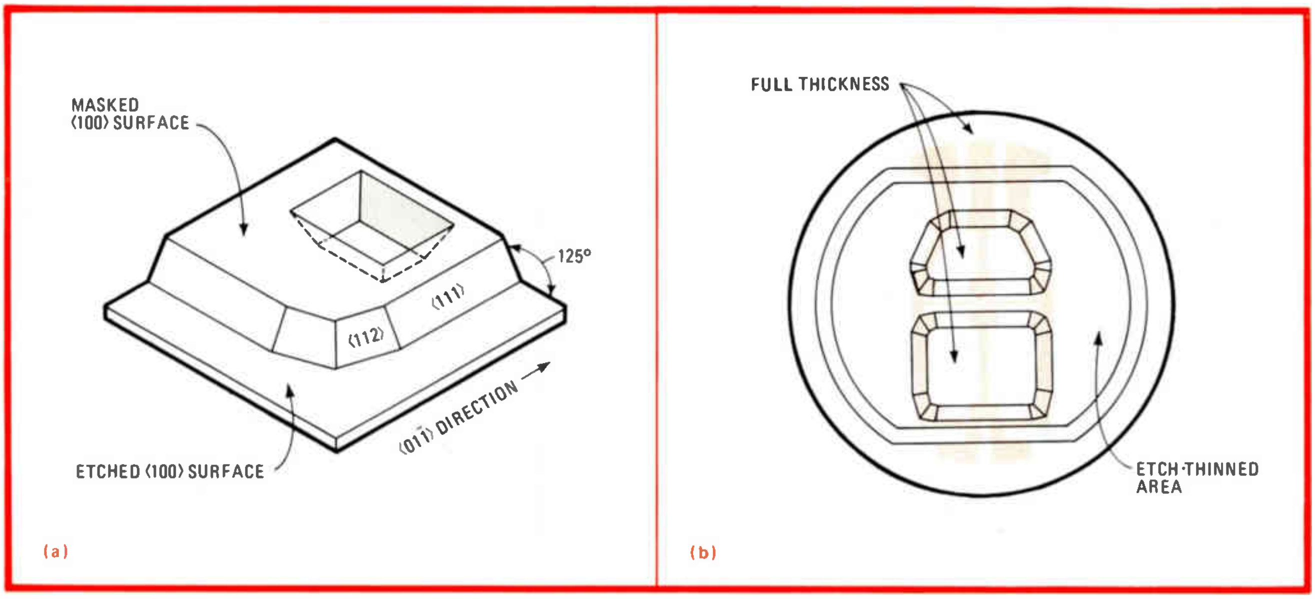
Besides pressure, silicon can be used to sense position, temperature, stress, magnetism, fluid level and flow, force, assorted gases, radiation, and many other phenomena. In addition, it can satisfy a wide range of transducer needs, from small size and low cost to very high performnance and reliability. The well-known processing techniques for semiconductor materials can be used to fabricate the devices, which these days can also be bought in packages that do not detract from their performance.

In the beginning

A pioneer in this business is Kulite Semiconductor Products Inc. of Ridgefield, N. J., which in 1959 began producing first bulk-silicon and later diffused-silicon pressure sensors for military and aerospace needs. In the early 1960s it was the need of aircraft jet-engine and wind-tunnel testing for extremely small pressure sensors that accelerated the development of the type in which p-type silicon is diffused into an n-type silicon substrate.

Today this is the commonest type of silicon pressure transducer, and Kulite makes the smallest ones around—a unit in its CQ-030 series. With a diameter of just 0.03 inch, it is small enough to pass through the eye of a needle. The piezoresistive strain-gauge sensor is rated at 100 pounds per square inch and has a nominal output of 40 millivolts.

As for silicon's performance as a sensor, manufacturers have been adept at pushing it to heights unattainable by other transduction methods within a given set of size and cost constraints. Kulite, for example, now offers silicon sensors with the highest available operating tem-



1. Adaptable. Silicon may be optimally formed for pressure sensing by being anisotropically etched (a). Such etching ensures that maximum strain will be undergone by selected areas of the silicon. A typical anisotropically etched silicon pressure transducer die can be seen in (b).

peratures of 600°F, thanks to the presence of a silicon-dioxide layer between the diffused and the substrate silicon regions.

About a year ago, Conrac Corp.'s Systems-West division, Duarte, Calif., produced a high-temperature, high-accuracy sensor in which a silicon piezoresistive strain gauge is grown epitaxially on a sapphire diaphragm [*Electronics*, Nov. 22, 1979, p. 42]. The series 4720 transducer, which handles up to 1,000 psi and delivers up to 50 mV, can operate over a compensated-temperature range of −65° to +475°F. Conrac is another early pioneer in diffused semiconductor sensors.

Others like Bell & Howell Co.'s CEC division in Pasadena, Calif., use Pyrex diaphragms upon which the silicon piezoresistive strain gauge is mounted. The linearity and hysteresis performance thus obtained by CEC is better than for conventional stainless-steel–diaphragm silicon sensors.

Anisotropic etching can shape the silicon transducer so that the selected areas undergo maximum strain (Fig. 1). Endevco's Dynamic Instrument division, San Juan Capistrano, Calif., for example, has a patented etching method that produces an optimal combination of high sensitivity, high linearity, and high resonance in a silicon sensor.

Strength, too

The high reliability offered by silicon sensors appeals particularly to automotive manufacturers. Silicon is an extremely strong material and as a pressure-sensing element usually operates far below its maximum stress and strain levels, so that it has a long lifetime. The ratio of its Young's Modulus (a measure of strength) to its weight is higher than steel's. According to Donald Lynam, president of Foxboro/ICT, San Jose, Calif., his firm is manufacturing a silicon pressure sensor that is handling gravity forces of 100,000 g in a missile, forces that would wipe out any other pressure sensor, given the small size the application dictates.

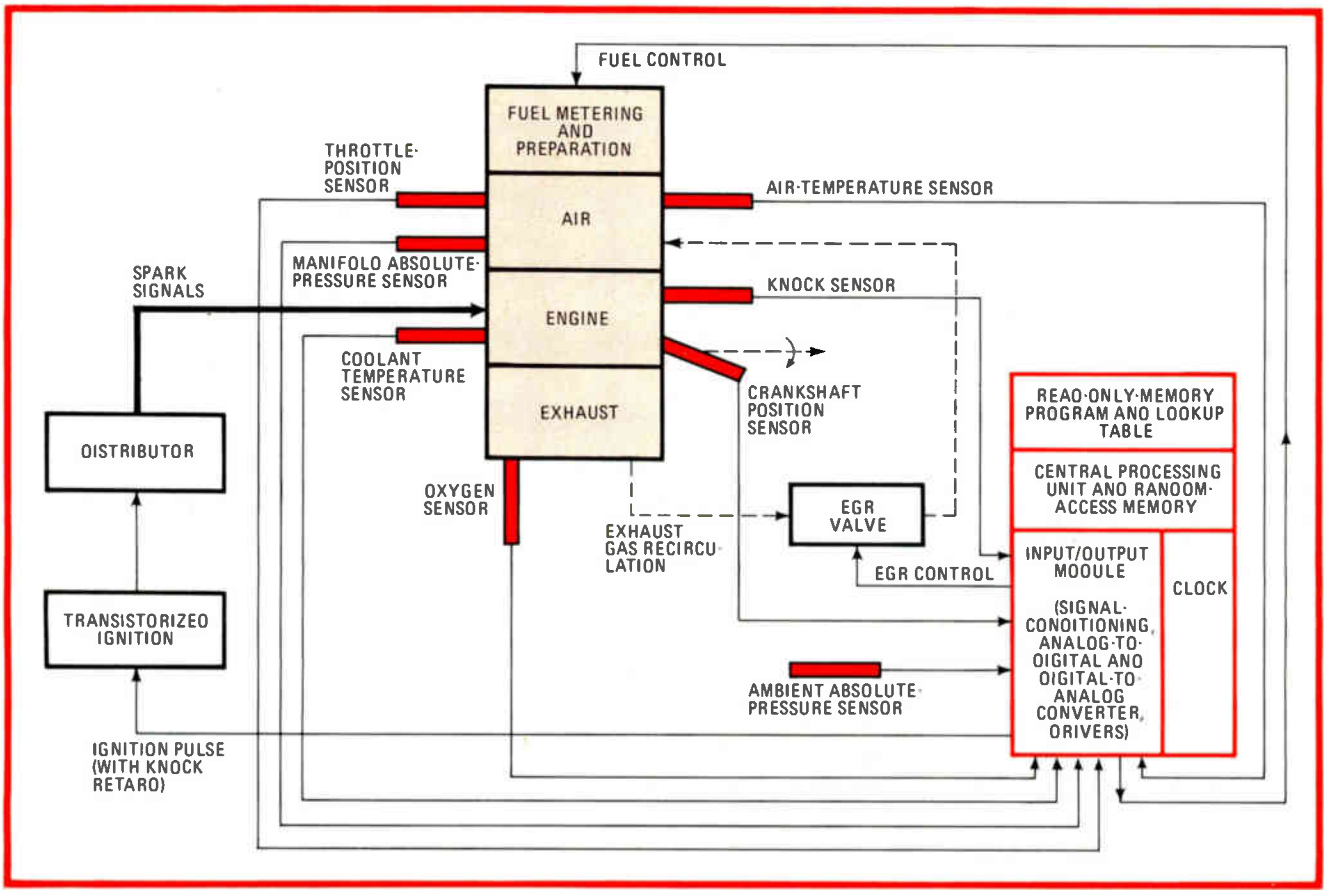
One major barrier to the wider acceptance of solid-state pressure sensors has been packaging. Virtually every application requires a different package. Thus it remained for a universal package to be developed before solid-state sensors could hope to cash in on broader markets. A fairly precise and stable silicon sensing chip has been relatively easy to make; but its useful properties were often compromised once it was placed within a package because of the interaction of chip and substrate it is mounted on. But this last problem, too, seems to have been largely solved by some manufacturers.

Automotive market produces a challenge

Over the last few years, several big semiconductor companies have had large programs with automobile manufacturers, part of which was to develop inexpensive solid-state pressure sensors. But not all of them managed to deliver the right degree of sensor precision at the right price. One result was that the Delco Electronics division of General Motors Corp., Kokomo, Ind., decided in 1979 to produce its own for sale to its parent company. It made nearly 1 million piezoresistive ion-implanted silicon strain gauges last year for 1980 vehicles and expects to produce some 5 million of them next year.

Despite this fact, some large semiconductor makers feel they can now supply low-cost sensors of sufficient precision and are ready to tackle that market anew. Providing a further incentive is the fact that microprocessor-based engine-control systems now in design may yet surface in future passenger automobiles (Fig. 2).[1] According to Frank Jaumot, Delco's director of advanced engineering, "we have to compete for General Motors' sensor business like anyone else, and if other manufacturers can come in at a better price for the same or better performance, they could conceivably get that business."

One possible competitor is Motorola Inc.'s Semiconductor Products Group, Phoenix, Ariz., which developed the X-ducer piezoresistive silicon strain-gauge transduc-



2. Control. Future automobiles may contain a microprocessor-based engine-control loop to replace conventional analog control loops. Yet to be decided is whether the controls will be organized as a set of federated loops, as slave loops, or as a single loop. (Source: IEEE.)

er [*Electronics*, Sept. 25, 1980, p. 44]. The breakthroughs in its design and packaging have allowed Motorola to peg the basic MPX100D chip's price at from $2 to $5, depending on quantity and performance.

The X-ducer produces a maximum output of 65 mV at 1 atmosphere of differential pressure when excited by a 3-volt dc source. A pressure range of 1 to 40 psi (differential and absolute) can be handled. Besides being free of hysteresis, the sensor has a worst-case repeatability of ±1% and a full-scale temperature coefficient of −0.2%/°C. Maximum zero-pressure offset is 35 mV, and sensitivity is 3.42 mV/in.².

Operating principle

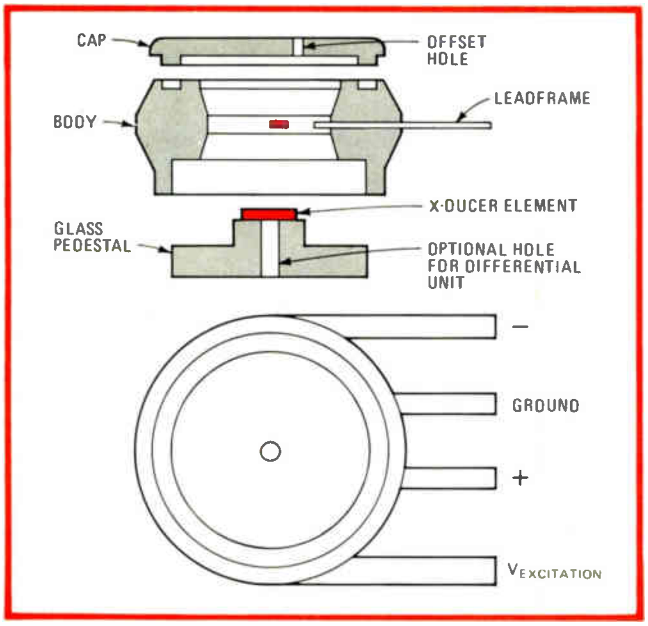
The device is named for its key part—a single X-shaped p-type silicon element that operates on a shear-stress principle to produce its output voltage. Thus it has no need for the implanted resistors that form a Wheatstone bridge in conventional piezoresistive silicon pressure sensors. Furthermore, the chip is mounted in a chip-carrier Motorola developed that simplifies the product's testing by automatic testing equipment (Fig. 3).

Available in an automotive housing as the MPX80MD, the modular product comes fully assembled, calibrated, and tested for interfacing with microprocessors—it contains signal-conditioning electronics to produce a 5-V dc maximum full-scale output. In other housings, the device can also be used for process-control and industrial applications. The basic chip approach with a simple package that can be easily terminated to electrical and pressure signals is important, since it opens up the X-ducer's markets to a broader range of applications. Each of these different applications can use the basic chip package and either build upon it or modify it for best results.

During the mid-1970s, Honeywell Inc.'s Micro Switch division in Freeport, Ill., a leading maker of solid-state sensors, produced about 80,000 pressure sensors for Oldsmobile Toronado cars. Only a handful of them failed, and then only because of classical wire-bond openings. But with its IPT, its first integrated pressure sensor to have on-chip signal conditioning, Honeywell is aiming at medical and environmental control as well as the automotive markets.

The IPT (Fig. 4) advances the state of the art in pressure sensors. Pegged for sale at under $10 in large volumes, the 0-to-15-psi (absolute) sensor delivers a full-scale output of 5 V dc and has a linearity of ±1% of full-scale output. As for other specifications, repeatability and hysteresis are ±0.15% of full-scale output, and its temperature coefficient is 125 parts per million per °C. Null offset is 1 V dc.

In its 0.2-by-0.25-in. package, the IPT is the smallest of three piezoresistive silicon strain-gauge pressure transducers Honeywell Micro Switch has introduced over the last two years. According to Charles Hudson, director of technology for the Micro Switch division, that basic IPT package is universal enough to be modified



3. Basic. Because of its simplified construction (top) and packaging (bottom), the silicon pressure transducer from Motorola called the X-ducer should appeal to a broad range of users. The optional hole is normally not present in absolute-pressure sensors.

relatively easily to meet a variety of applications.

Honeywell Micro Switch is no newcomer to automotive position sensors, either. Chrysler Corp.'s Dodge Omni and Plymouth Horizon automobiles from the first included its Hall-effect integrated position-detection sensors in place of the conventional but more expensive and less reliable reluctance types in the distributors.

Motorola also plans to unveil Hall-effect sensors for automotive applications next year. The two devices will use two Hall elements, in place of the customary one, to sense the transition region between north and south magnetic fields. As a result, the devices have a well-defined square-wave output. Distributor, automotive crankshaft, and speed pickup applications are among their likely uses.

Level sensing on the rise

Monolithic devices for sensing solid, liquid, and gas levels are also proliferating. Together with microprocessor technology, monolithic—albeit multichip—systems are now available that can measure and control these levels as well as sense them.

For automotive liquid-level systems, for instance, Texas Instruments Inc. of Dallas has developed a sensing element (ST004) that fits into a probe (STS004-B). A

How big is the market?

Trying to size up the various markets for solid-state transducers is hard. Historical data is lacking because the devices are only just emerging in quantity to complement the steadily proliferating microprocessor system. Moreover, while many estimates of the overall market in transducers, including solid-state types, track each other closely, each seems tentative about some potential market segment or other. Most probably, then, actual figures are likely to exceed all present estimates.

Experts talk of an overall 1985 market of $1 billion in transducers of all types. The automotive share in that is often put at between $200 million and $250 million. On that basis, many semiconductor manufacturers are deducing a huge solid-state transducer share, which also seems reasonable in the light of microprocessor growth.

One of the first detailed market studies performed on pressure sensors came out this year, entitled "The Pressure Transducer and Transmitter Industry: A Strategic Analysis," by Venture Development Corp., Wellesley, Mass. The study projects a 1984 U. S. market for pressure transducers/transmitters of $576.8 million, and of that total, $90 million will be diffused semiconductor transducers. These figures are up from 1978 totals of $182.8 million and $27.3 million, respectively. The study, considered a conservative one by most solid-state transducer manufacturers, estimates an annual average rate of growth of 22% for diffused semiconductor transducers, the predominant type of solid-state pressure sensors.

Yet it should be noted that the study does not include transducer production for passenger cars by the Delco Electronics division of General Motors Corp., for it views that as a captive market. However, Delco has indicated that it could conceivably lose that market to competitors, and many automotive and solid-state experts estimate that Delco's solid-state transducer production will reach about 12 million units by the mid-1980s, at an average selling price of $8 to $10 each.

Despite the fact that semiconductor transducer manufacturers have not been totally successful in penetrating passenger automobiles, some feel there is more to the automotive market than just passenger cars. National's Zias feels that there are markets for solid-state sensors in trucks, buses, trains and off-road vehicles, markets that are not as price-sensitive as the one in passenger cars for a given level of performance precision.

Another often overlooked source of demand is consumer products. For instance, for a conventional home bathroom scale, where weight is translated into pressure that is displayed on a readout, a microprocessor and a digital readout is now available for only a few dollars. Noticeably missing, however, has been a suitably priced sensor. Recent solid-state pressure-sensor developments are about to change all this. Similarly, in dozens of other consumer appliances, from washing machines to toasters, a need exists for an inexpensive sensor to complement the inexpensive microprocessor electronics in use.

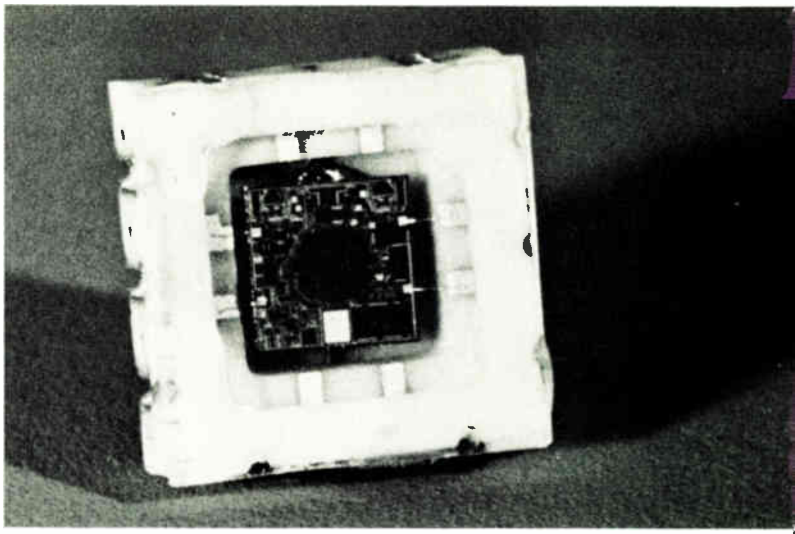
This picture can also be extended to other potentially large markets like automotive applications and machine tools, where any number of at least a dozen phenomena besides pressure need to be measured inexpensively.

Finally, the traditional performance-sensitive markets in process control, military/aerospace, and biomedical applications are bound to grow further as the many kinds of solid-state transducers gain greater recognition in the mass markets.

Undoubtedly, the biggest advantage solid-state transducers have over other types is that they can cash in on the learning-curve experience of integrated-circuit technology, making use of conventional IC processing techniques for truly low-cost devices.

companion printed-circuit board circuit (LLSM-1) is used for liquid-level monitoring. The heart of the sensing element is a tiny silicon chip 20 by 20 by 6 mils, with a lead wire connected to either face. Current passed through the chip changes as the resistance of the silicon changes in response to the temperature of the surrounding medium (liquid or air comes into contact with the chip through holes in the probe assembly). More heat is lost to a relatively dense medium, for example, like oil or water, than to a medium like air.

Texas Instruments is working on developing a control integrated circuit that could be used to interrogate this and several other liquid-level sensors and thus check the levels of motor oil, brake fluid, radiator coolant, power-steering-fluid, windshield washer fluid, transmission oil, and fuel more or less simultaneously. Such a configuration would amortize the control IC's cost over several sensors. Present control electronics for each sensor come in at about $8 to $10, according to Texas Instruments, whereas automotive users can afford only about $1 to $2 per sensor.



4. Integrated. Honeywell Microswitch's IPT (for integrated pressure transducer) measures a mere 0.2 by 0.25 inch and houses signal-conditioning circuitry as well as a silicon pressure transducer. The 15-psi sensor delivers a 5-volt dc signal within ± 1% linearity.

A two-element type

Texas Instruments has also developed a dual-element solid-state fluid-flow sensing system for automotive applications. Working on a principle similar to that of the hot-wire anemometer, it is said to be more rugged and offer higher resolution than the latter method. In addition, the system is specially suited to such uses as automotive fuel-line flow measurements because of the small size of the two solid-state sensors employed.

Both sensors are mounted in the pipe in which fluid or gas is to be sensed. One is a level sensor of the kind just described. The other, mounted upstream from it, is a temperature sensor that employs the spreading resistance concept. The two are connected to an external resistance bridge and maintained at a constant temperature differential, with either one of the sensors being at the temperature of the fluid or gas in the pipe, and thus providing a reference point. Flow transfer rate can be determined by the heat-transfer rate of the hotter of the two silicon elements.

At National Semiconductor Corp.'s transducer operation, Sunnyvale, Calif., a two-pronged exploration effort is under way for making solid-state sensors for low rates of liquid flow (gallons/hour) and gas flow (cubic feet/hour). One involves variable-capacitance transduction and the other is a variation of the piezoresistive silicon strain-gauge principle used in pressure sensors. Both principles will be implemented with the standard processing steps employed to make such piezoresistive pressure transducers, of which National is a leading manufacturer.

Industrial applications ahead

"Nearly one-half of all U. S. manufacturing employs pneumatic and hydraulic lines, since they use less energy than electrically controlled valves do," explains Foxboro/ICT's Lynam. "As a result, solid-state pressure sensors can now make possible computer control of such lines and many process-control firms are buying our sensors for such purposes."

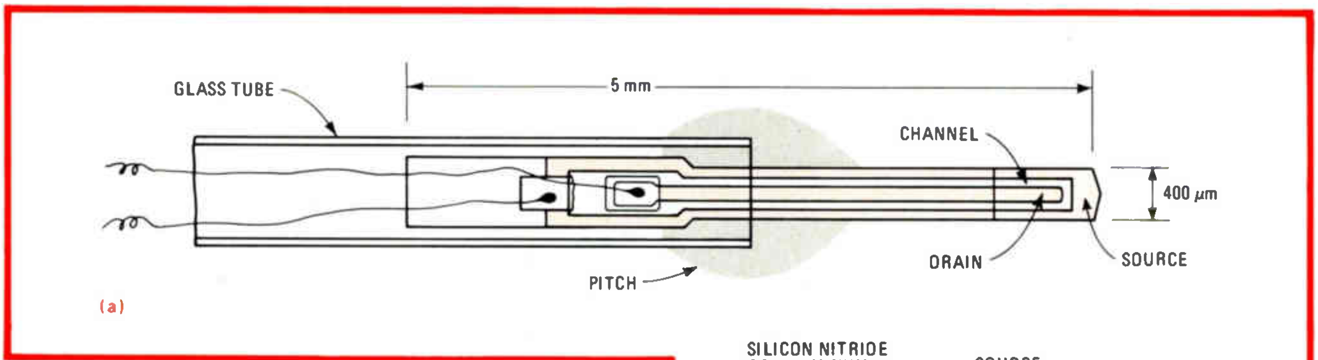
In hydraulic servo-loop machine-tool controls, for instance, pressure sensors can now be implemented to increase the machine tool's throughputs. As for industrial robots, there has always been a need for small and inexpensive solid-state sensors to give greater scope to the robots' intelligence.

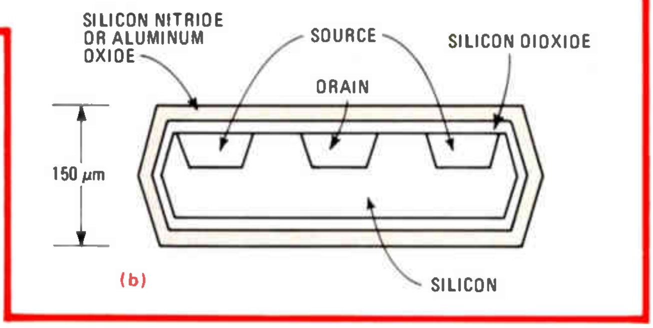
National Semiconductor's transducer business manager, Art Zias, notes, too, that the solid-state transducer's inherently long lifetime of several years is an advantage for machine-tool applications, where a tremendous number of repetitive machine operations involving much banging and shock translate into relatively short conventional sensor lifetimes, on the order of 1 month and less.

Before process-control and machine-tool applications for monolithic sensors begin to take off, however, the sensor manufacturers must develop basic devices that can be applied more universally to such applications. No two process-control and machine-tool applications are alike, with each requiring a specific type of sensor within a control system. Even the microprocessor compatibility of sensors has a long way to go, since few solid-state sensors on the market produce microprocessor-compatible outputs, at least not directly. Another problem is that traditional control-system manufacturers are unaccustomed to microprocessor-based electronic systems and therefore require more help in integrating electronics in their systems.

In a relatively new industrial application, chemical-sensing silicon transducers are being developed to sense ionic concentrations and to facilitate pH measurements. These ion-selective field-effect transistors, or IS FETs, are manufactured with inorganic gate films. Each is composed of a conventional ion-selective electrode and a metal-insulator-semiconductor FET, or MIS FET. Each operates in a similar manner to the conventional MIS FET. The metal-gate electrode, however, is removed to expose the device's insulator layer to the solution it measures for pH content.

One such device has been developed at Tohoku Uni-





5. Sensitive. Industrial chemical sensors that facilitate pH measurement are beginning to be made out of silicon. This ion-selective field-effect transistor, shown from above (a) and in cross section (b), was designed at Japan's Tohoku University. (Source: IEEE.)

versity, Sendai, Japan, by Hiroshi Abe, Masayoshi Esashi, and Tadayuki Matsuo (Fig. 5).[1] The researchers investigated the use of various inorganic insulator-gate IS FET structures for pH sensitivity, including silicon-dioxide, silicon nitride, aluminum oxide, alumino-silicate, and sodium-alumino-silicate gate dielectrics. The most suitable and practical material for pH measurements turned out to be aluminum oxide.

Another chemical sensor

Similar work is going on at the Moore School of Electrical Engineering of the University of Pennsylvania in Philadelphia. There researchers have designed and built a chemically sensitive semiconductor device that operates like a gate-controlled diode. Their ion-controlled diode (ICD) is being proposed as an alternative to the IS FET, the latter having long-term drift problems that make it unsuitable for multiple-electrode structures. The ICD works on the principle that gate-controlled diodes become transit-time–limited at high frequencies (that is, carriers moving in the inversion layer of the gate-controlled diode cannot remain in phase with the applied gate potential at high frequencies). Because of this limitation, the ICD's substrate source admittance becomes dispersive, allowing it to be used for the measurement of gate-voltage (and hence ionic-concentration) variations.

Both piezoresistive and piezoelectric silicon accelerometers are finding use in a wide variety of applications, particularly military ones. In the development, testing and monitoring of machinery and various structures, for example, a silicon accelerometer's wide frequency and amplitude-response bandwidths, as well as its small size, light weight, ease of use, and ease of installation are advantages in the measurement of shock and vibration over conventional accelerometers.

One of the most advanced silicon accelerometer designs was perfected by the Signetics Corp., Sunnyvale, Calif., jointly with the Diax Corp., also of Sunnyvale, for an inertial-guidance system. The work was performed under contract to Wright-Patterson Air Force Base in Dayton, Ohio.

The piezoresistive accelerometer is made of a folded cantilever beam spring and is etched anisotropically for accurate control of its shape. Since silicon has a very high temperature coefficient of resistance, which increases with increasing temperatures, the accelerometer was packaged in a controlled 125°C environment using self-regulating heaters.

A solid-state cantilever-type accelerometer at least two orders of magnitude smaller in area than other solid-state accelerometers has been developed by a researcher at International Business Machines Corp.'s San Jose, Calif., facility (Fig. 6). Kurt Petersen will describe it at this year's International Electron Devices Meeting in Washington, D. C.

Using on-chip detection circuitry and measuring 24 mils to a side, the sensor/detector chip operates by a capacitance variation of 40 attofarads/g caused by the cantilever beam's motion due to acceleration forces. These variations are sensed by the detection circuitry whose sensitivity of 2 mV/g allows it to detect values as low as 10 attofarads.

Measuring acceleration as well

Of all of the phenomena silicon sensors are capable of measuring, none is more pervasive and less amenable to categorization than temperature. Over the last few years, semiconductor companies have been developing silicon diode temperature sensors. As low-cost devices offering high accuracy, linearity, and stability, silicon temperature sensors afford a combination of features not normally present in alternative thermocouple, resistance temperature detector, thermistor, spreading-resistance sensor, and thyristor temperature switch methods. Moreover, in some applications, both pressure and temperature sensing can be implemented on the same piece of silicon, with no additional cost.

Silicon's positive temperature coefficient is only useful up to about 250°C, however, beyond which it cannot function as a linear device. Some like Texas Instruments are investigating the use of chromium-doped gallium arsenide for temperature sensing up to 500°C, using the material's negative temperature characteristics. GaAs,

GENERAL PRESSURE- AND TEMPERATURE-SENSING TECHNIQUES					
Transduction method	Principle of operation	Range	Approximate accuracy error	Advantages	Disadvantages
Pressure					
Capacitive	Deflections of pressure diaphragm acting as one plate of a parallel-plate capacitor cause capacitance changes	0.01 – 200 psi	0.05 %	high accuracy and sensitivity; ruggedness; temperature insensitivity	high cost; unsuitability for high pressure
Inductive	Deflections of pressure diaphragm or Bourdon tube cause inductance changes in inductance bridge or differential transformer	0.04 – 10,000 psi	0.5 %	high outputs; wide pressure range	instability with temperature; susceptibility to shock and vibration
Piezoelectric	Pressure on a quartz or Rochelle-salt crystal produces an electrostatic voltage across it	0.1 – 10,000 psi	1 %	no need for excitation; wide pressure, frequency-response, and temperature ranges	low output and accuracy; instability
Piezoresistive (strain gauges)	Pressure-induced strain in sensing element causes resistance change in gauges	0.5 – 10,000 psi	0.25 – 0.5 %	high sensitivity, low hysteresis and cost (semiconductor types); ruggedness; wide temperature range	low output; temperature sensitivity
Temperature					
Thermoelectric (thermocouples)	Electromotive force is generated at the junction of two dissimilar metals, each at a different temperature	−200° – +2,000°C	1 – 5 %	wide temperature range; high temperatures	low output, accuracy, and sensitivity; instability; high cost
Resistance (thermistors, resistance-temperature detectors)	Resistance changes because of temperature, in metal oxides or metallic conductors	−100° – +400°C (thermistors) −273° – +850°C (RTDs)	1 – 10 % (thermistors) 0.01 – 0.1 % (RTDs)	(thermistors) high output and sensitivity; low cost (RTDs) high accuracy, stability, and linearity; wide temperature range	(thermistors) nonlinearity; small temperature range (RTDs) high cost; long thermal time constant
Semiconductor diode	Base-emitter voltage of a forward-biased diode changes with temperature	−55° – +200°C	0.1 – 1 %	high accuracy, stability and linearity; low cost	low output; limited upper-temperature range

however, is difficult to dope, and its behavior is also hard to predict over time and temperature variations.

Silicon temperature sensors offering accuracies on the order of ±1°C are now available. Motorola offers its MTS102, 103, and 105 series of silicon sensors with matching to within ±2°C and output linearity to within ±1%. Designed for use in automotive and consumer as well as industrial systems, they do not require the tedious and time-consuming recalibration procedures other temperature sensors demand and are available in plastic TO-92 cases. The three devices offer accuracies of ±2.0°, ±3.0°, and ±5.0°C over an operating range of −40° to +150°C and are priced at $1.25, $0.85, and $0.50, respectively, for quantities of 30 to 99.

An indication of the high linearity of silicon temperature sensors is the 400 mV of change the MTS devices produce over that −40° to +150°C range. Over the same range, in contrast, a type K Chromel-Alumel thermocouple produces a less-than-10-mV change, which is harder to amplify accurately and is also more susceptible to noise.

A recent entrant in the silicon temperature business is

Pressure-sensing fundamentals

Pressure, expressed as force per unit area (as in pounds per square inch) has historically been measured by applying stress to one side of a thin-walled mechanical structure. A different pressure on the other side of the structure causes it to deflect, and the deflection is translated into an electrical signal by capacitive, inductive, piezoelectric, or piezoresistive changes. In formal terms:

- Absolute pressure (psia) is a measure of the pressure present on one side of the transducer's thin structure, with the other side at vacuum or 0 pounds per square inch.
- Atmospheric or gauge pressure (psig) is a measure of the pressure present on one side of the transducer's thin structure, with the other side exposed to local atmospheric pressure of 14.7 psi.
- Differential pressure (psid) is a measure of the pressure difference between both sides of a transducer's thin structure, with each side exposed to a different pressure level.

Pressure is commonly sensed piezoresistively. The most usual type of piezoresistive pressure transducer is the strain-gauge transducer, which includes unbonded wire, bonded foil, bonded semiconductor-bar, thin-film, and diffused semiconductor types. Most strain-gauge pressure transducers employ diaphragm sensing structures with active strain elements either on the diaphragm or on a beam that is actuated by the diaphragm.

The active strain elements are generally connected in a Wheatstone bridge arrangement that allows the measurement of resistance changes caused by applied-pressure changes, when an excitation potential is applied to the circuit.

Though the strain-gauge principle in various metals has been well known for decades, it was not until 1954 that Charles Smith of Bell Laboratories came across the piezoresistive effect in silicon and germanium. It was discovered that, as a strain element, silicon has many advantages over conventional strain-gauge transducers because of its excellent mechanical properties. These included a high gauge factor (sensitivity), nearly hysteresis-free behavior (repeated stress of the silicon does not prevent it from returning to its original form), accuracy, stability, and the inherently long life of a semiconductor material.

During the middle to late 1950s, many transducer firms made (and some still make) solid-state transducers, employing silicon bars as the strain elements. These were attached to a stress-sensitive metal diaphragm by an adhesive bond. This bonding, however, degraded the silicon's mechanical properties through creepage and hysteresis, resulting in transducers hardly more accurate than the adhesive material used. Furthermore, during this same period of time, the need for solid-state transducers was limited to specialized markets, leaving their design and manufacture to the smaller solid-state houses.

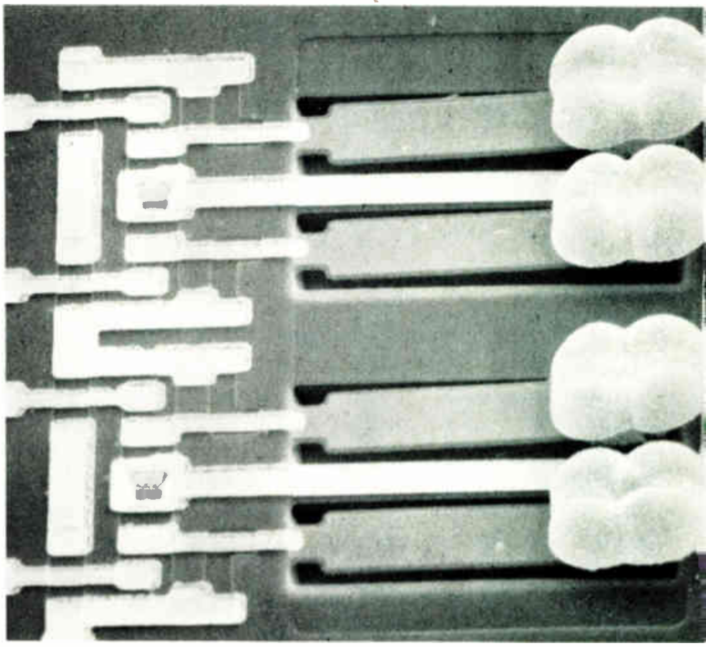
By the early to middle 1960s, the need for an extremely small high-performance sensor for wind-tunnel and jet-engine aerospace applications led to the development of the diffused silicon strain-gauge pressure transducer. In such a device, a p-type silicon material acting as the strain element is diffused into an n-type bulk silicon substrate. This type predominates among all solid-state pressure transducers today.

Intersil Inc., Cupertino, Calif. The firm has been offering the AD590 sensor as a second source to the AD590 temperature sensor made by Analog Devices Inc. of Norwood, Mass. Intersil's AD590, like the Analog Devices' unit, is available in TO-52 cans offering an output of 1 microvolt per Kelvin, an output that varies linearly with absolute temperature. It comes in two versions: the AD590IH with 3°C linearity and priced at $1.65 (100-piece quantities) and the AD590MH with 0.3°C linearity and priced at $17.95 (also in lots of 100). Both feature 0.5°C resolution over an operating range of −55° to +150°C.

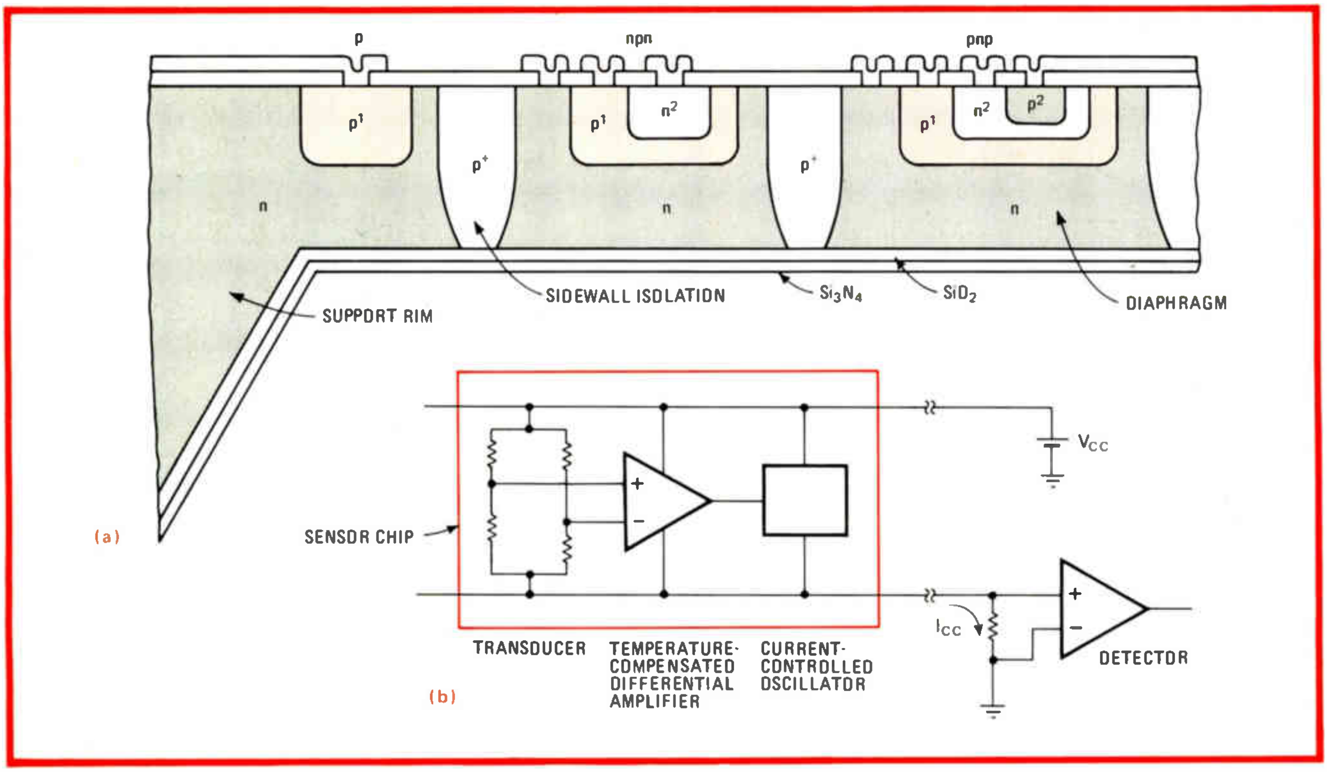
Coming soon

Intersil will shortly unveil its ICL8073 and ICL8074 silicon temperature sensors, also in TO-52 cans, with outputs of 1 microampere per °C and 1 μA/°F, respectively. Both devices operate over −55° to +125°C, need no trimming, and can be interfaced with all of the company's analog-to-digital converters. The former will be offered in 0.5°, 1°, and 2°C accuracy versions at 0.1°C resolution. The latter will be offered in 1°, 2°, and 4°F versions at 0.2°F resolution. Approximate pricing for both will be $2.45 each (again in 100-unit quantities).

Another important vendor of silicon temperature sensors is Kulite Semiconductor Products. Its STQ and STH series of diffused silicon temperature sensors offer a wide operating range of −46° to +177°C and a high output in a tiny package 0.2 by 0.2 by 0.0625 in. Each has a Wheatstone bridge configuration, with the former offering an output of 0.5 mV/V/°F at ±0.75% linearity of full scale, and the latter offering a higher output of



6. Miniature. This tiny silicon accelerometer, made by IBM Corp., is at least two orders of magnitude smaller in area than other solid-state accelerometers. The cantilever-beam unit has on-chip detection electronics, yet its dimensions are a mere 24 mils on a side.



7. Integrated. University of Michigan and Air Force researchers have used the triple-diffused bipolar structure in (a) to cram both a silicon pressure-sensor and signal-conditioning electronics (b) into a die that measures less than 1.2 mm on a side. (Source: IEEE.)

1.5 mV/v/°F at the expense of less linearity—±2.0% of full scale. Single-quantity pricing is set at $75 and $85, respectively.

Biomedical applications of solid-state transducers range from the highly commercial to the highly esoteric. One recent fallout of inexpensive solid-state sensors is their use in "do-it-yourself" sphygmomanometers, or blood-pressure machines. Sensors in series like National Semiconductor's LX0503, which takes absolute pressure readings, and the LX0603, which takes differential pressure readings, are suitable for such an application. They are inexpensive enough, selling from about $20 each in 100-lot quantities, and are capable of measuring pressures up to 30 psi.

Meanwhile, in leading academic and industrial laboratories, researchers are putting solid-state transducers to work in implantable electronic packages. Such sensors are being developed to measure intracranial pressure for neurosurgical applications, intrauterine pressure for obstetrical applications, air pressure for respiratory applications, blood pressure for intensive-care and surgical applications, and even air and liquid pressures in urinary and abdominal cavities to aid in the diagnosis of diseases in those regions.

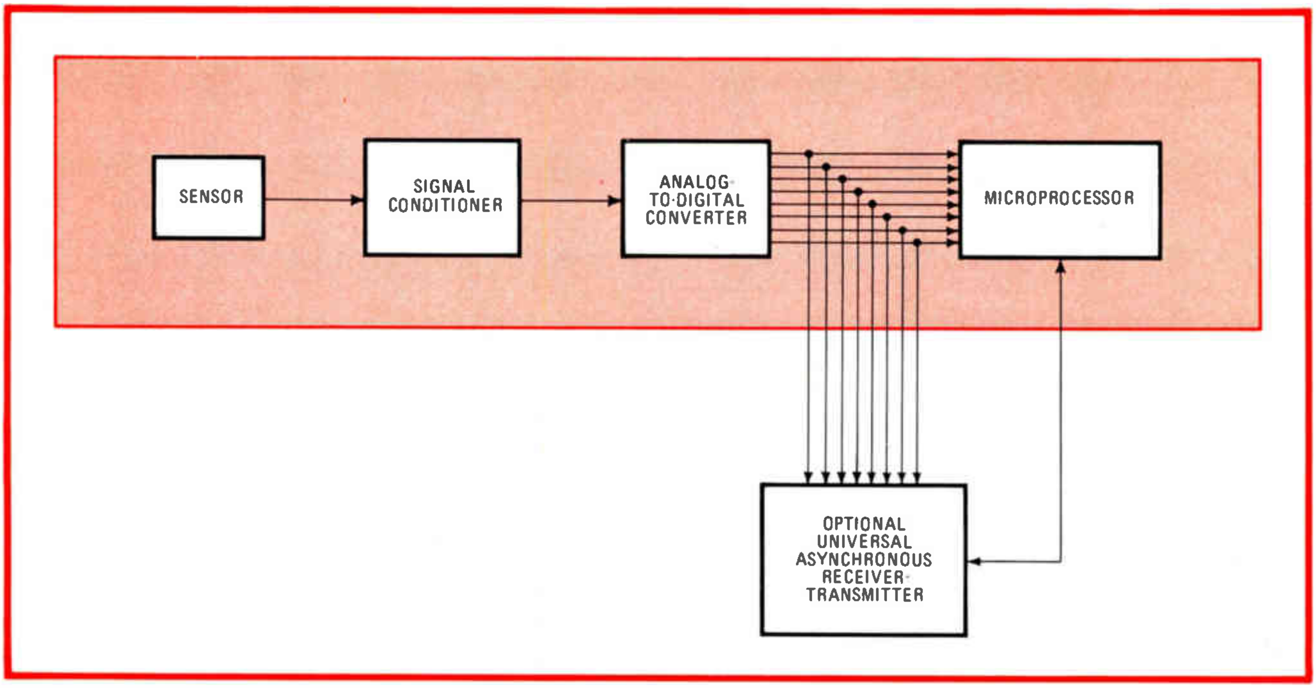
Deaf aid

Some of the more interesting developments out of the Stanford Electronics Laboratory of Stanford University in California include an eight-channel implantable tantalum-on-sapphire multielectrode array, used to help turn acoustic signals into electrical stimulation of the auditory nerves for those hard of hearing and deaf. The monolithic array acts as the interface between the human nervous system and other implantable auditory electronic circuits.

Yet another biomedical development is a silicon pressure sensor for implantable applications and containing signal-conditioning electronics on the same 24-by-24-mil chip (Fig. 7).[1] Developed by John Borky of the Air Force's Institute of Technology at Wright-Patterson Air Force Base and by Kensall Wise of the University of Michigan, Ann Arbor, the second-generation design has a resolution of 1 millimeter of mercury (1 mm of mercury=0.49115 psi at 0°C). Its linearity is within 1% over a pressure range of 0 to 250 mm of mercury. The sensor and its associated signal-conditioning circuitry require no external components and can be accessed through a pair of external leads. Several of them can be threaded through a catheter having a diameter of less than 1.5 mm. The sensor output is a temperature-compensated frequency-modulated signal that acts as the analog of the applied pressure.

An environmental application

Also at the Stanford Electronics Laboratory, Stephen Terry, John Jerman, and James Angell have succeeded in using the principles of gas chromatography to produce a silicon sensor for the analysis of gaseous samples. The sensor consists of a sample injection valve and a 1.5-meter-long separating capillary column, fabricated photolithographically and chemically etched in a spiral on a silicon substrate. The entire system can thus fit into a jacket pocket. Angell, professor and associate chairman of Stanford's department of electrical engineering, notes that the speed of a gas chromatograph's response in analyzing a gas is roughly dependent on the ratio of the



8. Intelligence. In upward integration of an intelligent sensor, signal conditioning, a-d conversion, and microprocessor circuits are added. A universal asynchronous receiver-transmitter can also optionally connect separate a-d converter and microprocessor circuits.

capillary column's volume to its area. He and his colleagues therefore etched onto the silicon wafer a long spiral groove and sealed it hermetically with a Pyrex glass cover, creating a roughly rectangular 1.5-m-long gas channel, with a typical width and depth of 200 and 30 micrometers, respectively.

Conventional gas chromatographs of equivalent capability are roughly the size of a desk. Moreover, the Stanford device has an analysis response time of approximately 3 to 4 seconds versus about 2 minutes for conventional ones. "This is an exciting development," explains Angell. "Eventually, it will reach the point where people working in hazardous-air environments can wear it on their shirt lapels to detect dangerous gases nearly instantly." Another obvious application is as an automotive exhaust analyzer for detecting the presence of gaseous pollutants.

Intelligent sensors to follow

Although the monolithic sensor is at present considered an external device when it comes to microprocessor-based circuits, this may not always remain the case. Particularly with the emphasis on developing sensors that interface with microprocessors, designers are giving much thought to the idea of an intelligent sensor, one with a central processing unit on the same piece of silicon.

Integrating the sensor and the microprocessor on the same silicon chip can, however, offer either benefits or disadvantages, depending on the application. Explains Larry Rehn, sensor development engineer for Texas Instruments' Electronic Devices division in Dallas: "The point one is sensing may not always be environmentally suitable for the microprocessor. It might be so hot, humid, or caustic that putting the microprocessor in the same location as the sensor would prove impractical. On the other hand, separating the sensor from the microprocessor, particularly through lengthy transmission lines, invites noise problems for low-level signals. It all depends on the application." TI is one of many firms with intelligent-sensor programs.

For many original-equipment manufacturers, the availability of other electronic circuits within their equipment often precludes the need for an intelligent sensor. Such users can generally use a basic sensing device and perform signal conditioning and other functions with the equipment's available electronic circuits.

The major elements to be considered in the upward integration of a sensor are the signal-conditioning electronics, the a-d converter, and the microprocessor. A universal asynchronous receiver/transmitter for interfacing a microprocessor with the output of an a-d converter at a different location is another element (Fig. 8). But for the moment, most sensor manufacturers are concentrating on the next stage—that of implementing signal-conditioning electronics on the same chip as the sensor or within the same package housing the sensor.

One factor that mitigates against too much upward integration of the sensor chip is cost. Unless a market can be found that is extremely large, further integration of a sensor chip like adding an a-d converter and a microprocessor makes the device more specialized and defeats its low-cost advantages. Nevertheless, some research is under way to integrate sensors and microprocessors, with large consumer markets like appliances, cameras, biomedical instrumentation, and automobiles providing the incentive. □

References

1. The Institute of Electrical and Electronics Engineers' Transactions on Electron Devices, December 1979, a special issue on solid-state sensors, actuators, and interface electronics. Figures labeled "Source: IEEE" are taken from this volume.

Digital multimeter satisfies bench and systems needs

6½-digit unit chooses JFETs over relays, uses special converter and a single processor chip to provide generic features for less

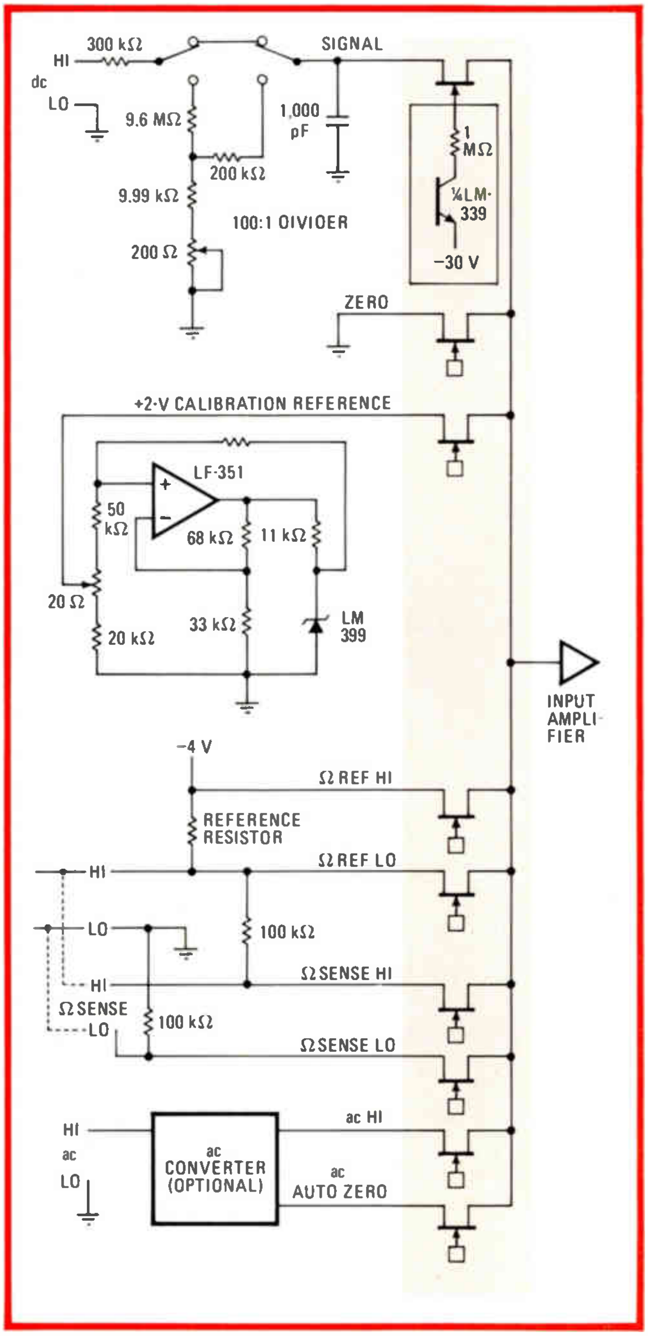
by Thomas J. DeSantis, *Keithley Instruments Inc., Cleveland, Ohio*

☐ Common sense and creativity combine in the design of the 192 digital multimeter, which focuses in on the engineer's real needs and finds ingenious ways of minimizing the cost of meeting them. A 6½-digit meter, it has all the essential capabilities of an instrument costing $3,000 or more. Yet in its bench configuration it sells for under $1,000 and in its system configuration for under $1,400. The instrument has a basic accuracy of 0.005%.

Some other bench DMMs claim system features yet can take only 2.5 readings per second. In contrast, the DMM 192 can provide 8 per second on the bench and up to 35 per second in a system and can store up to 100 readings in a buffer while the system controller is busy elsewhere. Nor has analog performance been sacrificed to flashy features.

With the optional IEEE-488 interface, the 192's ability to detect changes of 0.5 part per million and to measure 20 volts while keeping input impedance at 1 gigohm makes it particularly useful in a semiconductor measurement system. So does its ability to take and store 35 5½-digit readings per second or to provide a triggered reading output in 27 milliseconds. Then, too, by giving access to each of the three signal-conditioning circuits through its separate dc, four-terminal-ohms, and optional ac ports, the system designer can reduce the amount and cost of external switching needed to present measurement signals.

On the bench, the 192 can be programmed from the front panel using a shift key and one of eight other buttons. One button allows the user to choose 5½- or 6½-digit readings and a second button adds extra digital filtering. There are three buttons for often used mathematical programs such as scaling ($Y = sX + b$), percentage deviation, and minimum or maximum input determination. A different button sets the meter to compare a reading to user-entered high and low values and display a simple HI, LO, or PASS, a feature that makes the unit an excellent low-cost acceptance tester. (Rear panel relay outputs let the 192 signal an automated handler without an additional controller.) Further, another button turns the 192 into a data logger, storing up to 100



1. Low-noise, low-cost multiplexing. Accurately switching the desired signal from the signal-conditioning circuitry (left side) to the input amplifier (right side) is the work of inexpensive n-channel JFETs (tinted). Their gate-to-channel leakage is less than 1 pA.

readings at one of nine reading rates ranging from the maximum 8-per-second bench rate to its 1-per-hour minimum.

In providing these capabilities, the experience gained in the design of the 191 5½-digit bench DMM was particularly valuable. The analog-to-digital converter first used in that unit was modified and the input multiplexer and amplifier redesigned. But the 192 is more than just a revised 191, for its exploitation of its 6808 microprocessor makes it a true systems meter as well as extremely versatile on the bench.

Converter savings

Instruments with performance comparable to the 192's usually employ a successive-approximation analog-to-digital converter in which the unknown input is compared with accurately known binary fractions of its full-scale input capacity.

While such a converter is fast, it has several disadvantages. It requires precision parts like resistors that drive costs up. It needs an analog filter to eliminate line pickup, and this increases an instrument's settling time as well as adding to its cost. The converter also requires as many as 15 calibration adjustments, which make it more costly to maintain.

The 192 therefore uses a charge-balance–single-slope (CB-SS) converter like the one first used in the 191 (see "Low-cost a-d conversion," opposite). However, the 192 converter gives faster results by being run for a shorter, line-frequency–dependent interval. Further, its front end (the transconductance amplifier) has been modified to permit higher input for greater resolution.

Unlike the successive-approximation converter, the CB-SS converter integrates over a period that inherently minimizes line pickup. This eliminates both the cost of the line-noise filter and its braking effect on converter speed. Furthermore, because the converter employs a microprocessor to calculate the final reading, it need function only in a highly linear manner with short-term repeatability, not with absolute accuracy. The result is that it needs only a few relatively inexpensive components and just one precision part.

As in the 191, the input circuitry before the 192's converter consists of a multiplexer (to deliver the multiple analog components of each measurement) and an input amplifier. But since readings are being taken with higher resolution and higher input impedance at 20 V in the 192, the input multiplexer and amplifier had to be redesigned.

Measurement sensitivity demanded multiplexing switches, with low noise and low thermal voltages (less than 1 microvolt), that would not contribute significantly to the input current. Relays capable of doing the job would have proven both expensive and, considering the duty cycle imposed by the scheme, unreliable over an extended period of time.

The recent availability of high-quality n-channel junction field-effect transistors provides a cost-effective answer to the multiplexing problem (Fig. 1). The devices have low-thermal copper leads and inherently low noise. With gate-to-source voltages of 50 V, leakage is insignificant, less than 1 picoampere. Although their 10-kilohm on-resistance is relatively high, it is not a problem since current through the JFETs is typically less than 25 pA.

The low-current aspect of the FET ensures that the voltages needed to calculate a reading are precisely presented to the high-impedance input amplifier. A dc voltage measurement, for example, relies on the performance of the top three FETs shown in Fig. 1.

In taking a dc reading on the bench, the voltage seen at the high dc voltage input terminal is switched by the associated FET to the isolating input amplifier. Thereupon the amplifier passes the voltage to the converter, which digitizes it and passes it on to the processor which stores it. Next, the zero input set is turned on and a zero input is processed and stored in the same way. Then the output of the 2-V reference circuit, which is used to correlate the reading, is processed and stored, and finally, another zero input is similarly processed. When all four inputs have been obtained, the processor retrieves them, calculates a reading, and displays it.

In system operation, a dc voltage reading is obtained in a slightly different manner to get faster results. In the one-shot mode, the meter continuously multiplexes, digitizes, and stores zero and calibration inputs until a measurement trigger signal is received. When that happens, the dc voltage HI FET is turned on and the input from the high terminal is digitized. The processor can then produce a reading much faster than it would using the bench method.

For a resistance reading, four inputs are required so that the 192 can obtain a reading by means of a ratiometric technique, in which the voltage drop created by a current through a known resistance is compared to that created by the same current passing through an unknown resistance. Each of the four FETs associated with the resistance measurement inputs (Fig. 1) are turned on for one line cycle, and the resultant voltages they present are digitized. The processor employs the inputs from the top two resistance FETs to calculate the voltage drop across the known resistor and those from the bottom two to calculate that for the unknown resistor. Using the value of the reference resistor, the processor then calculates a resistance reading.

When only two input terminals are used to take a measurement, the voltage drop across the unknown resistor is sensed through 100-kΩ resistors. But since the current flowing in the input line is negligible, those resistors also contribute negligibly to measurement uncertainty. If a four-terminal measurement is made, the sense leads are connected directly to the unknown resistor and the voltage drop across it is sensed without the error due to lead resistance.

The right fit

The FETs are capable of directly switching up to 20 V to the input amplifier without attenuation. Thus, if the input amplifier can handle 20 V, it is possible to let the circuit under test see the amplifier's high input impedance in the 20-V range.

Designing such an input amplifier was not a trivial task. It had to provide an output swing of 40 V (±20 V), yet work with a low input current of less than 25 pA. It also needed less than 3 μV of noise and less than 10 ppm

Low-cost a-d conversion

Because of the way it is designed to operate, the charge-balance–single-slope converter avoids the need for precision parts. It begins operation when the input amplifier's output is fed to the converter's transconductance amplifier, or g-amp. The g-amp converts the bipolar voltage supplied by the input amp into a unipolar current. The use of a unipolar current is possible because the polarity of the input is determined during calculation of the reading. Since the input, zero, and calibration signals all pass through the g-amp, its gain need not be precisely fixed, only linear and noise-free.

The output of the g-amp is gated to the integrator by a current switch (change balance enable) for a known integration period. The output of the integrator is allowed to ramp up to approximately 2 volts, at which point a constant current opposing the g-amp current is switched in so as to balance part of the charge on the integrating capacitor. After precisely 2 microseconds, this current is switched off and the integrator output again ramps up until it reaches 2 V.

This cycle of ramp up and charge balance is repeated until the end of the integration cycle, with a pulse being generated each time the balancing current is turned on. Since the number of pulses that are generated is proportional to the rate of rise of the integrator output, it is also proportional to the value of the input voltage.

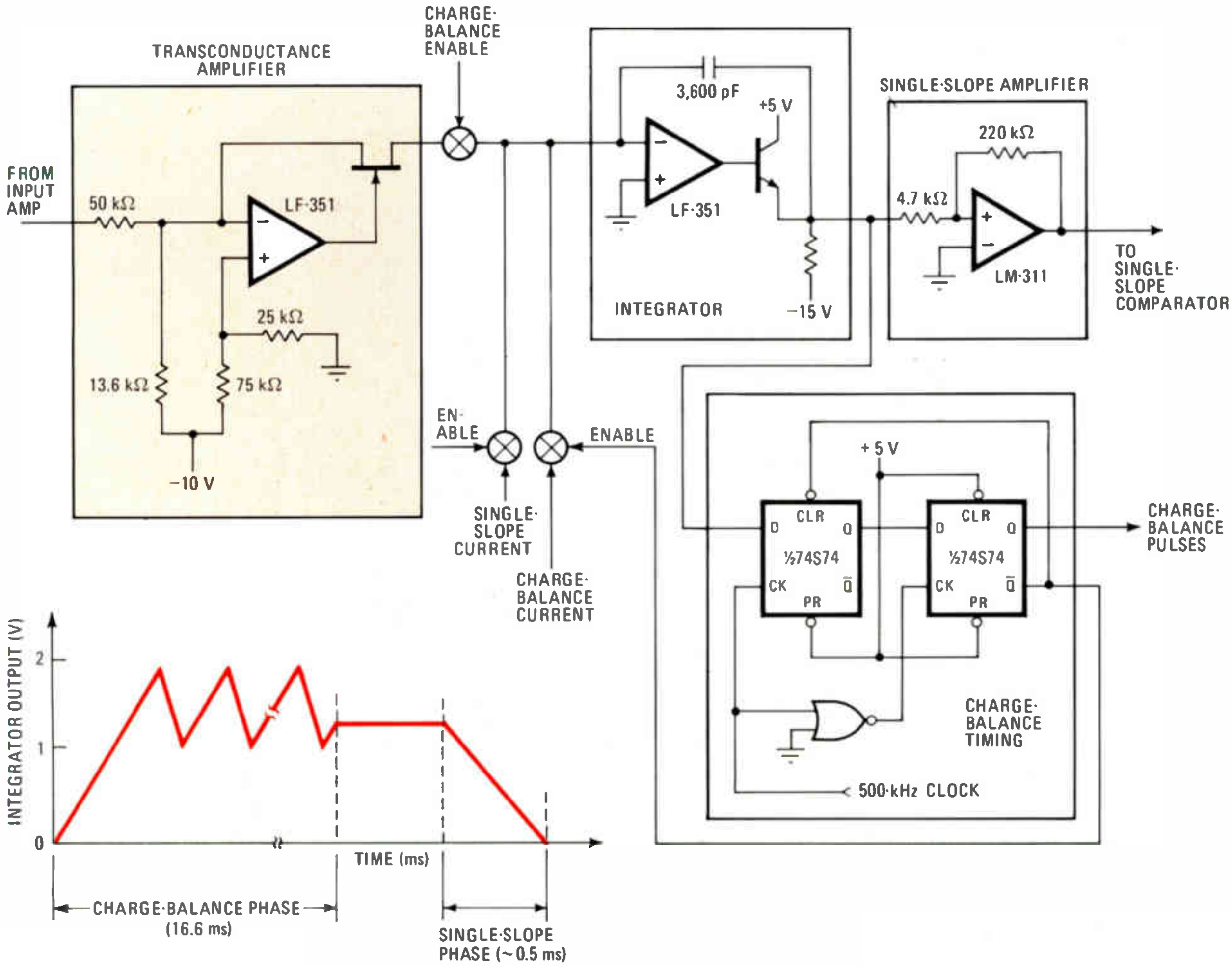
If this charge balancing is performed for one line cycle (16.6 ms), only 4,000 counts can be generated at maximum, insufficient to provide high resolution. However, at the end of this period, a charge is left on the integrating capacitor. Quantizing this charge extends the resolution.

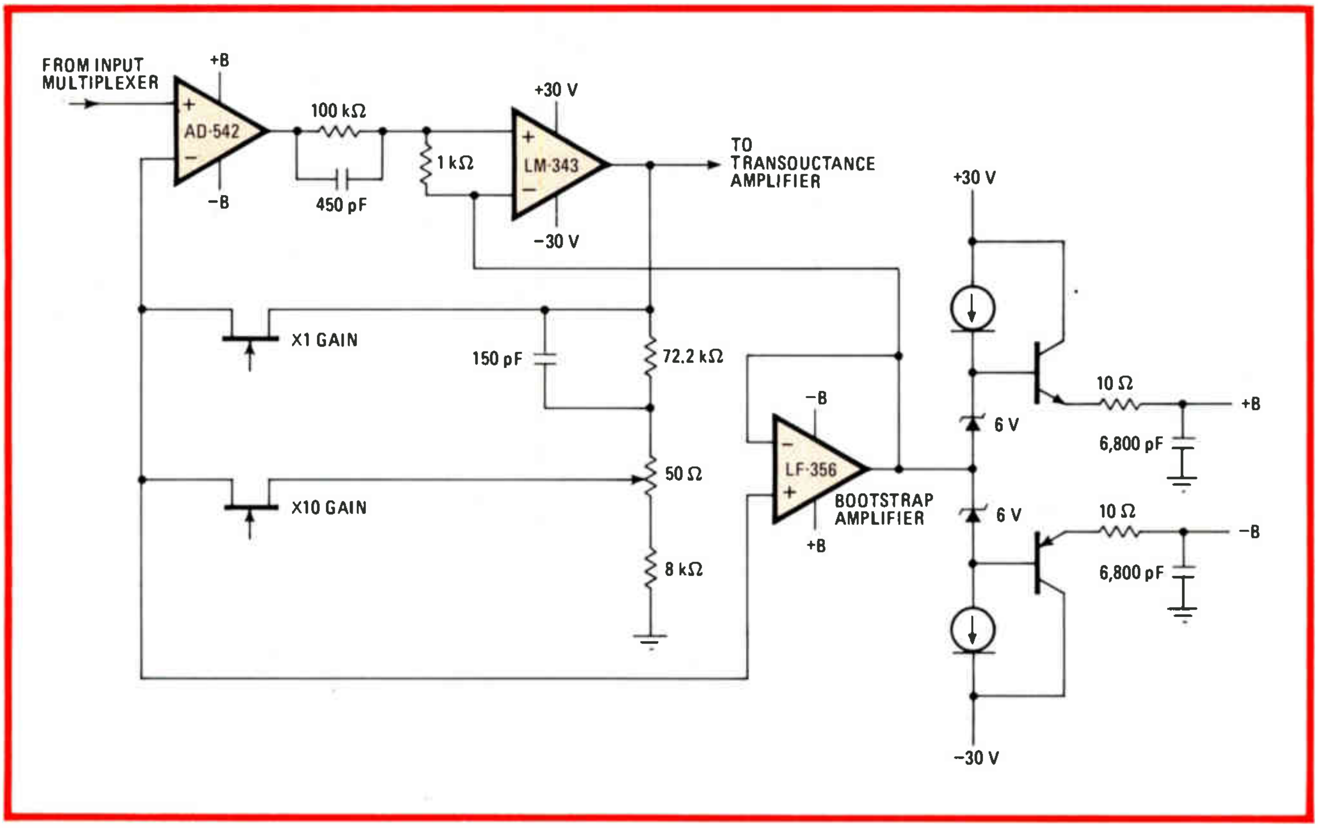
During this second, single-slope phase, a current $^1/_{128}$ that used in the charge-balance phase is applied to the integrating capacitor to remove the remaining charge. The time it takes to remove that charge is measured with a 4-MHz clock. Since both phases quantize charge by applying current for a known time, it can be shown that the quantized values are related by the equation $Q_{C_B} = 1{,}024\ Q_{SS}$. Thus multiplying the charge-balance count by 1,024 and adding the single-slope count provides a count capable of giving 6½-digit resolution.

To obtain a reading in dc volts, for instance, three values must be digitized by the converter: the input high (signal), the input low (zero), and a 2-V internal reference (cal). The output of the converter for each of these inputs is plugged into the equation:

$$\text{Reading} = 2(\text{signal} - \text{zero}) / (\text{cal} - \text{zero})$$

by the microprocessor to calculate a reading. The factor of two compensates for the use of a 2-V reference.





2. Strapping down cost. The bootstrap amplifier, the LF-356, in the input amplifier circuit above lets the supply voltages (±B) float 6 V above and below the input level. This permits use of the low-cost AD 542, with its excellent small-signal characteristics, for basic amplification.

of nonlinearity if accuracy was to be maintained. These specifications precluded the use of a single, off-the-shelf operational amplifier.

Such an amplifier could have been built with selected discrete components, but that would have been expensive. Instead, the 192 uses a bootstrapping technique employing three standard op amps. One provides low input current and low noise, one does the bootstrapping, and the third supplies the high voltage capability.

The low-input-current, low-noise op amp is an AD 542 (Fig. 2). Its supplies and inverting input are bootstrapped to the output of the LF-356 amplifier, which operates in a unity-gain mode. This amplifier provides a low reference for the 542's supply voltage. As a result, the supply voltages are always 6 V above and below the input voltage; if the input were, say, 20 V, the supply voltages would be +26 V and +14 V.

Bootstrapping the supplies and the inverting input in this way eliminates the nonlinearity errors due to power supply rejection; the summing junction is always at 0 V with respect to the supplies. Were the technique not used, the 80-decibel common-mode rejection ratio of the 542 could yield 100-ppm nonlinearity.

If the input amplifier had to provide only unity gain, this arrangment would be adequate. However, to achieve 1-μV resolution on the 200-mV range (5½-digit reading), a gain of 10 is needed to provide a 2-V full-scale input to the converter. The same gain is needed on the 2-V range to provide a 20-V input to the a-d converter and thus fully utilize the converter's dynamic range to provide 6½-digit readings. Further, an exact ×10 gain enables the precision 2-V reference to be used on the 20-V range, eliminating the cost of another reference.

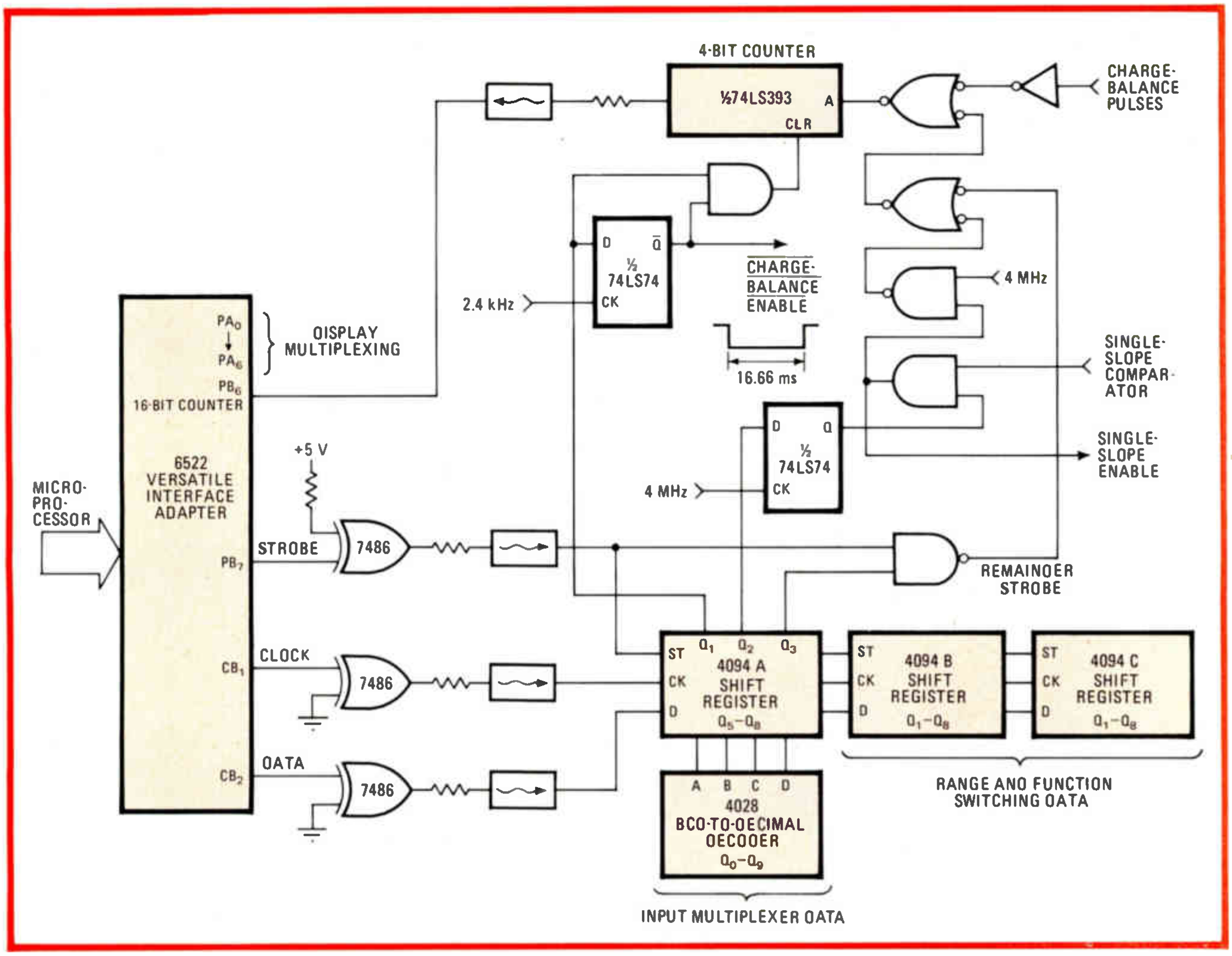
However, for any voltage above +0.6 V or below −0.6 V, the bootstrapped supplies cannot provide sufficient range for a gain of 10. For example, for a 1-V input a 10-V output is needed, but the positive supply is only 7 V. The way around this dilemma was to include a high-voltage amplifier, the LM 343, in the input amplifier's feedback loop.

Of one mind

Much of the 192's digital design aimed at enabling the instrument to talk and listen on the IEEE-488 bus, a capability the 191 lacked. The fact that it would be necessary to isolate the digital outputs from analog inputs and that a processor would be needed to interface the instrument to the bus made it logical to have a processor on the digital side. But the question was then how to control the converter and range and function switching on the analog side.

Other instruments sometimes put one processor on the analog side that communicates with another on the digital side. However, the use of two processors and associated circuitry would have increased both hardware and software costs and also boosted power consumption.

The solution elected was to use one microprocessor, the 6808, to control the IEEE interface, read front panel switches, multiplex display data, control the analog electronics, and perform the math routines, from the digital side. The analog electronics are controlled by the processor through a 6522 versatile interface adapter (VIA) that



3. One fewer processor. The 6522 (left) lets the processor on the digital, bus-controlling side handle the optically isolated analog side also (right). The shift registers decode data for range and function switching, input multiplexing, and conversion control.

is optically isolated from the analog circuitry in Fig. 3.

The VIA automatically converts range and function information into serial shift clock and data, which it sends across optical isolators to the analog side. The serial data is latched into three 4094 shift registers with the isolated strobe line.

A timer within the VIA generates a 1-ms real-time clock. This clock sets the integration period in conjunction with a crystal oscillator on the analog side that provides the exact timing.

Before the integration period begins, range and function data are sent to the 4094 B and C shift registers; data sent to 4094A latches Q_5 through Q_8 is decoded by the 4028 and is used to set the input multiplexer to select the voltages to be digitized (signal, zero, or calibration for dc volts). The charge-balance integration period begins by setting the 4094A Q_1 to a logic 1.

At the next rising edge of the 2.4-kilohertz crystal clock the charge-balance-enable flip-flop output begins an integration period of one line cycle (16.66 ms at 60 hertz). After 16 ms, Q_1 is reset to logic zero. The next rising edge of the clock ends the integration period. Thus the processor controls the integration period, yet time periods have crystal-controlled accuracy. For 50-Hz operation, the microprocessor automatically detects the line frequency and changes the integration period to 20 ms to obtain the 60-dB normal-mode rejection.

At the start of the charge-balance phase, a 4-bit counter is cleared and ready to prescale the charge-balance pulses by 16. (This prescaling makes it possible to use a low-frequency low-cost opto-isolator.) During the integration period, the counter overflow is fed to the VIA's internal 16-bit counter. At the end of the integration period, the least significant bits of the charge-balance output are left in the 4-bit counter. They are read out serially by injecting remainder-strobe pulses into the counter. Sixteen minus the number of remainder strobes necessary to overflow the counter equals the remainder left during charge balance.

During the single-slope phase, the same prescaler is fed a 4-megahertz clock. When the integrator output crosses zero, the single-slope comparator gates off the clock from the prescaler. Again the VIA counter contains the most significant bits, and the least significant bits are read from the 4-bit counter. The combination of charge-balance and single-slope counts completes one voltage digitization phase.

In bench operation, four of these phases are necessary

CONVERSION CODES FOR IEEE-488 OPERATION		
Code	Type of conversion	Time from trigger to first byte out (ms)
S0	4½-digit, 4-ms integration	27
S1	5½-digit, line-cycle integration	39
S2	6½-digit, line-cycle integration with filter 1	320
S3	5½-digit, line-cycle integration with filter 2	1,120
S4	6½-digit, line-cycle integration with filter 3	1,120
S5	5½-digit, 100-ms integration	136
S6	6½-digit, 100-ms integration with filter 1	1,240
S7	6½-digit, 100-ms integration with filter 2	2,900
S8	6½-digit, 100-ms integration with filter 3	2,900

to compute a valid reading. First the input signal is digitized, after allowing a short delay while the input RC network settles, after which a zero measurement is made with the amplifier input switched to low. The precision 2-V reference is next digitized, followed by the input switched to low again. The time needed to execute each of these four phases is approximately 25 ms. Allowing 25 ms for the processor to compute the reading and perform digital filtering, the bench reading rate is eight readings per second.

Systematically speedy

As both a system and bench unit, the 192 is partitioned into functional blocks so that only useful combinations of integration period, resolution, and digital filtering can be selected. Given the ability to choose these parameters independently, the system designer would have to specify a multidimensional array via the bus each time he wished to configure the instrument. In addition, many combinations would produce invalid readings that the novice user might not perceive. Further, the determination of trigger periods becomes extremely difficult, since it involves the addition of several time periods for each combination of parameters.

This problem is solved in the 192 with nine special codes for conversion rates (see table), which give the systems designer useful, clearly defined combinations to meet his or her measurement needs. To make a 5½-digit measurement with one line cycle integration and digital filtering, for example, an S_1 would be sent by the controller to the 192. The trigger time specified by the code permits several measurements and digital filtering before the result is sent out on the bus.

Unlike front panel operations, however, changing the range or mode via the bus does not force other parameter changes. For instance, the instrument can be changed through the bus from the dc mode with 4½-digit resolution to the ac mode without affecting integration period, filtering, or resolution. Thus the controller is relieved from having to receive status information each time one parameter is modified.

A parameter of particular concern to systems designers is the interval from when the instrument is triggered to when valid data becomes available on the IEEE bus. With the popular dual-slope method, an entire a-d conversion process is necessary, including auto zeroing and auto calibration, to produce a reading. The digital storage of auto zero and auto cal readings in the 192 gives it trigger-to-data-available times comparable to those of very expensive DMMs.

In the fastest modes—trigger and one-shot—the 192 performs zero and calibration digitizations until the trigger event. When triggered by the IEEE bus, the ongoing conversion cycle is aborted and an input signal measurement is performed by the a-d converter. Since there is no analog input filter, measurements with high source impedance settle in a short time. The processor does calculations using the most recent zero and calibration data. The result is a minimum trigger time of 27 ms for a 4½-digit reading. A 5½-digit reading with 60-dB normal-mode rejection can be obtained in less than 40 ms, or within 10 ms of $3,000 DMMs.

User-oriented philosophy

The front panel and systems operation of the 192 is optimized for ease of use, without sacrificing versatility. For instance, high-resolution high-sensitivity measurements often require zeroing the instrument, to counteract thermal voltages, lead resistance, or slight offsets in the a-d converter. In addition, it is often desirable to zero the initial display so as to read deviations from it. The 192 can be zeroed by pushing one button and can store a different digital zero for each function. For example, lead resistance can be saved in ohms, while a voltage offset can be stored in dc volts.

Digital filtering is present on all ranges and functions in the front panel mode. The filter simulates a three-pole analog filter, except for the settling time. The processor senses the new reading and determines whether it is noise on the input signal or a step input change. If the reading is greater than six counts from the filtered reading, the filter is disabled and the display assumes the new reading. Once the input settles, the filter resumes at the new value, without a long settling time. The result is a settling time up to 40 times shorter than an analog filter's, yet with the same amount of noise reduction.

The front panel programs are made simple to use by limiting them only to useful operating conditions. For example, the percent-deviation program displays up to ±200% only, since 5½- or 6½-digit measurements are usually within a few percent. If more than 200% is necessary, the next higher range can be selected, with a decade loss in sensitivity. When a front panel program is executing, all other instrument parameters are locked to prevent invalid or unknown operating conditions. When a function is changed via the front panel, a set of default conditions selects instrument parameters for optimum bench operation. □

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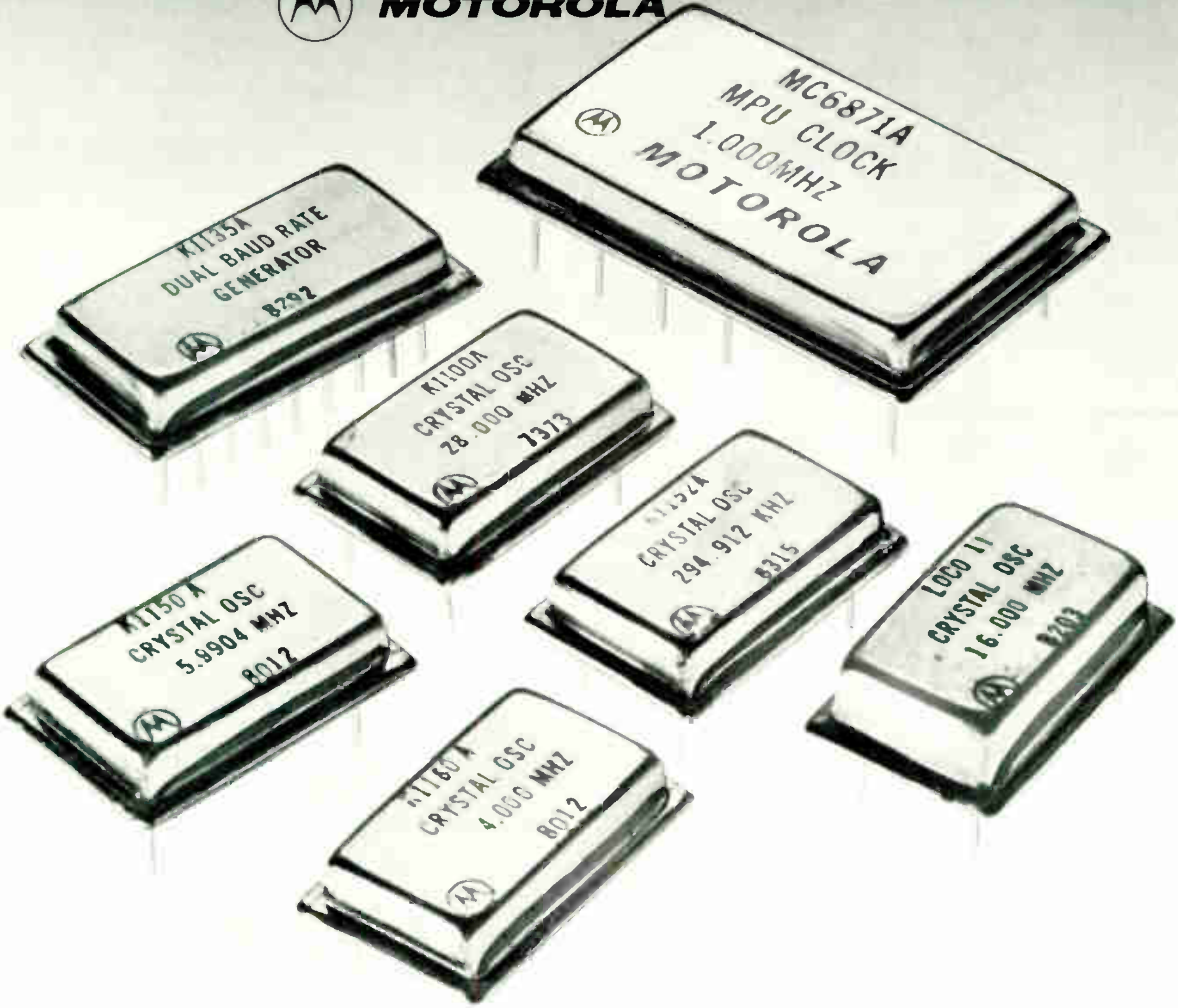

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Circle 129 on reader service card

On/off timer maintains precision over wide range

by Alfred C. Pinchak, *Cleveland Metropolitan General Hospital, Department of Anesthesiology, Cleveland, Ohio*

This circuit improves in several ways upon available designs for timers whose on and off periods are selectable. Specifically, it provides more precise control of those periods, a wider range over which the time base can be set, and a more flexible range that the supply potentials may assume. The circuit, which is implemented mostly in complementary-MOS, draws a maximum of 20 milliamperes at 5 volts, including relay power.

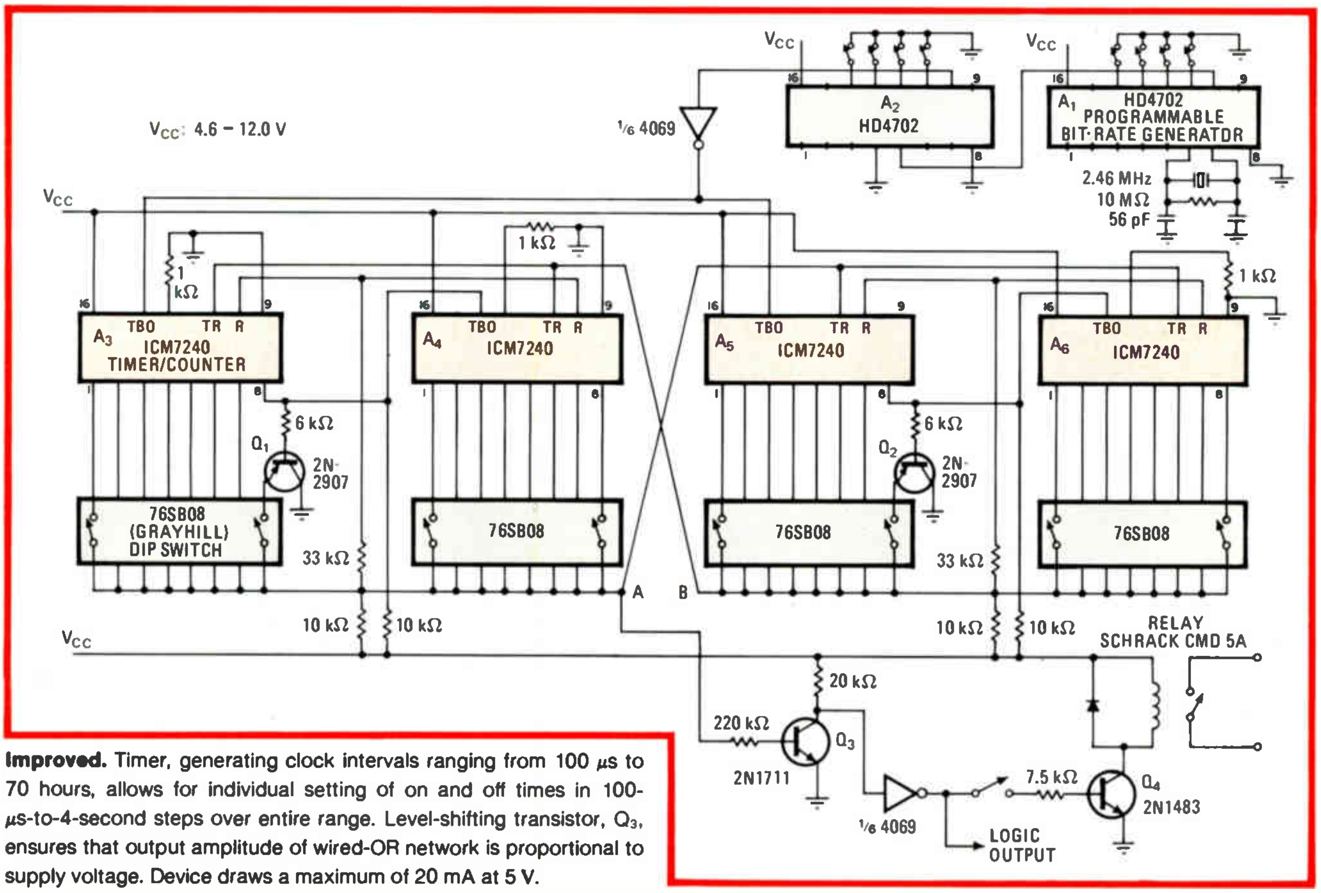
As shown, the HD4702 bit-rate generators, A_1 and A_2, provide a crystal-controlled clock signal for the ICM7240 timer-counter chips, A_3–A_6. Clock periods of from approximately 100 microseconds to 4 seconds are ordered by A_1 and A_2. The timer-counter outputs are wire-ORed together and are weighted in a binary fashion, with each position increasing in a 1, 2, 4, . . . 32,768 sequence. Thus by adjusting each dip switch appropriately, the on and off periods of the output signal can be independently set over the range $T_c < T_{on} < 65{,}536T_c$, where T_c is the clock period and $T_{on} = T_{off}$.

A_3 and A_4 form a one-shot that determines the off (low) period. Similarly, one-shot pair A_5–A_6 sets the on (high) period. Because the output of each one-shot (points A and B) are tied back to its own reset terminal and also to the trigger port of the other one-shot pair, the output at A is inverted with respect to B.

The 4702 time-base generators provide a direct clock signal for A_3 and A_5, with A_4 and A_6 driven by pins 8 of A_3 and A_5, respectively. A_3 and A_5, through transistors Q_1 and Q_2, also are part of the wired-OR network. Thus, all portions of each timer chip can be utilized to set the high and low periods. This feature is in contrast to previously published designs that cascade 2240 timers but restrict the T_{off} time to an integral multiple of $128T_c$.

Unfortunately, because of the wired-OR arrangement, the amplitude of the output signals at points A and B does not increase proportionally with supply voltage. In order to increase the effective range of the supply voltage, Q_3 is added to provide a level-shifting function. This extends the maximum supply voltage range from approximately 5.5 to 12 V.

The minimum supply voltage for an electronic output is approximately 3.8 V. However, the actual minimum voltage in cases where a relay is used will depend on the particular relay chosen. In this case, the minimum supply voltage was about 4.6 V. □



Improved. Timer, generating clock intervals ranging from 100 μs to 70 hours, allows for individual setting of on and off times in 100-μs-to-4-second steps over entire range. Level-shifting transistor, Q_3, ensures that output amplitude of wired-OR network is proportional to supply voltage. Device draws a maximum of 20 mA at 5 V.

Pulse modulator provides switched-mode amplification

by P. H. Pazov
Polytechnic of Central London, England

Using pulse-width modulation to provide switched-mode amplification, this circuit affords the same advantages in the analog world as does its switching power supply counterpart—simplicity, efficiency, and low power consumption when a complementary-MOS logic family is employed. Noise rejection and distortion characteristics also are better than can be achieved with a conventional analog arrangement.

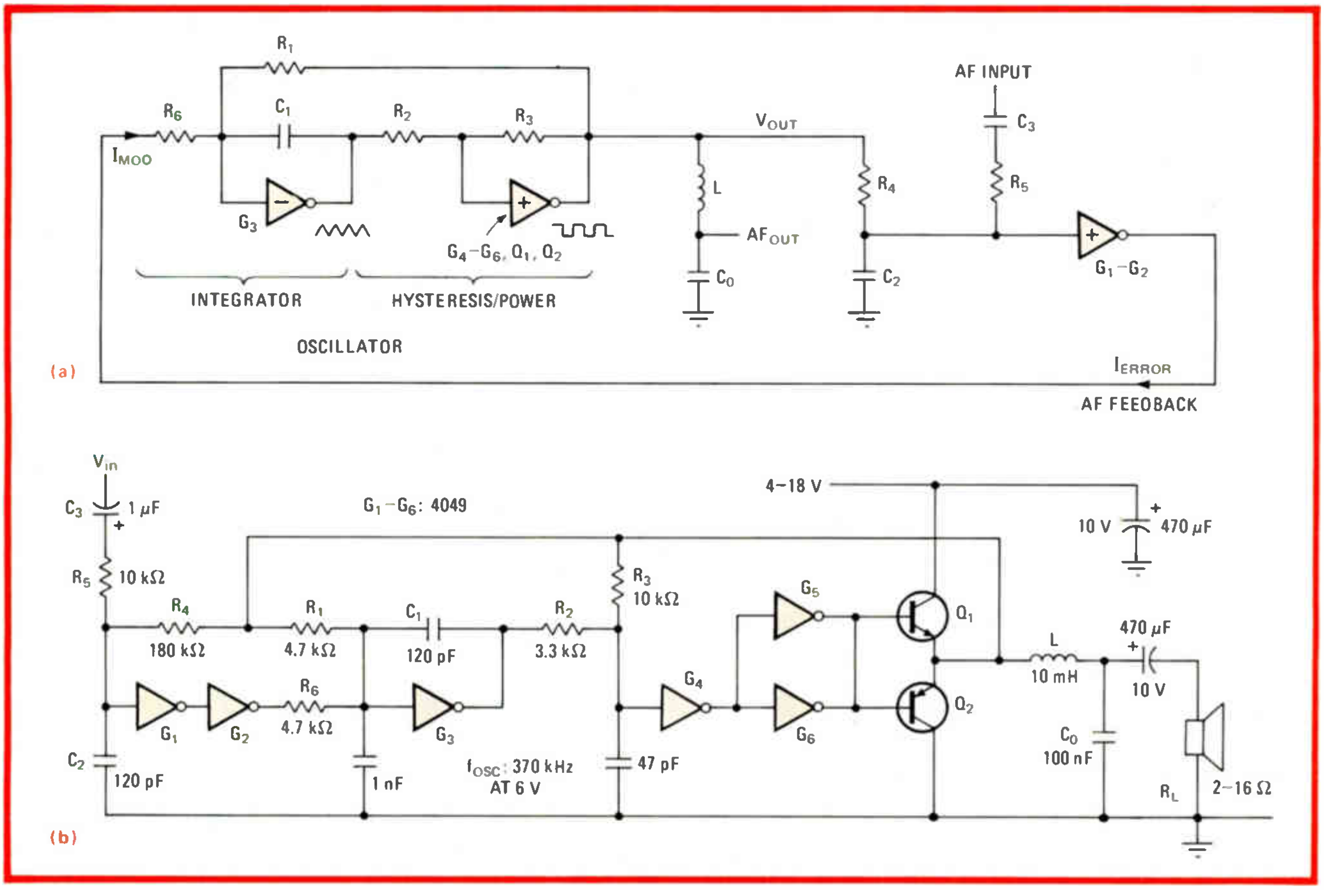
As shown in the general function diagram (a), a feedback current, I_{mod}, is derived from the audio input signal for the purpose of varying the pulse width of a free-running oscillator, which itself is formed by a digital integrated-circuit integrator and a hysteresis/power stage. C_2 and R_4 develop a dc feedback signal from comparison of V_{out} with the audio input, from which an error current is created. The ratio of R_4/R_5 sets the amplification factor. C_2 and C_3 act to integrate V_{out}, so that any long-term imbalance appears as an error and can be corrected.

The active digital elements thus switch in the linear mode, ensuring that the output pulse width is proportional to the amplitude of the input signal. The output, as taken at the junction of L and C_o, represents the instantaneous change in the oscillator's pulse width. With such an arrangement, the amplifier's efficiency is better than 90% at any signal level, as would be expected with any linear switched circuit.

The practical implementation is shown in (b). One 4049 inverter is used for all switching functions. C_2 and R_4 set the total bandwidth at about 20 kilohertz, with C_3 determining the lower cutoff frequency of 100 hertz. The circuit has an amplification factor of 15. It will drive a load as low as 2 ohms at a noise level that appears low enough for headphone-monitoring applications. With a supply voltage of 6 volts, the current consumption will be a mere 5.6 milliamperes.

As mentioned, the circuit's noise performance is very good. This is partly due to the fact that, as the modulation current increases toward the maximum charging current required to attain the maximum pulse width in the oscillator, a form of frequency modulation occurs, giving rise to an S-shaped transfer curve that is characteristic of an fm discriminator. This characteristic results in a lower noise and distortion factor than can be achieved using a purely linear approach.

As with all high-frequency circuits, a good earth ground and no ground loops are essential to proper operation. Otherwise, all sorts of oscillations appear and add to the noise level. □



Linear logic. This digitally switched network (a) amplifies audio signals linearly by modulating the pulse width of an RC oscillator. The practical circuit (b) is uncomplicated. Excellent noise-rejection performance is achieved by the modulator's S-shaped transfer curve.

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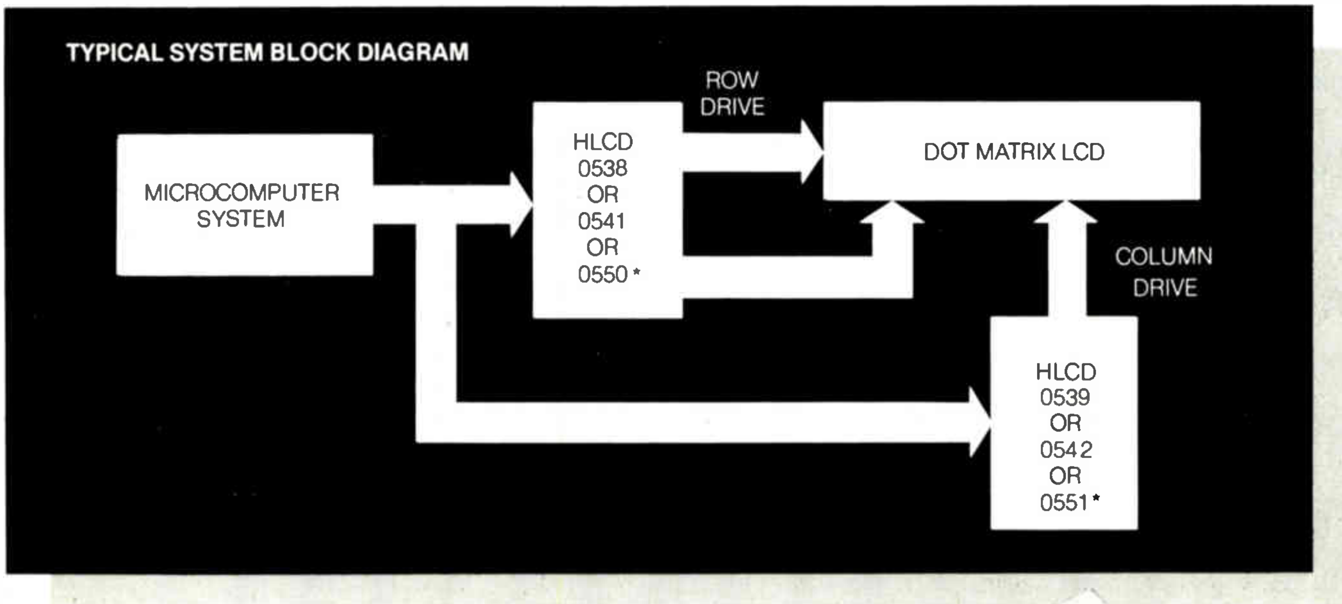

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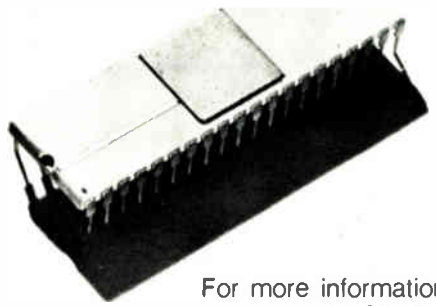

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Stepper resolves motor's angular position to 0.1°

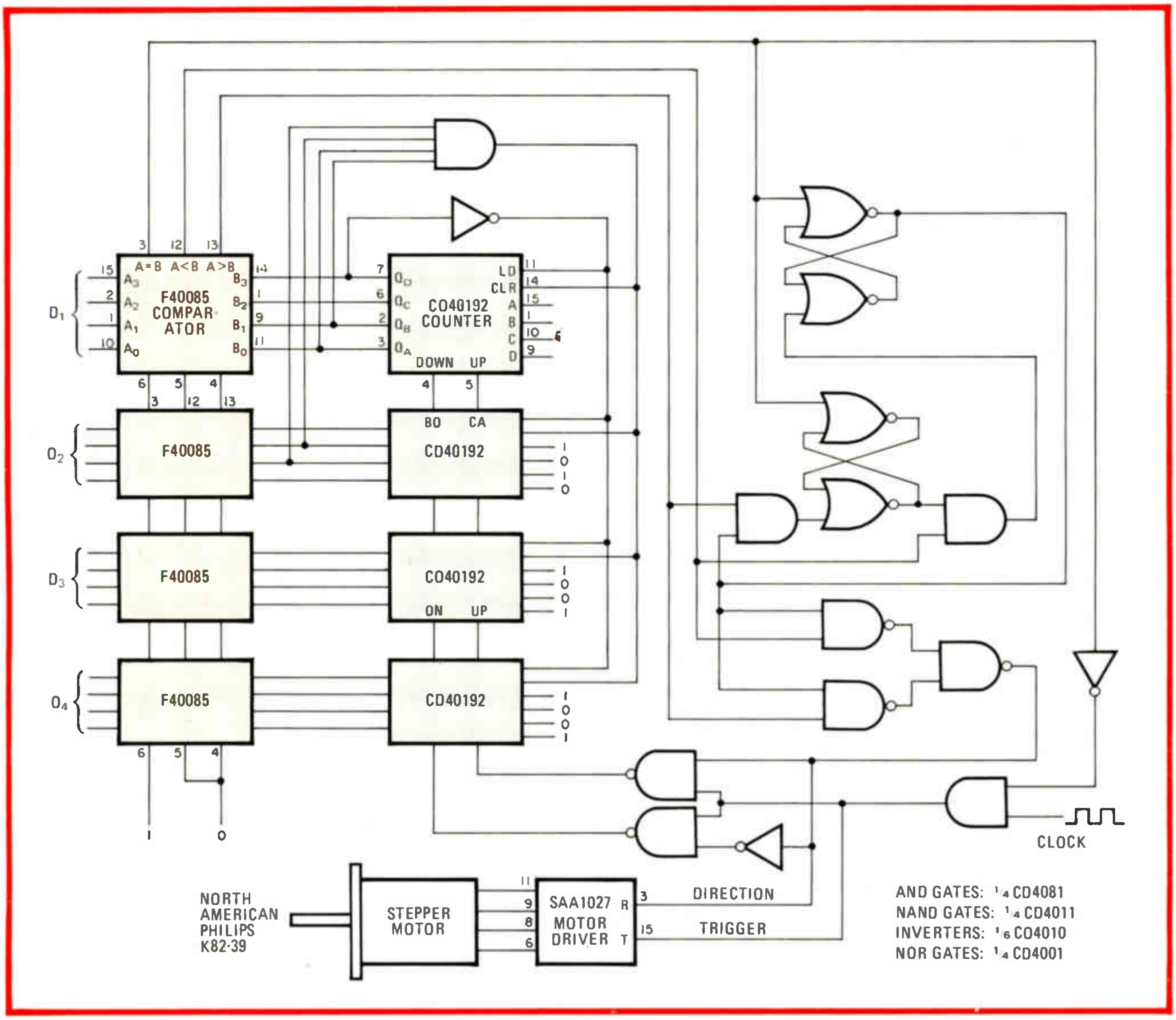
by Jaykumar Sethuram
Electronic Associates Inc., West Long Branch, N. J.

One-chip digital comparators and counters simplify the design of this controller, which resolves the position of a stepping motor to 0.1°. Using complementary-MOS circuitry, the unit is low in cost and power consumption is minimal.

The set of four binary-coded decimal numbers, D_1 to D_4, introduced to the cascaded 40085 4-bit comparators, are the command signals that order the motor to the desired bearing expressed in hundreds, tens, units, or tenths of a degree, respectively. The range of the input set is thus 0000 to 3600. With the aid of the comparators and sequential logic, the 40192 up/down counters track the position of the stepper at every instant, updating its count and thus rotating the motor until its contents match the setting of D_1–D_4.

As can be seen, the sequential logic circuitry determines the direction of rotation of the stepper and counter by monitoring the A = B, A > B, and A < B outputs of the output comparator. The logic is designed to rotate the stepper from its current position to the desired position in the minimum number of steps. Thus, if the motor's present position is at 5° and the intended position is 300°, the stepper will automatically be rotated in a counterclockwise direction.

The circuit can be easily modified for applications where the input data is available for only a very short time. In such cases, it is only necessary to add input latches to capture the data. □



Move a bit. Stepping motor is rotated into desired position with comparators and sequential logic that minimizes the difference between the 4-bit command set D_1–D_4, and the output of the up/down position-tracking counter. Angular position is resolved to 0.1°.

CAREERS

Engineers of the '80s look to the future with optimism

by Pamela Hamilton, *New York bureau manager*

☐ The engineers of the 1980s are looking at their careers with strong optimism mixed with practicality. After a five-year period of unprecedented prosperity in the industry, their attitudes are upbeat, forward-looking, and growth-oriented. However, with a seemingly unlimited demand for their talents, they are not losing sight of what has happened in previous boom and bust cycles. No longer content to be simply engineering practitioners, they are using this favorable period to strive for increased recognition as professionals.

These are some of the conclusions about recent trends drawn from a questionnaire sent to a random sampling of 2,000 *Electronics* subscribers. The survey and its computer-tabulated results were prepared for the magazine by McGraw-Hill's research department. There were 969 responses, representing a 48% rate of return.

A 1977 survey also reflected a rosy glow on engineering careers [*Electronics*, July 7, 1977, p. 87], as the industry was making a rebound from the 1973–74 recession. Also prepared by McGraw-Hill's research department, the earlier questionnaire had 1,304 responses from a total of 3,000 randomly selected *Electronics* subscribers, representing a 43% response. A comparison of the surveys shows little change in career attitude among engineers, with most of them continuing to express satisfaction and claim professional growth. In other areas, however, changes have been dramatic.

For example, the 1980 survey shows an almost 35% jump in the average salary of an engineer. Also, more engineers have had to learn about microprocessor applications and software for job assignments, and more of them use personal computers on desk or bench. Current topics—patent rights and profits, the role of technicians versus full-fledged engineers in a shortage situation, and why engineers live where they do—all reflect options that most engineers did not have 5 to 10 years ago in a low-demand market.

In the eyes of many, age discrimination is playing a diminishing role in the engineering realm these days. Also, many engineers who wish to continue their careers up the engineering ladder without switching to management now believe it is possible to do so.

When questioned about job satisfaction, engineers in this survey answered resoundingly in the affirmative. Just over 40.8% gave a "very satisfied" vote with their career, while 47% were moderately satisfied and 10% expressed dissatisfaction. (These percentages and others do not add up to 100% because not all respondents replied to all the questions.) In 1977, 32.6% were very satisfied with their jobs; 51.5% were moderately satisfied; and 15% claimed dissatisfaction (Fig. 1).

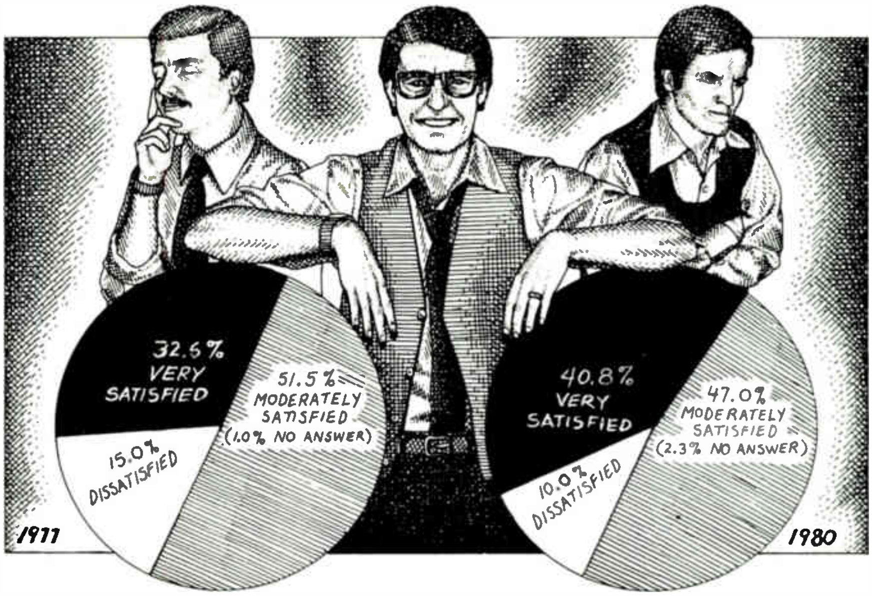
This time, of those who are very satisfied, the greatest number—17.2%—earn between $20,000 and $24,999. Of those who are moderately satisfied, 23.5% earn $25,000 to $29,999. The greatest number of dissatisfied engineers—22.7%—earn $20,000 to $24,999.

Job satisfaction differs

Different age groups responded differently to the two surveys on job satisfaction. In the most recent survey, younger engineers were more likely to be dissatisfied with their jobs than older engineers; in 1977, the reverse was true. The greatest percentage of those who are dissatisfied, 45.4%, are in their 30s this year. In 1977, the highly disgruntled engineers were in their 40s, representing 26.2% of the very dissatisfied group. Of those moderately satisfied, 21% were in this group, and also 19.5% of the very satisfied. In the 1980 survey, only 17.5% of those dissatisfied were in their 40s.

Job satisfaction was expressed by the engineers in the two different surveys in such areas as: completion of a successful working design (9.8% reported this in 1980 and 9.7% in 1977); finding solutions to problems, especially technical ones (9.2% in 1980 and 11.5% in 1977); general creativity and development on the job (9.6% in 1980, 8.5% in 1977); and a sense of accomplishment or

Results from a survey of *Electronics* readers indicate that EEs paint their career opportunities with enthusiasm and voice strong opinions on issues affecting their profession



1. Satisfaction up. More of this year's respondents are very satisfied or moderately satisfied with their jobs compared with those who were surveyed in 1977. Total dissatisfaction is down by 5%, reflecting the upbeat response of most engineers polled.

personal achievement (10.6% in 1980, 10.1% in 1977). Challenging work was important to 6.7% of the 1980 respondents, and working to motivate others was almost equally important, cited by 6.2% of this year's engineers.

Frustrations facing engineers in both surveys seem to center on management. Incompetent upper management, company politics, and bureaucracy headed up this year's list, with 18.1% of those polled mentioning one of these as areas of major conflict. In 1977, 15.2% of those surveyed reflected a similar feeling.

This year's survey included complaints of unfair treatment by management or administration (2.4% versus 6.9% in 1977); dealing with disorganized management (5.1% this year as opposed to 8.9% in 1977); and lack of rewards or recognition of the individual engineer by management (7.1% to 10.5% in 1977). Paper work unrelated to the job was cited by 7.8% this year, whereas only 6.0% mentioned it last time. But engineers do not appear to be as worried about lack of future growth or long-term job security: this year only 2.6% cited it as a concern, compared with 5.9% in 1977.

New frustrations growing

Other dissatisfactions are beginning to surface, however. Issues such as shortages in engineering talent, long lead times for some devices, cost of living, and compression of salaries are starting to bother many engineers.

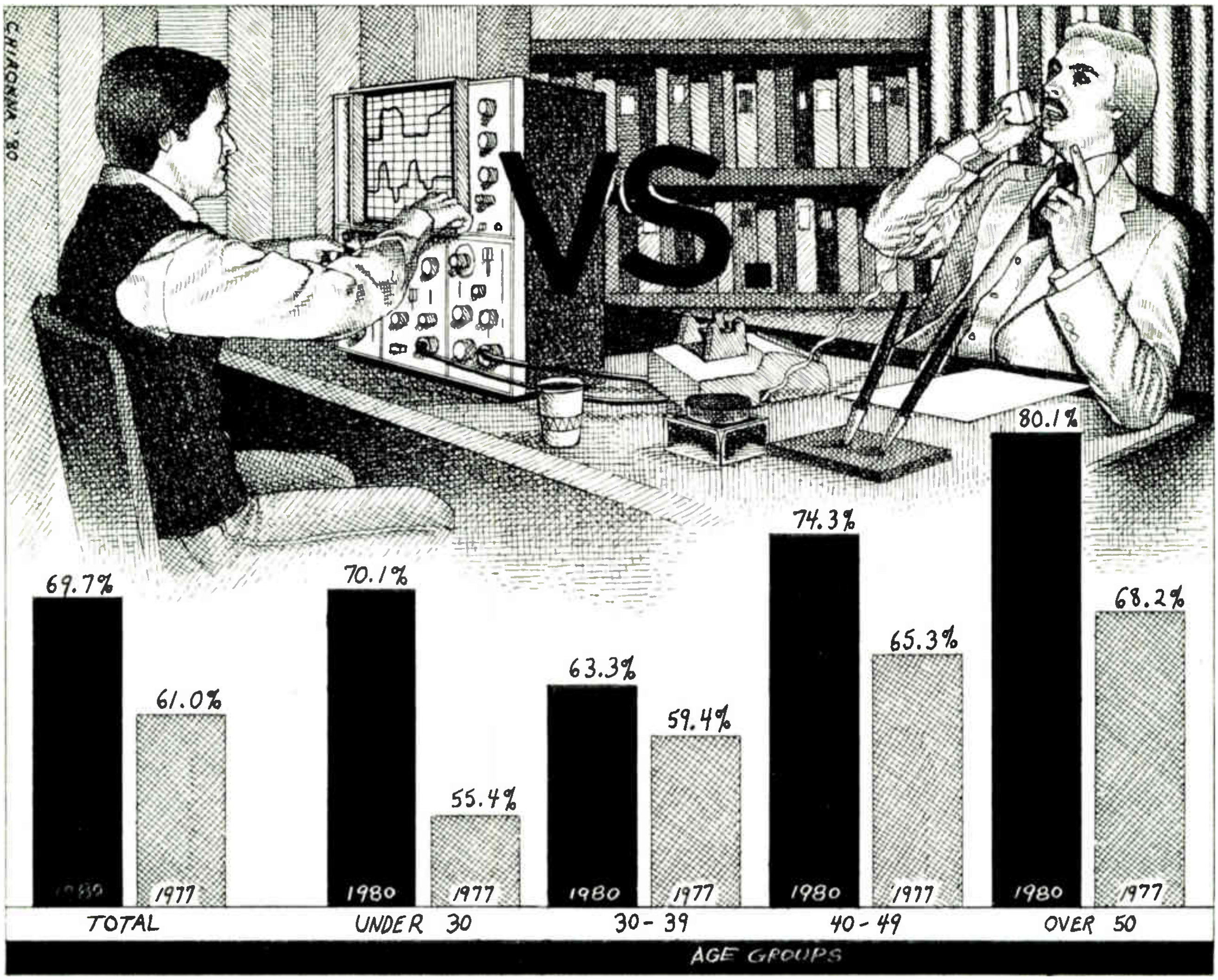
"I could increase throughput with expanded operation, but I can't because of the understaffing problem. The parts shortage causes headaches in planning, too," notes the president of a company doing microprocessor application and prototype work in State College, Pa. A product line manager working with a MOS memory company in Salt Lake City, Utah, feels the shortage, too. "Recruiting engineers with the shortage of qualified people is my biggest problem," he says.

"I don't like the way industries bunch together, as in Sunnyvale. This drives up the cost of living, housing in particular," says a senior design engineer employed by a telephone-answering device company in Torrance, Calif. And for a research project leader working for a test and measurement instrumentation company, a lone frustration is salary compression. An applications engineer employed by a numerical controls company in Cleveland puts his finger on another concern for many engineers whose skills are not being used primarily for engineering work: "There's a large amount of clerical work and not enough use of computers."

Lifetime careers seem possible

But at the same time engineers are confident about being able to remain in engineering throughout their careers, without having to switch to management positions. This growing optimism may, in large part, be directly attributable to the increased demand for engineers. A total of 69.7% of this year's respondents believe they will be able to make engineering a lifelong career, 20.1% believe they will not, and 10.2% did not respond or were unsure. This compares with 61% saying yes, 27.8% saying no, and 11.2% either not knowing or not answering in the earlier survey.

The fact that many engineers are now incorporating human engineering factors into their designs, as well as applying electronic technology over a wide variety of fields, may be contributing to the optimism. In fact, for those engineers under 30, 70.1% believe it is possible to remain in engineering, compared with 55.4% in 1977. In the 30-to-39 category 63.3% say yes, compared with 59.4% last time. Of those 40 to 49, 74.3% believe it is possible, whereas in 1977 only 65.3% shared this belief. For those engineers over 50, fully 80.1% think a lifelong



2. Dual-ladder growth. The percentage of engineers in 1980 who believe that it is possible to make engineering a lifelong career without switching to management positions is up over 1977 results. All age groups reflect this general optimism, especially those over 50.

engineering career is possible, as opposed to 68.2% who expressed this belief in the 1977 survey.

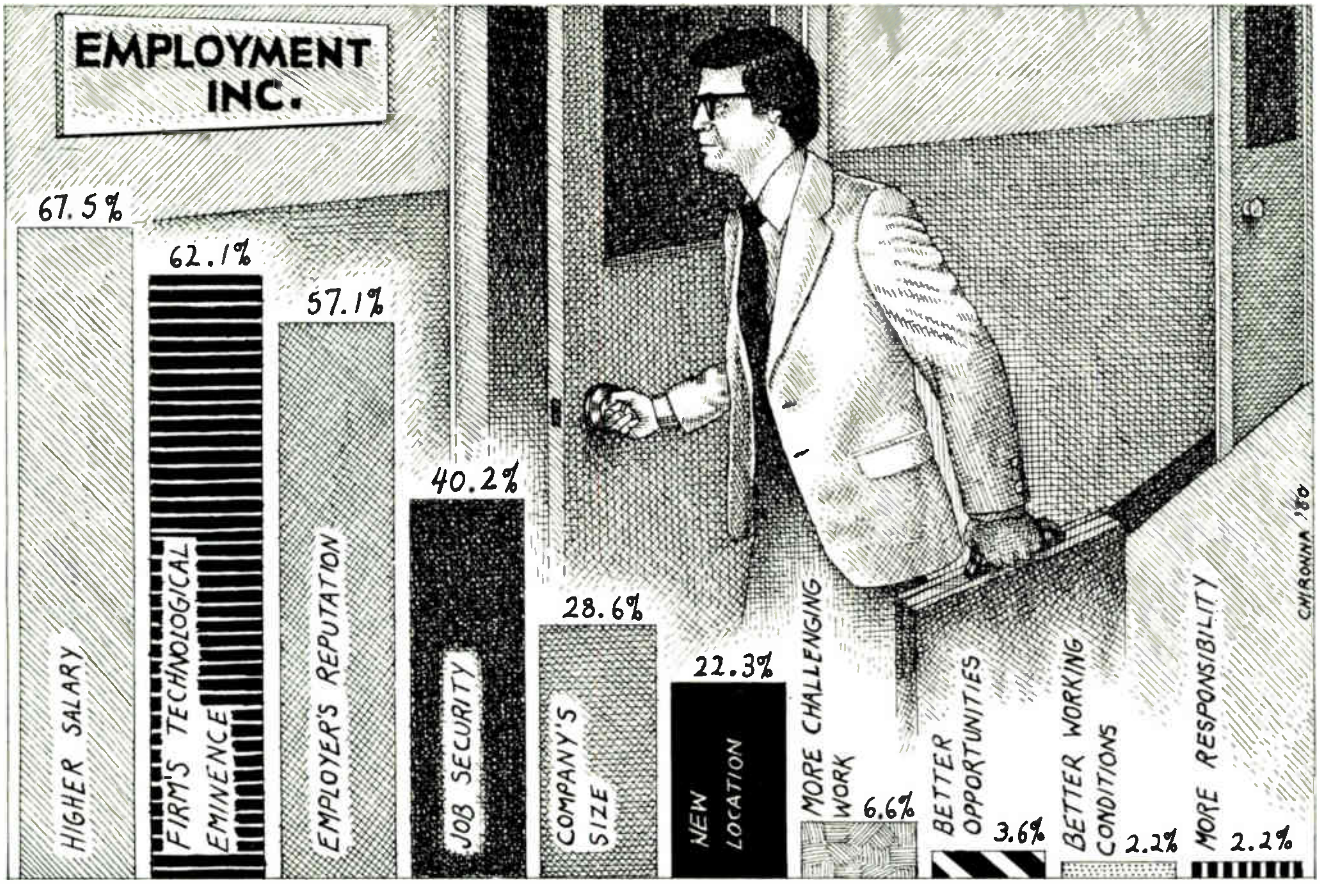
The positive response may also be the result of companies offering workable dual-ladder promotion and salary increases to engineers who prefer to remain in technical assignments as well as to those who wish to transfer into management positions. Although this year's results did not reflect a great change from 1977 on this issue, 40% of the respondents claimed their company did have such a dual-ladder promotion scheme; in 1977, 37.5% said their company did. An almost equal number—40.5%—said their employer did not have such a scheme, but that percentage is down from 45.3% in 1977. This year 19.5% either did not know or did not answer; in 1977 that number was 17.2% (Fig. 2).

Also reflecting the good times electrical engineers are experiencing are the many rapid advancements most have had in the last five years. For instance, in this year's survey, more engineers have been promoted in the last year and in the last two years than were reported in 1977. In the last year, 34.1% reported being promoted as opposed to 28.5% in 1977, and 22.8% report a promotion in the last two years, compared with 19.5% in the last survey. The promotions in the last five years have dropped somewhat since 1977: 16.5% say they have had a promotion, whereas 24.6% reported such a promotion in 1977. This year 26.6% did not know or did not answer, down slightly from 1977 when 27.4% did not respond.

The respondents to this year's survey grouped themselves into three major categories: 12.4% consider themselves company managers, 23.5% engineering managers, and over half—56.2%—engineers. Some other areas mentioned were sales and marketing, software support and development, and research and development.

Future ambitions

Despite the belief that engineering can be made a lifelong career and the fact that more companies seem to be offering workable dual-ladder career options between engineering and management positions, fewer of the total number of respondents appear to want to stay in engineering. Only 34.7% want this, compared with 38.9% in 1977. A third—33.4%—of those who answered this year's questionnaire wish to continue into engineering management; this compares with 31% last time. And 20.1% want to start a new company, whereas only 18.9%



3. New job pluses. Obviously salaries head up the list of what an engineer looks for in a new job, but close behind is the reputation of a company, both technically and as an employer. Job security, in this time of plenty, is not as important a factor.

wished to begin their own venture in 1977.

Interestingly enough, if the responses are taken from those who currently consider engineering their major responsibility, more than half—51.9%—wish to advance in engineering. For those in engineering management. 64.9% would like to continue on that path, and 33.3% of those in company management would like to start new companies.

New job opportunities

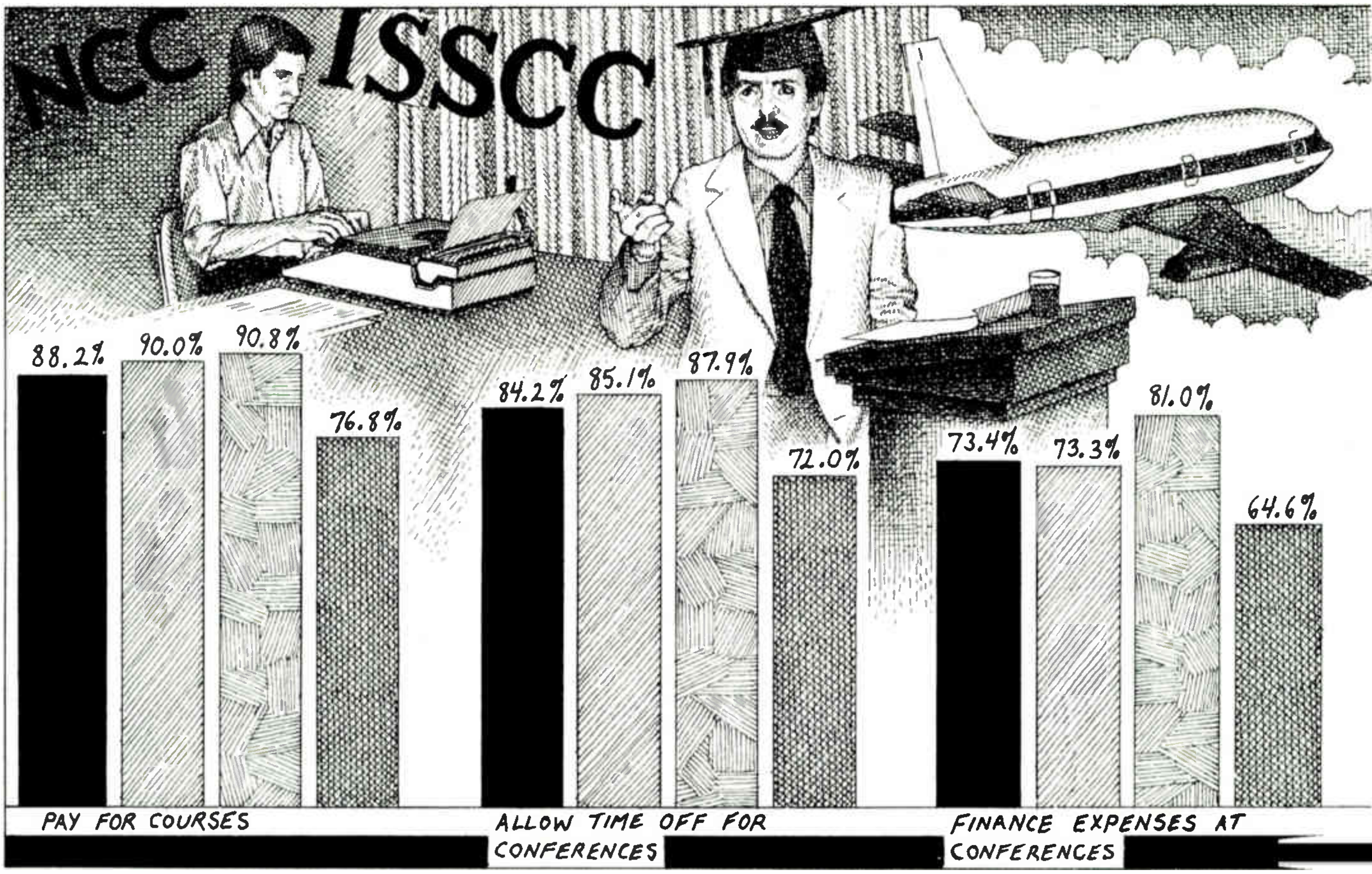
Higher salaries, the technological eminence of a company, the company's reputation as an employer, job security, the size of the company, and the desire for a different location head up the list of what engineers would look for in a new job or company in 1980. Not surprisingly, over two thirds—67.5%—cite higher salaries as a prime prerequisite in a new job. The technological eminence of a company is important to 62.1% and the company's reputation as an employer would be a major factor for 57.1%. Job security is listed by 40.2%, and over a quarter—28.6%—think the size of a company worth considering. Only 22.3% state that a different location would be of importance in a job change. Most important to those who stated that their major responsibility was engineering is a high salary (73.4%), followed by the technological reputation of the company (66.2%), the reputation of the company as an employer (58.2%), and job security (47.7%) (Fig. 3).

In this time of plenty, far fewer respondents believe companies practice age discrimination. In 1977, 55.4% believed that companies did have such practices, with 16.6% saying no and 28% unsure or not answering. In 1980 the figures seem to reflect a down playing of this issue, with 44.3% saying yes, 19.7% saying no, and 36% not knowing or not responding to the question.

For those under 30, 38% say yes, 20.1% say no, and 41.9% have no answer. In 1977, for the same age group, 49% said yes, 17.3% said no, and 33.6% did not know or did not answer. For those aged 30 to 39 in the 1980 survey, 43.3% believe there is age discrimination, 18.5% do not, and 36.3% do not know. In 1977 that age group responded with 56.6% saying yes, 15.8% saying no, and 27.5% not knowing or responding. The 40-to-49-year-olds are most vehement in 1980 about age discrimination: 51.9% believe it exists, 21.4% do not, and 26.7% are unsure or did not answer. In 1977, however, 58.8% of this age group said yes, 15.9% said no, and 25.3% did not know or answer. In the over-50 category, 47.3% think there is discrimination at present, 20.5% do not, and 32.2% have no opinion. For the 1977 survey, 58.1% said yes, 18.4% no, and 23.5% did not know or did not answer the question.

Corporate support

More than ever, engineers believe that companies have an obligation to plan and support the professional growth of electrical engineers. Over three quarters, or 78.4%, of those surveyed this time agreed, compared with 70.3% in



1977. The "no" vote was 15.3% this time and 18.9% last time. Those who did not know or did not answer were 6.3% this time and 10.8% in 1977.

But the group who resoundingly approves of this support are those under 30—89.7% felt companies should give this support, compared with only 70.2% in 1977. Those who consider themselves company management did not give as wholehearted a "yes"—only 68.3% said support should be forthcoming, with 22.5% giving it a nay vote.

Of those who were for support, 88.2% believe it should be in the form of paying for accredited continuing education courses in engineering. Nearly that same percentage—84.2%—believe that companies should allow time off for professional seminars, shows, and conferences, and 73.4% believe that the company should finance the engineer's expenses at these seminars. Financial assistance for engineers in graduate work is considered by 70.7% a company obligation, whereas 47.9% believe the company should develop accredited continuing education courses in engineering. And finally, 44.2% believe companies should give a bonus to electrical engineers working on technical papers for journals and seminars.

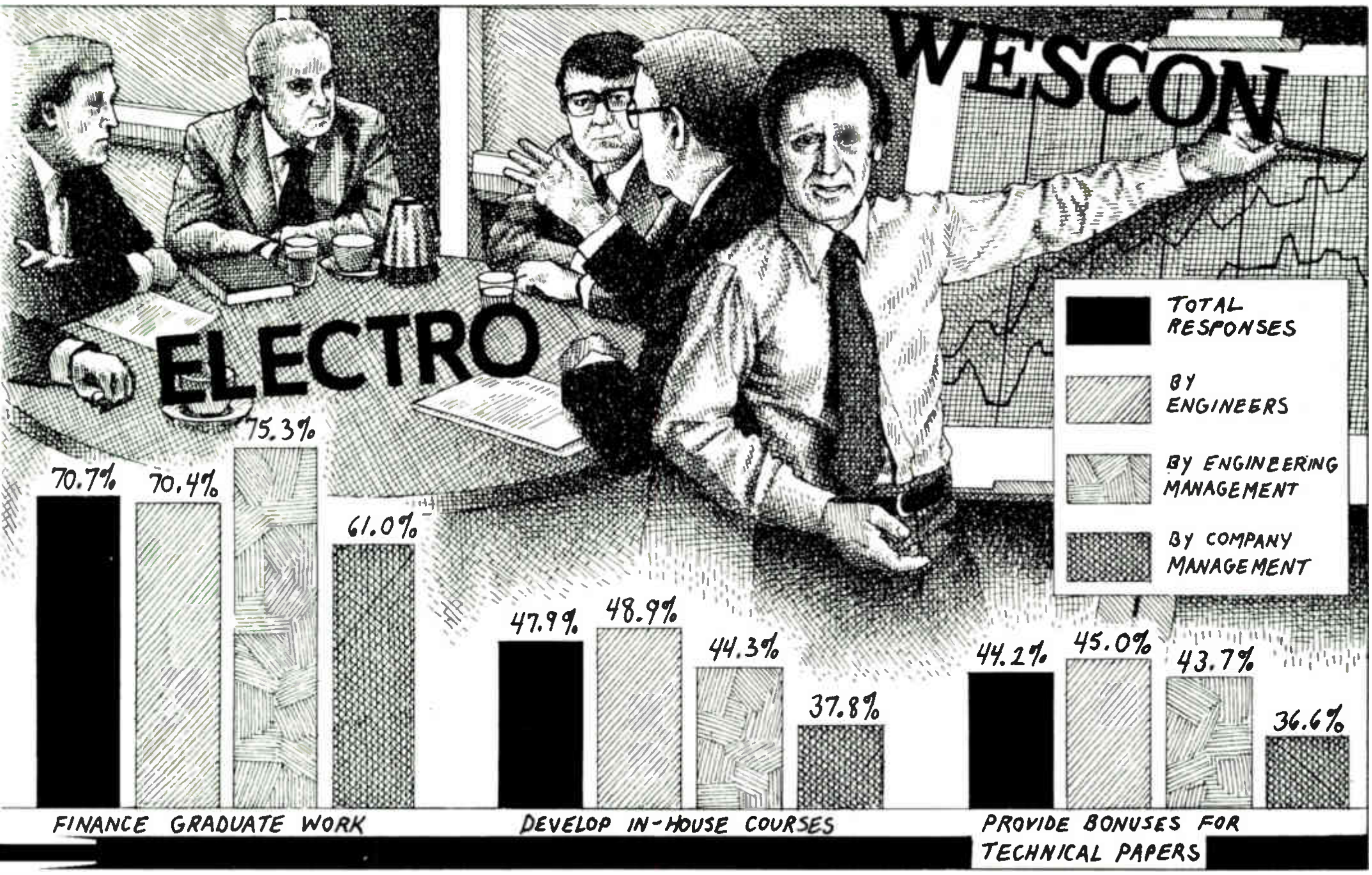
Among those in company management who believe in supporting engineers, these percentages were somewhat lower: 76.8% agreed on paying for courses; 72% thought time off was necessary; 64.6% agreed to finance time off; 61% said financial assistance for graduate work was needed; 37.8% thought developing courses necessary; and 36.6% were willing to provide bonuses (Fig. 4).

A few of the respondents have some innovative ideas for support programs for engineers. One recent graduate who works in Watervliet, N. Y., notes that electrical engineering teachers should have higher salaries so that "they are not tempted to leave their teaching careers." A senior development engineer in Cleveland advises companies to "provide a paid leave of absence for 1 year every 10 years for a thorough graduate update." A third respondent, who is also from Cleveland, works for a numerical controls manufacturer as an applications engineer and believes that "companies should support student co-op programs."

Salaries and fringes

Perhaps salary more than any other area demonstrates an engineer's worth to society, and the salaries represented in the 1980 survey are up, on the average, some 35% over those in 1977. With inflation taken into account, it is probably not much of a hike, but nevertheless the rapid increase is causing such problems as salary compression, bitterness between younger and older engineers, and uneasiness between those with bachelor of science degrees in electronic technology and those with BS degrees in electrical engineering.

In this year's survey the average annual salary is $31,772, up from $23,464 three years ago. Those who are very satisfied with their careers at present have an average annual salary of $33,930, compared with $25,532 in 1977. Engineers who are moderately satisfied have an average salary of $30,497 now; it was $22,814 in the last survey. For those who are dissatisfied, the average salary is $28,984, compared with $21,392 in 1977.



4. Corporate support. Although all respondents believe that companies have a responsibility to support engineers in keeping up with technology, engineering managers are in the vanguard. Company managers, on the other hand, lag 7% to 12% behind.

Those under 30 earn, on the average, \$24,281—up from \$18,139 in 1977. In the 30-to-39 age group, the average salary is closest to the total average salary—\$31,578, as it was in 1977 at \$23,050. The mean salary for those between 40 and 49 is \$38,162, compared with \$29,075 in 1977. These respective salary figures are slightly higher than for those in the 50-and-over group—\$36,408 in 1980 and \$28,544 in 1977 (Fig. 5).

Fringe benefits enjoyed by engineers do not seem to have changed much in the last three years. Of those surveyed this year, 68.4% have a pension plan, whereas 69.2% had one in 1977. This year, 92.5% have a medical or hospital plan, compared with 89.8% in 1977. For major medical, 84.4% report having it this year, and 82.8% had it in the last survey. Disability insurance is available to 74.7% of those surveyed, up from 71.5% earlier. Those with a dental plan are down a little from last time—12.5% this year compared with 14.5%.

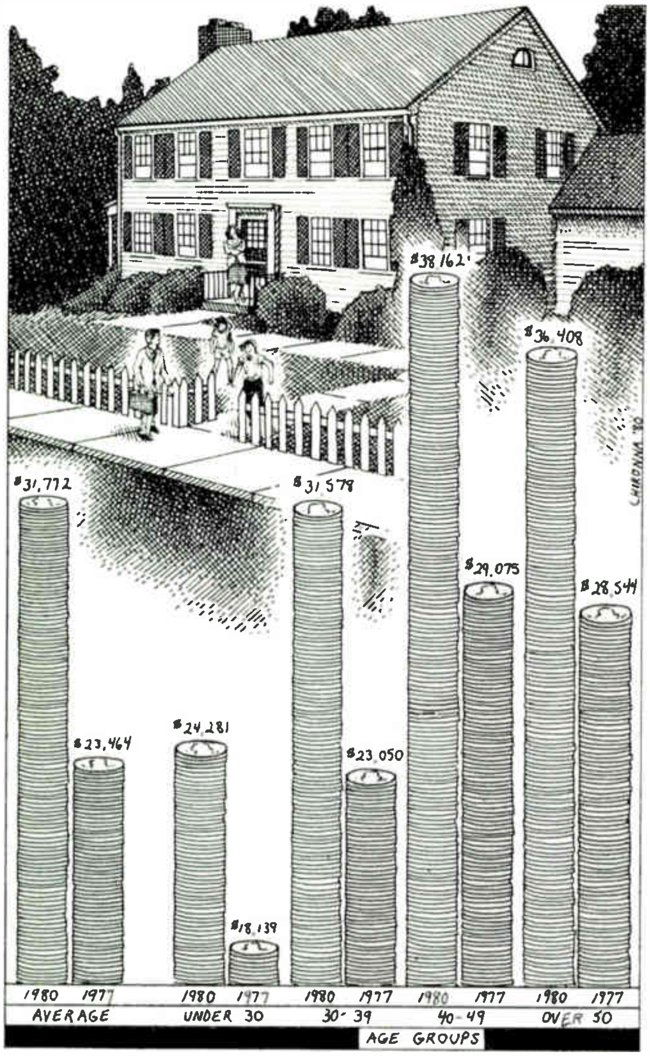
This year, 33.8% of the respondents report they have a profit-sharing plan, and over a third—35.4%—have a stock option plan. Other benefits cited in the current survey include eye care, life insurance, the use of a company car, and bonuses.

The number of engineers who feel that their school engineering training is relevant to their present work dropped dramatically. Nearly three fourths—74.3%—feel that their background is relevant, compared with 91.7% three years ago. Nearly one quarter of those surveyed in 1980—23%—find their education irrelevant, whereas only 6.7% found it so in 1977. For those who did not know or who had no answer the results of the questionnaires are similar: 2.7% in the latest survey and 1.6% in the previous survey.

A general dissatisfaction with engineering schools is reflected in how the respondents feel the schools are keeping up with teaching new technologies, such as microprocessor applications. Only 42.5% believe that the schools are doing well in these areas, compared with 49.7% three years ago. Over one quarter—27.3%—believe the schools are not keeping up, very close to the 27.4% who thought that way in 1977. In 1977, 22.9% did not know or did not answer, whereas in the present survey 30.2% had no opinion or answer. Only a slim majority—54.3%—of those most recently graduated (under age 30) believe the schools are keeping up. On the pessimistic side, less than one third (29.2%) of company managers believe the schools are producing graduates knowledgeable in the state of the art.

Advice for schools

One staff engineer in military avionics in Sylmar, Calif., sums up some of these feelings: "Engineering schools should teach basics, not turn out ready-to-use workers for industry." And a technical manager working for a telecommunications systems company in Shelton, Conn., thinks that even if engineering schools do keep up to date with the latest technologies, other problems may



5. Salaries skyrocket. Increased demand for engineering talent and inflation in general have pushed electrical engineers' salaries up over 35% since 1977. In the 1980 survey the average annual salary is $31,772, compared with $23,464 in 1977.

be accruing: "The real shortage is of engineers really well grounded in the basics of engineering—we are getting a generation of microprocessor programmers who think they are engineers."

Individual engineers are keeping up in ways similar to those of three years ago, in almost equal numbers. Almost 100% use technical magazines and journals—98.6% this year and 97.9% in 1977; 30.5% opted for company training courses both in 1980 and 1977; and 30.1% today think part-time college courses are the answer, compared with 31.4% in 1977. Other methods of keeping on top in 1980 include: seminars, conferences, and shows; home-study projects; reading current books; and attending meetings and joining clubs.

Perhaps in no other area more than in microprocessor applications and software have engineers had to keep abreast of new technologies. In 1977, a little more than half—58.4%—said they had had to learn about microprocessors. In 1980 that number has jumped to over three quarters—77.8%. Only 20.6% now feel they have not had to dabble in the art of microprocessor implementation, compared with 39.6% three years ago (Fig. 6).

Another area where engineers need to keep informed is in software programming, and fully two thirds—68.6%—of the 1980 respondents report they spend some time programming now. Of these, 13.8% spend a tenth, 13.4% a fifth, and 11.8% a third of their time at this activity. Less than half of these—47.4%—spent much time five years ago doing software programming, and of those who did, 7.6% spent a tenth, 7% spent a fifth, and 5.6% spent a third.

The era of the personal computer is fast approaching, and from the results of this year's survey, many engineers are well aware of it. Over a third—34.2%—now own a personal computer, and nearly half—49.8%—of those who do not are planning to buy one in the next two years (Fig. 7).

For those under 30 who do not now own a computer, 55.5% plan to purchase one in the next couple of years. Engineers and company managers are equally enthusiastic about personal computers—52.2% and 51.3% respectively—but engineering managers have not taken to the idea quite so fervently—only 43.1% plan a purchase in the next two years.

IEEE loses points

The Institute of Electrical and Electronics Engineers has slipped a little in popularity over the last three years—only 39.8% of those responding to the 1980 survey belong to the organization, compared with 41.7% in 1977. Of those who belong, only 19.7% are active in IEEE affairs, compared with 22.4% earlier. Of that number only 12.6% of the members under 30 are active, whereas nearly twice that percentage—22.6%—were active in 1977. Over one fifth in the 40-to-49 age group—22.5%—and over one quarter—26%—in the 50-and-older category are active now. In 1977, corresponding percentages were 25.6% and 30.4%.

When asked if they had voted in the last IEEE election, only 56.7% said they had, as opposed to 68.6% three years ago. On the other hand, the IEEE reported an overall 28% ballot return from all members 1980 election. In 1977, 58.9% of those under 30 voted, but in 1980 only 29.5% did so.

Reasons for belonging to the IEEE seem to be much stronger than before, however, with 91.5% of those responding saying they joined for access to technical information, compared with 86.6% in 1977. The professional activities of the IEEE attracted 37% of those who joined, compared with only 30% three years ago. Low-cost insurance is also cited as a reason by 14.8% in the latest survey, compared with 9.7% in 1977.

Despite an enthusiastic mandate from members to promote the professional development and status of EEs, the IEEE did not receive a good rating from this year's respondents for its programs. In 1977, 72.4% of those who belonged to the organization supported its efforts to provide programs concerning the professional status of electrical engineers. In 1980, only 38.9% of members responding find these programs worthwhile. Among those 50 and older, 47.9% express satisfaction; 46.2% of the company managers and 45.4% of the engineering managers are also happy with the programs.

Of those dissatisfied with the IEEE's effort, 18% cite no real accomplishments, no progress, or ineffectiveness on the part of the organization. Shallow, petty, unrealistic goals are the complaints of 8.6%. Nearly one tenth—9.4%—believe that the IEEE does not focus its attention on problems of the working engineer, and 8.6% believe its professional programs benefit only academics and managers.

"The program is hardly visible," observes a chief engineer for an industrial instrument company in New Jersey. A systems engineer living in Nevada is more acerbic, noting that "the IEEE is an impotent, irrelevant organization that represents academic and large employer interests—not individual working engineers." A manager working for a company producing passenger vehicle engine-control systems says, "The IEEE management presumes it knows what engineers want, and I don't think it does." And for a senior systems analyst working in microcomputer-based office system products on Florida's east coast, the major concern is the IEEE's lack of effectiveness in dealing with large companies. "The organization has no clout against corporations abusing EE talent, not even a poll from IEEE members rating individual companies on their behaviour toward their

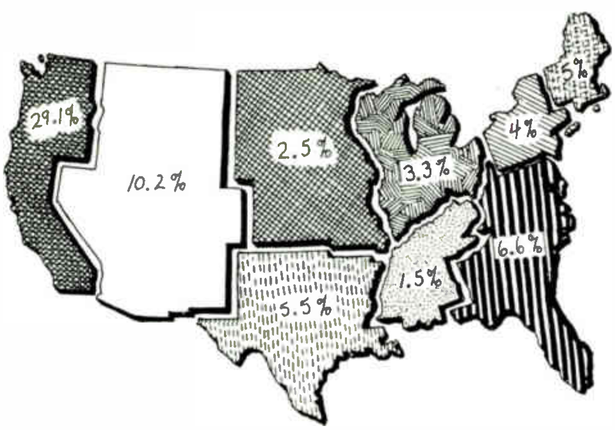
Where they live

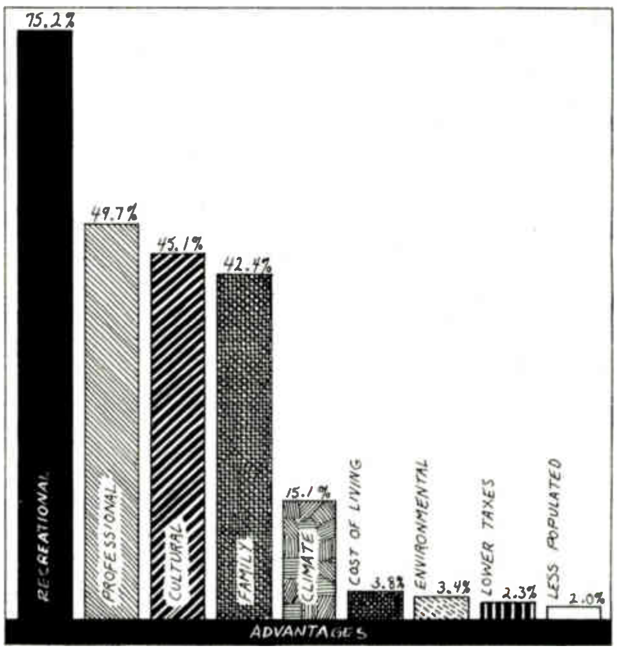
Electronics companies are still located predominantly on the West Coast, according to the 1980 survey, as they were in 1977. Nearly a third—29.2%—of those surveyed work in California, Alaska, Hawaii, Oregon, and Washington. That figure compares with 29.4% in 1977. Of those polled, 7.8% work in New England—Maine, Vermont, New Hampshire, Massachusetts, and Rhode Island—compared with 6.5% in 1977. For the Mid-Atlantic states of New York, New Jersey, Pennsylvania, and Connecticut, that count has dropped somewhat: 14.9% now work there, compared with 16.6% in 1977. The South Atlantic region—Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, and the District of Columbia—boasts 11.9% of the total work force, whereas it had 11.5% in 1977. In the East North Central area—Illinois, Indiana, Michigan, Ohio, and Wisconsin—12.2% are employed; in 1977, 13.1% worked there. The West North Central area, with Iowa, Kansas, Minnesota, Missouri, Nebraska, and North and South Dakota, has the fewest of the engineers surveyed—5.1% compared with 6.0% in 1977. The West South Central area has 7.9% of the survey respondents, up from 5.7% in 1977; it includes Arkansas, Louisiana, Oklahoma, and Texas. The Rocky Mountain area currently employs 7.4% of those surveyed, compared with 6.5% three years ago. This region covers Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming. Only 1.7% did not answer this question in 1980, compared with 3.7% in 1977.

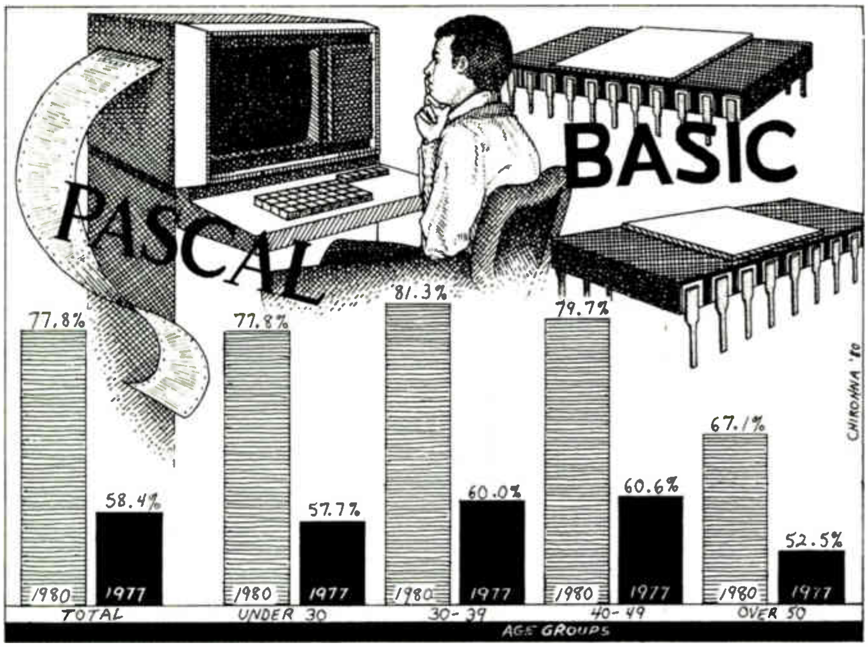
When asked to name their ideal location, only two thirds—67.7%—of those surveyed replied (see map). But 29.1% considered the Pacific region the ideal place; 10.2% thought the Rocky Mountain area best; 6.6%, the South Atlantic states; 5.5%, the West South Central block; 5.0%, New England; 4.0%, the Mid-Atlantic states; 3.3%, the East North Central section; 2.5%, the West North Central region; and 1.5%, the East South Central.

Recreational advantages are cited by 75.2% of the total respondents as the primary reason for considering a particular region ideal to live in (see bar chart). Nearly one half—49.7%—consider professional advantages important, while 42.4% say that family considerations, such as schools, influenced their choice. Climate and weather conditions are strong reasons for 15.1%, and cultural advantages are favored by 45.1%. Other factors named include the cost of living, taxes, environmental conditions, and the size of a town.

More than one half of those surveyed—52.7%—have lived in one area less than 15 years. Almost one fifth—18.8%—have lived in the area where they presently reside for 30 or more years; 10.7% for 25 to 29 years; 8.0% for 20 to 24 years; and 8.4% for 15 to 19 years. The total mean time of residency in one area is 16.41 years. For those under 30, that time drops to 12.42 years; for those 30 to 39 the number is 13.62; for those in the 40-to-49-year-old group, it jumps to 19.92; and for those 50 and over, the figure reaches to 26.23 years.







6. Learning curve. As microprocessor technology spreads, more engineers have had to learn about device applications and software. On the average, 20% more of this year's respondents have had to learn about the devices than those surveyed in 1977.

own engineers," he says, lamenting the situation.

One of the driving forces behind engineers' high salaries in 1980 appears to be the shortage of qualified engineers, although nearly a third of the people in the field are unsure whether a shortage truly exists. Asked if they think there is a long-term shortage of electrical engineers, 41.1% of the respondents said they do, 27.6% said they did not, and 31.3% either had no opinion or answer. Only 35% of those under 30 say there is a shortage and 29.1% deny it, with 35.9% not knowing or not answering. Company managers—who in looking for qualified people would be more sensitive to this issue—are very concerned that there is such a shortage, with a full half believing one exists and only 15% saying it does not; 35% did not know or did not answer.

The respondents did not think the Federal government was actively concerned about the problem—only 8.6% said there was Federal involvement, while 56% said there was not, with 35.4% abstaining. Of those 41.1% respondents who feel that there is a chronic shortage of electrical engineers, 11.3% believe that Government is actively concerned, while 63.6% believe it is not; 25.2% offered no opinion.

Although over half—54.6%—of the respondents offered no suggestions as to what might be done about a shortage, the rest had constructive comments. The greatest percentage—11.5%—of all the respondents suggested added involvement by high school students in engineering courses. Some suggested financial assistance for education in one form or another; higher salaries and more benefits and incentives were the answers for others; a few suggested increasing the professional status and prestige of the electrical engineers; less paperwork was another suggestion; and some of the group thought the law of supply and demand in the market will take care of the problem. Other suggestions included better salaries for teachers, more in-house training of technicians and support personnel, stabilization of the market, more job security, and more public awareness of the shortage. A few vocal engineers demanded no Government interference whatsoever.

Typical comments included: "Stop using engineers for menial jobs. The shortage is in good technicians, designers, etc.," according to a project engineer at a digital panel meter firm on the West Coast. A director for a data-communications company in the Southwest takes a more national view of the problem: "Get America back

Who they are

The typical engineer taking part in this survey is just about 35 years old and is male, white, and a U. S. citizen. He will most likely have graduated from college, receiving his bachelor's degree in electrical engineering, since 1970, and will find his engineering training relevant to the work he is now doing. Since receiving his degree he is most likely to have worked for two or more companies and has probably spent slightly over six years with his present employer. He may be the one out of every three engineers who has earned a graduate degree.

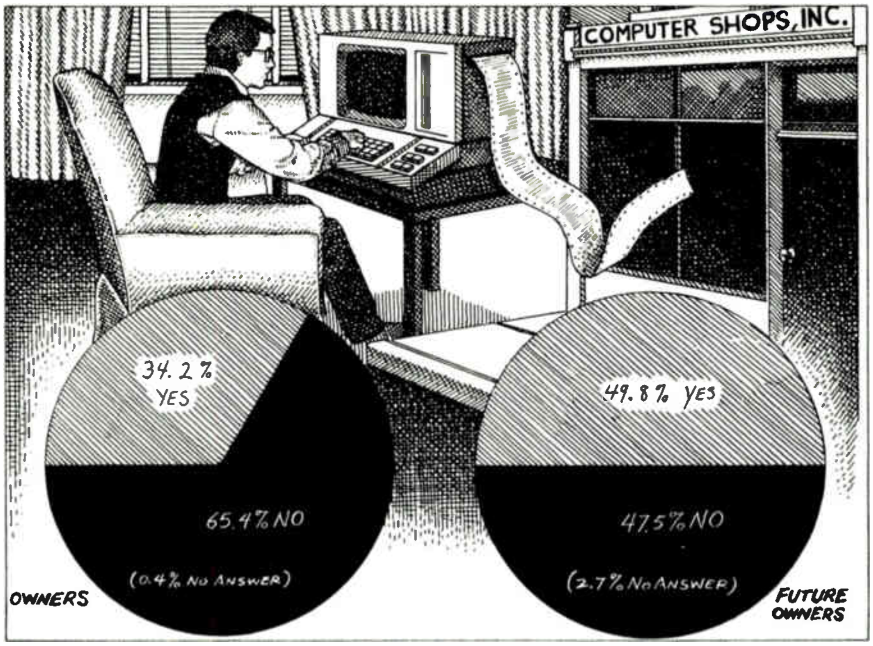
His mean salary is $28,005 and his salary has increased by at least 50% in the last five years. He is moderately satisfied with his job and would not consider relocating overseas. He does not belong to the Institute of Electrical and Electronics Engineers and uses technical magazines and journals to keep up with state-of-the-art technology. He either owns a personal computer or will own one within the next two years; he has had to learn about microprocessor applications and software for his work.

On the question of age discrimination, the engineer is more likely to believe that companies do practice it or else to be unsure. He is skeptical that a long-term shortage of engineers exists. He believes companies should share patent rights with designers and that profits should be divided—75% to the company, 25% to the engineer.

The typical engineering manager has an average annual salary of $37,059 and, like the engineer, is white, male, and a U. S. citizen. He received his undergraduate degree in electrical engineering between 1965 and 1975, and he, like the engineer, has worked for two or more companies since receiving that degree. He finds his engineering schooling relevant to the work he is now doing. He has a graduate degree and is almost 40 years old. He has spent almost nine years with his present employer and has received at least a 50% increase in pay in the last five years. He is very satisfied with his job and keeps up to on a technical course!" A chief engineer from Ogallah, Neb., remembers previous shortages and is of the opinion that this one "should be allowed to continue. An abundance will lead to the problems of 1974."

A senior programmer analyst working in Minneapolis believes that a little more planning between universities and businesses might go a long way toward alleviating any shortages. "Cooperation and planning between industry and universities could help solve this shortage," he says. "Equal salary opportunities between universities and industry might help, too."

An electronics engineer with a computer peripherals supplier in New England has a list of directives: "First, abolish mandatory retirement. Second, introduce computer programming and kit building in grade school. Some students are bound to develop an interest in design, which should be cultivated from the start. The sooner that interest develops, the greater the incentive to work at those studies which are necessary but don't 'come natural' to an individual."



7. Personal computer craze. The predilection of the general public for small computers may not be growing quickly, but a third of the EEs surveyed now own one, and of those who do not, one half plan to buy a unit within the next two years.

Where should engineering begin?

Of all those surveyed, only 23.2% agree with the engineer from New England and feel grammar school is the place where a basic engineering education should be introduced. Nearly half—47.6%—disagreed and 29.2% had no answer. Those in company management were more supportive—32.5% agreed with the idea—whereas only 17.5% of those under 30 backed it.

The response was far higher to introduction at the high school level: more than three fourths—77.9%—supported the idea, with 11.6% against and 10.5% not responding. Company management was again out front, with 80% saying training should begin in high schools.

But 80.1% of the total respondents still opt for basic engineering courses remaining at the college level. A mere 2.4% disagreed, and 17.5% did not know or did not respond. Company management did not respond so strongly in the affirmative—69.2% said yes.

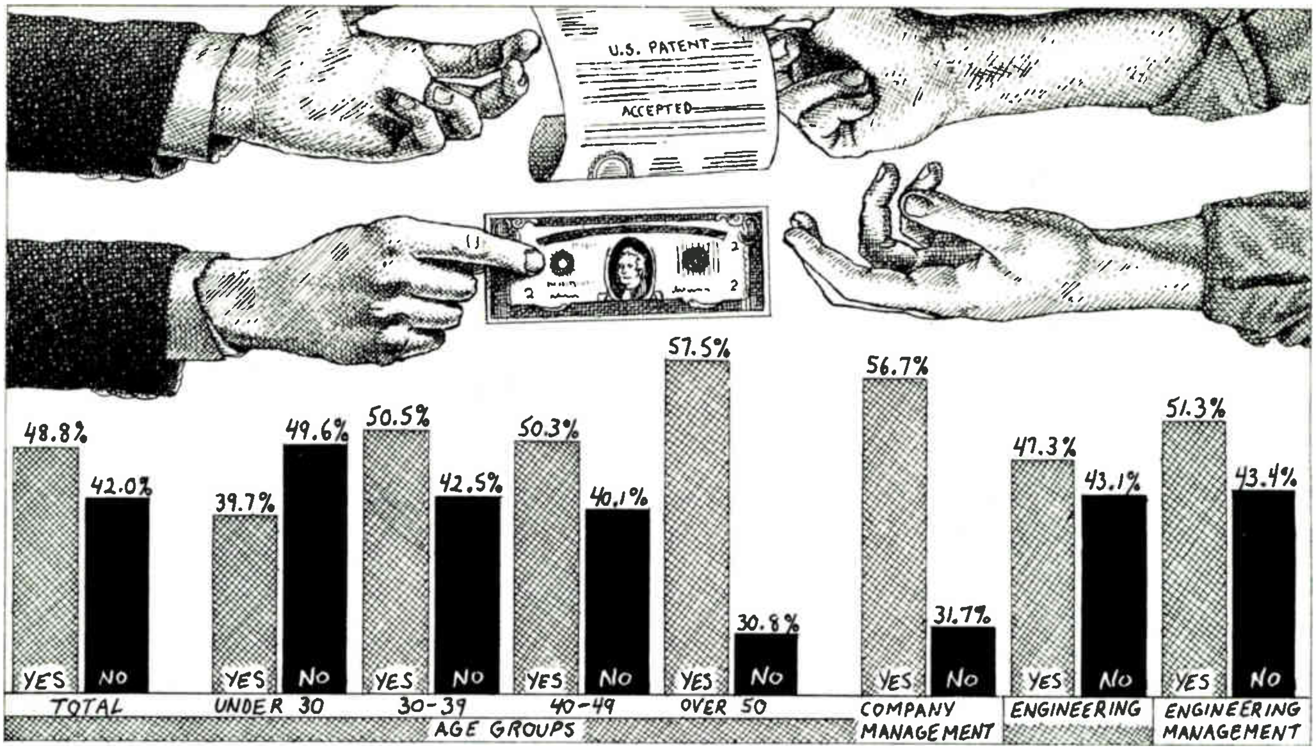
Another emerging issue is the human engineering side of design and the ecological, safety, and health factors of particular products. At least 78.3% of the respondents to the 1980 survey felt that such social factors will be of importance in the future, while only 11.7% did not. An even 10% either did not know or did not answer.

Patent rights and to whom they should belong is a divisive issue for many companies. The respondents to

date with technology through technical magazines and journals. He is a little more likely than his corporate counterparts and the engineers who work for him to join the IEEE, though there is more than a 50% certainty that he will not. He will not relocate overseas.

He is less likely to buy a personal computer than the engineer, although he has probably learned about microprocessor developments for his work. He believes there is in fact a chronic shortage of engineers and doubts that the Government is tackling the problem. He believes that companies practice age discrimination. He thinks companies should share patent rights and believes wholeheartedly that they should share the profits derived from those patents, with 25% going to the engineer.

Finally, the typical company manager is likely to have an electrical engineering degree, is more likely than an engineer to have a graduate degree, and also finds his training relevant to current work. White, male, a U. S. citizen, and nearly 43 years old, he has worked for more than three companies since he received his undergraduate degree. He probably received that degree between 1955 and 1970, and his annual salary is $40,905. He has been with his present employer a little over nine years and has received a 50% or more increase in salary in the last five years. He does not belong to the IEEE, using technical magazines to keep abreast of technology instead. Within the next two years he will buy a personal computer, and he, too, has probably had to learn about microprocessor applications and software. He is very satisfied with his engineering career and would not consider relocating overseas. He does not feel that companies practice age discrimination. He emphatically believes that there is a shortage of engineers and sees the Government as unconcerned. He thinks that companies and engineers should share in rights and profits—with, again, 25% of the latter going to the engineer.



8. Sharing patent rights. Although most of the respondents appear equally divided on whether companies and engineers should share in patent rights, more engineers over 50 believe in sharing, as do more than half of the company managers.

this year's survey seemed equally divided on whether engineers and companies should share in rights, whether companies should have total claim to the patent, or whether it is the individual engineer's prerogative. Those surveyed had a mixed response to the question: "Regarding patent rights, suppose an engineer works on a product or system, independent of his primary job responsibility. If this product is patented, do you believe the engineer and the company should share in the rights?" Nearly half—48.8%—thought the engineer and company should share the rights and 42% said no. Only 9.2% had no response. Significantly, company management was slightly more inclined to agree with the proposition than engineers are themselves; 56.7% of the company managers said yes, while only 31.7% said no, and 57.5% of the total respondents over 50 also responded positively. For those under 30, only 39.7% agreed, while 49.6% actually said no (Fig. 8).

Splitting patent profits

When asked if the company and the engineer should share in the profits, 54.8% agreed, 35.2% did not, and 10% had no response. Company management once again remarkably supported the idea by 62.5% to 25.8%, while those under 30 were not so enthusiastic—46.6% said yes against 40.2% who said no.

When those who were in favor of dividing profits were asked how these should be split, 41.6% said the company should receive 75% and the engineer 25%; 35% believed in a 50-50 split, while 8.1% supported a 25% company—75% engineer split. Only 5.8% thought the engineer should get everything, and 0.9% thought the company should receive 100%.

On another question besetting the engineering community today, the respondents did not have so positive a response. When asked whether those with BS degrees in electronic technology and those with BS degrees in electrical engineering should be compensated differently, 42.2% believed in a difference in salary, 41.2% believed in a difference in title, and 47.9% in job responsibilities, with 27.3% not responding or not sure. Others thought the difference should depend on individual experience, attitudes, and ability or that it should affect starting salaries only. A small percentage believed there should be no difference whatsoever.

If this is a problem, one solution would be professional licensing, but only 32.6% of those surveyed believed that electrical engineers should be professionally licensed. Almost half—49.7%—gave a vehement no, while 17.6% refused to answer or had no opinion. As expected, those in the 40-to-49-year-old group are the most vocal about this, with only 27.3% behind the idea and 56.7% opposing it entirely. These results support the theory that, although many government officials are promoting the concept of professional licensing, the EE is not especially enthusiastic about it.

Of those 32.6% believing the electrical engineer should be licensed, 65.2% think a professional association should oversee the licensing. Just about one fourth—24.7%—believe state government should be involved, while 15.8% said the Federal government should be. In fact, for a majority of respondents in all age groups, regardless of their primary job responsibility, a professional society is the body to oversee any professional licensing procedures. □

Ann Graham Hannon and Jeffrey A. Wolf of McGraw-Hill Inc.'s Research department researched this article.

64-K static RAM surrounds n-MOS cells with C-MOS circuits

N-doped wells replace p-type in C-MOS process to cut fabrication steps and optimize memory-cell transistors

by Takashi Ohzone, *Matsushita Electric Industrial Co., Semiconductor Research Laboratory, Osaka, Japan*

☐ Because of its speed and density, n-channel technology has generally won out for large static random-access memories. But complementary-MOS has grown increasingly attractive because of its low power dissipation, particularly on standby. A compromise offers a near-ideal solution: use n-channel transistors in the array, reserving C-MOS for the peripheral circuits, where most of the RAM's power is dissipated. A 64-K static RAM—the highest capacity yet achieved for such a device—does just that, while adding a second level of polysilicon for cell load resistances to compress the layout further.

In addition, the polarity of dopants used in the bulk C-MOS fabrication process is reversed. In other words, instead of beginning with an n-type substrate and diffusing p-type wells to form n-channel transistors, n-type wells are diffused into p-type starting material. This approach was taken because the p-type substrate is optimized for n-MOS, and in this design n-channel devices greatly outnumber their complement.

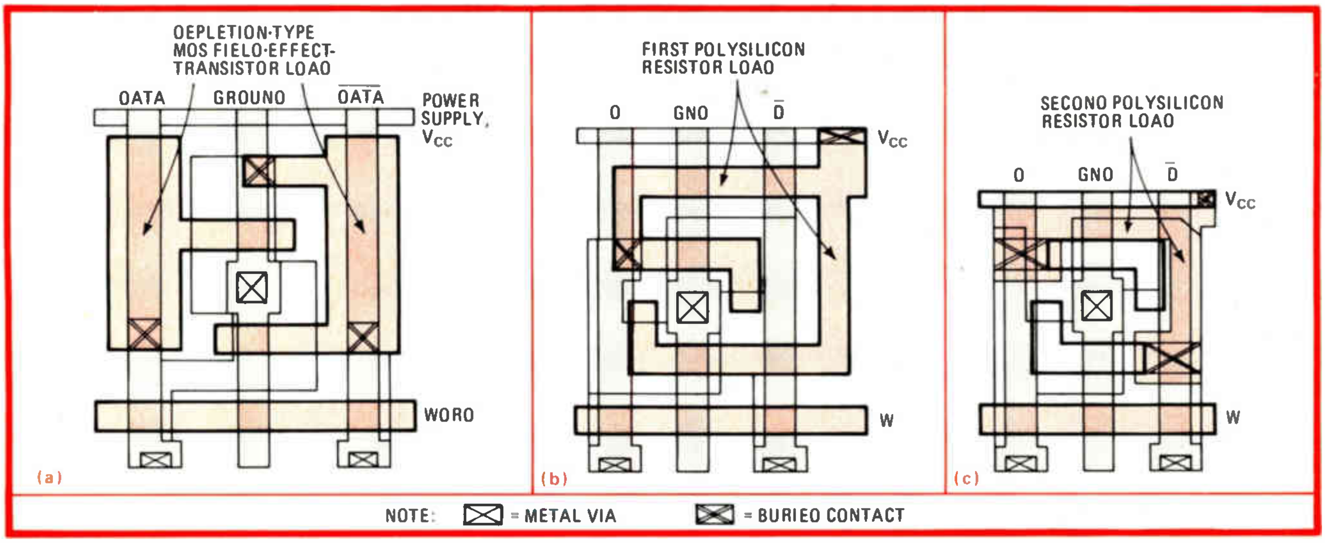
In the latest static RAMs, over 90% of the devices are used in the storage array, which typically consumes 60% to 70% of the chip's area. Obviously, then, small cells and efficient packing rules are a must, especially in a memory of these proportions.

However, the cell in a truly static RAM is composed of at least six components: four MOS field-effect transistors and two pull-up, or load, devices. Depletion-mode MOS FETs, doped single-level polysilicon resistors, and doped second-level polysilicon resistors all have been used as pull-up devices. Figure 1 compares the relative size of these three load device types, assuming each uses the same design rules.

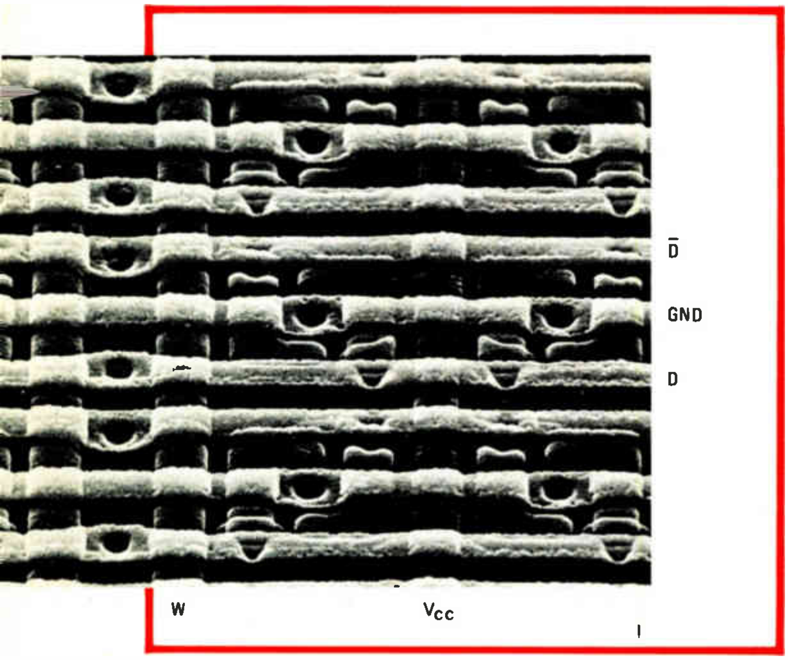
The important reason for choosing for the 64-K RAM the double-polysilicon shown approach in Fig. 1c is that, since the resistors can be folded over and placed on top of the cell, they do not contribute to cell area at all. The size of the cell is determined solely by the four MOS FETs built with the first layer of polysilicon.

If the area of the cell with depletion loads in Fig. 1a is taken as 1.0, the areas of Figs. 1b and 1c are 0.85 and 0.57, respectively. Thus the area taken up by a cell in the 64-K RAM is well below 80% of that possible if only one plane of polysilicon were available.

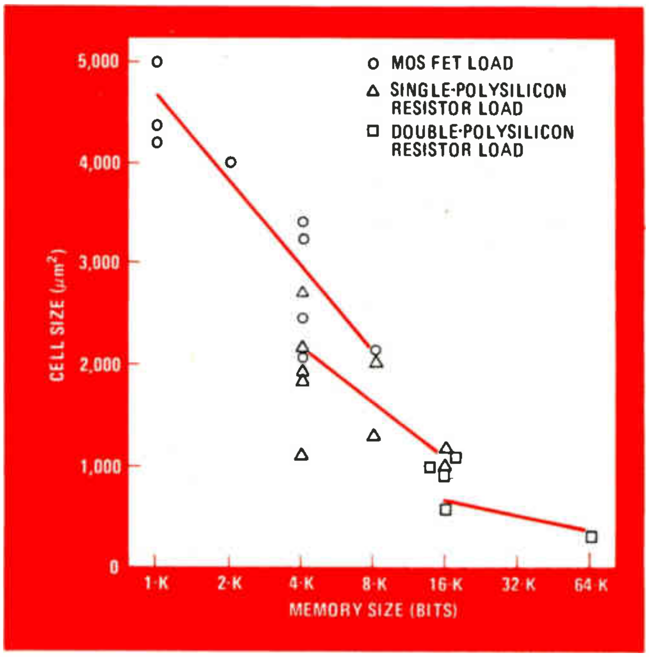
In the 64-K RAM, first-level polysilicon is used to form the gates of the two driver MOS FETs, the word line (W) supplied to the transfer transistor gates, and the power-supply line (V_{cc}) in Fig. 2. The load resistors, as well as the interconnections for the gate-to-drain cross-coupling



1. Squeeze play. In static random-access memories, three types of load devices have been tried: the depletion-mode field-effect transistor (a), single-polysilicon resistor loads (b), and double-polysilicon resistor loads (c). Matsushita's 64-K RAM uses the last type because its area is nearly half that of a RAM using depletion-mode loads. If the area (a) is assigned a value of unity, (b)'s would equal 0.85, and (c)'s, 0.57.



2. At an angle. Word and power-supply lines, which run vertically in this photomicrograph, are formed in the first level of polysilicon. The two data lines for each cell and the ground lines are of aluminum. The area occupied by each cell is just over 300 μm^2.



3. Declining. Cell area as a function of memory density is plotted for three types of loads. The decreasing slope of each segment is the result of finer features. In time, 256-K and 1-megabit static RAMs will be possible on chips not much larger than that of the 64-K.

of the driver MOS FETs, are formed with the second level of polysilicon film. One ground line and the two data lines for each cell are metal.

Sizing the cell

Figure 3 plots cell area versus memory capacity for MOS static RAMs. The circles, triangles, and squares represent the structures that use MOS FET, single-polysilicon, and double-polysilicon loads, respectively. The discontinuities from one line to another result from the introduction of the successive load device types, whereas diminishing geometries are responsible for the smooth downward slopes of each segment.

Actually, the double-polysilicon cells used in this 64-K RAM were employed previously in a 16-K static memory. But 3-micrometer features were used in that chip, and a cell in it measured 621 square micrometers. Design rules of 2 μm are being used to build the 64-K chip, and at 304 μm^2, its cells are less than half the size of the 16-K's.

Interestingly, the ratio of the reduction in cell size—0.49—is nearly equal to the square of the ratio of the reduction in feature size between the 16- and 64-K devices (0.44). Using this relationship, when the design rules are further scaled down to 1 μm and then to 0.5 μm, the respective decreases in cell size relative to the 64-K RAM should be about one fourth and one sixteenth. Thus, the cell structure promises 256-K and 1 megabit fully static RAMs on chips no larger than that for the 64-K memory.

As mentioned, the double-polysilicon n-channel transistors and the n-well C-MOS circuits in the RAM share a common p-type substrate. This substrate is lightly doped for high resistance and high performance.

The table compares seven C-MOS processes in terms of substrate-impurity concentration, doping of wells, and ion implantation steps employed for threshold voltage control. Three of the processes use p wells, three use n wells, and one uses both polarities of well in an undoped, or intrinsic (π), substrate. This comparison assumes 2-μm-wide n^+-polysilicon gates and 5-volt logic. Gate- and field-oxide thicknesses are 40 and 400 nanometers, respectively, and the gate and field threshold voltages of the n- and p-MOS FETs satisfy the relationships $V_{Tn} = -V_{Tp} = 0.8$ and $V_{TFn} = V_{TFp} \leq 6$ V.

All's well with n wells

The A processes in the table require only one implant for threshold control, but as gate lengths are scaled down to about 2 μm, high impurity concentrations start to degrade performance. Low junction capacitances and high speed can be obtained with the two C processes and the dual-well process, but four ion implantation steps are required in all three of these cases.

The B process with n-type wells was chosen for several reasons. For one, the n- and p-type transistor gate thresholds are simultaneously controlled with a single p-type ion implant. In addition, this process allows lower impurity concentrations to be used in substrate and wells alike, resulting in medium and low junction capacitances in p- and n-channel transistors, respectively.

The n-well process has the further convenience of being very similar to standard all-n-MOS processes; indeed, the same p-type substrate can be used for both. In addition to low junction capacitances, this substrate ensures a high surface mobility in the n-MOS FETs.

The somewhat higher junction capacitances of the p-channel devices in the process hardly affect switching speeds. The peripheral C-MOS circuits that use the p-channel transistors—the row, column, and word drivers—need to drive large capacitive loads. Consequently,

COMPARING p-WELL AND n-WELL COMPLEMENTARY-MOS PROCESSES								
Ion-implantation steps		P-well processes			N-well processes			P-well – n-well process
		A	B	C	A	B	C	
V_{TFn} control (B^+)		no	no	yes	no	yes	yes	yes
V_{TFp} control (P^+)		no	yes	yes	no	no	yes	yes
V_{Tn} control (B^+)		no	no	yes	no	yes	yes	yes
V_{Tp} control (B^+)		yes	yes	yes	yes		yes	yes
Surface impurity concentration (cm^{-3})	p well	20×10^{15}	20×10^{15}	$<5 \times 10^{15}$	—	—	—	$<5 \times 10^{15}$
	n well	—	—	—	8×10^{15}	8×10^{15}	$<5 \times 10^{15}$	$<5 \times 10^{15}$
Substrate impurity concentration (cm^{-3})		8×10^{15} (n-type silicon)	$<5 \times 10^{15}$ (n-Si)	$<1 \times 10^{15}$ (n-Si)	20×10^{15} (p-Si)	$<1 \times 10^{15}$ (p-Si)	$<1 \times 10^{15}$ (p-Si)	$<1 \times 10^{15}$ (π-Si)
Comments		well-impurity concentration cannot be controlled	high junction capacitance and large substrate bias effects in n-MOS FETs	low junction capacitances and low substrate bias effects in both n- and p-MOS FETs	well-impurity concentration cannot be controlled	medium and low junction capacitances in p- and n-MOS FETs, respectively	low junction capacitances and low substrate bias effects in both n- and p-MOS FETs	low junction capacitances and low substrate bias effects in both n- and p-MOS FETs

Assumptions for the calculations:
C-MOS processes with n^+-polysilicon gates of about 2 μm for 5-V operation circuits.
$V_{Tn} = -V_{Tp} = 0.8$ V, $V_{TFn} = -V_{TFp} = 6$ V, $T_{OXG} = 40$ nm, $T_{OXF} = 400$ nm.

their performance is almost entirely governed by the gate capacitance of the MOS FETs to be driven and by the capacitive loading of the aluminum interconnections.

In sum, the process achieves nearly the same switching speeds of other processes, but with fewer total processing steps. Figure 4 shows a cross section of the resulting structure. The n^+-doped polysilicon gates—which are free of boron impurities—are used for both n- and p-channel MOS FETs to prevent any of the instabilities that have been observed in boron-doped gates.

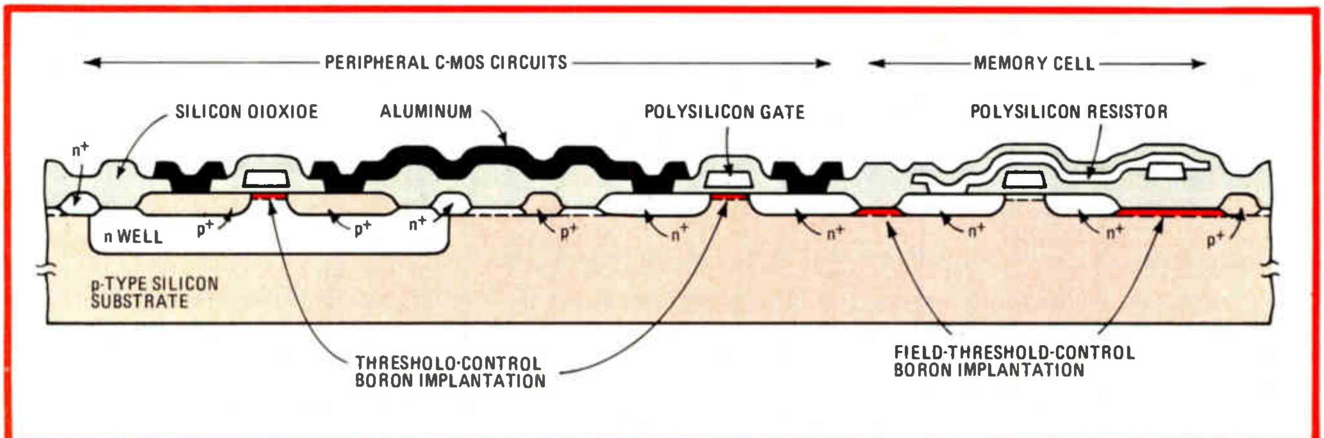
In all, six ion implants are used in the process. They are for:

- N-well formation.
- Field threshold voltage control in p-type substrate regions.
- Simultaneous n- and p-channel MOS FET threshold voltage control.
- N-channel MOS FET source-drain formation.
- P-channel MOS FET source-drain formation.
- Sheet resistance control of the polysilicon resistor loads.

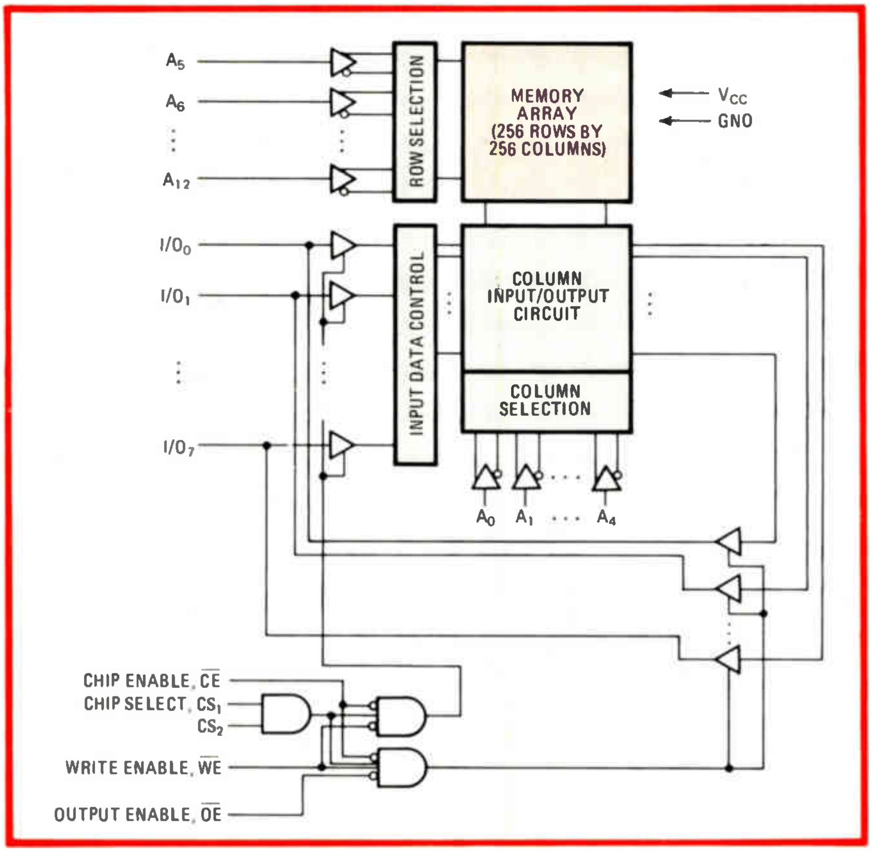
Dry etching techniques are used extensively to resolve 2-μm patterns in silicon nitride (Si_3N_4), polysilicon, and aluminum films.

The 31.6-square-millimeter (48,980-square-mil) chip is a bed for 271,400 MOS FETs and 131,100 load resistors, for a total of 402,500 individual elements. The die area is only 2.2 times that of the 16-K-RAM mentioned earlier, with the storage array occupying 63% of the total. The cells are arranged as 256 rows by 256 columns, but data is organized as 8 blocks of 8-K each. Access times as low as 80 nanoseconds at a power dissipation of 300 milliwatts have been measured.

The RAM's 8-K-by-8-bit organization suits both 8- and



4. Two in one. The process used to build the 64-K RAM combines a double-polysilicon n-MOS process and a complementary-MOS process that relies on n-type wells. The C-MOS peripheral circuits and the n-MOS array share a common high-resistivity p-type substrate.



5. 8-K bytes. The storage array, arranged as 256 rows by 256 columns, is seen from the outside as eight blocks of 8-K each. The RAM's power-down mode is controlled by the chip-enable and -select signals. When the output-enable pin is high, the outputs assume a high-impedance state.

16-bit microprocessors. The device's 28 pins are compatible with sockets for standard 64-K read-only memories and programmable ROMs. Pins 3 through 26 match those of standard 16-K static RAMs for a simple upgrade to the 64-K density level.

Made for the microprocessor

Figure 5 shows a block diagram of the memory. The 256 rows and 32 columns of each 8-K data block are selected via address signals A_5–A_{12} and A_0–A_4, respectively. The RAM's power-down mode is activated by the chip-enable ($\overline{CE}$) and the chip-select (CS_1, CS_2) signals. When the output-enable ($\overline{OE}$) pin is high, all of the eight input/output pins (I/O_0–I/O_7) assume a high impedance state.

The RAM is designed to take on one of four different chip-select modes through a metal mask option. These are $CS_1 \cdot CS_2$, $\overline{CS} \cdot CS_2$, $CS_1 \cdot \overline{CS}_2$, and $\overline{CS}_1 \cdot \overline{CS}_2$, where the dot indicates a logical AND. With one each of the four variations, a 256-K store can be built without external logic. Addresses A_{13} and A_{14} are simply supplied to the chip-select pins (26 and 27), and the I/O pins of all the chips may be bused together.

The C-MOS circuits in the static RAM—the row and column decoders and the control circuitry for chip-select and read/write operations—consume absolutely no dc power while in operation or on standby.

Two types of circuit do, however, use dc power: the MOS FETs that pull up data lines in the memory array and the sense amplifiers. However, dc dissipation of the former is held to zero on standby because the chip-select signal tells the row-address circuits to unconditionally ground the word lines during this mode. Similarly, the chip-select signal ties to the gates of current controlling n-channel transistors in the sense amps to shut down that circuitry, too, while idle. As a result, only the current flow through the extremely high-resistance polysilicon loads in the memory array contributes to the standby power dissipation.

Voltage and temperature variations

The address access time (T_{AA}) and chip-select access time (T_{ACS}) improve with an elevated supply voltage but stretch out as the temperature rises. The active and standby currents (I_{CC} and I_{SB}, respectively) both increase with supply voltage and temperature. T_{AA} and T_{ACS} are typically 80 ns with 5 V and an ambient temperature of 25°C. T_{AA} increases about 10% when the temperature is elevated from 25° to 75°C.

With this same increase in temperature, I_{SB} becomes about three times higher as a result of the negative temperature coefficients of the polysilicon loads in the memory array. I_{CC} does not increase nearly as rapidly. The discrepancy is explained by the fact that the rise in I_{CC} is somewhat compensated for by the decrease in dc current flowing in the pull-up MOS FETs and in the sense amps. These currents act to decrease effective surface mobility in MOS FETs.

Each memory cell draws about 0.2 microwatt for an overall standby dissipation of about 15 milliamperes. When the sheet resistance of the load resistors in the memory is increased to be on the order of several gigohms per square, I_{SB} will plummet to just hundreds of microamperes. □

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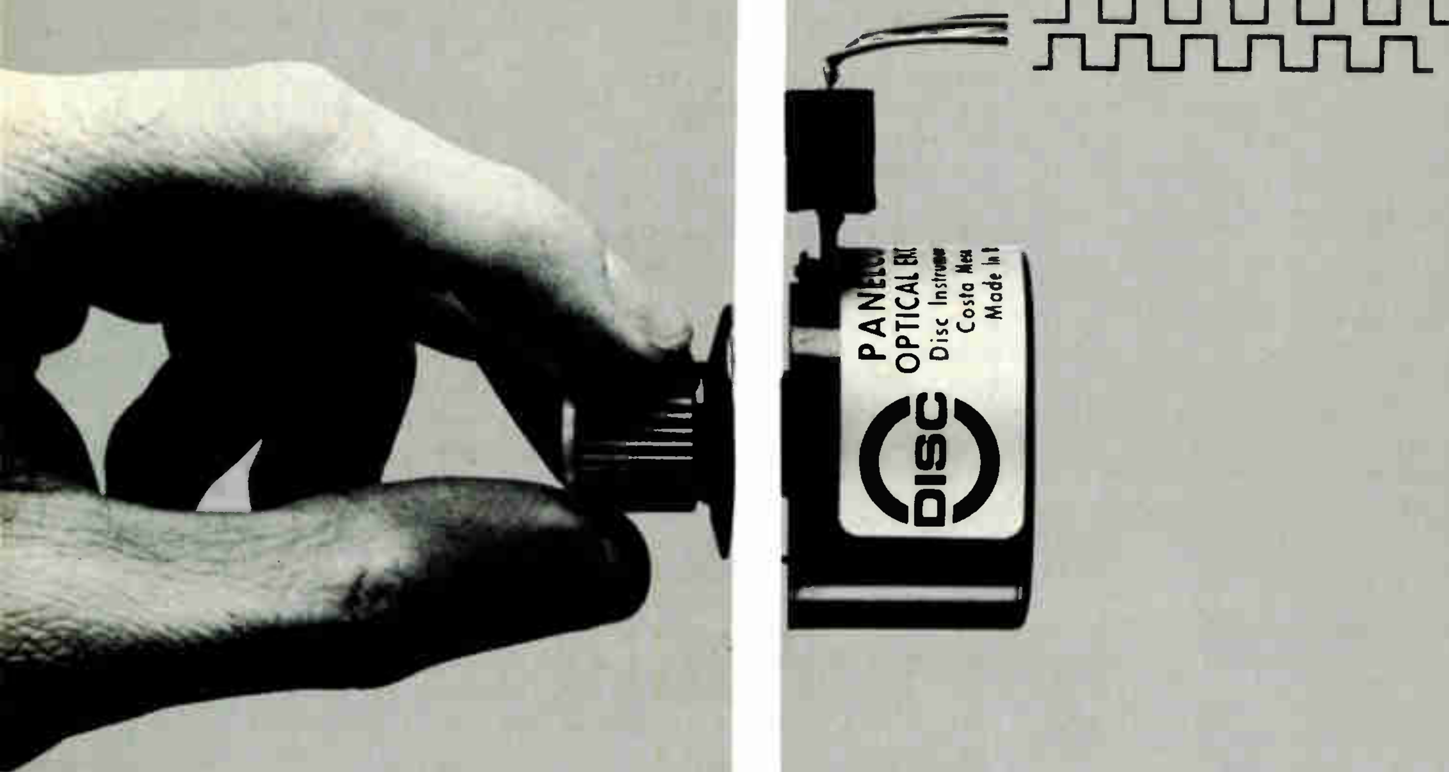

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Single-slope a-d converter makes a comeback with 20-bit linearity

Microprocessor cancels capacitor absorption effects; absolute accuracy depends mainly on the voltage reference

by Jim Williams, *National Semiconductor Corp., Santa Clara, Calif.*

□ Old ideas may appear dead, but they often contain unexpected life. The single-slope analog-to-digital conversion technique of 20 years ago, recently considered obsolete, has revealed some redeeming technological value, thanks to the microprocessor. The combination of the two has yielded a developmental a-d converter with 20-bit linearity (1 part per million). Furthermore, the converter is capable of extremely high absolute accuracy, as that value is limited primarily by the absolute accuracy of the voltage reference used.

The linearity produced by the unlikely combination of a microprocessor and a single-slope a-d conversion circuit surpasses conventional approaches by more than an order of magnitude. The approach points the way toward a generation of "smart" a-d converters with linearities of 12 bits and higher and high accuracy levels over extended temperature ranges.

Although the conversion technique employed is relatively slow, it suits transducer-based measurement systems that require high levels of resolution over time and changes in temperature. Furthermore, extensions of the basic converter design have yielded 15-bit digitization of signals of more than 30 millivolts in magnitude, with no sacrifice in linearity and stability. Such an instrumentation-type a-d converter can work directly with low-level analog signals.

Reexamining the past

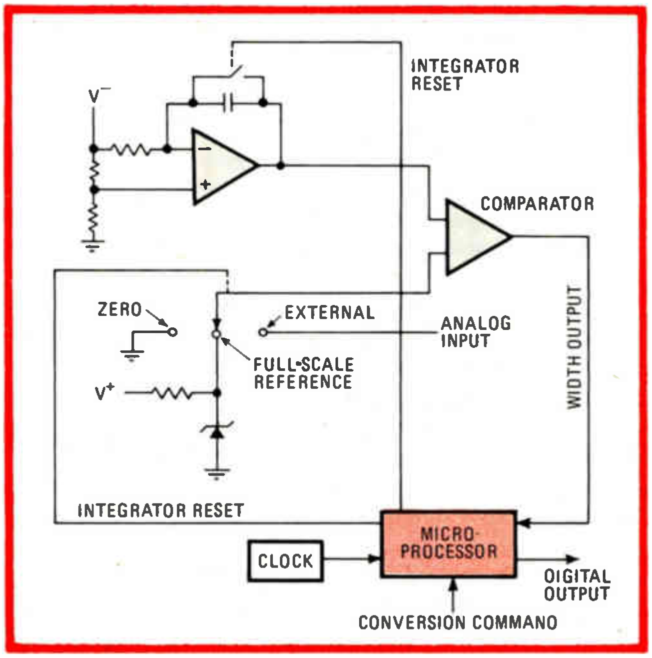
Used in the late 1950s and early 1960s, the single-slope integrator is one of the earliest a-d converter circuits. In one form of this circuit, a linear reference voltage ramp is compared with the unknown input voltage. When the ramp potential crosses the unknown input voltage, a comparator changes state. The length of time between the start of the ramp and the comparator's changing state is proportional to the magnitude of the input voltage. It is measured digitally and is presented as the converter output.

The inherent strong points of a single-slope a-d integrator circuit are simplicity and a high degree of linearity. On the other hand, the circuit's dependence for stability on an integrating capacitor is generally an unacceptable weakness. This shortcoming has limited the use of the single-slope integrator circuit to early converters and digital voltmeters.

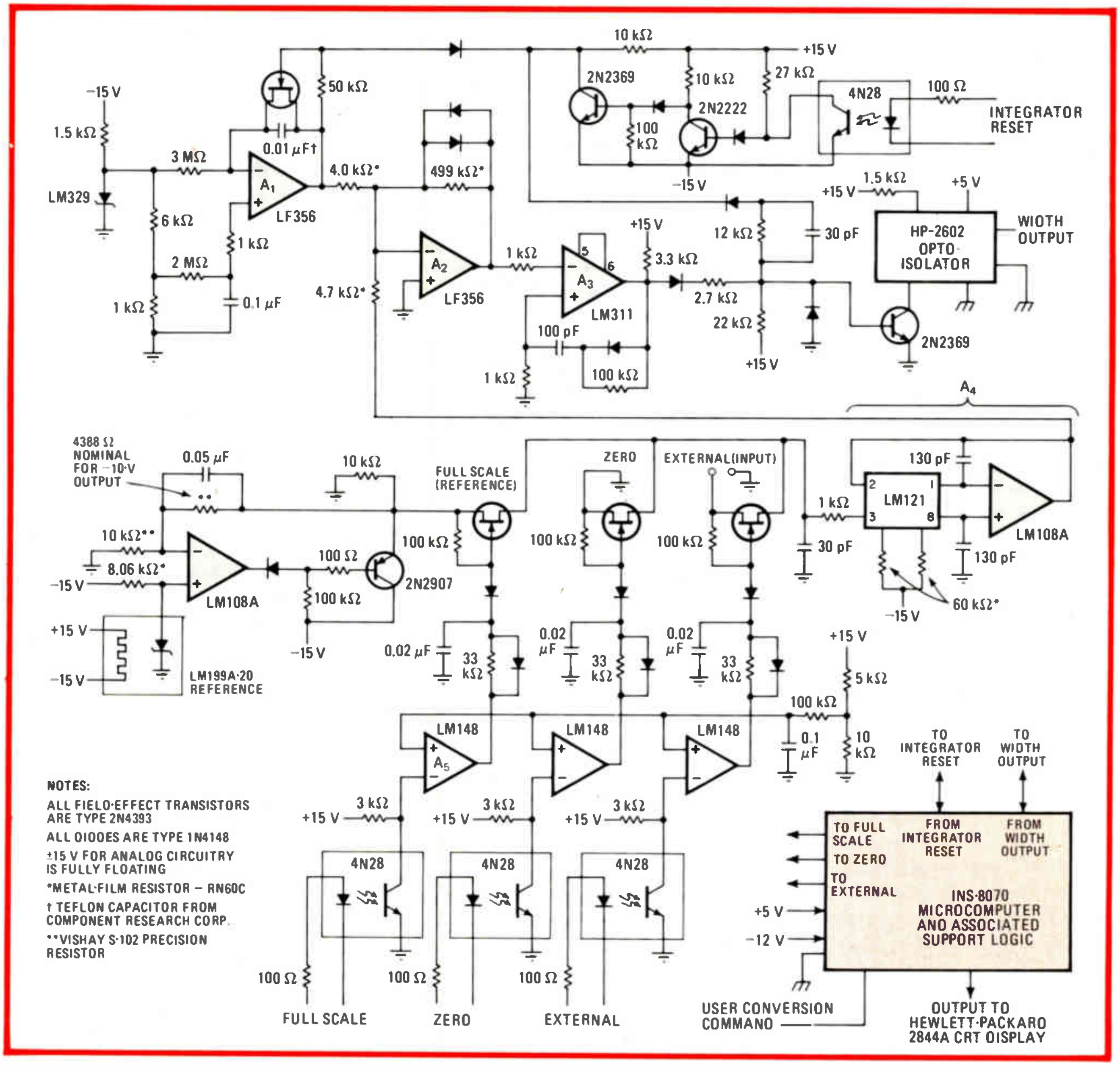
The dual-slope integrator circuit, now universally preferred, solves the problem of integrating-capacitor drift with time and temperature by error cancellation techniques. It provides a-d conversion stabilities by appropriate zero and full-scale drift corrections. In this type of circuit, the comparator's output represents the ratio of the fixed time required to integrate the unknown voltage to the time required to get back to the unknown voltage's starting point. The latter time is measured by the use of a reference voltage whose polarity is the opposite of that of the unknown voltage.

Limited by 'soakage'

Dual-slope integrator circuits suffer from the major shortcoming of poor linearity. This is caused by a parasitic effect in capacitors known as dielectric absorption, or "soakage." Dielectric absorption is the result of an equivalent-circuit resistor and capacitor in series with each other across the main capacitor. The parasitic resistor and capacitor prevent the main capacitor from



1. Correction. This microprocessor-based analog-to-digital converter eliminates the shortcomings of single-slope and dual-slope integrators while retaining precision and simplicity. It cancels dielectric absorption effects and corrects for zero and full-scale drifts.



2. 20 bits. This prototype microprocessor-based a-d converter achieves 20-bit linearity and its absolute accuracy is limited only by the accuracy of the voltage reference. The LM199A-20 reference and the LM108A op amp combination provides 0.25-ppm/°C stability.

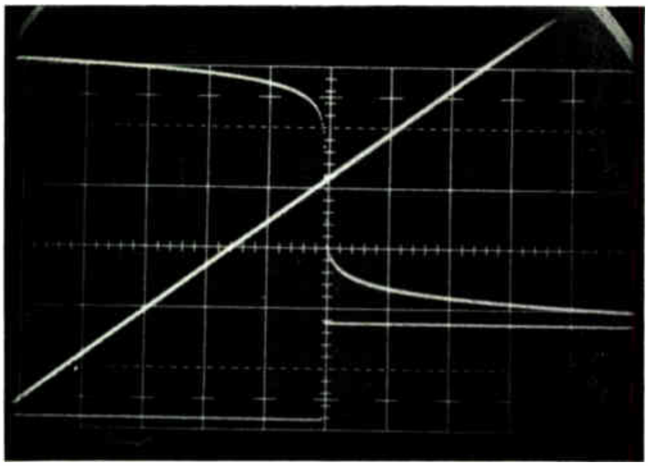
completely charging and discharging instantaneously (the capacitor's charging and discharging characteristics are influenced by the history of its current flow, including current magnitude, duration, and flow direction).

When a capacitor is discharged, even through a direct short, a certain length of time is needed to remove all of the charge in the parasitic capacitance across it, as a result of the parasitic resistance present. In the opposite direction, some charge is absorbed by the parasitic capacitor after charging of the main capacitor has ceased, unless the charging source is maintained for many parasitic RC time constants.

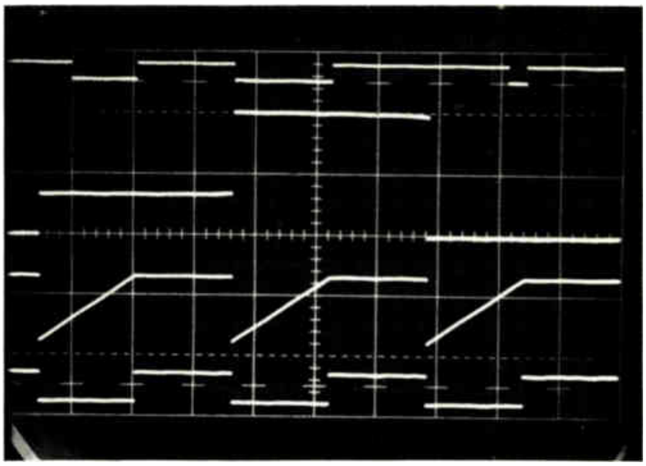
Teflon, polystyrene, and polypropylene capacitors have low dielectric absorption characteristics. Paper, Mylar, and glass capacitors are relatively poor in this regard, and electrolytic capacitors are the worst. Unfortunately, even the best capacitors exhibit enough dielectric absorption to lead to residual nonlinearity effects for a-d converter circuits. Furthermore, dielectric absorption can cause the circuit to provide different outputs for a fixed input as the conversion rate is varied over large ranges. Some compensation schemes can offset this type of behavior. However, they are difficult and expensive to implement for converter circuits requiring optimum linearity levels.

The microprocessor to the rescue

What is really needed is a conversion scheme that not only inherently cancels dielectric absorption effects, but simultaneously corrects for zero and full-scale drifts as well. The microprocessor-based circuit of Fig. 1 fulfills such requirements.



3. Precise. Ramp signal (straight line at 0.05 V/division) of the A_2–A_3 stage in Fig. 2 allows precision comparator performance. Output of A_2 (top left at 0.2 V/division) emerges out of diode-bound line. Bottom signal (at 5 V/division) is A_3's output. (Division = 200 ms.)



4. Conversion. Signal elements of the converter circuit are, from top to bottom: integrator reset, ramp and A_1 output, multiplexer output at A_4, and width output. The signals are shown at 10, 10, 5 and 10 V/division and at 50 µs/horizontal division.

This circuit sequentially switches zero, full-scale reference, and external signals into one input of a comparator. The other comparator input is driven by the ramp voltage output of an operational-amplifier integrator.

If no conversion command is applied to the microprocessor, the circuit is quiescent. In this state, the microprocessor sends a continuous, regularly spaced signal to the integrator reset switch. The integrator's output is a ramp signal whose period (50 milliseconds) and magnitude (10 volts) are fixed and remain so regardless of the converter's operating state. The ramp signal is assumed to be sufficiently linear for the conversion task at hand, and the time between the ramps is sufficiently long to ensure resetting of the integrating capacitor.

When a conversion command is sent to the microprocessor, the latter switches the comparator input to the zero position, waits for the next available ramp signal, and measures the length of time required for the ramp signal to cross 0 V. This information is then stored in memory.

This procedure is repeated by the microprocessor for the full-scale reference and external switch positions, with information also being stored in memory. The microprocessor can now determine the absolute value of the external signal in microvolts, using information stored in its memory, according to the equation:

$$Ex = [(C_{EX} - C_{ZERO})/(C_{FULL\,SCALE} - C_{ZERO})]K$$

where Ex = the external signal, C = the count obtained, and K = a constant, typically 10^7.

After solving the equation, the microprocessor presents the answer at the converter circuit's output and gets ready to receive the next command signal.

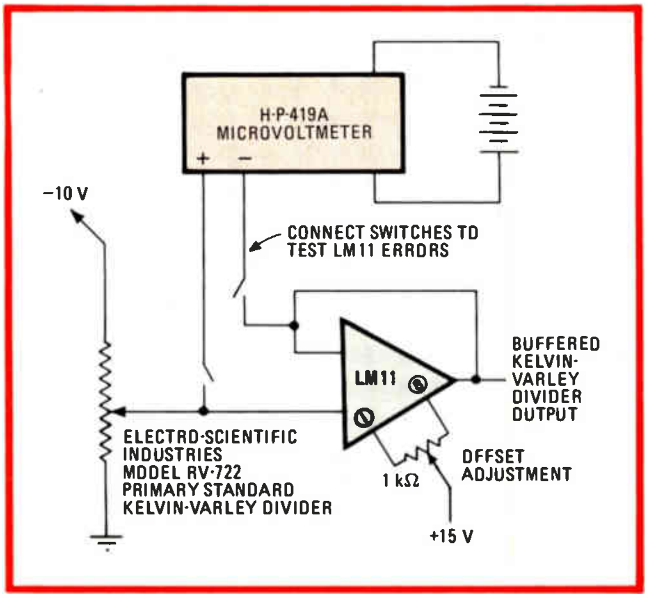
This circuit provides many of the advantages of a dual-slope integrating converter. The use of the microprocessor also yields additional advantages. The key features of the circuit are:

- It continuously corrects for zero and full-scale drift in all components in the a-d converter circuit regardless of changes in time or temperature. The primary limitation on accuracy is the stability of the full-scale reference. The zero signal is derived through a conventional high-quality grounding technique. These features are similar to those of a dual-slope integrating converter.
- Because the integrating capacitor is always charged in a continuous pattern and in the same direction, the error due to dielectric absorption is relatively small and constant and appears as an offset voltage. This offset voltage can be removed during the microprocessor's calibration cycle, a unique feature that is the key to high linearity.
- The comparator always sees the ramp voltage approaching the trip point from the same direction and at the same slew rate, regardless of operating conditions. This consistency helps maintain repeatability at the trip point in the face of noise and gain-bandwidth limitations in the comparator.
- Unlike a dual-slope integrating converter, the circuit has no inherent noise rejection capability. The external input signal is directly coupled to the comparator input with no filtering, a decided disadvantage, since most real-world signals require some smoothing. If a filter were placed at the converter input, a substantial time lag due to settling-time requirements would occur, and therefore, because the converter relies on short time intervals between multiplexer states to effectively cancel drift, an input filter is not desirable. One solution is to have the microprocessor digitally filter the input signal using averaging techniques.

A closer look

Figure 2 shows a detailed schematic diagram of a prototype a-d converter with 20-bit linearity. For clarity, the National Semiconductor INS8070 microprocessor and its associated logic are shown in block form. The entire analog section is fully floating from the digital section to eliminate clock and digital current-spiking noise. Both sections communicate with each other via type 4N28 opto-isolators.

The full-scale reference for the converter is provided by the LM199A-20 voltage reference and LM108A operational amplifier combination. Together, they allow the circuit typically to deliver a stability of 0.25 ppm/°C



5. Testing. The 20-bit a-d converter was tested with this Kelvin-Varley voltage divider, a primary standard with guaranteed linearity of within 1 ppm. LM11 op amp is low-bias-current and low-drift follower for the divider. Readings were taken on a HP 419A microvoltmeter.

and drift of several parts per million per year. As mentioned earlier, the absolute accuracy of the voltage reference is the primary limitation on the absolute accuracy of the converter.

The reference output is fed to a multiplexer, switched by field-effect transistors, that also receives the external and zero signals. Because all these sources are at a low impedance level and only one is switched on at a time, leakage currents and on-resistances do not contribute significant errors.

The A_4 amplifier, composed of the LM121 preamplifier and LM108A op amp, provides a low-bias-current unity-gain follower section with a common-mode rejection ratio of greater than 1 million to 1 (120 decibels), preserving converter linearity. Drifts in this follower section are not significant, since they are canceled by the microprocessor's calibration cycle. The microprocessor's digital commands to the FET switches are received by the opto-isolators. The LM148 quad op amp (A_5) generates the voltage swing necessary to control the FET switches. Discrete components at each amplifier output are used to generate one-way time delays, providing the switches with break-before-make action. This action prevents crosstalk between the zero, full-scale reference, and external sources.

Another FET is used to reset the integrator and is biased by a brute-force level-shifting edge-speedup network formed by the 2N2222–2N2369 transistor combination. A 4N28 opto-isolator biases this network after receiving the reset signal from the microprocessor. A_1, an LF356 op amp, is biased at its positive input to −1 V, ensuring that the ramp will start far enough below ground to determine a true zero signal.

The requirement for a comparator with a trip-point noise of 1 ppm (1 least significant bit at 20 bits) cannot be met by a standard device. At 10 V full scale, 1 ppm of trip-point noise is only 10 microvolts. The ramp signal's relatively slow slew rate means that the gain-bandwidth and noise characteristics of a standard differential-input comparator will cause considerable uncertainty at the trip point. In addition, as the common-mode voltage (formed by the crossing of the ramp and multiplexer output signals) changes, the trip point of the comparator shifts, introducing nonlinearity.

Stretching comparator precision

The foregoing problems are addressed by the A_2–A_3 stage combination, which forms a high-precision comparator. A_4's negative output is resistively summed at A_2 with the positive output of the A_1 ramp. A_2 normally operates at a low gain, since the diode-bound pair in its feedback loop limits gain.

When the currents produced by the ramp potential and A_4's output balance closely, A_2 comes out of bound and operates at a gain (of about 100) determined by the 499-kilohm feedback resistor. A_2 remains in this high-gain state as long as currents caused by the ramp signal and the A_4 output remain nearly equal. As the ramp signal becomes more positive, the current into A_2's summing junction goes to zero and then becomes positive until the A_2 output becomes negative.

The output of A_2 drives the A_3 stage, an LM311 comparator that acts as a zero-crossing detector. Components in the positive-feedback path of A_3 ensure a sharp transition, as shown in Fig. 3. The ramp signal (straight line) is shown highly expanded. The A_2 output signal (top left) can be seen emerging cleanly out of the diode-bound line just before the ramp signal balances A_4's output and returning to the bound line after the crossing occurs. The bottom signal is A_3's output.

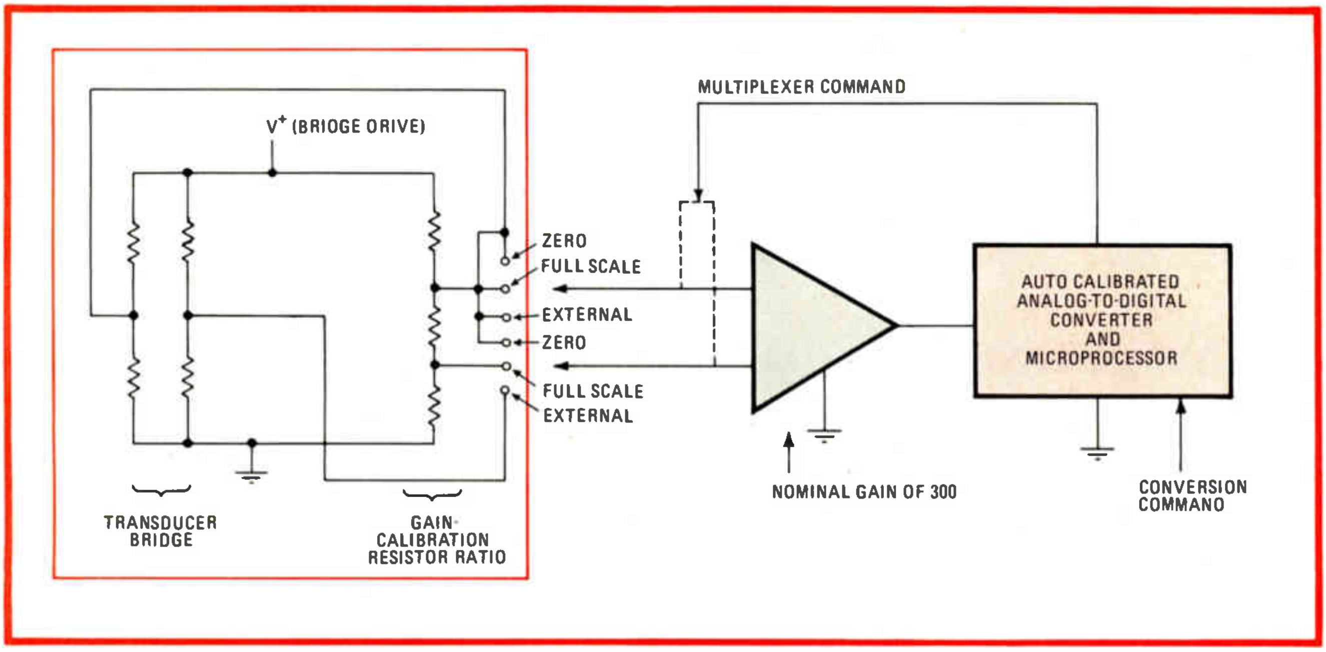
The A_2 stage simplifies the A_3 stage's task. It amplifies the voltage difference of the two signals to be compared by a factor of 100, thus negating the effect of A_3's input uncertainties. It also produces a hundredfold increase in the ramp-signal slew rate at the trip point, allowing A_3 to spend that much less time with its inputs nearly balanced in an uncertain and noise-sensitive condition. Finally, A_2 presents the difference signal as a single-ended zero-crossing signal. This eliminates errors due to changing common-mode voltages that a differential comparator's inputs would face. Such errors manifest themselves as overall converter nonlinearity.

The output of the A_3 comparator is fed to a 2N2369 transistor that functions as a level-shifting gate. It gates out the portion of the width output signal caused by the length of the integrator reset signal. The transistor is a low-storage-capacitance device with high speed, even in the relatively slow common-emitter configuration. An HP 2602 fast optocoupler transmits the width information to the digital circuitry.

At work

Figure 4 shows the a-d converter at work. From top to bottom are the integrator reset signal from the microprocessor; the ramp signal at A_1's output; the multiplexer output at A_4, with the zero, full-scale reference, and external states; and the width output. Ample time is allowed for each state before the ramp signal begins.

The converter was tested as shown in Fig. 5. The



6. Instrumentation converter. This 15-bit a-d converter with 30-millivolt full-scale input has an input-amplifier gain of 300, making it useful for low-level instrumentation applications. Its basic conversion principles are the same ones used in the 20-bit a-d converter of Fig. 2.

Kelvin-Varley voltage divider, a primary standard, has a guaranteed linearity to within 1 ppm. The LM11 op amp provides a low-bias-current, low-drift follower stage for the Kelvin divider network. Since the LM11 has more than 120 dB of common-mode rejection, its voltage output tracks the linearity of the Kelvin divider. To test this tracking, the LM11 is adjusted for an offset null and a battery-powered microvoltmeter is connected between its inputs. A 20-bit-linear (1-ppm) transfer characteristic is verified by running the Kelvin divider through its range and noting less than 10 μV of shift (1 LSB at 10 V full scale) under all conditions. The a-d converter voltage reference is then used to drive the Kelvin divider input and the LM11 output connected to the external input of the a-d converter.

Proof of the pudding

The a-d converter's output was verified on a Hewlett-Packard 2644A cathode-ray-tube terminal. For each conversion command to the microprocessor, the number of counts for zero, full-scale reference, and external switch positions were displayed, along with the final computed answer. The final count was computed to 1 part in 10 million. In four conversion commands, zero full-scale reference, and external-switch position counts all were within ±1 ppm despite the fact that they were individually spaced nearly an hour apart in a changing thermal environment. The linearity of the converter over a 10-V range was verified at 10 points by varying the most significant bit of the Kelvin divider. Although the prototype converter takes 300 milliseconds to complete a cycle, faster speed is attainable by increasing the 20-megahertz clock rate.

Higher conversion speeds are easily obtainable at low resolutions simply by shortening the ramp time. By juggling clock speed and ramp time, the converter's output word length and conversion time may be varied over a wide dynamic range.

Although a 20-bit converter is useful for some applications, many others do not require that degree of precision. However, the basic conversion technique is readily adaptable for practical solutions of common transducer and other low-level interface problems.

Figure 6 is the block diagram of a 15-bit a-d converter with a 30-millivolt full-scale input. In this application, the converter has a differential input amplifier with a nominal gain of 300. The amplifier's offset and gain drift are canceled by the microprocessor's calibration loop. The external signal is the output of the transducer bridge. The full-scale reference signal is derived by measuring across the middle resistor of a string that has the same voltage across it as the nominal bridge output for a given bridge drive signal. Thus, even if the bridge drive signal varies, the gain of the system remains calibrated by ratiometric error cancellation. The zero signal is derived by shorting both amplifier inputs to the common-mode voltage at the bridge output. The circuit maintains 15-bit accuracy over a 75°F temperature range.

Prospective builders of the microprocessor-based a-d converter described here are advised that construction steps are extremely critical. For the converter to operate properly, the greatest care must be paid to grounding, guarding, and shielding techniques. □

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Push-pop program aids 6800's register swapping

by P. R. Apte
Tata Institute of Fundamental Research, Bombay, India

Unfortunately, the popular 6800 microprocessor lacks the push and pull stack instructions that its counterpart, the 8080, uses so efficiently to exchange index registers and accumulators. With the addition of a simple routine and appropriate hardware for modifying the system's nonmaskable interrupt service routine, however, implementation of these functions is easy.

In the unmodified system, it is necessary to store the index register in memory in order to access two or more tables in a program, because the 6800's code is nonreentrant and thus is inefficient for register swapping. This program and three chips coordinate the data transfer much as is done in the 8080, with little complexity and at low cost.

As seen from the program and with the aid of the figure, the routine first checks for the occurrence of an active interrupt request on lines IRQA and IRQB by polling ports CRA and CRB of the 6820 peripheral interface adapter. The PSHX and PULX routines are called in accordance; otherwise, the system's usual nonmaskable interrupt routine is executed.

The TST codes are used for ordering the PSHX and PULX routines, with addresses D_1 and D_2 on the 6800 bus being decoded and presented to the 6820. Upon the arrival of a pulse at CA_1, the interrupt bit in the control and status register is set, making IRQA low. The timing diagram shows how this signal combines with the system-generated NMI output so as to interrupt the microprocessor.

Flip-flop A_3 is set by the NMI system input. One-shot A_2 generates a negative pulse when either IRQA or IRQB goes low. As one-shot A_1 is triggered only when there is no IRQ signal from the 6820, A_1 is not triggered during the execution of the PSHX and PULX codes, making these routines noninterruptible.

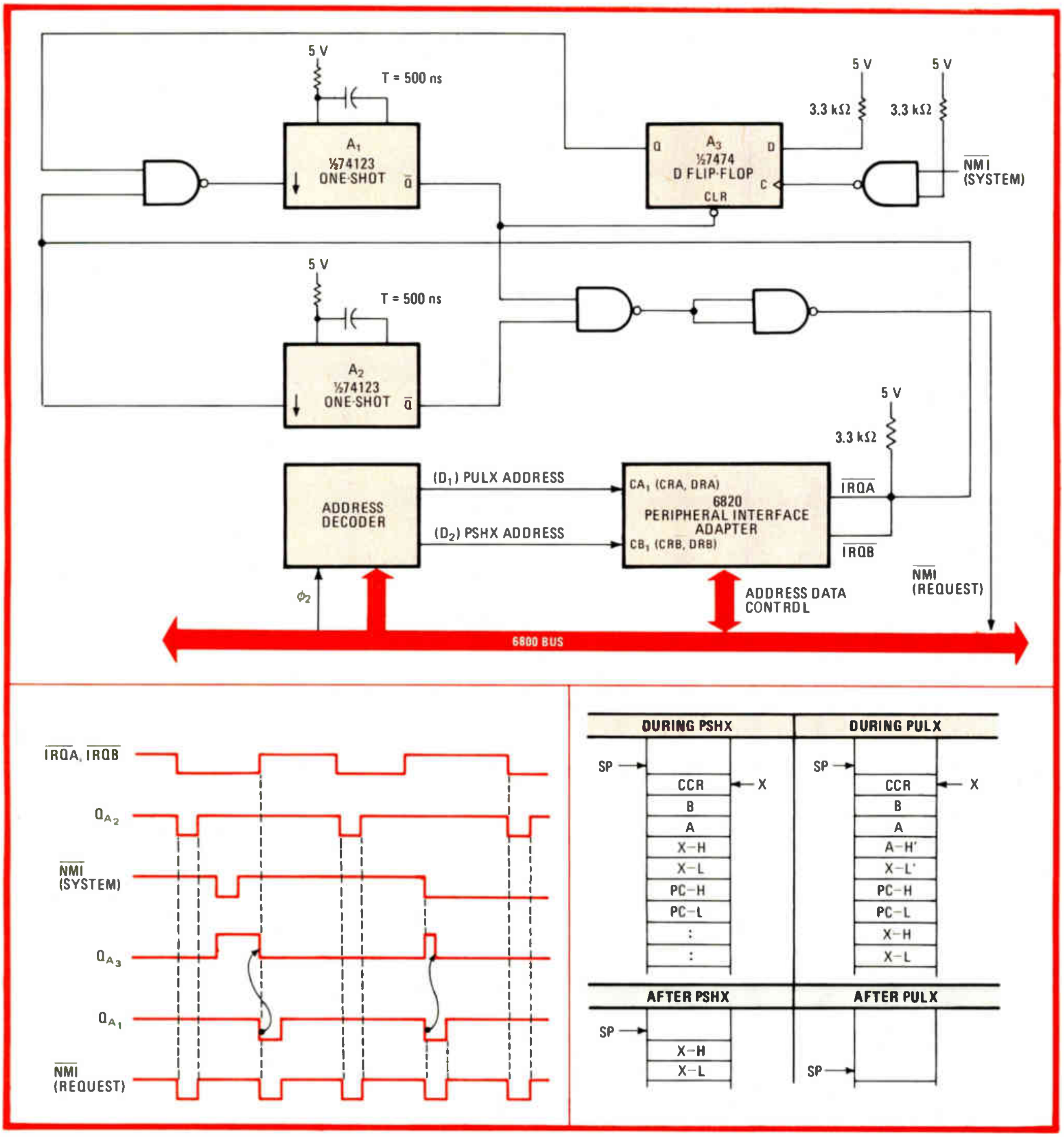
The PSHX and PULX routines take the IRQA or IRQB signal high just before returning from the service routine. The maximum delay for responding to a system NMI signal is 158 clock cycles. The PSHX and PULX require 150 and 158 cycles, respectively. However, it is possible to reduce this time to 98 cycles by allowing the system's condition codes to be modified. □

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.

REENTRANT ROUTINE FOR 6800 MICROPROCESSOR

Label	Source statement		Comments
NMI	LDAA	CRB	
	BMI	PSHX	Test PSHX interrupt
	LDAA	CRA	
	BMI	PULX	Test PULX interrupt
	BRA	RNMI	
PSHX	DES		Push X register on stack, shift
	DES		present 7-byte status up stack by 2 bytes
	TSX		X register = SP + 1
	LDAA	2,X	
	STAA	0,X	Move CCR
	LDAA	3,X	
	STAA	1,X	Move ACC-B
	LDAA	4,X	
	STAA	2,X	Move ACC-A
	LDAA	5,X	
	STAA	3,X	Move X-H
	LDAA	6,X	
	STAA	4,X	Move X-L
	LDAA	7,X	
	STAA	5,X	Move PC-H
	LDAA	8,X	
	STAA	6,X	Move PC-L
	LDAA	3,X	Put X register on stack
	STAA	7,X	in the 2 empty byte locations
	LDAA	4,X	
	STAA	8,X	Move X register in place
	TST	DRA	Remove IRQA
	RTI		Return from PSHX
PULX	TSX		Pull X register from stack
	LDAA	7,X	transfer from stack to status on stack
	STAA	3,X	
	LDAA	8,X	
	STAA	4,X	Shift X register
	LDAA	6,X	Move 7-byte status down stack 2 bytes
	STAA	8,X	Move PC-L
	LDAA	5,X	
	STAA	7,X	Move PC-H
	LDAA	4,X	
	STAA	6,X	Move X-L
	LDAA	3,X	
	STAA	5,X	Move X-H
	LDAA	2,X	
	STAA	4,X	Move ACC-A
	LDAA	1,X	
	STAA	3,X	Move ACC-B
	LDAA	0,X	
	STAA	2,X	Move CC-REG
	INS		
	INS		New SP
	TST	DRB	Remove IRQB
	RTI		Return (regular NMI routine following)

Exchange. Hardware and software for implementing push and pop functions on data registers of 6800 microprocessor is simple. Timing diagram (figure) details logic sequences required to generate interrupts. System, which generates the reentrant routine, coordinates data transfers efficiently. Table shows locations of stack pointer before and after push-pop operations.



Military acronyms prepare engineers for defense work

by Jim Lee and Linda McDaniel

Hughes Aircraft Co., Space and Communications Group, Culver City, Calif.

The military budget allotted to the Department of Defense is expected to grow about 5% annually over inflation during the next five years, and this growth is likely to increase the number of defense contracts awarded the private sector. Consequently, the number of engineers engaged in military-related work should grow, too.

This list of more than 100 abbreviations and acronyms covers the basic technical jargon most likely to be encountered in project-development efforts.

AAH	advanced attack helicopter
AAM	air-to-air missile
AAW	anti-air warfare

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*Fortran 77, Cobol, Basic, PL/1 and RPG II

Circle 158 on reader service card

ACM	advanced cluster munition
ACSM	advanced conventional standoff missile
Ada	a high-order language
Ahaws	advanced heavy-assault weapons system
AIAAM	advanced intercept air-to-air missile
AIFS	advanced infantry fire system
AIM	air intercept missile
ALCM	air-launched cruise missile
AMAS	advanced multipurpose armor system
Amaws	advanced medium-assault weapon system
Amraam	advanced medium-range air-to-air missile
ARP	advanced radiation projectile
ASAS	all-source alarm system
ASAT	anti-satellite
ASH	Aerial Scout Helicopter
ASOJ	anti-standoff jammer (missile)
ASPJ	advanced self-protection jammer
Asraam	advanced short-range air-to-air missile
ASW	antisubmarine warfare
ATF	advanced tactical fighter
BB-(no.)	battleship (number = name)
BETA	battlefield exploitation target acquisition system
BMD	ballistic missile defense
Cawgs	covert all-weather gun system
C4U	C-4 upgrade (Trident II alternative to new D-5 missile)
CG	consolidated guidance
C^3/I	command, control, communications, and intelligence
CX	Cargo X (new airlift aircraft for Rapid Deployment Forces)
Darpa	Defense Advanced Research Projects Agency
D-5	new Trident II missile
Divad gun	division air defense gun
DPS	defense package sets
DSP	defense support program
EAM	emergency-action message
ECM	electronic countermeasures
E-4	new version of airborne command post
ERAM	extended range air munition (smart mine)
ETF	enhanced tactical fighter
FA-SSN	proposed attack submarine
FOI	follow-on interceptor (for strategic defense)
FVS	fighting vehicle system
FYDP	five-year defense plan
GBU	glide-bomb unit
GLLD	ground laser locator designator
GPS	global-positioning system
HARM	high-speed antiradiation missile
HASC	House Armed Services Committee
HEL	high-energy laser
HOE	homing overlay experiment
IFF	identification friend or foe
IFFN	identification friend, foe, or neutral
IOC	initial operational capability
IRST	infrared search and track
JTIDS	joint tactical information distribution system
Lamps	light airborne multipurpose system
Lantirn	low-altitude navigation and targeting infrared night system
LCAC	landing-craft air cushion
Loads	low-altitude air-defense system
LSD-(no.)	amphibious ship
MCM	mine countermeasures
MHV	miniature homing vehicle
Milcon	military construction
MLRS-TGW	multiple-launch rocket system–terminally guided weapon
MPLM	multipurpose lightweight missile
MPWS	multipurpose weapon system
MRASM	medium-range air-to-surface missile
NCTR	noncooperative target recognition
O&M	operations and maintenance
OMB	Office of Management and Budget
OSD	Office of the Secretary of Defense
PA&E	Program Analysis and Evaluation (OSD office)
Pivads	product improved Vulcan air defense system
PLSS	precision-location strike system
POM	program objective memorandum
RDF	Rapid Deployment Forces
RDTE	research, development, test, and evaluation
RFX	reconnaissance fighter X
RPV	remotely piloted vehicle
RSI	rationalization, standardization, interoperability
Sadarm	search and destroy armor
SASC	Senate Armed Services Committee
SBSS	space-based surveillance system
Scamp	supersonic cruise air maneuvering program (F-16–related)
Shorad C^2	Short-range air defense command and control
SLAT	surface-launched, aerially targeted
SLEP/Cilop	service life extension program/conversion in lieu of procurement
SOJS	standoff jammer system (Navy surface-to-air missile)
SPO	Systems Project Office
SPW	self-protection weapon
SSBN	strategic submarine, ballistic nuclear
SSLD	single-seat laser designator
Stanag	statement of NATO agreement
SUW	surface warfare
Talcm	Tomahawk air-launched cruise missile
Tencap	tactical exploitation of national capabilities
TFD	Tactical Fusion Division
TLAM-C	tactical land-attack missile–conventional
TOS	Army tactical command and control system
TPQ-(no.)	a counter-mortar radar
TSS	tactical surveillance system (Navy satellite)
VHSIC	very high-speed integrated circuits
WAAM	wide-area anti-armor munitions
WASP	WAAM minimissile
WIC	warning information correlation

Engineer's newsletter

Learn about Japanese ICs and suppliers

Engineers from Hewlett-Packard Co. and the Xerox Corp. will be getting together next week with interested designers to discuss Japanese semiconductors. The presentation, headed by Dick Eichenseer of HP and Roger Dunn of Xerox, who have several years of practical experience with various Japanese devices, will focus on the quality and reliability of 16-K dynamic random-access memories and large-scale integrated circuits and on the difference between Japanese and U. S. versions. **They'll also discuss methods of ranking suppliers and how to compete with them.** In addition, they'll present their experiences to illustrate pitfalls to avoid in doing business with Japanese firms. The meeting will be held at the Hacienda Hotel, 525 North Sepulveda Blvd., El Segundo, Calif. Dinner will be at 6 p.m., and the session will begin at 7:30. Dinner is $7.00, including tax and tip. For dinner reservations or more details, contact Jack Fort at Xerox, (213) 679-4511, ext. 1776 or 1483.

Getting on the Multibus

Intel's Multibus backplane has an 86-pin edge connector with pins on 156-mil centers, but practically all equipment that mates to the Multibus is based on connectors whose pins are on 100-mil centers, including the popular flat-cable connectors. To ease this problem, Mupac has just introduced an input/output panel. **A small printed-circuit board with an 86-pin connector, it mates directly to the Multibus backplane connector.** On the pc board, the 86-pin connector is tied through printed wiring to a 72-pin plug (with 100-mil centers) that is grounded between critical signal paths. A potential user simply plugs a 72-pin flat-cable assembly into the latter. Two additional 6-pin connectors are mounted on the board to handle ground and power connections.

With the adapter, Multibus backplanes can be connected to each other or to other digital equipment with standard commercial flat cable. For more information, contact Russell Petit at Mupac Corp., 646 Summer St., Brockton, Mass. 02402.

Electronic blackboard uses special resistive coating

You may think of polymeric resistive thick films in terms of screening and firing carbon resistive elements onto all sorts of printed-circuit substrates, but Western Electric Co. has sent such a film to school. It used a special polymer resistive composition supplied by Electro-Science Laboratories when it created an electronic blackboard system to transmit an instructor's lessons to remote classrooms. The information is written with ordinary chalk, sent via standard telephone lines, and displayed on a TV monitor.

The new teaching aid consists of an aluminum honeycomb sandwich faced by two closely positioned plastic sheets. **The sheets are coated with the special resistive ink such that contact between them generates voltages representing the X-Y position of the chalk.** This position is converted into a digital code that is transmitted as electrical impulses over phone lines. A video monitor at the receiving end decodes the impulses and displays the message. The basic resistivity of the film is approximately 700 Ω/sq, but this value is not critical, though it is essential that the resistance distribution be uniform to within ±10% throughout the blackboard. For more on polymeric thick films, contact Electro-Science Laboratories Inc., 2211 Sherman Ave., Pennsauken, N. J. 08110. **-Jerry Lyman**

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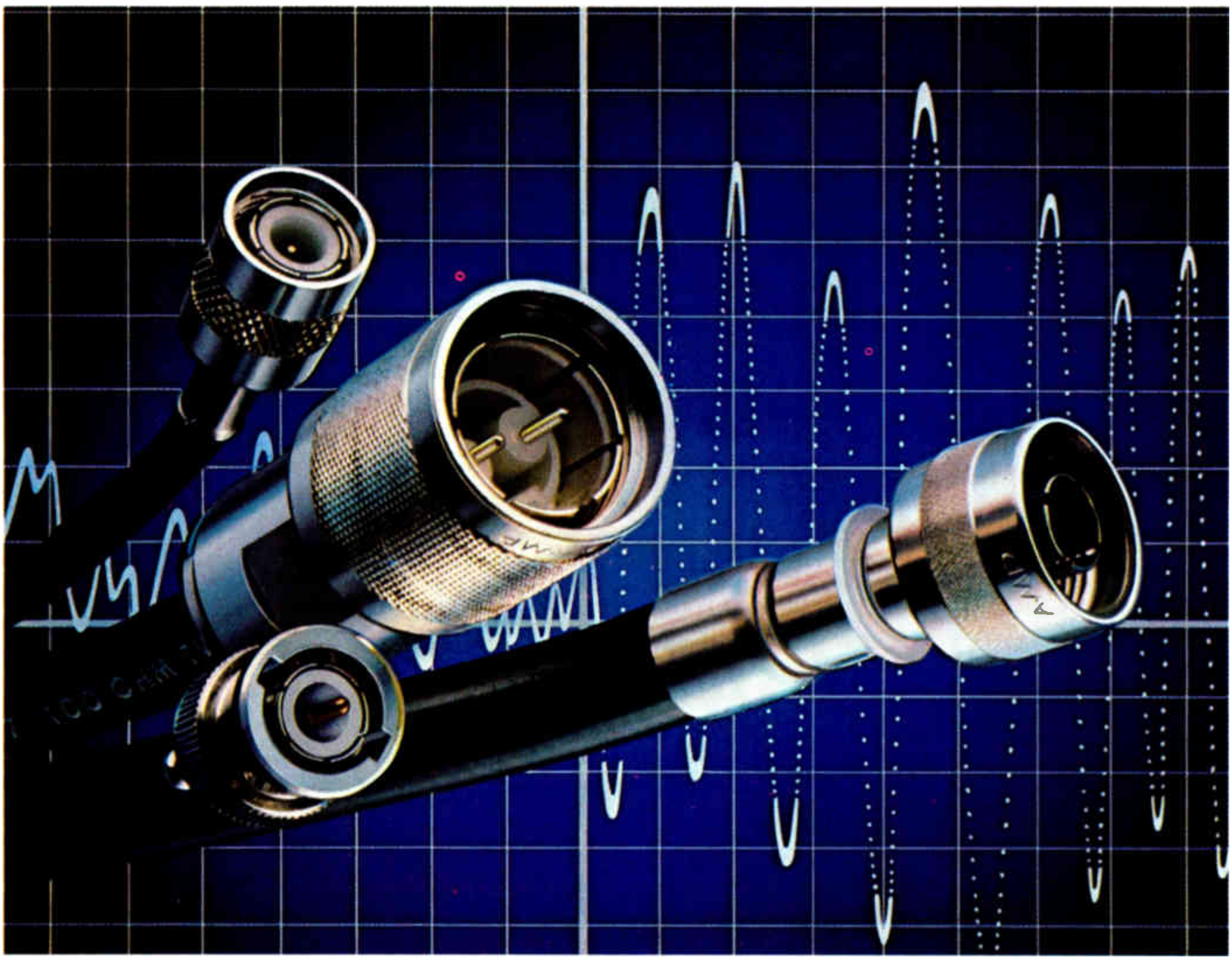

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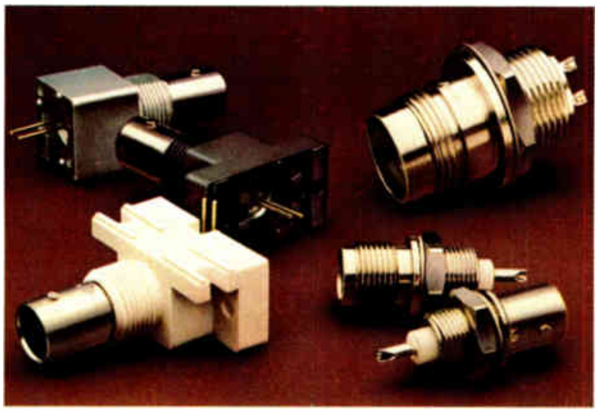
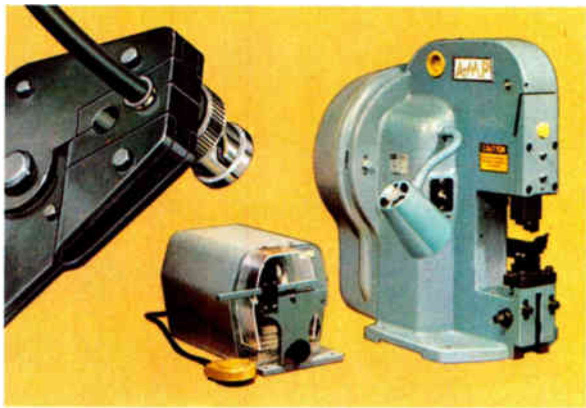
AMP has a better way.





Some facts worth knowing about AMP commercial coaxial connectors.

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Rated Working Voltage—
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Frequency Range—
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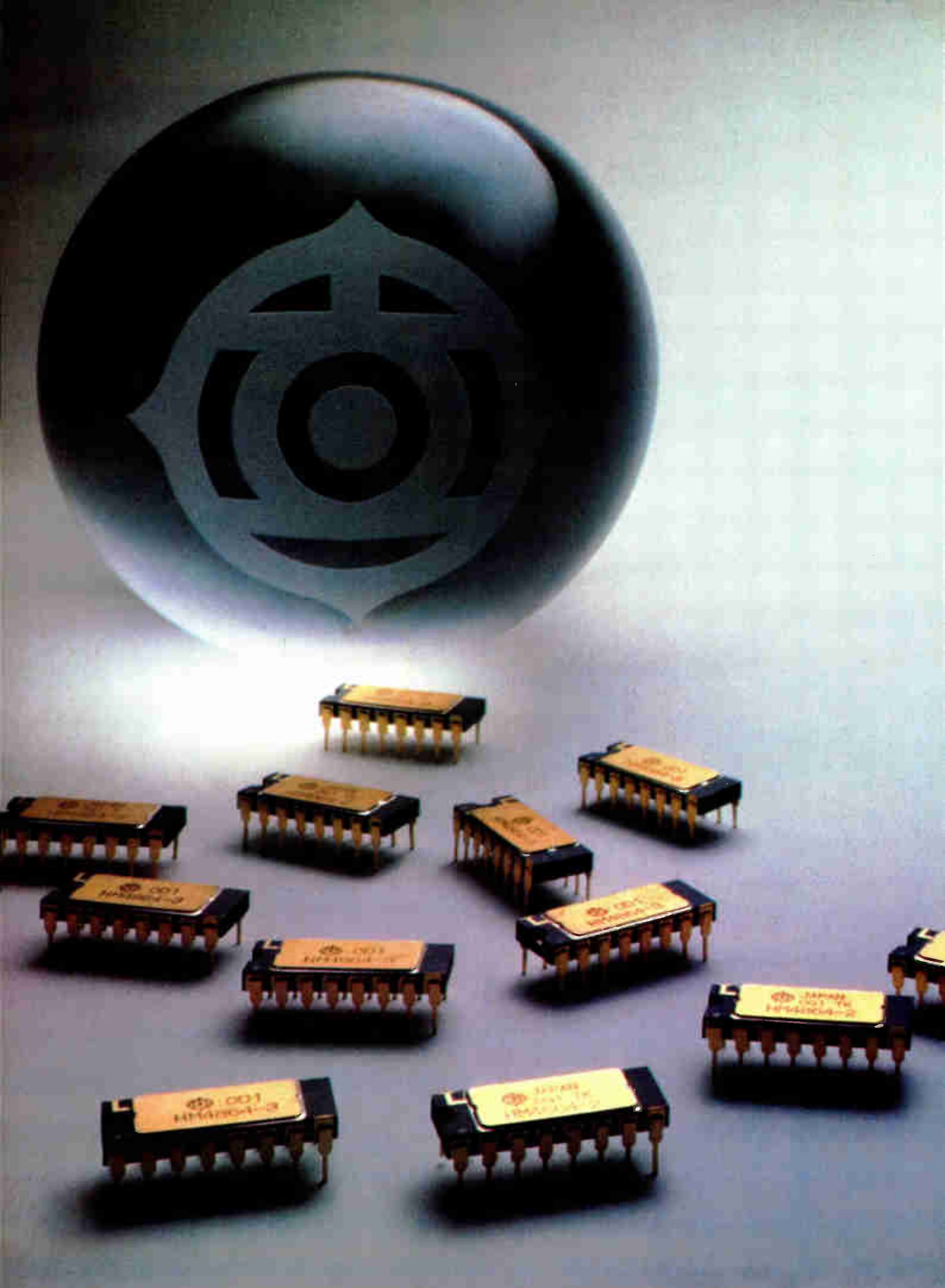
TNC 0-7 GHz
Voltage Standing Wave Ratio (VSWR)
—Less than 1.3
Contact Resistance—
3.0 milliohms, max. (gold contact)
Insulation Resistance—
5000 megohms, min.
Dielectric Withstanding Voltage—
1500 volts, min.
Temperature Range: −55°C to +85°C

N
Impedance—50 ohms
Rated Working Voltage—
1000 volts RMS
Frequency Range—0-11 GHz
Voltage Standing Wave Ratio
(VSWR)—Less than 1.3
Contact Resistance—
3.0 milliohms, max. (gold contact)
Insulation Resistance—
5000 megohms, min.
Dielectric Withstanding Voltage—
2500 volts, min.
Temperature Range: −55°C to +85°C

TWINAX
Nominal Impedance—Non Constant
Rated Working Voltage—
500 volts RMS
Insulation Resistance—
5000 megohms, min.
Dielectric Withstanding Voltage—
1500 volts RMS/minute
Temperature Range: −55°C to +85°C

AMP

Circle 165 on reader service card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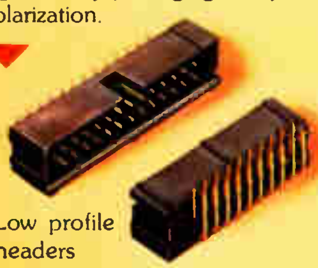
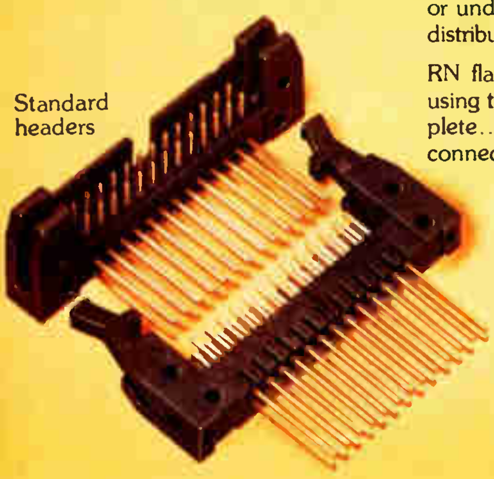
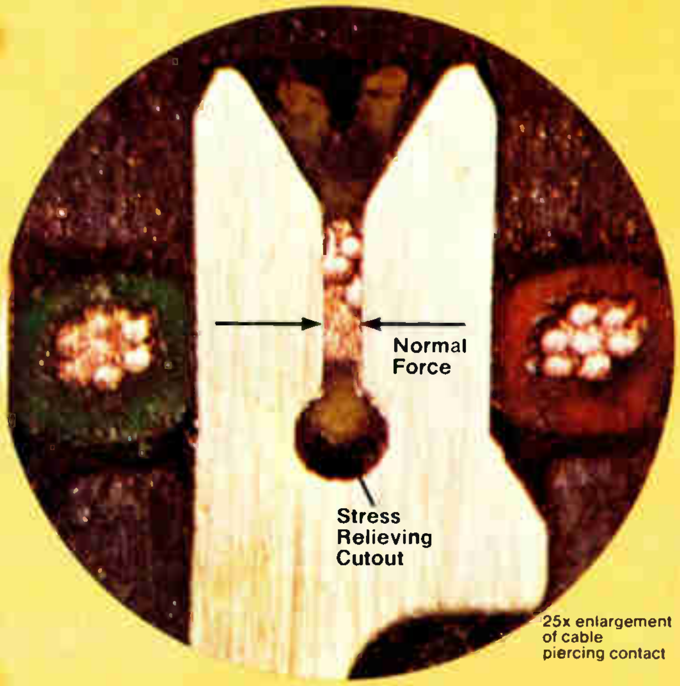


Low profile headers



Standard headers



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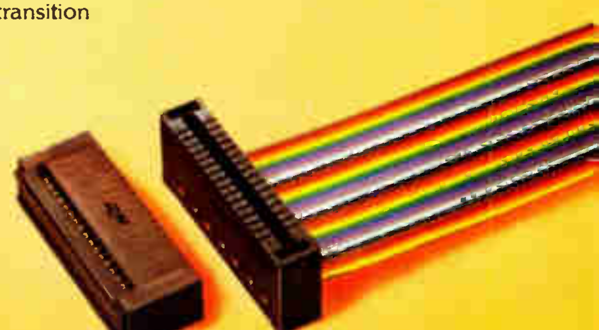

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Circle 169 on reader service card

4½-digit hand-held DMMs arrive

Two firms come at the untested market for extra-digit meters with practical, field-ready units costing $219 and $279

by James Brinton, Boston bureau manager, and Richard Comerford, Test, Measurement & Control Editor

Not one but two next-generation field-service tools—4½-digit handheld multimeters—are filling suppliers's shelves this month. The $60 difference in price between the two reflects the differences in specifications and the type of battery used.

The 255 from Data Precision is one of the firm's miniature portable series. Unlike earlier members, however, its nickel-cadmium battery will keep it running for up to 100 hours without recharging, making it more practical in the field. It measures 5.5 by 3.5 by 1.5 in. and weighs 21 oz. In its specifications it resembles the same firm's 2408R benchtop digital multimeter.

Keithley's 135 has the form typical of hand-held meters and is a 4½-digit follow-on to the 130, a 3½-digit hand-held meter introduced a year ago [*Electronics*, Nov. 8, 1979, p. 165]. It weighs only 10 oz and measures 7 by 3.1 by 1.5 in. The 135's battery supports it for 100 hours in the field, too, but it is a 9-V alkaline type. The 135 is priced at $219; the 255 costs $279.

For each of the five parameters both units measure—resistance and ac and dc current and voltage—the 255 has five ranges, or 25 in all. The dc voltage ranges cover 200 mV to 1,000 V full scale, and ac voltage ranges top out at 500 V. Its ac and dc current ranges are identical, covering 200 μA to 2 A full scale. Sensitivities are 10 μV, 10 nA, and 0.1Ω.

The 255 measures ac current and voltage using an averaging technique accurate over a specified range of 50 to 500 Hz. Although benchtop units typically offer more bandwidth, the sort of measurements Data Precision foresees as common for the unit will be at dc or at power-line frequencies and their harmonics—50 and 60 Hz, 120 and 180 Hz, and 400 Hz. The dc common-mode rejection ratio is 140 dB and normal-mode rejection is 50 dB, measured at 50 and 60 Hz for both. Common-mode voltage is 500 V and input impedance on all ranges is 10 MΩ.

Keithley's 135 offers 17 ranges in which to take measurements. Its resistance ranges (20 kΩ to 20 MΩ) are the same as the 255's. Ac and dc voltage measurements are tackled in four ranges, starting at 2 V full scale and rising to 1,000 V dc and 750 V ac. For both ac and dc current measurement, two ranges are provided, 2 A and 10 A full scale. Keithley vice president Joseph Reedholm notes that the 10-A range, also a feature of the 130, has proven "extremely valuable in many industrial applications." The 135's best sensitivities are 100 μV, 100 μA, and 0.1Ω.

The 135 also uses an averaging technique for ac measurements, with readings calibrated in root mean square of a sine wave, and the bandwidth over which its accuracy is specified in the 20- and 200-V ranges is the same as that of the 255. In the 2-V range, the bandwidth extends to 10 kHz, however, which Reedholm indicates is necessary for applications at present seen in military areas. The 135's dc common-mode rejection ratio is 120 dB and normal mode rejection is 60 dB at 50 and 60 Hz. Common-mode voltage and input impedance are the same as for the 255.

Low-power displays. Both units present readings on a liquid-crystal display updated every 400 ms and also use the display to indicate polarity, overrange conditions, and battery status; Keithley's 0.6-in.-high digits make it easier to read in some circumstances than Data Precision's 0.4-in.-high ones.

Both units also use dual rotary dials, one for range and one for function selection. Holding the 255 and ranging it is a two-hand operation. Range and function changes can be

Portable. Slightly different in form but comparable in features are Keithley's 135 (left) and Data Precision's 255 4½-digit meters.

made with the thumb while holding the 135 in the left hand, but the input lead has to be shifted to a different input terminal when the function is changed; the Data Precision unit uses a single set of terminals for all ranges.

In choosing between the two meters, prospective purchasers will have to determine not only what ranges they will actually need but also how accurate they really want those readings to be. Harold Goldberg, Data Precision president, stresses the 255's "quality features"—accuracy as well as thermal stability—which parallel those more typically found in benchtop units.

The accuracy specifications given by both units' manufacturers are valid for a temperature range of about 18° to 28°C. In addition, both specify temperature coefficients that apply outside this range, from 0° to 17°C and from 29° to 50°C, that make it possible for users to adjust readings taken under harsher thermal conditions.

Uncertainties. On the dc voltage range, the 255's accuracy is to within ±(0.03%+2 counts) up to the 2-V range and decreases to within ±(0.05%+1 count) for the three higher ranges. The 135's dc voltage accuracy for the two lower ranges is to within ±(0.05%+1 count), whereas for the higher ranges it is to within ±(0.1%+1 count).

The difference in accuracy between the two meters for the 2-V range, the 135's lowest, is negligible for most readings. For example, a 1.4000-V reading would have a measurement uncertainty of ±0.0008 V with the 135 and ±0.0006 V for the 255. In the higher ranges, however, uncertainty creeps into the second least significant digit of the 135, whereas it stays in the least significant digit with the 255.

For the remaining parameters, the 255's listed specifications are tighter than those given for the 135. Ac voltage accuracy varies with range and frequency in the 255; it is accurate to within ±(0.5% to 1% plus 3 to 8 counts). For the 135, ac voltage is accurate to within ±(1%+15 counts) on all ranges within the specified bandwidth; above that bandwidth it is ±5%+15 counts on the two lowest ranges.

Similarly, the 255's dc current specs are ±(0.1% to 0.2%+2 counts) and that for the 135 is ±(0.5%+2 counts). For ac current, the 255 comes in at ±(0.75%+4 counts) and the 135 at ±(1.5%+15 counts). For resistance, the 255's best accuracy specification is to within ±(0.07%+1 count) on the three lowest ranges; that for the 135 is to within ±(0.2%+2 counts) on the three middle ranges.

The temperature coefficients given for the 255 are lower across the board than those for the 135. For example, taking a 1.4-V dc reading at 38°C adds to the uncertainty a temperature factor of ±0.0020 V with the 135 and ±0.0006 V with the 255.

With regard to specifications, Keithley notes that its specs are extremely conservative and guarantees them for one year. Before verifying the units' specs, the firm performs a drop test. In that test the unit is dropped from a height of five feet onto a concrete floor. Additionally, the Keithley unit has a low parts count, about 100 parts in all, including case and screws, which furthers reliability.

Data Precision also guarantees its specifications for one year. Though the 255 is not drop-tested, it is subjected to a 3-g vibration test. The instrument has 97 electronic parts and a total parts count of 130.

The Keithley unit's single-quantity price of $219 includes test leads, manual, and battery. The 255's $279 covers carrying case, battery pack, recharger, test leads, and manual. For extending the current range of the 255 up to 1,000 A, Data Precision offers a clamp-on Hall-effect ac/dc current probe, the CG-100A, priced at $198. The two multimeters are available from stock.

Data Precision Corp., a division of Analogic Corp., Electronics Avenue, Danvers, Mass. 01923. Phone (800) 343-8150 or in Massachusetts (800) 892-0528 [338]

Keithley Instruments Inc., 28775 Aurora Road, Cleveland, Ohio 44139. Phone (216) 248-0400 [339]

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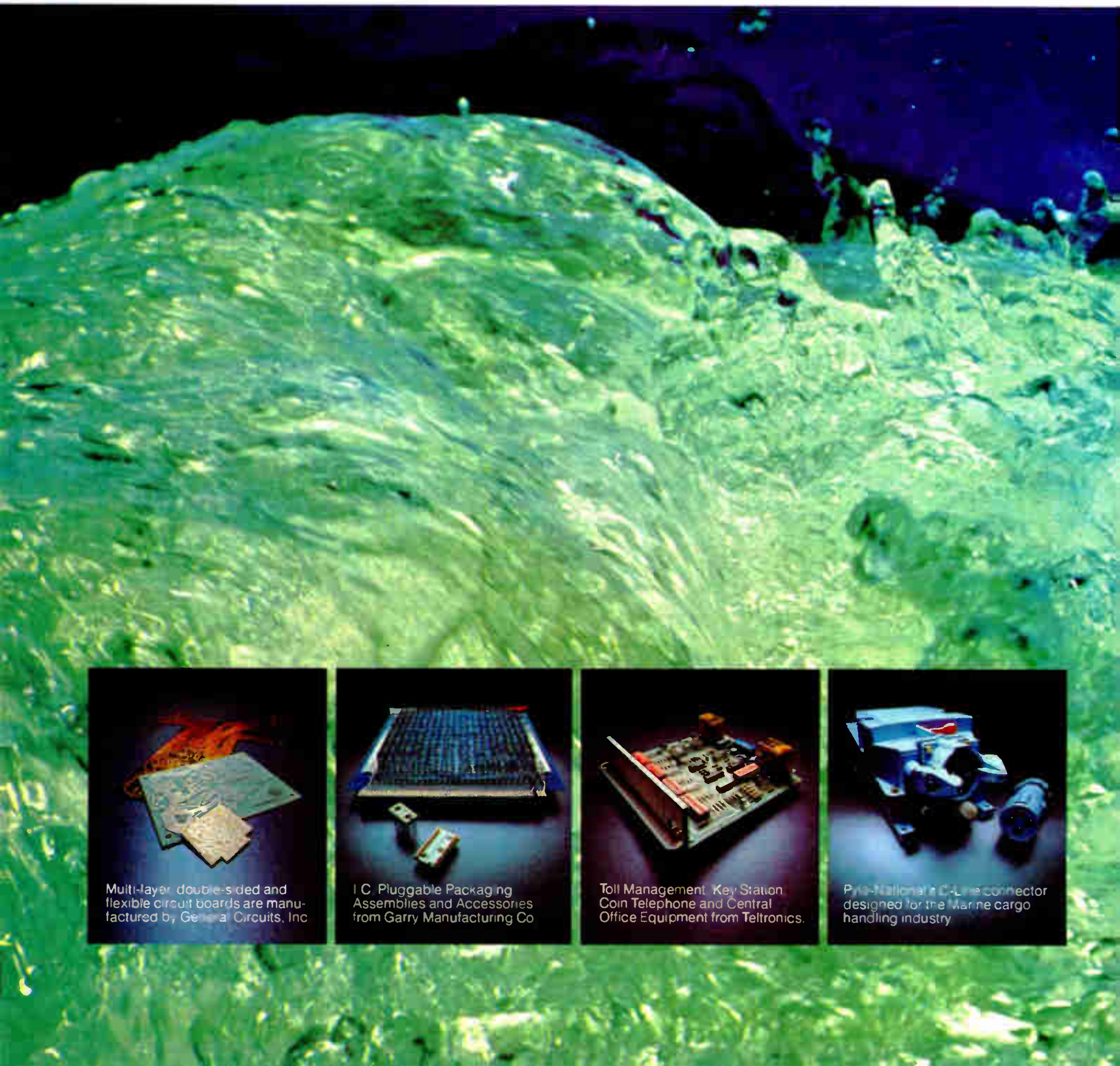

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PROGRESS. OTHERS MAKE THEM.

Chip detects errors in 25 ns

16-bit IC uses modified Hamming code to detect and correct data errors in fast bipolar and MOS microprocessor systems

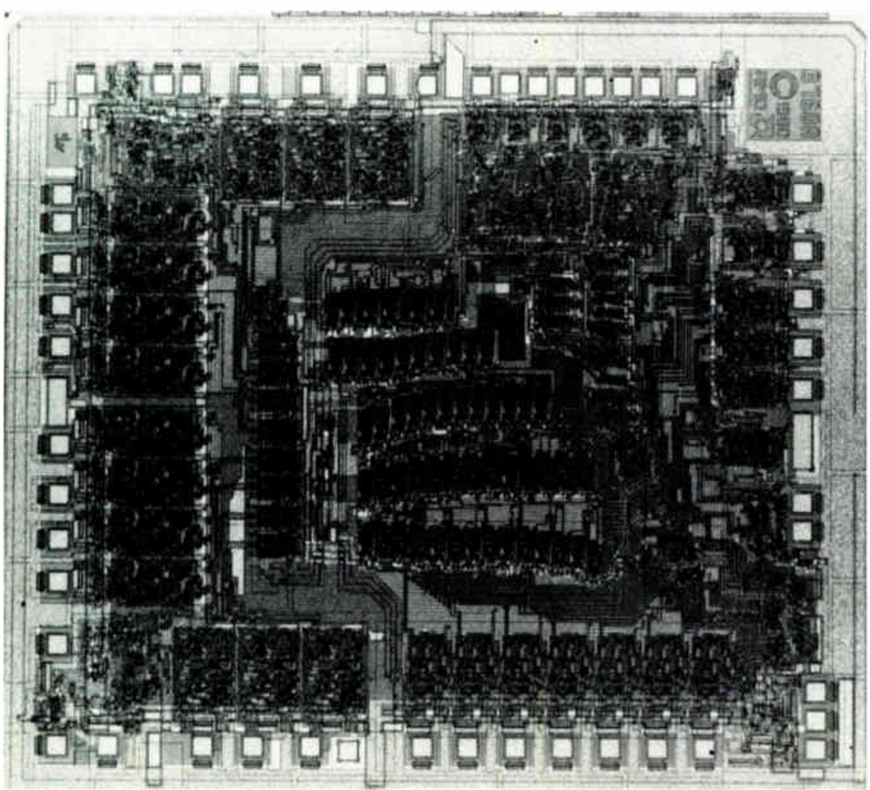
by Bruce LeBoss, San Francisco regional bureau manager

As memory systems grow, and particularly as higher-density semiconductor random-access memories more prone to soft errors are used error-checking and -correction schemes play a more important role in maintaining system reliability. ECC implementations using medium-scale integration typically require 25 to 50 chips and add significantly to system cost. But Advanced Micro Devices has ready a large-scale integrated circuit for what it calls error detection and correction (EDC). Its developers claim the Am2960 "matches or exceeds the performance" of alternative approaches.

The 2960 uses a modified Hamming-code scheme, generating several check bits for each word entering memory. The check bits are stored with the data word and retrieved when the data is called out. As data is transferred from memory, the 2920 uses the extra bits to detect errors; these bits contain enough redundant information to "correct all single-bit errors and to detect all double-bit and some triple-bit errors," explains Geoff Tate, AMD's product marketing manager for bipolar microprocessors. The chip also "detects the gross error conditions of all 0s or 1s."

Tate claims that use of the 2960 "boosts system reliability by a factor of 60 or better." Since "the new 64-K RAMs have error rates about five times higher than 16-K dynamic MOS RAMs" due to soft errors induced by alpha particles, such compensation is vital. EDC "adds about 5% to overall systems cost," he says, "but field maintenance savings alone could cover this cost."

The 2960 is a 16-bit expandable EDC unit flexible enough to handle words 8 to 64 bits wide. It is microprogrammable and operates in modes suitable for mainframe, minicomputer, or MOS microprocessor applications. It works with systems based on AMD's 2900 bit-slice microprocessor family, as well as with Z8000 16-bit microprocessors. For the latter, the EDC unit will be available as the AmZ8160. Although the chip takes, typically, 25 ns to detect errors and 40 ns to correct them, "such timing is well within the MOS microprocessor memory-cycle timing budget," says Tate.



Save bits. The number of check bits required depends on word width: 5 check bits are used for 8-bit words, for instance, and 8 check bits are used with 64-bit words. Tate cites two ways of reducing the number of check bits required: first, "sacrificing the ability to detect all double-bit errors saves 1 check bit per word"; the second way "is to make your memory word wider than your system data word." By storing a 32-bit word in memory, only 7 check bits are needed (22% memory overhead), as compared with 6 check bits for storing 16-bit words (37% overhead). This does, of course, add to the complexity of the memory control logic.

In 32- and 64-bit configurations, two to four 2960s replace more than a board of logic, according to Tate. Further external logic is avoided by the chip's built-in latches for both data and check bits. Other features include initialization, byte-wide write enabling, and diagnostics.

Following power-up, system memory will contain random bit patterns with check bits that do not match the data bits. The 2960's initialization feature forces the data-output

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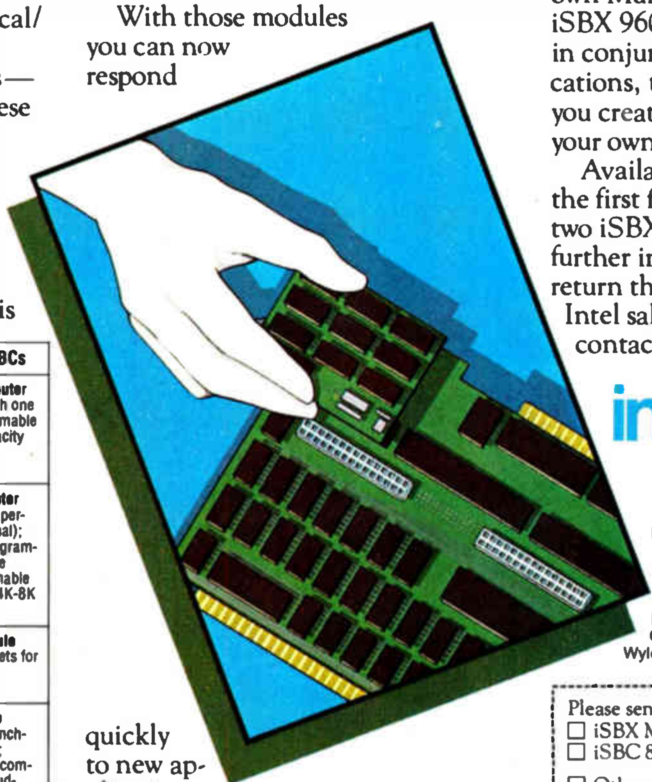
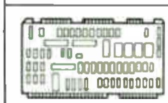
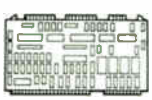
The new Multimodule family

Multimodules represent a whole new family of plug-in expansion boards. They allow you to add a variety of special performance features to your existing iSBC system. Currently available add-ons are shown below. Soon you'll also be able to add other Multimodules for D-to-A and A-to-D conversion, communications, peripheral interfaces—and more.

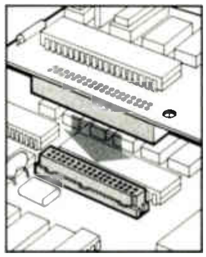
With those modules you can now respond



quickly to new applications opportunities. Examples? Take data acquisition or industrial control: to add extensive I/O processing power, you simply plug in the iSBX 350 board. Or consider communications networks. Now there's no need to add entire USART boards; just use the iSBX 351 unit. In laboratory control applications, instead of an independent math processor, now you can choose the more economical iSBX 331 or 332 math modules.

New Multimodules and iSBX Bus-compatible iSBCs	
	**iSBC 80/10B Single Board Computer** 8080A-based microcomputer with one iSBX bus connector; 48 programmable I/O lines; one USART; timer; capacity for 1K-4K bytes RAM; up to 16K EPROM
	**iSBC 80/24 Single Board Computer** 8085A-2 based microcomputer operating at 4.8 MHz (2.4 MHz optional); two iSBX bus connectors; 48 programmable I/O lines; one USART; three programmable timers; programmable interrupt controller; capacity for 4K-8K bytes RAM; up to 16K EPROM
	**iSBX 350 Parallel I/O Multimodule** 24 programmable I/O lines; sockets for inverting and noninverting transceivers
	**iSBX 351 Serial I/O Multimodule** Programmable synchronous/asynchronous communications channel; standard RS232C or RS449/422 compatibility; software-selectable baud-rate generation; two programmable 16-bit BCD or binary timers/event counters
	**iSBX 331 Fixed/Floating Point Math Multimodule** Fixed point single- (16-bit) and double- (32-bit) precision arithmetic; floating point single- (32-bit) precision functions; floating-to-fixed and fixed-to-floating point conversions; transcendental functions
	**iSBX 332 Floating Point Math Multimodule** Single- (32-bit) and double- (64-bit) precision arithmetic; compatible with proposed IEEE format and existing Intel floating point standard.

New Multimodule-compatible iSBC boards



iSBX 960-5 Connector

Intel's new 8-bit iSBC 80/10B and 80/24 single-board computers are the first of many iSBCs to offer iSBX Multimodule expansion capabilities. Both are improved versions of widely used iSBC boards. (See table).

Custom tailoring, too

For users who want to design their own Multimodule boards, Intel offers iSBX 960-5 connectors. When used in conjunction with the iSBX specifications, this set of connectors lets you create modular boards that meet your own unique requirements.

Available from Intel today are the first four iSBX Multimodules and two iSBX-compatible iSBCs. For further information, or to order, return this coupon or call your local Intel sales office or distributor. Or contact Intel at the address below.

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Please send information on:
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Intel Corporation, 3065 Bowers Avenue, Santa Clara, CA 95051. Telephone (408) 987-8080.

latch to all 0s and generates the correct corresponding check bits for writing into all memory locations just after power-up.

Separate byte-wide enable functions on the data-output latch "greatly simplify byte-write operations,' says Tate, and reduce the time and hardware needed for such operations. The 2960 also has a diagnostic feature that allows it to be checked out under software control.

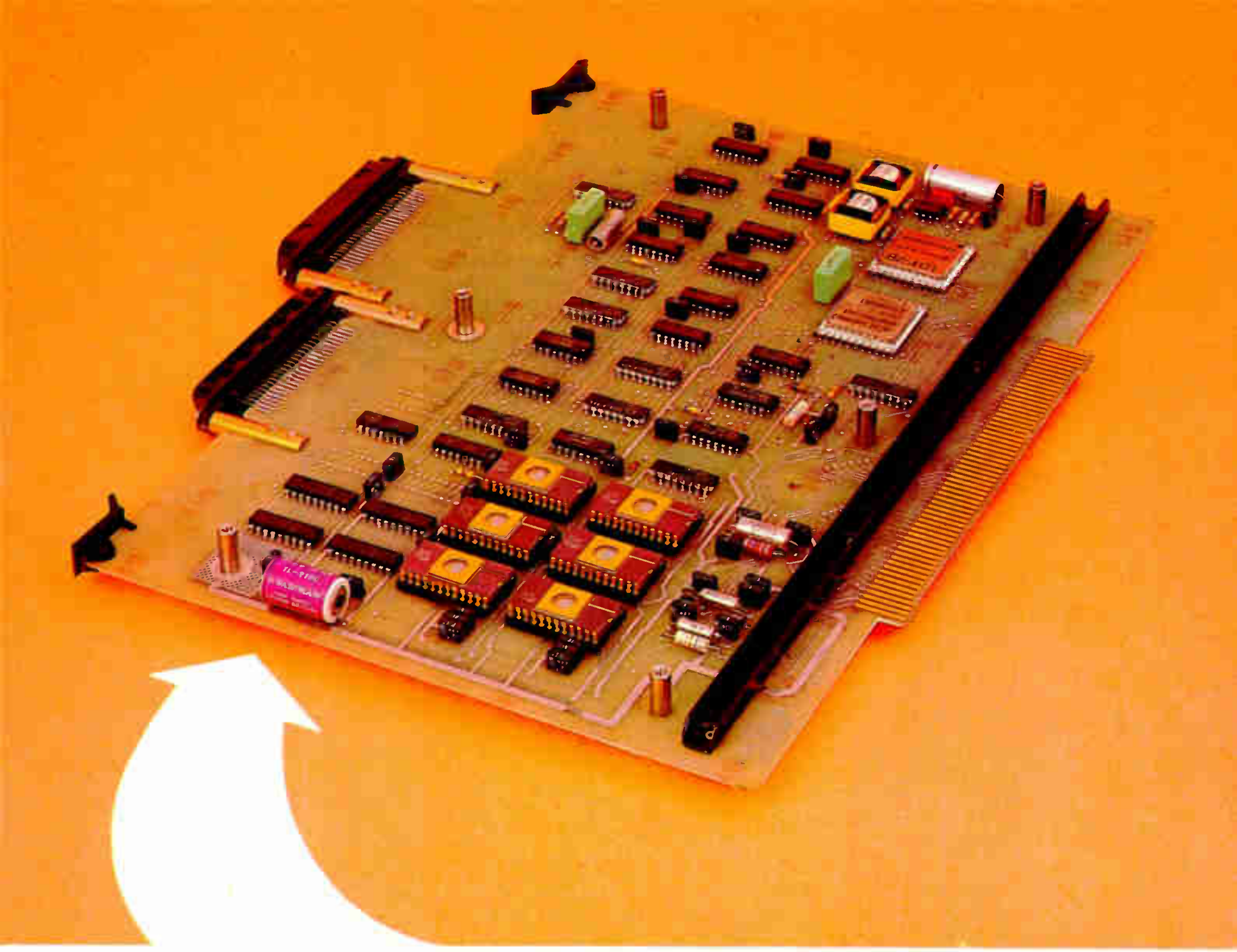
Prevention. Furthermore, the 2960 allows logging of data errors for preventive maintenance through syndrome outputs. Upon detecting an error, the chip "generates syndromes that may be logged for later examination. This allows RAMs exhibiting an increasing intermittent error pattern to be replaced before they permanently fail," explains Tate.

The 2960 can operate in a check-only mode that allows it to protect high-performance systems without slowing them down, taking advantage of the low probability of errors. In this mode the chip monitors the data path and generates an interrupt to the central processing unit if an error is detected. The interrupt typically occurs just 25 ns after bad data appears on the bus. Then the CPU can take the corrective action designated by its designer: automatic correction, write-back to memory, error logging, or diagnostics.

The 2960 is one of a family of memory support chips, all of which are to be available by the end of the year. These include the Am2961/62 4-bit EDC multiple-bus buffers (one inverts signals going to the data bus, the other does not), the Am2964 dynamic memory controller, and the Am2965/66 dynamic RAM drivers (also inverting and noninverting). The family will also be available with parameters characterized for the Z8000.

Housed in a 48-pin commercial ceramic dual in-line package, the Am2960/AmZ8160 costs $96 in quantities of one to nine and $60 each at the 100-piece level. It is available in a military Cerdip package at twice the price.

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086 [340]



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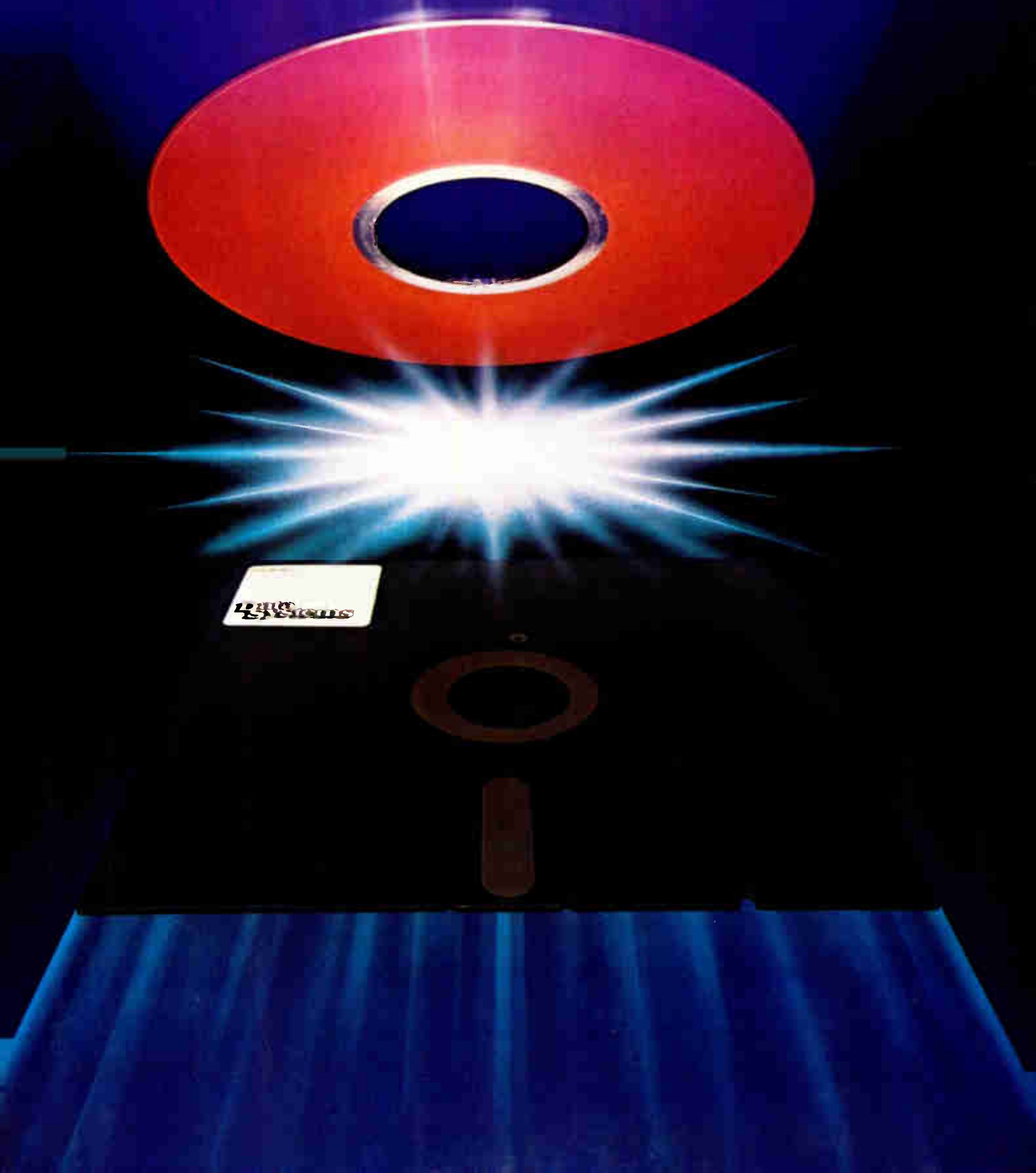

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Circle 181 on reader service card

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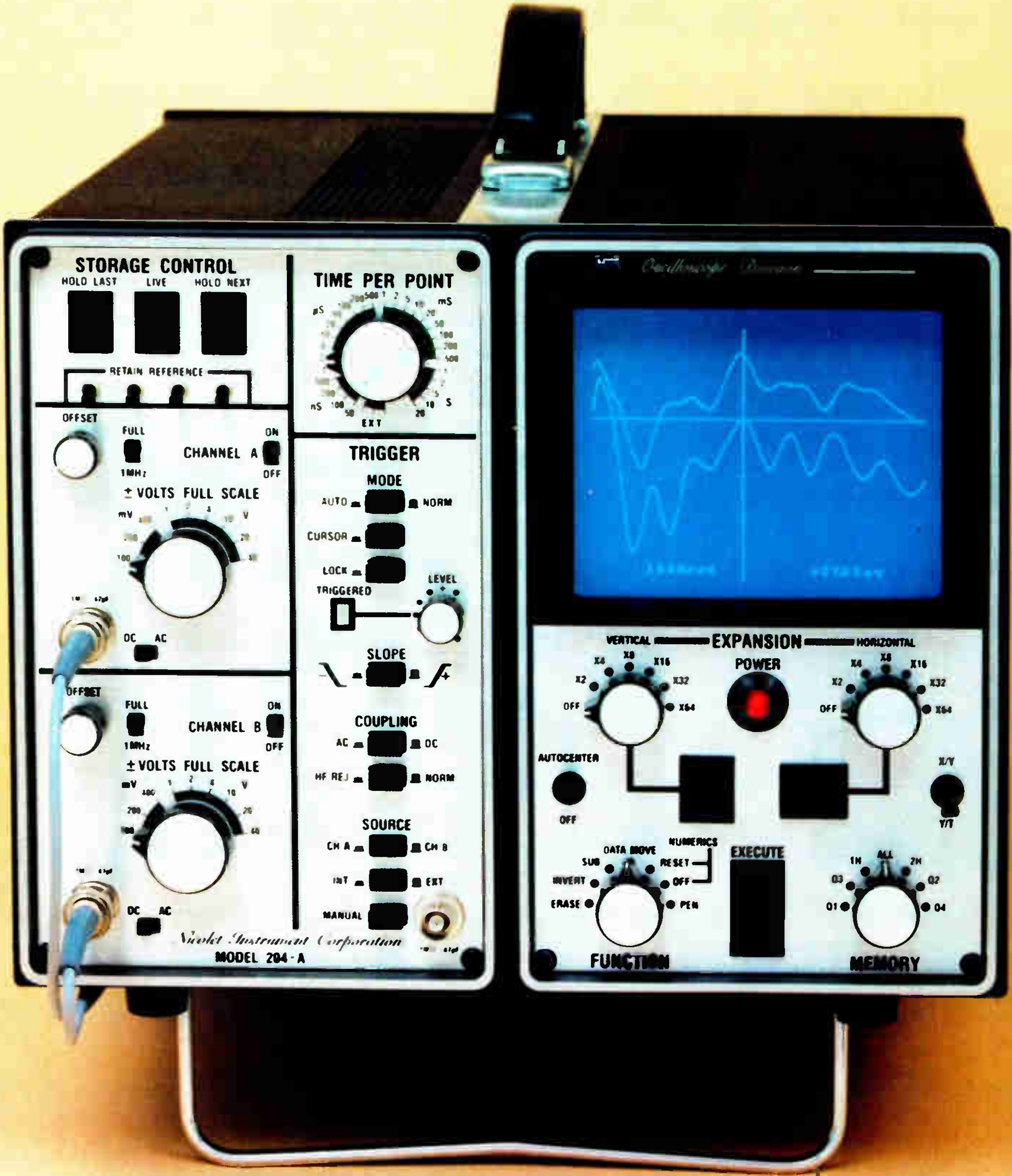

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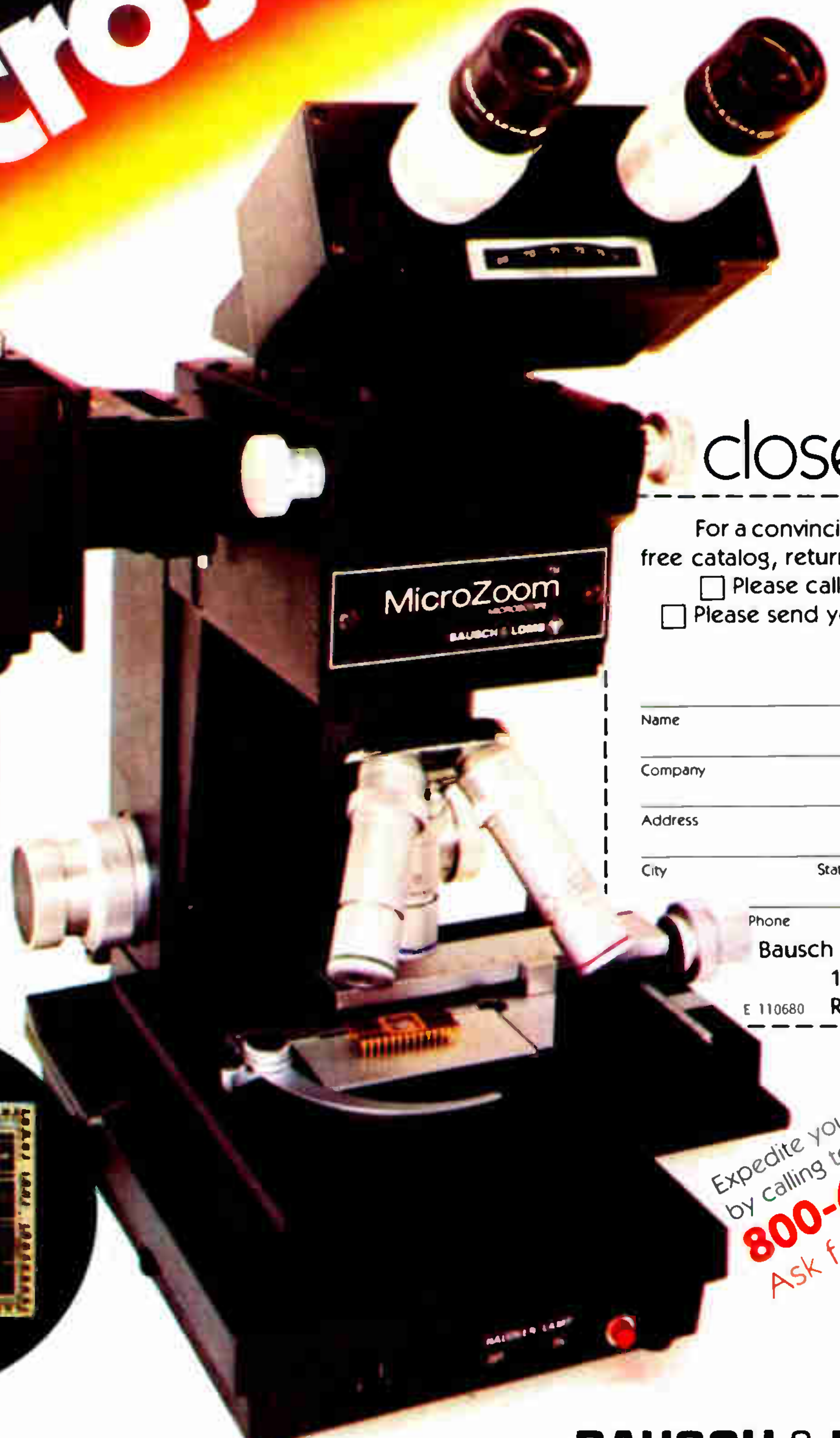

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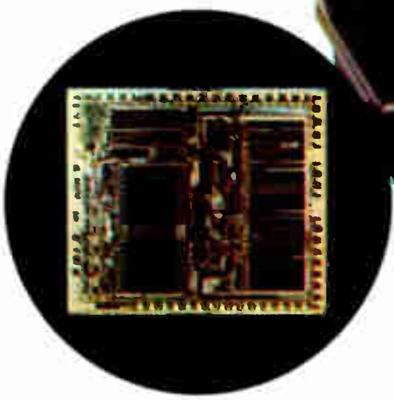


A full ¼″ chip can be viewed at the lowest magnification (22.5X).

Chip photo courtesy of Motorola Corp

BAUSCH & LOMB
Scientific Optical Products Division

Circle 185 on reader service card

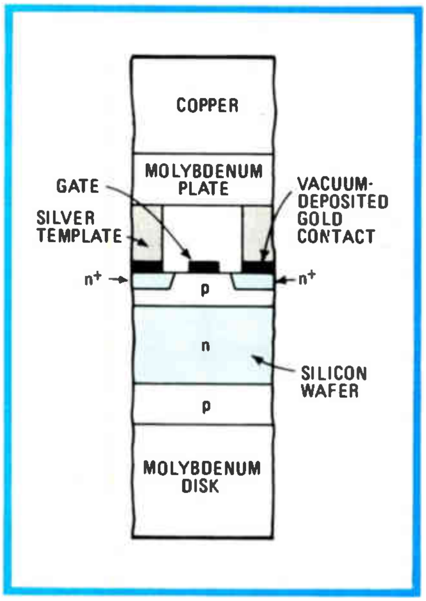
Components

Gate structure cuts SCR losses

Interdigitated gate pattern, cathode contact assembly improve power thyristors

AEG Telefunken has brought a series of high-power inverter thyristors with improved switching characteristics to market in the U. S. Using an interdigitated amplifying gate design, Telefunken says it has been able to reduce switching losses and turn-off times.

The T 505 S, the T 630 S, and the T 930 S are silicon controlled rectifiers in the family. Each part comes in versions whose rates of rise of off-state voltage (measured to DIN 41784) are specified as 50, 400, and 1,000 V/µs, except for the 630, which does not come in a 1,000-V/µs version. The 505 has a DIN rating for rate of rise of on-state current for continuous operation of 400 A/µs; for nonrepetitive operation this figure is 1,200 A/µs. The 630's continuous and nonrepetitive di/dt ratings are 300 and 1,000 A/µs, and the 930's are 250 and 1,000 A/ µs.



Contact. AEG Telefunken's new power thyristors' pressure-contact cathode assemblies use precisely adjusted silver templates with photolithographically etched gate branches.

As for the other major specifications, the repetitive peak off-state and reverse voltages for the 505 range from 600 to 1,400 V; for the 630 and 930 those ranges are 1,400 and 1,600 to 2,000 V (parts rated at the high end of each range are available in limited quantities).

Current names. The on-state current is 1,500 A rms for the 505 and 630 and 2,000 A rms for the 930. The average on-state current gives the devices their names—for the 505, it is 505 A at 85°C and 960 A at 21°C; for the 630 it is 630 A at 85°C and 960 A at 50°C; and for the 930 it is 930 A at 85°C and 1,274 A at 62°C.

The maximum surge current for 10 ms at 45°C is 7,500 A for the 505, 9,700 A for the 630, and 20,000 A for the 930. At 125°C, those current ratings drop to 7,200, 8,500, and 17,500 A, respectively.

The threshold voltage for the 505 is 1.15 V, with a slope resistance of 0.60 mΩ. The 630 has a threshold voltage of 1.25 V and a slope resistance of 0.60 mΩ. For the 930, the threshold voltage is 1.30 V and the slope resistance is 0.33 mΩ.

Prices start at $350; availability is from stock.

AEG Telefunken Corp., Route 22 at Orr Drive, P. O. Box 3800, Somerville, N. J. 08876. Phone (201) 722-9800 [341]

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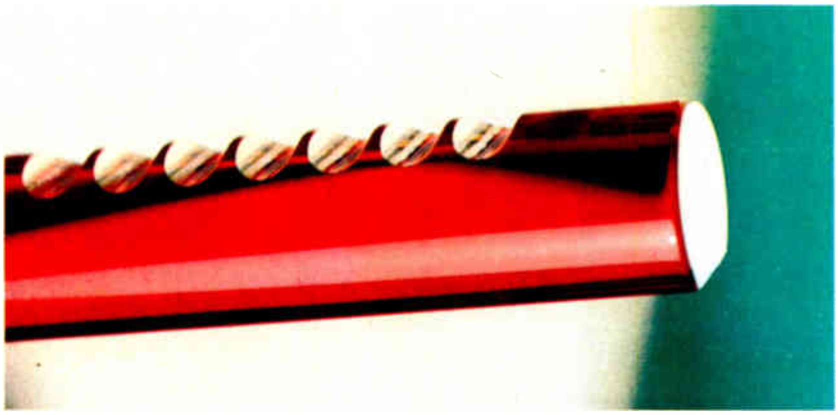

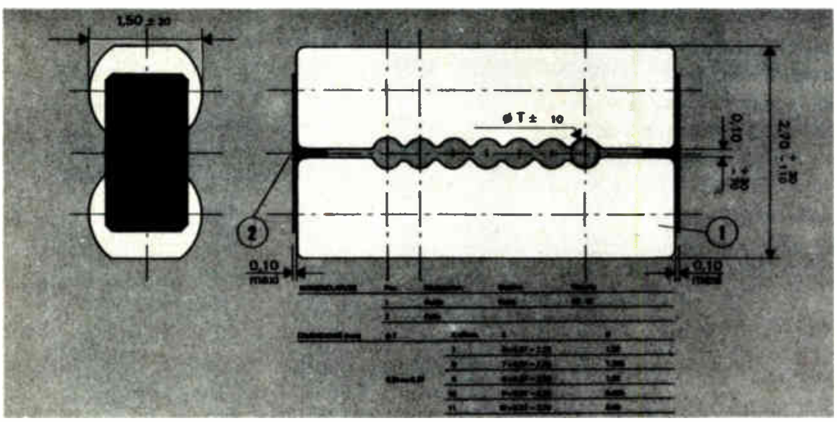

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thin sheets or tubing. The last-named parts have replaceable delay tips to insulate the transducer's face against wear and can be contoured to fit curved surfaces. Immersion transducers, which measure irregularly shaped objects submerged in a liquid, are the fourth type; they are capable of introducing sound waves at any desired angle. Completing the line are angle-beam (shear-wave) transducers, which test parts where contact directly above the flaw is impractical by directing the sound beam away from normal incidence to the entry surface.

All the basic types are available with a variety of connector styles, case and lens configurations, frequencies, and element sizes. The company also offers custom design and engineering services to meet special requirements.

Sonic Instruments Inc., 1014 Whitehead Rd. Ext., Trenton, N. J. 08638. Phone (609) 883-5030 [343]

0.10- to 100-μH inductor chips sell for 75¢ to 99¢

Molded chip inductors priced at 75¢ each in 10,000-piece quantities or 99¢ each in 1,000-unit lots are available with an inductance of from 0.10 to 100 μH, with a typical quality factor (Q) of 50 at 50 MHz. The units are a maximum of 0.11 by 0.11 by 0.10 in. and weigh less than 0.1 g. They all come in welded lead frames and are suited for use in pocket pagers, two-way radios, miniature receivers, and medical electronics.

Vanguard Electronics Co., 930 W. Hyde Park Blvd., Inglewood, Calif. 90302. Phone (213) 678-7161 [344]

4½-digit DPM is instrument-, microprocessor-compatible

Designed to be compatible in microprocessor and instrumentation applications, the series 600 4½-digit panel meter offers a variety of features. It has three-state parallel and multiplexed binary-coded decimal out-

puts, true ratiometric operation, run and hold command input, strobe and busy output, display-blanking and lamp-test inputs, and an output of ±12 V dc at 5 mA. An optional blank board allows the user to add special circuits.

The unit's ranges are 199.99 mV dc and 1.9999, 19.999, 199.99, and 1,000 V dc. Input impedance is 1,000 MΩ for the 200-mV and 2-V ranges and 10 MΩ for all others. Zeroing is automatic, and the 0.5-in.-high red light-emitting diodes have an externally selectable decimal point.

The accuracy of the series 600 panel meter is to within ±0.008% (±1 digit) of full scale. The power input is 5 V dc ± 5%, 300 mA, or 120/240 V ac at 50 to 60 Hz.

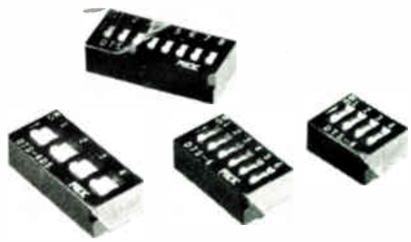
Single units sell for $125 apiece, and delivery is from stock to four weeks.

International Microtronics Corp., 4016 E. Tennessee St., Tucson, Ariz. 85714. Phone (602) 748-7900 [345]

DIP switch comes with tape seal

A factory-applied tape seal is provided on all DTS series dual in-line package switches at minimal cost. For example, a four-pole DIP is only $2.18 in 250-unit quantities. The bottom of the switches is entirely potted to ensure maximum seal integrity. Flux entry during wave soldering is thus prevented and contamination is eliminated, says the manufacturer. The switches provide positive on and off switching action with highly visible flush actuators. Gold plating on contacts and terminals results in extended shelf life and

New products



allows easy soldering.

Alco Electronics Products Inc., 1551 Osgood St., N. Andover, Mass. 01845. Phone (617) 685-4371 [346]

Detector and transimpedance preamp come on one chip

Offering the functions of a photodiode detector and a transimpedance amplifier on the same chip, the MFOD404F integrated detector and preamplifier combines high sensitivity and speed for fiber-optic data communications. The unit will sustain data rates of up to 10 Mb/s over medium distances even with a responsivity of 30 mV/μW. The unit is designed for use with AMP-compatible metal fiber-optic connector barrels, which provide immunity from radio-frequency interference and make it easy to assemble the units into fiber-optic systems.

In quantities of up to 24, the detector-preamplifier sells for $37 per unit, and in quantities of 100 to 499 for $32 apiece. They are available immediately.

Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Ariz. 85036. Phone Jim Herman at (602) 244-4556 [347]

Nichicon aluminum vs. tantalum

An apples-to-apples comparison for quality, reliability and size.

When you have a production line to keep running, performance levels that can't be compromised and you're faced with soaring tantalum capacitor prices and overextended lead times, it's time to turn to Nichicon.

An apples-to-oranges comparison for price, availability and delivery.

Axial and Radial Low Leakage Series

Start saving with Nichicon's Low Leakage Series of Axial and Radial Miniature Aluminum Electrolytic Capacitors. They're available now from your local Nichicon distributor, and they give you tantalum-like performance over a capacitance range of 0.1μF to 100μF. And you'll get low-leakage reliability of only 0.002CV or 0.4μA from $-40°C$ through $+85°C$.

Super Miniature 4mm Radial Series

When super miniature size is just as critical as low-leakage performance and reliability, it's time to consider Nichicon's 4mm Super Miniature Radial Series. Samples are available now in a capacitance range from 0.1μF through 47μF.

So why put up with tantalum prices and lead times when we give you performance, super miniature size, quick delivery and savings to 40%.

Call your local Nichicon representative or distributor or write us for data sheets and samples.

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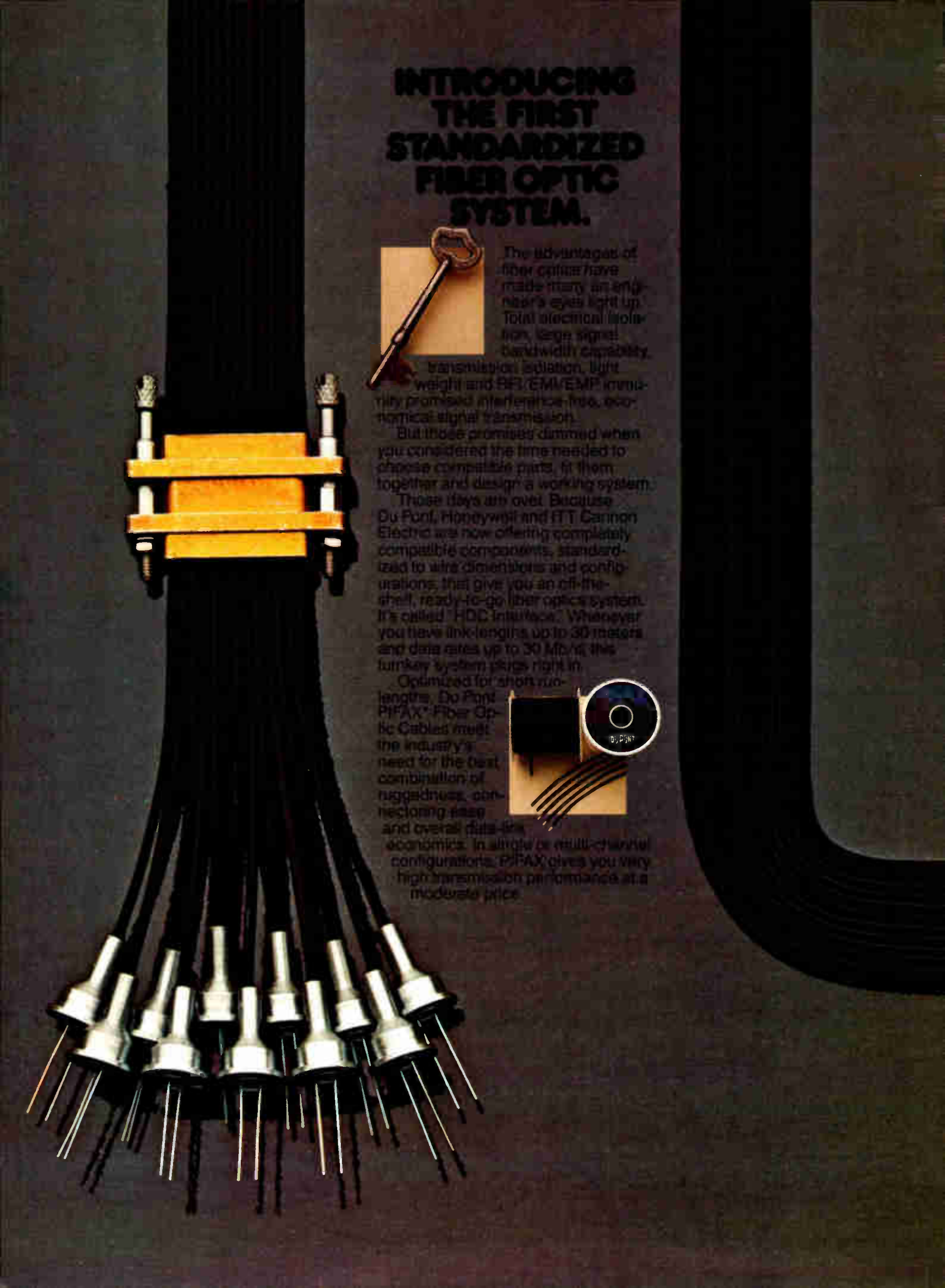
Division of Nichicon Capacitor Ltd., Kyoto, Japan

Circle 193 on reader service card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The advantages of fiber optics have made many an engineer's eyes light up. Total electrical isolation, large signal bandwidth capability, transmission isolation, light weight and RFI/EMI/EMP immunity promised interference-free, economical signal transmission.
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Those days are over. Because Du Pont, Honeywell and ITT Cannon Electric are now offering completely compatible components, standardized to wire dimensions and configurations, that give you an off-the-shelf, ready-to-go fiber optics system. It's called "HDC Interface." Whenever you have link-lengths up to 30 meters and data rates up to 30 Mb/s, this turnkey system plugs right in.
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Powerful SWEET SPOT ** LEDs from Honeywell Spectronics Division intensify LED output to launch more power into large diameter fibers than other low-cost LEDs. Now this technology has been repackaged for use in a low-cost, high volume fiber optics system. You get a wide selection of optical detectors and the most practical opto-mechanical interface available.
SPECTRONICS
From ITT Cannon come multichannel connectors that let you use both electrical and fiber optic lines simultaneously. When space is limited there's the miniature line with densities capable of contact spacing down to .050 centers. Available soon are adaptations for other standard Cannon connectors in the D Subminiature, environmental and military lines.
So let fiber optics become standard equipment in your system.
Whenever you need a data link for short distances in applications ranging from medical instrumentation to control equipment, we'll supply the system in one easy installment. To help you get information about HDC interface and to make ordering easy, contact Fiber Optics Product Manager, ITT Cannon Electric, a division of International Telephone and Telegraph Corporation, 666 E. Dyer Road, Santa Ana, California 92702. Telephone (714) 557-4700. TWX: 910-595-1131. TELEX: 65-5358.
*DU PONT TRADEMARK
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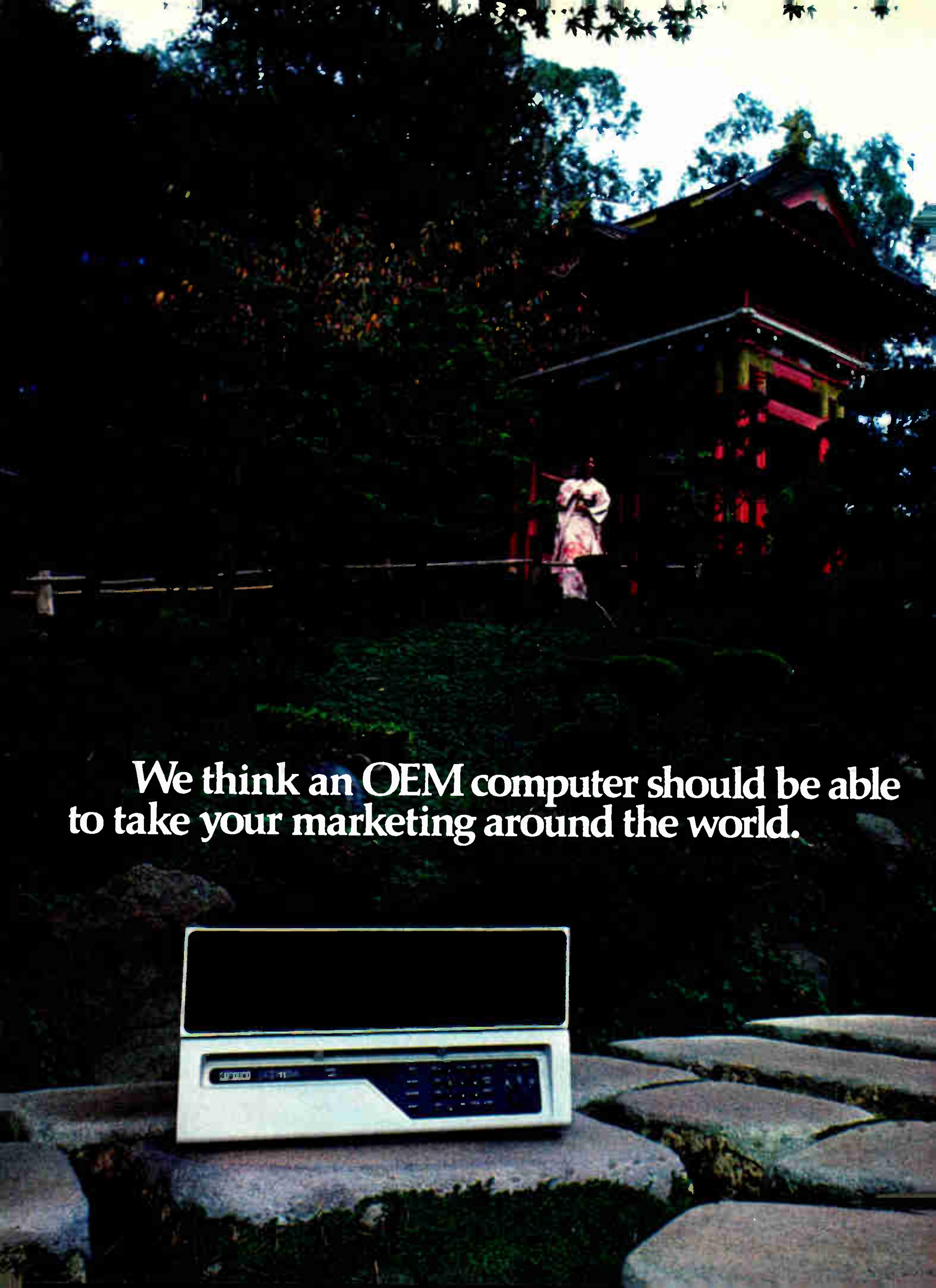
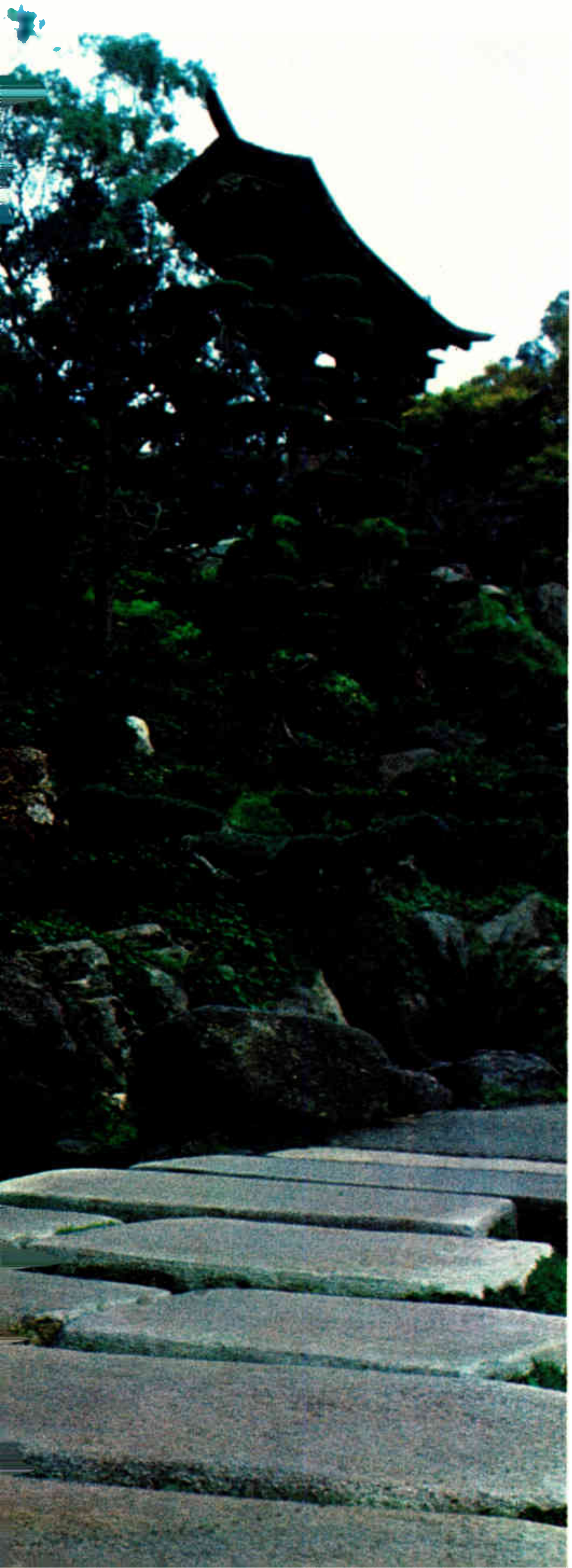
You can always connect with Cannon
Circle 195 on reader service card


We think an OEM computer should be able to take your marketing around the world.



At Digital, we think the last thing an OEM computer should do is limit your options.

Not just your performance options.

But your marketing options too.

That's why we make computers that you can add value to, and then sell virtually anywhere.

They're available with features like a universal power supply that will work from any electrical current in the world at the flick of a switch.

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At Digital, our approach has always been to give OEMs more than just great product. Just as important are the extra quality features, the extra testing that can make your design and marketing job easier. The software compatibility that can take you from micros to 32-bit large-scale computers, from one generation to the next. The worldwide service capability that can be tailored exactly to the way you run your business. It's an approach designed to help you meet a wide range of computer strategies.

You probably already know a lot about Digital performance. To find out the rest, send for our new brochure, "The Thinking Behind the Industry's Largest Selling Line of OEM Computers."

Digital Equipment Corporation, (PK3/M-86), Maynard, MA 01754. (617) 493-6253. In Europe: 12 av. des Morgines, 1213 Petit-Lancy/Geneva. Tel. 93 33 11. In Canada: Digital Equipment of Canada, Ltd.

We build a lot more than performance into an OEM computer.

digital

Circle 199 on reader service card

Computers & peripherals

16-bit terminals store 60-K bytes

Intelligent work stations have microNova processor, up to 716-K bytes on diskette

Aimed at original-equipment manufacturers and sophisticated end users, Data General's new MPT family of intelligent work stations should give the firm a stronger foothold in distributed data-processing applications. The company's former top-of-the-line terminals, the Dasher series, were not "dumb," but they weren't this smart. The MPTs are based on Data General's proven microNova processor. Compatible with all the firm's central processors, including the recently announced 32-bit Eclipse MV8000 [*Electronics*, May 8, p. 185], the new terminals can also stand alone.

The local intelligence offered by the MPTs allows them to capture and validate data on site; host-system resources need not be tapped, local files can be stored independently, and local error checks cut host overhead and keep data cleaner.

Off-line storage is the only factor that sets the three terminals apart. The $4,800 MPT/80 has none, the $6,000 MPT/83 comes with one double-sided, double-density diskette; the $7,100 MPT/87 comes with two. The /83 and /87 offer 358- and 716-K bytes of storage, respectively.

All three MPTs include a full 16-bit microNova central processor with 60-K bytes of MOS random-access memory (partially used for display refreshing), two programmable RS-232-C ports, and an external input/output bus. The full complement of electronics is mounted on a single large circuit board.

The RS-232-C ports allow two-way data transfer at up to 19.2 kb/s; they can be used to drive printers, to allow downloading of software from remote hosts, or to perform general data transfer.

The MPT's I/O bus allows it to interface with virtually all microNova peripherals, including 1.26-megabyte flexible-disk drives, Winchester disk drives, data-acquisition and sensor systems, and an expansion chassis. Users can load the expansion chassis with an asynchronous line multiplexer, and through it, cluster other MPT or Dasher terminals around a central MPT. Thus an MPT can act as the equivalent of a cluster controller.

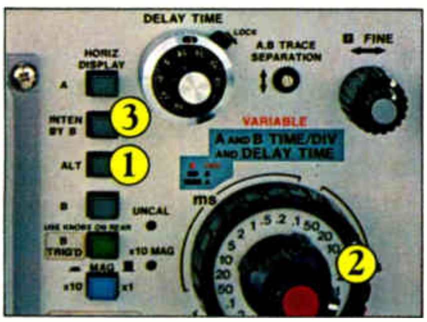
The consoles each use a 12-in. cathode-ray-tube display and include an 83-key keyboard with 10 user-defined function keys. In addition to a standard ASCII character font, additional fonts stored in read-only memory are available for international symbology tailored to applications in Britain, France, Sweden,

No other 50-MHz oscilloscope gives you as many features as the LBO-517.

It's the surprising leader for under $2000.

Compare the LBO-517 with all other 50-MHz oscilloscopes. Only Leader gives you total capability with:

- **Calibrated delayed time-base**
- **Simultaneous display of main and delayed time-bases.**
- **Two trigger-view channels.**
- **1 mV sensitivity (<10-MHz).**
- **Alternate/composite triggering.**
- **Variable trigger hold-off with B-ends-A mode.**
- **20 kV accelerating potential dome-mesh CRT.**
- **Two-year warranty.**



Very low-level signals, complex waveforms, fast pulses at low rep rates, asynchronous signals... no other 50-MHz oscilloscope handles such a wide range of demanding applications, and does it so well as the Leader LBO-517.

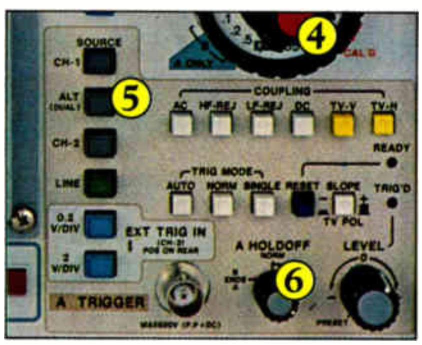
Simultaneous Dual Time Base Viewing.

Unlike many other 50-MHz units, the LBO-517 has an alternate time-base mode, (1) above. This permits simultaneous viewing of both the main "A" and delayed "B" time bases (2). The delayed time-base is also shown as an intensified portion of the main time-base display (3). Ideal for studying and measuring complex waveforms.

Fast Sweep Rates, Alternate Triggering, Hold-off and B-ends-A Mode.

The LBO-517 provides main sweep rates from 0.5 sec/cm to 0.05 μsec/cm in 22 steps (4). Delayed sweep rates are from 0.1 sec/cm to 0.05 μsec/cm in 20 steps. For displaying very rapid phenomena, both can be increased to 5 nsec/cm with the X10 magnifier.

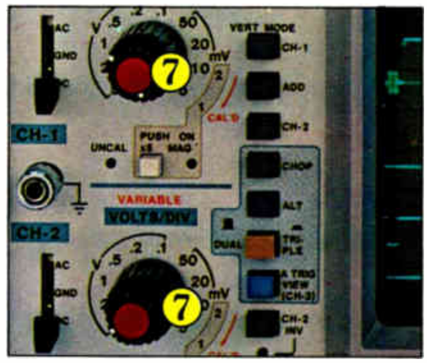
The LBO-517 also offers alternate (composite) triggering (5) for stable viewing of two asynchronous signals, along with variable trigger hold-off with a B-ends-A mode (6). Variable hold-off ensures stable triggering of complex signals by ignoring intermediate false trigger points. B-ends-A is used to increase the sweep repetition rate for brighter displays of low-frequency signals.



Outstanding Small Signal Performance.

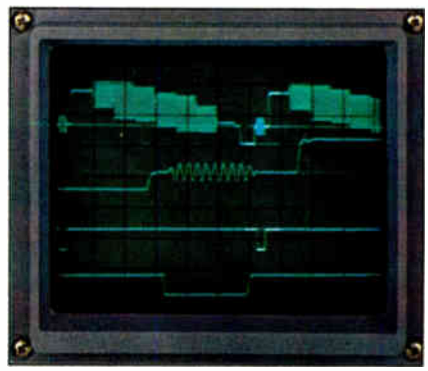
The vertical amplifiers of the LBO-517 offer calibrated deflection coefficients from 5 mV/cm to 5 V/cm in 10 steps (7). A X5 vertical multiplier delivers a maximum sensitivity of 1 mV/cm up to 10 MHz... 5 times the sensitivity of more expensive oscilloscopes.

An amplified output of channel 1 is also available at a rear panel BNC connector for using the LBO-517's high sensitivity to drive frequency counters and other less sensitive instruments.



Brightest, Sharpest of All.

The LBO-517 uses a recently developed dome-mesh CRT operating with a 20-kV accelerating potential. The result is an exceptionally bright, sharp display... with an illuminated internal graticule.



Call Toll Free (800) 645-5104.

Call today, to get all the facts on the LBO-517, its two-year warranty, the name of your nearest "Select" distributor, or to arrange for an evaluation unit.

When Quality Counts

LEADER Instruments Corporation

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Circle 201 for product literature

Circle 230 for product demonstration

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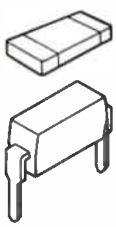
Unitrode makes monolithic ceramic capacitors in volume that stand above the crowd. In reliability. And in delivery.

So now, you can get the most reliable caps with the most reliable delivery, from a company committed to performance.

In fact, we have the world's most modern capacitor plant, so we can produce quality capacitors in the quantities you need.

Unitrode's caps come in three forms, Chips, Axial-Leaded, and 2-pin DIP. Every NPO, X7R and Z5U capacitor we make is tested for capacitance and dissipation factor before it goes out the door. Our leads are tested to eight pounds pull. And our proprietary process controls maintain the integrity of terminations and minimize delaminations and corner cracking.



This kind of quality control pays off. For example, in over three billion glass seals, we've had less than .1% returns.

Unitrode also outperforms the others in delivery. So instead of delivering promises, we deliver capacitors. At very competitive prices.

So when it comes to caps, come to Unitrode. For more information, contact your nearest Unitrode representative listed next to this ad. And find out why our commitment stands head and shoulders above the rest.

Unitrode Corporation,
5 Forbes Rd., Lexington, MA 02173, U.S.A. Telex 95-1064, TWX 710-326-6509.

UNITRODE

Germany, Spain, and Denmark.

The units execute a run-time version of the microNova MP/OS multitasking operating system. Because MP/OS is compatible with Data General's Advanced Operating System (AOS), users can develop and debug programs for MPT work stations on any Data General computer. Software already available for the MPTs includes Pascal (with extensions allowing structured programming, string manipulation, an assembly-language interface, and access to operating system routines) and Fortran IV. The latter is aimed at real-time applications and those using double-precision and mixed-mode arithmetic.

Other software includes power-up self-diagnostics, a Dasher-D200 terminal emulator, file-transfer programs, and a variety of other file- and disk-related routines. Available utilities can customize screen-menu and access-security features without reprogramming applications software. This feature allows quick response to changing I/O needs and flexibility in the OEM marketplace.

Data General also expects the MPTs to open slots for its central-processor line. Users tend to expand their needs for local intelligence, the company claims. So the MPT's compatibility tailors it to applications with upward growth potential.

Delivery of the intelligent terminals takes 90 days.

Data General Corp., Route 9, Westboro, Mass. 01581. Phone (617) 366-8911 [361]

Color graphics computer uses 68000 central processor

The model CGC 7900 high-resolution color graphics computer, priced at $19,995 without options, is driven by Motorola's MC68000 16-bit central processing unit, which is capable of 32-bit operations. The computer has a 19-in. color cathode-ray tube with 1,024-by-1,024-bit graphics memory that can display a maximum array of 256 colors at one time. The 53-in.-high, 22-in.-wide, and 34-in.-deep computer contains the CRT, CPU, floppy-disk drives, and keyboard and can accommodate an optional 10-megabyte Winchester disk drive.

An overlay mode permits alphanumeric characters or graphics to be overlaid on a bit-map display that is totally unaffected by the roll, pan, or zoom of the underlying image.

The screen can be divided into eight graphic windows, with eight additional overlay windows. A dual-screen buffer option gives the 7900 the ability to hold a second full-screen display in memory while another is on the screen. For additional cursor control, there is an optional joystick for zoom, X-Y pan, and cursor positioning. Other options include a light pen and a real-time clock. RS-232-C and RS-449 serial communications ports will be available for interfacing the 7900 with host computers. Deliveries will begin in 120 days.

Chromatics Inc., 2558 Mountain Industrial Blvd., Tucker, Ga. 30084. Phone (404) 493-7000 [362]

Entry-level computer works as store-and-forward terminal

Digital Equipment Corp.'s Datasystem 315 can be used as an entry-level small business computer, a network node, or a store-and-forward terminal. Using the PDP 11/23 microcomputer, the 315's base memory is 64-K bytes (expandable to 256-K bytes). The system includes a video terminal and a dual double-density floppy-disk drive for 1 megabyte of mass storage. It is available with either the commercially oriented CTS-300 operating system or the RT-11 general-purpose operating system and with a choice of six programming languages, including Fortran IV, Basic, Focal, and APL. It can be used for real-time applications. The system can support additional peripherals—another dual floppy-disk drive and more terminals—and a communications interface.

The Datasystem 315 with the CTS-300 operating system and a

New products

printer starts at $17,600 with full support. Deliveries start this month.

Digital Equipment Corp., Maynard, Mass. 01754. Phone 897-5111 [363]

Multifunction work station is first of computer cluster

The Convergent model CT-1111-1, the first in a series, is a single desktop work station with a 1-megabyte dual floppy-disk drive in a cabinet at deskside. The full line ranges to a cluster of 16 such stations with a shared-resource processor, 58 megabytes on a 14-in. Winchester disk drive, and one floppy disk—what the manufacturer considers is the memory capacity and processing power of a large minicomputer installation.

The Convergent family features a fully programmable video display, five programming languages (assembly, Basic, Pascal, Cobol, and Fortran), the CTOS operating system, a dual-bus architecture for easily expandable hardware, an optional Intel 8087 mathematics processor, and complete software portability between the work stations. Single unit prices begin at $11,990 for the CT-1111-1. When the 16-unit cluster is available the second quarter of 1981, it will sell for $133,500. Basic work-station hardware without mass storage or operating system software has a 100-unit price of $3,990.

Convergent Technologies, 2500 Augustine Dr., Santa Clara, Calif. 95051. Phone (408) 727-8830 [364]

System processes both words and data

A low-cost information-processing system called Spectrum 80 has been designed to handle both word and data processing. The system centers around a File Management Computer that manages and schedules all resources. Its price of $6,790 includes the central processing unit, 64-K bytes of system memory, a 2-megabyte fixed disk drive, and a 1.2-megabyte diskette drive. A choice of

LOOK WHO JUST JOINED FORCES.

Now you can look to a single quality source for three families of components. Because now, along with our Cutler-Hammer Commercial Switches, we offer Crystaloid Liquid Crystal Displays and Compu-Lite Illuminated Pushbutton Switches.

Crystaloid Liquid Crystal Displays offer state-of-the-art technology in both standard and custom LCD's. What's more, we have the design capability to meet the most demanding requirements—especially for matrix and multiplexed display applications.

Compu-Lite Illuminated Pushbuttons feature momentary or alternate action, 1 to 4 poles, and can be panel or PC board mounted. Matching indicator lights are available.

Cutler-Hammer Commercial Switches deliver rugged reliability and long life. You can choose rockers, toggles or pushbuttons in standard, miniature and sub-miniature versions.

For more information on these products or engineering assistance for specific applications, write Eaton Corporation, Commercial Controls Division, 4201 N. 27th St., Milwaukee, WI 53216.

EATON Electrical/Electronic Control

Circle 205 on reader service card

InfoCenters is offered—one each for data, word, and information processing. The Data Processing InfoCenter is a work station designed to handle general accounting functions. It consists of a Multifunctional Processing Computer (MPC) with a 12-in. screen, 64-K-byte memory, and printer. It sells for $9,200. The Word Processing InfoCenter has an MPC with a 15-in. screen, 64-K bytes of memory, and a printer, all for $10,690. The Information Processing InfoCenter, priced at $11,150, allows concurrent word and data processing. It has an MPC with a 15-in. display, 64-K bytes of memory, printer, and word-processing software.

Management Assistance Inc., Basic Four Information Systems Division, P. O. Box C-11921, Santa Ana, Calif. 92711. Phone (714) 730-2315 [365]

Fixed-disk drives store 2.5 billion, 571.3 million bytes

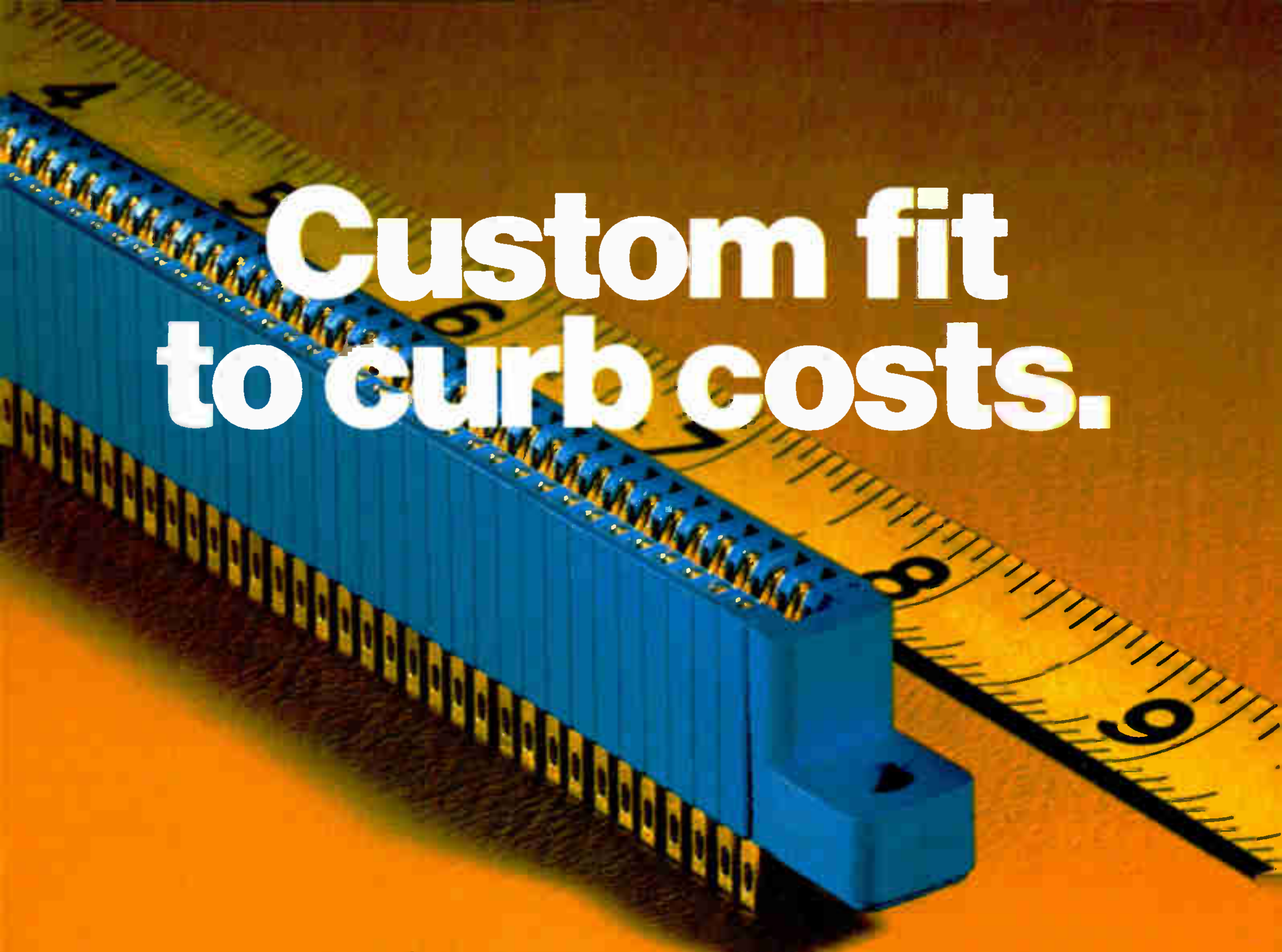
The STC 8380 and STC 8370 direct-access storage devices are fixed-disk drives that can hold 2.5 billion bytes of data and 571.3 megabytes respectively.

The 8380 is fully compatible with IBM's 3380 disk drive and may be attached to the equivalent of any IBM 370/158, 370/168, or 303X processor. Data-transfer rate is 3.0 megabytes/s, and average seek time is 16 ms.

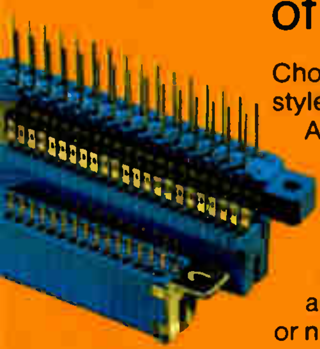
The other unit, the 8370, is compatible with IBM's 3370 disk drive and requires no software migration from that drive. Transfer rate is 1.86 megabytes/s, and average seek time is 20 ms. The STC 8370 will range in price from $25,270 for a basic model to $46,330 for one equipped with all options. It is scheduled for delivery in the fourth quarter of 1981. The STC 8380, scheduled for the second quarter of 1982, will range in price from $79,380 for a basic drive to $139,630 for a fully equipped drive.

Storage Technology Corp., 2270 S. 88th St., Louisville Colo. 80027. Phone (303) 497-5151 [369]

Custom fit to curb costs.



Pay only for what you need with Amphenol® 225A Series Edge Connectors. Because there are thousands of combinations.



Wire wrappable
Solder eyelet
Dip solder

Choose the contact type, position, mounting style. Pick any of three different contact tails.

And tell us how many contacts you want—up to 85 per side. That's custom fitting for you. And the end of too-long, too-late, too-costly connectors.

Contact tails are solder eyelet, dip solder, or wire wrappable. Mounting styles are standard foot, stepped foot, metal foot, or no mounting provision at all. Order the 0.100″ contact spacing and get up to 85 contacts per side. Order the 0.156″ contact spacing and get up to 50 contacts per side.

The 225A Series also has full bifurcated contacts to compensate for warped P.C.B.'s and to improve reliability.

Customized free sample available by contacting the closest distributor listed below.

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Circle 207 on reader service card

See for yourself why design engineers specify more CTS cermet resistor networks than any other make.

There is one large overriding reason. Reliability!

Each CTS SIP and DIP network is 100% value and tolerance tested before shipment. And, with more than 1 billion element hours of extended load life testing, CTS resistors have exhibited a failure rate of only 0.00047%/1,000 hours @ a 95% confidence level.

CTS networks are built reliable...using top quality materials, precision screening equipment, proprietary cermet formulations and computer controlled lasers for fine tolerance adjustment. Terminals are anchor-locked into the substrate for maximum mechanical and electrical reliability.

CTS has been a leader in custom designed circuits for over 15 years. Ask us about customizing your special network requirements or choose from 400 standard part numbers available off the shelf from authorized CTS distributors.

For the utmost in cermet network reliability, quality and availability, you can't choose a better network source than CTS. Send for your free samples and resistor network catalog today. Write CTS of Berne, Inc., 406 Parr Road, Berne, Indiana 46711. Telephone: (219) 589-8220.

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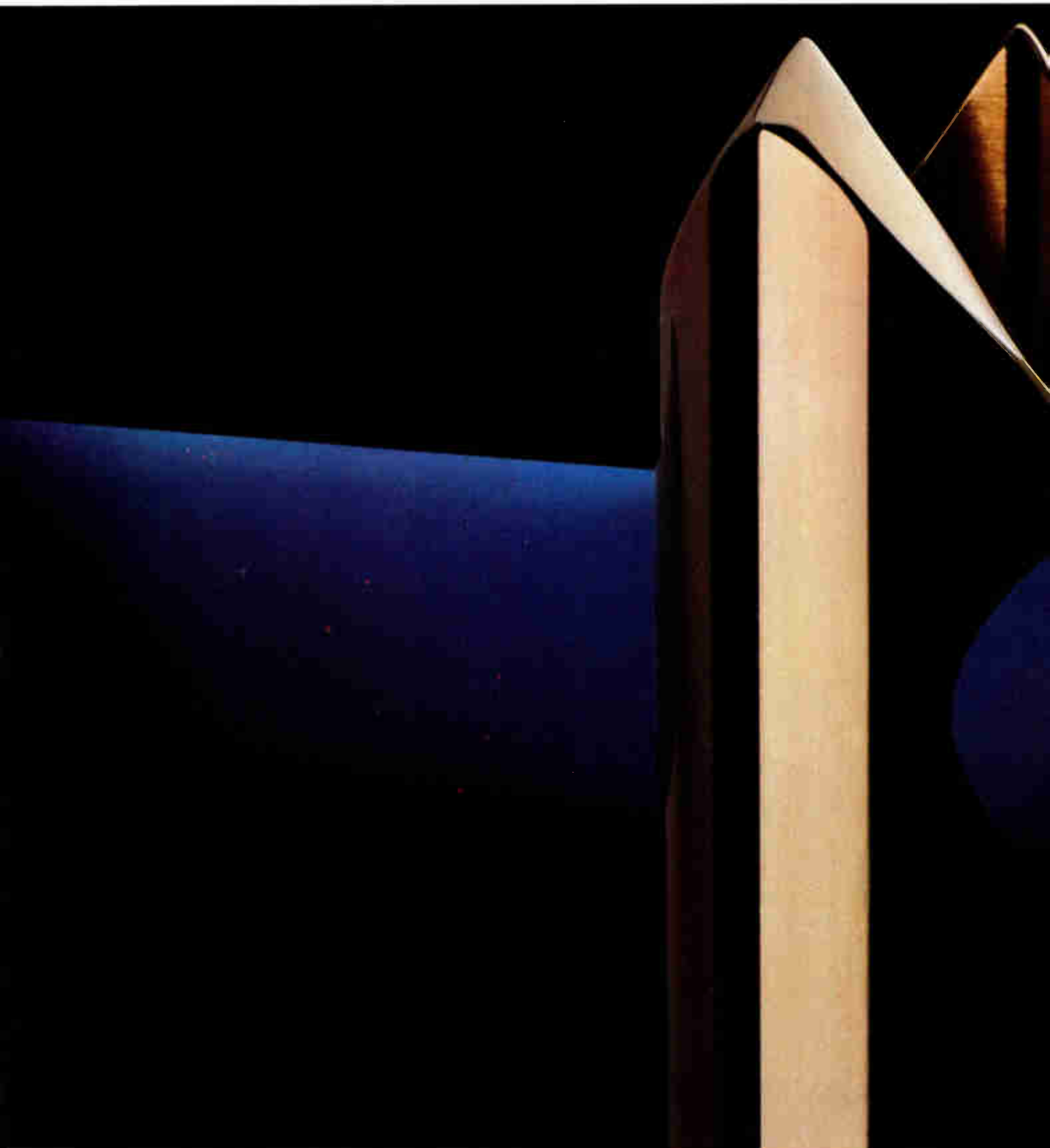
You either have it,



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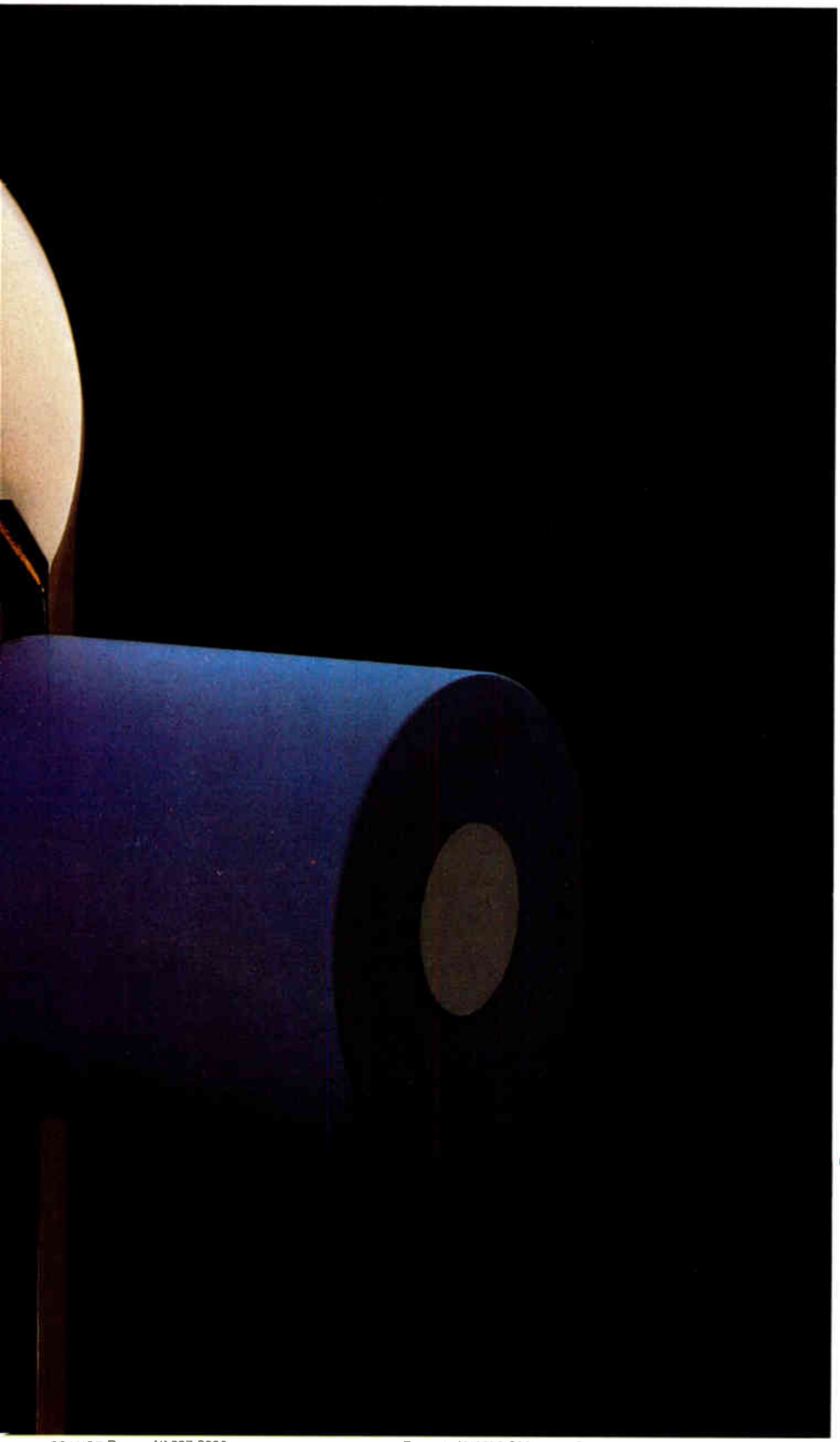
or you don't.



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Circle 211 on reader service card


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Instruments

System emulates 35-ns memory

Bit-slice development system has 80-bit trace, allows unlimited use of breakpoints

The DS 500 bit-slice microprogramming development system aims to compete with Advanced Micro Devices' popular system 29 by improving upon it. One improvement, points out Bjorn Dahlberg, president of Hilevel Technology, is that the DS 500 uses a 4-MHz Z80 microprocessor as its central processing unit, rather than the 2-MHz 8080 used in the AMD system.

Another is that the DS 500 has a unique unlimited-breakpoint feature. It offers simultaneous and independent arming, as well as either conditional or unconditional breaking or triggering on any number of addresses within an 8,192-address space.

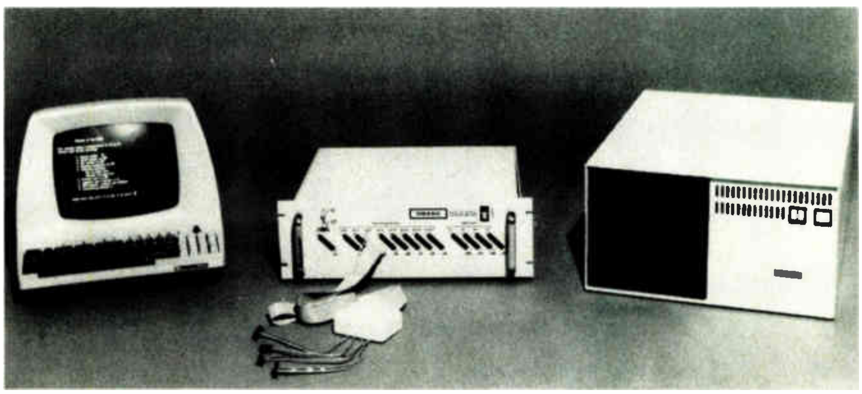
This feature allows the designer to "mask off" subroutine loops from the tracing procedure so that he may trace only the activity before and after the execution of a given loop. The ability to analyze the activity within a loop using normal triggering features is also included. The unlimited breakpoint capability also allows several different loops, located at nonconsecutive addresses, to be masked off.

The DS 500 makes available a full 64-K bytes, expandable to 128-K bytes, for assembly. In the read-only memory emulation mode, the DS 500 also has a slightly faster access time than that provided by the random-access memories used in the AMD System 29. The DS 500 uses RAMs with an access time of 20 ns, giving a total access time of 35 ns to its system memory. This compares with a 48-ns access on the standard AMD system, although the same fast RAMs used in the DS 500 system could potentially be installed in the AMD system.

The logic trace feature of the DS 500 is 80 bits wide, as are those from AMD and Step Engineering [*Electronics*, Sept. 11, 1980, p. 218]. The depth of its trace, however, is 1-K word, compared with 256 words for the AMD and Step Engineering development systems.

The DS 500's tracing functions have a high maximum rate—20 MHz. Two external event break/trigger inputs on the trace feature can also capture glitches as narrow as 8 ns and, after recognizing the glitch, invoke and independently trigger or arm the trigger.

Logic compatibility. Although TTL compatibility is standard on the DS 500, the company will also provide options for interfacing with an emitter-coupled-logic system. The company will also accommodate designers of systems using programmable ROMs by providing them with three-state logic or open-collector inputs and with registers, if needed, ranging in capacity from 1 K to 32 K. The maximum width of the standard DS 500 word is 128 bits, although the company is willing to support words



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Circle #119 for more information
Circle #215 for a demonstration

Circle 216 on reader service card

that are up to 480 bits wide.

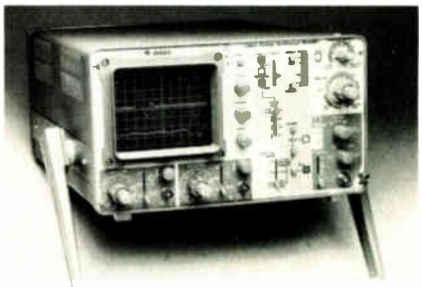
The DS 500 runs a meta-assembler that is software-compatible with Amdasm, AMD's assembly language. Downloading to the target system is accomplished through an RS-232 connection at rates up to 19.2 kb/s. The DS 500 does not provide a parallel port for high-speed loading or dumping, but as Dahlberg points out, the limiting factor is usually not the transmission rate, but the processing power of the computer.

As with other bit-slice development systems, the cost of the DS 500 varies greatly according to the amount of memory required and the width and depth of the logic trace. A typical starter system would have 32 channels by 1 K of control store and a trace feature 16 bits wide and 1-K word deep. With the meta-assembler, it would cost $14,900. Delivery is from stock to eight weeks.

Hilevel Technology Inc., 14661 Myford Rd., Tustin, Calif. 92680. Phone (714) 731-9477 [351]

Storage scope quadruples horizontal resolution

The promised digital storage scope from Gould [*Electronics*, Oct. 9, p. 249] has made its debut. For use in electromechanical, physical science, and medical testing applications, the portable dual-trace model OS4020 has a 2-MHz sampling rate, 8-bit vertical resolution, and a 4-K-byte random-access memory. The unit also has a variety of display modes, analog outputs for pen recording, and provision for data input/output and remote control via the IEEE-488 bus. The 4-K-by-8-bit memory, which is unusual for a por-



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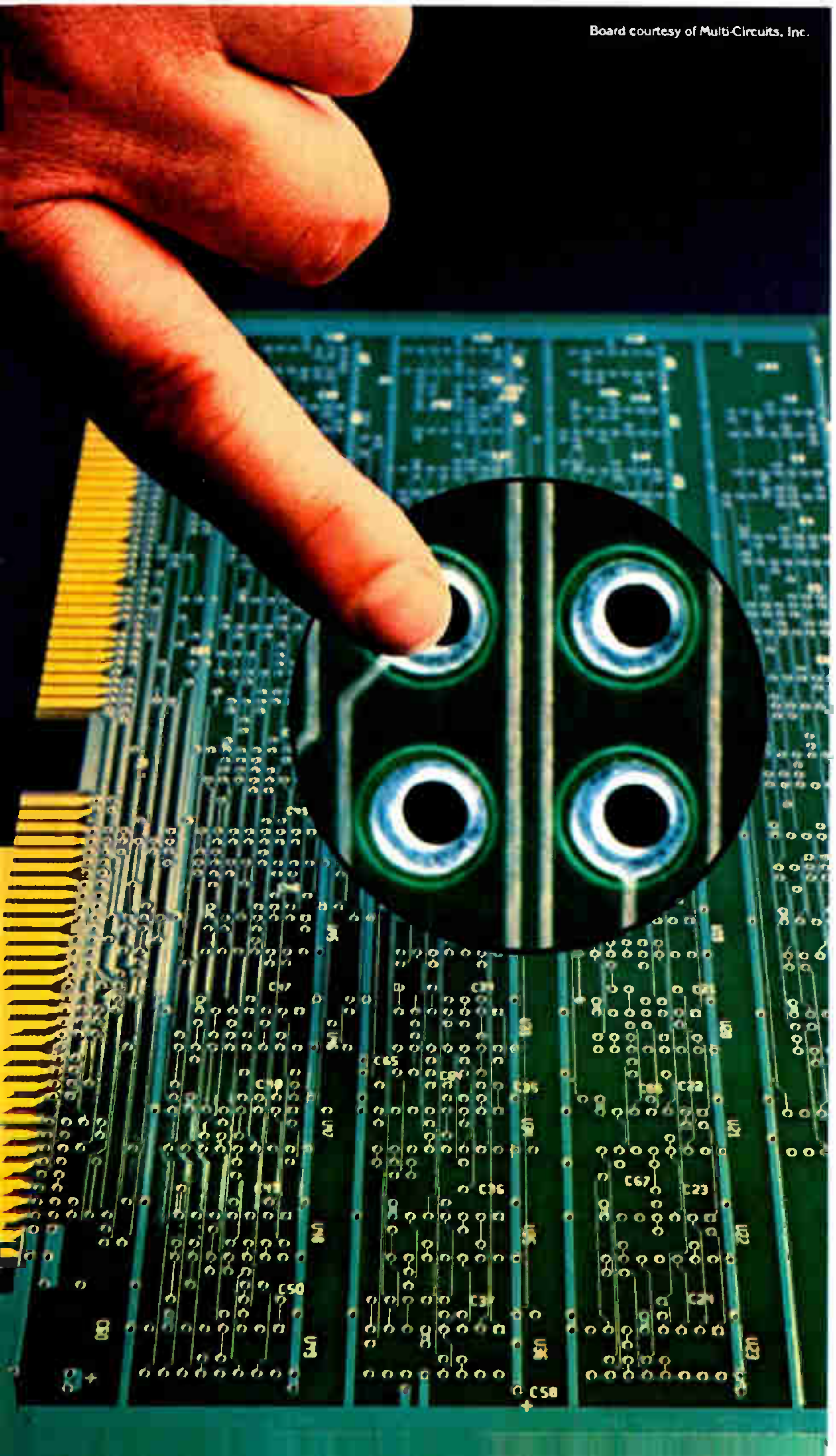

Fine line printed circuit board designs call for tight conductor spacing. And with spacing tolerances of less than 0.3mm (0.012 inch), you need circuitry protection beyond the capability of ordinary screen printed solder mask. You need VACREL dry film solder mask.

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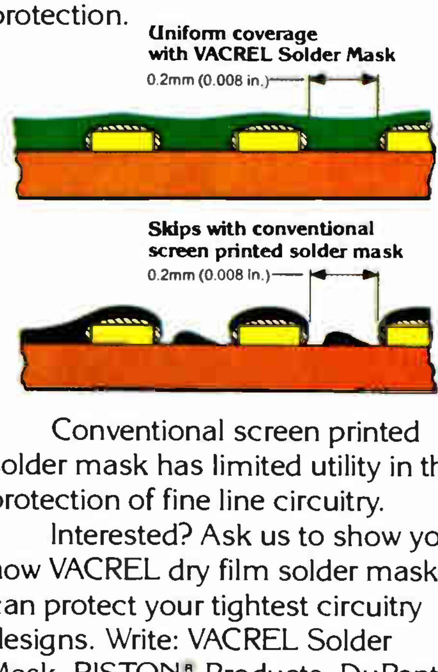

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Circle 217 on reader service card

table storage scope, has up to four times the horizontal resolution for captured waveform data than is possible with similar units that have only 1-K byte of memory, says Gould.

The instrument operates as a conventional 10-MHz dual-trace scope with 5 mV/cm to 20 V/cm vertical sensitivity and sweep speeds from 100 ns/cm to 0.5 s/cm. It also operates in a refreshed mode that plays back input signals via the store and in a roll mode in which fresh data becomes historic data, much like the display on a strip chart recorder. The price for the basic OS4020 is $4,700 and deliveries are scheduled to begin in January of next year.

Gould Inc., Instruments Division, 3631 Perkins Ave., Cleveland, Ohio 44114. Phone (216) 361-3315 [353]

ECL functional tests can be done right on pc boards

Testing of ultrahigh-speed logic families need not be done exclusively on a component-by-component basis since a module for the model DTS-70 tester permits digital functional stimulus-and-response testing with emitter-coupled logic on printed-circuit boards. Using a Hewlett-Packard Testaid logic simulator and the DTS-70, over 300 ECL components can be tested on their own boards. The DTS-70 has an output impedance of 75 Ω and is capable of driving transmission lines from 50 to 100

Ω. Up to 360 pins are available to be wired with either coaxial cable or twisted pairs of wire. Maximum rise and fall times at the unit's interface are less than 15 ns; noise immunity is guaranteed at less than 125 mV on the DTS-70's ECL module's driver and 160 mV on the receiver. The U.S. price for each ECL board-testing module with 15 drivers and receivers is $1,000, and the base price of the DTS-70 is $83,000.

Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, Calif. 94303 [354]

Two hand-held instruments test RS-232 transmissions

Two hand-held instruments test data transmissions on RS-232 interfaces and provide visual displays. The model 920 terminal and test set is microprocessor-controlled and enables data entry or retrieval as well as testing in both duplex synchronous and asynchronous modes. The 921T interface test set gives direct access to RS-232 leads.

The 920 terminal and test set can receive or send all ASCII, EBCDIC, Transcode, and Baudot codes. It displays them on a 16-character, 16-segment display in either alphanumeric or hexadecimal format. Data entry can be made into buffers or directly to the line in the asynchronous mode via the unit's keyboard. The buffers may also be loaded with received data or from a user-accessible programmable read-only memory. The set includes a fully interactive RS-232 interface. It sells for $1,595 and is available off the shelf.

The model 921T is installed between transmitting and receiving equipment and uses mark and space signal simulation. It can display 11 leads on 13 light-emitting diodes. Its RS-232 leads can be connected to any terminal by cord patching or independent switching. The steel-encased instrument can be battery- or ac-powered and sells for $220, including plug-in RS-232 cable.

Nu Data Corp., 32 Fairview Ave., Little Silver, N. J. 07739. Phone (201) 842-5757 [355]

YIG-tuned oscillator/filter has −40-dBc harmonics

A fundamental-output YIG-tuned transistor oscillator has gallium arsenide field-effect-transistor buffer amplifier and integral tracking YIG filter. The 2-to-8-GHz model AV-7248 offers a maximum harmonics output of −40 dBc. Nevertheless, the oscillator/filter provides 30 mW minimum output power and ±0.1% tuning linearity and includes an fm tuning coil. It weighs 17 oz and is packaged in a 2-in.-diameter, 1.4-in.-long hermetic case. It can be delivered in 90 to 120 days.

Avantek Inc., 3175 Bowers Ave., Santa Clara, Calif. 95051. Phone (408) 727-0700 [356]

Software cuts functional-test program-development time

A software package for the Eaton Macrodata 25-MHz M-1 memory device tester cuts the time required to write dc parametric and functional memory test programs for incoming inspection by several orders of magnitude. The Interactive On-Line Program Generator (IOPG) functions on an LSI-11/23 microcomputer with 64-K words of main memory and is supplied on 3M-type cartridge tape.

Video-terminal menus and pro-

Circle 219 on reader service card

tected formats facilitate the entering of values directly from memory data sheets. The system automatically translates, compiles, and generates the test programs. Programs that normally require one week to prepare can be written, checked, and debugged in less than one hour.

To perform a test, a known good device is loaded and appropriate output-loading components are installed. Then the IOPG, once initiated, displays a screen format for dc operating characteristics. Values and test conditions are entered, followed by read- and write-cycle data for the functional portion of the test program.

One or more test patterns selected from a menu on the screen exercise the device. Before functional testing programs are executed, the M-1 automatically performs an end-to-end calibration and programmed voltage and timing values are compared with actual waveforms at the test head. All 18 edge connectors can be calibrated in less than 15 seconds. The IOPG is priced at $7,500. Delivery takes 30 days.

Eaton Macrodata, 21135 Erwin St., Woodland Hills, Calif. 91365. Phone (213) 887-5550 [357]

Digital temperature controller features analog control

A temperature controller designed for cryogenic temperatures, the model DRC-80C features continuous analog control even though it is basically a digital instrument. A digital microcomputer is used to generate an analog error voltage, which is then used in an analog control loop. The microcomputer linearizes both the temperature sensor signal for display or output and the temperature setpoint for comparison to the analog sensor voltage. The instrument operates in the 1.4-to-380-K range with 0.1-K resolution, though at temperatures under 100 K, resolution can be increased to 0.01 K.

Lake Shore Cryotronics Inc., 64 E. Walnut St., Westerville, Ohio 43081. Phone (614) 891-2243 [358]

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This unique reference book and its updates provide objective descriptions of virtually every microprocessor on the market today. It lets you know what's available, how it works (or doesn't work), and how to use it. Each microprocessor is tested under controlled conditions to determine its special capabilities and limitations.

Book #15-2	Binder #16-0	Six updates #97
Retail price $25.00	Retail price $5.00 $6.99 on Jan. 1, 1981	Retail price $25.00

Volume 3: Some Real Support Devices

This reference describes support devices with the same in-depth detail found in Volume 2. Includes memory devices, data converters, data communication devices, direct memory access controllers, busses, and much more.

Book #18-7	Binder #19-5	Six updates #98
Retail price $15.00	Retail price $5.00 $6.99 on Jan. 1, 1981	Retail price $25.00

HANDBOOKS

Can be used as stand alone references

The 8089 I/O Processor Handbook

Describes 8089 functional logic and organization. Discusses how to configure the 8089 for various 8086/8088 system applications. Contains complete operating instructions as well as programming guidelines and operating limitations. The 8289 Bus Arbiter is described with the same careful attention to design and application.

#39-X $5.95 ($6.99 on Jan. 1, 1981)

The CRT Controller Handbook

This economical handbook describes five devices in the same thorough detail you'll find in Volume 3. The handbook fully covers pins and signals, programmable registers, microprocessor interface, screen memory, transparent memory addressing, character generator interface, and much more. There are 13 tables and 149 separate illustrations.

#45-4 $5.95 ($6.99 on Jan. 1, 1981)

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Software

Block structure comes to Basic

High-level S-Basic allows structured programming on development systems

S-Basic is a high-level language with the control blocks needed for structured programming. It is aimed at original-equipment manufacturers looking for alternatives to the software tools supplied with the development systems they are using.

Both interpretive and compiler facilities are available for S-Basic. Programs are normally entered and edited using command processor software that includes line-editing features. They can then be executed and debugged in the interpretive mode with the help of tracing tools built into the interpretive execution option. The compiler then accepts the debugged program and produces assembly language for the host system. The compiler's output goes directly to a file in mass storage and may be converted into object code by the development system's standard assembler.

S-Basic source statements are included in the compiler's assembly language output as comments, as are meaningful error messages. Indentation to delineate control blocks is optional.

S-Basic adds to the common Basic statements termination keywords for control blocks (ENDIF, ENDFOR), multiway branching (ELSEIF), an alternative looping structure (REPEAT), and facilities for prematurely exiting a loop (EXITFOR, EXITREPEAT, EXITWHILE). Variable names have had their length restrictions removed; they appear in the assembly language output in full.

For speed. Micro is another block-structured language offered by the company, but it is intended for use where very fast execution is more desirable than the convenience of a standard high-level language. It grew from assembly language development tools designed by Cogitronics to assist in its own programming work. It assumes no underlying operating system and is intended for use by system designers.

Besides the conditional (IF-THEN-ELSE), the multiway branch (CASE), the repeating structure (LOOP), and string-handling facilities, Micro includes operators for controlling queues and stacks without resorting to assembly language. It also supports seven data types, three of them user-definable. Like other Cogitronics products, the output of the Micro compiler is assembly language for the host system, with Micro statements carried along as comments.

Other compatible programs offered by the company include two source-text editor/managers (C-PREP, C-COMP), an assembly language optimizer (C-OPT) that speeds up execution modules as much as 25%, and a floating-point library (FPAC) that gives the assembly language programmer access to math conforming to the IEEE floating-point math standard.

The above software is currently available for either a GenRad/Futuredata ADS 2300 or a Tektronix 8002 host system and either a Z80 or 8080/8085 target processor. Other configurations are under development. S-Basic is priced at $2,000, Micro at $1,500; both are available for leasing. Manuals can be had separately for $10.

Cogitronics Corp., 5470 N. W. Innisbrook Pl., Portland, Ore. 97229. Phone (503) 645-5043 [381]

Multitasking operating system supports floppy, hard disks

A multiuser, multitasking disk operating system supports Cromemco floppy and hard disks. The system has multiple hierarchical directories and subdirectories, a versatile shell program for flexible and reconfigurable user interfacing, date and time support, and a password security system that limits system and file access and protects the files with read, write, append, and execute attributes. File size is limited only by the available disk capacity. The operating system, called Cromix, includes a CDOS simulator that not only allows CDOS programs to be executed directly on this new system but enables them to run even faster than they do under CDOS. Minimum memory required for the Cromix operating system is 128-K bytes. One additional 64-K memory card must be added for each additional user or task. Cromix is priced at $295.

Cromemco Inc., 280 Bernardo Ave., Mountain View, Calif. 94043 [393]

PDP-11 graphics package works with Tek devices

The GP-10 package of Fortran-callable graphics subroutines works with Digital Equipment Corp. PDP-11 computers that use the RT-11, TSX, RSX-11M, or IAS operating systems and will operate any Tektronix-compatible graphics device. The package fits in less memory than other such packages need, yet retains full control of every capability of the graphics device, says the maker. The software can be expanded module by module to take advantage of any special features a particular graphics device may have, such as selective erase or zoom.

GP-10's routines perform three basic functions: move, draw, and point. A figure or graph may be displayed on only a portion of the graphics area by specifying a device window. The software also provides routines that accept absolute or relative virtual coordinates. For terminals with readback capability, GP-10 contains several routines that enable a hard copy of data on the terminal screen to be produced. Single-user licenses are $450 and include a user's manual plus a set of installation notes tailored to the specific computer, operating system,

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Circle 227 on reader service card

and graphics device used. Discounts are available for original-equipment manufacturers.

Syscon Design Inc., 815 Manhattan Ave. Suite F, Manhattan Beach, Calif. 90266. Phone (213) 372-8544 [397]

Ohio Scientific C3 computer gets faster version of CP/M

CP/M2, a new version of CP/M, has been released for Ohio Scientific C3 computers. It is compatible with the original Ohio Scientific CP/M disk format. CP/M2 operates only with the Z80 processor, so disk read operations are four to five times as fast and disk write operations can be as much as 50 times faster. The software compensates for 2- or 4-MHz processor operation and is easily configured for slow-stepping disk drives or newer, fast-stepping ones.

The software includes a fast CP/M disk-to-disk copy routine, a memory test program for the Z80, and input/output drivers for the company's peripheral devices. It costs $200.

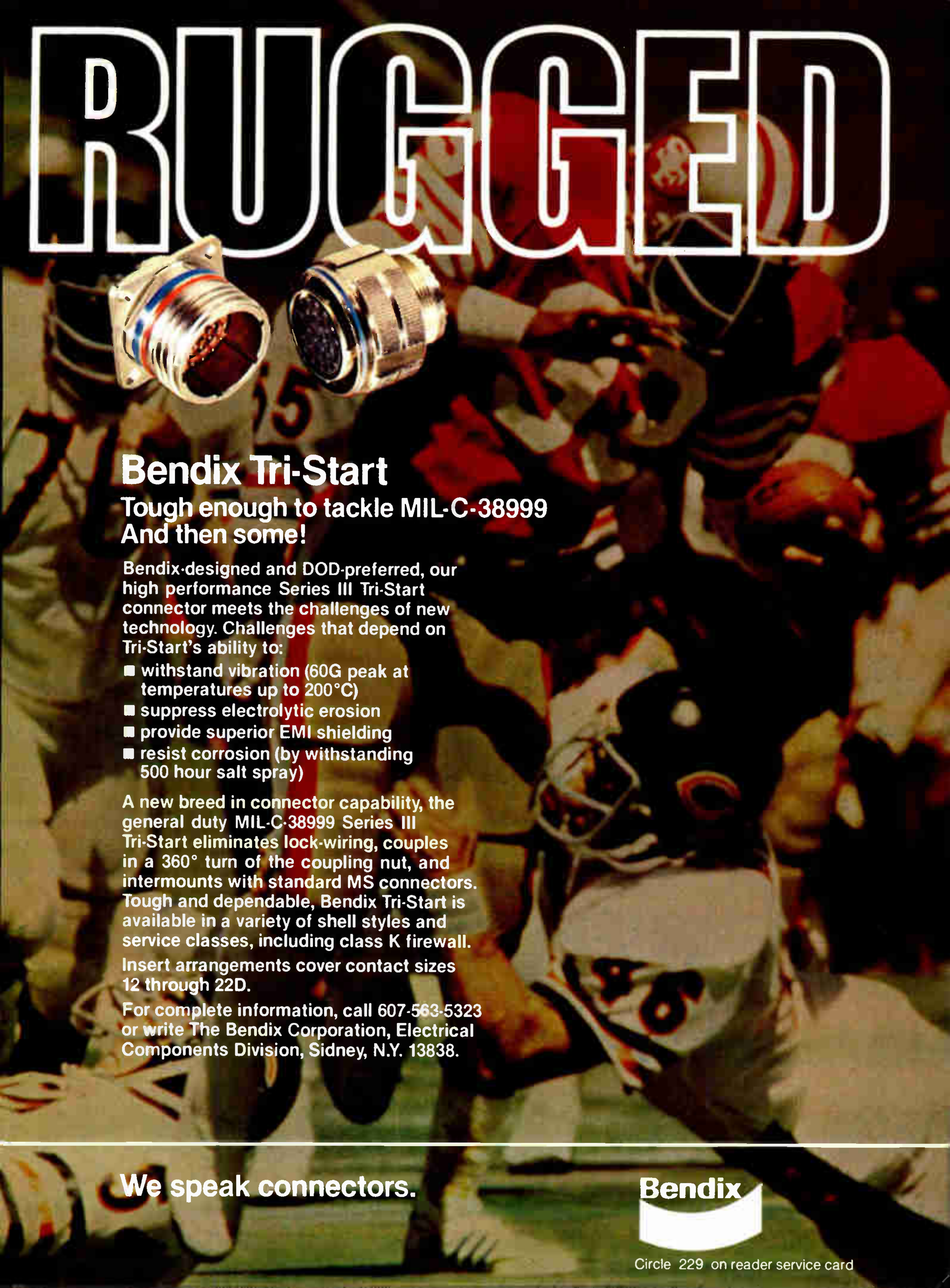
Lifeboat Associates, 1651 Third Ave., New York, N.Y. 10028. Phone (212) 860-0300 [395]

Industrial version of Pascal works with M68000, Z8000

An industrial version of the Pascal language supports all of the functions of PL/M-like compilers but has Pascal syntax. The HA-Pascal/I for the M68000 and Z8000 16-bit microprocessors features 32-bit arithmetic, assembler routines that may be called for time-critical operations, and object code in read-only memory.

The compiler produces machine code directly and also runs under the HA-SP/68000 or HA-SP/Z8000 operating systems, which are also produced by the HA-Pascal/I maker. Single end-user price in the U.S. is $400.

Hemenway Associates Inc., 101 Tremont St., Boston, Mass. 02108 [396]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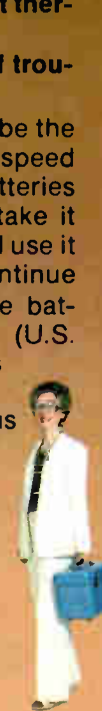
This new Dash II may very well be the final word in portable/lab high speed recorders. With rechargeable batteries and built in charger, you can take it anywhere — land, sea or air, and use it for 4 to 5 hours. Then, you can continue to operate *while recharging* the batteries. Accuracy? The patented (U.S. #4,134,062) Pathfinder™ galvo is *position feedback* with better than 99.5% accuracy. High stylus pressure delivers crisp, clear traces on low cost thermal paper.



Get all the facts. Call or write

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Circle 230 on reader service card

(Advertisement)

Don McCafferty

Choosing the right mechanical fastener

When choosing a mechanical fastener for a particular application, following past company design practices or an in-house preference list may cause you to overlook current "state of the art." When viewing an application, start fresh and consider the following:

MATERIAL COMPATABILITY between fastener and components is a must. If dissimilar materials are to be used, check a galvanic series chart to assure compatibility of base materials. Don't forget to investigate plating or other special finish options.

STRESS AND VIBRATION are factors that dictate type, diameter and number of fasteners, which, in turn, affect spacing. Spacing rules are: 1) On-center spacing between fasteners should be *no less* than three fastener diameters. 2) Fasteners should be placed no less than two diameters in from the edge of materials being joined.

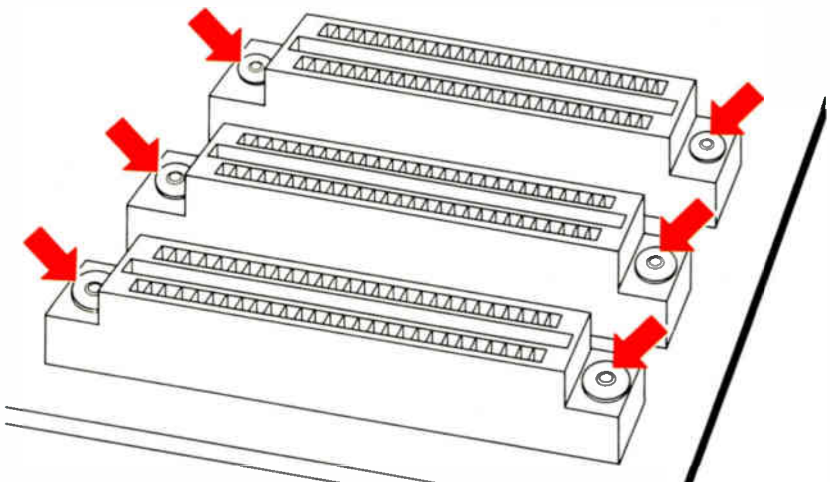
USE A SINGLE FASTENER TYPE for comparable functions to save money.

SAVE ASSEMBLY COSTS by choosing a minimum labor fastener. Include cost of hole preparation, rework and "floor loss" in your calculations.

Can I help you with your fastener questions, especially those pertaining to blind fasteners? Write me at Cherry Commercial Fasteners, Townsend Div. of Textron Inc., Box 2157, Santa Ana, CA 92707.

Circle 74 on reader service card

Announcing a totally new rivet for electronics. The Cherry LBPP:



The end of broken boards and components.

The new Cherry LBPP rivet is especially designed to fasten tightly—*without breaking, cracking, crazing,* or *chipping fragile circuit boards.*

- Extremely low breakload for extremely low breakage.
- Softens the shock of installation.
- Positive mandrel retention: no popouts to interrupt circuit integrity.
- Excellent vibration resistance.
- Also ideal for fastening soft or breakable plastics of all types.
- Money-saving replacement for time-consuming threaded fasteners.

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Circle 231 on reader service card

SHARP

Z-80

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SHARP CORP. is the second source manufacturer of ZILOG Z-80 Series.

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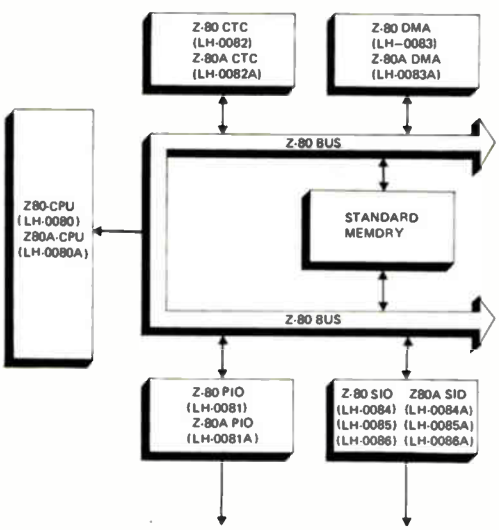

ZILOG	SHARP Type No.	Explanation	Features	Package
Z-80 CPU Z-80A CPU	LH-0080 LH-0080A	Central Processing Unit	• 158 instructions – includes all 78 of the 8080A instructions • Three modes of maskable interrupt plus a non-maskable interrupt • 22 internal resisters • •	40 DIP
Z-80 PID Z-80A PID	LH-0081 LH-0081A	Parallel I/D Controller	• Two independent bidirectional ports • Any one of the following modes of operation may be selected for either port: Byte input/output, Byte bidirectional bus, Bit Mode • •	40 DIP
Z-80 CTC Z-80 CTC	LH-0082 LH-0082A	Counter Timer Circuit	• Four independent programmable 8-bit counter/16-bit timer channels • Single phase clock • •	28 DIP
Z-80 DMA Z-80A DMA	LH-0083 LH-0083A	Direct Memory Access	• Single channel 2 port • Three classes of operation • 3 Modes of operation • Up to 1.25MB search rate • •	40 DIP
Z-80 SIO/0 Z-80 SID/1 Z-80 SID/2 Z-80A SID/0 Z-80A SID/1 Z-80A SID/2	LH-0084 OH-0085 LH-0086 LH-0084A LH-0085A LH-0086A	Serial I/D Controller	• Two full duplex channels • Asynchronous operation • Binery synchronous operation • HDLC IBM SDLC Mode • 0 ~ 550k bits/Sec • •	40 DIP

Vcc (V): +5 • Z-80: clock frequency 2.5MHz Z-80A: clock frequency 4MHz

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Electronic Components Export Sales Department
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Circle 233 on reader service card

Communications

X.25 node handles 1,500 virtual circuits

With the recent surge of interest in local networks and internetworking [*Electronics*, Oct. 23, p. 42], the X.25 international packet-switching standard for data communications continues to gain importance. Recognizing that a network packet processor with the ability to handle large numbers of virtual circuits is a product whose time has come, Tran Telecommunications has come up with a system dubbed the M3216 XPRO. At $50,000, it is not for the uncommitted.

The M3216 switches packets between X.25-compatible terminals and other digital equipment; at the same time it takes care of access and concentration functions. An auxiliary packet assembly/disassembly unit allows it to serve the more conventional asynchronous and IBM-compatible Bisync devices.

Operating as a switching node in a packet network, the system can support aggregate data rates of 300 kb/s on up to 1,500 virtual circuits distributed among 64 channels. The auxiliary unit mentioned lets asynchronous terminals transfer data at 9.6 kb/s and synchronous terminals at 64 kb/s.

Users with heavy data traffic (up to 1.25 Mb/s aggregate) can attach three M3216s to a single Tran M3201 network processor. The resulting hybrid multiprocessor can handle both time-division-switched and packet-switched data simultaneously.

The M3216 can be had 90 days after receipt of order. Tran will work closely with the customer in determining the specific system configuration his requirements dictate. External power supplies are needed, totaling 1,600 W in a redundant-supply arrangement or 2,600 W in a nonredundant setup.

Tran Telecommunications Corp., 2500 Walnut Ave., Marina del Rey, Calif. 90291. Phone Richard A. McLaughlin at (213) 822-3202 [401]

Compact antenna range covers 4.0 to 60 GHz

The model 5752 antenna test range operates in the frequency range between 4.0 and 60 GHz. Compact antenna test ranges like this one are used to develop and test antennas in indoor laboratories. Their use reduces or even eliminates the need for expensive outdoor facilities that require a lot of space. The 5752 is available for delivery within six months at a $225 price.

Scientific Atlanta Inc., 3845 Pleasantdale Rd., Atlanta, Ga. 30340. Phone (404) 449-2000 [403]

Bell 103A-compatible modem operates at 300 bits/s

Offered as a replacement for acoustic couplers in low-speed telecommunications, the HS2500 modem is Bell 103A-compatible and transmits asynchronously at a rate of 300 b/s. It allows the use of a multiline telephone at a reasonable cost: the unit's basic price is $285. An option for full- and half-duplex operation adds $20 to that price, and an originate/answer option adds $20 more for a full-option price of $325.

The HS2500 is available with an RS-232 communications interface, but can be specially ordered with a teletypewriter interface. The modem is easily installed: the handset of the telephone is plugged into the modem, which is plugged into the phone base. An automatic signal-level-compensating circuit and an active filter circuit permit reliable operation on even long-distance connections.

Komda Corp., 2500 Central Ave., Boulder, Colo. 80301. Phone (303) 443-5910 [404]

Transmitter and receiver send 24-bit word on two wires

The Star serial transmitter and receiver set requires only one pair of twisted wires to transmit 24-bit data words. Expansion modules can increase the word length to 96 bits using the same two wires. The devices, which are designed for use in remote displays, controls, and data processing, transmit at a rate

exceeding 7,000 b/s.

The transmitter's parallel inputs are compatible with switches, open collectors, or transistor-transistor or complementary-MOS 5-V logic, which may be true or inverted. They interface with most types of analog-to-digital converters or encoders.

The receiver's latched outputs are standard logic drivers or high-power open collectors rated at 50 V at 0.3 A. An optional six-digit 0.8-in.-high solid-state display is available with its own receiver circuitry. The display unit also requires only two wires for the data input.

Analite Inc., 24 Newtown Plaza, Plainview, N. Y. 11803. Phone (516) 752-1818 [405]

30-lb portable repeater can be used on 8 frequencies

A portable repeater for setting up temporary communications measures 18 by 13 by 6.5 in. and weighs 30 lb. It is particularly suitable for

use in emergencies, mobile surveillance, and security. Contained in an attache case for mobility, the unit comes in two versions: for scrambled or clear frequency-modulation operation. It can be used on up to eight frequencies. It includes a speaker and microphone, backup battery, and panel lights. It can operate off 12 V dc or 115 V ac (50 or 60 Hz).

Motorola Inc., Communications Group, 1301 E. Algonquin Rd., Schaumburg, Ill. 60196. Phone Pat Schod at (312) 576-6612 [406]

Linear amp's tetrodes deliver 1,250 W from 220 to 400 MHz

Model 1000HA, a broadband power amplifier, puts out a minimum of 1,250 W from 220 to 400 MHz. The $37,000 unit's output stage can absorb 100% reflected power—a feature that makes the amp useful for component testing. The output stage consists of liquid-cooled vacuum-tube tetrodes in a distributed amplifier configuration. The power amp offers linear operation over a 90-dB dynamic range for fm, a-m, and pulse modulation. Full rated power is instantly available at any frequency in the amplifier's bandwidth, without tuning. Instant bandwidth allows swept-frequency operation and frequency hopping for testing susceptibility to electromagnetic interference, as well as for wattmeter calibration and broadband communications.

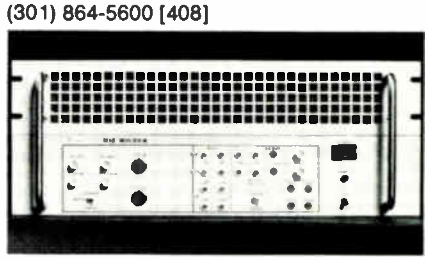
The unit is cooled by forced air or tap water. It measures 56 by 152 by 58 cm. An optional IEEE-bus–compatible interface module is available for control of the amplifier's functions. Delivery takes 120 days.

Amplifier Research, 160 School House Rd., Souderton, Pa. 18964 [407]

Multi-/demultiplexer handles 1.5 to 44,736 megabits/s

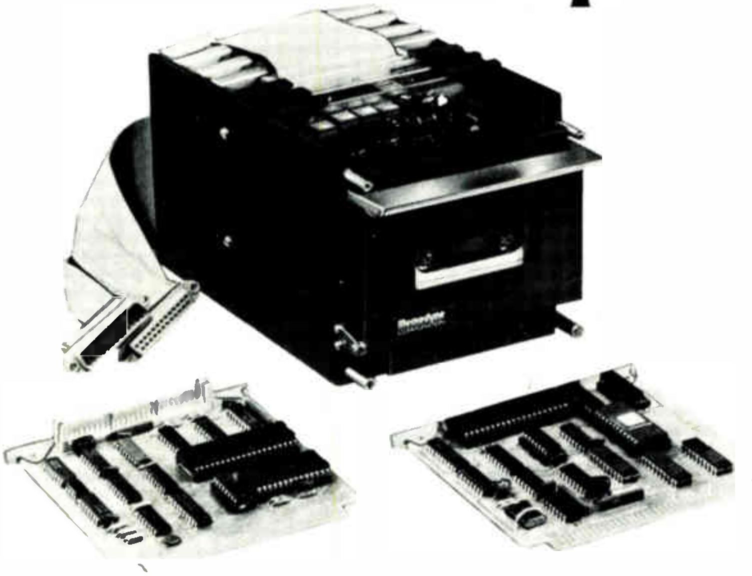
The M13 Muldem, a high-speed, time-division multiplexer/demultiplexer, combines 28 asynchronous digital channels at transfer rates of 1.544 to 44.736 Mb/s in hierarchical stages. The unit is designed for use with a fiber-optic channel but is easily adapted for use with coaxial and microwave channels. At the high-speed stage, the device has full automatic redundancy, while at low speed it has shared redundancy. The rack-mountable 19-by-24-by-20-in. unit weighs 60 lb.

Amecom Division, Litton Systems Inc., 5115 Calvert Rd., College Park, Md. 20740. Phone (301) 864-5600 [408]



HERE AT LAST!

A Standard "Custom" Data Collection Device The Memodyne M80 Cassette Computer



The M80 is a general purpose Z80™ based computer combined with a rugged, high-speed digital cassette drive in a compact, panel mounting module. Modem and terminal RS232C and TTY current-loop serial ports are provided for easy interfacing. A 2K PROM is programmed to implement completely interrupt driven control of the recorder and communications functions. A 1K RAM provides data buffering which allows the M80 to handle continuous streams of data up to 9600 BAUD.

TM Z80 is a trademark of ZILOG Corp.

FEATURES:

- Standard program in CPU Card Prom implements 30 recorder and communication commands plus numerous mode selections.
- A Microprocessor based computer that is small and compact, a rugged module that can operate in hostile environments with its own removeable medium memory, immune to hazards that disable disks, printers, and other peripherals.
- High speed: Can read or write continuous data streams at up to 9600 Baud with block size of 100 bytes or more.
- 500,000 Byte formatted capacity.
- ANSI/ECMA-34 compatible tapes, both tracks accessed.
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- Recorder control and communications are interrupt driven and transparent to user programs.
- Small cards make for sensible modularity with modern high density ICs and are easily inserted and extracted.
- Small module fits behind standard 5 inch panel.

IF YOU NEED:

1. A Process Control Computer.
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THE PIONEERS OF LOGIC PROGRAMMING HAVE JUST OPENED A NEW TERRITORY.

Data I/O offers a new System 19 programming pak for all Signetics 28 pin Integrated Fuse Logic devices. Now you can program the complete 28 pin family of Signetics integrated fuse logic (IFL) devices with one intelligent programming pak for the Data I/O System 19 and 17.

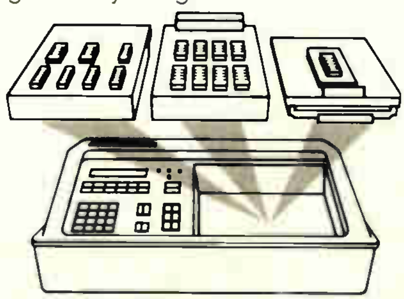
The new pak allows direct keyboard input of logic variables. There's no need to write software or use a computer to develop your programming data. You can work directly from the System 19 keyboard or a CRT terminal.

Data I/O can keep you on the forefront of programmable logic. At Data I/O, we believe that programmable logic is the wave of the future. Logic devices like the PAL,™ FPLA, FPRP, FPLS, FPGA and PMUX offer the designer the unique advantages of real estate savings, design flexibility, and speed in bringing a product to market. They also reduce "hidden" product costs through simplified assembly and lower inventory costs.

When we introduced our first logic programmer six years ago, we began our commitment to logic. Our new Systems 17 and 19 were developed with an eye to logic programming as well as bipolar and MOS device programming.

There's one thing you can depend on when you explore the possibilities of logic programming. Data I/O will be there with new ways to program new devices on programming systems that exist today. That's the theory behind our Systems 17 and 19—offer designers a standard mainframe and enable them to maintain state of the art programming capability by simply adding programming paks.

In the future we will be introducing new capabilities to complement the System 17 and 19 that will offer design engineers even more flexibility and enable them to program a larger variety of logic devices.



Here are the paks now available for the System 19:

For bipolar PROMs and EPROMs
- UniPak programs more than 200 bipolar PROMs and MOS devices.
- MosPak programs single MOS devices.
- Gang Module programs eight EPROMs at once.

For individual PROM families
- More than 40 approved programming paks.

For logic devices
- Logic Programming Pak handles Signetics IFL 28 pin family.
- Individual programming paks for more than 30 different logic devices.

Let us show you the future. The Data I/O interactive logic pak for Signetic IFL devices is available now. To make arrangements for a demonstration, or to get your free copy of our 32-page book on PROM and logic device programming, circle reader service number or contact Data I/O, P.O. Box 308, Issaquah, WA 98027. Phone 206/455-3990 or Toll Free 800/426-9016.

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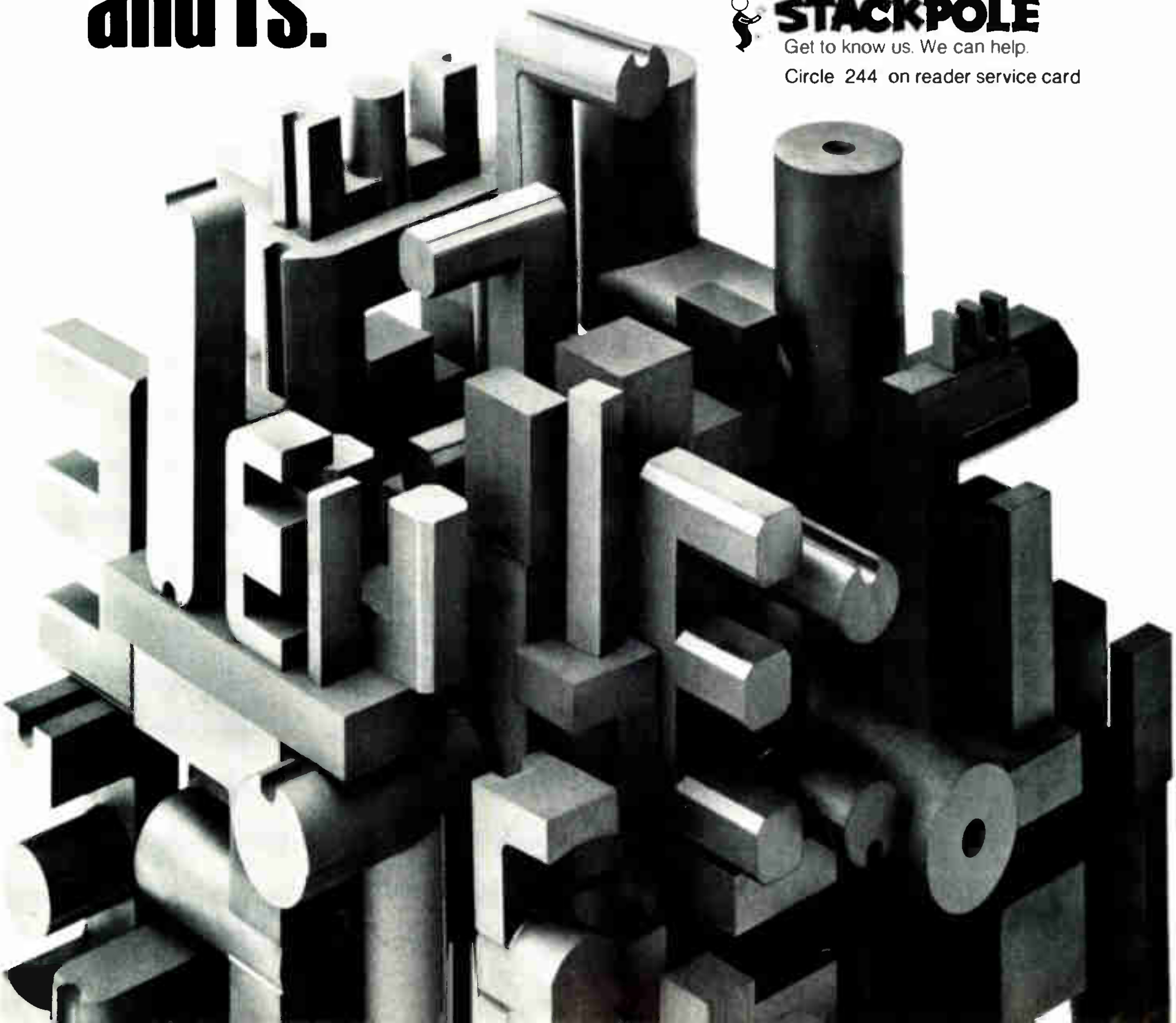
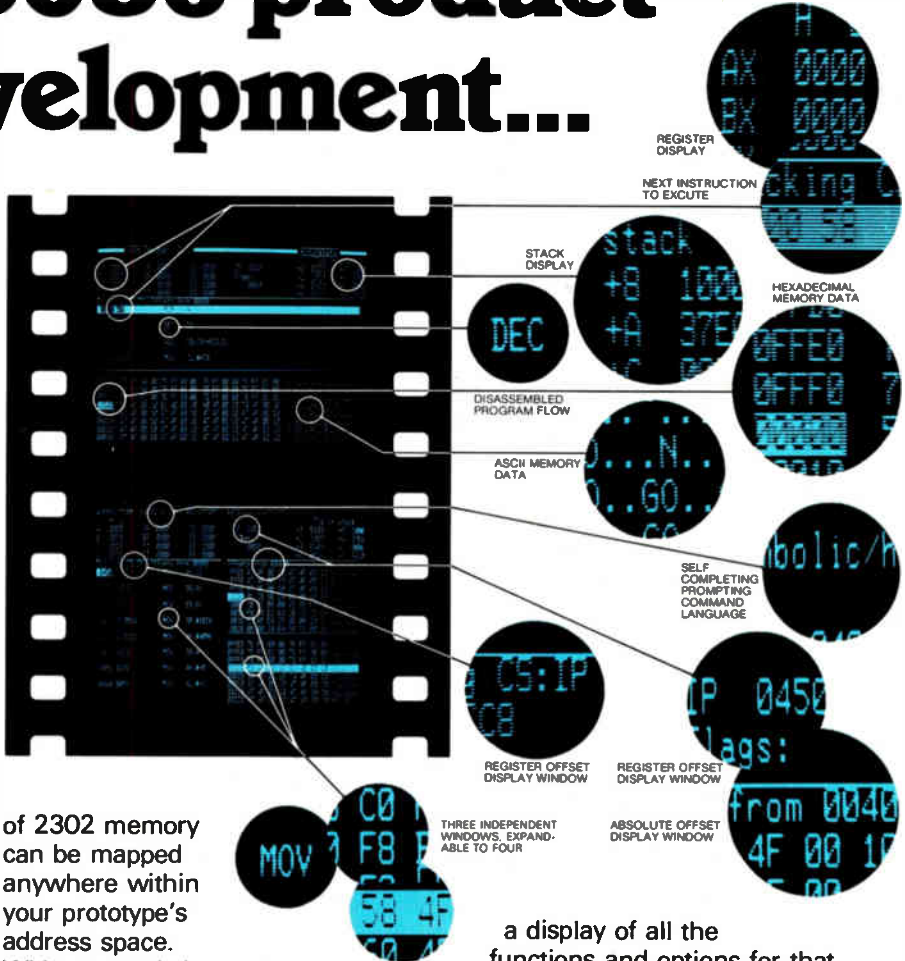


Best supporting actor for 8086 product development...



the GenRad Slave Emulator

Our slave emulator thinks and acts just like the 8086 microprocessor. At the same speed. Without interruption. And so transparently that your prototype may never know there's an "actor" in the circuit. In fact, no other emulator can play this 16-bit part so well. Because the 2302 accesses its "lines" via a separate processor-memory bus. Emulator and development system (or network station) operate independently and simultaneously. The resources of your target processor aren't needed for debugging. Programs are executed at full 8086 speed from an internal or prototype clock. Without wait states or other timing constraints. Up to 512k bytes of 2302 memory can be mapped anywhere within your prototype's address space. Without restrictions on control line use or interrupts.

Full symbolic debugging makes hardware development faster too. With easily remembered short program labels that replace absolute addresses in your commands. With an "auto command completion" function that allows you to produce a full command on the display with just a few keystrokes. And by entering a "?" after any command you see a display of all the functions and options for that command, reducing the need to reach for a "cue" card.

The 2302 allows you to view your program in single-step, snapshot or logic analyzer modes. In a format that matches your needs even for the most complex memory segmentation, interrupt driven or multi-processor environments. With the 2302 your stage is set for bigger and better hardware developments. For simultaneous emulation of multiple processors. For other 16-bit parts (68000), 8-bit parts (6809) and for processors in the wings (Z-8002).

Ask for a command performance today.

GenRad 2300 Microcomputer Development System with 2302 Slave Emulator for 8086 microprocessor. (Also available for GenRad 2301 network stations.)

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Circle 245 on reader service card

Industrial

Vision, software add talents to sorter, welder

A better robot will not by itself increase productivity in manufacturing—better sensors and software are what is needed, and 10-month-old Automatix Inc. intends to prove it with the introduction of two industrial systems that include visual feedback and easy-to-implement software. The products—a fully programmable robotic arc-welding system called Robovision I and a sorting and inspection system called Autovision I—made their debut at the Robots V Exhibition in Dearborn, Mich., last week.

The addition of vision to robotic manufacturing processes creates both flexibility and a need for the use of computers for more sophistication, says company president Philippe Villers. "Arc welding is a case in point," he adds. "It's being done blind today by robots that do not take into account part-to-part variations." The firm expects its robot's vision to open up new arc-welding applications.

Robovision I uses the AID 800 all-electric robot, which moves in five axes to provide accurate torch positioning and orientation. It can maintain repeated positioning in all axes within ±0.2 mm while welding at speeds programmable to 70 in./min (1,800 mm/min).

Teaching. The microcomputer-controlled robot can be taught to weld at three levels. The operator can use a teaching pendant—a calculatorlike device with a limited number of keys—to take the robot through the welding maneuvers, which are then stored in memory. A simplified high-level language—RAIL—is also available for computing transformations between joint angles and Cartesian coordinates to provide straight-line motion between points. Finally, source code is available in most cases from the manufacturer so those users familiar with Pascal can make necessary changes in the robot's program. Memory for up to 448 programming steps is standard.

The Robovision I's computer also controls a solid-state welding power supply and wire feeder for metal-inert-gas(MIG)-welding applications. The Lincoln DC-600 supply operates at 600 A and has a 100% duty cycle. The wire feeder is a Lincoln LN-9 with solid-state circuitry.

Optional equipment includes a positioner that holds fixtures for a wide variety of parts and moves between welding and loading positions under computer control. The positioner allows one fixture to be loaded while the robot is welding on another. With vision, says Villers, instead of needing specialized grippers and tooling, "all you need is a general-purpose gripper to pick up a part from a table."

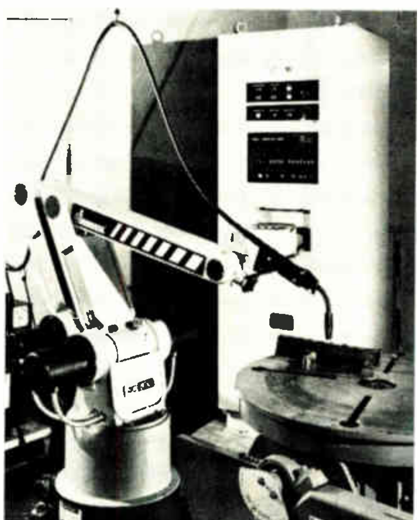
This concept lies behind the Autovision I, which uses a modified General Electric TN-2200 solid-state camera with 128-by-128-pixel resolution to identify, sort, align, and orient parts. The information provided by the system may be used for parts inspection and robotic material handling. Autovision I may also be used as a component in computer-aided manufacturing systems.

The system uses a vision processor that interfaces the camera with a computer, performing high-speed binary image-processing functions in hardware. It can handle four cameras and flash lamps. A control processor features 32-bit internal architecture with 152-K bytes of semiconductor memory. Autovision I also includes an alphanumeric cathode-ray-tube terminal with graphics capability, a dual tape cartridge system, and 16 input/output lines.

Sight. Autovision I's software permits automatic extraction of object features including area, perimeter, number of holes, hole area, object's center of gravity, moments and principal axes of inertia, radius vector statistics, and perimeter-area ratio. It also supports general-purpose connectivity analysis, training by showing, a nearest-neighbor-classification algorithm, and a flexible keyboard interpreter. Like the Robovision I, Autovision I can respond either to commands in the RAIL language, for easy interfacing with conveyors, actuators, or computer-controlled systems, or to modifications to its Pascal software.

Options include an X-Y CRT monitor to display the actual picture as seen by the camera or the binary image, a flash lamp attachment, and custom interfaces that include additional opto-isolated control lines, analog-to-digital and digital-to-analog boards, and RS-232 ports.

Robovision I will sell for about



Teachable. The Robovision I welder (left) and the Autovision I sorting and inspection system both can be shown how to perform a task by an operator unfamiliar with programming.

$85,000, including the welding equipment. Autovision I has not been finally priced but is intended to fall in the $30,000 range.

Automatix Inc., 217 Middlesex Tpke., Burlington, Mass. 01803 [371]

Solid-state video imaging measures parts on line

The Vidicom Qualifier 863, a noncontact automatic gage, uses solid-state video imaging, dedicated microprocessor control, and analysis software to measure production-line parts ranging from small electronic components to large cam shafts with

an accuracy to within 0.0001 in. All measurements are recorded on cassette tape, displayed on a cathode-ray tube, and printed by a Hewlett-Packard 85 desktop computer. The 863 will sell for about $50,000 to $55,000.

Optical Gaging Products Inc., 850 Hudson Ave., Rochester, N. Y. 14621 [373]

Thermal cutoff with 23 AWG wire interrupts current at 5 A

The 4000 F Microtemp thermal cutoff has a 23 AWG wire and interrupts 5 A with an opening temperature range of 58° to 240° ± 4°C. The one-shot temperature limiter must be replaced—and the fault corrected—before the motor or transformer it monitors can function again. The price is 13¢ to 50¢, depending on quantity.

Micro Devices Division, Emerson Electric Co., 1881 Southtown Blvd., Dayton, Ohio 45439 [378]

NEW AWARD-WINNING DESIGN
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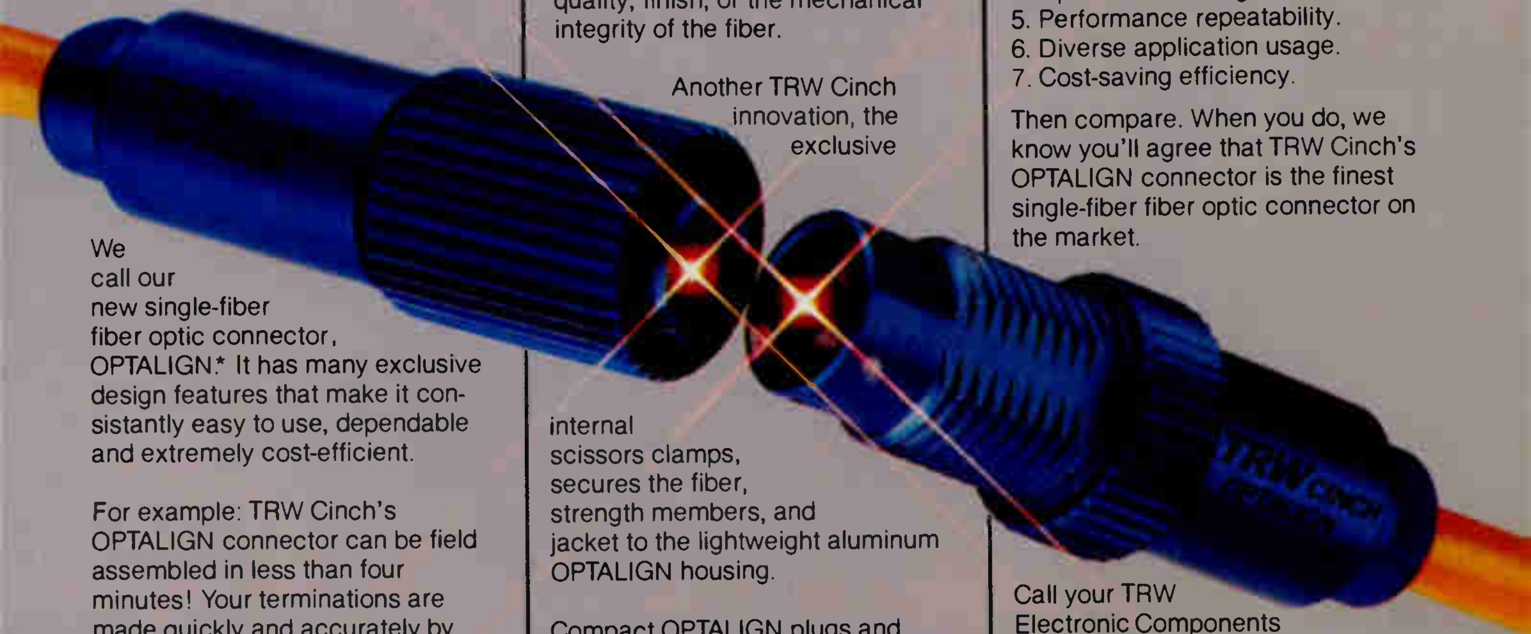
OPTALIGN* connectors keep light losses under 1db.



We call our new single-fiber fiber optic connector, OPTALIGN.* It has many exclusive design features that make it consistently easy to use, dependable and extremely cost-efficient.

For example: TRW Cinch's OPTALIGN connector can be field assembled in less than four minutes! Your terminations are made quickly and accurately by hand without using time-consuming epoxies. The need for polishing or tuning upon engagement has also been eliminated.

TRW Cinch has developed a unique alignment system that restricts light losses to less than 1 db and is compatible with most commercially available fibers. This system is based on a four-rod glass array that is clean, inert, stable, and mates fibers in a manner that yields excellent shock and vibration immunity. The glass array element does not require precision tolerances to achieve ultra-precise fiber alignment and low light losses.

The OPTALIGN connector is designed to give you unmatched fiber alignment accuracy and repeatability everytime the connection is made. Be assured that repeated connect/ disconnect will not affect the optical quality, finish, or the mechanical integrity of the fiber.

Another TRW Cinch innovation, the exclusive internal scissors clamps, secures the fiber, strength members, and jacket to the lightweight aluminum OPTALIGN housing.

Compact OPTALIGN plugs and receptacles are ideal for computers, CATV, telecommunications, medical, instrumentation and military applications. Dimensions are 5/8″ diam. X 1½″ in length.

So when evaluating fiber optic connectors, consider the outstanding benefits that OPTALIGN connectors have to offer:

1. Fast, easy assembly.
2. Minimal light loss.
3. Vibration/shock immunity.
4. Optimum fiber alignment.
5. Performance repeatability.
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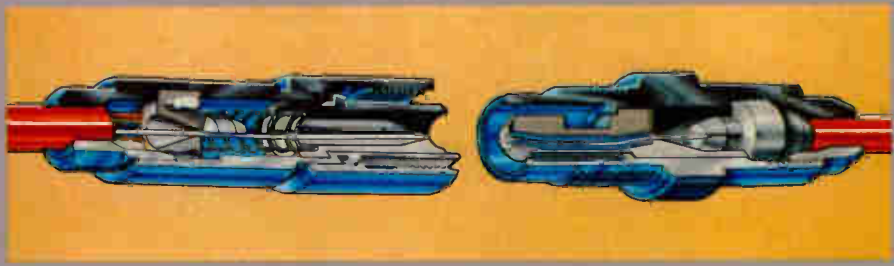

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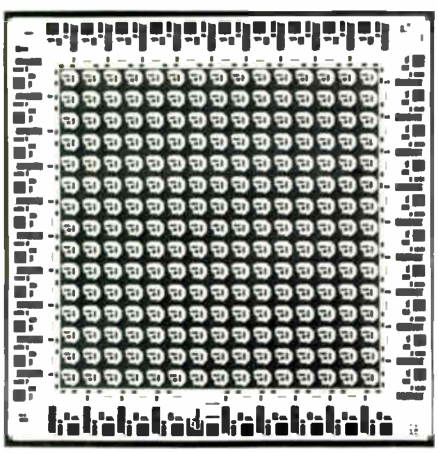

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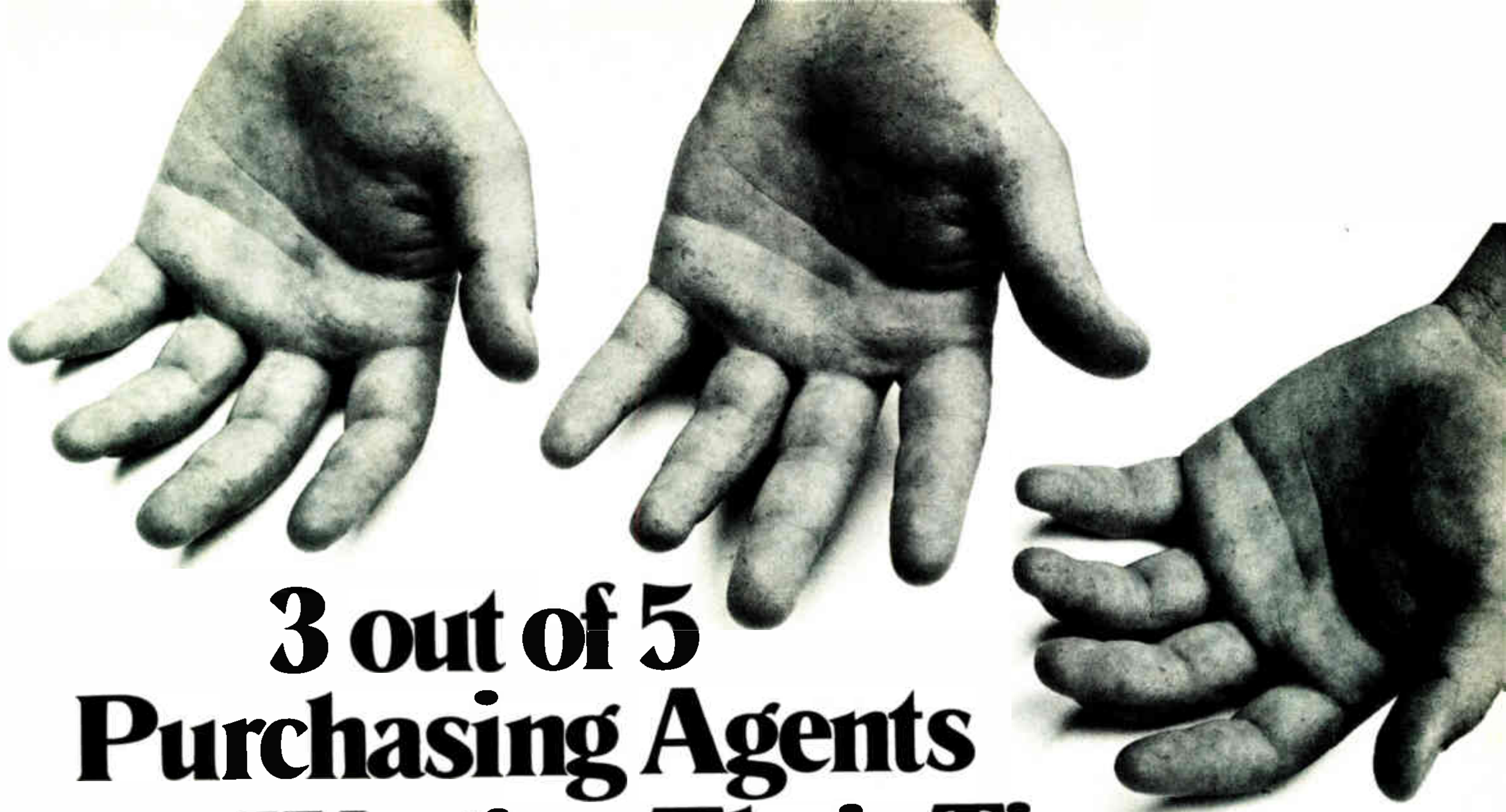

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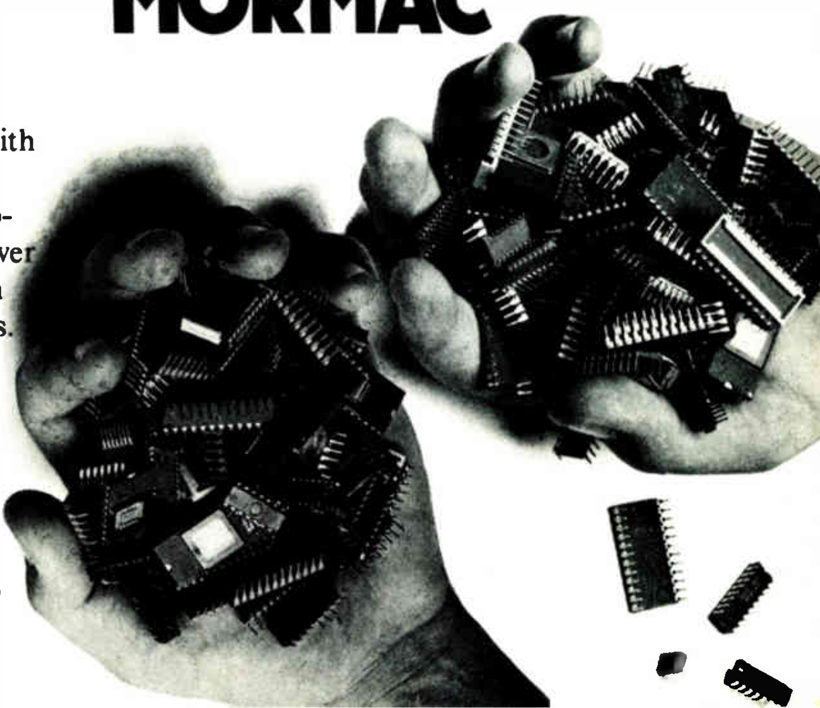

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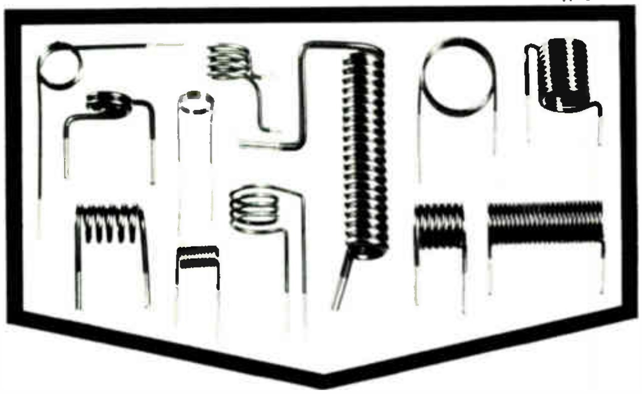

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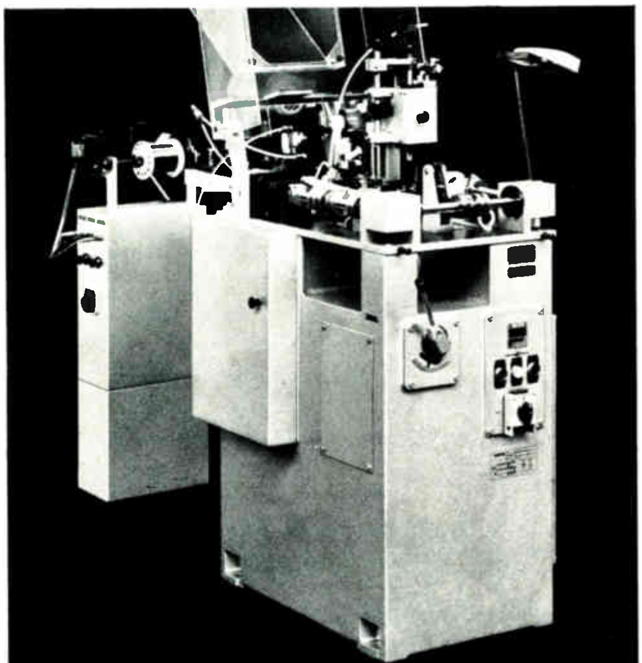

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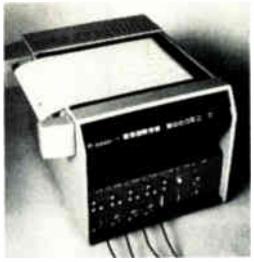

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Products Newsletter

Litronix shows intelligent display at Electronica

Attendees at the Electronica components exhibition opening this week in Munich will be able to get a preview of an intelligent display system (IDS) soon to be made available by Litronix Inc., the Cupertino, Calif.–based affiliate of West Germany's Siemens AG. Combining Litronix' intelligent display assembly concept [*Electronics*, June 5, p. 243] with **a new controller having an Intel 8035 8-bit microprocessor** on board, the portable system performs many cathode-ray-tube terminal functions. It does not require additional segment drivers or ASCII-character decoders.

16-bit a-d unit settles current output in 2 μs

Despite its 16 bits of resolution, the model 4059 hybrid analog-to-digital converter boasts **settling times of 2 μs and 10 μs for current and voltage outputs,** respectively. Aimed at medical instrumentation, process control, and military systems requiring fast, accurate performance, the 4059 has maximum nonlinearity guaranteed to within ±½ least significant bit to 14 bits over the full military temperature range. Teledyne Philbrick, Dedham, Mass., will begin shipping the $250 converter in January.

Fluke previews analyzer at test conference

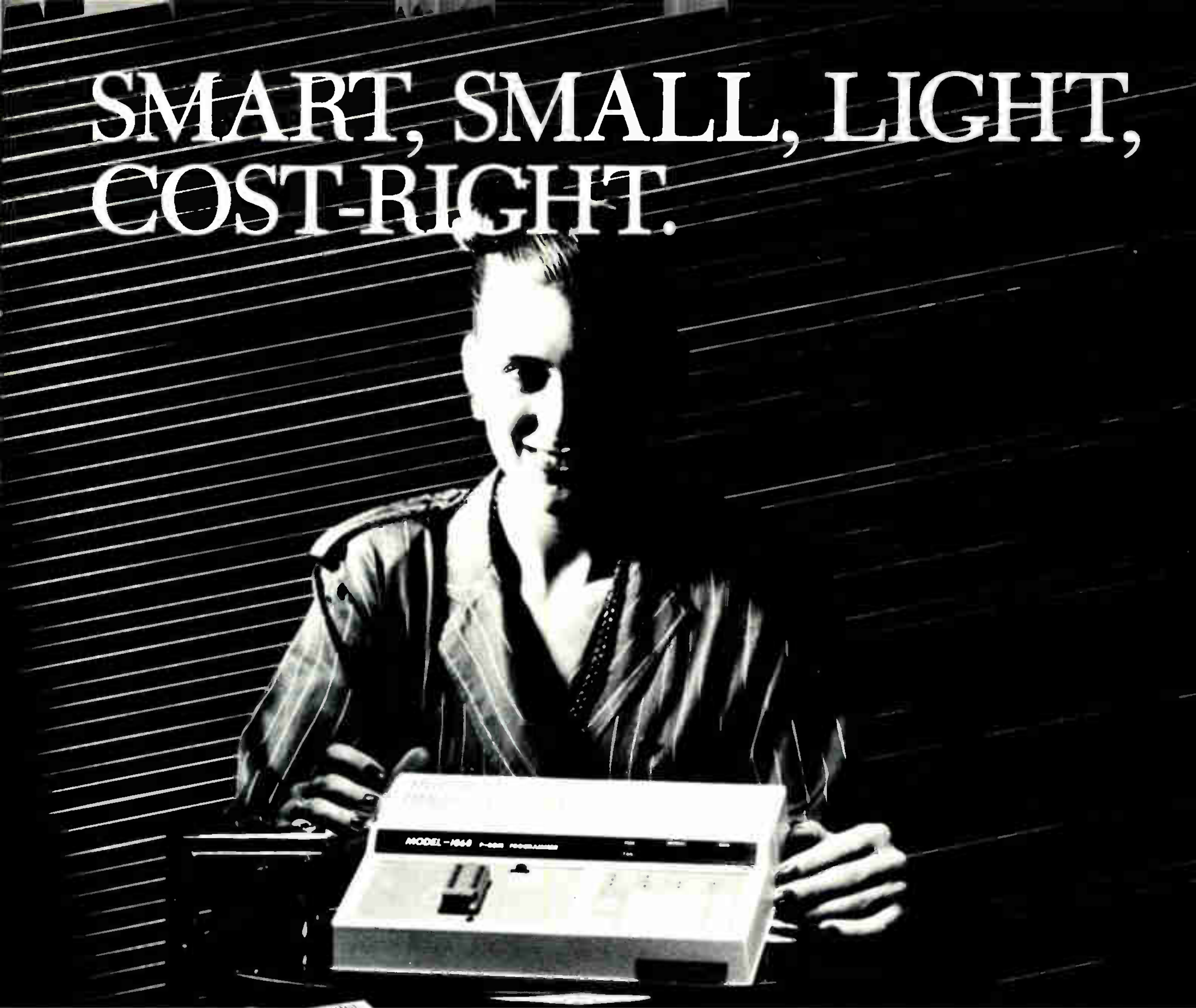
Fluke Automated Systems Inc. will privately show at next week's 1980 Test Conference in Philadelphia a prototype of **a new low-cost circuit board analyzer** that will be formally introduced in January at the ATE Seminar and Exhibit in Pasadena, Calif. The model 3200 performs functional tests on both bare and loaded circuit boards, as well as most tests performed by in-circuit test systems. The Mountain View, Calif., firm is expected to price a basic 3200 at less than $40,000.

Prime and Harris introduce software

Prime Computer Inc., Natick, Mass., has unveiled an advanced version of its **Terminal Application Processing System.** TAPS is said to cut business applications program development time to half that of competing systems. Meanwhile, Harris Corp.'s Computer Systems division, Fort Lauderdale, Fla., is offering its **Diagnostic Environment Monitor (Demon) for preventive maintenance on data-processing systems.** Demon tests operating system reliability and exercises a system's central processing unit, memory, and peripherals in simulation of a real-world timesharing environment.

Price cuts

- **Going after the Apple III market, Digital Equipment Corp., Maynard, Mass.,** has started cutting prices on its entry-level small-computer systems, while unbundling much of their software and peripherals. Now, an unbundled PDP-8–based WS78 with two-diskette drives, cathode-ray-tube console, and a printer will go for $7,295, whereas before it sold for $11,995. A Datasystem 408 with printer and operating system drops from $12,545 to $8,095 retail.
- **Harris Corp.'s Semiconductor Products division** is reducing the starting prices on its 8-K programmable read-only memories from $28 to less than $18 in quantities of 100 or more because the Melbourne, Fla., division is now producing 8-K PROMs at the rate of more than 1 million annually.
- **American Microsystems Inc., Santa Clara, Calif.,** is slashing the price of its repertory dialer chip sets by 43% from $12.70 to $7.25 each in orders of 10,000 or more. The sets can store 16 16-digit or 32 8-digit phone numbers.



Model 1861

Model 1860
P-ROM Programmers

		Model 1860	Model 1861
Programmable devices		i2716 (i2758), i2732, i2732A, i2764, TMS2532, TMS2564, i8755A, i8748A, i8741A and compatible.	Exclusively for simultaneous ganged programming of 8 MOS. i2716, i2732, TMS2532, and compatible.
Interface	Serial	RS-223C and 20mA current loop (or TTL level) switch selectable.	RS-232C, 20mA current loop, or TTL level selectable as specified when ordering.
		Baud rate: 110, 300, 600, 1200, 2400, 4800, 9600	
	Parallel	PTR parallel interface	
Size, weight		280 (W)×208 (D)×65 (H) mm, 2.5kg	280 (W)×208 (D)×75 (H) mm, 3.5kg

New Series 1860 P-ROM Programmers.
New Model 1860 Series for the age of P-ROM diversification Minato Electronics New Series 1860 P-ROM programmers meet the demands for wide applications. They are super compact, light weight and inexpensive.

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Model 1861 simultaneously programs 8 ganged MOS.
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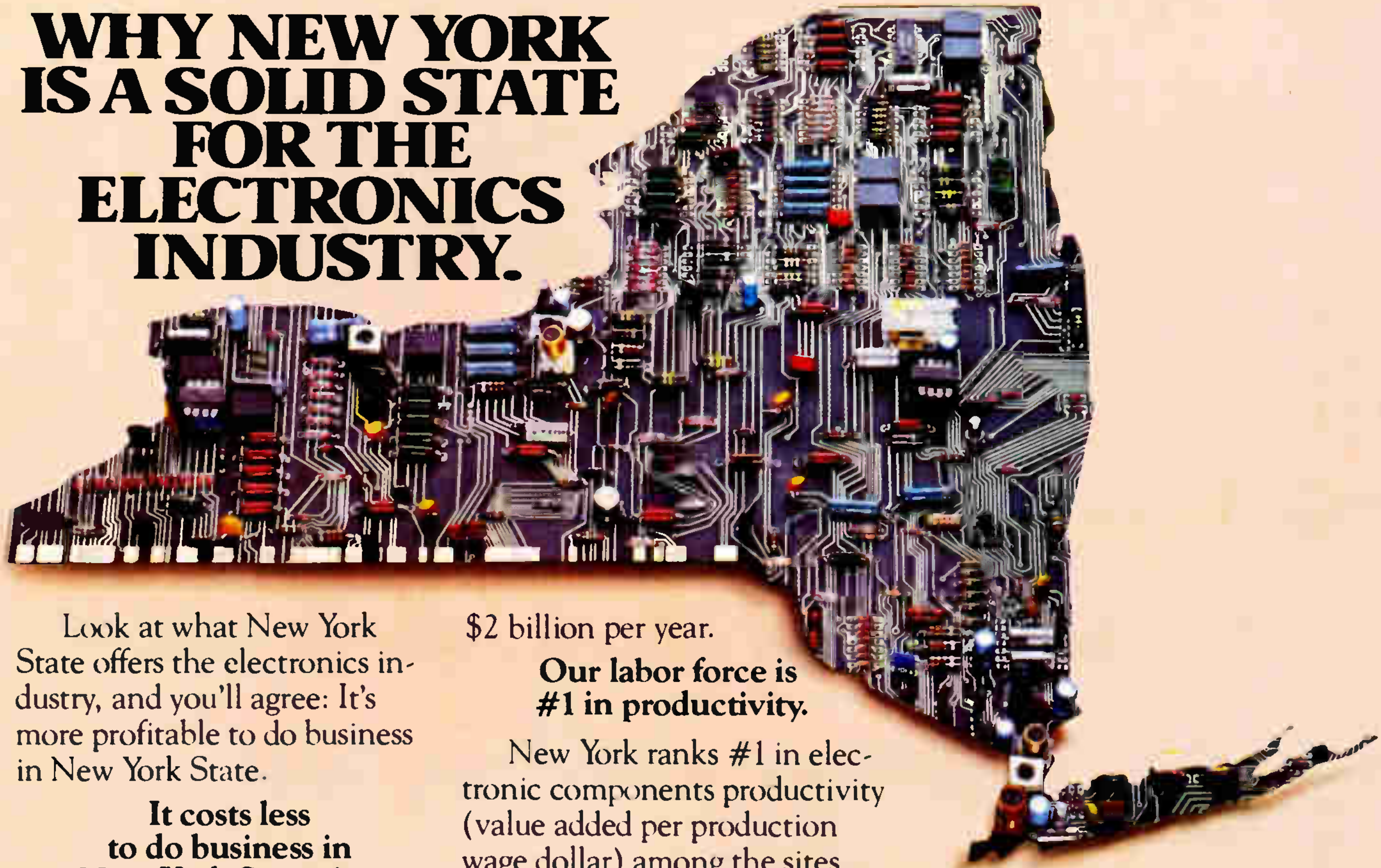
WHY NEW YORK IS A SOLID STATE FOR THE ELECTRONICS INDUSTRY.



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.

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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.

Tell me more about why New York is a solid state for business. I am particularly interested in information on:

- ☐ Electronic Components
- ☐ Small Computers
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Career outlook

Women speak up at Midcon

The demand for engineers and their talents is creating unprecedented opportunities for women. Reflecting this trend, an entire session at this year's Midcon, held Nov. 4–6 in Dallas, was devoted to the topic. Entitled "Career Opportunities and Advancement for Women in Engineering," it took a hard look at what is available for women in electrical engineering as life-long career.

Organized and headed by Mary Alys Lillard, chairperson for the Institute of Electrical and Electronics Engineers' Committee on Professional Opportunities for Women, a panel composed of five women offered pointers on divergent subjects dealing with careers in the electronics industries, how to present oneself in these industries, and what to expect in job assignments.

Lillard, a software engineer at Advanced Business Communications Inc., Dallas, had put together an informal discussion for Electro/80. "There was quite a bit of interest generated at our Electro get-together—enough so I was able to convince the IEEE to offer a session at Midcon," she says.

On the panel was Heather D. Bryce, microprocessor planning engineer for Motorola Inc.'s Integrated Circuit division in Austin, Texas, who discussed "Career Opportunities in the Semiconductor Industry"; Elinor S. Pape, associate professor for industrial engineering at the University of Texas at Arlington, who spoke on "Upward Mobility for the Engineering Educator"; LeEarle Ann Bryant, member of the corporate engineering staff for Rockwell International Corp., Pittsburgh, who presented "Out of the Classroom—Into Industry"; Vivian A. Carr, district manager, fundamental planning, tariff and cost department, American Telephone & Telegraph Co., New York, who explored the whys and wherefores of career guidelines in "Career Planning, Who Me?"; and Sherry Lee Herring, editor and publisher of Electronic Woman, who described self promotion in "Personal Public Relations."

In her paper, Bryce highlighted career opportunities and what is needed to take advantage of them in the semiconductor industry. On the marketing side, she mentioned tactical marketers who work primarily with the sales force and need no particular engineering or science background. Applications engineers also fulfill a marketing function, although they are usually electrical engineers or computer scientists. Strategic marketing engineers and system design engineers work closely together, both requiring very technical backgrounds. On the product side, chip or circuit designers and process, assembly, test, and product engineers all work closely with different phases of the design. All of these jobs require degrees usually in electrical engineering or physics but in some cases in chemistry.

Describing the advantages and disadvantages of becoming an engineering educator, Pape warned that much trail-breaking still remains to be done in this field. "Compared with other engineering educators who are male, the woman has entry-level advantages but will probably have disadvantages climbing the administrative ladder if that is her goal. Phrased very simply, she doesn't look like, walk like, or talk like the engineering administrators we have known. Her primary advantage is her greater visibility. She has high visibility, and she'd better be good," Pape summarizes.

Bryant's paper discussed the general approach a newly graduated engineer, whether male or female, should take toward the first job. She cited gaining experience rather than position as an important first step, as well as determining whether technical or managerial roles are more desirable for the individual. She pointed out that as much technical and business expertise should be obtained as quickly as possible in order to move into a decision-making position.

Advice Bryant directed specifically at women is that acceptance may be harder to come by in industry than in academia. She said the supervisor who hires a woman should be prepared to help her become a functioning member of a team without forcing her to prove her credentials time and time again.

Carr's paper outlined a career plan as a first step in identifying career goals. She noted that being an engineer is a good foundation for growth but need not last a life time. Herring's paper explored further how to meet some of these career goals by marketing oneself through a good appearance and a positive attitude.

Sputter and etch basics. Used extensively for the production of complex semiconductors and hybrid integrated circuits, sputtering and plasma etching will be the subject of both basic and advanced classes, as well as discussions at the Material Research Corp.'s Sputter and Plasma Etch School and Conference. Held from Dec. 9 through 11 at La Posada Resort Hotel in Scottsdale, Ariz., the conference will be headed up by Eric Kay, manager of the surface thin film and plasma science department at International Business Machines Corp.'s San Jose Research Laboratories.

The general theme of the courses is "Practical Process Detail, Plasma Surface Physics and Automated Systems for Sputtering and Plasma Etching of High Resolution Integrated Circuits."

Further information and registration forms may be obtained by writing Rosemary McPhillips, Conference Coordinator, Materials Research Corp., Orangeburg, N. Y. 10962, or by phoning (914) 358-2002.

Electron beam's future. "Electronic-Beam Lithography for Microelectronic Device Manufacture" has the dual purpose of reviewing the overall state of the art in electron-beam lithography and its use in fabricating microelectronic devices, as well as investigating the needs for this technology and its various limits and parameters. Presiding over the conference will be Robert A. Geshner, manager for advanced mask technology at RCA Corp.'s Solid State Technology Center, Somerville, N. J. The conference will be held at the Highlands Inn, Carmel, Calif., Nov. 16–18.

Various companies' experiences in working with this technology will be examined. Other topics covered will be resists and materials, software development in computer-aided design, electron-beam equipment control functions and limit tests, and quality-control inspection approaches needed to determine whether the results of electron-beam drying are effective.

Companies that will be represented at the conference include IBM Corp., Philips Research Laboratories, Mead Chemical Corp., Siemens AG, Rockwell International Corp., OKI Electric Industry Co., Perkin Elmer ETEC Inc.

Sessions will be held on the following topics: "The Electron-Beam System Approach: An Overview"; "Resists Used For Electron-Beam Lithography"; "Electron-Beam Technology in Japan"; "Electron-Beam Status in Europe and Mask Making with MEBES"; "Other Equipment Approaches for Sub-Micron Drawings"; "Electron-Beam System Calibration and Performance Monitors"; "Software Architecture of the Philips Beamwriter"; "Mask Quality."

For more information, contact Richard D. Murray, Director of Conferences, Institute for Graphic Communication Inc., 375 Commonwealth Ave., Boston, Mass. 02115, or by phoning (617) 267-9425.

To the Sunbelt. Workers in search of a job may well look to the sunnier South. According to a recent survey conducted by the Economics department of McGraw-Hill Inc.'s Publications Co., the Sunbelt will support 56% of all manufacturing workers by 1990, compared with the 36% it supported in 1955. This future growth will depend in a large part on the production of such durable goods as electrical equipment, instruments, and machinery. The employment share of the South is expected to rise at a rate of 0.6% per year through 1985 and then at a rate of 0.4% until 1990.

-Pamela Hamilton

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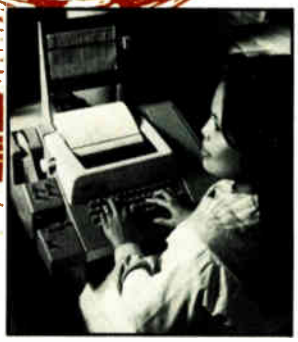

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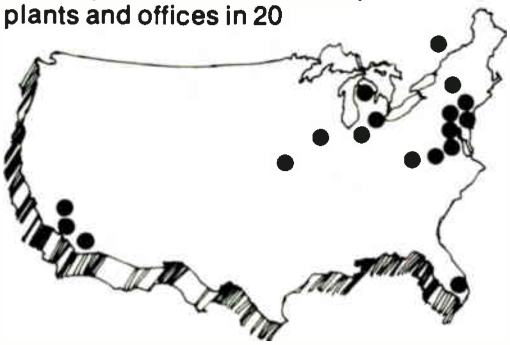

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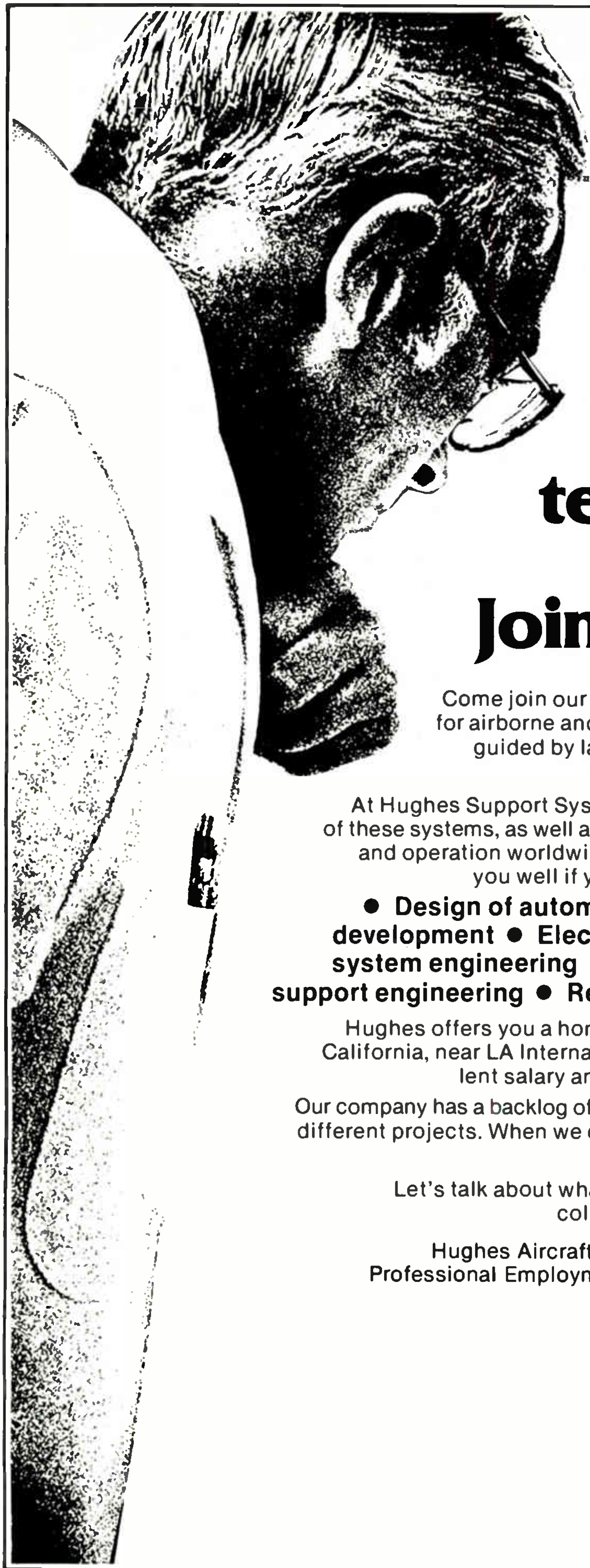

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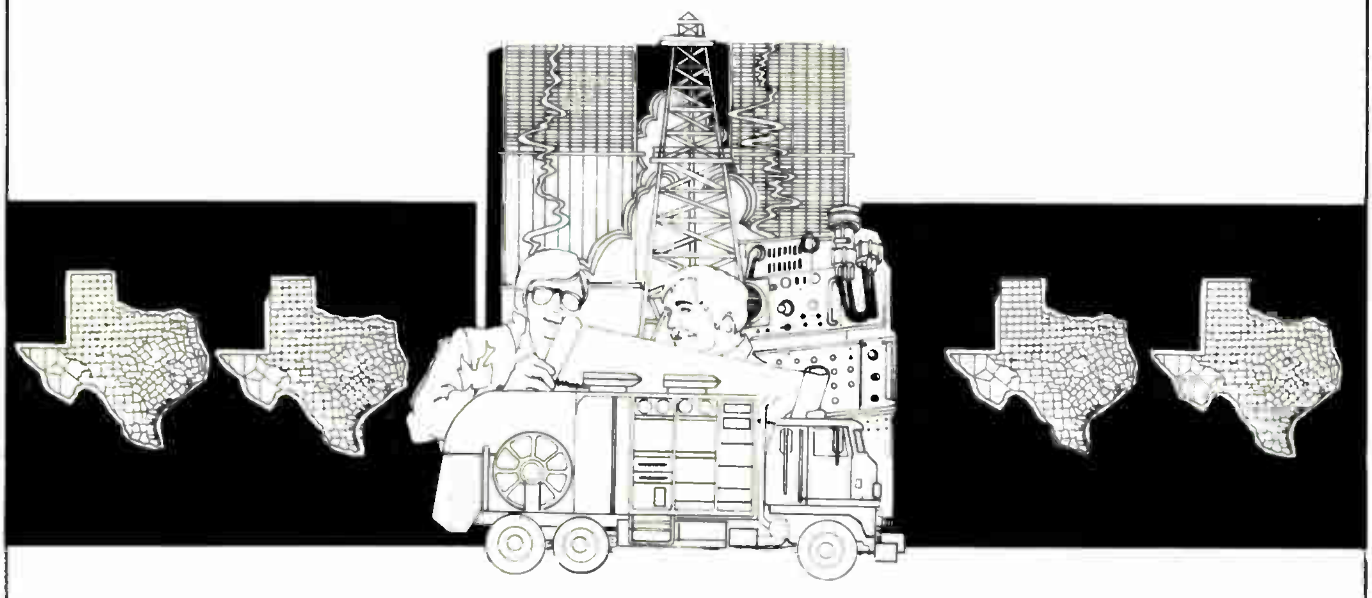

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