JANUARY 4, 1979

**CCD MEMORIES FACE AN UNCERTAIN FUTURE/85**

Designing fault detection into microprocessor systems/139

New 64-pin microprocessor package fights heat/130

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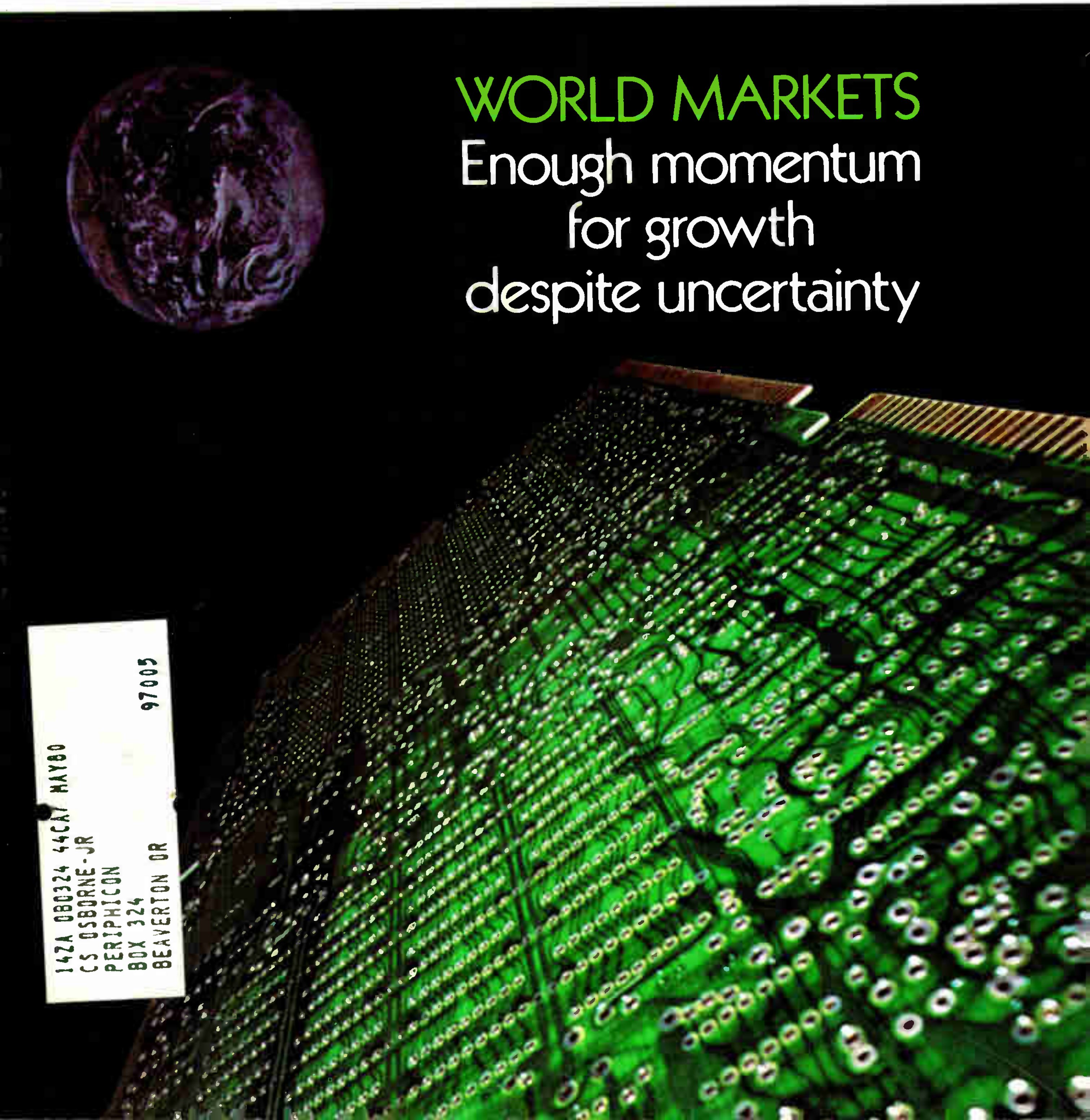

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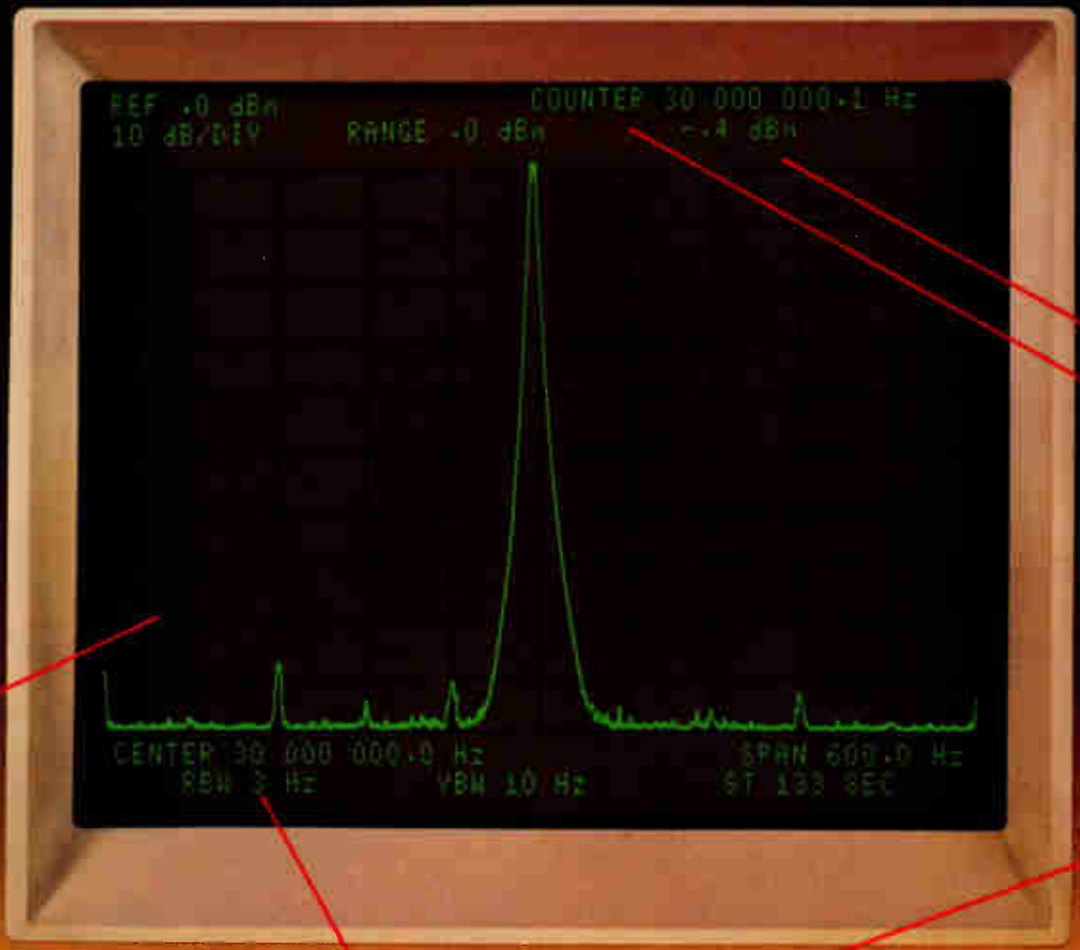


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Circle 2 on reader service card

You can even store two traces and display them either separately or together. Or display the arithmetic difference to simplify comparisons.

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But that's just the beginning. For complete details on the 3585A Spectrum Analyzer, talk with your local HP field engineer.

* HP's implementation of IEEE Standard 488-1975.

098/48

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# Electronics

**The International Magazine of Electronics Technology**

**Vol. 52, No. 1 • January 4, 1979**




## Highlights

**Cover: Solid growth despite uncertainty, 105**
Electronics markets will continue to outpace individual countries' Gross National Products, but an anticipated general economic downturn and inflationary pressures, including the recently announced increases in oil prices, make predictions more tentative than usual.

For 1979, *Electronics*' annual survey predicts a 13% increase to $136.7 billion for U. S., West European, and Japanese consumption of electronics equipment. Leading will be Japan, with an expected growth rate of nearly 15% (p. 123). The U. S. should grow 13.5% (p. 106), and Europe 10.9% (p. 118).

Cover photograph is by Don Carroll.

**SAW devices turn a minus into a plus, 81**
The bulk wave in surface acoustic-wave devices has always degraded their frequency response but now is being used to enhance it by researchers in the U. S. and the UK.

**64-pin QUIP keeps chips cool, 130**
Smaller and sturdier than the 64-pin dual in-line housing, the new quad in-line package, designed for microprocessors, also has low thermal resistance, low pin-to-pin capacitance, and low lead resistance.

**Building in fault detection, 139**
Microprocessor systems faced with demanding applications must be able to detect failures, sound warnings, and protect themselves. Possible methods use self-diagnosis, external hardware, or redundant systems.

**And in the next issue . . .**
High-level languages for microcomputers: a special report . . . testing microprocessor-based system boards . . . a data-link control chip that supports all three bit-oriented protocols.

# Electronics




## Publisher's letter

**Well before the** United States recognized the People's Republic of China, a group of 15 Americans from the Institute of Electrical and Electronics Engineers Computer Society toured the country as part of an educational exchange. It was a fascinating trip that demonstrated China's interest in outside technology.

As the Probing the News about China (p. 92) points out, the Chinese have fallen behind in computers and electronics generally, largely because of the total eclipse of scientific research and development during the ill-fated Cultural Revolution of the last decade. Today, the only efforts to build computers take place at the universities, according to Barry Borgerson, one of the tour members and director of research and technical planning for Sperry Univac in Blue Bell, Pa.

He reports that these universities accorded the Americans a very friendly reception. Apparently every one of the schools visited gave almost the same welcoming address, an apology for the decline of Chinese technology during the Cultural Revolution. Borgerson met one Chinese Ph.D. who spent the period working on a farm.

Despite the belief that China is a country of complete solidarity, computer projects are poorly coordinated. The same model machine made at different universities may have completely different designs, so that there is virtually no chance of interchanging the end products. Harvey Garner of the Moore School of Electrical Engineering at the University of Pennsylvania (where the first U. S. computer was built) estimates that the Chinese universities build only about 10 computers a month. Virtually all of them are used to teach computer technology to others.

One major hindrance, the Americans discovered, is that the Chinese have translated very little computer information available in English, which has forced designers to learn English.

The U. S. visitors are now compiling their information and comparing notes in order to prepare a full report on the trip for the society. It should make interesting reading in view of the recent, more general opening of the People's Republic to relations with the U. S.

**Oil crisis, Part** 2, may once again begrime electronics business in 1979. This year's market forecast (p. 105) is generally optimistic, despite the uncertainties. The main reasons are that electronics has usually been able to outperform the general economy and that there is considerable momentum left over from 1978.

Back in 1974, during Oil Crisis, Part 1, total U. S. electronics equipment consumption was up about 8%, well above a dismal Gross National Product. West European and Japanese electronic production was harder hit but still managed to move ahead of its associated GNPs that year. So there is some basis for looking on the bright side this year.


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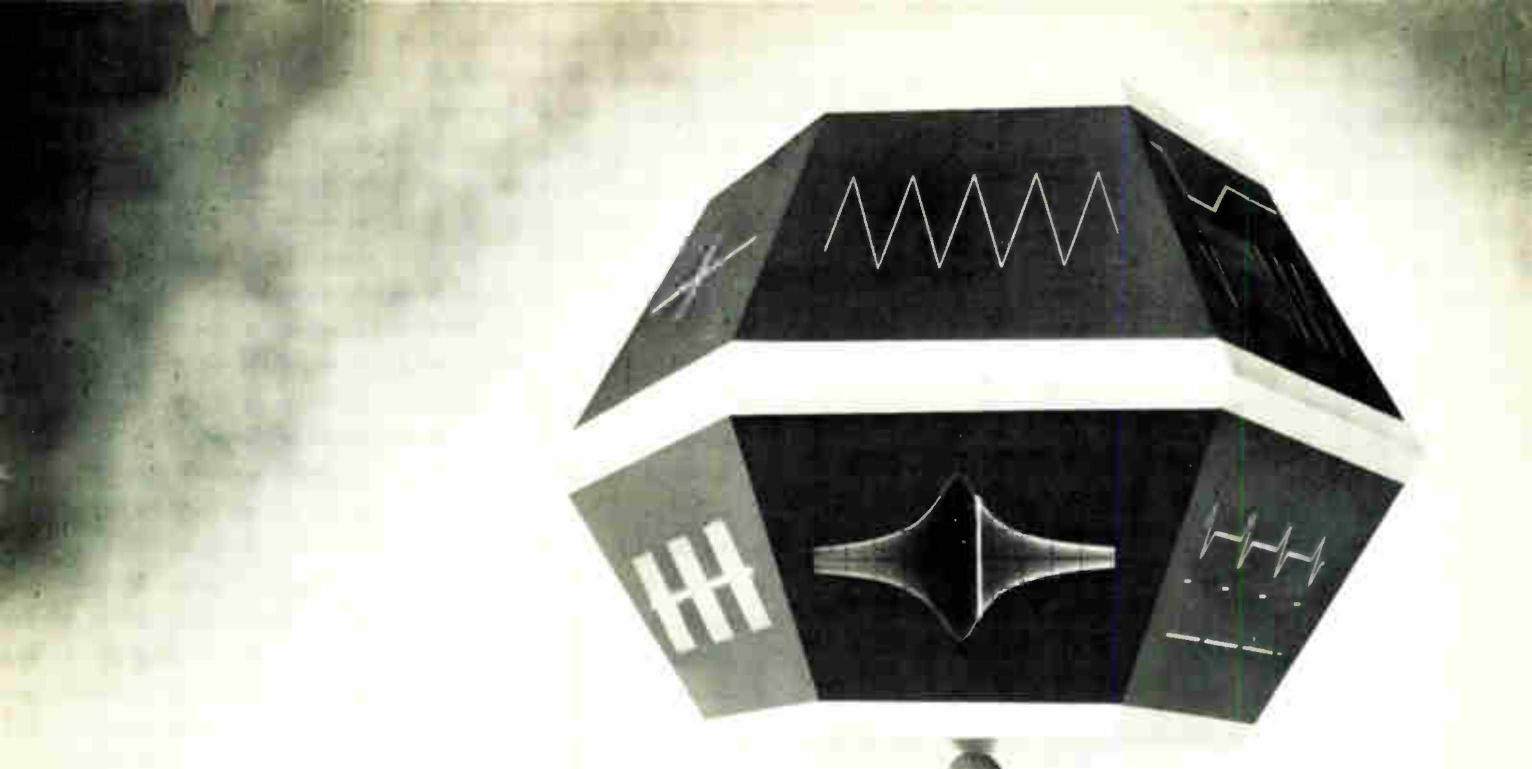

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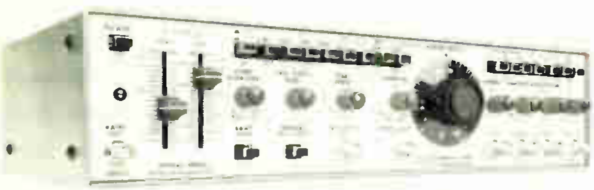

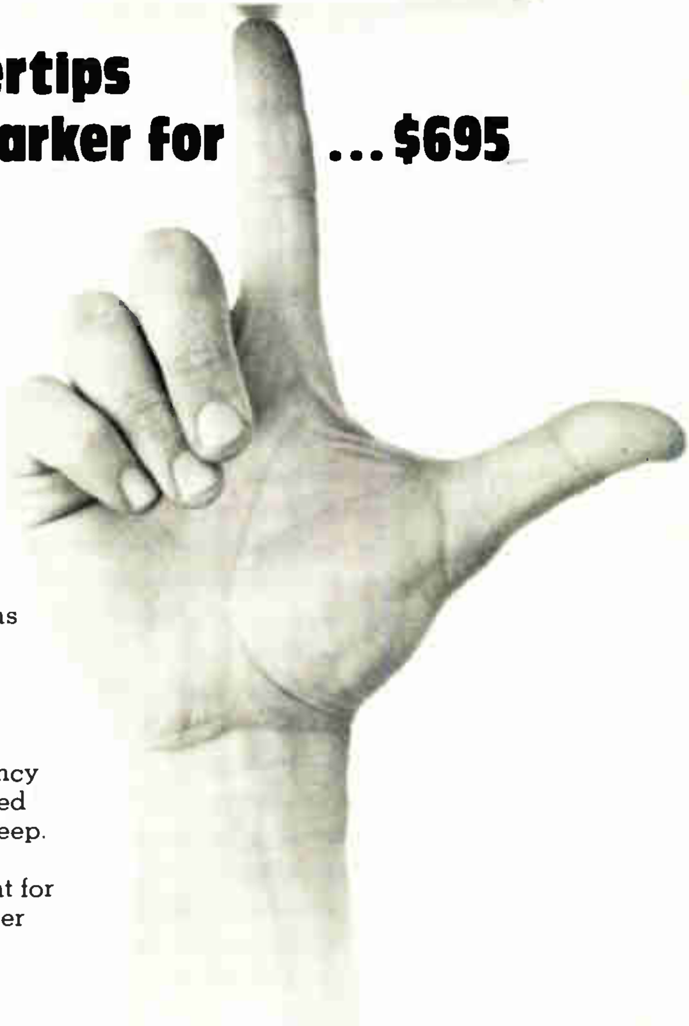

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# Readers' comments

### Please note

**To the Editor:** Your article on very large-scale integration ["Tackling the very large-scale problems of VLSI: a special report," Nov. 23, p. 111] is informative and insightful. However, it omits any mention of TRW's LSI and VLSI products.

In the early 1960s, TRW originated transistor-transistor logic, now the standard logic circuitry around the world. Today, we manufacture integrated circuits with 30,000 electronic elements, 2-micrometer lines, and less than 1-picojoule gate-switching energies.

We agree that there is a trend toward fixed-function parts that perform highly complex tasks. We disagree, though, that analog functions will receive more attention as VLSI technology advances.

We also disagree with the statement by Thomas A. Longo on page 115 that producible die sizes will *eventually* exceed 90,000 square mils. We have already surpassed that size with our 24-bit multiplier, the dimensions of which are 324 by 348 mils, or 112,752 square mils.

Ralph Miller
TRW LSI Products
Redondo Beach, Calif.

### The more, the better

**To the Editor:** Your article "Standard symbols let designers grasp logic operation quickly and easily" [Dec. 7, p. 143] was very much appreciated. However, as a member of the Institute of Electrical and Electronics Engineers' SCC 11.9 committee on logic symbols, which is responsible for preparing the five-year update to ANSI Y32.14, I want to indicate that other companies have adopted this standard. Digital Equipment Corp., Sperry Univac, Control Data Corp., and Honeywell, to name a few in the U. S., are active in using the standard. A number of European firms also use it.

ANSI Y32.14 is the U. S. standards work that is closely aligned with International Electrotechnical Commission (IEEE) Publication 117-15. IEC publication 117-15 is in process of another update as a result of the effort by IEC Technical Committee Number 3 in Europe. The Europeans, as well as ourselves, have had a continuing effort going for several years now.

In fact, this committee is coming to the U. S. in April 1979 for a five-day meeting with SCC 11.9 to discuss much-needed updates of microcircuit symbolism; currently, rules for complex large-scale, as well as many types of medium-scale, integrated circuits are not included to an extent that allows easy, uniform buildup of symbols.

John P. Russell
Richfield, Minn.

### Move that decimal point

**To the Editor:** The article on Hewlett-Packard's beam-penetration color display leaves me confused ["Beam-penetration displays get cheaper," Nov. 23, p. 167]. In two places (title and text) it states that the beam writing rate is 25.4 cm (10 in.) per second, which with a 50-Hz refresh base allows writing of only one 0.2-in. vector flicker free. But the article also states that full-screen (7 in.) deflection is only 100 nanoseconds; however, at 70 in./microsecond that is equivalent to $117.8 \times 10^6$ cm/s, which is a rather large difference. Which is correct?

J. M. H. Heines
Newport, R. I.

■ *The first figure is incorrect. It should have been 25.4 centimeters per microsecond. Also, HP says that its writing speed is greater than 25.4 cm/μs and that its deflection time is less than 100 ns, which should account for the remaining discrepancy.*

---

### Corrections

*Electron Beam Microfabrication Corp. of San Diego, Calif., says delivery of its electron-beam projector will be in 1981, not 1979 ("E-beam projector takes giant step towards practicality," Nov. 23, p. 73). The company also says it does not own the rights to the initial electron-beam projector work of Westinghouse Corp.*

*In "HP-67/97 program performs current analysis" (Dec. 7, p. 152), instruction 152 should read* R↓ *and instruction 178 should read* $X \neq 0$?.

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## News update

■ Bell's ESS No. 4, the high-capacity, all-digital switch with international telephone network switching capabilities that was first installed in New York [*Electronics*, Oct. 26, 1978, p. 179], is working as planned. By the early 1980s, all international calls from the U. S. will be switched by offices equipped with this electronic switching system.

The company expects to realize substantial savings in equipment and operating costs compared with switching centers using the nondigital No. 4A crossbar switching systems, some of which were installed more than 25 years ago. One reason is that the ESS No. 4 provides efficient, full "gateway" operation; that is, it can handle all three types of international calls—calls to or from the U. S. and transit calls (between West Germany and Australia, for example.)

Though the older technology could also handle all three, the steady growth in international traffic requires greater capacity, reliability, and easier maintenance—which the No. 4 delivers. Also, Bell is continuing to develop hardware and software for new features and capabilities for the system.

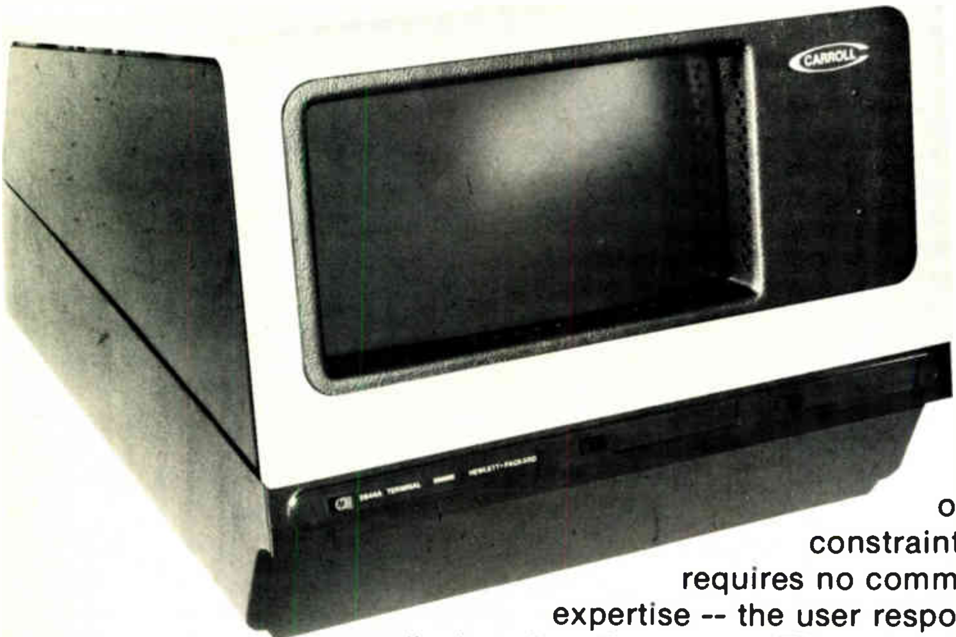
■ In 1928, the British Broadcasting Corp. installed a set of radio broadcast transmitters. *Electronics* did not report on the matter because the magazine did not yet exist—it was born in 1930. But here's news of the replacement of those original transmitters: the BBC has installed 11 50-kilowatt solid-state devices from Marconi Communications Systems Ltd. The new systems may be operated in parallel for a total of 150 kW of working power for the British broadcasters in each installation.

Thirteen more transmitters are on order. When they are placed on line, the BBC network will be fully automatic and will be capable of unattended operation.

The decision to change was stimulated by an international conference in 1975 that reallocated the frequency band occupied by the BBC.

**Harvey J. Hindin**

# Carroll put the touch on Hewlett-Packard*

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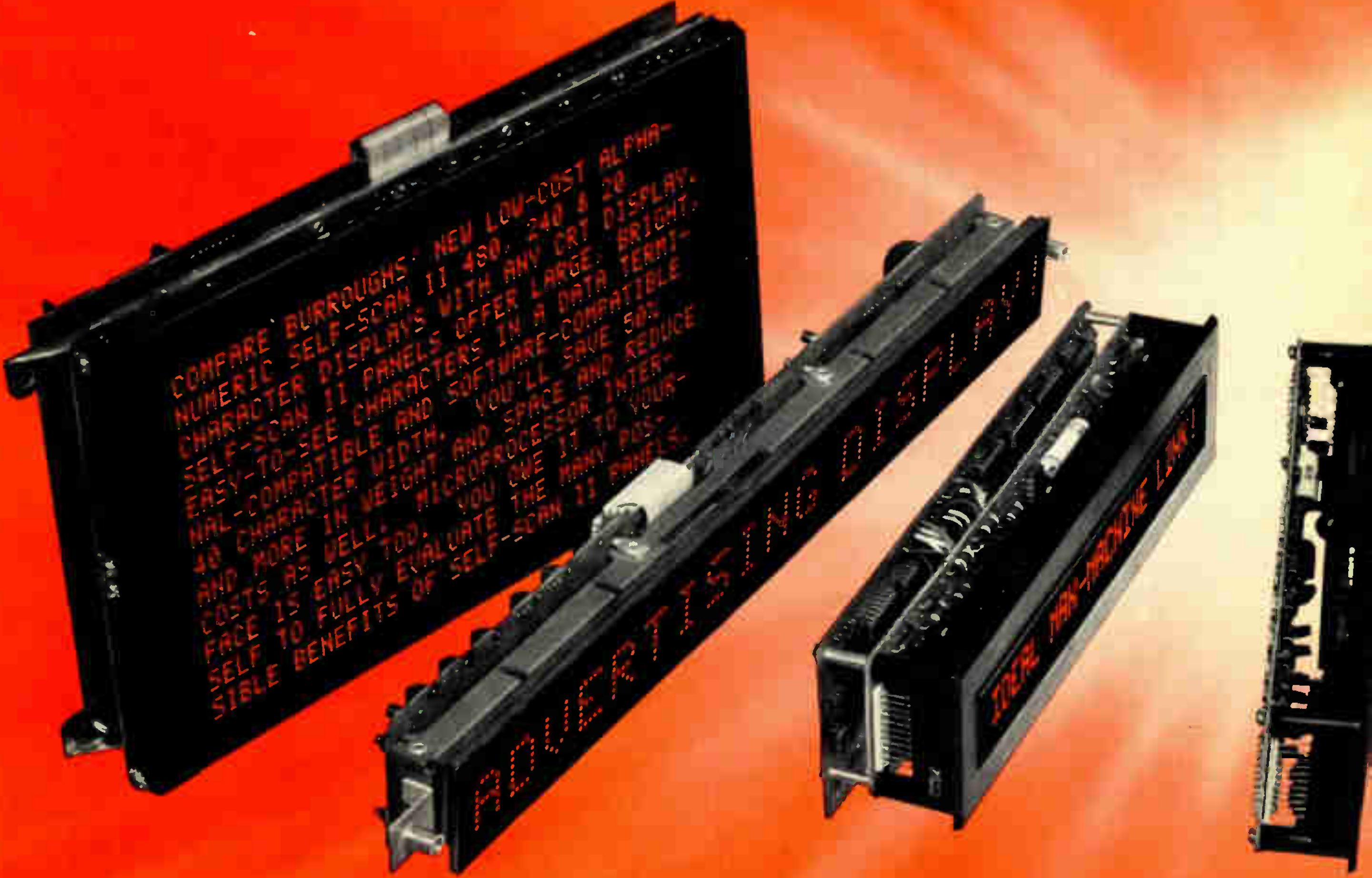


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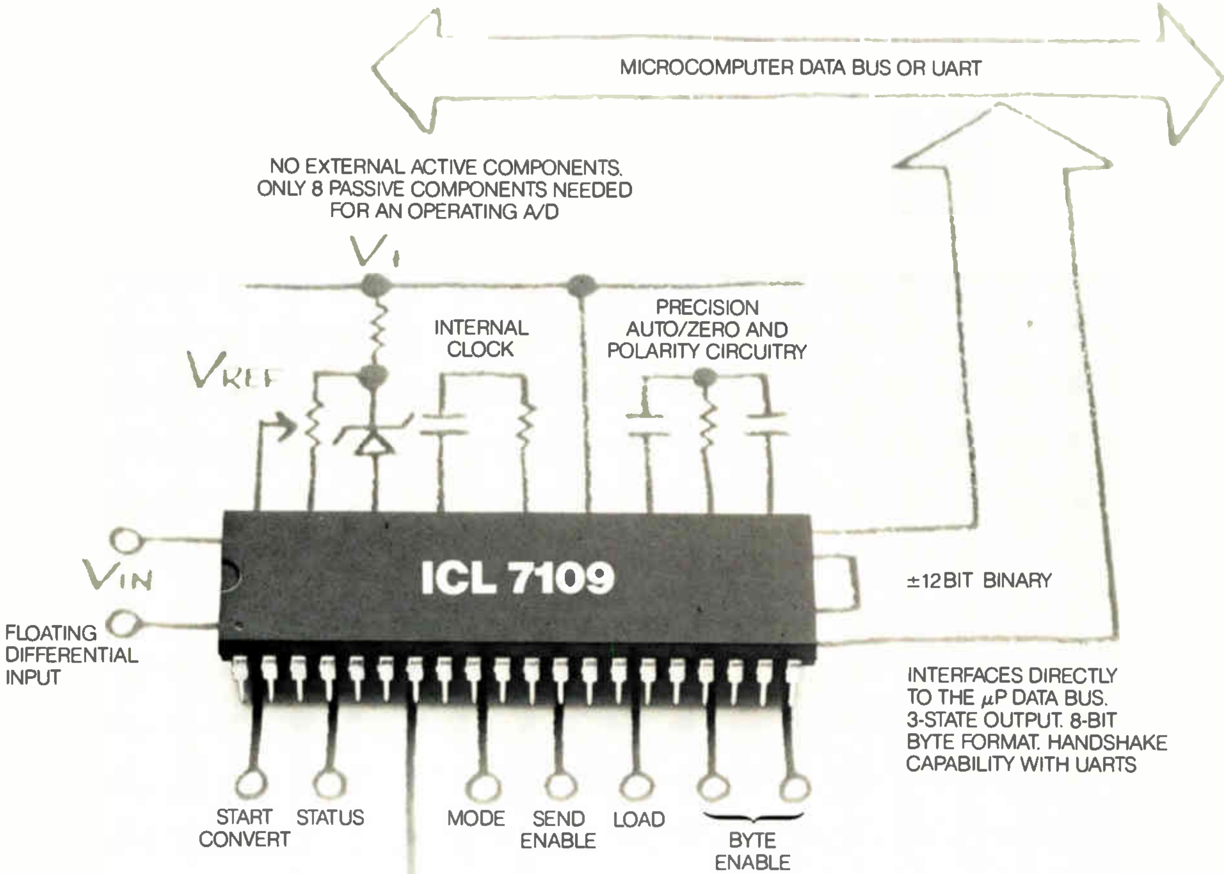


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# People

## Fast 8-bit chips fuel bipolar PROMs, says MMI's Santoro

Demand for bipolar programmable read-only memories is higher than ever with an increasing number going on boards alongside metal-oxide-semiconductor microprocessors. In particular, the higher speed versions of 8-bit MOS microprocessors introduced last year are helping push bipolar PROM sales to new heights, says Carm Santoro, the new executive vice president at Monolithic Memories Inc., Sunnyvale, Calif.

"These new CPU chips work at clock rates that push MOS eraseable PROMs to their limit," he explains. More and more engineers, therefore, are turning to the faster bipolar PROMs. This unexpected trend is adding extra pressure on bipolar chip makers like Monolithic Memories to beef up production to handle the growing number of orders.

**Changes.** Santoro, 37, is faced with two problems as head of manufacturing operations: an eleventh-hour change in fuse-technology on the PROMs from nichrome to titanium-tungsten fuses and an operations group he feels needs rearranging.

The restructuring is necessary because "the organization I found here actually has two groups: one for bipolar products and one for industrial products. One has responsibility for wafer fabrication, the other handles quality control. Testing is smeared between the two."

Activities were often divisive and reduced sales by $20 million over the last two years, Santoro believes. He intends to restructure into "a single unit responsible for all operations."

His approach will be the same as that he learned during his eight years with Motorola Semiconductor Group where he rose to manage MOS manufacturing and engineering. Before joining MMI, he spent three years at American Microsystems, Inc., as vice president of worldwide operations. He holds a Ph. D. in solid state physics.

Why would he leave an executive position at the much larger American Microsystems for the smaller

**First thing.** One of Santoro's top priorities is straightening out manufacturing at MMI.

Monolithic Memories ($32 million in yearly sales)? "It's a unique opportunity for me to be a part of a privately-owned semiconductor company on its way to going public," he says. "With startup costs so high, now, no one can get into it. Those that formed when it was affordable are either public, acquired or gone."

## Bass of Zilog looks for 16-bit boards to grow

Charlie Bass, the general manager of Zilog Inc.'s new Systems division, likes what he sees. "The upturn in the board business the last three months has been very dramatic," he says, pointing to doubled production in just one quarter. And with Zilog's new high-performance Z8000 16-bit microprocessor chip to make use of [*Electronics*, Dec. 21, p. 81], he expects even more growth.

"Board configurations will rival low-end minicomputer configurations," predicts Bass, 36, who came to Zilog in Cupertino, Calif., in 1975 to head up its software development. His credentials included a Ph.D. in electrical engineering and some years teaching in the computer science department at the University of California, Berkeley. The Systems division incorporates development of software and board computers.

The minicomputer makers are really going to notice the 16-bit board, Bass says. Much of the


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**No frills.** Software is best developed by small teams, Zilog's Bass believes.

responsibility for making them take notice will be his. He will introduce a new board with the Z8000 early this year, a development system by mid-year, and "finally a full computing system" by the end of the year. Zilog also plans software support that will convert 8-bit Z80 programs into Z8000 format.

However, Bass believes the real take-off for 16-bit boards will come after the lag that accompanies their design-in. They also will not be priced competitively, at first. In the long run, however, their performance will make them cost-effective for such applications as mail handling, automated inventory control, and "super-intelligent" data logging.

A key part of Bass' job is managing the software development. He prefers small development teams. "It's easy for the software development effort to get too big, but I'm determined to inhibit that kind of growth, principally because large-scale software enterprises can be deadly," he says. Most software jobs are two- to three-person efforts. The "interaction of extra people has a draining effect," Bass continues.

"If you keep it small, it reduces the complexity and raises the visibility of the people," Bass says. "Your potential for success, which means the quality of the result, depends on their individual abilities. That's what we will rely on." □


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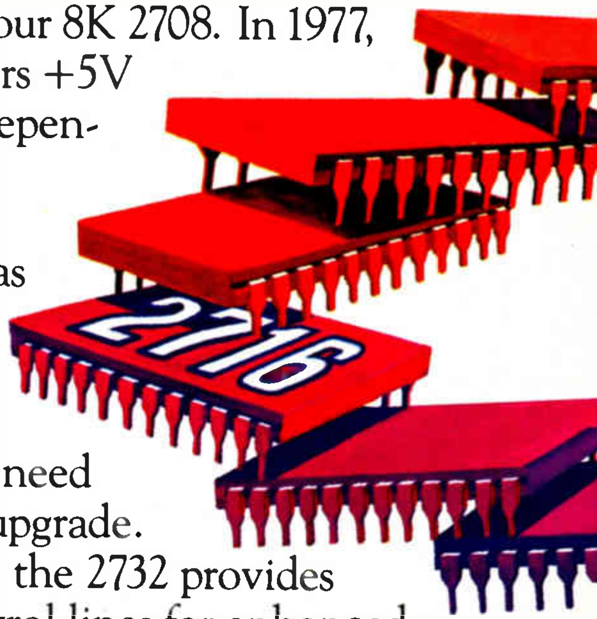


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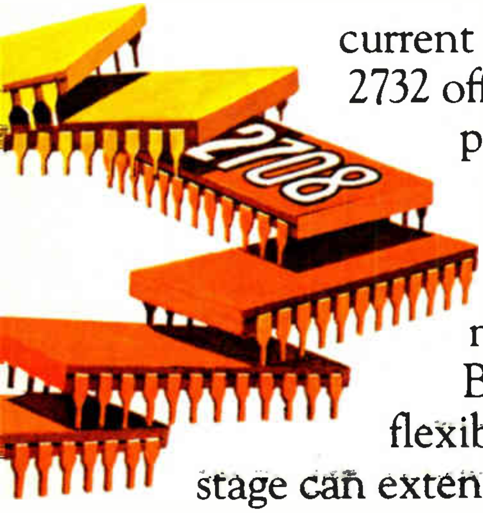
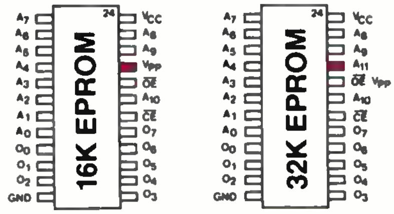



current of only 150 mA, the 2732 offers lower power per bit than any other EPROM. In standby, current is reduced 80%, to 30 mA maximum.




| | 2716 | 2732 |
|---|---|---|
| Organization | 2K x 8 | 4K x 8 |
| Power Supply ($V_{CC}$) | 5V | 5V |
| Active $I_{CC}$ (max.) | 100 mA | 150 mA |
| Power per bit (max.) | 32 $\mu$W/bit | 24 $\mu$W/bit |
| Standby $I_{CC}$ (max.) | 25 mA | 30 mA |
| Access (max.) | 350-450 ns | 450 ns |

Because foresight and flexibility at the design stage can extend a product's life cycle by years, we've written a comprehensive application note, AP30, on using EPROMs in 5V microprocessor systems. AP30 tells you how to get the best performance from today's EPROMs and how to design for easy mobility to tomorrow's higher density devices. For a copy of AP30 and our 2732 data sheet, contact your local distributor or write Intel Corporation, 3065 Bowers Ave., Santa Clara, California 95051.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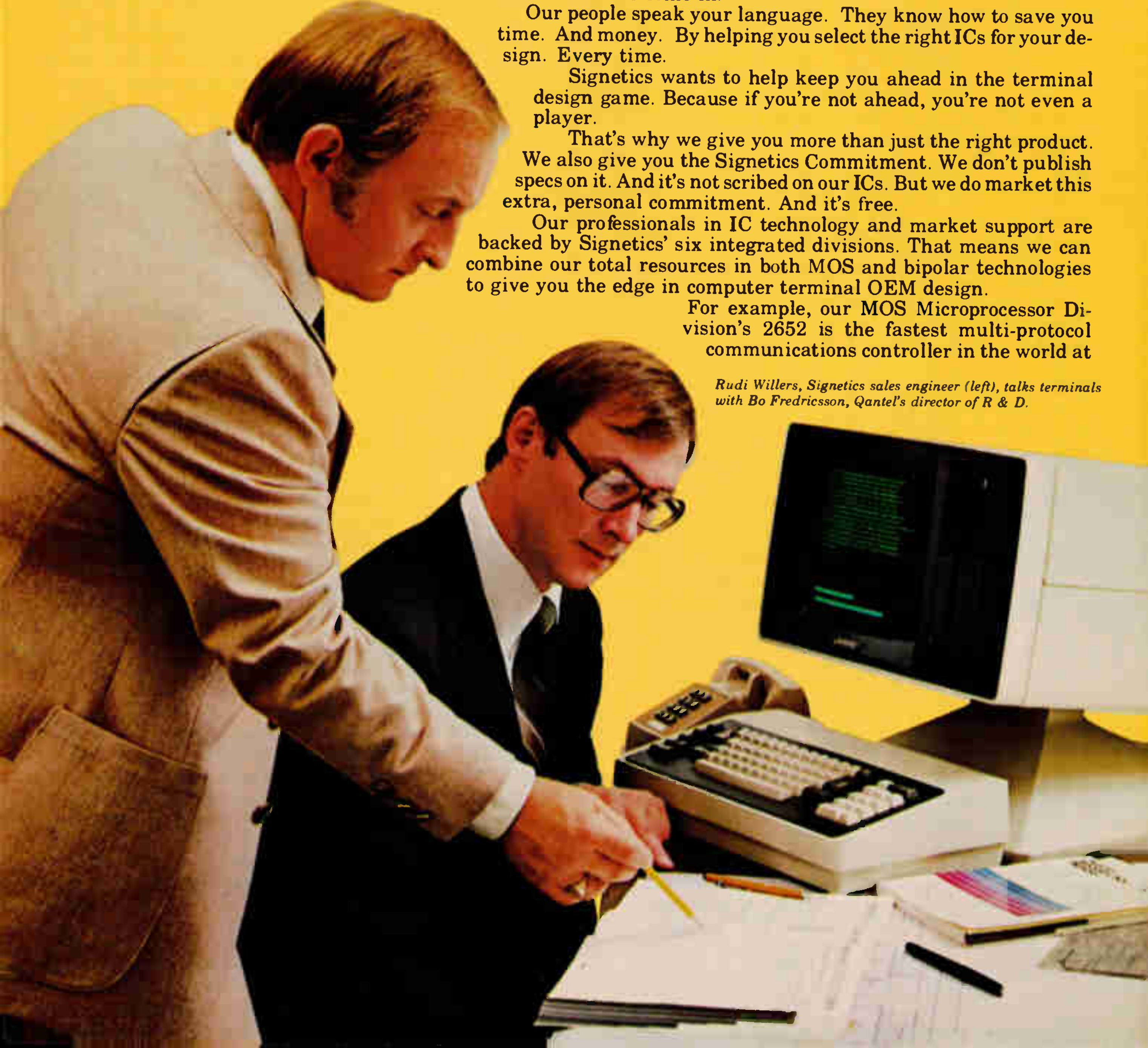

*Rudi Willers, Signetics sales engineer (left), talks terminals with Bo Fredricsson, Qantel's director of R & D.*

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# Editorial

## For 1979, the signs are mostly positive

The year 1979 for the electronics industries will be, in a word, good. But the science of making predictions about the economy being what it is, that estimate rests on a foundation pitted with ifs and buts. What emerges is the realization that electronics manufacturers are simply going to have to become accustomed to operating in an uncertain economic environment and learn that they have nothing to fear but fear itself.

While economists talk of Gross National Products hovering at a growth rate of 2% or so, the consensus adduced by *Electronics*' annual market report (p. 105) is that worldwide electronics sales growth will easily outpace the GNPs of individual nations.

American electronics firms appear to be adopting the view that business will continue to grow, though at a slower rate, while preparing at the same time for a slowdown. Some economists point out that capital investment is going into projects that can easily be dropped: improved machinery rather than new plants, for example. But the highly respected annual prediction of the U. S. business outlook by the McGraw-Hill Publications Co. economics department says, "Unless currency markets preempt domestic economic policy flexibility, the Federal Reserve errs seriously on the side of restraint, or aggressive consumer spending patterns persist, the declines will be neither sharp or protracted." In short, no recession.

Another important upside indicator is that, while sluggish growth is one of the signposts toward recession, other important factors are absent. The McGraw-Hill report points out that three major nonfinancial excesses are not showing up. For one thing, the rate of housing starts is not too high to be absorbed; for another, inventories are under control; and third, capital spending is restrained. "Thus," says the forecast, "if recession occurs in 1979 it is more likely to be the product of the normal irregular pattern of activity than a signal of serious economic imbalance." Or, to put it another way, a recession would occur because its time has come.

For the electronics barometer watchers, the key words are "lead times" and "capacity." Lead times are stretching out, but they do not yet approach what they were—52 weeks in many cases—in the bad old days of 1974. For example, for low-power Schottky devices the lead time is 20 to 22 weeks with heavy double ordering reported; for transistor-transistor logic, 14 weeks. As for capacity, companies are tending to upgrade existing equipment—putting their dollars into new front and back ends, for example—rather than planning new buildings.

On the whole, then, the electronics industries should do better than the economy as a whole. Unless . . .

## Meetings

**Advanced Semiconductor Equipment Exposition,** Cartlidge & Assoc. (Sunnyvale, Calif.), San Jose Convention Center, San Jose, Calif., Jan. 16–18.

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

**Fourth Automated Testing for Electronics Manufacturing Seminar and Exhibit,** Benwill Publishing Corp. (Boston), Marriott Hotel, Los Angeles, Jan. 23–25.

**Forum on Future Computer and Communications Systems,** International Information Technology Institute (Newtonville, Mass.), Barbizon Plaza Hotel, New York, Jan. 24–26.

**Microprocessor Programming,** IEEE Continuing Education (Piscataway, N. J.), University of Washington, Seattle, Jan. 24–26.

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

**Microelectronics Measurement Technology Seminar/Exhibit,** Benwill Publishing Corp. (Boston), Hyatt House, San Jose, Calif., Feb. 6–7.

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

**Phase-Locked Loops Seminar,** George Washington University, Continuing Engineering Education, Washington, D. C., Feb. 12–13.

**International Solid-State Circuits Conference,** IEEE, Sheraton Hotel, Philadelphia, Feb. 14–16.

**Sixth Energy Technology Conference and Exposition,** Electric Power Research Institute (Palo Alto, Calif.), Sheraton Park Hotel, Washington, D. C., Feb. 26–28.

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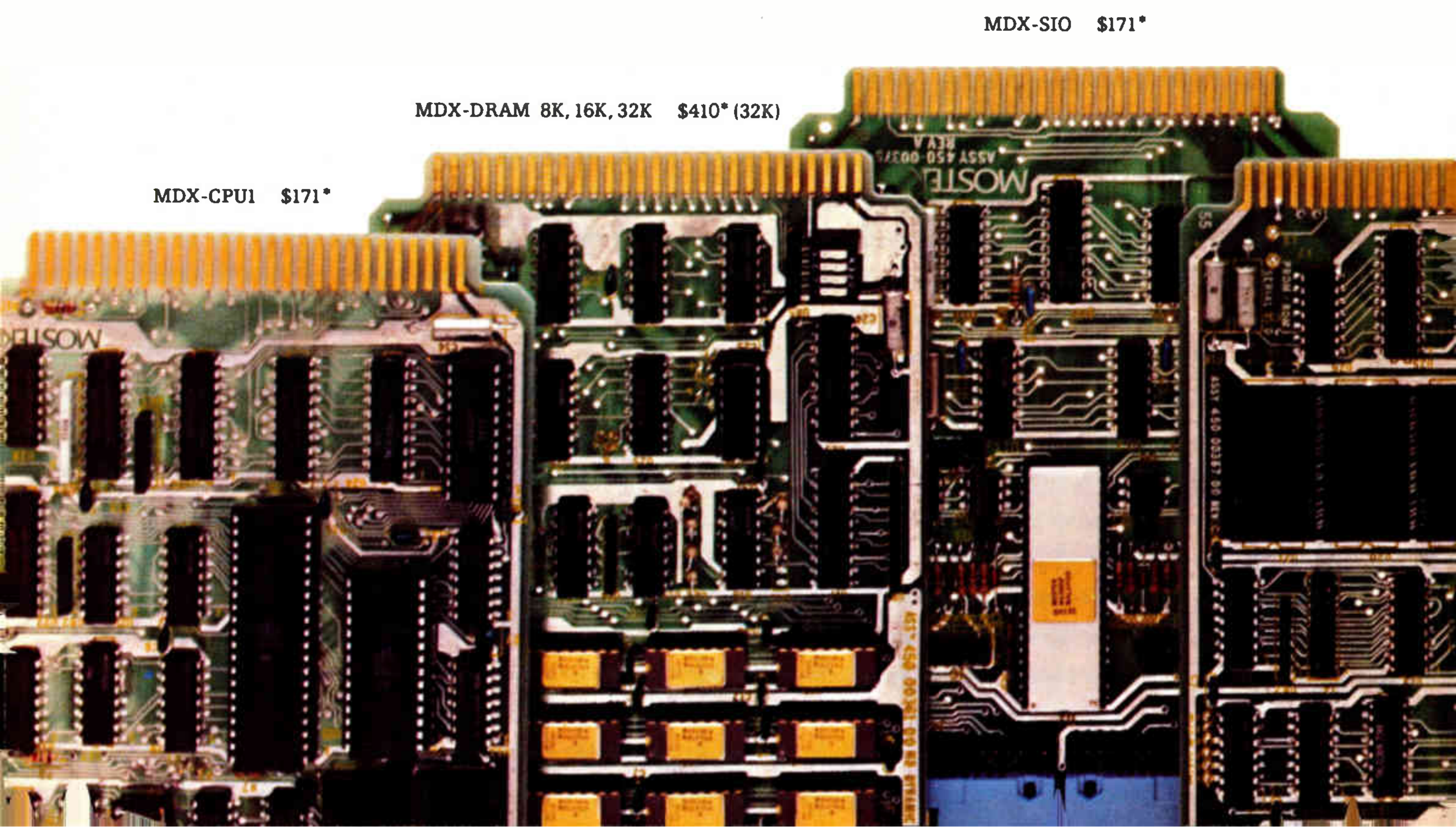

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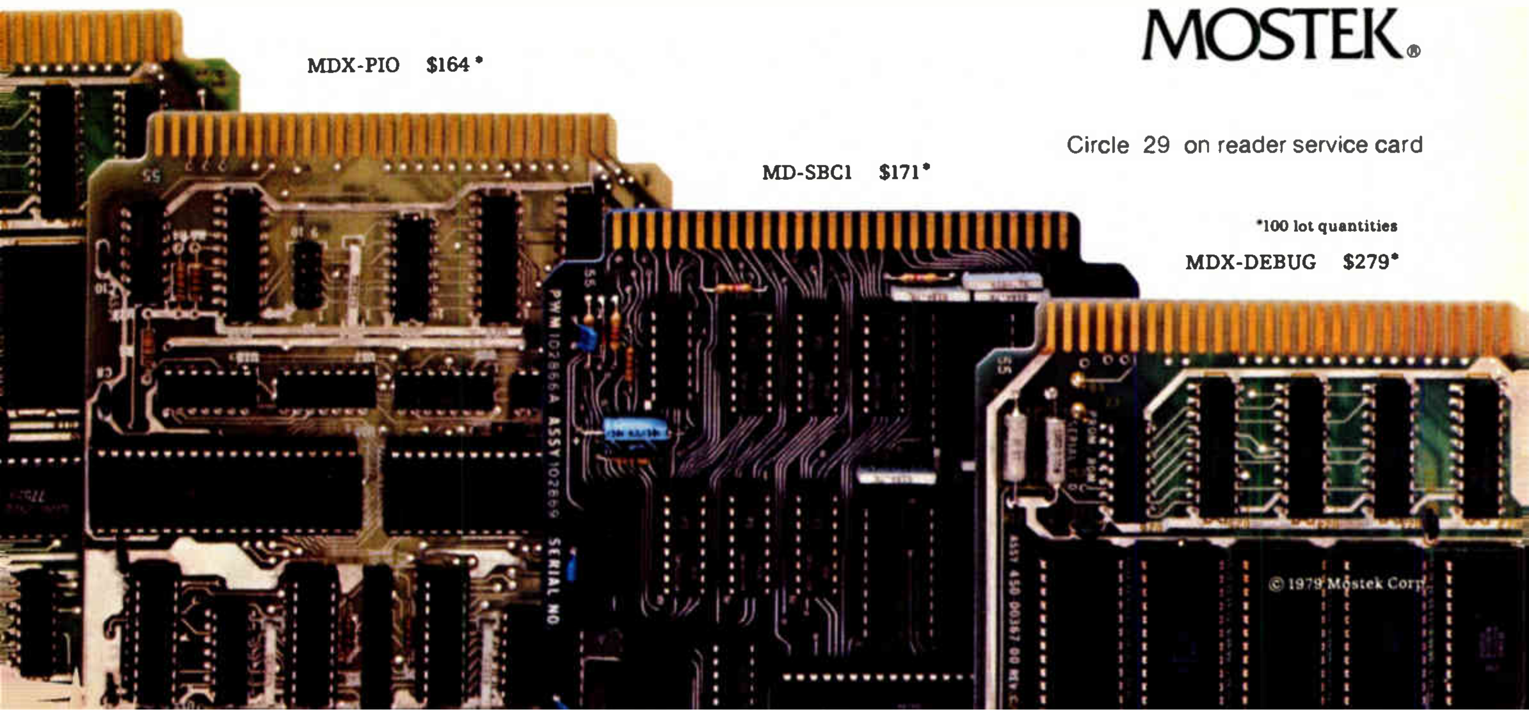


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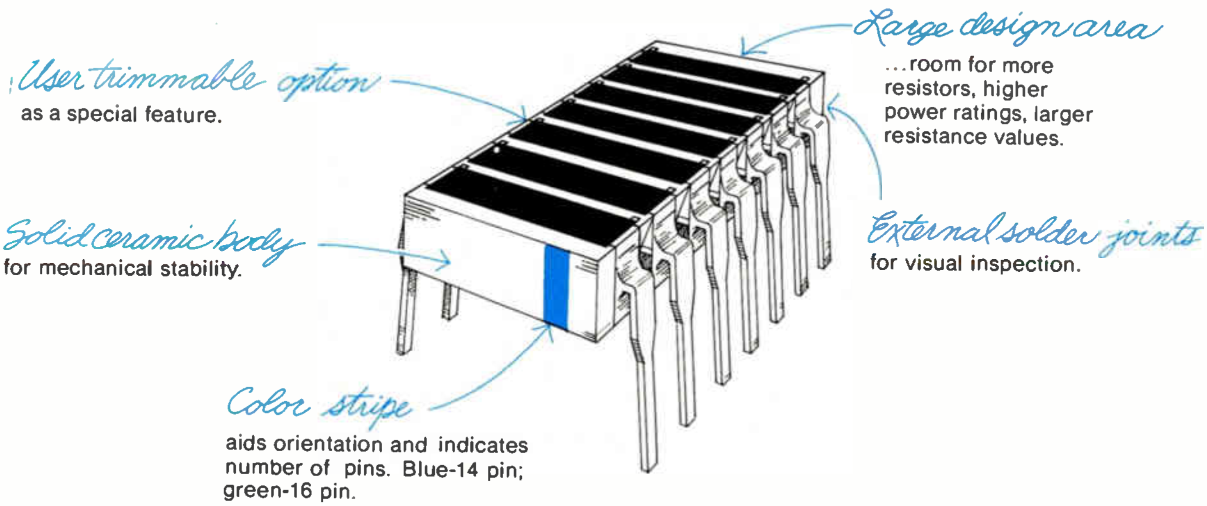


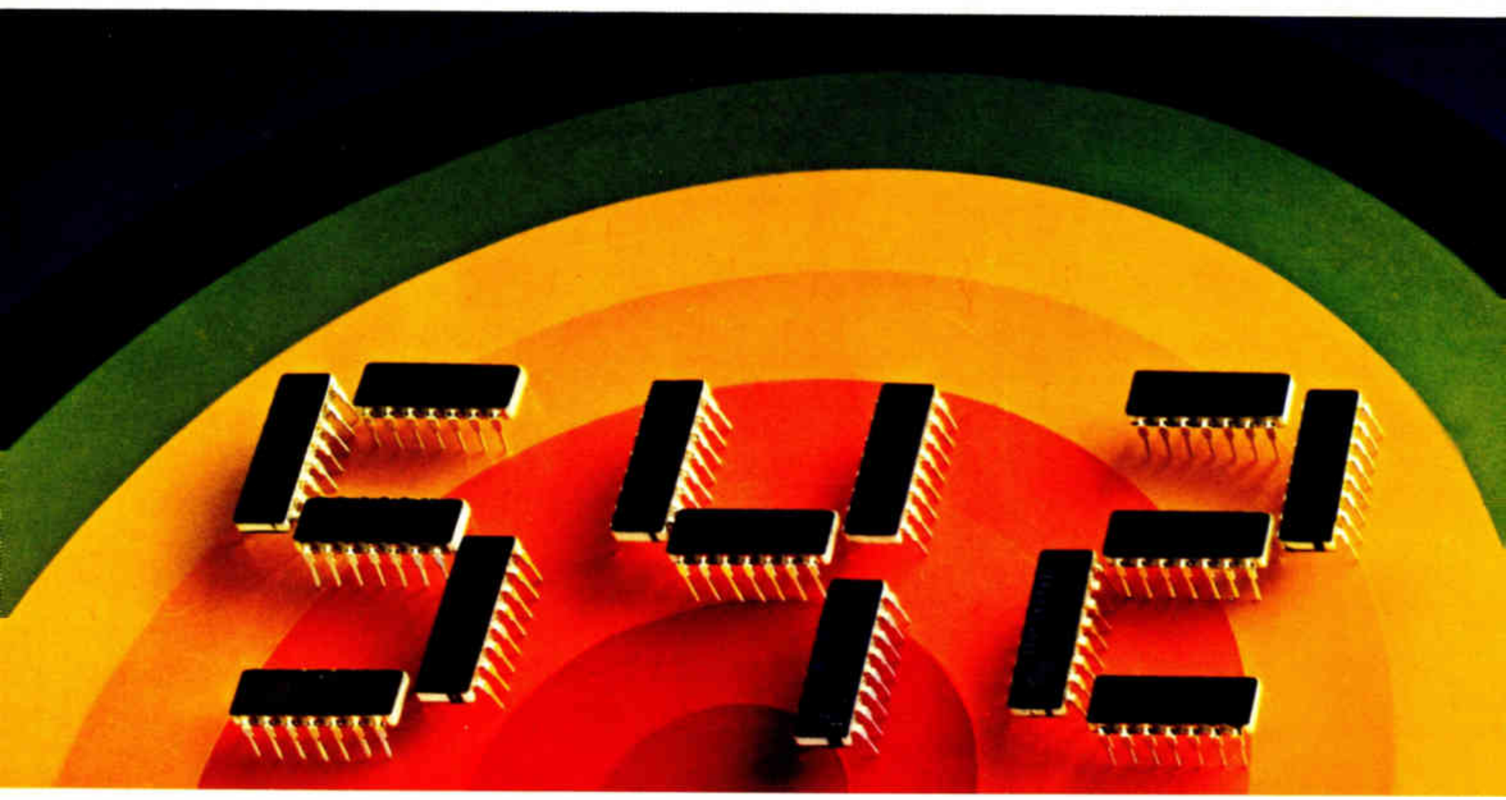

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# Electronics newsletter

**Mostek teams with Intel on 64-K pinouts**

Although the function to be offered on pin 1 of Mostek Corp.'s forthcoming 64-K dynamic random-access memory (RAM) has not yet been revealed, it looks as if the Carrollton, Texas, semiconductor manufacturer will have a second source in its competition with the 64-K chips from Texas Instruments and Motorola. **Intel Corp. will apparently design its 64-K RAM to be functionally compatible with Mostek's.** This is a follow-up to the agreement under which Mostek second-sources Intel's 8086 microprocessor. The 64-K RAM arrangement will be simply a verbal agreement on function, with no technology exchange.

**Canadians test fiber link to 35 homes**

Bell Canada has started a unique two-year technology field trial of a fiber-optic system that brings the fiber directly into the homes of 35 Toronto subscribers, linking them to the telephone company's first interconnection level, or loop plant. The systems can handle simultaneous telephony and data and video transmission. Bell feels that the installation has **great potential for bypassing the economic expansion limits that coaxial television distribution systems have reached** using conventional technology. Moreover, the company feels that it is time for an in-home test without waiting for the development of the so-called optimum all-digital fiber system.

**AMI uses V-MOS for higher speed slots**

For speedier memory sockets, American Microsystems Inc. expects to have a 16-K-by-1-bit fully static random-access memory (RAM) with a 70-ns target specification ready by the end of 1979 and also is planning a 4-K-by-4-bit part. Also due out as the company expands its V-MOS beachhead, is an S4028 2-K-by-8 static RAM featuring a maximum 22-ns access time and a maximum 100-mA supply current. Later, it expects to announce a 250-ns version of its S4264 8-K-by-8-bit fully static read-only memory with power down.

**Mostek looks to Intel's PL/M for development**

Now that Mostek Corp. has elected to second-source Intel's 16-bit 8086 central processing unit [*Electronics*, Nov. 23, 1978, p. 46], it is expected to provide development tools on its AID-80F microcomputer development system. **Chances are the Carrollton, Texas, firm will either license or redesign Intel's PL/M language for that purpose within a year.** It is still eyeing CAP-CPP's Microcobol system for the AID-80F and may become the first U. S. distributor to offer that British language [*Electronics*, May 25, 1978, p. 33]. Says Ron Baldridge, Mostek's strategic marketing manager for microcomputer products: "We're using Microcobol in house and evaluating the possibility of becoming a distributor. It's a good software package and we're very satisfied with it."

**Panasonic, Quasar to push harder in U. S. after shakeup**

Look for more aggressive marketing in the U. S. from Panasonic and Quasar Electronics Co. after Japanese parent Matsushita Electric Industrial Corp.'s reorganization of Quasar in Franklin Park, Ill. President Robert T. Bloomberg was eased out, an industry insider says, because **he failed to provide aggressive marketing leadership.** He has been reassigned as a staff adviser to Keiichi Takeoka, Matsushita's senior official in the

U. S., but Bloomberg says he hasn't decided whether to stay with the company.

In the reorganization, Quasar's plants will be integrated into Matsushita's worldwide manufacturing operation. Richard A. Kraft, president of Matsushita Industrial Corp., the new assembly division of Matsushita Electrical Corp. of America, says, "When market volume and demand become large enough to support manufacturing in the domestic plants, we will do it." Kraft was vice president of manufacturing at Quasar before being promoted to his new job.

Panasonic color TV sets are to be the first non-Quasar products to be assembled at the suburban Chicago plant, which can turn out 50,000 sets a month. **In the future, insiders predict, the plant also will handle video tape recorders and microwave ovens.** Employment there is now 2,000, down from a peak of 3,400 before a $15 million modernization.

## TRW converter can operate at 8 GHz

A 5-bit analog-to-digital converter that operates at up to 8 GHz has been built in the laboratory at the Defense and Space Systems group of TRW, Inc., Redondo Beach, Calif. It is fabricated in gallium arsenide as part of a TRW program for the Office of Naval Research to push GaAs development in small integrated circuits. Besides the very high variable sample rate, **the converter needs only five active devices,** including a field-effect transistor as current source.

## OEMs keeping Rockwell upbeat about 256-K bubbles

The interest of original-equipment manufacturers in Rockwell International Corp.'s 256-kilobit bubble-memory devices and related products introduced in September [*Electronics*, Sept. 14, 1978, p. 161] has been much more intense than anticipated, says Howard D. Walrath, president of the Electronic Devices division in Dallas. On the basis of the current high level of prototyping activity, an understandably optimistic Walrath says it now appears that the total available **noncaptive annual bubble market will reach $500 million by 1983,** more than three times the $150 million figure originally projected by Rockwell.

The company's RBM256 device and RLM658 multichip module are competing against Texas Instruments Inc.'s TIB0303, a 256-K bubble part introduced last August. Though the Rockwell and TI parts are the only devices currently available as samples, other manufacturers are expected to enter the 256-K bubble race this year, including Intel Corp., National Semiconductor Corp., and several overseas manufacturers.

## Addenda

Sears, Roebuck and Co. is believed ready to sell a home computer in three to 10 test markets early this year. While Sears won't confirm that, Atari Inc., which has supplied its Pong video games to the giant retailer, says it has been talking to Sears about a computer. . . . IBM has developed an experimental material that expands when exposed to ultraviolet light. **The jelly-like material could be irradiated with a computer-controlled ultraviolet light to yield printing plates that don't need solid type,** says Ari Aviram, who created the material at IBM's Thomas J. Watson Research Center in Yorktown Heights, N. Y. The substance, synthesized from two organic compounds containing carbon, hydrogen, oxygen, and nitrogen, expands about 35% in each of its dimensions, or about 145% in volume.

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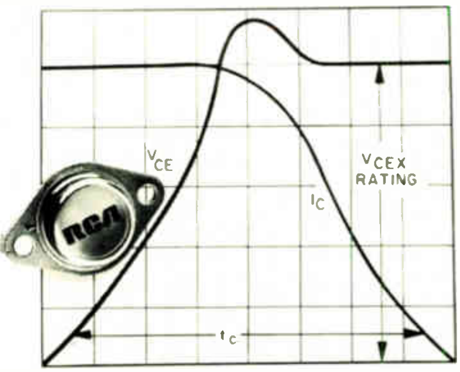


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|---|---|---|---|---|---|
| 2N6671<br>2N6672<br>2N6673 | 450 V<br>550 V<br>650 V | 0.1 (25°C)<br>1 (125°C) | 1 (25°C)<br>2 (125°C) | 5A | 0.4 (25C)<br>0.8 (125C) |
| 2N6674<br>2N6675 | 450 V<br>650 V | 0.1 (25°C)<br>1 (100°C) | 1 (25°C)<br>2 (100°C) | 10A | 0.5 (25C)<br>0.8 (100C) |
| 2N6676<br>2N6677<br>2N6678 | 450 V<br>550 V<br>650 V | 0.1 (25°C)<br>1 (100°C) | 1 (25°C)<br>2 (100°C) | 15A | 0.5 (25C)<br>0.8 (100C) |

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**Application Note AN-6741** describes the use of the RCA 2N6676 15-ampere SwitchMax power transistor as a driven pulse-width-modulated flyback-converter stage, in a 20-kHz off-line power converter providing 340 watts output.

**Application Note AN-6743** is a description and analysis of a 900-watt off-the-line half-bridge converter using two 15-ampere SwitchMax high-voltage power transistors. This Note, too, demonstrates the outstanding capabilities of SwitchMax in a typical switching application.

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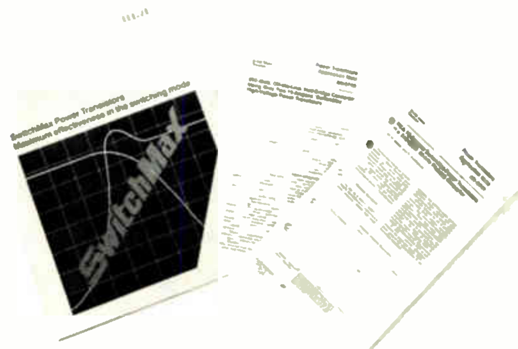



Circle 37 on reader service card

RCA

# Two microprocessors share the chores in home computer

System proposed by General Instrument offers computing and entertainment; programs run from secure cassettes

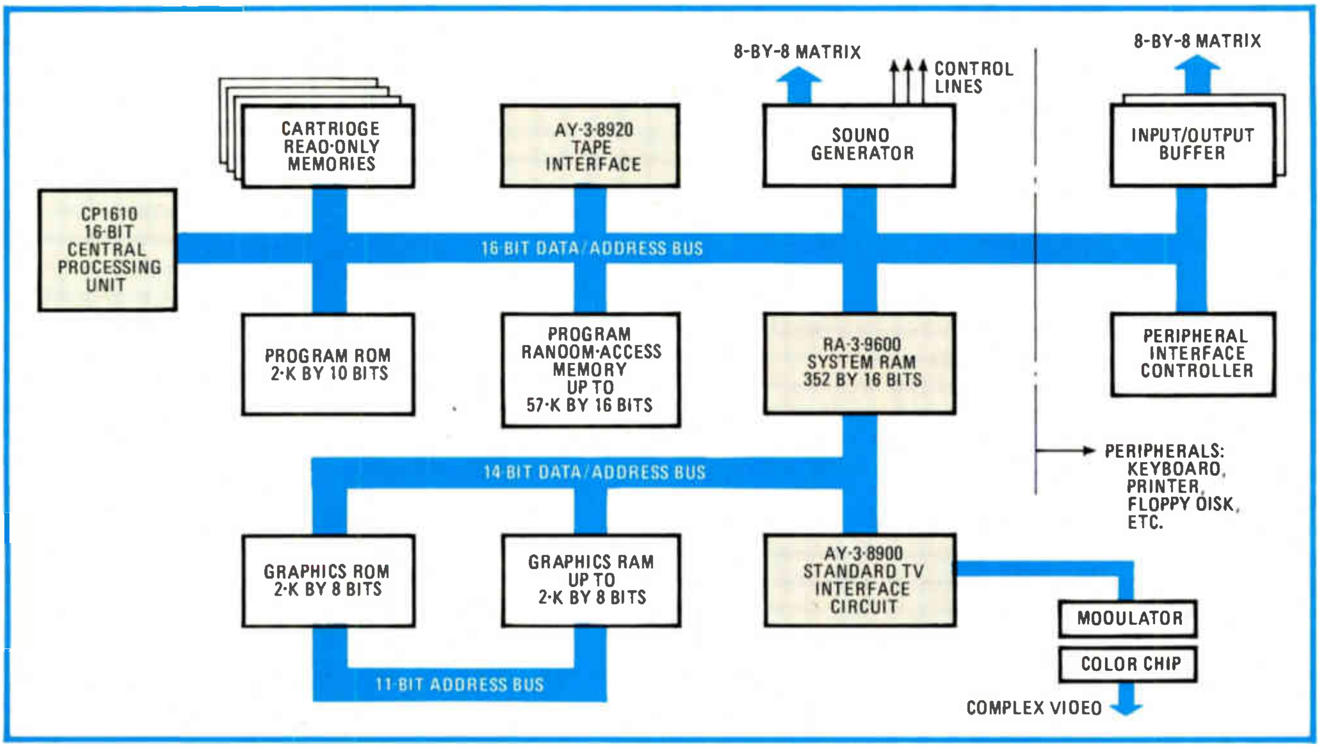
**As personal computers** and programmable video games merge into a product called the home computer, hardware makers face a problem: how to make these machines easy to use but at the same time capable of doing more computing than playing a mean game of chess. One answer from General Instrument Corp.'s Microelectronics division is to put two microprocessors to work instead of one.

The Hicksville, N. Y., division's concept is a home entertainment and information system built around GI's 16-bit CP1610 central-processing-unit (CPU) controller and a 14-bit AY-3-8900 processor dedicated to color display tasks. It also includes a handful of peripheral chips (see diagram).

The two-microprocessor, dual-bus, distributed architecture expands the system's capability for video games. It also permits a consumer to use the machine as a home computer without learning a program language.

The system comes in two versions, both intended to connect to a color TV set as the display. The basic version is programmed by read-only-memory (ROM) cartridges similar to those used for programmable games. The other employs either special four-track tape cassettes or ROM cartridges. It also has a tape interface chip, an input/output buffer chip, and a peripheral-interface controller chip.

The tape cassette opens the system to many more programs than is possible with a ROM cartridge. It has two tracks for audio and two for digitally coded programs. One cassette can carry up to 1.6 million bits of storage, so that just one side can




**Big center.** Standard TV interface circuit in deluxe version of GI's home entertainment/information center contains dedicated 14-bit microprocessor for color display, freeing CP1610 CPU for accepting programs from cartridge ROMs and tape cassettes.

## Inside the home computer

System architecture in the General Instrument concept (see diagram, p. 39) is based on two microprocessors sharing a common system random-access memory (RAM). The first is the CP1610, a 16-bit unit that controls all functional blocks—RAMs, read-only memories (ROM), sound generator, and tape interface—on its 16-bit data and address bus. The second, the AY-3-8900, controls graphics ROM and RAM and RA-3-9600 system RAM.

The AY-3-8900 has a 14-bit instruction set, but instead of arithmetic or logic instructions, it uses character position, character library selection, and color as the definitions within its microprogram. It takes digital data introduced into the system and converts it into the correct waveforms for a 525-line noninterlaced NTSC system. Its output drives the AY-3-8915 peripheral color chip, which generates a single composite color signal for the standard color TV set.

The RA-3-9600 system RAM provides a communications link between the two processors. It contains several added logic functions that allow it to operate as a pseudo-dual-port memory. The unit has a 16-bit address register and control decoder for the 16-bit bus interface and an 8-bit address counter and control circuitry for the 14-bit bus interface.

hold hundreds of games. Also, pages of books synchronized with stereo sound can be displayed, along with related graphics, extending the system to do-it-yourself and other educational applications in the home. For interactive uses, the computer is addressed by hand controllers or a 64-key keyboard.

**Partners.** To secure the cassettes against program pirates, GI has entered into a partnership with EMI Ltd. of Great Britain, which has an unusual means of "watermarking" tape. This proprietary process magnetically codes the tape with unerasable keys that cannot be recorded.

When a cassette is inserted, software resident in the GI system searches for the tape's "watermark." The system will not accept data from an unmarked tape.

The advantage of using two microprocessors is the extensive color graphics made possible by dedicating one of them to the TV interface, says Stephen Maine, GI's director of engineering for audio visual products. While the 16-bit CPU handles other computations, including monitoring an alarm system or a room-temperature controller, the 14-bit interface microprocessor processes picture information.

The interface processor digitally creates its 16-color graphic images using the TV screen's 16,000 picture elements (pixels). The digitized images are created from computer algorithms and stored data and not from the analog color generator typical of most video games.

As with all of its consumer product concepts, GI has no intention of supplying the home entertainment and information system directly to the consumer in a completed product. Instead, the firm will follow its usual procedure of demonstrating the capability, providing technical assistance, and of course, supplying the necessary chips to a manufacturer. Maine estimates that the price for such a system would range from $150 to $400, and the programmed cassettes should run about $5. □

### Consumer

## Winter Show has lots of little things

Those who made timely reservations for the 1979 International Winter Consumer Electronics Show in Las Vegas, Nev., will have lots of little things to look for amid the crowds. Hotel rooms at the affair, which begins a four-day run on Jan. 6, are all booked, and the show will dwarf last year's gathering: 811 exhibitors, more than 40,000 attendees, and almost a half million square feet of exhibit area.

Unlike last year's dominance by the home computer, this year will see an across-the-board outpouring of new products, especially in areas like personal telephones, televisions, and audio components.

Home computers will make their mark again. All the established makers will expand their software offerings in efforts to widen the appeal of their machines. There will be newcomers, too, like Atari Inc. [*Electronics*, Dec. 21, 1978, p. 38].

Another product area with success dependent on greater consumer interest is fancy telephone accessories, such as answering machines. Here, competition is intense: remote message pickup, for example, is moving from $300 machines down to units that will cost less than $150.

**Dialers.** Also on display from several firms will be automatic dialers that store 35 phone numbers and display the number dialed and the time of day and date, as well as warn when a call is about to go over three minutes. Typical is the $230 Freedom Dialer from Royce Electronics Corp., a North Kansas City, Mo., firm known for its citizens' band radios.

Royce's product manager, Phil Love, characterizes the new area of the telephone business as "one of those rare industries where the technology can do more than the consumer is asking for. Usually it's the other way around—demand for features is the motivating force behind product innovation."

The "other way around" is certainly the case with television sets. The great mobility of Americans is boosting demand for what are being called minicombos, which put a small-screen black-and-white TV, an a-m/fm radio, and an audio cassette player-recorder into one lightweight unit. Screen size typically is 5 inches, but U.S. JVC Corp., Maspeth, N.Y., will be offering a unit with a TV that is only 2 in. measured diagonally. By next year JVC color units should be arriving here from Japan.

Miniaturization will also be evident in high-fidelity audio components. Panasonic Co. will unveil a

40-watt-per-channel power amplifier, a preamplifier and an a-m/fm tuner, each measuring only 2 by 12 by 8¼ in.

**Performance.** The audio field will continue to exhibit greater emphasis on performance than on convenience features, according to Don Palmquist of Kenwood Electronics Inc. of Carson, Calif. Palmquist, who will speak on hi-fi product innovations at one of the show's technical program sessions, believes that features such as microprogram control can have transient success at best. "Stereo buyers are interested in one thing: sound quality. We've stayed away from frills and concentrated on improving the transient response of our high-end integrated amps and tuners."

Conservative hi-fi designers may also be in for a shock when they see Carver Corp.'s magnetic-field power amplifier. Bob Carver, says that his Everett, Wash., firm has eliminated the inefficient and costly power-transformer and power-supply capacitors. He still stores energy in a magnetic field, but he will not say how—yet. His 200-W-per-channel stereo amplifier is about the size of a telephone and will retail for $300. □

**More than a game.** Programmable in Basic, Atari-400 computer also accepts programmed solid-state cartridges, records on a tape cassette, plays through an ordinary TV.


## TI's personal computer not ready yet

Texas Instruments Inc. will not introduce its long-awaited personal computer at the Winter Consumer Electronics Show, as had been rumored. Instead, its entry is expected in about three months.

When it comes, the Dallas company's product can be counted on to break new ground in personal computing, including the use of plug-in read-only-memory software modules similar to those used in the company's TI-59 programmable calculator. Another strong possibility is the incorporation of speech capabilities for the machine, based on p-channel metal-oxide-semiconductor speech-synthesis techniques proven in TI's Speak & Spell learning aid [*Electronics*, June 22, 1978, p. 39].

### Solid state

# Encryption chip codes 167 kilobytes/second

The business of building systems to encrypt digital data against unauthorized use is getting an important boost. The Data Communications division of Western Digital Corp., Newport Beach, Calif., is readying a chip with the speed to encrypt data for most applications.

"The device handles both clear and encrypted data on a multiplexed bus at high speed," says Charles A. Von Urff, division vice president and general manager. His company specializes in not-so-high-volume products often neglected by other firms.

The DE2001 will be available in sample quantities at $40 each by March. It is the first in a family of parts and comes in a 28-pin package.

**High speed.** Along with its price, Von Urff says, the main attraction of the device is a 167,000-byte-per-second data-transfer rate, driven at a 2-megahertz clock input. This rate is fast enough for many real-time tasks. It is implemented in n-channel silicon-gate metal-oxide-semiconductor technology, and all inputs and outputs are compatible with transistor-transistor logic.

The chip itself consists of a 56-bit register loaded with a key word used to code each transmission and a 64-bit data register that holds the message itself (encrypted or not). It also has enough logic to check the keys and implement the National Bureau of Standards' algorithm and an 8-bit command register that controls and monitors. Although the device can work with many processors or minicomputers, it is tailored to the popular 8080A family, says Von Urff.

Systems for encrypting digital data got a boost back in July 1977 when the NBS adopted a data-encryption algorithm to be applied to the protection of data in Government computers [*Electronics*, March 3, 1977, p. 74]. However, until now, only one other bus-oriented encrypting chip had emerged, from Intel Corp.

Running at the low speed of 80 bytes per second, it is aimed at equipment like teletypewriters and automatic bank tellers. Usually, original-equipment makers have relied on subsystem modules and encryption boards.

In a typical data-communications system, the DE2001 would operate by entering an algorithm using a code for each transmission according to the NBS key word chosen by the user. A similar chip on the receiving end of the data decrypts the transmission by matching it with the same key word.

**Programmable.** Besides making the device fast and cheap, Western Digital's goal is to "simplify the user's life as much as possible by taking things out of software and putting them into hardware," Von Urff says. Thus, the chip can be

## Electronics firms build encryptor boards

Though semiconductor makers have not exactly rushed to exploit the National Bureau of Standards algorithm with low-cost data-encryption chips, a few big communications-oriented firms are selling boards and modules to original-equipment makers. Both Motorola Inc.'s Government Electronics division and Rockwell International Corp.'s Collins Telecommunications Products division, for example, have been selling them since late 1977.

The Scottsdale, Ariz.–based Motorola division builds two encryption boards, tabbed at slightly less than $500, and two subsystem modules. The boards fit into two microprocessor development systems, Motorola's own Exorciser and Intel Corp.'s Intellec. They are intended to help engineers work with encryption. One module plugs into a PDP-11 minicomputer and costs $1,995; the other module is a four-board stand-alone unit, which is priced at $3,300 to $3,500.

The Rockwell division's big seller to date is a single-board encryptor, the CR300, costing $500 to $800, depending on quantity. The CR200, an end-user unit with data rates up to 9,600 bits per second, went into production at the Cedar Rapids, Iowa, plant last month; it is priced at $2,500. Another high-data-rate encryptor capable of processing at 56 kilobits per second is planned for late 1979.

The encryption chips incorporated in these products are made by semiconductor arms of the respective firms, which have no plans to sell them outside. Motorola Semiconductor Group, however, does plan to market encryption chips of a different design in the future, says a spokesman.

programmed either by the bus or through an input pin for remote-access and direct-memory-access compatability and on-chip bias generation.

An important specification for an encryption chip, says a Western Digital engineer, is how long it takes to execute a 64-bit cycle of the algorithm. This time is 48 microseconds for the DE2001. The 167-kilobyte-per-second speed of the chip probably puts it in the class of those used in encryption modules manufactured by Motorola and Rockwell International (see "Electronics firms build encryptor boards," above).

Other semiconductor makers planning to offer this type of chip are keeping quiet. That includes Fairchild Camera and Instrument Corp., which announced a set of 4-bit-slice chips with data rates of 10 to 12 megahertz [*Electronics*, Sept. 1, 1977, p. 32] for January 1978 at $30 a set. The company has quietly shelved them. However, Intel is currently readying a faster version of its chip.

The next unit in the Western Digital family, the 40-pin DE2002, has dual-port operation, handling plain and cipher messages on separate 8-bit buses, rather than multiplexing them on one. This will give better control of data, says Von Urff, and makes possible multiple keys. The military especially, which does not like mixing secret and open transmission on the same bus, should like this version, he thinks. □

### Business

## Trade, incentives next AEA targets

Fresh from gaining exceptions to the Carter Administration's wage guidelines that allow the electronics industries to offset labor shortages with higher wages, the American Electronics Association is planning to attack a long slate of governmental issues, says Noel J. Fenton, AEA chairman for 1979.

On his agenda are such topics as improving international trade, restoring the qualified stock option so that new companies can afford to attract engineers and managers, cutting the red tape in Federal equal employment laws, and protecting privately developed patents when companies are under Federal contracts. Also, he wants to open a full-time Washington, D. C. office and to begin a series of talks with the Electronic Industries Association on how the two trade groups can work together.

That may seem like a tall order, even for an association with some 1,200 companies. But Fenton feels that the Palo Alto, Calif.–based AEA has become a very effective lobby. It uses "a grass roots approach," he explains, in which company presidents draw on their own experiences to discuss issues directly with Washington leaders.

It also supplies ample data to back its contentions and supports issues that affect other industries as well, Fenton continues. Furthermore, it can respond quickly when vital issues arise, as it did in pressing for the wage guidelines exception [*Electronics*, Dec. 21, 1978, p. 33].

So far in the past year, Fenton asserts, these approaches have made the AEA instrumental in helping to kill the Renegotiation Board, unsnarl customs red tape [*Electronics*, Aug. 31, 1978, p. 45], and in its biggest coup, liberalize the capital gains provisions in the new tax act.

**No. 1 issue.** "International trade is really the number one issue," says Fenton, the 40-year-old president of Acurex Inc., a Mountain View, Calif., measurement-controls manufacturer. "We're going to form a task force, like the capital gains task force, to try and get our arms around the issue." The aim is to "frame coherent proposals at the Federal level to help the U. S. become more competitive." Possibilities include creating a cabinet-level office to promote foreign trade and to make export licensing easier, he says.

Number two on his list is to form a working group to try and "reinstate the qualified stock option and make nonqualified stock options more attractive from a tax standpoint," he says.

The qualified stock option gave an employee the right to buy stock at a low price, which could be exercised years later when the stock's value was higher. In effect, it gave an engi-

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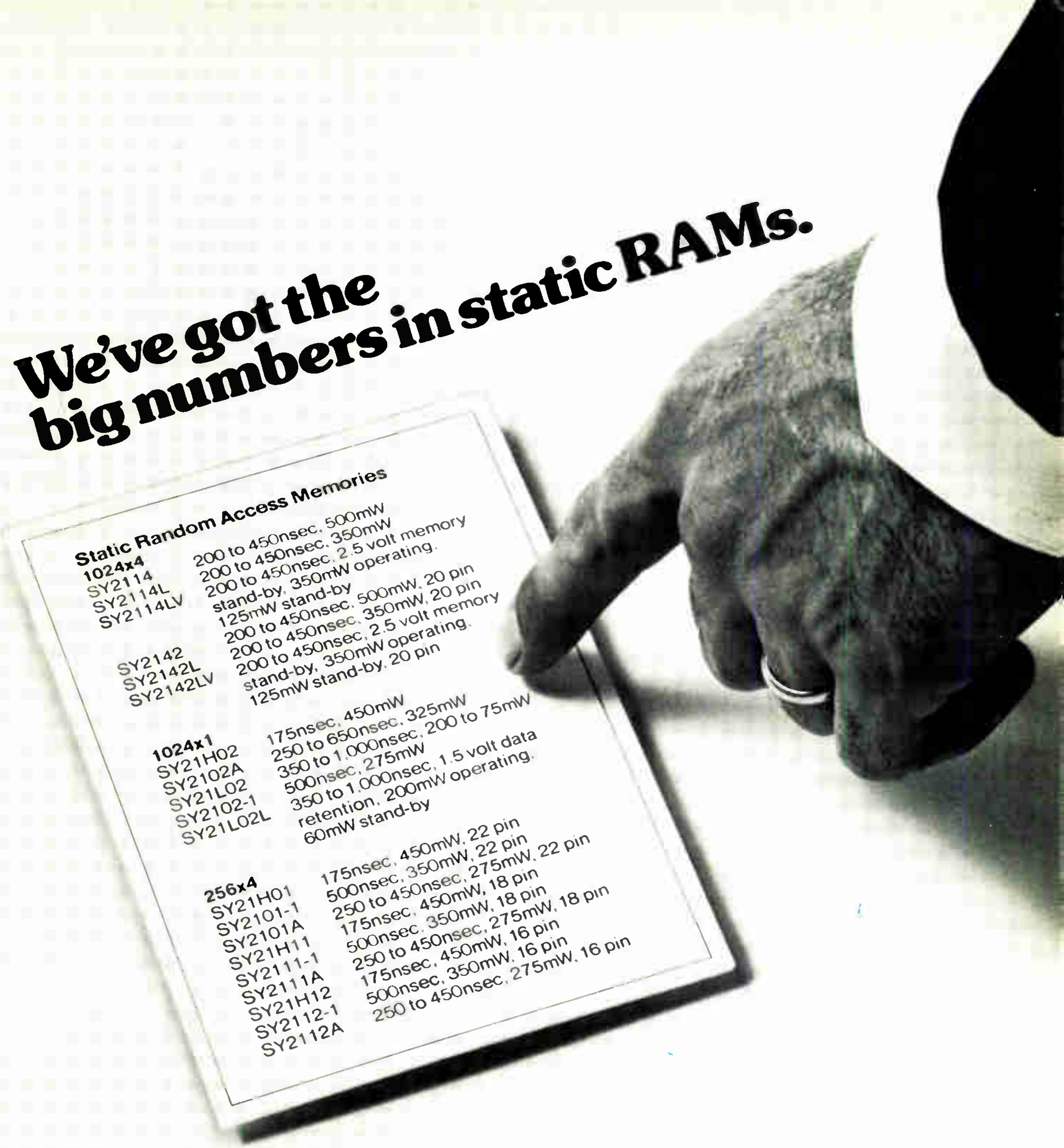


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**Chairman.** Noel J. Fenton says his AEA task force on foreign trade will frame proposals to make the U. S. more competitive.

neer or manager equity in a company and a capital gains tax break as well. Often, new companies can bid for employees only with stock options because they cannot afford higher salaries, Fenton explains.

"Right behind that is some sort of reform of the Federal Office of Contract Compliance," he says. By this, he means cutting the red tape in proving compliance with Federal fair employment laws without harming their intent, a complaint voiced by his predecessor as AEA chairman, Edwin V. W. Zschau [*Electronics*, Oct. 26, 1978, p. 14].

On patent protection for Federal contractors, Fenton acknowledges that "we're not sure we know the answer, but we do know that it's a problem." He does not like the idea that, after "I invent something on my own nickel, if I sell to the Government I have to disclose it to the Government and the public." □

## Minicomputers

# Sperry Univac design put software first

Traditionally, minicomputer vendors design the machine, then write the software. Not so with Sperry Univac's new system, the first to emerge from the old Varian Data Machines operation acquired in June 1977.

The new minicomputer system is the V77-800, a terminal-oriented design that tops out the V77 line of machines introduced by Varian a little over two years ago. Software has certainly taken the lead: the Sperry Rand Corp. division poured nearly 75% of a $10 million product development budget into what it calls the Summit operating system.

"We nailed down Summit before even starting on the 800," says Angus McLagan, director of technical operations at Sperry Univac's Minicomputer operation in Irvine, Calif. Executives there see the emphasis on software giving the machine an edge over competitors. "Making specific software decisions first about Summit actually influenced the way we designed the 800," McLagan says.

**First time.** The result is a package with features and options not previously put together by a minicomputer maker. Perhaps most eye-catching is a module that supports the Pascal high-level language, whose control structure and organization have great appeal [*Electronics*, Oct. 12, p. 81]. Moreover, Summit handles popular languages, including Cobol and Fortran.

It also allows on-line program development, transaction processing, and data-base management. Distributed data-processing modules permit both entry and access within the system, plus communication with other mainframes, including Sperry Univac's machines and the IBM 370. "All these [operating features] are something mainframe customers are used to, but mini users have never had in one package at the price," McLagan asserts.

With the introduction of the 800, Sperry Univac, one of the nation's leading vendors of mainframe computers, permitted the first look into the minicomputer operation acquired from Varian Associates. With twice as much main memory (up to 2 megabytes) and half the central-processing-unit cycle time (150 nanoseconds), the V77-800 fits above the V77-600 as the most powerful machine in the V77 line.

It pits Univac squarely against machines like Digital Equipment Corp.'s PDP 11/70 and its VAX 11/780 and Data General Corp.'s high-end Eclipse M/600 machines. The smaller V77 models weigh in against machines like DEC's PDP 11/04, 11/34, and 11/70 and Data General's Nova 3 and Eclipse.

**Eight terminals.** A typical V77-800 system, to be delivered beginning next July, goes for $135,000 with eight asynchronous terminals, CPU, disk printer, and tape unit, all Summit-operated. Summit itself costs $6,000, with the Pascal module pegged at $2,000 more. A data base inquiry/update language, 077, is available for $3,000.

When designing hardware, "software decisions made in advance not only make it easier, but also help boost system performance," claims James D. Mansfield, product manager for software. One example is higher speeds for such operations as Fortran language compiling. Sperry Univac "got a quantum jump in speed here," he says, by designing a writable control store to aid arithmetic calculations of the floating-point processor.

But, as McLagan points out, the 16-bit processor breaks little new ground in hardware design, sticking with proven low-power Schottky transistor-transistor logic and the cache memory employed earlier by Varian. As for the software-first design approach, Mansfield knows he will not be faced with an old computer industry bugaboo. "There's too much history of hardware being finished and then [the company] doesn't deliver what the buyer expects and was promised." □

## Instrumentation

# Fiber optics isolate scope from voltage

Every electrical engineer has been faced with the problem of observing on an oscilloscope a small-signal waveform that is floating on a high dc voltage removed from ground. The usual solution, though inconve-

Circle 45 on reader service card

nient and unsafe, is to float the entire instrument and refrain from touching the scope or its controls.

At the Oak Ridge National Laboratory in Oak Ridge, Tenn., those dc voltages reach into the hundred-kilovolt range, however. Engineers there did not cotton to peering at waveforms with their hands held oh-so-firmly behind their backs, scarcely daring to breathe. Instead, they isolated the scope by first feeding the waveform to a transmitter that floats at the high voltage. Then they converted the waveform to light signals and sent them, via a fiber-optic cable, to a receiver and a decoder at the scope. Such isolation is an obvious application for fiber optics because the cable will not transmit the high dc voltage.

**Step further.** The Oak Ridge engineers also converted the analog waveform to digital equivalents and sent digital signals over the light pipe. This conversion eliminated a cause for concern: analog voltage-to-frequency conversion and the subsequent optical transmission produced response times on the display that were functions of the input signal level. For the short-duration, pulsed signals such as the lab deals with in its magnetic-fusion research, this was unacceptable.

"We needed to isolate a 0-to-10-volt signal superimposed on a 150-kilovolt dc voltage," says Oak Ridge engineer James W. Pearce. "This had to go to a computerized data-acquisition system for which 8-bit [1 part in 256] resolution was acceptable. On the way, we wanted a visual display of the data waveform."

The transmitter consists of an 8-bit a-d converter, a universal asyn- (UART) module, and timing logic. (UART) module, and timing logic. The converter's parallel digital output is connected to the transmitter buffer register at the UART input. The UART converts the data to serial form and adds start and stop bits that are recognized by the receiver.

**Simple.** The UART output goes to a standard light-emitting diode through an impedance-matching emitter-follower transistor stage. The diode's light then passes through the fiber-optic cable to the receiver and a p-i-n diode detector.

The detector's output is amplified, shaped, and fed to the receiver section of another UART. There the data is converted from serial to parallel form. A digital-to analog converter then converts the digital word to an analog signal that drives the oscilloscope. Since the UARTs do not require precise high-frequency stability, inductive-capacitive timing oscillators suffice. Other power and timing circuitry is as simple.

"We were very concerned with the safety aspects of the system, and the critical fiber-optic cable was tested to see how much voltage gradient it could withstand," Pearce says. Gradients in the cable of up to 10 kV per centimeter were achieved without introducing noise to the displayed signal, according to Pearce. With cables to the scope of about 3 meters long, the 150-kV levels he was concerned about were safely handled. "The combination of transmitter and fiber-optic cable has proven itself useful and could find application wherever isolated grounding is required," he concludes. □

**Industrial**

## Farm equipment adds microcomputers

Microcomputers are being designed into automobiles, but into four-wheel-drive farm tractors, too? Of course, say Massey-Ferguson Inc. and other farm equipment makers.

The microcomputers do more than monitor engine and equipment parameters; they also help to control the machines. Basically they are low-end off-the-shelf units, programmed and packaged by the electronics suppliers to replace hydraulic logic elements and mechanical linkages that have been doing the job.

They are faster and more reliable, boosting productivity, and they can be relatively easily programmed with safety and other new features. Also, they are much less expensive to modify for the larger and smaller models in a tractor series.

**Baler.** Loading operation in Sperry New Holland automatic bale wagon is sequenced by an on-board C-MOS digital control unit.

The electronics adds a relatively slight $1,000 to $2,000 to the price of a machine, generally in the $45,000-and-up class. The extra features provided are, moreover, an attractive selling aid.

**Tough specs.** However, Duane H. Zeigler, senior engineer at Deere & Co.'s Harvester Works in Moline, Ill., points out that the tough vibration, temperature, and other environmental specifications seem to be scaring off suppliers. For the sensors that feed data to the controllers, "we need military specs at automotive prices," he says.

Massey-Ferguson in Des Moines, Iowa, recently delivered its first four-wheel-drive tractors to be equipped with a microcomputer. It is a variation of the unit Bosch GmbH of West Germany supplies for automotive fuel-injection systems.

On the tractor, it controls the hitch between the tractor and a plow or other implement, explains Joseph L. Jessup, chief tractor engineer at Massey-Ferguson's development laboratory in Detroit. For a plow, for example, once the blade depth has been set by a dashboard dial, the microcomputer maintains a constant force and depth by applying signals to solenoid-controlling hydraulic valves at the hitch. Voltage variations from inductive sensors that are mounted on the hitch provide the microcomputer with the input sig-

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Circle 47 on reader service card

nals needed for its control program.

Other farm-equipment makers applying microcomputers include Sperry Rand Corp.'s New Holland (Pa.) division and International Harvester Inc., Chicago. Sperry is using a complementary-metal-oxide-semiconductor controller on a new haybale wagon to help collect, load, and stack bales of hay. Bale position is sensed by Hall-effect switches, with the controller linked to solenoids that activate hydraulic valves. A Sperry Rand spokesman says the electronics eliminates 60% of the mechanical linkages, cuts the work the wagon operator had to do, and helps load bales faster.

Deere and International Harvester are both readying microcomputer-controlled wheat-harvesting combines. International Harvester is working with the Automotive Products Group of TRW Inc. They have a prototype controller that, in part, automatically adjusts the cutting bar to avoid objects that could damage the equipment, maximizing grain yield. Deere is interested enough in electronics to have formed its own product development group but declines to discuss its development effort otherwise. □

## Consumer

# Prospects brighten for dual TV picture

Football fans and other television addicts should be glad to hear of two advances in the technology of putting two pictures on one TV screen. Papers at the Chicago Fall Conference on Consumer Electronics detailed a new hardware approach to storing a complete TV picture in memory, with one offering two new features: the second picture in full color, and stop-action capability.

Such picture-on-a-picture systems add a small, soundless inset from another channel to the main picture, usually in a corner of the screen. The inset picture is stored temporarily in memory, then read out.

So far, two manufacturers have

**TV extra.** Inset picture in Hitachi TV system has less resolution than does the main picture but is adequate for its size.

marketed TV sets that add a black-and-white inset to the main color picture: Grundig AG of West Germany [*Electronics*, Sept. 1, 1977, p. 102] and Sharp Corp. of Japan. Both sets use circuitry by Intermetall GmbH to store the inset picture in an analog memory made from bucket-brigade devices, which are inexpensive metal-oxide-semiconductor delay lines.

The two approaches at the Chicago conference attempt to improve the quality of the inset picture. One system, in development at Fairchild Camera and Instrument Corp. of Mountain View, Calif., does this by using charge-coupled devices to store the inset in analog form. The other, with a digital memory for a color inset, was developed at Hitachi Ltd.'s Consumer Products Research Center in Yokohama, Japan.

**Two memories.** Fairchild's system is conventional in that it uses two memories, one for each interlaced field of the inset picture. While one memory is storing one 120-element-by-80-line field, the other memory is reading out the previous one. The black-and-white inset is one-third scale, or one ninth the area of the large picture. The system uses charge-coupled devices to store the inset, rather than bucket-brigade devices, because the signal loss of the latter can cause a weak or "snowy" picture. Both memories are on one chip, another innovation.

Hitachi's use of digital memory to store TV pictures is not a first; it is routine in expensive broadcast-

 

studio equipment. But cost is a major deterrent to designing a consumer product with a digital memory big enough to store picture elements of an entire field with, say, 5-bit gradation.

**Optical shortcut.** To reduce memory size (and cost) with little degradation in picture quality, Hitachi engineers use a technique called line-sequential coding, which is based on the high correlation between successive TV fields: things do not change much from one to the next. This technique allows all luminance (brightness) information to be stored in one 64-line-by-96-element-by-5-bit (per element) memory and read out three times faster through a small buffer memory that prevents a read-write conflict.

The 96-element horizontal resolution gives the inset picture, with one fourteenth the area of the large picture, the same bandwidth as the large one. The inset's resolution is lower, but adequate for its size.

Color data for every other line of the inset picture is stored in a separate 64-line-by-48-element-by-5-bit digital memory. A one-chip, 4-bit microprocessor controls the system and implements features like freezing the inset picture (impossible without digital memory).

Target cost for the electronics package is $15 to $25, says Fairchild. Estimates are that the extra-picture feature could add up to $200 to a color TV's price. □

## News briefs

**Midcon, turnout sparse, looks to Chicago**

Despite a sparse turnout that left many exhibitors grousing, Midcon/78 officials said attendance at the Dallas affair last month was sufficient to merit continuation of the show, intended as an annual event held alternately there and in Chicago. The unaudited head count at Midcon's Dallas debut was 12,521, including about 1,900 exhibitor personnel, says William C. Weber Jr., general manager for the show's operator, Electronic Conventions Inc. Attendance had been projected by show backers to hit 15,000 [*Electronics*, Nov. 23, 1978, p. 28]. "We went in with a little higher expectations than we should have," Weber concedes now. "We just kept looking for a Wescon-size crowd and that was unrealistic." Among other things, Weber blamed timing too close to the holidays for the lackluster turnout. A November show date has been scheduled this year in Chicago, where the first Midcon show in 1977 also played to disappointing crowds.

**U. S. firm cancels contract with Iran**

Electronic Data Systems Inc., a Dallas computer services firm, canceled a $20.5 million contract with Iran last month because the politically troubled government was about $5 million behind in payments. Company officials say they will hold continuing discussions with the Iranian ministry of health and social welfare on an eventual resumption of the contract, which calls for design, implementation, and operation of a software system to manage the country's national health insurance and social security system. About 50 employees are leaving, but 40 remain on contracts with industry.

**Minicomputer firm sets up semiconductor facility**

A dedicated, large-scale-integration semiconductor design capability is a must for minicomputer makers, concludes General Automation Inc. The Anaheim, Calif.-based firm is setting up a microproducts operation in Phoenix, Ariz. It is intended to replace GA's 20% interest in Synertek Inc., a specialty LSI house sold last year to Honeywell. Named to head it as vice president is Jack Foster, formerly national industrial sales manager for Motorola's Semiconductor Group. The operation will concentrate on logic required in interface modules for minicomputer systems. Also, it will upgrade GA's memory packages from 32 to 128 kilobits, with 16-K chips instead of the present 4-K devices.

**Rockwell tries gallium-arsenide CCDs**

The high-frequency operation possible with gallium arsenide has prompted Rockwell International Corp.'s Science Center in Thousand Oaks, Calif., to apply them to the construction of charge-coupled devices. The result is an experimental 10-cell CCD that exhibits a charge-transfer efficiency of 0.9994 at a 1-megahertz rate. The cells act like Schottky-barrier gates, ensuring low-noise operation. The Rockwell researchers used a GaAs field-effect transistor as the charge-detection amplifier. The next step is to integrate the two parts on a common GaAs sustrate. This could open up a whole new technology for very high-speed analog signal processing.

**Magnavox sues others on video games**

Magnavox Consumer Electronics Co., Fort Wayne, Ind., last month filed suit in Federal district court against Bally Manufacturing, Fairchild Camera and Instrument, Montgomery Ward, and Sears, Roebuck. It alleges infringement on its Odyssey video game patent. This action brings the total number of companies sued by Magnavox to 16.

### Medical

# Aids help sharpen handicappeds' skills

A mix of engineering students and professors from MIT and occupational therapists working at a nearby hospital is generating electronic aids designed to help the handicapped. The devices help children with afflictions like cerebral palsy develop coordination.

Creative Technological Aids Inc. is the nonprofit organization set up at Kennedy Memorial Hospital, Brighton, Mass., to design aids for developing motor skills. CTA's "employees" have been donating time, often as part of student projects at Massachusetts Institute of Technology in Cambridge, since 1974. Now its first two products are about to emerge.

Six months from production is a device called a Magic Light Pen,

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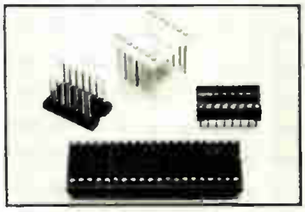

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Circle [illegible] on reader service card designed to give a child positive reinforcement when tracing a prescribed path on a sheet of paper. The other, to begin tests soon at the hospital, is called Secret Code. With it, a person must repeat a series of colors or numbers in a prescribed sequence.

Made of heavy-duty plastic, the Magic Light Pen is about the size of a toothbrush holder. It works with sheets of paper on which are drawn conductive-ink, single-line patterns of varying complexity. One sheet at a time is fastened with metal hooks to a lap tray with a conductive aluminum surface and containing electronic circuitry. The pen plugs into the tray via a flexible cord.

The object for the child is to hold the pen's point within the width of the line while tracing out the pattern. As an incentive, a light on the pen stays lit while the pen remains on the line, and a buzzer sounds when the pattern tracing is completed.

In the lap tray, a Signetics 556 dual-timer integrated circuit drives a tone-generator chip, and a transistor switch controls the small incandescent bulb in the pen. Everything is powered by a 12-volt battery in the lap tray. The pens are in a preproduction run at Goodwill Industries, Harrisburg, Pa.

CTA's aim is to keep the prices of its devices down, although no prices are set yet. This means the electronics is as simple and as inexpensive as possible, says Robert W. Mann, Whitaker professor of biomedical engineering at MIT and a CTA board member.

**Yet to come.** The Secret Code device is much further off. It has six buttons with illuminated overlays that display such things as a color, number, or letter of the alphabet. Controlled by a Motorola 6802 microprocessor, the buttons light up in a random sequence.

The child must remember the sequence and repeat it by pushing the right buttons. An Intel 2708 4-K random-access memory stores the sequence and the responses as well. Pushing the buttons correctly triggers a flashing red light and a buzzer. □

## *SCIENCE/SCOPE*

Recent test firings have proved the interchangeability of Roland all-weather air defense systems built by the U.S., France, and West Germany. At White Sands Missile Range, N.M., supersonic missiles were fired against computer-simulated targets, drones, and unmanned F-86 and F-102 fighters. U.S. missiles were fired from both U.S. and European units mounted on tanks and armored vehicles, and European missiles from U.S. units. Test distances ranged from 800 to 6000 meters, with targets passing the fire units at various angles, and at altitudes from 60 to 3000 m.

Next, Roland's all-weather, day/night capability was demonstrated with test firings when the gunner could not see the target, relying on radar to track it. The dual-mode fire-control system includes optical sight and infrared missile tracker for fair-weather daylight operations and two-channel tracking radar for night and both fair and bad weather. Roland is being built by Hughes and major subcontractor, Boeing Aerospace Co., under license from Euromissile, a joint venture of Messerschmitt-Boelkow-Blohm of West Germany and SNI Aerospatiale of France.

First test units of the Position Location Reporting System (PLRS) have been completed by Hughes under contract to the U.S. Army Electronics Command. PLRS is designed to keep a commander informed of the precise location and movement of his troops at all times, in all weather, and over any terrain. A command and control center, two master units (MUs), and 64 user units are being produced for the Army and Marine Corps for test evaluation. Lightweight, battery-powered user units can be carried by a soldier, or mounted on and powered by vehicles and aircraft. Each communicates automatically with an MU that can be moved anywhere by truck or helicopter. Soldier-carried units may be programmed for a position update every 32 seconds, vehicles more often, aircraft as frequently as every two seconds.

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New product from Hughes: a new high-power amplifier, designed to operate in the earth terminal transmitters of commercial satellite communications systems using the new 12/14-GHz frequency (Ku-band). Designated Model 9225H-04, it provides 250 watts of CW output power at the 14.0- to 14.5-GHz satellite uplink frequency band. Upcoming programs that will use this frequency include SBS (Satellite Business Systems), Canada's Anik B and C, and Intelsat V. The amplifier features extensive monitoring capability, including the ability to switch all operational status indicators and control switches to a remote control. A full-year, unlimited-hour warranty is offered.

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**FCC looking for uhf improvements in major effort . . .**

A major investigation aimed at possible mandating of an improved design for uhf television receivers and better transmission standards was launched at year's end by the Federal Communications Commission, confirming an earlier report [*Electronics*, March 16, 1978, p. 57]. Persuaded by a Texas Instruments Inc. prototype uhf tuner that an improved receiver could be built, **the FCC voted unanimously to begin an inquiry under General Docket No. 78-392.** First comments are due by July 1, followed by replies by Oct. 1. The TI tuner, built under FCC contract, showed that uhf interference could be reduced using surface acoustic-wave filters and metal-oxide-semiconductor field-effect transistors. The FCC says it will evaluate the receiver's design, potential benefits, and cost, as well as possible design changes, transmitter standards, and coverage protection.

**. . . and to develop standards for TV performance**

Complementing its investigation into uhf TV design improvements, the Federal Communications Commission is beginning a second inquiry to develop receiver performance standards under General Docket No. 78-393. **FCC rules now require only measurement of the uhf noise figure and related peak picture sensitivity,** which the commission has found do not consistently predict receiver sensitivity, especially in weak signal areas, and is but one of many parameters affecting performance. Areas on which comments are sought include: overall and interstage receiver selectivity, dynamic range, interference rejection, an objective measure of color rendition, picture resolution, abrupt picture transitions, effect of circuit design on apparent noise, audio performance, and cable TV service characteristics. Also, receiver stability will be tested in the presence of such variables as input supply voltage, vibration, movement, ambient temperature, and time in service. June 1 is the deadline for comments, with replies due by Sept. 1.

**Navelex names two to compete for Marines' TAOC-85**

The Naval Electronic Systems Command has named Litton Industries Inc., Beverly Hills, Calif., and Sperry Rand Corp.'s Sperry Univac division, Blue Bell, Pa., as finalists in the competition to design an engineering development model of TAOC-85, the tactical air operations central system for Marine Corps use in 1985. **The winner of the competition will receive a full-scale development contract in late 1979,** leading to full production in 1982 at an estimated cost of more than $75 million. Losers in the latest competition were Hughes Aircraft Co. and Westinghouse Electric Co.

**Whitehead to run new Hughes unit for military Satcom**

**A $335 million Navy contract for military maritime satellite communications** has prompted Hughes Aircraft Co. of Culver City, Calif., to form a new subsidiary and hire a former White House aide as head. Clay T. Whitehead, director of the White House Office of Telecommunications Policy from 1970 to 1974, will run the new Hughes Communications Services Inc. He most recently headed Allison Technical Services, a small consulting company. Hughes Communications Services will put together and operate the Pentagon's leased worldwide defense satellite communications system using satellites now being built by Hughes Aircraft's Space and Communications group. The first satellite is set for a 1982 space shuttle launching.

# Washington commentary

## America's 1979 programs to enhance its technological leadership

There is a common thread running through the shredding fabric of United States relations with the nations of the Middle East, the problems still to be resolved with Japan, and the opportunities apparent in establishing normal relations with the People's Republic of China. That thread is trade—an issue crucial to the continuing growth of electronics and other high-technology U. S. industries in 1979.

Trade in electronics embraces everything from imports of components and entertainment products to exports of weapons. Whatever the product or its origin, its success in world markets is dependent upon the research and development that preceded it. Thus it is particularly troubling to U. S. government leaders that investments in R&D by American industries, including electronics, continue to decline, while the nation's negative balance of trade keeps rising. U. S. imports of nonmilitary merchandise exceeded exports by more than $27 billion in the first nine months of 1978. That trade deficit was nearly 23% larger than the year before. American exports of electronics continue to surpass imports, but the margin of that positive trade balance is getting smaller.

### The problems overseas

Those numbers are unlikely to improve in 1979, despite President Carter's China initiative. Selling Peking the technology it wants may very well cost American electronics manufacturers this year more in long-term investments than they get back. Moreover, U. S. consumer electronics manufacturers are writing off the prospect of Government support for reducing import competition from Taiwan as part of the price they have to pay for Carter's diplomacy.

As for Japan, U. S. telecommunications makers see little hope of persuading Nippon Telegraph & Telephone to open that market to American products [*Electronics*, Dec. 21, 1978, p. 49]. As the State Department explains in its year-end announcement that the U. S. and Japan have reached "a comprehensive understanding on all principal issues" in the forthcoming world trade talks in Switzerland, individual non-government entities like NTT are exempt from the negotiations.

The outlook is no better on the Middle Eastern front, where U. S. trade in electronics is dominated by military systems plus some developing business in domestic telecommunications. Iran's internal political problems now threaten shipment of a variety of military electronics systems to that country.

That is the dismal side of the U. S. electronics trade picture for 1979. If nothing else, it makes it clear that America's manufacturers cannot afford to let the question of their success or failure in the world's markets depend on political actions over which they have no control. That brings us back to domestic R&D, where manufacturers have better control and where the picture is somewhat brighter.

A few examples: the electronics industries should find it easier to attract investment risk capital to support more R&D this year after having succeeded in getting the 1978 Congress to reduce the capital gains tax. Moreover, President Carter has promised to support a sustained rate of real growth in the Pentagon's technology base budget, reversing the decline in purchasing power caused by inflation.

Beyond that, the White House is setting up a Government-wide review of national policy on industrial innovation. The President favors "specific strategies in support of selected goals," explains one participant. In other words, the U. S., like competing nations, means to work more closely with its leading industries so that they shall remain competitive. That represents a significant reversal of the usual adversary relationship between business and Government. It could be a change for the better.

### A new climate of cooperation

The Pentagon's William J. Perry, for one, believes it will be. The White House review, according to the DOD under secretary for research and engineering, "offers a unique opportunity to improve the climate for innovation in America." As Perry put it recently to the National Academy of Engineering, "As people, we still have the innovative spark needed to conceive, develop, and market new products. But as a nation, there are signs of stagnation—not so much in the absolute sense, but relative to most other industrial nations. Perhaps the most serious signs of stagnation are in the long-term, international exploitation of innovation."

No one can yet say whether or not this stagnation will be eliminated by improved tax and regulatory structures, increased Federal money for R&D, or national policies more supportive of industrial innovation. Like the R&D they will encourage, the success of these programs depends on how they are carried out. None of them can be expected to contribute directly to the electronic industries' 1979 profits. Yet they are all steps in the right direction, for they are reversing the decline in R&D that has handicapped the country increasingly for more than a decade.

**Ray Connolly**

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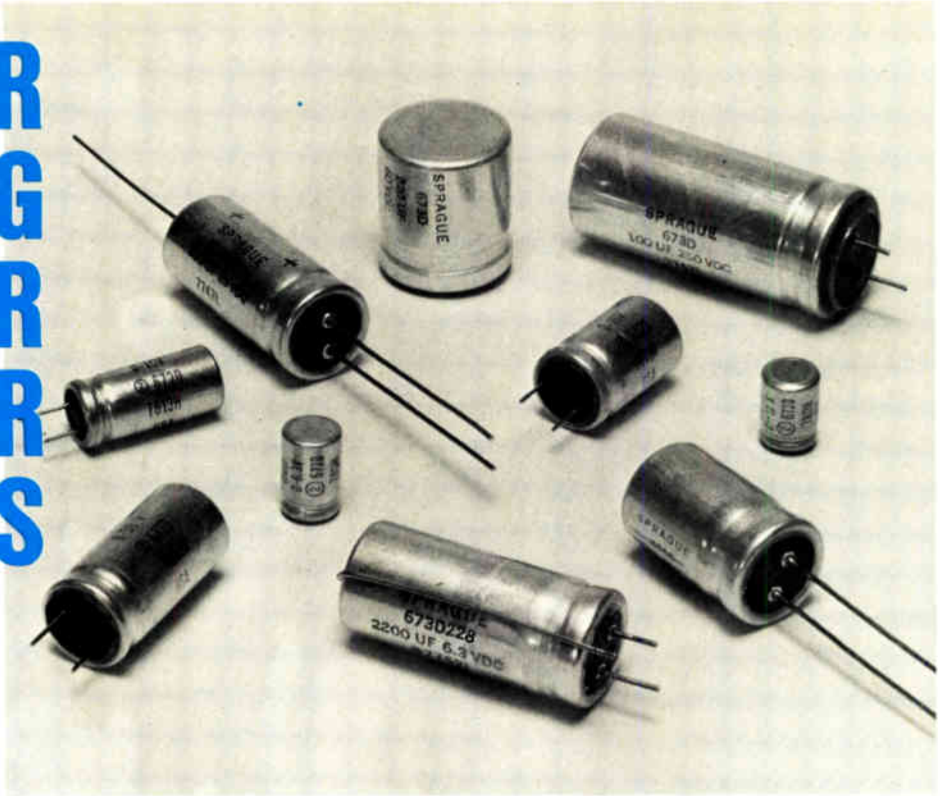

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**Tandberg data division still breathing**

Although government efforts to salvage Tandbergs Radiofabrikk A/S failed late last month, Norway's state-owned electronics manufacturer will continue to build data terminals for Siemens AG under a contract that accounts for about 50% of its terminal production. **A reorganization of Tandberg's data division is under way, with 40% to be held by the state industry fund and 20% by each of three other partners,** Kongsberg Vaapenfabrikk, Norsk Data, and Simrad. Siemens has stated its wish for continued delivery of data equipment by Tandberg. The division also hopes to go on producing electronics for educational applications.

**Optical loop links communications**

Instead of tying subscribers into the usual central switching facility, a new concept for a communications network would link them by a glass-fiber loop. A group of West German firms, headed by the Heinrich Hertz Institute of West Berlin, is developing components for the system, a working model of which will be ready for trials at the West Berlin institute by mid-1980. **In the decentralized system, the subscriber's equipment establishes the connection.** When a party is called, the signals travel around the loop past the various tie-in points. A microprocessor constantly monitors the loop and, at the desired party, recognizes and picks out the correct call signals and makes the connection. Use of fiber optics allows broad-band communications that could support videotext, teletext, video telephone, and other services.

**Hitachi adds new processor for distributed system**

Joining the parade of manufacturers bolstering their distributed processing schemes with additional offerings, Hitachi Ltd. has unveiled a multistation processor for use with a Hitachi mainframe host and up to 15 intelligent work stations under the Hitachi Network Architecture (see related story on p. 70). The HITAC L-320/60 uses 4-bit-slice logic with a 16-bit word length and has 96 kilobytes of 16-K chips plus 32 kilobytes of firmware in main memory, regardless of the number of stations. **Additional stations require no extra memory because each station has an 8-bit processor with 48 kilobytes of memory,** in addition to a keyboard and 1,920-character display. For ¥310,000 a month, a user will get central-processing unit with memory and firmware, 9.2-megabyte disk, 243-kilobyte floppy disk, one work station, and a 120-character-per-second serial printer.

**Industry takes to Bath technique of digital speech-encoding**

Among companies talking about nonexclusive licenses on the patented technique for digitally encoding speech developed at Bath University are Racal Electronics Ltd. and International Telephone & Telegraph Corp. Racal is interested in its application for military communication systems, and ITT reportedly in its use for speech-recognition systems. The technique, called time-encoded speech (TES), **promises four CCITT standard speech channels in a single 64,000-baud digital link** or one mobile-Q radio-quality voice channel in a bandwidth of 5 kHz [*Electronics*, Aug. 17, 1978, p. 68]. Racal has already begun an independent research program into TES and is backing two other techniques, including one under development at Edinburgh University. The Bath group is also expecting a contract from the Royal Signals and Radar Establishment, Malvern, to develop a microprocessor-based real-time encoding and decoding system.

# International newsletter

**Nordic data net will start by dispensing cash**

When the Nordic Public Data Network starts up in November, the first major system to use it will be an on-line cash-dispensing system. Twelve Swedish commercial banks, together with a group of cooperative banks, have just placed **a $37 million order for 11 CII-Honeywell-Bull Mini 6 series computers and special application software, plus an almost $13 million order for 302 terminals** manufactured by Chubb and Son Ltd. of the UK and sold by Philips. Any of the branch-located terminals will be able to access any customer's account. Though trials will be made on a limited number of terminals, some 400 should be in operation by 1980.

**NEC will launch 135-kilobit bubble**

Nippon Electric Co. has developed a bubble chip with 135-kilobit capacity in a 20-pin dual in-line package similar to that used by Texas Instruments for its 92-kilobit chip. The chip is now being delivered in sample quantities inside the company, and **will be sold to other customers as a discrete component or as one of four on a memory-system board** with general-purpose peripheral ICs starting the first quarter of this year. Its major-minor loop configuration is organized as 768 22-byte blocks, including redundant bits. Bubble diameter is 3.2 $\mu$m, and the chip measures 6.9 by 8 mm. The four-chip board has an average access time on the order of 3 or 4 ms and a cycle time of 15 ms.

**Bundespost picks SEL for viewdata centers**

West Germany's post office, which will introduce its version of viewdata service in 1982, has picked ITT subsidiary Standard Elektrik Lorenz AG (SEL) to head a consortium of firms that will develop centers for the service. **The centers will contain the data-processing equipment for monitoring and controlling incoming calls, as well as the data bank** for storing the information that subscribers may seek. After considering proposals from several companies in West Germany, the post office decided in favor of SEL's concept because of its partly decentralized nature: instead of only a few, many viewdata centers will be spotted throughout the country.

**Wafers cause boom in ion analyzers**

The drive by semiconductor houses around the world to acquire the technology for very large-scale integration has turned out to be a boon for the French instrument maker Cameca, a subsidiary of Thomson-CSF. The world leader in ion analyzers has received more orders for its latest machine, the IMS/3F, from semiconductor-research establishments than from traditional customers like geological and metallurgical laboratories. Japan's Musashino Electrical Communication Laboratory already has one of the $470,000 machines, and **IBM Corp. is just putting one into service at its Fishkill, N. Y., facility.** The machines analyze the wafer-doping profiles of successive 50-angstrom layers with impurity concentrations as low as several parts per billion.

**Scandinavia wants a TV satellite**

A Nordic consortium has been formed to **bid for a proposed TV satellite that would cover Denmark, Finland, Norway, and Sweden.** A decision on the satellite—called Nordsat—is expected in 1980. The consortium plans to invest about $1 million on designing the bird. Included in the group are Saab-Scania AB and L. M. Ericsson of Sweden, Christian Rovsing AS and Elektronikcentralen AS of Denmark, Kongsberg Vapenfabrikk A/S and Elektrisk Bureau A/S of Norway, and Nokia Oy of Finland.

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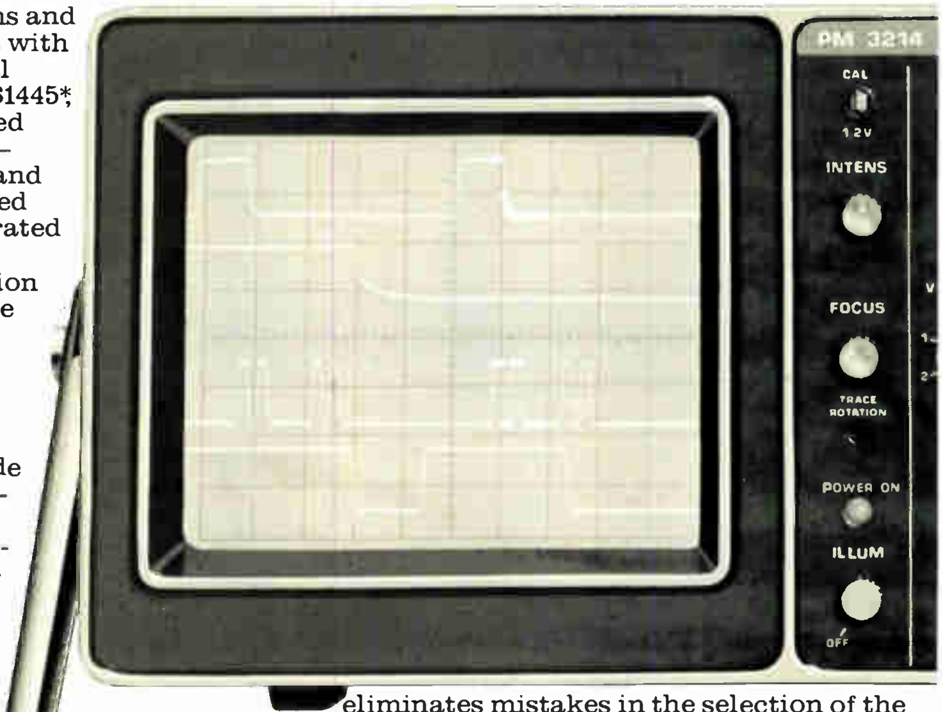


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# Siemens in the U.S.

# Paging system broadcasts nationwide on fm radio channel

System broadcasts over Sweden's existing network; commercial service performs a variety of tasks

**The Swedish penchant** for solitude—immortalized by Greta Garbo's "I vant to be alone"—suggests that Sweden is a most unlikely place for a nationwide personal paging system. But the Swedish Telecommunications Administration, Televerket, has launched just such a system, using the existing fm radio network for signal transmission.

Known as MBS (for *mobilsoekning*, mobile searching), the system has been in planning for almost 10 years. Now the first subscribers have signed up and bought pocket page receivers. Televerket operates the service, which cost $1.5 million to develop and install, on a purely commercial basis.

It charges a one-time sign-up fee of $23, plus a quarterly fee that ranges from $15 to $85, depending on the type of paging service required. There is a charge of about 7 cents—the cost of two local phone calls—for each paging. In addition, the subscriber purchases a pocket receiver for about $900.

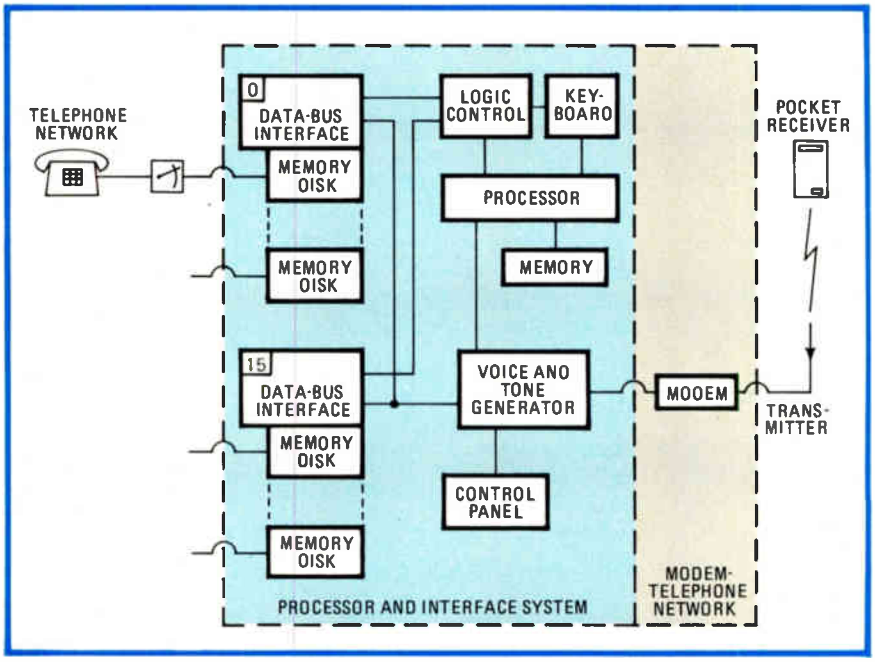
**Recycled.** Setting up a transmission network dedicated solely to paging would have been economically prohibitive in thinly populated Sweden: 8 million Swedes are spread out across a nation the size of the state of California. So Televerket decided to use the 87-to-104-megahertz band of the fm radio network, which covers some 99% of the nation's geography, as well as some of Denmark and Norway.

Political approval for use of the existing fm radio transmission system was easier to obtain than might have been expected. Televerket handles transmission of all programs broadcast by the Swedish Broadcasting Corp., the sole radio and television broadcasting company in the nation. Three channels, called programs, are broadcast over fm, all of them stereo. For the paging system, Televerket uses the third program, which plays popular music.

According to Oesten Maekitalo, who heads Televerket's Radio Laboratory, a major problem in using the fm band for transmitting additional information was finding a way to modulate the signal without interfering with existing stereo program reception. Televerket's solution was to add an extra subcarrier in the fm broadcast transmissions.

The frequency of the paging subcarrier is 57 kilohertz (±6 hertz) and the frequency deviation caused by the subcarrier is ±3 kHz. When paging signals are transmitted simultaneously with stereo programs, the 57-kHz subcarrier is phase-locked to the 19-kHz stereo multiplexed pilot signal.

Each 52-bit paging code consists of two blocks of 16 information bits and 10 parity check bits. To broadcast a subscriber's code, the paging subcarrier is product-modulated by a signal obtained by phase-modulating a 1.187-MHz (±0.1-Hz) tone with differentially coded binary informa-




**Paging.** After caller dials in subscriber's code, it is converted into a 52-bit binary code by the central processor. Code is used to modulate the paging subcarrier.

tion. A 1 in the original binary information causes a phase shift of 180°, while a 0 means unaltered phase.

Televerket offers seven different paging services—from the simplest—transmission of an audio or visual paging signal—to the most sophisticated, in which the caller's number is displayed on a light-emitting-diode display on the receiver.

In the middle is a system that enables a caller to dial the subscriber's paging number and then dial in the number for the subscriber to call back. The caller's phone number, which is stored in a central computer for two hours, is repeated to the subscriber in synthesized voice form when he dials the central exchange. Another option is a privacy code that prevents unauthorized callers from paging the subscriber.

**Getting in touch.** To page someone, the caller dials a four-digit entry number, then the subscriber's six-digit number. If the subscriber has additional services, such as the call-back display or a privacy code, the caller then dials in these digits.

The signals from the telephone network are sent to a central processor, a Motorola M/6800, over a data bus interface and a logic controller, which checks and processes all incoming calls and calls in progress. There are 15 data-bus interface units in the system nationwide, each equipped with disk memory. After processing, the information is sent through modems to transmitters located throughout the nation.

**Receivers.** At the subscriber's end, the receiver scans the 87-to-104-MHz frequency range every 10 seconds. It is designed so that it automatically tunes in for reception of a radio paging call by searching for and locking onto the special MBS system identification code. This feature is necessary because third program transmission is on various frequencies in different areas.

The first manufacturer to gain Televerket's type approval on a receiver is Japan's Mitsubishi Electric Corp. The Mitsubishi receiver has a complementary-metal-oxide-semiconductor microprocessor with programs stored in a C-MOS programmable read-only memory. An LED readout displays up to 12 digits for subscribers who opt for the call-back feature. Expected to gain type approval soon are Sonab of Sweden and Salora of Finland. □

## West Germany

# Intermetall GmbH goes it alone in developing very large-scale integration

In their anxiety to keep up with the U. S., government after government in Europe is helping semiconductor firms prepare for the very large-scale integration technology of the 1980s. So when a company gets set for VLSI without government financial help, the effort becomes noteworthy.

One such company is Intermetall GmbH, lead house of the ITT Semiconductors Group, based in Freiburg, West Germany. Probably the only semiconductor producer in Europe that has thus far financed its VLSI efforts entirely on its own, the group has dished out more than $13 million during the past two years to get itself into harness for the future. Additionally, some $5 million to $7 million are currently being spent for further VLSI projects.

**Facilities.** In the group's new six-story research and development facility, centers for computer design, mask making, and diffusion stand ready for the challenges of VLSI design and fabrication. "For our VLSI activities we have installed the latest research, development, and production equipment available on world markets," says Heinz Rössle, group general manager for ITT Semiconductors worldwide. The lineup includes modern data-processing gear for circuit design, a new electron-beam system for mask making, and equipment for processing 4-inch wafers—all installed in super-clean environments.

In the design center, a model 400 Prime Computer is being used in an approach that, says Rössle, should halve VLSI development time, even when circuits become more complex and exhibit increasingly higher levels of integration. Because the computer takes on an active role in circuit design, Rössle prefers to call the approach "computer design" instead of the conventional computer-aided

**Clean job.** Inspector checks circuit in super-clean environment of mask-making center at ITT Semiconductors' new research and development facility in Freiburg, West Germany.

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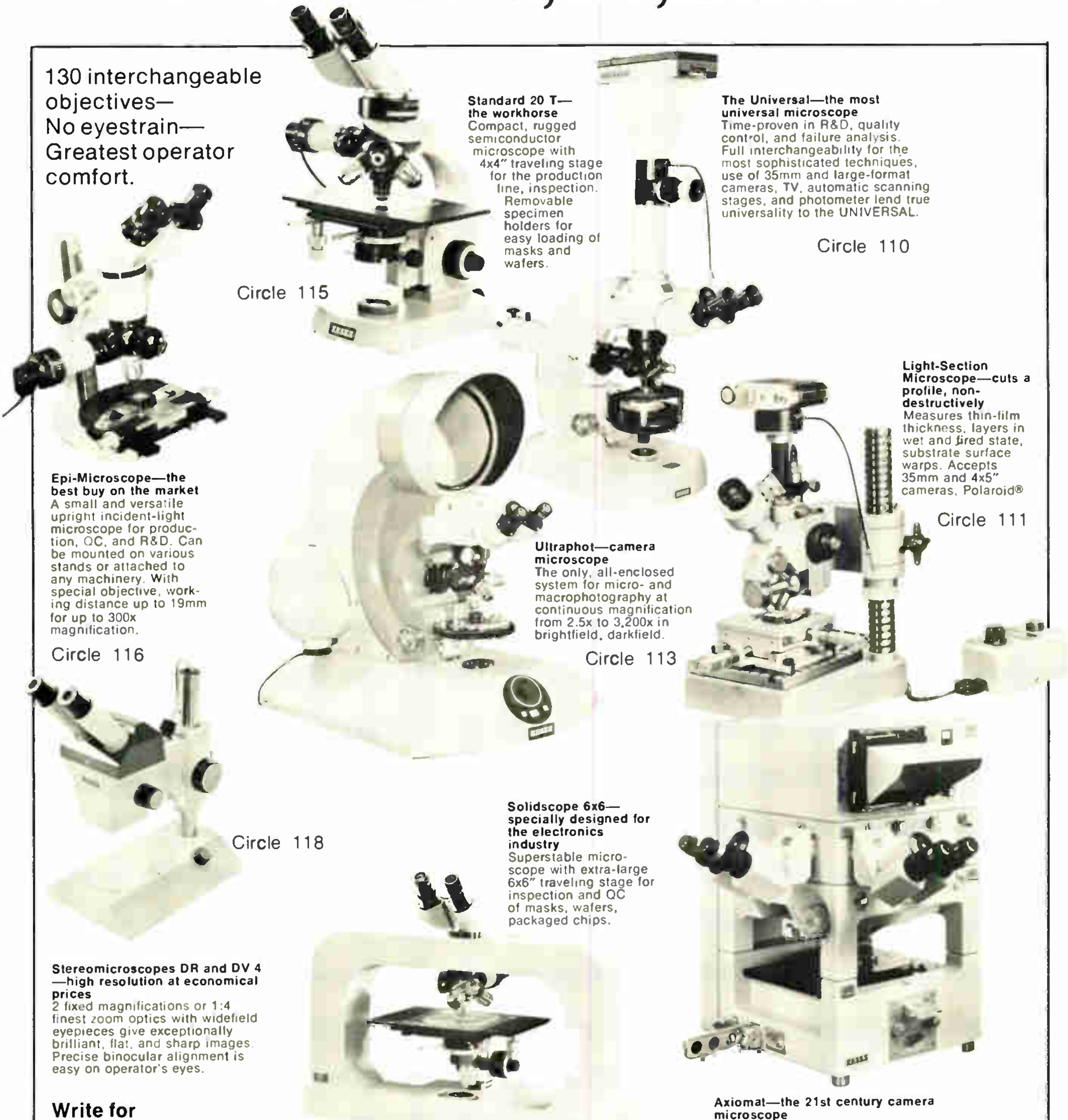

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design. The technique, he says, cuts the time needed for data comparison from months to a few weeks. Moreover, the computer is not yet being fully exploited. Faster access is possible, as well as refinements in circuit optimization.

Working at a display terminal, the designer feeds the data for circuit layout into a computer. From then on the computer takes over. Using an extensive software package, it produces a magnetic tape that contains all data for the layout of masks needed for fabricating single- or multi-layer circuits.

The display terminal permits the designer to carry on a virtually direct dialogue with the computer. From a magnetic-tape data carrier, which stores circuit elements ranging from simple networks to highly integrated memories, the designer can pick out the element he needs and display it on the terminal. If necessary, he can then simplify, supplement, or correct the element and finally instruct the computer to use it in producing layout data for the mask.

The software package ensures that changes the designer makes in the circuit topography are correctly transferred to the affected circuit layers. It also ensures that no chip area is wasted. Furthermore, it optimizes circuit design with respect to both testability and manufacturing yield.

**Fabrication.** A piece of equipment ITT Semiconductors officials consider a gem is their $2.5 million electron-beam exposure system from the U. S. firm ETEC Corp. Called Mebes (for manufacturing electron-beam exposure system) and one of the first delivered to Europe, the system is installed in the company's mask-making center. It can trace structures as fine as 1 micrometer with an accuracy of 0.125 μm.

ITT engineers are already producing VLSI circuit masks on the Mebes system by feeding computer output data from the design center's computer directly into the electron-beam equipment. This bypasses two steps: drawing a layout with plotting equipment and the subsequent photographic reduction process. The masks will be used not only at Freiburg but at facilities in the U. S., the UK, and in France.

Experimental work is now aimed at using the computer data for direct writing on the wafer using Mebes. Advances in photo-resist chemistry must still be made before direct writing will be a viable proposition. □

## Japan

# NEC intensifies distributed processing effort with N4700 system for ACOS mainframes

Now that all the mainframe manufacturers have introduced their philosophies for distributed processing, they are scrambling to get real systems to market to bolster these theoretical frameworks. Nippon Electric Co. is now realizing its scheme, called Distributed Information Processing Network Architecture, or DINA, with the introduction of the N4700 system.

NEC compares its system with IBM Corp.'s 8100, over which it claims a price-performance advantage. But the firm is quick to point out that the 4700 is not initially aimed at hookups to IBM systems. Rather the firm wants to expand its business among present users of NEC and Toshiba Corp. ACOS 77 series mainframe systems with an enhanced functional equivalent of the 8100. And although the 4700, like the 8100, is capable of stand-alone operation, such sales will not be stressed.

The 4700's operating system resembles that of NEC's MS series minicomputers, except that it has been optimized for distributed processing by means of DINA, which NEC considers a step in the direction of unifying its various operating systems. The operating system executive links with both user-facility and system-development software, enabling the operating system to control protocol to facilitate interconnection of units and file transfers, while offering multiprogramming and single-batch–processing.

Switching capabilities and the ability to work with sensor-base

COMPARISON OF NEC 4700 AND IBM 8100 SYSTEM

| | Low end | | High end | |
|---|---|---|---|---|
| | IBM 8130 | N4740 | IBM 8140 | N4750 |
| Processing speed ratio (Average instruction execution time) | 1 (3.3 μs) | 1.4 (2.4 μs) | 1.7 (2.0 μs) | 1.7 to 1.9 (1.4 to 2 μs)[1] |
| Main memory cycle time per word | 1,200 ns | 700 ns | 800 ns | 465 ns |
| Cache memory (access time per word) | – | – | | 8 kilobytes (200 ns) |
| Maximum memory size | 512 kilobytes | 512 kilobytes | 512 kilobytes | 1 megabyte |
| Floating point computation hardware | – | option | standard (some models) | option |
| Instructions | 112 standard | 124 standard 62 supplemental | 112 standard 30 supplemental[2] | 156 standard 30 supplemental |
| Maximum communications lines | 10 | 16 | 15 | 32 |
| Maximum work stations | 24 | 32 | 24 | 64 |

Notes 1. Higher speed and shorter execution time for N4750 result from full utilization of cache memory.
2. Supplemental instructions for 8140 are for floating point arithmetic.

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For sorting you have 8 proportional segments formed by the display periods. When tweaking signal levels, you simply watch the limits bar approach the desired value. To probe logic you set 0.5V and 6V limits; the floating bar gives you zeroes and ones.

The Calcumeter's automatic warning beeper tone helps also, as it sounds off on "Error."

Limits display and measurement is just one of 6 special measurement modes on the Calcumeter, plus a myriad of manipulative advantages made possible by its Cmos microcomputer control. Basic features include:

**3½-digit DMM**—Autorange or fixed range; continuous or hold measurements (up to 1,000,000 single measurements from one 9-volt battery!); versatile display control enables you to shift into engineering notation, scientific notation or fixed decimal in 8 digits.

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Anyone desiring automatic data printout will want ESI's optional Data Logging Printer that plugs into the Calcumeter's data port. Sampling can be adjusted from 3 seconds to 3 hour intervals.

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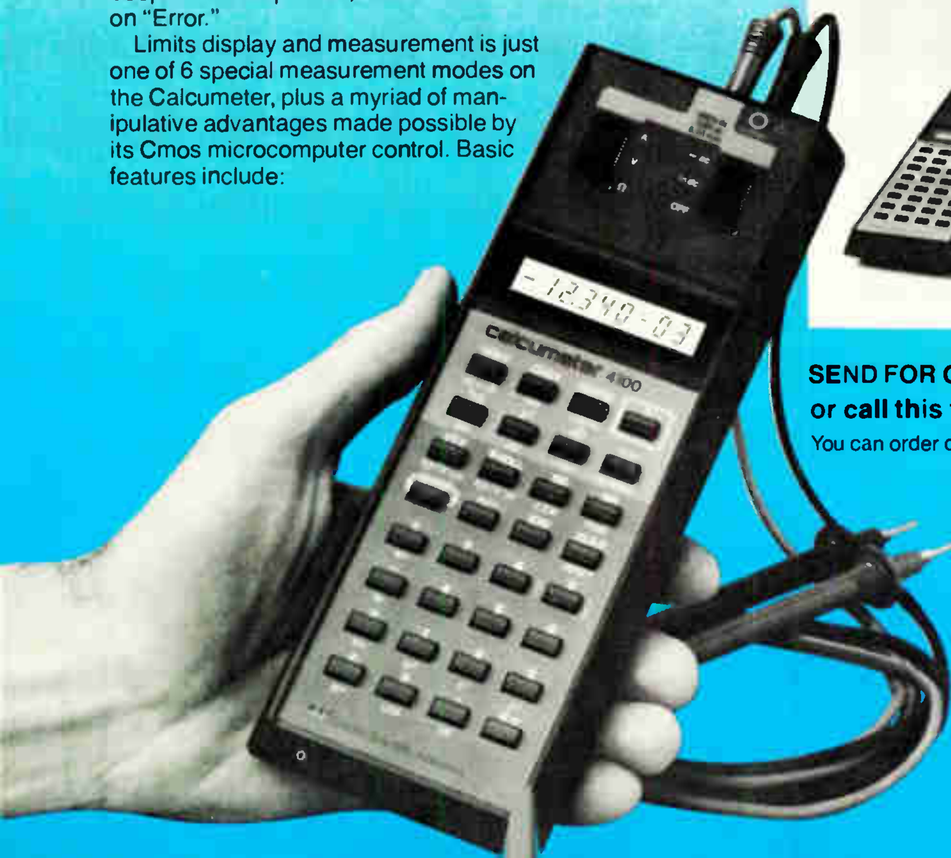


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information and perform control functions makes the 4700 useful in integrated data-processing systems. The host and distributed processing system computer can also turn each other on and off, load programs, and supervise each other.

**Aggressive.** In comparing the 4700 to the 8100, NEC not only claims higher performance and lower price, but also two months' earlier delivery—June 1979. Memory chip capacity is perhaps the only area in which the firm does not claim to be ahead, and even there NEC says its 16-kilobit chips make for faster memory cycle time (see table for a comparison of low- and high-end N4700 and IBM 8100 systems).

As for the software for the new system, it has been completely unbundled and is available on the same rental basis as the hardware. As a result, a minimum N4740 system can be had for ¥242,000 a month, almost 10% less than a corresponding IBM system would cost in Japan. Such a system would include cabinet and central processing unit, 256 kilobytes of memory, 1-megabyte floppy disk, 40-megabyte disk, firmware, a communications and line control unit, and a series printer with control unit. Four keyboard-and-cathode-ray-tube work stations raise the price to ¥326,000 a month, while software increases the overall price to ¥376,000 a month. Price for comparable IBM equipment is said to be ¥406,000 a month.

**Hardware.** Internally, the N4700 technology is similar to the MS series, being built around the same 4-bit slice CPU, 700-gate transistor-transistor-logic circuits, and metal-oxide-semiconductor devices of up to 3,000 gates used as peripheral controllers.

Maximum file capacity of both the 4740 and 4750 is two 1-megabyte floppy disks plus eight 80-megabyte disks, or roughly 640 megabytes. The 80-megabyte disks are also available in a version that adds 0.96 megabyte of fixed-head disk. Data rate of the 1-megabyte floppy disks is 62.5 kilobytes per second; for the 80-megabyte disks it is 1.198 megabytes per second. NEC also offers 20- and 40-megabyte disks with the same data rate.

Sales will not be a solo effort: NEC-Toshiba Information Systems, a joint venture with Toshiba Corp. that sells ACOS mainframes to Toshiba's customer base, will also sell the N4700. Most sales will be to Japan Electronic Computer Co. Ltd., the government-backed joint venture of Japan's six mainframe makers that buys computers from the manufacturers and rents them to users. NEC says it may sell a few systems outright, but does not expect direct sales to be an important part of the market. □

## Great Britain

# Battle of boards begins in Britain

With few extra pounds lying around, the British received early attempts to market personal computers without enthusiasm. But when Kerr Bolrand and John Marshall introduced their Z80-based board-computer kit a year ago for $400, 7,000 buyers thought the price was right.

The pair's Nascom Microcomputers Ltd. scored well by moving fast and selling hard at a time when most American systems were in an altogether different price-performance category. But now that the first inexpensive board-computer imports—like Ohio Scientific's Superboard 2 from Abacus Computers Ltd., and Synertek's VIM computer board—are finding their way into the market, will it prove too hot for one of the few surviving UK manufacturers of personal computers?

The company is not unused to taking heat. Its reputation was tarnished by an inability to deliver in the early months. Then competitors pointed out that the company offered only the most rudimentary hardware, making even the most elementary programming tasks laborious, and that few promised options were available.

In 1979, Nascom is aiming to meet this criticism head on. According to Tony Rundle, who has been taken on to strengthen the company's in-house software capability, there is a full development program under way leading to a full floppy-disk operating system. Options will be added to the basic board, which for its $400 comes with a program monitor stored in a 1-kilobyte read-only memory, 2 kilobytes of random-access memory, video modulator for connection to the user's television, a cassette interface, programmable 16-line input/output, and a custom-built 48-key contactless keyboard.

Coming is a 32-kilobit RAM board, a new data bus, a buffer board, an erasable programmable ROM board, and E-PROM programmer. To keep costs of its data-bus-extension system low, Nascom engineers plan to use industry-standard single-sided development boards and edge connectors for 77 I/O lines. This bus hardware is much cheaper than the double-sided boards and connectors needed for the S-100 bus, says Rundle, undeterred by the growing number of S-100 users.

**Soft options.** On the software side, Tiny Basic will be supplemented with Basic packages from Microsoft Co. of Albuquerque, N. M., that can fit on a floppy disk or in 8 kilobytes of ROM. Bolrand is so confident that the company will grow that a $1.5 million order has been signed with Mostek Ltd. for additional component kits. Also, when the current development program has been completed, he is talking of bringing Nascom to the U. S.

But first the company will have to fight it out on the home market to maintain its niche. Observers agree that the industry shakeout will continue and that its tempo is quickening. But the UK government is now committed to spending over $110 million on paying up to $4,000 of free consultancy to companies looking at ways to use microprocessors in new products. The market should therefore mature fast, making the New Year critical in Nascom's bid for respectable old age in the face of the American personal-computing invasion. □

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| .30 | DL-700 | single digit light pipe | | 1.50 |
| .30 | DL-300 | single digit reflector | | .90 |
| .43 | DL-7000 | single digit filled reflector | | 1.30 |
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| .510 | DL-720 | two digit light pipe | | 1.60 |
| .630 | DL-740 | single digit light pipe | | 2.55 |
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| .80 | DL-6800 | multi-digit array reflector | | 1.75 |
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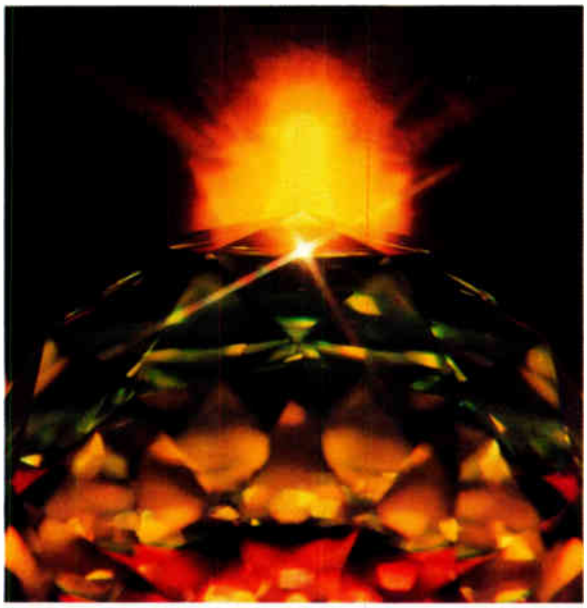

Circle 73 on reader service card

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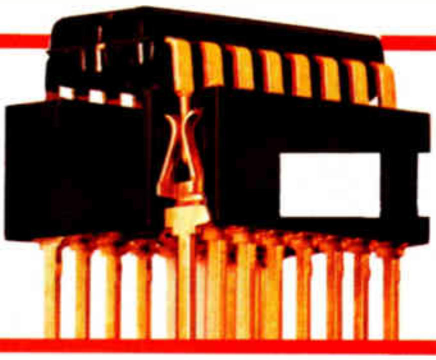

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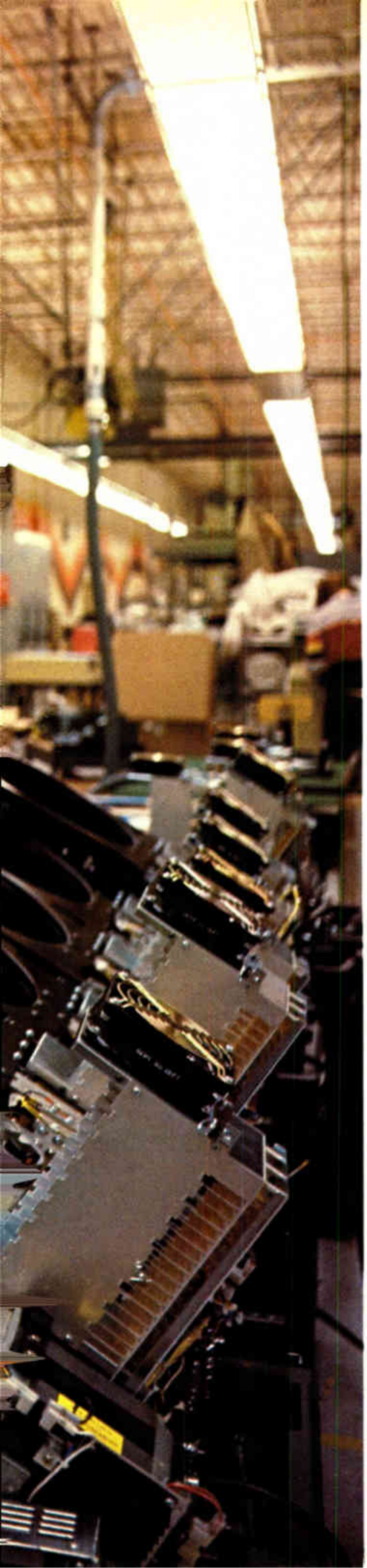

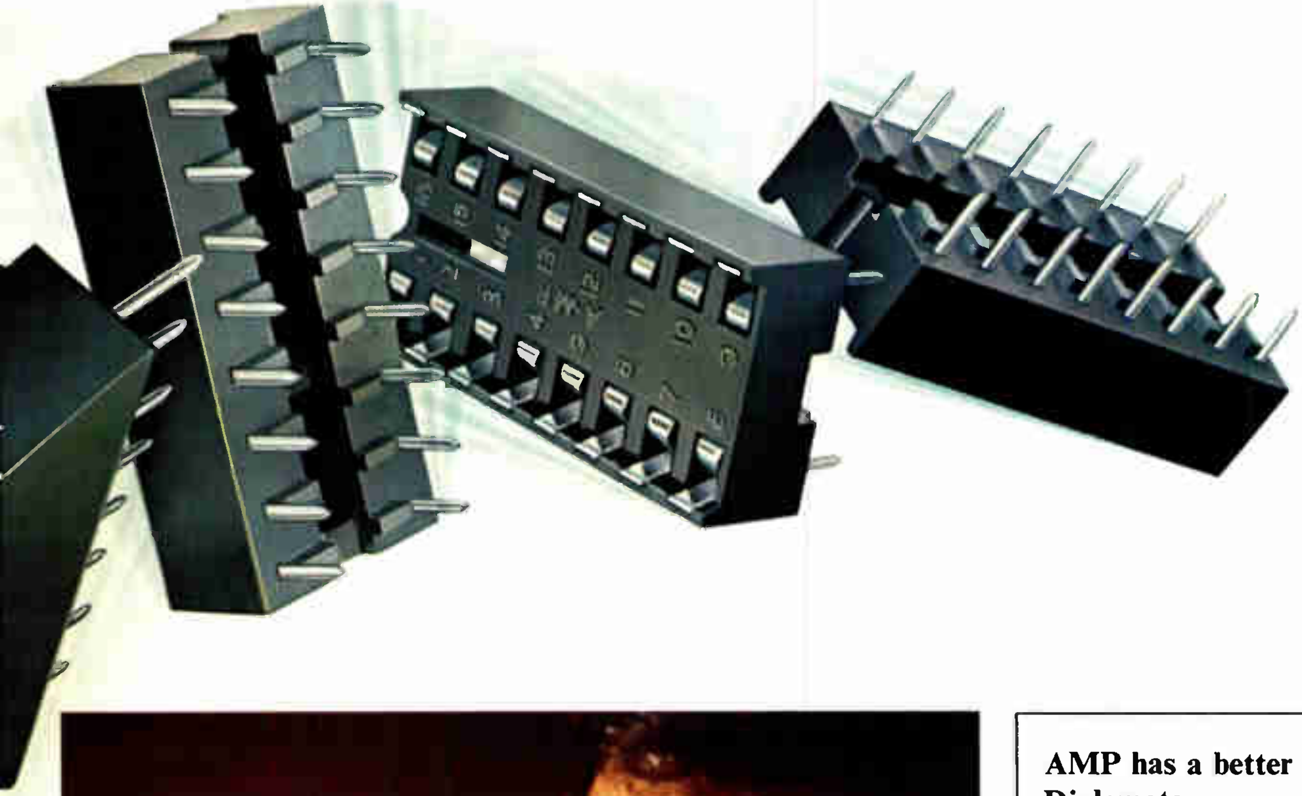

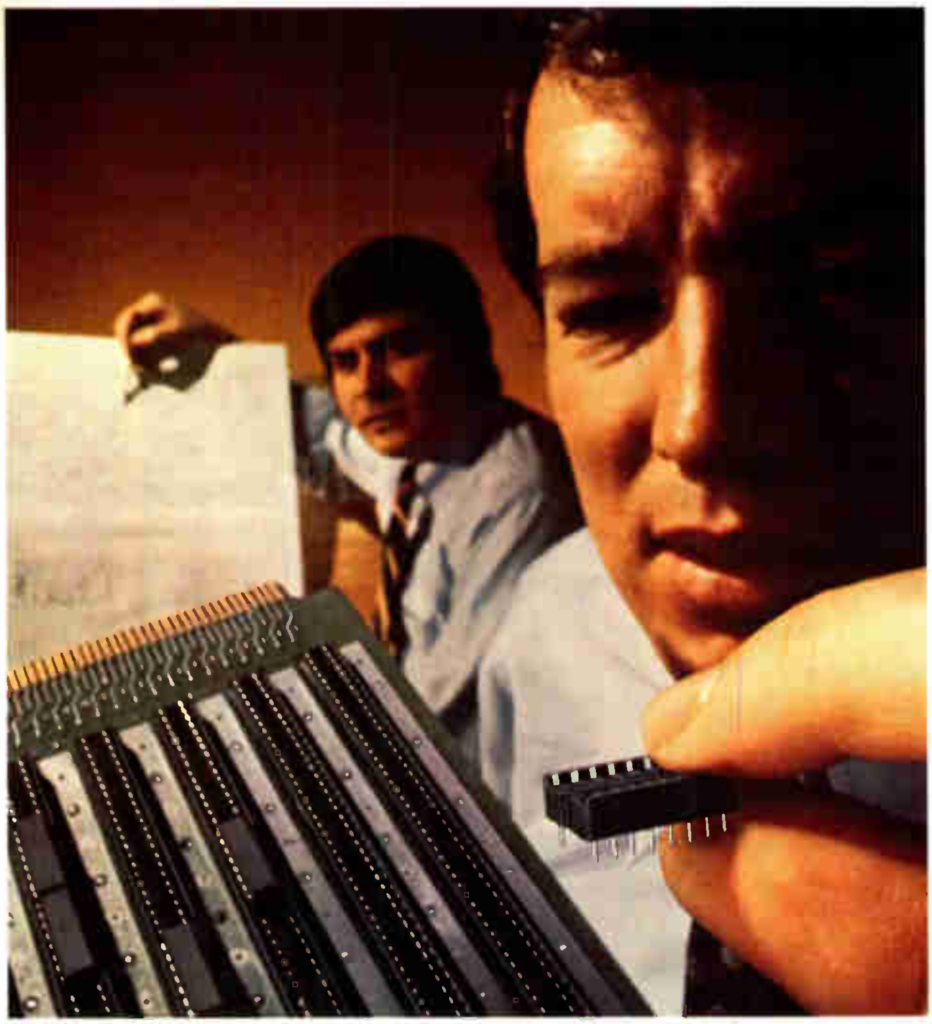

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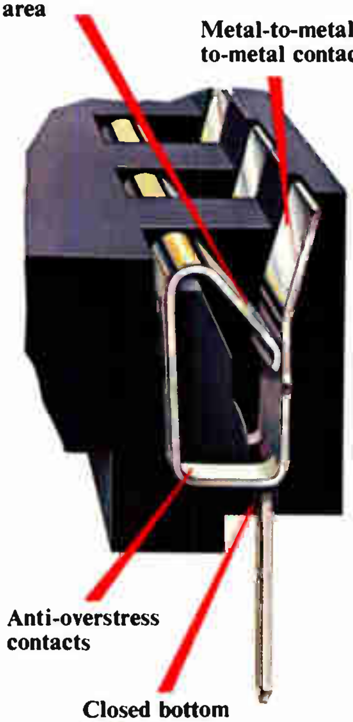


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Circle 79 on reader service card

# Riding the surface acoustic waves

That's what researchers in U. S. and Britain are doing as they harness surface-skimming bulk waves to reach higher frequencies

*by Harvey J. Hindin, Communications & Microwave Editor, and Kevin Smith, London bureau manager*

**To operate communications** systems at higher frequencies requires, among other things, acoustic-wave devices that are smaller, hence more difficult to manufacture. But researchers in the U. S. and Great Britain are working on new parts that would permit operation at higher frequencies at no decrease in size, and they are doing this by turning a problem-causing secondary effect of surface acoustic waves into an asset.

When a conventional SAW is launched along the surface of a piezoelectric substrate, a second, speedier bulk wave also propagates in the substrate itself. If this wave reflects off the bottom, it can degrade frequency response or cause spurious responses in filters and oscillators. It is this effect that the researchers are seeking to turn to their advantage.

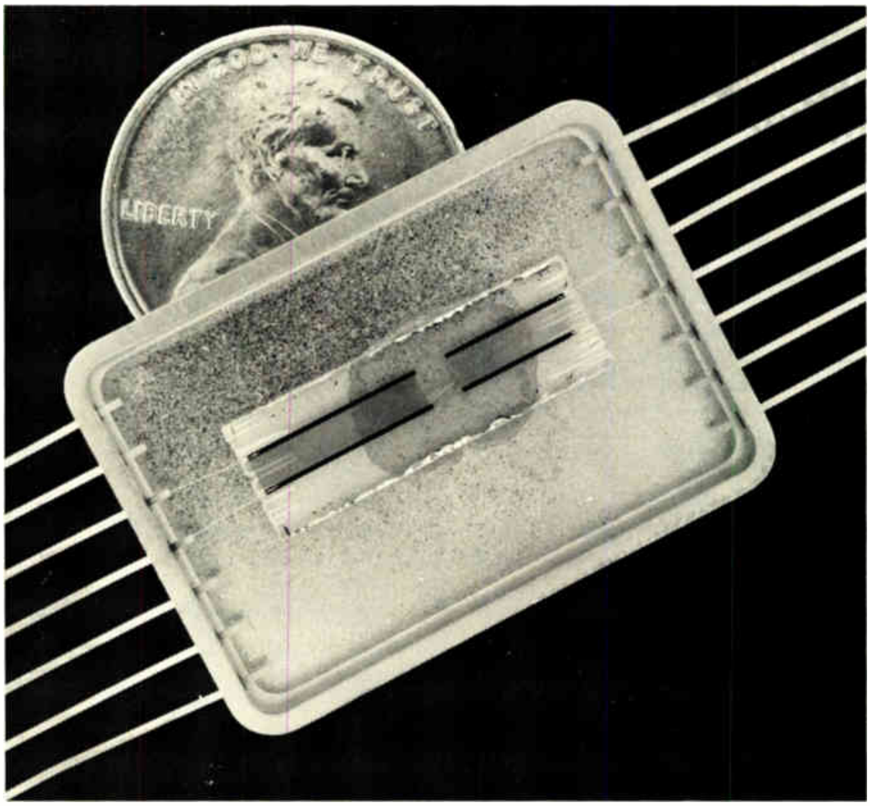
For example, scientists at the Royal Signals and Radar Establishment in Malvern, England, say that devices using the new surface-skimming bulk wave (SSBW) phenomenon not only offer improved frequency response over conventional SAW devices, but have low attenuation, good temperature stability, and insensitivity to surface contamination as well.

In particular, the group, headed by M. F. Lewis, has produced high-stability quartz-crystal oscillators and bandpass filters with frequencies up to 2.3 gigahertz. This figure could be further extended to 3 GHz with present-day photolithographic techniques, they say. That is about 1.6 times higher than the highest SAW frequency possible with ST-cut quartz. And, adds Lewis, all this is done with the same technology used for conventional SAW devices.

In conventional SAW devices, because the bulk acoustic wave travels at up to twice the speed of a surface wave confined to a depth of one wavelength, its reflection from the bottom surface can produce an unwanted response in the surface transducers. This response is minimized by roughening the bottom surface or by tilting it to skew the reflected wave.

But Lewis and his colleagues realized, as did Reynold Kagiwada and his team at TRW Inc.'s Defense and Space Systems group, Redondo Beach, Calif., that the frequency response of SAW devices could be greatly extended by exploiting the reflected wave rather than suppressing it. So they reversed normal practice and looked for quartz-crystal orientations that could give zero piezoelectric coupling to surface waves but that would launch the bulk wave at a shallow angle to the surface.

**Taking cuts.** A family of quartz cuts that supports such surface-skimming bulk acoustic waves is the rotated Y-cut class, in which propagation takes place at right angles to the X-axis. Also, for a small range of




**Only one.** With this TRW SSBW device no passband exists other than the fundamental frequency band. Its transducer center-to-center separation is 500 wavelengths at 248 MHz.

cut angles—33° to 38° and 48° to 55°—the temperature coefficient of delay is small. These cuts, Lewis says, are similar to the well known AT and BT cuts of conventional bulk-crystal oscillators, but their roles are inverted because in the new devices propagation is on the surface rather than perpendicular to it.

Says Lewis, "The temperature coefficient of surface-skimming bulk waves with these crystal orientations and cuts should be comparable to those of bulk crystals." One further advantage of the new devices stems from their insensitivity to surface contamination, indicating that they are probably two to three times less prone to aging than conventional SAW devices. This means they could be packaged in low-cost plastic.

At the Philips Industries' Research Laboratories in Redhill, the devices will soon be investigated for use in military systems. Meanwhile, the phenomenon is being heavily investigated in the U. S.

**Complementary devices.** At TRW, solid-state technology manager Kagiwada and his group have been working on the new effect independently of Britain's Malvern group. Though Kagiwada agrees that "more basic understanding is needed" he says that "for certain applications we can make devices now. For example, we can energy-trap the wave. This means that we know how to launch and control the energy to keep it close to, but below, the surface so that the propagation loss is kept to a minimum." Kagiwada notes that the Malvern people can also energy-trap the waves but do not appear to have built as many filters.

One of the advantages of the SSBW approach is that it and SAW filters appear to complement each other nicely. Present SSBW filters have insertion losses that are almost comparable to those of SAW devices. For narrowband applications, however, their improved temperature stability is an advantage. If temperature stability is not of interest, then SAW filters are better—at least at the lower frequencies.

From about 1 GHz up, Kagiwada notes, "the SSBW devices have a definite advantage because of their higher wave velocity. The velocity allows wider transducer fingers to be used for a given frequency; this has obvious manufacturing advantages."

Some of the results for various SSBW delay lines—another communications system signal-processing component—are shown in the table. This and other data lead Kagiwada to say that "SSBW devices promise to replace both bulk crystal and SAW devices in many future systems."

**DEMONSTRATED SSBW CAPABILITIES**

| | |
|---|---|
| Center frequency | 10 MHz – 2.3 GHz |
| Fractional bandwidth | 0.3% – 2%; 6.5% using lithium tantalate |
| Insertional loss | 13 dB |
| Sidelobe suppression | >55 dB |
| 40 dB – 3 dB bandwidth ratio | 1.4 |
| Temperature coefficient of delay | 0 for first- and second-order coefficient |

SOURCE: TRW INC.

**No more multipliers.** Interest by military agencies has so far been confined to the Electronics Research and Development Command at Fort Monmouth, N. J., where research physicist Ted Lukaszek of the Electronic Techniques and Devices Laboratory is sponsoring the work at TRW. This situation will change shortly, he says—for example, the Air Force has expressed interest.

Lukaszek's interest is in the possibility of making very stable fundamental oscillators using the skimming wave approach. Currently, for applications requiring the limits of stability and minimal drift with time, low-frequency (megacycle) bulk-wave oscillators are used with their output multiplied up to the desired frequency in the microwave region. The multipliers generate phase noise and require external power—two undesirable features.

A partial solution for these drawbacks has been to use a higher frequency conventional SAW oscillator, but its stability has not been as good as the classic lower-frequency bulk devices. The SSBW oscillator should provide system designers with higher oscillation frequencies and better stabilities than the SAW devices. Lukaszek is quick to point out, however, that though that is a reasonable supposition, it has not yet been fully proved with data.

Lukaszek is doing some in-house testing of his own and hopes to let another contract to build an actual oscillator when the present equivalent circuit and modeling work at TRW is done. He is also interested in studying the various different materials that can be used as a substrate in order to determine which if any is best and under what conditions. For example, he notes, the new piezoelectric material berlinite is being studied by researchers at the University of Maine.

**Still under development.** Potential oscillator applications is the prime interest of Don Lee at the Raytheon Research Center in Waltham, Mass. According to senior research scientist Tom Parker, the in-house supported work has centered at 400 to 500 MHz. Researchers there have been concentrating on fundamental understanding rather than on pushing an upper frequency limit; they have worked in a range where standard lithography was available. Among the items of interest here, as in the other organizations, are the various cuts, orientations, and materials that can be used to implement a SSBW device. □

Memories

# 64-K CCDs face an uncertain future

## Bright promise as replacements for 64-K RAMs is fading fast because they are difficult to build and are costly

*by Wesley R. Iversen, Dallas bureau manager*

**Will the** 64-K charge-coupled-device memories now coming on stream go the way of earlier generation 16-K CCDs? Those parts never reached their widely projected mass-market potential because they could not compete against faster dynamic random-access memories (RAMs) that had also reached 16-K densities.

Bets are still being placed. But a growing consensus among semiconductor manufacturers seems to favor a version of the latter scenario.

As they did with earlier CCD memories, device makers have found the 64-K parts difficult to build. This has stretched out product development times and once again allowed dynamic RAMs to narrow the density gap. Moreover, the cost per bit for the serially accessed CCDs does not have the fourfold advantage expected over the random-access parts.

More than two years after first 64-K samples were delivered, the charge-transfer parts are now at initial volume-production levels. Since 64-K RAMs are scheduled for initial production early this year, many industry sources now think the market window has closed on the 64-K CCDs.

Several companies, including Intel Corp., National Semiconductor Corp., Motorola Semiconductor Group, NEC America Inc., and Toshiba Ltd., have canceled or postponed plans to market a 64-K CCD part. Only Texas Instruments Inc. and Fairchild Camera and Instrument Corp. are firmly committed to the technology.

"The projected demand would have diverted too much of our capacity—which was already constrained—away from the very high-volume, high-profit lines," explains Jim Oliphant, applications and strategies manager for Intel's Memory Components division in Aurora, Ore. Intel scuttled plans for its 64-K CCD design last summer.

"At the 64-K level, we now think RAMs are going to be right on top of CCDs," Oliphant says. Additional pressure from the slower but denser 256-K bubble memory devices coming on stream will "make it one hell of a fight for the CCDs.

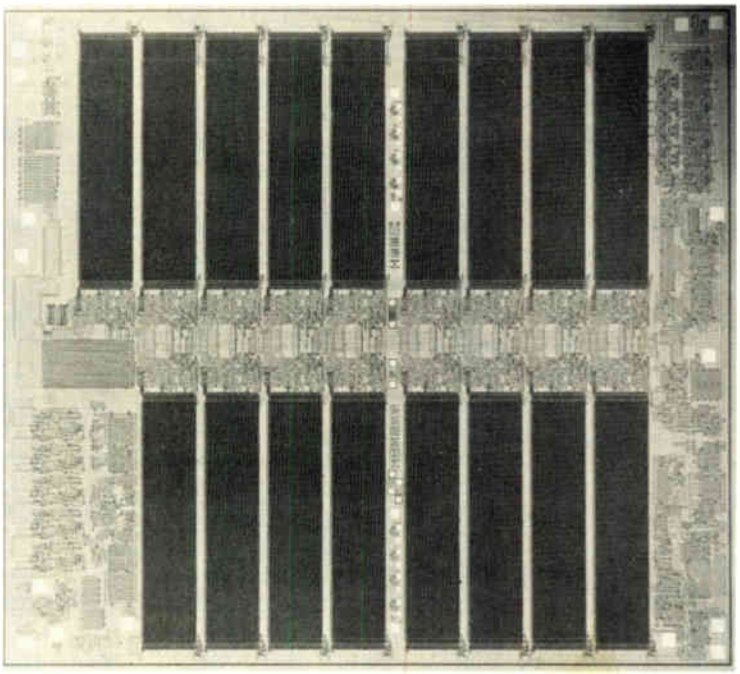
"That's not to say there are not applications. But the large market that we were trying to go after two or three years ago with a 64-K CCD is just not there any more."

It was only Intel that pursued that market: displacing dynamic RAMs in computer main memories. Fairchild and TI see a mass market for CCDs as buffer memories linking faster but more expensive main memories with slower but cheaper disk and magnetic-tape storage files.

Also, there are special memory markets where CCDs' cost disadvantage does not loom large, such as point-of-sale terminals and voice synthesis/recognition systems. But most manufacturers agree that, for penetration into the buffer-memory mass market, the cost per bit must be three to four times cheaper than the faster dynamic RAMs.

"We started out about a year ago thinking we could make a CCD part priced at about a fourth of the cost per bit of dynamic RAMs. But now it looks like you're doing darn well if you can get half the cost per bit," says David Ford, strategic memory marketing manager at Mo-

**From Texas.** At Texas Instruments, production of the TMS 3064 64-K CCD has reached 10,000 units a month. TI says demand exceeds ability to supply.



torola's Integrated Circuits division in Austin, Texas.

Motorola had announced plans to second-source Fairchild's F464 design, but stopped selling the part following "disappointing yields" on initial production runs, Ford says. The company is continuing limited research and development production, but has "significant doubts" that a cost-effective 64-K CCD can be produced, he adds.

**Lost advantage.** For the critics of CCDs as a memory technology, such cost shortcomings were predictable. The single-transistor storage cell technique used is essentially the same as that now used in dynamic RAMs, they point out. Thus the cost advantage over the earlier three-transistor RAM cell has disappeared.

While it is true that CCDs do have an inherent density advantage over RAMs, it is difficult for them to gain a cost advantage because a much larger RAM market volume allows that part to move down the learning curve much faster. CCD memories seem to be "a technology trying to find a home that just can't quite make it," sums up Barry Borgerson, research and technology planning director, Sperry Univac, Blue Bell, Pa.

Universally, delays in 64-K CCD products have been attributed by manufacturers to nothing more than the normal problems expected during production start-up on any new metal-oxide-semiconductor (MOS) product. Despite the process similarities to RAMs, a lack of actual CCD processing experience has made the move from design to the production line a traumatic experience.

Company spokesmen also single out CCD problems associated with soft errors caused by alpha particles at the 64-K level. Indeed, that was one factor in a recent decision by Nippon Electric Co. to delay its 64-K CCD program, says Jim Kelley, memory product marketing manager at NEC America's plant in Wellesley, Mass. The company, which had planned to second-source TI's TMS 3064, has placed the project on "a low-priority basis" and plans a final decision late this month, he says.

Despite the doubts of others, TI and Fairchild say they are firmly committed to the CCD memory programs. They are looking ahead to the 256-K level, and they also claim a strong demand for the 64-K parts.

At Fairchild, where initial F464 sampling began in late 1976, production shipment levels are still running "under 10,000 parts per month," says Gunnar Hurtig, group marketing director for large-scale integrated circuits. "But if we had the parts, we could be shipping 200,000 to 250,000 units per month."

Though Storage Technology Corp. and Memorex Corp. are the only two major firms to announce buffer memories with 64-K CCDs, Hurtig claims "several major commitments" from other companies will probably be announced soon. Total market demand is likely to reach 4 million units this year and could range from 8 million to 12 million during 1980, depending on price cuts, he predicts.

Average 1978 selling price for the F464 was in the $30 per unit range, or about 50 millicents per bit. By 1980, Hurtig expects the price to drop to the 10-millicent-per-bit range, which he says will be sufficient to compete successfully against dynamic RAMs.

**Demand high.** At TI, George Robillard, MOS memory marketing manager, declines comment on potential market size, noting only that "the demand for the 64-K CCD is far in excess of our ability to supply it over the forseeable future." The Dallas company's TMS 3064 has reached "initial quantity production levels," with current shipments amounting to more than 10,000 units per month, he says.

Since the part is currently "being marketed on a controlled basis," no price figures have been published. TI is negotiating sales of the 3064 "on a customer-by-customer basis," he says. Robillard does predict that "the 64-K RAM will quickly overtake the 64-K CCD as a cost-effective, viable memory part because the RAM market is so much larger and its volume will build much faster." But the 64-K CCD part must be viewed as "a stepping stone in the evolution of the technology." Like Fairchild, TI currently has a 256-K version on the drawing board. □

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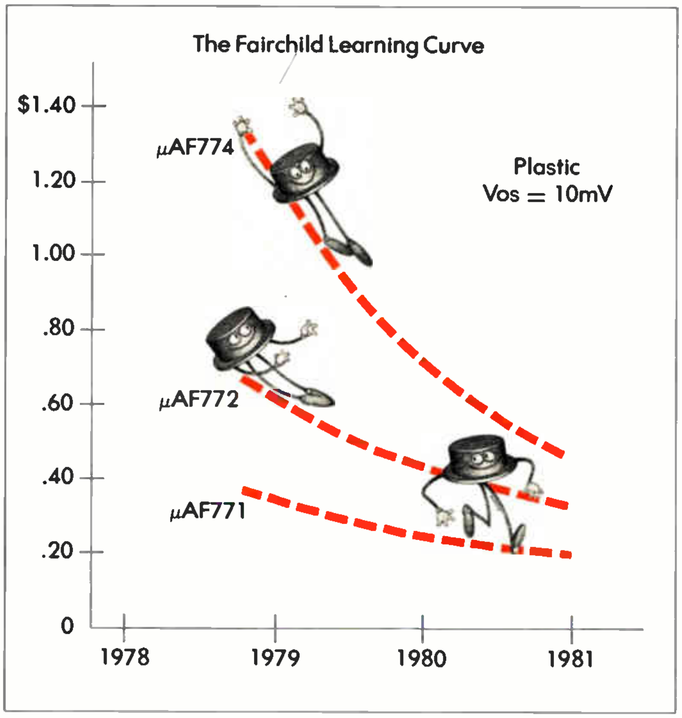



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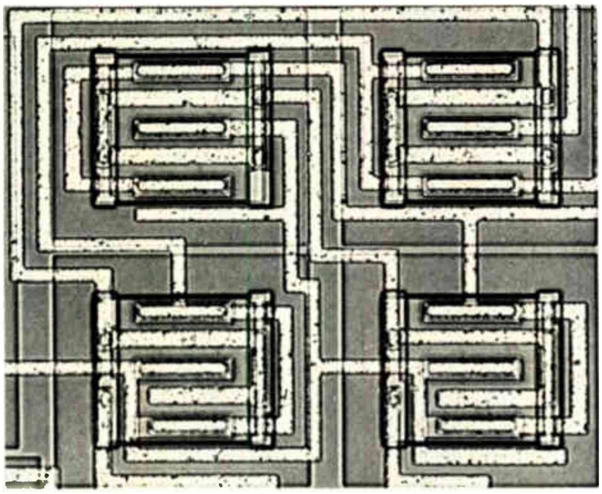

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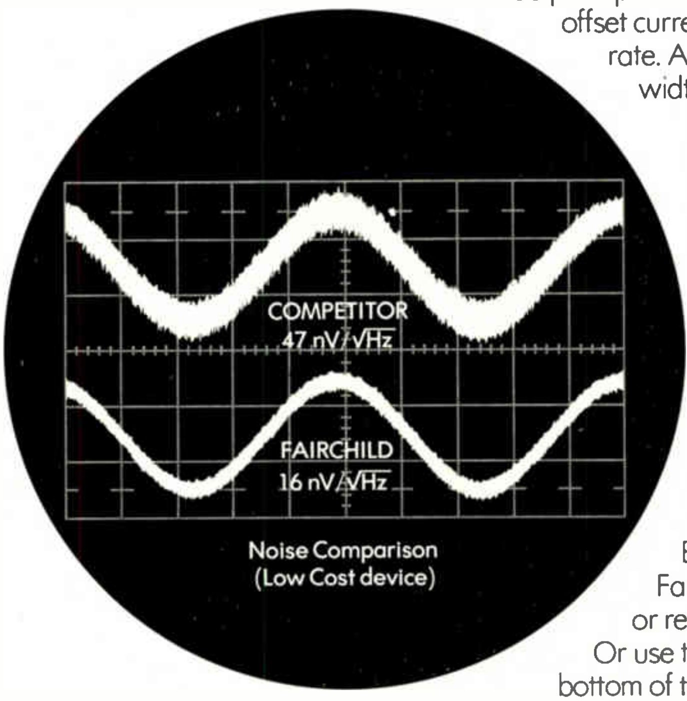


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# Data General at 10: all's well

## Company nears half-billion-dollar mark by paying attention to near term and letting long term take care of itself

*by Lawrence Curran, Boston bureau manager*

**In the Boston** area—the cradle of the minicomputer industry—the minicomputer companies that seem to be getting the most attention now are Digital Equipment Corp. and Prime Computer Corp.

But that does not seem to bother Edson de Castro. The president of Data General Corp. has his Westboro, Mass.–based company in its strongest position ever as its embarks on the second decade of its history.

In fact, little seems to ruffle the enigmatic and understated de Castro. In looking back over the first decade, which ended Sept. 30, de Castro says, "We've made a lot of progress, but we're entering an era where the data-processing industry is becoming more homogeneous. We're competing with IBM and all the rest, so depending on who we compare ourselves with, we either have a long way to go or we're in pretty decent shape."

But de Castro does not like to look too far ahead in his planning. One industry observer says that whereas DEC's philosophy involves substantial long-term planning, with the view that the short term will take care of itself, "Ed seems to tend to his knitting, concentrating on details for the short term, figuring that's the way to be around over the long term."

Not that Data General is not monitoring advanced technologies. Indeed, that is one of the responsibilities of Carl D. Carman, vice president of engineering. He has research and development programs going in both charge-coupled-device and bubble memories, although he is actually betting on bubbles as "the more significant device" for mass storage in the long run.

But the short-term attention to detail obviously has not hurt Data General. In the year ended last Sept. 30, it had sales of $379.9 million and should approach the $500 million mark in fiscal 1979. More convincingly, the company has the highest gross profit margins in the minicomputer industry, consistently between 20% and 22%, compared with 13% and 17% for DEC, according to investment bankers Bache Halsey Stuart Shields Inc.

There are a number of contributing factors to Data General's recent success that de Castro is counting on to get the second decade off to a solid start. The management team is balanced, with a resulting balanced emphasis on engineering, manufacturing, marketing, and maintenance.

**Do it yourself.** Another factor is the company's move to vertical integration, which contributes to profitability. It makes its own microprocessors and random-access memories in a Sunnyvale, Calif., plant that will soon encompass 90,000 square feet.

**DataGen's players.** Company president Edson de Castro, left, says he has a balanced team to lead Data General into its second decade. On that team are Carl D. Carman, center, vice president for engineering, and Paul Stein, vice president for manufacturing.



It also manufactures its own peripheral equipment, except for high-speed line printers.

Product-line breadth and compatibility are additional pluses for Data General, ranging from a single-board version of the microNova microcomputer through the just introduced, aggressively priced Nova 4 line of small to medium systems (see p. 206) up through the supermini-class Eclipse M/600 [*Electronics*, Feb. 2, 1978, p. 40].

**Sharing.** Portions of most of Data General's processors go through common production lines at several feeder plants before final assembly in two facilities. Paul Stein, recruited from Burroughs Corp. three years ago and now vice president for manufacturing, is a firm believer in product commonality and the idea of dedicating manufacturing facilities to processes, not individual product lines.

Data General is not often a technological pioneer, although, consistent with its belief in vertical integration, it was the first to establish its own semiconductor capability. But while the semiconductor industry is tooling up for production of 64-K random-access memories, the Sunnyvale facility is knocking out the less-risky 4-K parts.

**R&D.** The company does not skimp on research and development, however, spending a robust 10.1% of revenues. Engineering vice president Carman says development programs in the first decade were predominantly aimed at exploiting known technologies to bring a better price and better performance to the minicomputer market.

Now, he's looking ahead to a time when bubble memories have enough attributes for mass-storage applications to offset their present low-volume, high-cost status. He does not think bubbles will be "significant devices" for another two to three years, "and I might say that again a year from now, but they'll be the winning technology for mass storage over the long run."

**Pushing software.** But the fastest-growing beneficiary of Data General's development dollars is software. William E. Foster, director of software development, says that more than a third of all R&D is in software. Foster, recruited from competitor Hewlett-Packard Co., points out that over the past two years the software R&D effort has more than doubled, "and it's still going up—growing faster than any of the company's other R&D areas."

As for markets served, another fairly recent recruit from Burroughs, Rowland H. Thomas Jr., vice president for product marketing, says the company wants "to maintain a presence in the areas in which we've traditionally been strong—OEMs [original-equipment manufacturers], systems integrators, and more recently, business data processing."

With all these apparent financial, management, manufacturing, and market strengths, are there any weaknesses in the Data General edifice? For one, the company has yet to announce a computer with 32-bit architecture, as have rivals DEC and Systems Engineering Laboratories Inc., but Data General officials do not seem overconcerned, maintaining that there is still a lot of mileage left in the 16-bit architecture through innovative logic and memory design.

For another, though the company made a thrust into distributed data processing with some recent new Eclipse processor and software enhancement announcements, it still does not have a networking software package, as do DEC, Prime, and Hewlett-Packard.

Both the 32-bit machine and network software are undoubtedly in the works, but de Castro will not say. He does say that networking is in its infancy, with standards and protocols just being defined, "so I don't think we're late in not having a networking package; we have a strong interest in it."

**Good marketer.** The consensus of the investment community seems to be that there are no real chinks in the Data General structure. Typical are the comments of William Becklean, a vice president of Bache Halsey and manager of the firm's technology group in Boston. He says Data General is a "tightly and well run company, and a good marketing company. They do a good job of assessing what the needs of the market are and have developed products to meet those needs." □

Electronics abroad

# China poses problems, opportunities

Group just back from IEEE-sponsored trip says interest is high in computer and semiconductor technology

by Anthony Durniak, Computers Editor

**With the pending** normalization of relations between the United States and the People's Republic of China, vast new markets may open for American manufacturers, notably the electronics industries. A group of U. S. computer scientists who recently toured China say the opportunities may be especially good for semiconductor and computer manufacturers—if the Japanese don't get there first.

"One of the tenets of Maoism was self-reliance," notes tour member Harvey Garner, professor at the University of Pennsylvania's Moore School of Electrical Engineering in Philadelphia. "To a large degree, that has carried over to all areas, including electronics and computers. But now there are efforts to look outside."

Barry Borgerson, director of research and technical planning at Sperry Univac, Blue Bell, Pa., agrees that the Chinese are going outside to buy technology. This change of attitude will be especially noticeable in high-technology fields such as electronics, because "on the average they're 15 years behind the West in technology. We're such a fast-moving target that they'd fail to catch us, and in fact would lose ground, if they tried to develop these capabilities entirely internally."

Indicative of the change was the tour in October at the invitation of China's engineering society. It was coordinated by the Institute of Electrical and Electronic Engineers and its Computer Society.

On the month-long visit, the group toured universities, computer research centers and manufacturing facilities, and semiconductor fabrication plants in six cities. As the tour members begin collating their notes, an image of technology antiquated by Western standards emerges.

**Solid state.** In semiconductors, the Chinese are at about the small-scale integration level, using primarily Schottky transistor-transistor logic, with some 10-K emitter-coupled logic being developed for use in new computer families. There is some development work in metal oxide semiconductors, including complementary-MOS and C-MOS on sapphire, but reportedly no parts are in production.

In general, production techniques are primitive, with little automation and excessive handling of the wafers and parts resulting in low yields, Borgerson says. "The most surprising thing was when we toured the semiconductor facilities we put on clean gowns, bootees, and caps. Yet the rooms themselves are not air-conditioned and have the windows open."

The computer hardware is called the DJS family, but the fourth ministry of machine building, which controls all electronics in China, has apparently done little to coordinate architecture throughout the product line or the country. "They build the computers at various facilities, usually associated with a neighbor-

## The inscrutable market

Ask makers of semiconductors and instruments for their estimate of the opportunities in China and they generally reply with a version of "Who knows?" A spokesman for National Semiconductor Corp. notes that the U. S. has had diplomatic relations with the USSR for 30 years and that market has not exactly broken any records.

Texas Instruments Inc. does not expect immediate sales in computer, telecommunications, or consumer products with high average-unit costs. A spokesman does see possible opportunities in areas such as industrial controls and test equipment. Hewlett-Packard Co. has been selling—mostly instruments—to China since 1973. But orders for equipment such as computers that require licenses have been sparse because "to comply with regulations, the Chinese would have to specify where the equipment is going and for what purpose," says Lee Ting, HP's area manager for the Far East.

On Taiwan, native manufacturers of television sets are more concerned with U. S. import restrictions than with America's new diplomatic initiative. Of American companies assembling parts on Taiwan, the one with the biggest stake in the island's future is General Instrument Corp. Of its 23,000 employees some 12,000 work in its three Taiwan assembly plants, and a major new facility is planned that will manufacture components, primarily for telecommunications applications. The company expected the diplomatic realignment, says Frank G. Hickey, chairman. "It changes nothing as far as our intentions or operations are concerned." Equally sanguine is Oak Industries Inc. of Crystal Lake, Ill., which has announced a $2.5 million expansion of its facilities on Taiwan.

## Probing the news

**Handy.** Technician in Chinese semiconductor plant handles wafers—literally. Chinese seek to buy technology in such areas.

ing university," says Borgerson. "But they actually retool the design at each one. None of the components are identical, and the circuit boards are not interchangeable."

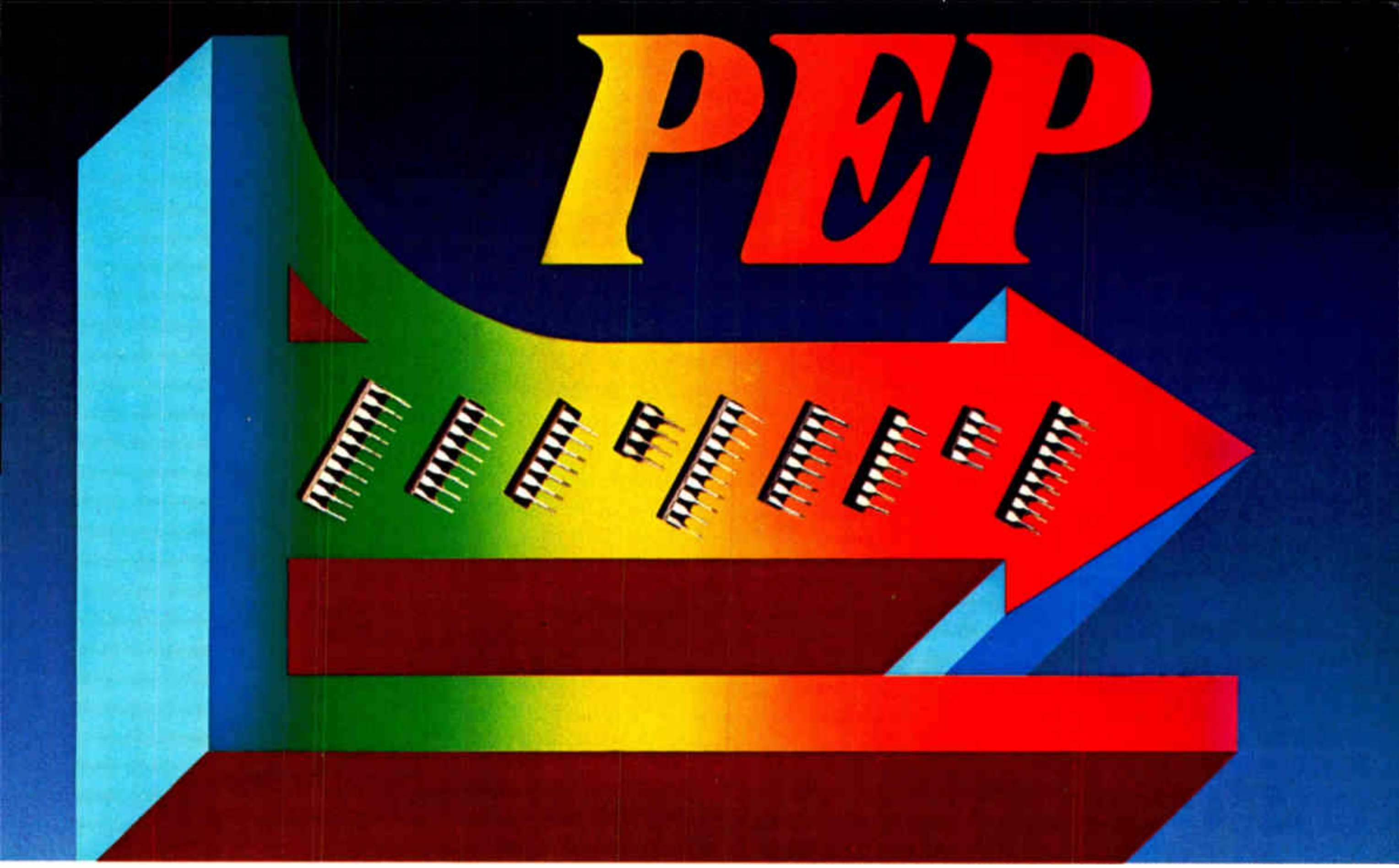
**Limited memory.** Most of the machines resemble Western minicomputers in power, according to the visitors, but are larger and are limited to main memories of between 32,000 and 64,000 words.

Only one machine of the 40 or 50 they saw had a disk drive. A 20-megabyte unit, it was at the national academy of sciences in Peking, attached to a computer with an operating speed of 1 million instructions per second. "It has 11 platters and 20 recording surfaces," Borgerson says. "But each platter is a meter in diameter and mounted on a horizontal shaft 2 meters long." Average access time is 50 milliseconds.

With a lack of computers and memory capacity, software development has also been severely hindered. The visitors report a lack of operating systems, no multiprogramming or interactive capabilities, and a limited amount of software in what few programming languages are available. "The Chinese are just starting to use higher-level languages, but operating systems are still primitive," Garner says.

The Chinese realize their technical shortcomings, however, and are trying to overcome them, the visitors report. Their libraries are stocked with U.S. publications, although there is apparently a problem in getting the information translated into Chinese. □

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| Continuity | 100°C | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 |
| Functional | 0°C to 70°C | 0.10 | 0.10 | 0.25 | 0.25 | 0.10 | 0.10 |
| DC Parametric | 0°C to 70°C | | | 0.65 | 0.65 | 0.25 (Note 1) | 0.25 (Note 1) |
| AC Parametric | 25°C (Note 2) | 0.65 | 0.65 | 1.00 | 1.00 | 1.00 | 1.00 |
| Fine Leak | $1 \times 10^{-6}$ Leak Rate | NA | 0.65 | NA | 0.65 | NA | 0.65 |
| Gross Leak | Step C-1 | NA | 0.40 | NA | 0.40 | NA | 0.40 |
| Mechanical Defects (Note 3) | Critical | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| | Major | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Notes:
(1) For linear devices, a 0.25% AQL at 25°C and a 0.65% AQL at 70°C apply.
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(3) Critical mechanical defects are those which affect device functionally. Major defects include problems not affecting functionality.

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Electronics abroad

# Japanese get a base in Britain

Joint venture of Hitachi and GEC is prelude to attempt to capture greater share of European color TV market

by Kevin Smith, London bureau manager

**In little over** a year since Hitachi UK Ltd. was forced by union and industry pressure to cancel plans for a television manufacturing unit in Britain, the Japanese consumer electronics giant has acquired a production base there. It has joined Britain's General Electric Co. Ltd. to form a new company: GEC-Hitachi Television Ltd.

The deal follows hard on the heels of a similar joint venture between the Rank Organization and Toshiba Ltd. under which Rank Radio International will initially manufacture at its factories in the west of England monochrome TV sets and audio systems that were formerly imported from Toshiba. Both Sony Corp. and Matsushita Electric Industrial Co. Ltd. had established production units in the United Kingdom before the outcry from the native industry, already working at only 60% of capacity, slammed the door on further invasions.

At first glance, the move to joint ventures suggests that the Japanese executives have become sensitive to the protectionist backlash that their hugely successful export machine arouses. But a longer-term perspective suggests that these latest moves are the prelude to a campaign to wrest a greater share of the European consumer electronics market from the market-leading Philips' Industries group and from the top German consumer electronics manufacturers.

In the video cassette recorder market, for example, the war is already on. Philips is losing market share as European suppliers clamor for licensing agreements with each of the main contenders. On its home ground, Philips' share of the Dutch recorder market will be around 20,000 systems out of a total market of reportedly 40,000. In the UK, sales are expected to be around 100,000 units next year.

There are two powerful reasons for the UK to become the market base from which to attack the European color television market. The first stems from the PAL system developed by AEG-Telefunken and used in most European countries (France uses Secam). The PAL license limits exports to no more than the number which a subsidiary—in this case, Japanese—supplies to the local market. And while the UK market is the second-largest in Europe, with color sales this year of 1.85 million sets, the country has a fragmented and weak indigenous industry.

This weakness has also made British manufacturers unable to withstand Japanese competition. The condition is highlighted in a Boston Consulting Group Ltd. report commissioned by the National Economic Development Office (NEDO), a government-union-management body. It spells out in stark terms the economies of scale enjoyed by Japanese companies.

In Japan, several manufacturers build more than 1 million sets a year, while in the UK seven indigenous suppliers scramble for the 1.85-million-set market—and Philips and Thorn Industries already have 20% each. Just as significant, comments the report, Japanese manufacturers have the purchasing power to demand that component reliability from suppliers that has won them an enviable world reputation. □

## The tube plot thickens

The British government has enthusiastically welcomed joint ventures like that between General Electric Co. Ltd. and Hitachi, seeing in them extra jobs, a strengthened home industry, and the prospect of increased exports. But other set makers and component suppliers are not so enthusiastic. In particular Mullard Ltd., the British subsidiary of Philips' Industries of the Netherlands, has repeatedly warned of the dangers of an over-reliance on components from other than Common Market sources.

Fueling its arguments, it has pointed to the anomaly of Japanese TV sets selling on the UK market for at least $200 more than British-made sets while their tubes sell competitively. Now, with a Hitachi tube plant coming on stream in Finland with an eventual 800,000-unit annual capacity, the battle will be joined for control of the all-important tube-manufacturing industry, on which control of the TV set industry itself rests.

But the once-outspoken Mullard officials refuse to rock the boat on the latest collaborative deals. "GEC are good customers of ours and we hope they will continue to be so," comments one spokesman. However, there is an obvious though unvoiced fear that GEC might eventually swing its purchasing to Japan. Patrick Sansom, managing director of GEC (Radio and Television) Ltd. comments, "We have bought tubes from both sources and will continue to do so."

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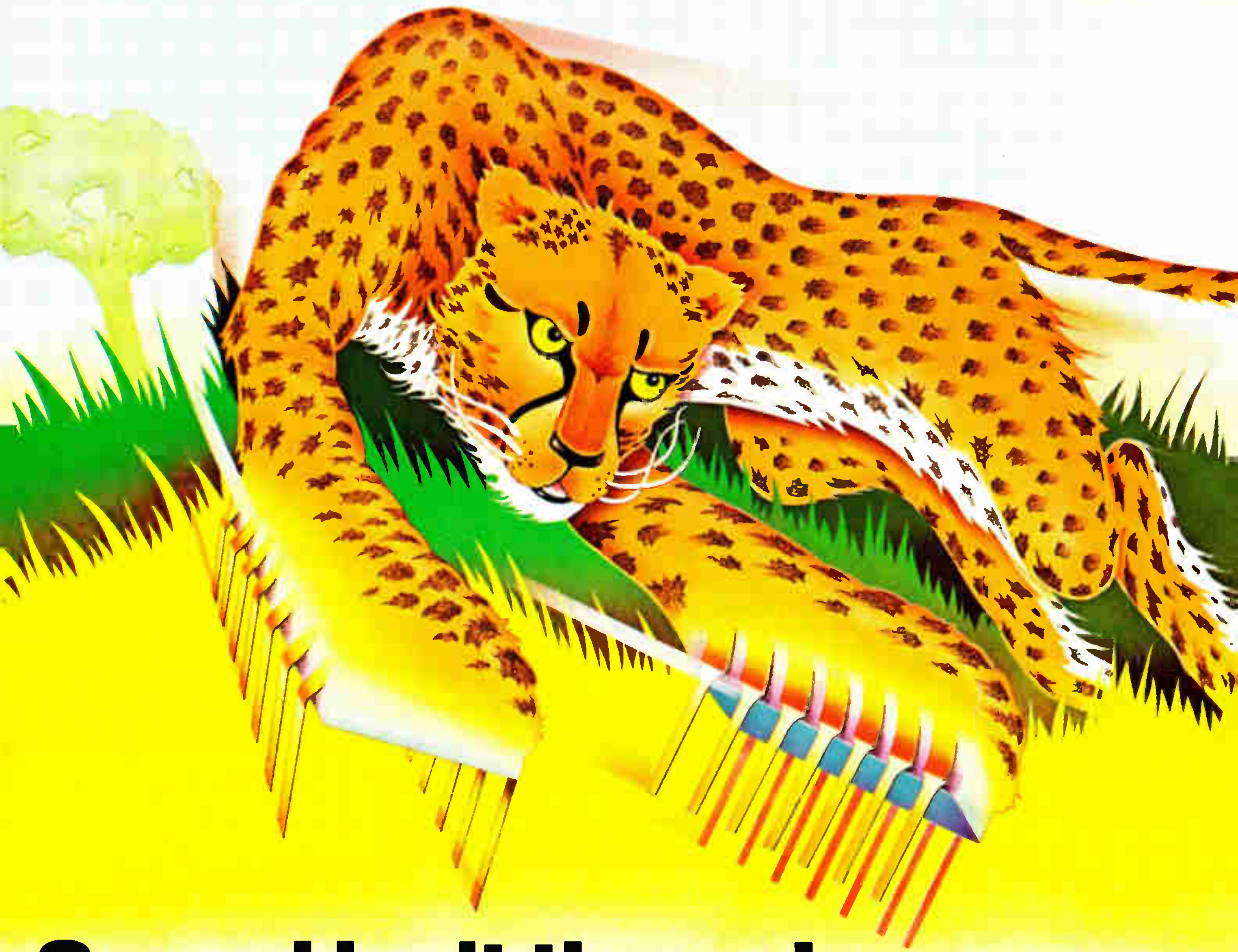

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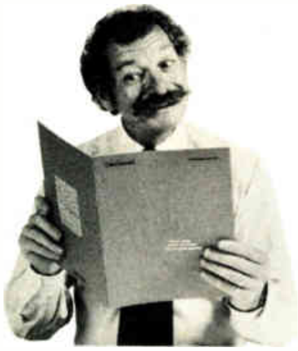

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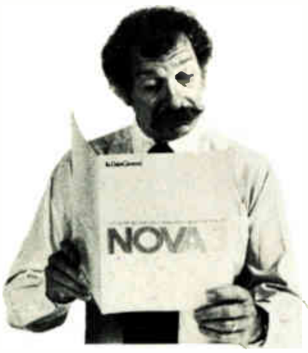


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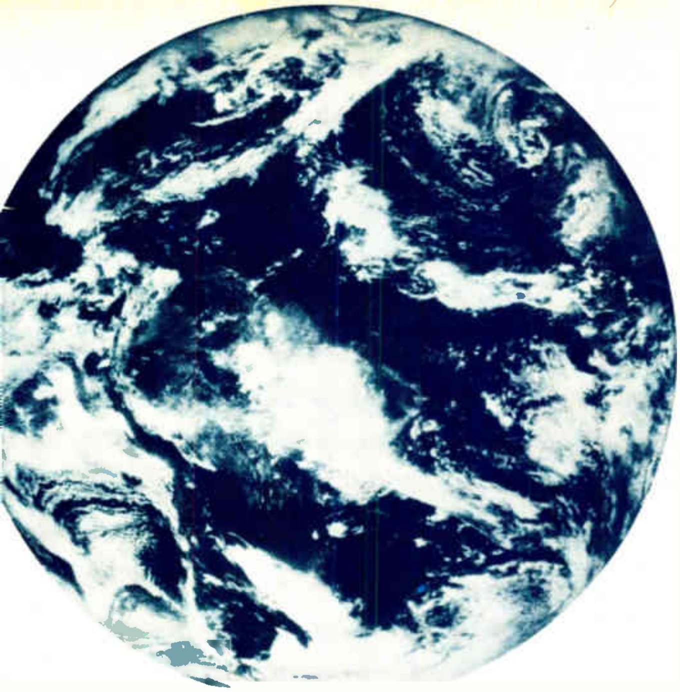
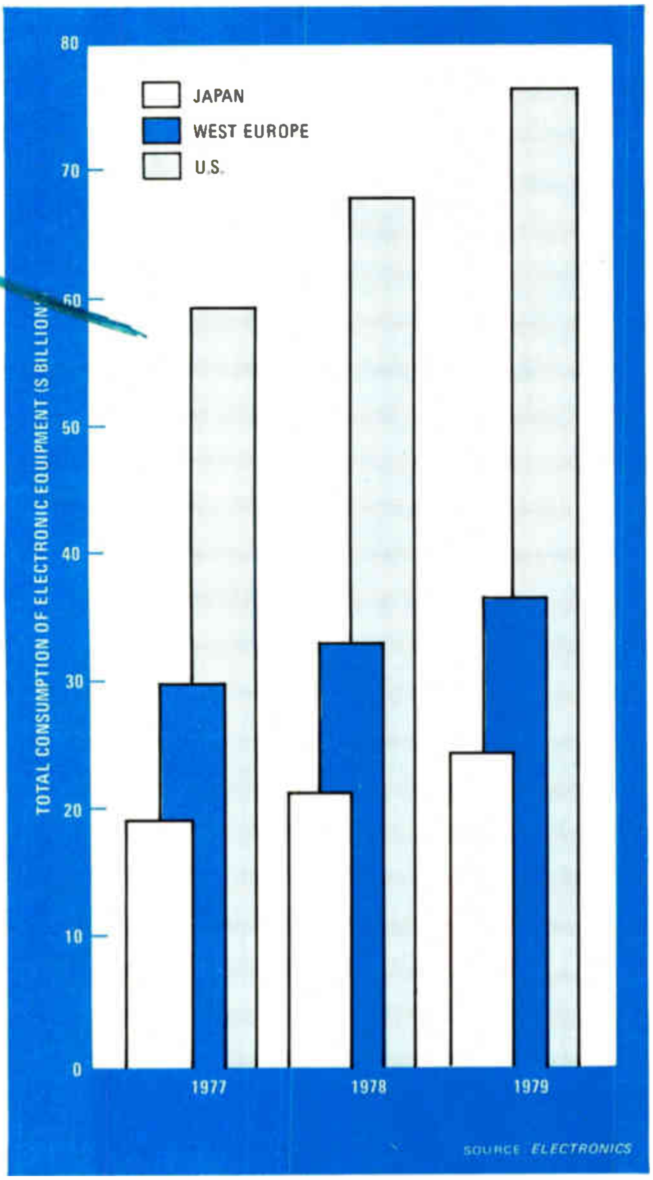


# 13% growth to push world equipment sales past $136 billion




☐ A world of uncertainty lies ahead for the electronics industries in the United States, West Europe, and Japan. The strain of getting the general economies of these countries to lift off is beginning to tell: the U. S. faces inflation and a possible recession; West Europe is exhausted trying to reach growth targets; and Japan has given up attempting to hit an unrealistic economic goal.

The recent oil price increases announced by the Organization of Petroleum Exporting Countries have therefore hit these industrialized nations at a bad time. The initial reaction has been that higher-priced oil will increase the inflationary pressure worldwide.

Consequently predictions for electronics consumption this year must be hedged somewhat against the possibility of at best slow growth in the industrial nations' Gross National Products. Nevertheless, electronics growth will easily outpace Gross National Products in these markets even if there is a slowing of consumption. Right now there is a good deal of momentum carrying into the New Year, particularly in the data-processing equipment markets. In fact, computers and related hardware will lead in dollar value for all three of these markets. And continued expansion of computers will boost other products, especially microprocessors and integrated memory circuits in the semiconductor category.

Total electronic equipment consumption for this year should be $136.7 billion, according to the annual survey of world markets conducted by *Electronics*. This works out to be a 13% increase over the 1978 total of $121 billion. The largest consumer, the U. S. electronics equipment market is expected to hit $76.4 billion this year, compared with $67.3 billion last year, the *Electronics* consensus reveals. Though a 13.5% gain, the number is a slight decline from last year's 14.3% growth rate. For Western Europe the figure is $37 billion, an 11% increase over 1978, which also registered a 11% jump. Total Japanese domestic consumption of electronics equipment will increase by $3 billion to reach $23.4 billion, a boost of 15% compared with 1978's 13.8% growth.

In the U.S., even the bullish electronics companies are anticipating some slowdown. However, there appears to be much less fear of overcapacity and inventory imbalance than there was during previous slow-downs. Whether this confidence is well-founded or merely whistling past the cemetery will probably not become evident until much later this year.

Well established as the biggest U. S. market, the data-processing category is set for a very healthy jump of 19% this year. This increase, according to the *Electronics* survey, should put computers and related equipment at $29.3 billion, well ahead of the second-place $19.9 billion slated for Federal electronics spending. (Computers for Government applications are probably buried in both totals, however.) The momentum in this market promises to drive data-processing equipment even farther ahead of the pack, so that by 1982 it will hold down almost 42% of the entire U. S. electronic equipment market.

Leading the way in the U. S. data-processing market are the well-established disk memories plus two relatively young product categories—word processing and distributed processing. In the last of these, the blend of communications and computers is creating new potential growth expected in the 1980s.

Not to be overlooked, of course, is the $19.9 billion in Government electronics outlays expected during the coming calendar year. This sector would be a likely spot for the Carter Administration to counter a possible recession. Therefore, when the fiscal year budgets emerge later this month, there may be even more dollars designed to make the incumbent look good in time for the election.

The picture in Western Europe varies from country to country, but the general outlook is for GNP growth in real terms of just under 3%. As usual, West Germany will carry the ball with a GNP growth rate of 4%. West Germany is similarly far out in front in electronics equipment consumption, with $11.35 billion this year. Then come France at $8.01 billion, the United Kingdom at $5.22 billion, and Italy at just under $4 billion.

Among market segments, computers rule the roost in Western Europe, too, gaining ground in good times and poor times alike. Computer sales will take the lead this year by a solid $824 million over the previous leader, consumer electronics. Total sales are projected to be $12.94 billion, a 14.3% growth over 1978. This increase follows a 14.5% jump last year.

Determined to meet a promise of 7% gain in GNP, the Japanese government of former Prime Minister Takeo Fukuda pushed economic stimulators, but was able to reach only 5% to 6%. And new Prime Minister Masayoshi Ohira has abandoned the 7% goal for this fiscal year ending in March. Japan's successes in the 1960s and early 1970s have propelled it into a new league economically, and it will probably have to adjust to this change with a complete structural reorganization.

The electronics market is already undergoing change as the once-dominant consumer electronics sector matures in certain products and the data-processing portion of the domestic market moves into the leading position. In addition, the Japanese computer companies are coming of age, depending less on government subsidies and preference-rate loans from government banks and competing toe to toe in the country's increasingly open market.

Computers and related equipment are expected to grow by 17.5% this year to $9.2 billion. In contrast the consumer group will increase by 12.7% to $8 billion. Thus the stage appears to be set for Japan's anticipated entrance into serious computer exports.

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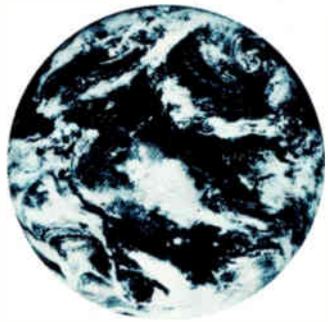


# U. S. MARKETS

☐ Seldom have the straws in the market winds been blowing in so many directions. The electronics industry's order books, inventories, and production levels all look good. Also, the consensus of the annual *Electronics* market survey is for a total U. S. electronic equipment consumption growth of $7.6 billion, or 13.5% above 1978. Last year, total electronic equipment growth was 14.3%.

So conditions appear favorable, despite problems hanging over the general economy that disturb the electronics outlook. One worry, which the recent oil price increases have exacerbated, is whether there will be a general recession, defined as two consecutive quarters of decline in the Gross National Product.

Another worry: if there is a real downturn in the second or third quarter, as some analysts predict, will electronics demand have enough momentum to carry through the year? Therefore, even though recession is not reflected in order books now, everyone is nervous. Once inventories begin to pile up, stagnation can set in pretty fast.

Thus it is with frequent glances over their shoulders at the economic situation that electronics marketers draw up this year's estimates. Different market sectors will plow through the year at different rates, and each will react differently to a recession, if it comes.

For example, the computer industry, coming off a good year in 1978, should have enough strength to make another good showing in 1979—up 19% to $29.3 billion. The consumer sector, however, may be more susceptible to the eddies in the economy since consumers often respond to both inflation and recession by not buying. Nevertheless, the *Electronics* consensus puts sales at $15.4 billion, a growth of 9.7%.

Communications, pegged at $4.3 billion, should grow by 11.6% if whatever recession may occur is not too severe. The industrial electronics sector is quite sensitive to the economy, indicating a modest increase on the year. Equipment for testing microprocessors and large-scale integrated memories will move the instruments sector.

Accentuating the positive, semiconductor marketers expect the 1978 boom to last into this year long enough to cushion a slow-up in the second half. Growth in components, though, appears less vigorous, although a couple of categories like liquid-crystal displays and thick-film resistor networks will pull up the rest.

# A top performance, no matter what

After a strong 1978, virtually all segments of the U. S. data-processing, peripheral equipment, and office equipment industries expect to complete a healthy 1979—no matter what the general economy does. Hardware purchases reached $24 billion last year and are expected to grow a solid 19% to $29.3 billion this year. But should the economy slow down in the second and third quarters, as projected, the industry is not sure its markets will retain their strength into 1980.

Leading the way into 1979 will be two relatively young markets—distributed data processing and word processing—and that old reliable, disk memories. Fueled by IBM's endorsement with its new 8100 system as well as by decreasing hardware costs and stable, if not increasing, communications costs, the distributed processing market is expected to grow 30% a year.

Because such an amalgam of mainframe, minicomputer, and terminal hardware is marketed in the name of distributed processing, estimates of market size vary. But Norman Zimbel, a researcher with Arthur D. Little Inc., Cambridge, Mass., estimates the market for complete distributed network products alone to have already reached some $400 million and to top $5 billion by 1983. Rallying around the cry of office automation, computer companies are peddling the "office of the future" and aggressively pursuing its major component, the word processing market. And they have good cause, since word processing is estimated to be a $1 billion market now, growing between 20% and 30% a year.

### Two-sided floppy disks pick up speed

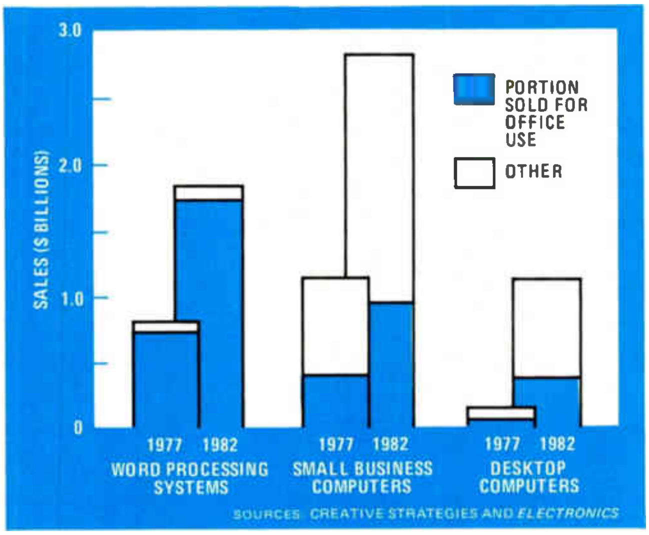
With virtual-memory operating systems gaining in popularity and additional computers being scattered around in distributed processing and word processing systems, demand for on-line storage is experiencing similar strong growth. The market demand for on-line disk and tape subsystems is estimated to be growing at some 30%, by market researchers International Data Corp., Waltham, Mass. Leading the way are the newer Winchester technology disk drives packaged for minicomputer systems and the double-sided, double-density floppy-disk drives. And the market for the traditional single-sided, 8-inch floppy disk, which grew a dramatic 46% between 1977 and 1978, is expected to slow this year to only 6% growth, according to James Porter, publisher of Disk/Trend Report, Mountain View, Calif. Among other peripheral products, data-communications terminals, primarily cathode-ray-tube units, are continuing a healthy 22% growth.

### Small computers getting bigger sales

Other rising stars in the computer industry are small computer systems and personal and desktop computer systems, or as some call them, "the small small-business-computers." Stimulated by the latest small business computer to be introduced by IBM, the System/38, the small-system market is expected to continue the 40% growth it experienced last year. Although now the smallest part of the entire computer industry market, the personal and desktop computers are just now finding their niche, primarily as small computers in offices and for businesses with less than $1 million in revenue. Now about a $260 million market, it will grow at some 90% annually, according to Creative Strategies International of San Jose, Calif.

The previous glamour growth market, minicomputers, is finally starting to show signs of slowing down. However, to the minicomputer industry, famous for its more than 40% annual growth rate, a downturn means growth rates of "only" 25% to 30%. And even though minicomputers may be particularly vulnerable if economic conditions force users to cut back on capital spending, it is seen as a cyclical slowdown rather than a technical or product problem.

The stalwart mainframe market, now at some $2.7 billion, will grow at some 15% in the New Year. Once again, IBM's moves, primarily with its 303X line of computers first delivered last year and the rumored E-Series expected early this year, have stimulated the overall mainframe market. The other U. S. mainframers—Burroughs, Control Data, Honeywell, NCR, and Sperry Univac—all reported record backlogs going into the New Year. Analysts warn, however, that backlogs are subject to order cancellation or delayed delivery—actions that users may take, if the economy slows down and forces them to postpone capital expenditures. The impact might not be felt until next year.




**Office of the future.** Efforts by various companies to automate the office are stimulating the growth of several computer market segments—word processing, the small-business-computer portion of the small-system market, and personal or desktop computers.

# Slower growth in the downturn

Following 1977's 17% jump in domestic sales, most consumer electronics manufacturers entertained the notion that the growth rate last year would have to slump. Actually the slump was more of a small dent, as consumption of consumer electronics hardware rose 16% to $14.03 billion.

And as 1979 begins, manufacturers find themselves in a similar position—torn between their hopes and the expected pressures of inflation and recession. In that context, *Electronics* projects that U. S. consumption of consumer electronics equipment will rise by 10% to $15.39 billion.

Focusing on the more dynamic segments of the market, better-than-average growth looks possible in home video cassette recorders (47%), microwave ovens (25%), video games (29%), and automotive electronics (22%). Eroding those gains somewhat will be color television, which should level off this year after a record-breaking performance in 1978.

### Varied outlook

The forecast for other consumer products is as varied as the products themselves. The New Year will be a flat one for calculators, electronic watches, and high-fidelity audio components; a rebounding year for black-and-white TV and radio; and a year for testing the waters with newer items like projection TV, personal computers, fancy telephones and video-disk players. Nonvideo games and toys, especially radio-controlled and educational products, should continue to score points this year.

For the second year in a row, color television was the big success story. More than 10 million sets were sold in 1978, breaking the record of 9.3 million sets sold in pre-recession 1973. This translated into $3.91 billion in sales, a 12% increase over 1977 and a far cry from the modest 1% gain predicted at this time last year.


**Diversification.** By 1982, sales of new consumer electronics products (VCRs, microwave ovens, video games, etc.) will surpass those of traditional gear (TV sets, radio, audio equipment, etc.) Total domestic consumption should hit the $20 billion mark.

Despite this sparkling sales performance, the color TV industry is struggling to be profitable. Some brands are running in the red, while others are walking a tightrope between price hikes and rapidly rising costs of labor and materials.

Competition among U. S. manufacturers for the domestic market, which intensified when a quota on Japanese imports was imposed two years ago, should reach a fever pitch if the U. S. extracts similar agreements from Taiwan and South Korea. At any rate, manufacturers expect a slight falloff in sales.

Video cassette recorders had a disappointing 1978, their first complete year as an established market. About 400,000 units made in Japan for both U. S. labels and Japanese competitors were sold last year, a good deal under the 500,000 to 750,000 that were predicted. Total unit sales this year should be at least 600,000 units.

Strong support for VCRs as a do-it-yourself entertainment medium will come from video cameras. A mild price war should help sales considerably; however, the market is still too new to make accurate guesses on how many units will be sold.

### Well done in microwave ranges

Another big-ticket item that should continue cooking this year is the programmable microwave oven. Look for more than 3 million units to be sold, for a total market value of $1.5 billion. Litton Microwave Cooking Products of Minneapolis, Minn., sees market penetration reaching 16% by the end of 1979.

This year will be a strong one for automotive electronics. Sales of established products like voltage regulators and electronic ignition systems will be flat at best, or possibly fall off a bit as the prices of semiconductor components drop.

In contrast, sales of engine- and emission-control hardware that use electronic fuel injection, fuel metering, and spark advance to cut pollution and increase fuel economy should grow by 20% next year. This market should explode in model year 1981, when 10 million American cars will need $30 worth of semiconductors just to comply with tough Federal standards for emissions and economy.

Home computers face a critical year. At year's end, few marketers were willing to project sales figures for 1979, citing the impact of technological heavyweight Texas Instruments' expected entry into the field. Attracting the average consumer, as well as the small business user, means that producers have to concentrate on making more software available and standardizing interfaces with input/output devices.

# Sending out favorable messages

The signals in the communications sector indicate another good year in 1979, up 11.6% over 1978 to reach a sales total of $4.3 billion. This projection will hold only if the midyear slump that many economists are predicting does not turn into a major recession.

Leading the way this year will be the continued growth of digital communications, plus the oncoming rush of fiber optics and multifeatured telephone sets for the home implemented by inexpensive large-scale integrated circuits. As usual, there will be complex legal cases engaging the industry. The growth of both the regulated and unregulated telephone industry will continue to be clouded by the legal maneuvering in the courts, the Federal Communications Commission, and the Justice Department. A scorecard is needed here to help keep track of who's serving whom with what papers.

In addition, AT&T with its Advanced Communications System, IBM and partners with their Satellite Broadcasting System, and Xerox with its XTEN (for Xerox Telecommunications network), all competing for the "office of the future" market, promise further complications. Meanwhile, Congress is overhauling the Communications Act of 1934, and the result could dissolve the FCC as a regulatory agency.

Further competition for AT&T comes from the exceptional growth of the non-Bell firms. They have developed a strong lobbying organization of their own, the North American Telephone Association, which has overseen a phenomenal growth of 25% in sales in 1977 to 1978 and expects to see a further growth in 1979—mostly in private branch exchange systems and key stations and systems. They already account for 7.9% in total lines and 12.1% in total systems installations.

All the observers of the telephone interconnection industry seem to feel that substantial growth is expected. For example, PBX systems will experience an average annual increase in sales of over 20%, according to the National Association of Regulated Utility Commissioners (see figure). Moreover, the total interconnection industry growth this past year is estimated at 25%, says NATA's research department survey of 98% of the manufacturing marketplace.

### Digital impact coming

The rise of all-digital systems in both satellite and terrestrial communications will help the digital data-handling and interface equipment makers, especially those will put out items that will allow users to keep up their substantial investments in analog equipment. Earth-terminal and associated equipment manufacturers will also see a rise in their volume to $132 million, but modem people will probably see a slowdown in growth, from 7.3% last year to 6.8% this. Though digital technology itself is booming, full system implementation is a slow and costly process and converting data from analog into digital form and vice versa will be necessary for a long time. Many users are in no great hurry to convert because they have not recouped their initial investments and the traffic volume does not justify it.

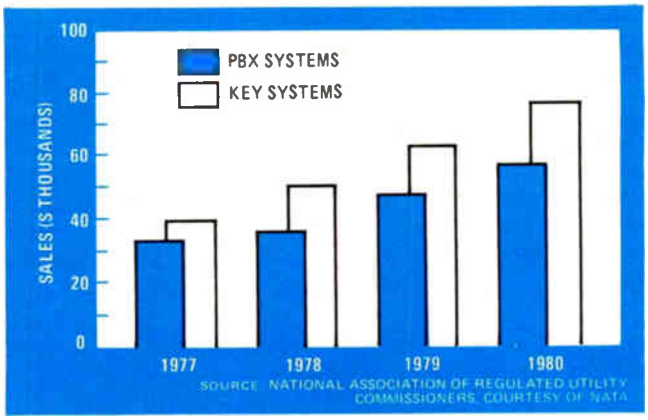
High-speed digital data-handling machines such as facsimile will show a 16% growth as business customers prepare to connect to either the AT&T, SBS, or Xerox office communication systems. However, the really big cash commitments will be delayed until users have a clearer idea of what companies will supply what services.

Fiber-optic applications continue to grow with new installations in both the commercial and military sectors. A hot area here is ready-to-go general-purpose data links that the user just hooks up and plugs in. This market alone should almost double in 1979 to $42 million, whereas it was almost nothing in 1977.

At the same time that this growth is proceeding, suppliers are complaining that widespread sampling and prototyping is the chief source of sales. Many devices are being sold in small quantities to systems houses for investigation purposes only, because no one wants to be caught unaware of the new technology. But these small and slow purchases are affecting the bottom line. Of the more than two dozen link suppliers, one or two have already dropped out of the business, several more are talking of doing so, while others are looking to distributors to handle their marketing.

### Lots of talk

The citizens' band market has not just ground to a halt but backslid 10% to $297 million. Farther up the personal communication scale, both old and new ham radio enthusiasts are being lured by expensive, multifeature transceivers that are appearing all over the place. The price tags reflect the increased capabilities of the devices and growth is projected here at 9%.




**Growth area.** Outpacing many segments of the communications marketplace, sales of private branch exchange and key systems are forecast to increase at rates of 25% and more. This growth reflects the aggressive marketing of the independent telephone companies.

# Business will turn slower

The industrial electronics sector ground out a surprisingly good year in 1978, and hopes are high that these firms can put together another satisfactory year in 1979 despite the more slowly turning wheels of the economy.

Last year saw total sales of industrial electronic gear reach $2.12 billion, up 14% from 1977. Industrial electronics manufacturers expect this positive momentum to carry them far enough into the new year to predict another 14% increase to $2.41 billion by year's end.

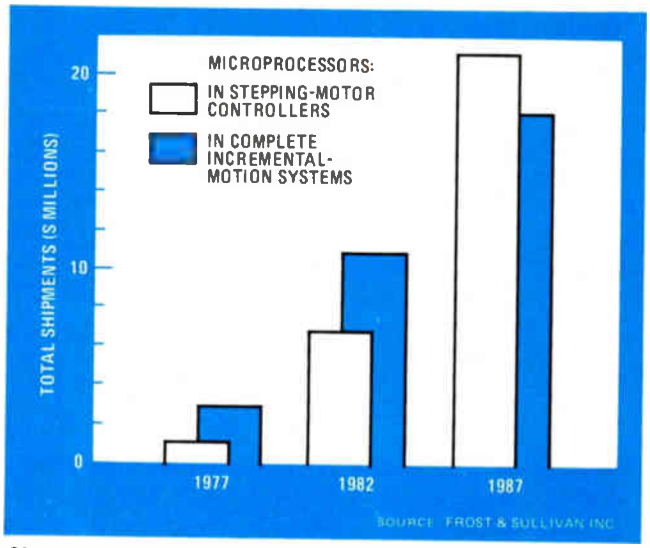
Of greatest concern to industry suppliers is the general health of the domestic economy, which largely determines the availability of capital. Real growth of only 2% in the Gross National Product is predicted for 1979; moreover, some analysts say that President Carter's recent decision to slow the economy by raising short-term interest rates will cause a mild recession in the middle two quarters of this year. On the other hand, the economy showed considerable underlying strength last summer, when it was able to expand despite interest rates that were already rising to near-record levels.

How will these economic factors affect the larger segments of the industrial electronics market? Numerical controls for machine tools, which registered a healthy 17% jump in sales last year, should show a respectable increase of 10% in 1979. Sales of energy-management electronics, still gathering steam after a slow start, should post a 33% gain. And process-control electronics—controllers, recorders and computer-based systems—should also do a brisk business, bringing in 14% more dollars than last year.

### Modest increases in capital spending planned

One of the reasons that industrial-electronics manufacturers are optimistic about 1979 is the anticipation of a 10% increase in capital spending by industry in general. According to the McGraw-Hill fall survey of capital spending, released last November, durable-goods manufacturers will spend 12% more for plants and equipment than they did in 1978, while makers of nondurable goods plan to invest 9% more capital. Inflation will erode both figures severely, however, and limit the overall real growth to 2%.

A good barometer of the mood of American business activity is the huge chemical-process industry. Although chemical manufacturers plan to increase capital spending by 9%, suppliers of process-control electronics are projecting a 14% rise in sales, less if capital is tight. These suppliers base their prediction on continued success for microprocessor- and minicomputer-based distributed control systems. These systems appeal to operations-conscious manufacturers because their installation does not disturb production; all that is needed are hookups to existing field transmitters. Also look for the Volkswagens of this market, single-board computers, to flourish as more and more users demand programmability by their operations personnel.




**Giant steps.** As digital electronics revolutionizes American industry, more production machinery will be controlled in positional increments, rather than continuously. Microprocessors, both in components and systems, will play a major role in this transition.

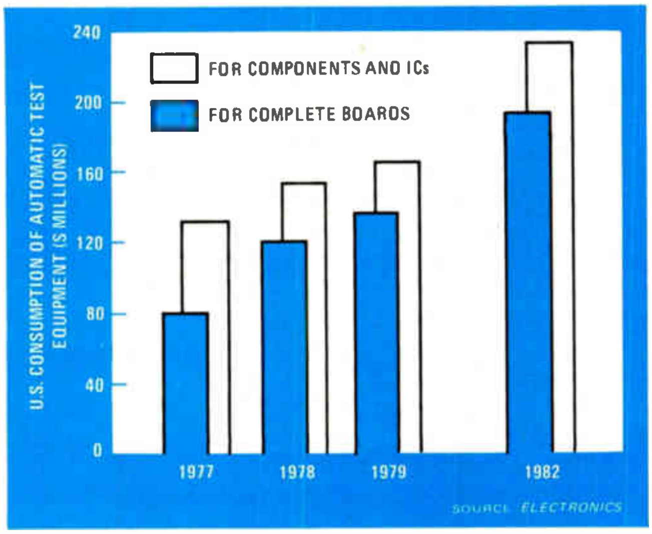
Microprocessors and minicomputers have continued their invasion of the numerical control field, too, and will eventually drive open-loop machine-tool controls into extinction. This past year, however, hard-wired controls held their own in admirable fashion. As vendors look forward to an equally good year in 1979, they also point to inventory shortages at domestic machine-tool manufacturers as the reason that many foreign suppliers are penetrating the U. S. market and bringing their electronics with them.

Sales of energy management systems and motor controls should both benefit from the skyrocketing cost of energy. Energy-intensive industries are countering higher electric-utility rates by minimizing demand with computer-based load-shedding systems. Just beginning to blossom is interest in microprocessor control of motors for greater overall energy efficiency. The vast number of installed motors in this country guarantees at least a healthy retrofit market for years to come.

Electronic pollution-monitoring equipment will also do well in this, and subsequent years, thanks to the efforts of Federal, state, and local environmental-protection agencies. Increasingly stringent air- and water-pollution standards will create a demand for more sensitive instruments to measure ever smaller quantities of industrial pollutants ever more accurately.

Second in importance to the microprocessor in industry's analog-to-digital conversion is data-acquisition equipment for continuous and discrete processes. Because of that importance, look for sales to jump a healthy 21% this year and a further 29% by 1982.

# Prosperity from microprocessors




**ATE trends.** As integrated circuits and the boards holding them increase in complexity and servicing costs, and as their use spreads to fields like automotive electronics, more and more makers and users are turning to automatic test equipment to ensure reliability.

Testing the economic climate, the instrumentation industry figures to record a mild growth this year to $2.4 billion, which is 11% over 1978. However, a number of product categories should get different readings from those voiced by the majority and in fact look forward to a better-than-average 12 months. These high rollers all have as their focal point hardware based on the microprocessor and associated large-scale integrated circuitry.

Hoping to cash in again on the good fortune of semiconductor manufacturers, the suppliers of the automatic test equipment for ICs and circuit boards, with combined sales of $243.4 million for 1978, expect total sales for 1979 to reach $271.3 million. The main thrust is being supplied by the board testers, whether functional, in-circuit, or combined types. Increased board complexity and rising servicing costs between them should catapult sales to $139 million from $120 million and the rate of growth to 15.8%.

Another ATE segment expected to cash in on the expanding applications in both the industrial and commercial area is linear IC component testers, which should experience a marked improvement in sales. This category is expected to grow to $19.1 million this year.

In addition, the demand for faster and larger memories, coupled with a growing desire to test at the actual speed, has created new market opportunities for IC component test equipment capable of meeting these needs. According to the *Electronics* survey, these testers should log sales totaling $39.2 million for the year. Large general-purpose LSI testers are also expected to do well, growing to nearly $60 million in 1979. The arrival of very large-scale integration will add to this segment, too, whether or not users want specialized testers. However, lower-cost, bench-top microprocessor and LSI testers are already having noticeable impact on the ATE market and are likely to have even greater effect should money become tight.

### Some instruments are hot, too

The general test and measurement instrument area surpassed everyone's expectations this past year, reaching $1.6 billion. Mixed feelings around the industry as to a slowdown this year have been emerging since last summer. And it seems no one wants to jinx this year by saying when the deceleration may start or how damaging it might be. One reason for uncertainty though is the considerable number of order backlogs likely to stretch out into the New Year. Observers feel that the industry's momentum will help prevent any drastic changes so that even the most ardent skeptics feel that the 11.4% rate will hold.

Both low-cost and system digital multimeters, which reached nearly $75 million in sales last year, should continue doing well. This should also be another good year for counters, both frequency and universal types. Signal sources, especially synthesizers, will exhibit a steady growth, as will spectrum analyzers, thanks to the microprocessor which has made them easier to use and more precise. Data-logging instruments are also experiencing a market expansion due to increased use of IEEE-488 programmable equipment for automatic testing.

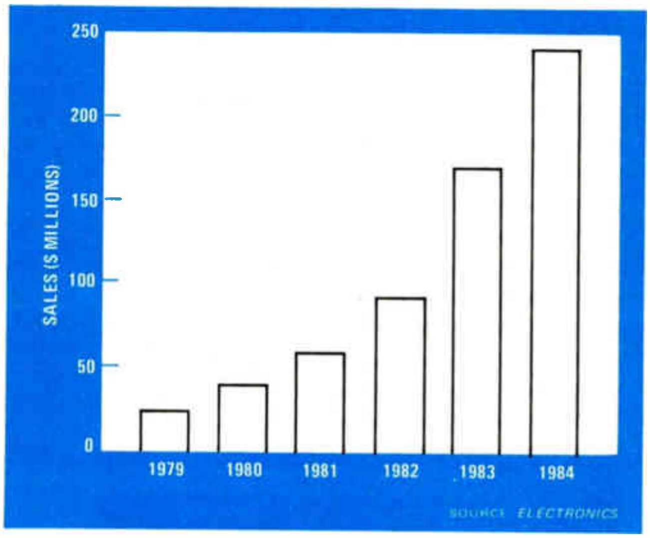
Oscilloscopes keep growing at a steady pace with a 9.4% rate expected in spite of the boom in competing logic analyzers that saw sales of $32.5 million last year and will near $45 million in the coming year. Field-service equipment still exhibits a tremendous potential for growth in years to come, as do the test and measurement instruments needed for optics.

The medical equipment market should improve this year because of increased acceptance by users. In addition, hospital administrators have become adept at preparing the certificates of need required by the Federal government for high dollar purchases, so that approval scores are improving. Sales of medical electronics are estimated to reach $1.7 billion this year.

Another active market area, analytical instruments, posted an 11% growth rate last year and gives all indications of performing equally well for the close of the decade. Topping the list of achievers in this market is the chromatography segment with a growth rate of 15% for 1978 and the same rate projected for the New Year.

One of the significant reasons for the general optimism regarding the market in analytical instruments is the increasing application of microprocessor control in them. The microprocessor, besides cutting test times and minimizing operator errors, can cut the user's costs and makes it possible to add data analysis and storage.

# How long can the boom last?




**Bubbles up.** Sales of bubble memory chips will begin exponential growth next year that could carry on for five years before flattening out as the devices are designed into small computer and office equipment. Most will be in new—not replacement—markets.

Rolling along on the momentum imparted last year by boom-level sales of integrated circuits, the semiconductor industry should come up with an affirmative answer to the question of whether the good times will last. At least, it's affirmative through the first half—after that, most analysts agree, there will be a cooling off.

As a result, the *Electronics* survey indicates the growth rate to be significantly less than last year; a 12.9% gain to $4.043 billion. The market once again will ride on the coattails of integrated circuits, which are expected to be up by 17.8% in 1979 to $2.845 billion. As last year, discrete semiconductors will retard overall growth, running just slightly better than flat for 1979 with sales of $961.6 million.

By comparison, 1978 was solid-state pleasure. Total U. S. consumption was $3.581 billion, up a whopping 17.6% from the previous year. That sum folds a sluggish 9% rise in discrete semiconductors of $0.96 billion into a bountiful 21% surge to $2.416 billion for ICs.

Although early indicators like lead times and suppliers' book-to-bill ratios as yet offer no clues, many manufacturers anticipate that order slowdowns could occur early in the second quarter, foreshadowing a mild sales dip. In fact, it will be the strength of 1979's first-half continuation of last year's boom that will bear the burden of any losses during a slowdown.

Despite the slowing, it is likely that semiconductor manufacturers would continue to sell strongly, swelling equipment makers' inventories. The reason is market share: it's almost easier for chip makers to come back from a recession than to build up market share in good times. This tactic could bring on overcapacity in parts like standard and low-power transistor-transistor-logic families, with stilted sales of $415.8 million from last year's $385 million, and discrete transistors, with flat sales of $469.7 million over $468.8 million.

Overcapacity will not be a problem, however, in the hotter metal-oxide-semiconductor areas where double ordering has been more of a concern. These include 16,384-bit dynamic random-access memories and 16-K erasable programmable read-only memories, as well as ROMs and fast static RAMs. In general, MOS memories will do best of all, with dynamics up 17.7% to $302.5 million, statics up 25% to $235.7 million, and EE-PROMs up 33% to $122.5 million.

The 64-K RAMs appearing late last year and early this year will not be in heavy production until the latter part of 1979 but, being closely compatible with 16-K parts, they will enjoy short design-in times and rapid acceptance. That means the 64-K will catch up with 16-K sales in a few years, and it is expected, in fact, that by 1982, the market for the 64-K will catapult to $200 million—nearly 33% of the entire MOS dynamic memory market.

Consumption of microprocessors rocketed last year, with total families up 53% to $234 million. Though lacking last year's ebullience, they will grow 37% to $319.9 million. That sum comprises steady shipments of commodity 4- and 8-bit microprocessors and microcomputers, as well as the newer 16-bit chips. With the 16-bit microprocessor business expanding this year to encompass several new devices, the market will undergo the growing pains associated with new-product support.

Single-chip microcomputer sales will gather speed, almost with the luster of last year's nearly 68% growth in sales to $32 million—a good 59% rise to $51 million.

### Caught up by the excitement

As for linear devices, analog-to-digital and digital-to-analog converters that are microprocessor-oriented will experience big growth. Of the $31.2 million market this year, an estimated 50% are in that category, mostly in the 10-to-14-bit resolution area. An ever-increasing shift from modular products in favor of hybrids and ICs will result in hybrids capturing a 30% to 40% share of the market and monolithics grabbing close to 50%.

Microprocessor-related sales growth for such discrete semiconductors as rectifiers, power transistors, and thyristors will show a rise from $220 million to $235.3 million, a 7% increase for 1979. Small-signal transistors, on the other hand, will drop at a faster clip than was expected, from $158 million to $141 million.

Magnetic-bubble memories will for the first time see heavy production this year, with consumption of the expensive parts hitting $25 million as manufacturers start designs of new products that use them. But it will not be until 1980 (see graph) that bubbles will begin to look like a real market.

## COMPONENTS

# Some parts do well

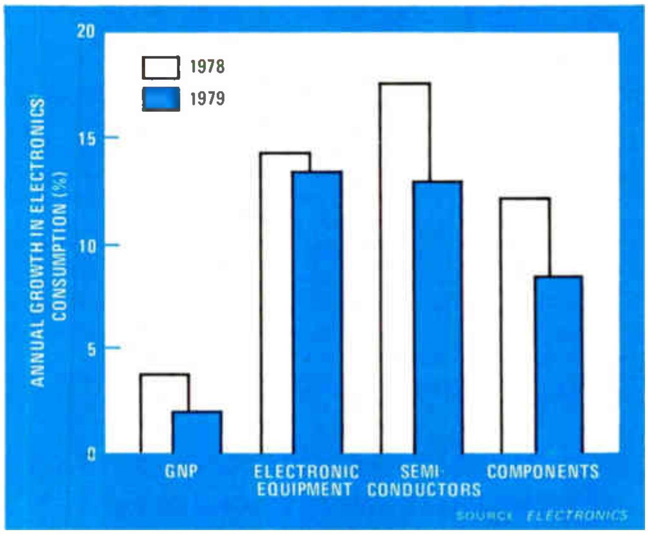
The growth of electronic equipment markets has not only fueled microprocessor and chip memory sales, but has fired up passive components as well. Thus the decline that a year ago some feared would hit components sales toward the end of 1978 did not materialize. Instead, healthy sales have continued into this year, but the next 12 months will border on a mild recession.

Overall, the *Electronics* survey pegs components at $7.7 billion for 1979, an 8.4% gain over a solid 1978. In the discrete semiconductor category, the growth rate is expected to be flat this year. Here, too, the decline predicted for 1978 did not materialize, despite the continued inroads on these parts made by integrated circuits. Growth was 9% last year. Next year, however, the percentage growth will slow down dramatically across the board (see graph).

In multidigit displays, liquid-crystal displays will grow at a rapid pace, rising from third place in the display spectrum with $25 million in sales in 1977 to first place by 1982. Light-emitting diodes are shrinking from 37% in 1977 down to 26% of the market by 1982, with total sales of $66 million.

A dramatic increase can be seen in charge-coupled imaging devices, which are expected to enjoy an astonishing revenue growth of 112% between 1979 and 1982. Also, laser diodes, to be used in large quantities within fiber-optic communications systems, will attain a 133% revenue growth in the same period.

Thick-film resistor networks will show a faster rise in growth than their thin-film and discrete counterparts. Last year, $71.3 million of thick-film devices were shipped as compared to $59.5 million in 1977. Some $78 million is expected this year. Meanwhile, thin-film types are expected to increase by 9% from $11.2 million to $12.2 million.




**Slowdown.** Whereas real GNP growth should slow only by 1.7%, the drop in growth in semiconductor and passive components is more dramatic. The 1978 semiconductor pace of 17.5% will give way to 12.9%, while components will slow by 3.7%.

## FEDERAL

# Looking good

Use of Federal spending as a means of leveraging the national economy is a well-established political tactic, and it has rarely been more evident than in the $19.9 billion in Government electronics outlays expected during the coming calendar year. Spending is calculated not only to help counter a possible recession, but also to make the Carter Administration look good.

For example, the 9.4% rise in total electronics outlays is the same as 1978, which gives suppliers a bit more than 2% in real market growth, if inflation can be held in check. Federal spending specialists like to cite the percentage gain as one that "provides economic stability," as promised by President Carter, and in itself "a check on inflation." But a look beyond the totals reflects other goals as well:

- Military electronics, with nearly $18.1 billion, still accounts for more than 90% of the Federal total. But the $8.5 billion proposed for electronics procurement will rise no more than 7.6% from the 1978 level.
- Engineering development will account for more than half of the Pentagon's new research, development, test and evaluation money, as a variety of tactical weapons like cruise missiles and tactical communications systems for North Atlantic Treaty Organization use have advanced to that stage.
- The $32 million boost in electronics spending by the National Aeronautics and Space Administration represents only an inflation-lagging 4%, although it is still a marked improvement on the 1% gain of 1978. Much of the new money will go on R&D for satellites, air traffic control, avionics, and so on.
- Money spent by the FAA will rise nearly 8% to $454 million, nearly double last year's increase.
- At the Department of Energy, a $15 million increase in outlays to $102 million will be mostly a 17% boost in photovoltaics. □

# U.S. MARKETS FORECAST 1979

**Market estimates represent industry-wide consumption (at the factory level) of goods shipped by U.S. and foreign manufacturers for the U.S. market. Some product categories have been added, deleted, or redefined. Therefore, these totals are not directly comparable to those of previous years.**

## COMPONENTS

| (millions of dollars) | 1977 | 1978 | 1979 | 1982 |
|---|---|---|---|---|
| **COMPONENTS, TOTAL** | **6,366.1** | **7,136.5** | **7,734.8** | **9,594.2** |
| **Resistors, total** | 509.4 | 554.2 | 581.2 | 670.3 |
| Fixed, total | 191.0 | 203.5 | 208.1 | 226.8 |
| Composition | 50.0 | 51.0 | 48.0 | 38.4 |
| Deposited-carbon | 20.0 | 21.5 | 23.1 | 28.4 |
| Metal-film | 68.0 | 75.0 | 79.0 | 92.0 |
| Wirewound | 53.0 | 56.0 | 58.0 | 68.0 |
| Variable, total | 215.7 | 232.2 | 243.9 | 281.6 |
| Potentiometers, wirewound | 30.0 | 32.4 | 32.7 | 34.3 |
| Potentiometers, nonwirewound | 90.0 | 97.0 | 104.2 | 128.2 |
| Trimmers, wirewound | 23.1 | 22.8 | 23.0 | 25.1 |
| Trimmers, nonwirewound | 72.6 | 80.0 | 84.0 | 94.0 |
| Thermistors | 33.0 | 36.0 | 39.0 | 47.2 |
| Resistive networks, total | 69.7 | 82.5 | 90.2 | 114.7 |
| Thin-film | 10.2 | 11.2 | 12.2 | 14.7 |
| Thick-film | 59.5 | 71.3 | 78.0 | 100.0 |
| **Capacitors, total** | **696.0** | **802.6** | **866.2** | **1,010.3** |
| Paper | 84.0 | 88.2 | 89.3 | 97.0 |
| Film | 90.0 | 98.0 | 100.0 | 112.0 |
| Electrolytic, total | 273.0 | 310.5 | 335.0 | 361.0 |
| Aluminum | 133.0 | 153.0 | 176.0 | 181.0 |
| Tantalum | 140.0 | 157.5 | 159.0 | 180.0 |
| Mica | 30.0 | 32.0 | 34.0 | 32.0 |
| Glass and vitreous enamel | 5.0 | 5.4 | 5.4 | 4.3 |
| Ceramic, except chips | 171.0 | 216.0 | 243.0 | 330.0 |
| Variable | 16.0 | 16.5 | 17.0 | 20.0 |
| Chip | 27.0 | 36.0 | 42.5 | 54.0 |
| **Relays, total** | **498.0** | **539.7** | **589.1** | **699.8** |
| General-purpose | 106.5 | 114.5 | 125.5 | 151.0 |
| Telephone-type | 26.0 | 28.0 | 30.0 | 37.0 |
| Crystal-can | 47.0 | 51.0 | 54.0 | 59.0 |
| High-sensitivity | 26.0 | 29.0 | 32.0 | 42.0 |
| Rf | 80.0 | 88.0 | 97.0 | 102.0 |
| Reed | 35.0 | 39.0 | 44.0 | 66.0 |
| Stepping and impulse | 4.5 | 4.0 | 3.6 | 2.7 |
| Time-delay | 22.0 | 23.8 | 27.1 | 33.3 |
| Solid-state | 24.0 | 27.4 | 32.9 | 43.8 |
| Other | 127.0 | 135.0 | 143.0 | 163.0 |
| **Switches, total** | **431.5** | **490.8** | **514.4** | **749.4** |
| Small-movement snap-action | 75.5 | 80.5 | 87.0 | 105.0 |
| Lighted | 65.0 | 78.0 | 89.0 | 136.0 |
| Push-button | 60.0 | 63.0 | 66.0 | 77.0 |
| Toggle | 25.0 | 28.5 | 30.2 | 35.0 |
| Slide | 22.0 | 23.3 | 24.7 | 29.4 |
| Rotary | 50.0 | 52.0 | 54.0 | 59.0 |
| Coaxial | 12.0 | 10.8 | 9.7 | 7.8 |
| Thumbwheel | 20.0 | 22.4 | 24.6 | 32.7 |
| Dual in-line | 22.0 | 26.8 | 30.6 | 39.0 |
| Keyboard, single-key | 15.0 | 25.0 | 31.0 | 43.0 |
| Keyboard, assemblies | 50.0 | 61.5 | 75.6 | 132.0 |
| Solid-state (including Hall-effect) | 15.0 | 19.0 | 24.0 | 43.0 |
| **Magnetic, total** | **369.0** | **392.8** | **408.8** | **455.0** |
| Computer memory cores | 20.0 | 19.0 | 18.5 | 12.0 |
| Transformers, chokes (except TV), total | 272.0 | 297.0 | 314.0 | 368.0 |
| Laminated | 175.0 | 194.0 | 204.0 | 233.0 |
| Toroidal | 59.0 | 63.0 | 67.0 | 82.0 |
| Pulse transformers | 38.0 | 40.0 | 43.0 | 53.0 |
| TV components | 60.0 | 61.0 | 61.6 | 63.0 |
| Rf coils | 17.0 | 15.8 | 14.7 | 12.0 |
| **Electron tubes, total** | **1,124.0** | **1,201.0** | **1,288.5** | **1,344.8** |
| Receiving | 120.0 | 111.6 | 104.0 | 62.0 |
| Power and special-purpose, total | 371.0 | 386.0 | 401.5 | 454.8 |
| High-vacuum | 60.0 | 59.0 | 58.0 | 56.0 |
| Gas and vapor | 16.0 | 17.2 | 18.5 | 22.8 |
| Klystrons | 42.0 | 45.0 | 48.0 | 59.0 |
| Magnetrons (including cross-field amplifiers) | 52.0 | 56.0 | 60.0 | 74.0 |
| TWTs (including backward-wave) | 97.0 | 102.0 | 107.0 | 122.0 |
| Light-sensing tubes | 14.0 | 14.8 | 16.0 | 18.0 |
| Image-sensing (including TV camera and image-intensifier) | 35.0 | 37.0 | 39.0 | 47.0 |
| Storage | 15.0 | 14.0 | 13.0 | 9.0 |
| Cathode-ray (except TV) | 40.0 | 41.0 | 42.0 | 47.0 |
| TV picture, black-and-white | 26.0 | 23.4 | 21.0 | 13.0 |
| TV picture, color | 607.0 | 680.0 | 762.0 | 815.0 |
| **Microwave hardware, total** | **108.5** | **120.5** | **133.4** | **286.3** |
| Mixers | 10.0 | 10.7 | 11.5 | 140.0 |
| Detectors | 5.0 | 6.2 | 7.3 | 9.4 |
| Amplifiers | 22.0 | 25.3 | 29.6 | 37.3 |

| (millions of dollars) | 1977 | 1978 | 1979 | 1982 |
|---|---|---|---|---|
| **SEMICONDUCTORS, TOTAL** | 3,046.2 | 3,581.1 | 4,043.0 | 6,043.4 |
| **Discrete semiconductors, total** | 880.0 | 959.2 | 961.6 | 995.5 |
| Diodes | 329.9 | 358.9 | 359.4 | 333.3 |
| Signal | 42.0 | 45.8 | 46.8 | 40.0 |
| Rectifier | 165.0 | 179.8 | 180.1 | 150.0 |
| Arrays | 16.9 | 18.4 | 19.0 | 16.5 |
| Zener, total | 69.0 | 72.3 | 71.5 | 69.0 |
| Voltage regulator | 50.0 | 51.6 | 51.0 | 50.0 |
| Reference | 19.0 | 20.7 | 17.0 | 19.0 |
| Special-purpose, total | 37.0 | 42.6 | 42.0 | 57.8 |
| Microwave, total | 29.0 | 34.0 | 36.0 | 48.0 |
| Varactor (less than 1 GHz) | 7.0 | 7.5 | 8.1 | 8.5 |
| Tunnel | 1.0 | 1.1 | 1.1 | 1.3 |
| Transistors, total | 430.1 | 468.8 | 469.7 | 500.2 |
| Bipolar, total | 393.0 | 428.3 | 427.0 | 450.0 |
| Small-signal (less than 1 W) | 151.0 | 158.0 | 141.0 | 100.0 |
| Power (1 W or more) | 196.0 | 219.0 | 234.0 | 285.0 |
| Rf and microwave | 46.0 | 51.3 | 52.0 | 65.0 |
| Field-effect, total | 37.1 | 40.5 | 42.7 | 50.2 |
| Junction, total | 23.5 | 25.5 | 26.7 | 32.2 |
| Small-signal | 23.0 | 25.0 | 26.0 | 31.0 |
| Power | 0.5 | 0.5 | 0.7 | 1.2 |
| MOS, total | 13.6 | 15.0 | 16.0 | 18.0 |
| Small-signal | 13.2 | 14.5 | 15.4 | 16.5 |
| Power | 0.4 | 0.5 | 0.6 | 1.5 |
| Thyristors | 105.0 | 114.5 | 115.0 | 140.0 |
| Protection devices (including varistors) | 15.0 | 17.0 | 17.5 | 22.0 |
| **Integrated circuits, total** | 1,996.7 | 2,416.2 | 2,845.2 | 4,716.4 |
| Standard logic families, total | 578.6 | 639.4 | 702.2 | 922.2 |
| RTL | 5.1 | 4.8 | 4.2 | 4.3 |
| DTL | 26.5 | 24.6 | 24.2 | 21.4 |
| TTL, total | 350.0 | 385.0 | 415.8 | 509.0 |
| Schottky | 112.0 | 162.5 | 200.0 | 301.0 |
| Standard | 238.0 | 222.5 | 215.8 | 208.0 |
| ECL | 36.0 | 43.0 | 49.0 | 72.0 |
| C-MOS | 161.0 | 182.0 | 209.0 | 315.5 |
| Microprocessor families, total | 152.8 | 234.0 | 319.9 | 776.6 |
| CPUs, total | 65.8 | 96.8 | 130.3 | 281.6 |
| MOS, total | 57.3 | 85.4 | 118.0 | 255.0 |
| 8-bit | 50.0 | 70.0 | 90.0 | 165.0 |
| 16-bit | 7.3 | 15.4 | 28.0 | 90.0 |
| Bipolar, total | 8.5 | 11.4 | 12.3 | 26.6 |
| Bit-slice | 6.4 | 7.0 | 7.6 | 9.6 |
| Full CPU | 2.1 | 4.4 | 4.7 | 17.0 |
| One-chip microcomputers | 19.0 | 32.0 | 51.0 | 94.0 |
| LSI peripheral chips | 68.0 | 105.2 | 138.6 | 401.0 |
| Dedicated LSI logic | 60.0 | 75.0 | 100.0 | 220.0 |
| Memories, total | 623.4 | 770.9 | 950.9 | 1,661.2 |
| Random-access, total | 375.4 | 449.5 | 540.3 | 918.7 |

| (millions of dollars) | 1977 | 1978 | 1979 | 1982 |
|---|---|---|---|---|
| Passive components, total | 34.0 | 37.6 | 41.2 | 47.8 |
| Waveguide | 8.0 | 8.6 | 9.2 | 11.3 |
| Coaxial and stripe-line | 26.0 | 29.0 | 32.0 | 36.5 |
| Switches, total | 9.5 | 10.2 | 10.9 | 13.4 |
| Waveguide | 3.0 | 3.2 | 3.4 | 4.2 |
| Coaxial and strip-line | 6.5 | 7.0 | 7.5 | 9.2 |
| Ferrite devices, total | 23.5 | 25.1 | 26.6 | 30.3 |
| Isolators | 6.5 | 7.5 | 8.6 | 10.7 |
| Circulators | 11.0 | 11.8 | 12.7 | 15.6 |
| YIG devices | 6.0 | 5.8 | 5.3 | 4.0 |
| Power limiters | 4.5 | 5.4 | 6.3 | 8.1 |
| **Readout devices, total** | **154.2** | **193.7** | **225.9** | **304.3** |
| Discrete, total | 44.2 | 47.3 | 51.0 | 48.3 |
| Gas-discharge | 3.0 | 2.4 | 1.9 | 1.6 |
| Incandescent | 4.2 | 4.5 | 4.8 | 5.9 |
| Fluorescent | 2.0 | 2.1 | 2.3 | 2.8 |
| Light-emitting diode | 35.0 | 38.3 | 42.0 | 38.0 |
| Multidigit, total | 110.0 | 146.4 | 174.9 | 256.0 |
| Gas-discharge | 38.5 | 51.0 | 59.5 | 89.5 |
| Segmented | 13.5 | 16.0 | 17.5 | 18.5 |
| Dot-matrix | 25.0 | 35.0 | 42.0 | 71.0 |
| Incandescent | 1.0 | 0.9 | 0.7 | 0.0 |
| Fluorescent | 2.2 | 3.7 | 4.3 | 4.6 |
| Electroluminescent | 2.3 | 3.1 | 4.2 | 5.9 |
| Light-emitting diode | 41.0 | 46.7 | 53.2 | 66.0 |
| Liquid-crystal | 25.0 | 41.0 | 53.0 | 90.0 |
| **Transducers, total** | **224.0** | **266.7** | **298.9** | **421.8** |
| Pressure | 121.0 | 140.0 | 162.0 | 250.0 |
| Temperature | 7.0 | 8.0 | 9.0 | 16.5 |
| Motion, linear | 25.0 | 30.3 | 31.8 | 37.0 |
| Motion, angular | 15.0 | 28.0 | 30.0 | 37.0 |
| Torque | 21.0 | 21.4 | 22.1 | 24.3 |
| Vibration | 35.0 | 39.0 | 44.0 | 57.0 |
| **Crystals, total** | **97.8** | **99.1** | **102.9** | **107.9** |
| Discrete crystals, total | 40.8 | 40.1 | 41.9 | 46.9 |
| Communications | 18.0 | 21.6 | 26.4 | 29.0 |
| Color TV | 2.3 | 2.7 | 2.8 | 3.1 |
| Watches | 16.0 | 11.0 | 7.6 | 8.7 |
| Filters | 4.5 | 4.8 | 5.1 | 6.1 |
| Assemblies (including mounts and ovens) | 57.0 | 59.0 | 61.0 | 61.0 |
| **Passive filters and networks, total** | **151.0** | **156.6** | **160.9** | **176.9** |
| LC filters | 40.0 | 40.8 | 41.6 | 43.7 |
| Electromechanical filters, total | 42.0 | 43.5 | 44.6 | 50.7 |
| Crystal | 32.5 | 32.5 | 33.0 | 36.0 |
| Ceramic | 7.0 | 8.0 | 8.3 | 10.4 |
| Other | 2.5 | 3.0 | 3.3 | 4.3 |
| Rfi and emi filters | 45.0 | 46.3 | 47.4 | 50.7 |
| RC networks | 11.0 | 12.0 | 13.0 | 16.5 |
| Delay lines | 13.0 | 14.0 | 14.3 | 15.3 |

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|---|---|---|---|---|
| **Hybrid and modular components, total** | **257.2** | **307.7** | **358.4** | **508.9** |
| Operational amplifiers | 17.6 | 20.0 | 22.0 | 30.0 |
| Instrumentation amplifiers | 2.5 | 3.0 | 3.5 | 6.0 |
| Isolation amplifiers | 1.7 | 2.0 | 2.5 | 4.5 |
| Data conversion, total | 56.0 | 71.4 | 83.0 | 127.5 |
| D-a converters | 26.5 | 33.0 | 37.0 | 53.0 |
| A-d converters | 23.0 | 29.4 | 34.0 | 51.0 |
| Multiplexers | 2.0 | 2.5 | 3.0 | 5.0 |
| Sample-and-holds | 3.0 | 4.0 | 5.0 | 7.0 |
| Converter subsystems | 1.5 | 2.5 | 4.0 | 11.5 |
| Data-acquisition boards | 3.4 | 7.5 | 10.6 | 14.5 |
| Functional circuits | 10.0 | 11.0 | 13.0 | 15.0 |
| Signal sources (including oscillators) | 2.0 | 2.4 | 2.6 | 3.4 |
| Active filters | 7.0 | 8.4 | 10.2 | 13.0 |
| Miscellaneous custom functions | 157.0 | 182.0 | 211.0 | 295.0 |
| **Connectors, total** | **671.5** | **767.7** | **834.4** | **1,150.5** |
| Coaxial, total | 70.0 | 75.0 | 79.5 | 99.0 |
| Standard size | 54.5 | 58.0 | 60.0 | 70.5 |
| Miniature | 15.5 | 17.0 | 19.5 | 28.5 |
| Cylindrical, total | 189.0 | 206.0 | 223.0 | 298.5 |
| Standard | 62.5 | 67.0 | 70.5 | 85.5 |
| Miniature | 79.5 | 85.5 | 90.0 | 114.0 |
| Subminiature | 47.0 | 54.0 | 62.5 | 99.0 |
| Rack-and-panel | 163.5 | 190.0 | 214.5 | 295.0 |
| Fused | 15.5 | 18.0 | 19.0 | 23.5 |
| Printed-circuit, total | 109.5 | 130.5 | 136.0 | 191.0 |
| Card-insertion | 80.0 | 96.0 | 100.0 | 129.0 |
| Two-piece, metal-to-metal | 29.5 | 34.5 | 36.0 | 62.0 |
| Flat-cable | 59.0 | 73.0 | 82.0 | 135.0 |
| Fiber-optic | 1.0 | 1.1 | 1.2 | 10.0 |
| Flexible-circuit | 4.0 | 4.6 | 5.2 | 6.0 |
| Special-purpose | 60.0 | 69.5 | 74.0 | 92.5 |
| **Printed circuits and interconnection systems, total** | **602.0** | **732.4** | **809.8** | **992.0** |
| Printed circuits, total | 470.0 | 569.5 | 606.0 | 715.0 |
| Rigid boards, total | 420.0 | 512.5 | 541.0 | 625.0 |
| Single-sided | 70.0 | 78.5 | 76.0 | 99.0 |
| Double-sided | 250.0 | 282.0 | 290.0 | 316.0 |
| Multilayer | 100.0 | 152.0 | 175.0 | 210.0 |
| Flexible circuits | 50.0 | 57.0 | 65.0 | 90.0 |
| Interconnections, total | 127.0 | 156.3 | 195.0 | 263.0 |
| Sockets and socket panels for DIPs | 55.0 | 68.8 | 86.0 | 123.0 |
| Backplanes | 72.0 | 87.5 | 109.0 | 140.0 |
| Prototyping boards | 5.0 | 6.6 | 8.8 | 14.0 |
| **Wire and cable, total** | **472.0** | **511.0** | **562.0** | **716.0** |
| Coaxial cable | 140.0 | 155.0 | 170.0 | 221.0 |
| Flat cable | 124.0 | 133.0 | 143.0 | 164.0 |
| Hook-up wire | 97.0 | 105.0 | 113.0 | 124.0 |
| Multiconductor, shielded | 64.0 | 60.0 | 57.0 | 63.0 |
| Multiconductor, unshielded | 37.0 | 38.0 | 39.0 | 44.0 |
| Fiber-optic cable | 10.0 | 20.0 | 40.0 | 100.0 |

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|---|---|---|---|---|
| Dynamic, total | 187.7 | 261.3 | 304.6 | 558.0 |
| p-MOS | 9.7 | 4.3 | 2.1 | 0.0 |
| n-MOS, total | 178.0 | 257.0 | 302.5 | 558.0 |
| 1-K | 18.0 | 20.0 | 15.0 | 2.0 |
| 4-K | 135.0 | 100.0 | 71.0 | 20.0 |
| 16-K | 25.0 | 137.0 | 209.5 | 286.0 |
| 64-K | 0.0 | 0.0 | 7.0 | 200.0 |
| Static, total | 127.3 | 188.2 | 235.7 | 360.7 |
| Bipolar | 57.0 | 76.0 | 89.5 | 130.0 |
| n-MOS | 53.3 | 87.7 | 114.7 | 183.7 |
| C-MOS | 17.0 | 24.5 | 31.5 | 47.0 |
| Read-only, total | 216.0 | 275.8 | 348.5 | 596.5 |
| Mask type (MOS) | 70.5 | 93.5 | 121.0 | 204.5 |
| Fusible-link (bipolar) | 74.5 | 81.3 | 90.0 | 122.0 |
| Erasable programmable type | 71.0 | 101.0 | 137.5 | 270.0 |
| Ultraviolet (E-PROM) | 65.0 | 92.0 | 122.5 | 230.0 |
| Electrical (EE-PROM) | 6.0 | 9.0 | 15.0 | 40.0 |
| CCDs | 4.0 | 12.7 | 19.0 | 40.3 |
| Magnetic-bubble devices | 4.3 | 12.2 | 25.4 | 91.0 |
| Shift registers | 23.7 | 20.7 | 17.7 | 14.7 |
| Linear ICs, total | 424.4 | 505.4 | 571.2 | 843.4 |
| Analog switches | 33.0 | 34.0 | 35.8 | 47.2 |
| Operational amplifiers | 90.0 | 103.0 | 110.0 | 146.0 |
| Instrumentation amplifiers | 3.0 | 4.5 | 6.0 | 14.0 |
| Comparators | 17.0 | 22.0 | 23.0 | 28.0 |

| | | | | |
|---|---|---|---|---|
| Voltage regulators | 35.0 | 45.5 | 52.0 | 73.0 |
| Timers | 37.0 | 42.0 | 48.0 | 65.0 |
| Other | 7.0 | 9.5 | 12.0 | 24.0 |
| Data conversion, total | 22.4 | 30.9 | 40.4 | 91.2 |
| D-a converters | 9.6 | 15.4 | 21.2 | 53.0 |
| A-d converters | 5.0 | 7.0 | 10.0 | 27.0 |
| Multiplexers | 4.4 | 4.8 | 5.2 | 6.2 |
| Sample-and-holds | 3.4 | 3.7 | 4.0 | 5.0 |
| Interface | 50.0 | 62.0 | 76.0 | 114.0 |
| Communications | 40.0 | 48.0 | 60.0 | 95.0 |
| Entertainment | 90.0 | 104.0 | 108.0 | 146.0 |
| Consumer product ICs, total | 157.5 | 191.5 | 216.0 | 283.0 |
| Calculator chips | 56.0 | 55.0 | 54.0 | 52.0 |
| Watch chips | 46.5 | 50.5 | 56.0 | 80.0 |
| Game chips | 32.0 | 46.0 | 52.0 | 83.0 |
| Other | 23.0 | 40.0 | 54.0 | 68.0 |
| **Optoelectronic devices, total** | **169.5** | **205.7** | **236.2** | **341.5** |
| Photovoltaic (solar) cells | 9.0 | 11.3 | 12.3 | 17.0 |
| Photoconductive cells | 6.0 | 7.4 | 8.5 | 11.5 |
| Light-emitting diodes | 100.0 | 120.0 | 140.0 | 200.0 |
| Laser diodes | 0.5 | 1.5 | 3.0 | 7.0 |
| Photodiodes (including arrays) | 5.0 | 7.5 | 8.4 | 11.0 |
| Phototransistors (including arrays) | 14.0 | 16.0 | 17.0 | 20.0 |
| Optically coupled isolators | 35.0 | 42.0 | 47.0 | 75.0 |

## INDUSTRIAL AND COMMERCIAL MARKETS

| (millions of dollars) | 1977 | 1978 | 1979 | 1982 |
|---|---|---|---|---|
| **INDUSTRIAL AND COMMERCIAL, TOTAL** | 30,084.7 | 35,048.0 | 41,037.6 | 59,908.2 |
| **Test, measuring, and analytical instruments, total** | 1,865.0 | 2,142.6 | 2,381.8 | 3,153.8 |
| **Test and measuring equipment, total** | 1,381.0 | 1,603.2 | 1,786.3 | 2,345.2 |
| Analog voltmeters, ammeters, multimeters | 18.0 | 17.8 | 17.3 | 16.9 |
| Digital multimeters, total | 67.5 | 74.6 | 83.0 | 102.2 |
| 3½-digit and below | 28.2 | 32.1 | 35.8 | 44.8 |
| 4½-digit and above | 39.3 | 42.5 | 47.2 | 57.4 |
| Multimeter accessories | 2.3 | 2.8 | 3.8 | 5.7 |
| Current probes | 0.7 | 1.0 | 1.4 | 2.1 |
| Temperature probes | 1.6 | 1.8 | 2.4 | 3.6 |
| Panel meters, total | 93.0 | 102.6 | 109.8 | 130.6 |
| Analog | 67.0 | 73.7 | 77.4 | 85.1 |
| Digital | 26.0 | 28.9 | 32.4 | 45.7 |
| Counters, time and frequency | 49.2 | 54.5 | 59.1 | 76.8 |
| Microprocessor-development systems | 70.0 | 93.0 | 110.0 | 155.0 |
| Logic analyzers | 25.0 | 32.5 | 45.0 | 82.5 |
| Logic probes | 2.0 | 2.1 | 2.2 | 2.5 |
| Word generators | 1.0 | 1.2 | 1.8 | 3.0 |
| Oscilloscopes, total | 192.5 | 210.5 | 230.3 | 277.3 |
| Non-plug-in | 116.0 | 125.9 | 136.6 | 174.5 |
| Plug-in main-frame only | 47.5 | 55.0 | 63.2 | 68.3 |
| Accessories and plug-ins | 29.0 | 29.6 | 30.5 | 34.5 |
| Network analyzers | 20.0 | 22.0 | 24.0 | 32.0 |
| Spectrum analyzers | 47.5 | 57.0 | 66.0 | 95.0 |
| Frequency synthesizers | 35.0 | 42.4 | 47.7 | 58.2 |
| Function generators | 23.5 | 26.5 | 31.0 | 39.5 |
| Signal generators | 54.6 | 60.8 | 66.5 | 84.2 |
| Sweep generators | 41.0 | 48.0 | 53.0 | 70.5 |
| Pulse generators | 13.0 | 14.5 | 16.0 | 21.2 |
| Oscillators | 14.0 | 15.8 | 17.7 | 20.5 |
| Waveform analyzers, distortion meters | 30.0 | 33.0 | 37.0 | 42.6 |
| Power meters, below microwave frequencies | 3.4 | 3.8 | 3.4 | 5.4 |
| Calibrators and standards, active and passive | 24.0 | 26.6 | 28.7 | 36.2 |
| Noise-measuring equipment, | 8.1 | 8.5 | 9.5 | 13.4 |
| Temperature-measuring instruments | 20.0 | 22.0 | 25.2 | 35.5 |
| Phase-measuring equipment | 23.0 | 25.0 | 28.2 | 36.2 |
| Field-intensity meters and test receivers | 7.0 | 8.0 | 9.1 | 11.4 |
| Antenna-pattern-measuring equipment | 5.0 | 5.0 | 5.0 | 6.0 |
| Amplifiers, total | 30.0 | 36.0 | 44.0 | 52.0 |
| Impedance bridges | 13.0 | 13.0 | 13.0 | 15.0 |
| Recorders and plotters, total | 148.0 | 164.5 | 177.5 | 220.8 |
| Strip- and circular-chart | 60.0 | 66.0 | 72.6 | 97.0 |
| X-Y | 20.0 | 24.5 | 25.5 | 32.5 |
| Magnetic-tape | 68.0 | 74.0 | 79.4 | 91.3 |
| IC testers, manual | 8.4 | 8.6 | 8.8 | 9.3 |
| IC testers, automatic | 94.4 | 114.8 | 120.8 | 194.4 |
| Component testers, manual | 21.0 | 22.0 | 20.0 | 19.0 |
| Component testers, automatic | 33.5 | 37.7 | 41.4 | 42.0 |
| Pc-board testers, total | 86.0 | 128.6 | 150.5 | 212.0 |
| Bare-board | 6.0 | 8.6 | 11.5 | 20.0 |
| Completed assemblies | 80.0 | 120.0 | 139.0 | 192.0 |
| IEEE-488 bus controllers | 30.0 | 37.5 | 46.9 | 78.8 |
| Microwave impedance-measuring equipment | 18.0 | 20.0 | 22.0 | 28.0 |
| Microwave-power-measuring equipment | 7.1 | 7.8 | 8.7 | 10.8 |
| Microwave wavemeters | 0.8 | 0.8 | 0.8 | 0.8 |
| Microwave modulators | 1.2 | 1.4 | 1.6 | 2.0 |
| Specialized test equipment | 538.0 | 624.4 | 725.0 | 1,167.0 |
| Automotive diagnostic equipment | 265.0 | 294.0 | 326.0 | 430.0 |
| Communications test equipment | 230.0 | 283.0 | 348.0 | 675.0 |
| Nuclear spectrometers | 24.0 | 26.4 | 29.0 | 36.0 |
| Radiation-detection and -monitoring, total | 19.0 | 21.0 | 22.0 | 26.0 |
| **Analytical instruments, total** | 484.0 | 539.4 | 595.5 | 808.6 |
| Chromatographs, total | 111.0 | 128.6 | 148.0 | 230.0 |
| Gas | 76.0 | 86.6 | 98.0 | 140.0 |
| Liquid | 35.0 | 42.0 | 50.0 | 90.0 |
| Spectrophotometers, total | 159.0 | 180.0 | 198.6 | 259.0 |
| Infrared | 30.0 | 33.0 | 36.3 | 43.0 |
| Ultraviolet-visible | 46.0 | 52.0 | 58.0 | 80.0 |
| Atomic absorption | 31.0 | 35.0 | 40.3 | 57.0 |
| Other | 52.0 | 60.0 | 64.0 | 79.0 |
| Mass spectrometers | 30.0 | 35.4 | 41.0 | 66.0 |
| Nuclear magnetic-resonance spectrometers | 18.0 | 19.1 | 20.2 | 23.0 |
| pH meters and ion-selective electrodes | 29.0 | 31.0 | 34.0 | 44.0 |
| Thermal analyzers, total | 15.0 | 16.3 | 17.7 | 22.6 |
| X-ray analysis | 42.0 | 45.0 | 48.0 | 62.0 |
| Other | 80.0 | 84.0 | 88.0 | 102.0 |
| **Lasers and related equipment, total** | 78.0 | 89.5 | 102.9 | 160.2 |
| Gas lasers | 27.0 | 32.0 | 38.1 | 71.4 |
| Semiconductor lasers | 5.0 | 6.0 | 7.0 | 10.0 |
| Other (ruby, neodymium-doped, etc.) | 22.0 | 23.0 | 24.6 | 30.0 |
| Laser power supplies | 17.0 | 20.0 | 23.0 | 32.0 |
| Modulators | 7.0 | 8.5 | 10.2 | 16.8 |

| (millions of dollars) | 1977 | 1978 | 1979 | 1982 |
|---|---|---|---|---|
| **Data-processing systems, peripherals, and office equipment, total** | 20,793.3 | 24,573.6 | 29,281.6 | 44,169.6 |
| System shipments, total | 8,035.0 | 9,842.5 | 12,303.0 | 19,620.0 |
| Desktop computers | 150.0 | 262.5 | 460.0 | 1,150.0 |
| Small (less than $100,000) | 2,655.0 | 3,800.0 | 5,320.0 | 9,800.0 |
| Medium (up to $1 million) | 2,730.0 | 3,030.0 | 3,360.0 | 4,470.0 |
| Large (greater than $1 million) | 2,500.0 | 2,750.0 | 3,163.0 | 4,200.0 |
| Micros and minis, total | 925.0 | 1,274.0 | 1,635.0 | 3,001.0 |
| OEM microcomputers | 355.0 | 476.0 | 637.0 | 1,274.0 |
| OEM minicomputers | 570.0 | 798.0 | 998.0 | 1,727.0 |
| Memory systems, total | 520.4 | 590.9 | 690.8 | 903.0 |
| Add-on systems | 300.0 | 338.0 | 396.0 | 528.0 |
| Core | 110.0 | 112.0 | 114.0 | 98.0 |
| Semiconductor | 190.0 | 226.0 | 282.0 | 430.0 |
| OEM systems | 220.4 | 252.9 | 294.8 | 375.0 |
| Core | 150.0 | 158.0 | 167.0 | 162.0 |
| Semiconductor | 70.0 | 94.0 | 126.0 | 208.0 |
| Magnetic-bubble | 0.4 | 0.9 | 1.8 | 5.0 |
| Data-storage devices, total | 2,218.8 | 2,492.6 | 2,785.5 | 3,463.0 |
| Disk pack | 750.0 | 728.0 | 735.0 | 540.0 |
| Fixed-disk | 450.0 | 608.0 | 760.0 | 1,155.0 |
| Combination fixed/cartridge disk | 350.0 | 385.0 | 400.0 | 440.0 |
| Flexible-disk | 120.0 | 168.0 | 227.0 | 443.0 |
| Reel-type magnetic-tape | 525.0 | 578.0 | 636.0 | 846.0 |
| Cassette magnetic-tape | 20.0 | 21.5 | 23.1 | 28.0 |
| Cartridge magnetic-tape | 3.8 | 4.1 | 4.4 | 11.0 |
| Input/output peripherals, total | 1,557.1 | 1,821.0 | 2,194.0 | 3,627.6 |
| Card-read/punch | 120.0 | 114.0 | 108.0 | 93.0 |
| High-speed line printers | 92.0 | 110.0 | 132.0 | 228.0 |
| Medium-speed printers | 450.0 | 560.0 | 700.0 | 1,368.0 |
| Low-speed serial printers, total | 280.0 | 352.0 | 446.0 | 605.0 |
| Impact | 220.0 | 282.0 | 361.0 | 469.0 |
| Nonimpact | 60.0 | 70.0 | 85.0 | 136.0 |
| Large nonimpact printers | 73.0 | 91.0 | 114.0 | 225.0 |
| Computer output microfilm | 140.0 | 161.0 | 185.0 | 280.0 |
| Optical character readers | 295.0 | 315.0 | 378.0 | 654.0 |
| Magnetic-ink character readers | 21.5 | 20.0 | 19.0 | 16.0 |
| Electromechanical plotters | 49.0 | 58.0 | 68.0 | 102.0 |
| Digitizers | 11.6 | 13.0 | 15.0 | 21.0 |
| Paper-tape devices | 25.0 | 27.0 | 29.0 | 35.0 |
| Key entry, total | 290.0 | 282.6 | 275.3 | 263.0 |
| Key punch | 125.0 | 119.0 | 113.0 | 100.0 |
| Key-to-tape | 20.0 | 18.6 | 17.3 | 14.0 |
| Key-to-disk | 67.0 | 72.0 | 77.0 | 94.0 |
| Keyboard-to-cassette/cartridge | 78.0 | 73.0 | 68.0 | 55.0 |
| Data terminals, total | 1,163.0 | 1,448.0 | 1,773.0 | 3,116.0 |
| Printing terminals | 115.0 | 126.0 | 139.0 | 153.0 |
| CRT terminals, total | 846.0 | 1,069.0 | 1,332.0 | 2,434.0 |
| Intelligent | 360.0 | 486.0 | 632.0 | 1,234.0 |
| Other | 486.0 | 583.0 | 700.0 | 1,200.0 |
| Graphics terminals, total | 178.0 | 228.0 | 276.0 | 489.0 |
| Storage and refresh | 160.0 | 192.0 | 230.0 | 397.0 |
| Raster-scan | 18.0 | 36.0 | 46.0 | 92.0 |
| Remote batch terminals | 24.0 | 25.0 | 26.0 | 40.0 |
| Source data-collection equipment, total | 975.0 | 1,092.0 | 1,238.0 | 1,884.0 |
| Point-of-sale systems, total | 328.0 | 368.0 | 414.0 | 597.0 |
| Electronic cash registers/terminals | 260.0 | 286.0 | 315.0 | 419.0 |
| Credit-authorization terminals | 42.0 | 51.0 | 62.0 | 104.0 |
| Electronic scales | 26.0 | 31.0 | 37.0 | 74.0 |
| Banking systems, total | 175.0 | 177.0 | 192.0 | 259.0 |
| Automated terminals, cash dispensers | 40.0 | 60.0 | 70.0 | 122.0 |
| Teller terminals | 135.0 | 117.0 | 122.0 | 137.0 |
| Industrial systems | 72.0 | 82.0 | 93.0 | 155.0 |
| Other specialized terminal | 400.0 | 465.0 | 539.0 | 873.0 |
| Office equipment, total | 5,109.0 | 5,730.0 | 6,387.0 | 8,292.0 |
| Nonconsumer calculators | 200.0 | 240.0 | 288.0 | 500.0 |
| Word processing | 800.0 | 1,000.0 | 1,200.0 | 1,830.0 |
| Dictation | 228.0 | 257.0 | 285.0 | 388.0 |
| Copying | 1,760.0 | 1,936.0 | 2,130.0 | 2,500.0 |
| Facsimile | 30.1 | 38.0 | 48.0 | 84.0 |
| Electronic typesetting | 225.0 | 245.0 | 267.0 | 350.0 |
| Accounting/bookkeeping | 1,236.0 | 1,327.0 | 1,420.0 | 1,740.0 |
| Printing/duplication | 630.0 | 687.0 | 749.0 | 900.0 |
| **Communications equipment, total** | 3,406.2 | 3,852.5 | 4,301.2 | 5,422.4 |
| Radio, total | 1,564.0 | 1,707.0 | 1,800.4 | 2,285.0 |
| Aviation mobile (including ground support) | 45.0 | 49.0 | 53.0 | 69.0 |
| Marine mobile (ship and shore stations) | 30.0 | 32.0 | 34.4 | 42.0 |
| Land mobile (mobile and base stations) | 739.0 | 883.0 | 958.0 | 1,356.0 |
| Amateur | 50.0 | 54.0 | 59.0 | 76.0 |
| Citizens' band | 375.0 | 330.0 | 297.0 | 216.0 |
| Microwave (complete system, incl. antennas) | 180.0 | 194.0 | 211.0 | 260.0 |
| Analog | 166.0 | 179.0 | 194.0 | 240.0 |
| Digital | 14.0 | 15.0 | 17.0 | 20.0 |
| Broadcast | 45.0 | 50.0 | 56.0 | 66.0 |

| (millions of dollars) | 1977 | 1978 | 1979 | 1982 |
|---|---|---|---|---|
| Satellite earth stations | 100.0 | 115.0 | 132.0 | 200.0 |
| Navigation systems | 147.0 | 154.0 | 162.0 | 178.0 |
| Telemetry (industrial only) | 37.0 | 46.0 | 64.0 | 83.0 |
| Voice switching system, total | 358.0 | 398.0 | 443.0 | 493.0 |
| Central office | 340.0 | 374.0 | 411.0 | 440.0 |
| PABX, total | 18.0 | 24.0 | 32.0 | 53.0 |
| Laser communications systems | 20.0 | 24.0 | 29.0 | 52.0 |
| Fiber-optic communications systems | 11.0 | 22.0 | 42.0 | 147.0 |
| Telephone-answering machines | 16.0 | 19.0 | 22.4 | 37.0 |
| Pocket pagers | 31.0 | 40.0 | 46.5 | 60.5 |
| Video recording units (nonconsumer) | 35.0 | 37.0 | 39.0 | 48.0 |
| Data-communications equipment, total | 865.0 | 1,042.0 | 1,244.0 | 1,520.0 |
| Modems, total | 165.0 | 177.0 | 189.0 | 233.0 |
| High-speed (2,400 b/s and over) | 70.0 | 77.0 | 82.0 | 101.0 |
| Low-speed (less than 2,400 b/s) | 95.0 | 100.0 | 107.0 | 132.0 |
| Multiplexers | 80.0 | 96.0 | 115.0 | 199.0 |
| Programmable concentrators | 68.0 | 88.0 | 114.0 | 150.0 |
| Front-end communications processors | 420.0 | 540.0 | 675.0 | 745.0 |
| Message-switching systems | 132.0 | 141.0 | 151.0 | 193.0 |
| Facsimile terminals | 97.0 | 113.5 | 132.0 | 187.0 |
| Television equipment | 225.2 | 250.0 | 276.9 | 331.9 |
| Broadcast equipment, total | 97.5 | 106.4 | 116.1 | 139.2 |
| Transmitters | 14.5 | 15.8 | 17.0 | 21.2 |
| Antennas | 12.0 | 14.0 | 16.4 | 23.0 |
| Cameras | 30.0 | 32.2 | 34.6 | 40.0 |
| Auxiliary equipment | 41.0 | 44.4 | 48.1 | 55.0 |
| CATV, total | 95.0 | 107.6 | 121.3 | 145.5 |
| Studio and head-end | 15.0 | 16.0 | 17.0 | 21.0 |
| Distribution | 30.0 | 36.6 | 45.0 | 60.0 |
| Transmission lines and fittings | 26.0 | 29.0 | 31.3 | 32.0 |
| Converters | 24.0 | 26.0 | 28.0 | 32.5 |
| CCTV, total | 32.7 | 36.0 | 39.5 | 47.2 |
| Cameras | 25.0 | 27.0 | 29.5 | 35.0 |
| Monitors | 7.7 | 9.0 | 10.0 | 12.2 |
| **Industrial electronic equipment, total** | **1,853.9** | **2,117.5** | **2,413.7** | **3,075.4** |
| Motor controls (speed, torque), | 166.0 | 175.0 | 187.0 | 210.0 |
| Numerical controls, total | 263.5 | 307.9 | 339.5 | 436.0 |
| Hard-wired | 40.0 | 40.0 | 41.0 | 11.0 |
| Direct | 4.0 | 5.7 | 7.0 | 10.0 |
| Computer-controlled | 91.5 | 107.2 | 114.0 | 190.0 |
| Microprocessor-controlled | 128.0 | 155.0 | 177.5 | 225.0 |
| Inspection systems, total | 46.0 | 51.5 | 57.4 | 67.7 |
| Ultrasonic | 14.4 | 16.0 | 17.8 | 19.4 |
| X-ray | 24.9 | 27.9 | 31.0 | 36.6 |
| Infrared | 4.9 | 5.5 | 6.2 | 8.7 |
| Ultraviolet | 1.8 | 2.1 | 2.4 | 3.0 |
| Thickness gages and controls, total | 101.8 | 113.2 | 123.5 | 156.0 |
| Photoelectric | 74.8 | 83.0 | 90.5 | 116.0 |
| Radiation-based | 27.0 | 30.2 | 33.0 | 40.0 |
| Data-acquisition systems, total | 503.6 | 598.0 | 722.0 | 930.0 |
| Continuous process | 176.2 | 205.0 | 258.0 | 360.0 |
| Discrete process | 327.4 | 393.0 | 464.0 | 570.0 |
| Process controllers | 70.0 | 80.5 | 91.8 | 110.0 |
| Process recorders and indicators | 80.0 | 85.5 | 97.5 | 116.0 |
| Sequence controllers, total | 82.7 | 109.0 | 122.0 | 182.0 |
| Programmable | 70.2 | 91.0 | 103.0 | 160.0 |
| Hard-wired | 12.5 | 18.0 | 19.0 | 22.0 |
| Ultrasonic cleaning | 11.3 | 12.9 | 14.4 | 18.0 |
| Pollution-monitoring equipment, total | 204.6 | 219.5 | 235.3 | 273.0 |
| Air | 119.7 | 131.7 | 144.9 | 165.0 |
| Water | 84.9 | 87.8 | 90.4 | 108.0 |
| Induction and dielectric heating and sealing | 50.0 | 55.0 | 60.5 | 76.0 |
| Welding controls | 12.5 | 15.7 | 19.0 | 26.0 |
| Process-control computer systems, total | 224.5 | 238.2 | 269.8 | 341.7 |
| Digital | 182.5 | 192.0 | 219.0 | 274.0 |
| Analog | 42.0 | 46.2 | 50.8 | 67.7 |
| Energy management equipment, total | 37.4 | 55.6 | 74.0 | 133.0 |
| Microprocessor-based | 12.0 | 16.0 | 21.0 | 38.0 |
| Minicomputer systems | 10.2 | 18.0 | 23.0 | 33.0 |
| Centralized | 15.2 | 21.6 | 30.0 | 62.0 |
| **Power supplies, total** | **390.0** | **434.4** | **480.1** | **674.0** |
| Encapsulated | 9.0 | 10.0 | 11.2 | 14.0 |
| Modular | 260.0 | 280.0 | 302.0 | 453.0 |
| Open-frame and card | 112.0 | 134.0 | 155.0 | 190.0 |
| Lab and bench | 9.0 | 10.4 | 11.9 | 17.0 |
| **Medical equipment, total** | **1,462.0** | **1,555.9** | **1,733.8** | **2,245.8** |
| Diagnostic, total | 803.0 | 773.4 | 877.5 | 1,131.1 |
| Tomographic X-ray | 300.0 | 200.0 | 220.0 | 286.0 |
| Other X-ray | 230.0 | 280.0 | 342.0 | 458.0 |
| Electroencephalographs | 13.0 | 14.0 | 15.0 | 18.0 |
| Electrocardiographs | 36.0 | 38.9 | 42.0 | 53.0 |
| Ultrasonic scanners | 60.0 | 64.8 | 70.0 | 87.0 |
| Automated blood analyzers | 90.0 | 97.2 | 105.0 | 132.0 |

| (millions of dollars) | 1977 | 1978 | 1979 | 1982 |
|---|---|---|---|---|
| Scintillation cameras and counters | 60.0 | 64.0 | 68.5 | 80.1 |
| Audiometers | 14.0 | 14.5 | 15.0 | 17.0 |
| Patient-monitoring systems | 135.0 | 158.0 | 164.0 | 184.0 |
| Prosthetic, total | 402.0 | 494.6 | 545.7 | 734.0 |
| Hearing aids | 127.0 | 134.6 | 142.7 | 170.0 |
| Pacemakers | 275.0 | 360.0 | 403.0 | 564.0 |
| Therapeutic, total | 84.5 | 88.2 | 100.1 | 131.0 |
| X-ray | 40.0 | 26.8 | 40.5 | 54.0 |
| Diathermy, shortwave and microwave | 8.5 | 9.4 | 10.4 | 12.5 |
| Ultrasonic generators | 11.0 | 12.0 | 13.2 | 16.5 |
| Defibrillators | 25.0 | 30.0 | 36.0 | 48.0 |
| Surgical support, total | 37.5 | 41.7 | 46.5 | 65.7 |
| Blood-flow meters | 9.0 | 10.0 | 11.1 | 13.0 |
| Blood-pressure monitors | 18.0 | 18.9 | 19.8 | 27.7 |
| Biomedical lasers | 10.5 | 12.8 | 15.6 | 25.0 |
| **Automotive electronics, total** | **237.0** | **282.0** | **343.0** | **807.0** |
| Voltage regulators | 22.0 | 22.0 | 23.0 | 25.0 |
| Emission-control systems | 70.0 | 102.0 | 150.0 | 245.0 |
| Electronic ignition systems | 112.0 | 115.0 | 117.0 | 127.0 |
| Fuel-injection systems | 15.0 | 23.0 | 29.0 | 50.0 |
| Fuel-metering systems | 12.0 | 13.0 | 14.0 | 220.0 |
| Safety systems | 6.0 | 7.0 | 10.0 | 140.0 |

| (millions of dollars) | 1977 | 1978 | 1979 | 1982 |
|---|---|---|---|---|
| **FEDERAL ELECTRONICS, TOTAL** | **16,638** | **18,210** | **19,920** | **24,460** |
| **Defense, total** | **14,963** | **16,487** | **18,086** | **22,258** |
| Procurement, total | 7,051 | 7,932 | 8,533 | 10,684 |
| Communications and intelligence | 1,205 | 1,317 | 1,356 | 1,697 |
| Aircraft, related ground equipment | 1,890 | 2,212 | 2,319 | 2,895 |
| Missiles and space systems | 2,310 | 2,541 | 2,857 | 3,478 |
| Mobile and ordnance | 436 | 471 | 538 | 683 |
| Ship and conversions | 1,210 | 1,391 | 1,663 | 1,831 |
| Research, development, test, and engineering | 4,945 | 5,440 | 6,283 | 7,732 |
| Operations and maintenance | 2,967 | 3,115 | 3,270 | 3,842 |
| **NASA, total** | **810** | **818** | **850** | **972** |
| **Transportation, total** | **405** | **421** | **454** | **582** |
| FAA procurement | 240 | 247 | 267 | 343 |
| FAA research and development | 100 | 111 | 121 | 165 |
| Highway and transit systems | 65 | 63 | 66 | 74 |
| **Health, Education, and Welfare, total** | **387** | **397** | **428** | **506** |
| Education systems | 107 | 111 | 112 | 125 |
| Health-care electronics | 280 | 286 | 316 | 381 |
| **Department of Energy, total** | **73** | **87** | **102** | **142** |

| | | | | |
|---|---|---|---|---|
| **CONSUMER ELECTRONICS, TOTAL*** | **12,135.0** | **14,030** | **15,393.6** | **21,402.2** |
| **Television receivers, total** | **4,031.5** | **4,465.8** | **4,197.0** | **5,186.2** |
| Black-and-white | 552.5 | 560.2 | 536.8 | 516.2 |
| Color | 3,479.0 | 3,905.6 | 3,660.2 | 4,670.0 |
| **Consumer audio equipment, total** | **3,664.5** | **3,879.2** | **4,141.6** | **5,073.0** |
| Radios, total | 972.0 | 907.0 | 978.0 | 1,110.0 |
| Table, clock, and portable radios, total | 572.0 | 475.0 | 520.0 | 565.0 |
| A-m only | 155.0 | 150.0 | 150.0 | 80.0 |
| A-m/fm | 417.0 | 325.0 | 370.0 | 485.0 |
| Automobile radios | 400.0 | 432.0 | 458.0 | 545.0 |
| Phonographs and radio-phonographs, total | 317.0 | 342.4 | 321.9 | 380.0 |
| Tape recorders and players, total | 969.0 | 1,056.8 | 1,145.7 | 1,350.0 |
| Automobile players | 307.0 | 319.0 | 350.0 | 410.0 |
| Cassette and cartridge player/recorders | 225.0 | 258.8 | 282.0 | 367.0 |
| Reel-to-reel players/recorders | 48.0 | 43.0 | 38.7 | 27.0 |
| Tape player/radio combination | 389.0 | 436.0 | 475.0 | 546.0 |
| Hi-fi audio components | 1,200.2 | 1,362.0 | 1,480.0 | 1,998.0 |
| Hi-fi audio consoles | 206.3 | 211.0 | 216.0 | 235.0 |
| **Other consumer electronics products, total** | **3,346.0** | **4,473.0** | **5,702.0** | **9,568.0** |
| Antennas, TV, and radio | 150.0 | 129.0 | 137.0 | 147.0 |
| Home video players/recorders | 141.0 | 301.0 | 442.0 | 960.0 |
| Home video cameras | 11.0 | 30.0 | 45.0 | 120.0 |
| Video projectors | 80.0 | 210.0 | 485.0 | 1,400.0 |
| Electronic organs, other instruments | 350.0 | 390.0 | 433.0 | 784.0 |
| Intrusion alarms | 166.0 | 204.0 | 255.0 | 446.0 |
| Electronic assembly kits | 75.0 | 84.0 | 92.0 | 122.0 |
| Microwave ovens | 800.0 | 1,200.0 | 1,500.0 | 2,250.0 |
| Smoke detectors | 60.0 | 71.0 | 85.0 | 149.0 |
| Telephone-answering devices | 20.0 | 25.0 | 35.0 | 100.0 |
| Electronic games | 400.0 | 617.0 | 840.0 | 1,515.0 |
| Calculators, hand-held | 643.0 | 655.0 | 665.0 | 678.0 |
| Electronic watches | 400.0 | 472.0 | 566.0 | 680.0 |
| Digital clocks | 40.0 | 64.0 | 88.0 | 152.0 |
| Home or personal computers | 10.0 | 21.0 | 34.0 | 65.0 |

*Includes domestic-made equipment, off-shore products sold under U. S. labels, and domestic- and foreign-label imports.

# EUROPEAN MARKETS

Like weary marathon runners slowing down as they agonize up a long, hilly stretch, the economies of Western Europe generally don't have what it takes to maintain the pace this year. Changed economic forces around the world are limiting growth in Western Europe despite a general desire to keep the output of goods and services on a strong upward climb.

One crucial change, of course, was the spurt in oil prices, now five times what they were five years ago. The end of cheap oil signaled the end of strong economic growth for Western Europe—it had averaged 5.5% during the high-flying late 1960s and early 1970s.

But oil was not all. Some traditional basic industries in Western Europe—particularly steelmakers, textile producers, and shipbuilders—ran into double trouble. As markets around the world went soft, they found themselves up against lethal new competition, mainly from Far Eastern countries. The resulting layoffs swelled European unemployment rolls, already at recession levels.

In easier times, governments could cope. They created jobs by channeling money into their economies. But now there is so much danger of excessive inflation—except in West Germany and Switzerland—that governments cannot chance it. What is needed, really, is a thoroughgoing restructuring of the West European economies—creating whole new industries to take up the slack of traditional ones condemned to falter, then perish.

But that will take several years, at least, if it can be done at all. Meanwhile, there is a worrisome pile of U. S. dollars overhanging the currency markets that are essential for world trade. Even more unsettling, potentially, is the underlying political situation, which is far from stable: in most West European countries, about half the people want to stick with the existing free-market economies and the other half want to extend the socialist philosophy.

It is easy to understand, then, why forecasters in Western Europe are not coming up with high growth numbers for the year ahead, whether their predictions are generated by sophisticated computer models or by hunch. But the foreground is much brighter than the background, so by and large they now think that the output of goods and services will expand a little more than it did in 1978, when the growth in real terms was under 3%. McGraw-Hill Inc. economists, for example, currently predict a 2.9% growth this year, just a shade better than last year's 2.7.%.

If the predictions hold, most of the credit will go to the front-running economy in Western Europe, West Germany, where the mild reflation program put together last year by Chancellor Helmut Schmidt's coalition government seems to have taken hold. "Confidence among industrialists is picking up and is combining with that of the consumers," says Manfred Beinder, chief economist at the ITT subsidiary Standard Elektrik Lorenz AG. That should be enough, West German economists think, to push growth to a respectable 4% this year. And when business does well in West Germany, the same can usually be said for its two small neighbors, Belgium and the Netherlands.

France, second in economic weight in West Europe, currently has about as much inflation as the country can stomach, so Premier Raymond Barre cannot push the economy too hard. Still, the Organization for Economic Cooperation and Development now says growth in France will run some 3.5% in 1979. Italy could match that growth rate, too. There will be lesser gains, presumably, in the United Kingdom, the Scandinavian countries, Spain, and Switzerland.

Business in general, then, should not be too bad this year despite the fundamental uncertainties for the long haul. And, as always, sales of electronics hardware will expand at a considerably faster pace than the economy overall. Nonetheless, the growth rate for equipment seems set to ease slightly and that for components to contract noticeably, according to *Electronics'* annual survey (p. 127).

The survey, carried out in 11 countries last fall, forecasts that equipment markets for 1979 will run some $37.01 billion. That is a rise of 10.9% over the figure for 1978, estimated at $33.38 billion. This year's growth will thus run the same as that logged last year. (For the survey, recipients were asked to estimate national markets for components and equipment in local currencies at current prices. These estimates were converted into dollars at the exchange rates in effect in late November 1978. No attempt has been made to adjust market prices for inflation, and for that reason the true rise is less than the figures indicated for most categories of products.)

Although integrated circuits seem set for a reasonable rise, components markets will not be as buoyant this year as they were last, the survey suggests. Sales of components for 1979 will add up to an estimated $8.74 billion, a 6.5% climb.

WEST EUROPEAN ELECTRONICS EQUIPMENT MARKETS
(Millions of U.S. dollars)

| | 1977 | 1978 | 1979 |
|---|---|---|---|
| West Germany | 9,488 | 10,313 | 11,348 |
| France | 6,249 | 7,120 | 8,066 |
| United Kingdom | 4,465 | 5,061 | 5,682 |
| Italy | 3,047 | 3,531 | 3,956 |
| Benelux | 2,389 | 2,546 | 2,739 |
| Scandinavia | 2,056 | 2,179 | 2,351 |
| Spain | 1,461 | 1,637 | 1,799 |
| Switzerland | 907 | 995 | 1,070 |
| Total | 30,062 | 33,382 | 37,011 |

# Running against the grain to take the sales lead

Computer makers continue to carry off their own particular economic miracle in Western Europe. Even when business falls in a country, they manage to keep their sales there on the rise. "The sector is anticyclic compared with the general economic cycle," is how Terrence Stones, director of planning at Honeywell Information Systems (UK) puts it. And when there is some growth in the country, they manage to exceed it as far as their own business goes.

A track record like that inevitably leads to the front of the pack, and that is exactly where computers and related electronic office equipment will wind up this year—by a good $820 million, according to *Electronics'* survey. Sales for this sector are projected at $12.94 billion, a solid 14.3% gain above the estimated $11.32 billion for 1978. To be sure, this growth rate runs a shade under the estimated 14.5% logged last year, but the difference is not worrisome. After all, a pace of 14% is not bad.

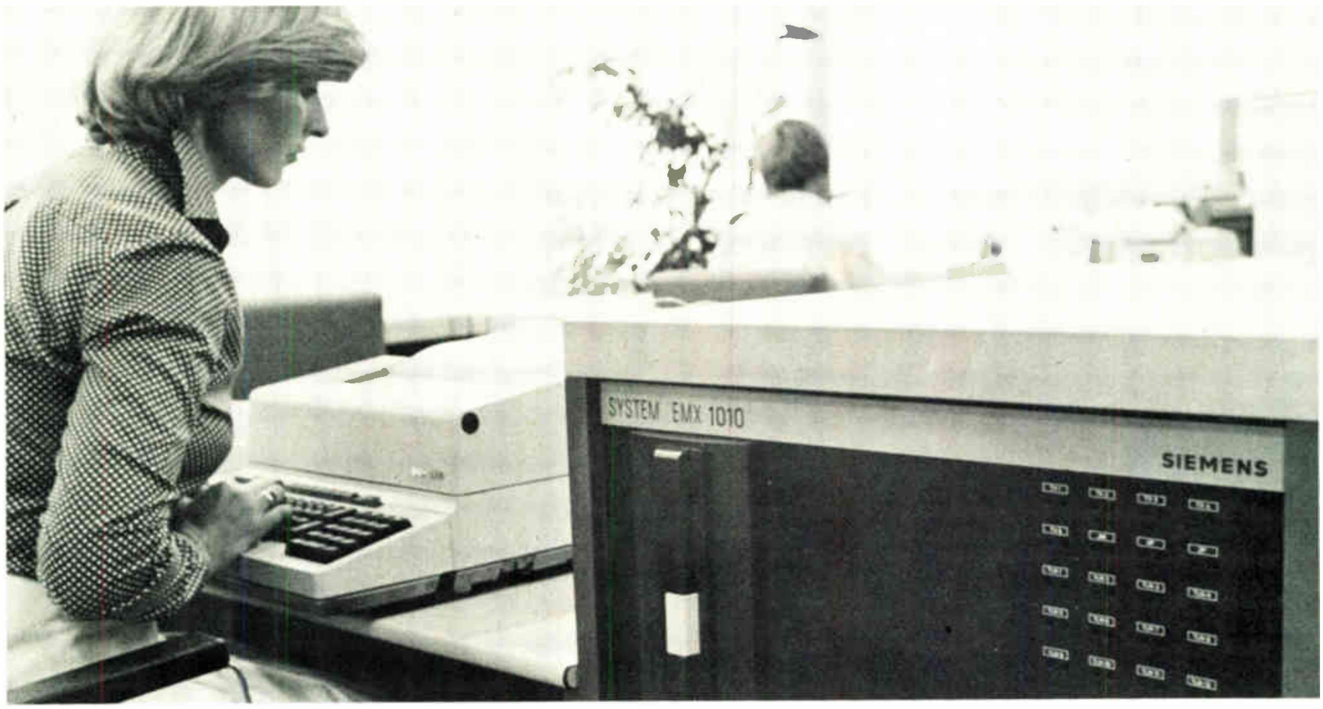
The big lift is coming from minicomputers, small systems, and terminals. Minicomputers—not counting original-equipment versions, which lose their identities when put in large systems—should soar 27.1% this year to some $1.22 billion, according to the chart. The percentage gains for small systems and terminals are less, but still considerable. The forecasts: a 19.0% jump upward to $2.00 billion for small systems and an 18.3% hike to $1.20 billion for terminals.

For some markets, the figures for minis and small systems will look low. "The rate in the Scandinavian countries is 30% or more," estimates Peter Bonne, marketing manager for Norsk Data AS, a fast-growing Norwegian computer and terminal maker. "Larger minis are nibbling at the lower end of the mainframe market," he contends.

The growth should stay high for some time. Per Jensen, sales manager for data systems for Philips Data Systems AS in Denmark, pegs the rate at better than 25% now. It will stay there for the next two or three years and then surge as small computers, their prices dropping some 10% to 15% a year, tap a new layer of customers. In much the same vein, Fulvia Sala, market research chief for Honeywell Information Systems Italia SpA, points out that there are some 30,000 manufacturing companies in Italy that have yet to buy a computer and 15,000 small commercial firms that rate as potential customers for minis as well.

The proliferation of small systems, however, does not signal the demise of large systems. "The minis are coming in alongside mainframes in distributed processing systems," notes Heiner Blässer, computer systems manager for Hewlett-Packard SA in Switzerland. And Jochen Rössner, a marketing specialist for Sperry Univac, the computer division of Sperry Rand GmbH in West Germany, maintains that a lot of large companies figure a giant can do the job better than a battalion of midgets. Siemens AG, too, has thumbs up for large computers; it is adding two new large-computer families to its hardware lineup.

The flurry in minicomputers and small systems has hit most Western European countries at about the same time. And since large-systems sales rebounded last year




**Moving.** Data communications and data terminals are two hot markets in Western Europe. Computers and related equipment will be worth almost $13 billion and communications $7 billion. Seen here is Telex electronic switching system EMX 1010 from Siemens AG.

as expected in West Germany, the growth rate among the major national markets is similar.

West Germany, of course, has the highest numbers for computers and electronic office equipment—$4.34 billion forecast for 1979, a hefty 15.5% above the estimated $3.75 billion for 1978. France, the UK, and Italy are much smaller markets, but they are not lagging terribly behind in growth. The UK, for example, will clock a 14.8% gain this year to reach $1.91 billion. Italy should move up almost as much—14.7%. As for France, computer markets there are forecast at $2.89 billion, for a gain of 12.5%.

## CONSUMER

# Color TV loses a step as market growth slips

Throughout Northern Europe, color television screens glow in millions of living room windows. But in many countries there are few windows left to light. The market for color television, the mainstay of consumer electronics, is growing at a slower and slower rate.

As a result, consumer electronics this year will lose its traditional place as the biggest money sector among West Europe's electronics industries. Last year, sales of consumer hardware ran $11.41 billion, according to *Electronics*' survey, roughly half a billion dollars better than the computer sector. But for the year ahead the consumer market is tagged for a modest 6.1% rise. At $12.11 billion, then, consumer electronics slips back to become number two.

**Good view.** Video cassette recorders like Grundig's SVR 4004 are expected to offset the slowing of color TV sales in northern European countries. However, the Japanese are also moving in on this market, which is estimated to reach $289 million this year.

Though its growth has slowed, color TV is still big business. The survey forecasts sales of $5.91 billion for 1979, compared with $5.56 billion for 1978. That works out to a 6.3% gain, but it is well below the near-10% rise that the chart shows for 1978, when the market caught fire largely because of the World Cup soccer matches transmitted by satellite from Argentina.

Hi-fi hardware, the second biggest market chunk, will slow, too, but not as noticeably as color TV. For hi-fi, the 1979 market is forecast at $1.58 billion, up 11.4% over last year's $1.42 billion; but last year's rise from $1.26 billion amounted to a 12.7% gain. Black-and-white TV sales will decline this year, continuing the trend. For radios, flat is the word overall.

There is no mystery about why the slowdown for color TV. Saturation has settled into the markets in West Germany, the United Kingdom, the Benelux countries, and Scandinavia. And this year there is no big sporting event to draw the dwindling number of first-set prospects into dealers' showrooms. What is more, replacements and second sets don't amount to much yet. "They won't have a real impact on the market until 1980 or so," judges Johanna von Ronai-Horvath, head of market research at West Germany's ITT Schaub-Lorenz.

It is not the same story elsewhere. France got off to a slow start in color television, and the market, far from being saturated, should continue on a strong uptick this year. The survey suggests sales of $986 million, up a respectable 13.5% over the $869 million for 1978.

Italy started even later than France—colorcasts did not start officially until 1976, although the market was actually launched a couple of years earlier by "pirate" transmissions from neighboring countries—and so the bloom is still on.

Inevitably, the southern countries will join their northern neighbors on the list of saturated color TV markets. Set makers in Western Europe then will have to put up with slow-growing markets heavily dependent on replacements and second sets. And second-set markets obviously have their drawbacks. People ordinarily opt for low-cost small-screen sets, so that less money funnels into the marketplace. And it is precisely in small-screen portables that the Japanese producers, now turning up in Western Europe in some force, are strongest.

So European set makers need a new product to tonic their markets. The first obvious candidate is the video tape recorder, or as market leaders Philips' Industries of the Netherlands and Grundig AG of West Germany would prefer, the video cassette recorders. Sales of VCRs this year will run close to $300 million, *Electronics* forecasts. To meet the demand, Grundig put a new plant in production last year and Philips is rushing completion on a $135 million facility in Austria to supply European markets. Also, Japanese suppliers, seeing solid market shares later on, have been shipping heavily to their

European outlets, especially in the UK.

Still, it is too early to judge the staying power of video tape machines after the almost-certain fast run-up in sight as the well-heeled Western Europeans acquire theirs. "The product is still not fully defined and its uses are not clear," says a top economist at Philips' central planning organization in Eindhoven.

## COMMUNICATIONS

### Up over 15%, market will be fastest growing

Business for communications equipment makers in Western Europe sometimes wanes as governments hold back on investments in telecommunications networks during national belt-tightening programs. But more often business waxes as the networks expand to keep abreast of demand for telephones and Telexes. At the same time, there is added push when the telecommunications operations add new services.

"Technology is leading to a merger of systems," says Cees Kok, marketing manager for Philips Telecommunicatie Industrie BV, headquartered at Hilversum, the Netherlands. "The telephone, Telex, copying, facsimile, and computer markets will integrate as the 'office of the future' evolves," he explains.

Although the office of the future will not be here this year, the extended services the networks are either offering or getting ready to offer account in part for the strong rise expected for communications hardware sales. And since the sector includes equipment that winds up in planes, tanks, and warships, it is doubly solid. The survey forecasts that the markets will run $7.23 billion this year, up from $6.26 billion last year. That is a jump of 15.6%, making communications the fastest growth sector on the chart.

For communications equipment in particular, the label "West Europe" signifies a collection of national markets, since the government agencies are normally patriotic purchasers. Thus the outlook varies considerably from country to country. This year again, the three largest countries will have the strongest markets. At the bottom end of the list come the Benelux countries, where the market will be flat, at best.

In West Germany, the Bundespost, which runs the phone network, will boost its total spending by 9% this year to $4 billion; a big chunk will go for electronic hardware. Most of the money is earmarked to improve conventional services like telephone and Telex, but some will go into new systems like cable TV, viewdata, and fiber-optic links. Then there is Telefax, which started with the new year. Private investments in communications gear, too, are on the rise. All told, then, the West German markets for communications gear are forecast to swell to $1.57 billion this year from a 1978 level of $1.31 billion.

There is a surge in store for French communications-hardware producers as well. The postal and telecommunications authority continues its drive to build up the phone network to 20 million lines by 1982, with a heavy accent on electronic switching. *Electronics*' survey shows an increase for semielectronic and electronic telephone exchange equipment—to $578 million this year from last year's $333 million. Carrier equipment, though, will drop off slightly from the estimated $302 million.

French defense-equipment suppliers like Thomson-CSF and Avions Marcel Dassault–Breguet Aviation SA have books bulging with export orders, and their home market is reasonably strong. Thus there is plenty of demand for radars, navigation aids, and radio equipment. Add this hardware to that destined for telecommunications uses and the total for the sector becomes $2.22 billion, a stunning 20.7% over the $1.84 billion that is estimated for 1978.

In the UK, too, communications equipment markets have a solid ring. Last year, they totaled $1.22 billion, according to the survey. They are forecast to move up 14.1% this year to $1.40 billion. The reasons for the rise are much the same as they are on the other side of the English Channel—heavy spending for semielectronic switching ($273 million, according to the survey, mostly for TXE-4 exchanges) and big exports of defense equipment. What is more, a spurt in private electronic switching systems seems to be in the making.

The end is nowhere in sight. There is Prestel, the telephone-television information service originally called Viewdata, coming along. And the British Post Office has its renewal program, too—12 million lines of stronger step-by-step exchanges to replace by 1995, many of them by an integrated digital telephone network. The first contracts for System-2, as the post office calls the digital network, reportedly will be let this year. They will presumably cover the first two exchanges, which the BPO wants to cut over by 1981.

## TEST AND MEASUREMENT

### Three-year sprint expands new markets

"I have the feeling that the growth rate for test and measurement instruments will be roughly the same in 1979 as in 1978 for Western Europe," says Ab de Boer, director of Philips' Science and Industry division in Eindhoven, the Netherlands. The feeling is generally shared among those in the business surveyed by *Electronics*. The forecast: sales this year of just under $900 million, up 10% over the estimated $817 million for 1978. That will be just a wee bit more growth this year than the 9.7% logged last year and will make it three good years in a row for the instrument markets.

There is no argument either over where the growth is coming from. Even though private investment levels are low and test equipment budgets pared to the minimum, product innovation is propelling the market upward.

For instance, there is a strong rise in data domain instruments, spawned by new needs of equipment designers who put microprocessors into their hardware. Sales of digital logic probes, analyzers, and like instruments will spurt almost 25% this year, the survey indicates. But some market watchers feel that estimate is not enough. "Data domain instruments are going up at least 50% a year," maintains Peter Kohl, instruments marketing manager for Hewlett-Packard SA, Switzerland. Whatever the rate, the market looks so attractive that Philips, which has developed a batch of these instruments for in-house use, plans to start putting them on the open market this year.

Automatic test equipment will bound up again this year, too. The survey pegs the rise to $91.5 million, 23.5% over the 1978 figure. The reason is obvious: testing has become so complex and so costly that powerful computer-based systems are the only answer.

## COMPONENTS

### *Running in step during a lull*

Except perhaps for biorhythm addicts, no group watches its cycles as closely as components makers. And these companies all know that at the moment the cycle looks overripe, particularly for semiconductors. But the woes that components makers traditionally suffer when the cyclic curves top out and start down probably will not be as severe as before, because the high overcapacity that made the declines so precipitous in earlier cycles so far has not manifested itself. And longish delivery lead times add a measure of comfort.

These sentiments are reflected in the survey results, which predict components markets totaling $8.74 billion in the 11-country region this year, up from $8.21 billion.

**MARKET REPORT EXCHANGE RATES**
(The rates below were used to convert European currencies to U.S. dollars)

Belgium: 30.5 francs/dollar
Denmark: 5.30 kroner/dollar
France: 4.50 francs/dollar
Italy: 855 lire/dollar
Netherlands: 2.10 guilders/dollar
Norway: 5.10 kroner/dollar
Spain: 72 pesetas/dollar
Sweden: 4.40 kroner/dollar
Switzerland: 1.75 francs/dollar
United Kingdom: 51 pence/dollar 1 pound = $1.95)
West Germany: 1.95 marks/dollar

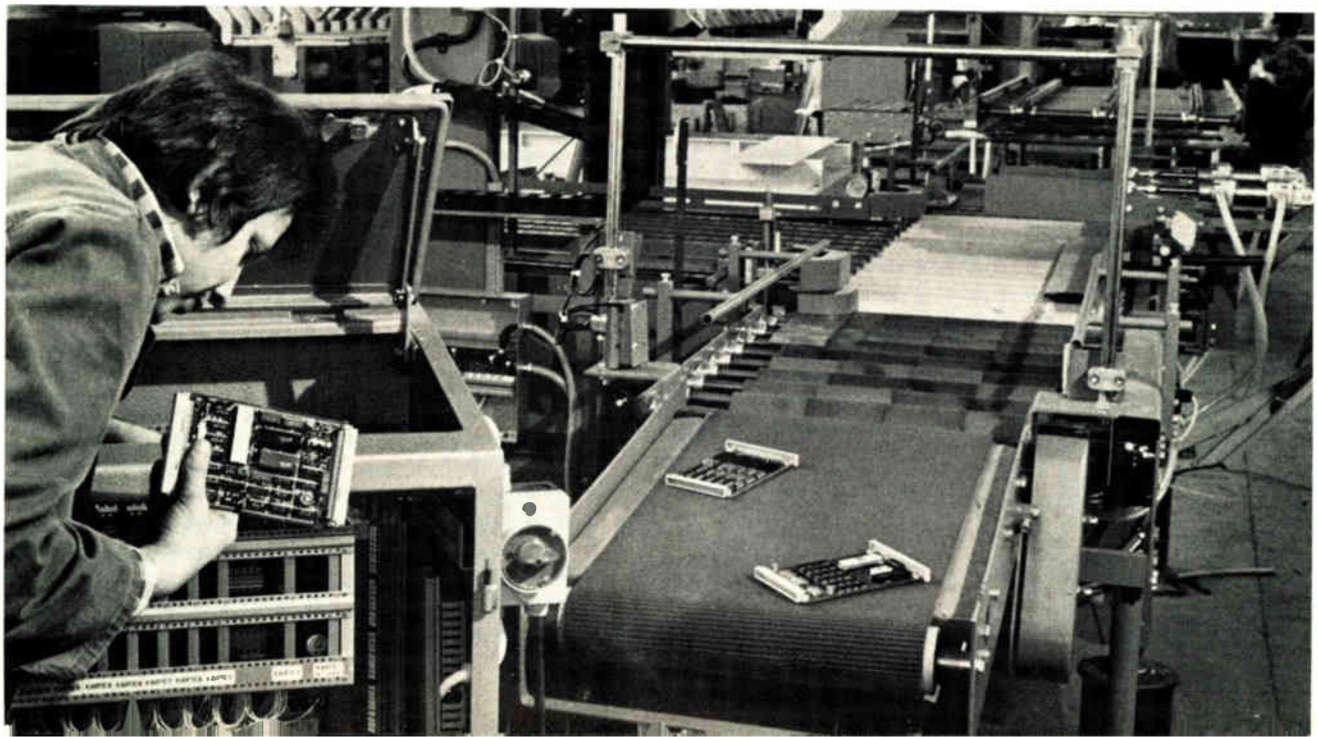
That is a 6.5% increase—adequate at best but well under the 8.6% rise that was logged last year over 1977's total of $7.6 billion.

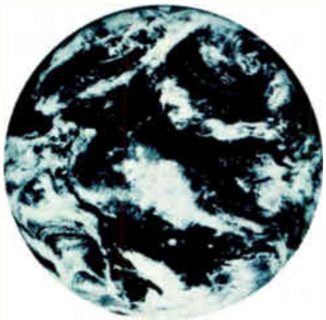
There are no particular surprises in the components chart. Sales of integrated circuits will set the pace in growth among the big-money categories. But it will not be an exceptionally fast pace. Integrated circuits are pegged at $1.32 billion for 1979, compared with an estimated $1.18 billion for 1978. That works out to a rise of just under 12%, well off last year's 16%. As expected, microprocessors and memories will outstrip linear ICs and logic circuits for growth, but not match them in sheer money volume.

Discrete devices figure to stay in the doldrums. Therefore, for semiconductors overall the growth figures become even less impressive: a modest 8.3% rise to $2.45 billion.

As for passive components and electromechanical parts, they still outsell semiconductors and tubes together. Forecast at $4.45 billion this year, they account for slightly better than half the components markets in West Europe. □

**Automation.** Microprocessors are gaining a larger and larger role in process-control equipment and machinery. Here, SMP80 microcomputers from Siemens are being installed in bottling and filling equipment at a large West German beverage machinery maker.





# JAPANESE MARKETS

## CONSUMER

No sumo wrestler could have as formidable a battle as Japan has had in grappling with its economic foes—slow growth, yen-to-dollar value fluctuations, and falling exports. Determined to meet its promise of a 7% gain in Gross National Product in 1978, the Japanese government threw itself into the contest with economic stimulators, but at year's end was having little success in moving the big, listless economy. To some it appeared that Japan Inc., the team of industry and government that gave the country a red-hot growth streak in the 1960s and early 1970s, was losing its grip.

This year could bring a return bout, particularly if the important American export market loses steam in the second and third quarters. A lot depends on ifs—if exports revive, if the currency settles down to a realistic value somewhere between ¥200 and ¥220 to the U. S. dollar, if the government's recovery program succeeds, and if domestic demand increases. But the 7% Gross National Product growth will not be reached even with the change in leadership from Takeo Fukuda to Masayoshi Ohira.

Japanese economists point out that the country has entered a new era economically, especially since the oil crisis, and that it is therefore necessary for the island nation to realign its industry. However, this notion may take a long time to be realized.

On the brighter side, Japan's electronics markets look better than the general economy. The *Electronics* survey (p. 127) projects a growth of nearly 15% for equipment consumption this year, slightly better than the percentage last year. The total for 1979 is $23.4 billion, though that figure is of course much inflated by the decline of the dollar in the last 12 months. (The exchange rate used in this report and in the table is ¥200 = $1.) But the concern over exports continues. The manufacturers may not know the worst until the next quarter, when they close their fiscal year and absorb the cumulative effects of the ups and downs of the yen during the fourth quarter of 1978.

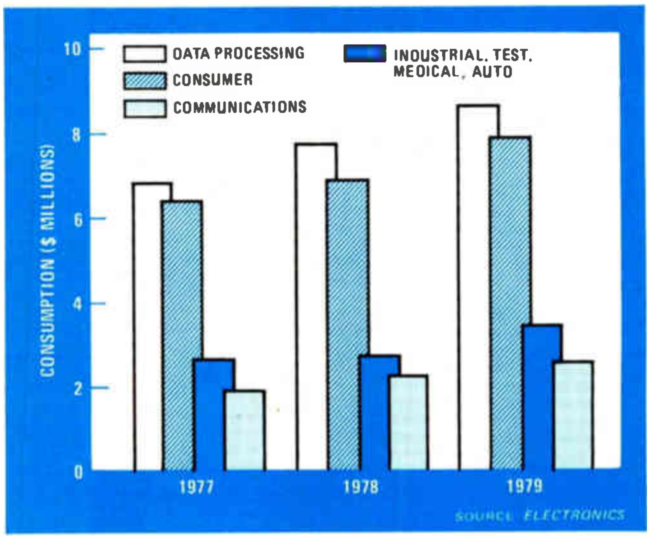
In the major domestic market segments (see graph), purchase of data-processing equipment, including office machines, will grow by 17.5% this year in dollar terms, surpassing the once-dominant consumer electronics sector. Consumer products, suffering perhaps most of all from a combination of domestic blahs and overseas market constriction, should edge up on the home front by 12.7%. Communications is expected to gain 9.5%, modest for this category; industrial, an excellent 23%. Dollar volume will increase by 7.5% for test instruments.

In the components categories, consumption of integrated circuits has swept further ahead of discretes, as expected. This year, according to *Electronics*' survey, consumption of ICs will be worth $1.66 billion, and sales of discretes will total $1.16 billion, for an overall semiconductor total of $2.8 billion. That means that the percentage of growth for ICs this year is estimated at 18%, while discretes will pick up by only 4%. Passive components will also register a 4% growth. The total in this category will be $4.2 billion.

### *Multiplex TV, hi-fi prop up unsteady markets*

Japan's consumer electronics companies, it seems, always find something to keep up their hopes and their domestic sales. Last year it was home video tape recorders (called video cassette recorders in the U. S.). This year it is multiplexed television broadcasting, which brings the home TV either stereo or bilingual sound (one language on each of two audio channels when fitted with adapters, tuners, and extra speakers). Also in the offing are additional fm broadcasting stations that promise to encourage hi-fi audio sales.

Otherwise, the Japanese makers have little to cheer about this year. With household saturation well past 90%, color TV sales are bumping along at over 5 million units per year—5.4 to 5.5 million in 1978, 5.5 to 5.8 million units this year—and are expected to hit 6 million only in 1980. Replacement sales are probably a little ahead of second- and third-set sales, although the small sets (those with screens measuring 14 in. or less diagon-




**Where the yen is.** With total electronic equipment sales of $23.4 billion this year, Japan's electronics industries are expecting a 15% gain, led by the data processing and office equipment sector. Dollar values were computed at ¥200 = $1, the rate at publication.

**VTR to the rescue.** Consumer electronics companies are depending on rapid growth of video equipment, such as these VHS units being produced by Matsushita, to help relieve the saturated color TV market. Domestic VTR sales are expected to be $1 billion.

ally) are still well ahead in percentage of units sold.

Set makers are continuing a year-old trend of putting premium features such as microprocessor-based tuning systems into new models in order to boost their price. As a result, the dollar value of color TV sets sold this year will increase almost 5% to $2.5 billion, despite flat unit sales. Multiplexed TV, broadcast on a limited basis since October, fits right into this trend. The set makers plan to cash in on it by building multiplexed sound into 18-in. and 20-in. color receivers and pricing them at $1,160 to $1,270. And both they and hi-fi audio marketers will be selling adapters and tuners priced at $175 and up to $530, respectively, for retrofitting present sets.

In 1981, the Electronic Industries Association of Japan predicts, the multiplexed feature will be found on over half (3.78 million) of the 6.3 million TV sets it expects to be sold. For this year, it predicts sales of 1.2 million such sets, and for 1980, 2.4 million.

At home, the video recorder market is still growing. The good news is that producers managed to avoid a domestic price war by following the same tactic as in TV receivers—stuffing in features such as programmable timers to push up prices. The bad news is that sales have fallen short of expectations in the important U.S. market. At the beginning of 1978, the EIA-J predicted there would be 1.4 million VTRs produced in Japan, 500,000 for domestic consumption and the rest for export. But apparently actual domestic sales were about 450,000 units last year and should climb to only 750,000 to 800,000 units this year, somewhat under the 1 million originally projeted for 1979. Total household saturation at the end of 1978 was only between 2% and 3%; this year it should be at about 7%, pushing to 10% next year.

All of the VTR makers have now introduced home color cameras that should begin to move this year. Estimates of sales for this year range from 10,000 units up to 50,000 units, indicating uncertainty about how well the color cameras will go over.

Hi-fi audio products, which took an unheard of dip in sales last year, should stage a mild recovery in 1979. Even in the worst of past economic times stereo sales have been vigorous, but with total saturation of stereo equipment approaching 60%, some slowing of growth was expected. Recently, though, the youthful buyers who are the stereo market's foundation have become less dependable. Moreover, the 15-to-24 age group in Japan has shrunk by 20% since 1970, though it should pick up again.

So the equipment makers are appealing to a different market—the 30-to-39 age group that is more interested in lower-cost easy-to-operate systems than are the audiophiles in the youth market. All the manufacturers have introduced small components: Pioneer Electronic Corp. brought out its Mini Component line, for example, and Matsushita Electric Industrial Co. its Concise line. Also, most of the companies have introduced in Japan tuner, amplifier, and deck combinations common in the U.S., again to appeal to this older buying group that does not go for the complexity, space requirements, and higher costs of separate components.

Besides multiplexed TV broadcasting and the sales it means for some audio manufacturers, more fm stereo stations are due to start broadcasting, which should also encourage equipment sales. Overall, hi-fi component sales this year should approach $1 billion, according to the *Electronics*' survey.

As for other consumer products, the outlook is mixed. Microwave range sales have been stalled at about 1 million units. There were 900,000 sold last year, and 1 million to 1.5 million should move this year.

The market for extra-thin calculators and calculator-clock combinations has been rolling along at a 10-million-unit level domestically. The watch market, on the other hand, has done a complete flip-flop in the last year: low-price pressure is now a factor in digital watches, which was not the case a year ago. Moreover, another newcomer, Sanyo Electric Co., has now entered the market, which the established watch companies have had pretty much to themselves. And Timex has reentered the Japanese market with a line of digital models. Other newcomers are likely to appear this year, some armed with low-priced units made in Hong Kong. Although the liquid-crystal digital models are creeping up on the quartz-crystal analogs, the latter still hold about a four-to-one numerical advantage: quartz-crystal sales, analog and digital, account for some 90% of all men's watches and 70% of women's watches.

## COMPONENTS

# One-chip microprocessors pace big IC advance

Integrated circuits gave a big boost to the semiconductor market last year, while as usual widening their sales lead over discrete circuits. Future growth in discretes appears to be confined to power devices, including rectifiers for new microprocessor systems and devices not easily incorporated into ICs.

Overall, *Electronics*' market survey shows that IC consumption in Japan increased by almost 20% in 1978 and is forecast to grow by about 18% this year. The biggest jump in 1978 was in microprocessors, which increased by a whopping 74%, led by 4-bit one-chippers for consumer electronics. New last year were single-chip microprocessors with on-chip analog-to-digital converters. For instrument and industrial applications, however, the 8-bit 8080 and its derivatives continue to head the list. Growth will subside to somewhat less than 30% this year because there are fewer new applications. Next year, though, could see another big jump as Japanese car manufacturers adopt microcomputers for a variety of uses including engine fuel-management systems and dashboard controls.

Consumption of metal-oxide-semiconductor memories, for use with both microcomputers and mainframes, was up over 37% last year and will run about 30% this year to over $214 million. Introduced this year will be 16-kilobit dynamic memories operating from a single 5-volt supply and also high-speed 4-K static memories like the 2147.

In programmable memories, 2708-type 8-K devices lead the field, though this year 2716-type 16-K devices should begin to have an impact. Leader in the 2716 type is now Toshiba Corp., but Nippon Electric Co., Hitachi Ltd., and others, including U. S. companies, will challenge its position this year.

Last year marked the start of demand for charge-coupled-device and bubble memories, although applications tend to be specialized. Bubble memories, for example, are used by Nippon Telegraph and Telephone Public Corp. in telephone exchanges but not in time-shared computer systems. Consumption this year will still be under $10 million for each of these categories but serious growth is expected in a few years.

In other ICs, calculator chip sets, once the star of large-scale integration, are still growing to $128.8 million but have been passed in value and growth rate by both microprocessors and memories. Coming up strong behind the calculators are watch chips, which grew by 31% last year and promise to run up by 16% this year to over $71 million.

As for logic circuits, demand for general-purpose bipolar devices is both larger and growing faster than for complementary-MOS, although C-MOS consumption increased more than 10% last year and will increase even more this year. New applications of bipolar logic are mainly in low-power Schottky. Also increasing, although usage is smaller, are sales of 4-bit-slice microprocessors.

Quantity demand for discrete devices is growing somewhat faster than dollar figures indicate, because prices are falling. The total consumption estimated for 1979 of $1.16 billion is just 4% ahead of last year.

Big guns in the tube department are picture tubes for TV and data terminals, microwave cooker magnetrons, and camera tubes. High-resolution color tubes that can display 80 or more characters per line used in data terminals are helping the picture tube makers boost sales while the color TV market has been in the doldrums. But CCD and MOS sensors should greatly erode the rapidly growing market for vidicons in the home video-camera market in the next few years. And various types of field-effect-transistor devices, both junction and MOS types, will have an impact on power tubes. New high-voltage bipolar power transistors recently announced by Mitsubishi Electric Corp. may also enter.

## COMPUTERS

# *Japanese battle each other awaiting IBM's next blow*

The domestic growth rate in computer consumption has definitely slowed—in part because of saturation, in part because of the stale state of the economy, and in part because many users are waiting for IBM to introduce its so-called E series of mainframes. Dollar gains for computer systems will be 11.5% this year, compared with 10.9% last year. However, the data-processing and office equipment sector as a whole will move up over 17.5% to $9.2 billion.

As usual, the Ministry of International Trade and Industry is playing a role in computer development. Even as the VLSI joint research project is running its course, MITI has requested funds to sponsor continued efforts by the five Japanese companies involved, this time to develop software and peripherals. Software, the manufacturers admit, may be the hardest task the Japanese have had to tackle in their race to match American programming know-how.

Meanwhile, changes are occurring in the market. Although the companies, Fujitsu Ltd., Hitachi Ltd., Nippon Electric Co., Mitsubishi Electric Corp., and Toshiba Corp., were able to cooperate to some extent on the development of their current lines, they are competing against each other in marketing as vigorously as they are against the Americans. For example, after Fujitsu introduced the large-scale M-200 series, its partner and ardent competitor Hitachi came out with its own version, the M-200H. NEC and Toshiba, formed Nippon-Toshiba Information Systems as a joint venture, yet NEC continues to compete against NTIS in the marketing of its ACOS series.

Another sign of the changes is that all the domestic makers are now openly reducing their use of Japan Electronic Computer Co., the joint computer-financing organization, and setting up their own rental plans. When Hitachi first announced it was pulling out of JECC a couple of years ago, the other members were reluctant to go along. But now Fujitsu has cut JECC financing to about half of its rental program, or less than 18% of its total business. NEC uses JECC only when a customer demands it, and then only for ACOS leases; Mitsubishi, too, finances only its high-end machines through JECC. Hitachi, meanwhile, has almost completely pulled out.

As in the U. S., the market in small-business machines is growing thanks both to new users and to present users' adding machines to branch facilities. Another solid growth area is electronic cash registers. Although the number of competitors has been increasing, NCR Japan Ltd., the NCR Corp. subsidiary, still has the largest dollar share of market because of its dominance in higher-priced machines. However, domestic companies are beginning to take over the low-end ($300–$400) markets.

## COMMUNICATIONS

### *Electronic exchanges keeping phone lines busy*

For some years now, Japan has been preparing for volume use of data communications, as evidenced by the annual consumption figures. This year, for example, electronic telephone exchanges, data-communications equipment, and facsimile equipment will move up hand in hand in the communications market. Domestic purchases of public electronic exchanges will climb from $292.5 million to $337.5 million, data-communications equipment from $162.5 million to $181.5 million, and facsimile terminals from $202.9 million to $250.6 million, according to *Electronics*' consensus.

Last year was the first that semiconductor memories were used across the board in Nippon Telegraph and Telephone Public Corp. electronic exchanges. Use of the memory made these exchanges competitive with small crossbar exchanges for the first time, rather than only large ones. Continuing a multiyear program, NTT purchases will be heavily weighted in favor of electronic exchanges, with crossbar exchanges used mainly to expand existing installations.

In the five years extending through 1982, most step-by-step exchanges will be torn out and replaced by electronic exchanges, as will some crossbar toll exchanges. Altogether, some 800 electronic exchanges will be installed, for both new business and replacement of step-by-step, providing a steady income for the telephone company's favored family of suppliers.

This March the D50 exchange will go into service on the DDX, or digital data exchange network; it is similar to the D10, but with time-division switching facilities added. Packet switching will also be added at the end of June.

The markets chart shows that facsimile terminal consumption increased by almost 26% last year and should show a similar increase this year. Unit sales will increase by several times that amount, though, as prices fall. Facsimile is made to order for the written language in Japan, so that continued rapid growth is assured.

## INSTRUMENTS

### *Revaluation changes rules of price-cutting contest*

Marketing test equipment became a whole new ball game last year as Yokagawa-Hewlett-Packard Ltd. cut most prices by 30%, Sony Tektronix Corp. cut prices up to about 20% on its competitive products, and John Fluke Manufacturing Co. pushed inexpensive digital multimeters. All of this price action by the Americans was courtesy of the falling U. S. dollar, which won them an artificial price advantage in Japan.

Many Japanese manufacturers either redesigned or were in the process of redesigning their instrument lines last year to meet this American challenge. Thus, the increase in the percentage of units sold exceeded the 7.5% increase in sales dollars last year. A slightly smaller gain is forecast for this year.

Although still a small market, digital logic analyzers registered the biggest sales increase. A better than 30% rise last year will be followed by a similar one this year. Microcomputer development systems, till now the preserve of semiconductor manufacturers, will be another new business for instrument manufacturers.

Recorders, which are being attached to more and more test systems, rose almost 13% in 1978 and promise to climb by 15% this year. On the face of it, oscilloscopes would look like another natural for growth: more are being used for computer and microprocessor servicing; higher-frequency models are being developed for designing with higher-speed logic families; and more digital readouts are being added. But prices have come down, damping growth to 7.4% last year and about the same this year. Several companies report that they have greatly reduced their business in special test systems because it did not pay. Yet automated test systems are proliferating.

## INDUSTRIAL

### *Better than expected, thanks to machine-tool controls*

Considering the dull state of Japan's heavy industries, the industrial sector had a better than expected growth of 12% in dollar terms last year, with 23% expected for this year. But the rise was due mainly to a 75% spurt in microprocessor-based machine-tool controls. This year, machine-tool controls should again lead the way with a 43% gain in consumption.

The large process-control market was in the doldrums with a modest 5% gain last year and 6% forecast for this year. There are few new industrial capital investment projects in Japan now and perhaps 50% to 60% of sales is to replace present controls.

Among the few exceptions are storage and distribution systems for oil and petroleum products. Hokushin Ltd., for example, has installed a computer-based system for a gasoline distributor.

With the change in customers, controls manufacturers have changed their philosophy. Until recently they tried to make deluxe instruments regardless of cost, and quality was perhaps excessive. Now, like the test equipment producers, they will redesign to cut costs while maintaining the best features. The outlook, therefore, may not be completely bleak even with the more expensive yen. □

# JAPAN/EUROPE MARKETS FORECAST 1979

| | JAPAN | | | WEST EUROPE | | |
|---|---|---|---|---|---|---|
| | 1977 | 1978 | 1979 | 1977 | 1978 | 1979 |
| **COMPONENTS, TOTAL (millions of dollars)** | **7,189.6** | **7,833.1** | **8,403.9** | **7,555.1** | **8,207.0** | **8,737.1** |
| **PASSIVE AND ELECTROMECHANICAL** | **3,801.0** | **4,021.0** | **4,199.6** | **3,895.6** | **4,178.8** | **4,447.9** |
| Capacitors, fixed | 886.7 | 890.4 | 841.0 | 829.2 | 874.0 | 920.9 |
| Capacitors, variable | 59.6 | 60.4 | 60.3 | 55.9 | 58.4 | 59.5 |
| Connectors, plugs, and sockets | 170.5 | 176.2 | 184.4 | 524.8 | 581.2 | 642.1 |
| Filters, networks, and delay lines | — | — | — | 84.5 | 90.8 | 95.7 |
| Loudspeakers, OEM type | 276.3 | 288.4 | 307.6 | 185.3 | 201.1 | 217.2 |
| Microphones, OEM type | 64.0 | 64.0 | 29.8 | 45.4 | 49.3 | 50.6 |
| Microwave components | — | — | — | — | — | — |
| Potentiometers, composition | 290.0 | 312.1 | 324.8 | 190.1 | 184.1 | 188.0 |
| Potentiometers, wirewound | 17.4 | 17.9 | 18.4 | 57.1 | 56.0 | 56.3 |
| Printed-circuit boards | 360.0 | 413.0 | 465.0 | 483.1 | 545.3 | 599.7 |
| Quartz crystals (including mounts and ovens) | 84.0 | 77.6 | 67.2 | 88.3 | 96.6 | 103.8 |
| Relays (for communications and electronics) | 250.0 | 300.0 | 375.0 | 337.0 | 366.3 | 382.7 |
| Resistors, fixed (including wirewound) | 249.2 | 252.3 | 250.3 | 291.3 | 290.3 | 293.9 |
| Resistors, nonlinear | — | — | — | 40.5 | 44.8 | 47.1 |
| Servos, synchros, and resolvers | 11.0 | 12.5 | 12.5 | 52.2 | 58.0 | 67.0 |
| Switches (for communications and electronics) | 269.5 | 288.0 | 308.0 | 235.7 | 258.5 | 271.3 |
| Transducers (pressure, strain, temperature, etc.) | 16.3 | 19.0 | 23.7 | — | — | — |
| Transformers, chokes, coils, TV yokes, and flybacks) | 796.5 | 849.2 | 931.6 | 393.4 | 424.1 | 452.1 |
| **SEMICONDUCTORS, DISCRETE, TOTAL** | **1,048.3** | **1,118.6** | **1,164.9** | **940.9** | **975.5** | **1,008.6** |
| Microwave diodes, all types (above 1 GHz) | 11.0 | 13.1 | 14.3 | 20.7 | 21.9 | 24.0 |
| Rectifiers and rectifier assemblies | 221.9 | 245.5 | 258.5 | 183.0 | 191.7 | 203.0 |
| Signal diodes (rated less than 100 mA, including arrays) | 122.1 | 128.8 | 125.4 | 84.3 | 86.9 | 87.5 |
| Thyristors (SCRs, four-layer diodes, etc.) | 76.8 | 89.6 | 99.0 | 110.0 | 113.8 | 120.1 |
| Transistors, bipolar power (more than 1-W dissipation) | 234.7 | 244.5 | 263.1 | 178.7 | 188.7 | 198.5 |
| Transistors, bipolar small signal (including duals) | 305.8 | 300.5 | 288.1 | 263.7 | 265.4 | 264.4 |
| Transistors, field-effect (power and small-signal) | 28.1 | 40.5 | 51.5 | 22.1 | 25.0 | 27.2 |
| Tuner varactor diodes | 18.8 | 23.5 | 29.0 | 28.9 | 29.6 | 29.8 |
| Zener diodes | 29.1 | 32.6 | 36.0 | 49.5 | 52.5 | 54.1 |
| **SEMICONDUCTORS, INTEGRATED CIRCUITS, TOTAL** | **1,175.0** | **1,409.4** | **1,660.1** | **1,018.8** | **1,183.2** | **1,324.0** |
| Hybrid ICs, all types | 102.9 | 114.4 | 128.5 | 103.6 | 116.9 | 129.0 |
| Linear ICs (except op amps) | 260.7 | 275.5 | 316.0 | 238.0 | 260.4 | 283.0 |
| Op amps (monolithic only) | 39.4 | 44.5 | 55.0 | 49.9 | 56.7 | 61.8 |
| Logic circuits, bipolar | 165.1 | 191.6 | 219.0 | 211.1 | 228.8 | 240.4 |
| Logic circuits, MOS and C-MOS | 112.0 | 124.1 | 140.2 | 166.9 | 198.2 | 223.6 |
| Memory circuits, bipolar | 27.1 | 31.6 | 39.6 | 37.8 | 44.2 | 50.1 |
| Memory circuits, CCD | 1.3 | 3.0 | 9.0 | — | — | — |
| Memory circuits, magnetic-bubble | — | 3.0 | 9.0 | — | — | — |
| Memory circuits, MOS and C-MOS (except microprocessors) | 119.6 | 164.8 | 214.8 | 130.9 | 165.5 | 193.5 |
| Microprocessors (includes CPU, memory, and I/O chips) | 70.2 | 122.4 | 157.2 | 41.8 | 67.2 | 91.1 |
| Calculator chip sets | 150.3 | 119.6 | 128.8 | 8.2 | 8.7 | 9.1 |
| Watch and clock chip sets | 46.6 | 61.3 | 71.2 | 20.5 | 23.8 | 26.8 |
| Other special-purpose circuits | 124.8 | 153.0 | 171.8 | 10.1 | 12.8 | 15.6 |
| **SEMICONDUCTORS, OPTOELECTRONIC, TOTAL** | **179.9** | **218.6** | **260.3** | **92.3** | **106.2** | **119.3** |
| Circuit elements (photoconductive cells, photodiodes, etc.) | 25.8 | 28.2 | 33.6 | 30.8 | 34.5 | 37.0 |
| Discrete light-emitting diodes | 49.4 | 65.5 | 77.5 | 22.3 | 25.0 | 28.0 |
| Readouts | 103.8 | 123.6 | 141.2 | 36.4 | 43.2 | 50.1 |
| Photovoltaic (solar) cells | 0.9 | 1.3 | 2.0 | 2.8 | 3.5 | 4.2 |
| **TUBES, TOTAL** | **985.4** | **1,065.5** | **1,119.0** | **1,607.5** | **1,763.3** | **1,837.3** |
| Cathode-ray tubes (except for TV) | 11.7 | 13.3 | 14.8 | 43.2 | 48.9 | 54.4 |
| Camera tubes and image intensifiers | 36.5 | 38.3 | 45.2 | 39.9 | 44.3 | 47.4 |
| Photomultiplier tubes | 13.0 | 9.0 | 9.3 | 25.0 | 27.1 | 29.1 |
| Power tubes (below 1 GHz), vacuum, total | 29.2 | 29.5 | 28.0 | 45.0 | 48.5 | 51.2 |
| Power tubes (below 1 GHz), gas or vapor | 5.5 | 5.5 | 5.0 | 52.6 | 56.5 | 61.2 |
| Microwave tubes, total | 13.5 | 14.5 | 15.0 | 109.9 | 118.6 | 129.8 |
| Cooker magnetrons | 54.8 | 55.0 | 65.0 | — | — | — |
| Receiving tubes | 7.5 | 8.5 | 7.0 | 60.9 | 54.8 | 48.2 |
| TV picture tubes, black-and-white | 75.3 | 83.1 | 88.4 | 85.2 | 81.3 | 73.9 |
| TV picture tubes, color | 738.4 | 808.8 | 841.3 | 1,145.8 | 1,283.3 | 1,342.1 |
| **EQUIPMENT, TOTAL (millions of dollars)** | **17,877.2** | **20,342.3** | **23,388.0** | **30,062.4** | **33,381.7** | **37,010.6** |
| **CONSUMER, TOTAL** | **6,430.0** | **7,112.8** | **8,019.1** | **10,558.3** | **11,412.8** | **12,111.4** |
| Audio tape recorders and players | 485.9 | 507.8 | 528.8 | 622.7 | 668.4 | 669.5 |
| Citizens' band transceivers | 9.7 | 9.4 | 11.8 | 138.2 | 144.4 | 150.7 |
| Electronic ranges (microwave ovens) | 297.6 | 292.9 | 311.4 | — | — | — |
| Hi-fi equipment | 892.3 | 889.2 | 948.5 | 1,257.1 | 1,416.3 | 1,577.6 |
| Musical instruments (organs, electric guitars, etc.) | 403.3 | 404.7 | 433.8 | — | — | — |
| Phonographs and phono radio combinations | 162.6 | 155.6 | 155.3 | 452.0 | 472.3 | 479.7 |
| Pocket calculators (four-function, personal) | 257.6 | 277.7 | 253.8 | 260.4 | 237.9 | 240.8 |
| Radios (including car radios) | 220.6 | 223.7 | 226.4 | 1,109.4 | 1,135.0 | 1,143.6 |
| Radio/recorder combinations | 488.3 | 594.9 | 531.1 | 565.3 | 602.1 | 634.7 |
| Radio/TV/recorder combinations | 72.5 | 70.7 | 76.7 | — | — | — |
| TV sets, black-and-white | 119.4 | 129.4 | 136.9 | 792.9 | 767.6 | 717.8 |
| TV sets, color | 2,209.1 | 2,388.3 | 2,504.3 | 5,056.8 | 5,562.6 | 5,911.7 |
| Video games | 10.0 | 10.0 | 10.0 | 27.9 | 43.5 | 59.8 |
| Video tape machines (consumer) | 351.1 | 608.5 | 1,089.3 | 79.9 | 163.4 | 289.1 |
| Watches and clocks, electronic | 450.0 | 550.0 | 800.0 | 155.7 | 199.3 | 236.4 |

| | JAPAN | | | WEST EUROPE | | |
|---|---|---|---|---|---|---|
| | 1977 | 1978 | 1979 | 1977 | 1978 | 1979 |
| **COMMUNICATIONS, TOTAL** | **2,004.2** | **2,342.9** | **2,566.5** | **5,480.4** | **6,256.2** | **7,230.0** |
| Broadcast | 77.8 | 87.3 | 98.0 | 177.2 | 194.4 | 208.0 |
| Cable TV | 17.5 | 93.7 | 101.1 | 39.5 | 43.3 | 46.8 |
| Closed-circuit TV | 63.2 | 76.2 | 89.2 | 163.7 | 175.9 | 195.7 |
| Data communications | 137.0 | 162.5 | 181.5 | 140.5 | 165.9 | 203.5 |
| Facsimile terminals | 161.6 | 202.9 | 250.6 | — | — | — |
| Fiber-optic communications | 1.8 | 2.8 | 6.3 | — | — | — |
| Intercoms and systems | 39.7 | 46.8 | 54.3 | 146.9 | 158.7 | 174.2 |
| Microwave relay | 145.0 | 155.0 | 160.0 | 208.4 | 240.7 | 249.0 |
| Navigation aids, except radar | 53.7 | 59.0 | 61.2 | 501.4 | 537.3 | 610.1 |
| Paging (public and private) | 20.0 | 22.0 | 25.0 | 28.3 | 35.8 | 35.7 |
| Radar (airborne, ground, and marine) | 123.0 | 131.7 | 140.5 | 850.8 | 920.7 | 992.5 |
| Radio communications (except broadcast) | 376.3 | 348.5 | 334.3 | 1,123.9 | 1,250.5 | 1,385.8 |
| Telephone switching, PABX[1] | 16.9 | 28.0 | 38.8 | 258.4 | 320.5 | 449.8 |
| Telephone switching, public[1] | 264.0 | 292.5 | 337.5 | 709.5 | 1,099.6 | 1,529.4 |
| Telephone and telegraph carrier | 480.0 | 603.8 | 652.4 | 1,131.9 | 1,112.9 | 1,154.5 |
| Video recorders and players (nonconsumer) | 26.7 | 30.2 | 35.8 | — | — | — |
| **COMPUTERS AND RELATED EQUIPMENT, TOTAL** | **6,766.2** | **7,869.1** | **9,248.5** | **9,886.0** | **11,320.1** | **12,935.0** |
| Data-processing systems, total[2] | 3,808.7 | 4,225.0 | 4,711.7 | 5,622.0 | 6,344.4 | 7,258.0 |
| Microcomputers (basic chassis value less than $1,500) | 100.0 | 112.5 | 137.5 | 28.9 | 40.3 | 60.0 |
| Mini (system value less than $50,000) | 238.0 | 328.3 | 330.2 | 784.7 | 959.8 | 1,219.8 |
| Small (up to $420,000) | 549.2 | 635.6 | 749.3 | 1,409.6 | 1,679.0 | 1,998.8 |
| Medium (up to $1,680,000) | 980.0 | 1,080.0 | 1,176.7 | 1,804.4 | 1,955.4 | 2,135.1 |
| Large (up to $3,360,000) | 1,187.0 | 1,287.0 | 1,437.1 | 1,135.9 | 1,219.1 | 1,313.7 |
| Giant (more than $3,360,000) | 754.5 | 781.6 | 880.9 | 458.5 | 490.8 | 530.6 |
| Add-on memories | 185.0 | 205.0 | 225.0 | 69.7 | 77.8 | 86.5 |
| Data acquisition | 93.3 | 117.8 | 149.3 | 157.2 | 172.9 | 185.5 |
| Data entry/output | 302.5 | 422.8 | 474.9 | 795.3 | 886.9 | 985.5 |
| Data storage | 1,047.5 | 1,225.0 | 1,367.5 | — | — | — |
| Data terminals | 616.7 | 751.5 | 1,204.3 | 808.6 | 1,014.7 | 1,200.5 |
| Electronic office equipment | 732.5 | 830.0 | 1,010.0 | 2,253.7 | 2,610.9 | 2,977.6 |
| Billing and accounting machines | 87.5 | 90.0 | 100.0 | 802.2 | 900.2 | 1,010.0 |
| Calculators, office type | 75.0 | 80.0 | 85.0 | 399.6 | 488.7 | 472.7 |
| Calculators, scientific type | 45.0 | 60.0 | 75.0 | 173.7 | 210.8 | 251.0 |
| Copying machines | 525.0 | 600.0 | 750.0 | 674.0 | 800.4 | 933.4 |
| Dictating machines | — | — | — | 60.3 | 64.6 | 67.3 |
| Word processing | — | — | — | 143.9 | 186.2 | 243.2 |
| Point-of-sale | 80.0 | 92.0 | 105.8 | 179.5 | 212.5 | 241.4 |
| **INDUSTRIAL, TOTAL** | **1,227.3** | **1,377.7** | **1,695.3** | **1,876.0** | **1,973.7** | **2,153.2** |
| Inspection and gauging equipment (X-ray, infrared) | 50.0 | 55.0 | 65.0 | 48.8 | 54.1 | 58.5 |
| Machine-tool controls | 100.0 | 175.0 | 250.0 | 131.9 | 147.9 | 171.6 |
| Motor controls | 180.0 | 185.0 | 187.5 | 73.9 | 76.4 | 79.0 |
| Photoelectric controls | — | — | — | 36.4 | 39.9 | 43.2 |
| Pollution monitoring | 107.9 | 117.0 | 129.5 | 30.1 | 31.8 | 25.5 |
| Process-control systems | 659.0 | 692.7 | 735.0 | 1,472.7 | 1,540.5 | 1,687.3 |
| Ultrasonic cleaning and inspection | 130.4 | 153.0 | 328.3 | 30.1 | 30.9 | 33.0 |
| Welding (with electronic controls) | — | — | — | 52.1 | 52.2 | 55.1 |
| **MEDICAL, TOTAL** | **547.5** | **615.7** | **682.0** | **1,234.1** | **1,300.9** | **1,360.2** |
| Diagnostic equipment (except X-ray) | 105.2 | 129.6 | 151.1 | 253.7 | 274.1 | 286.8 |
| Patient-monitoring | 39.6 | 47.9 | 56.5 | 112.0 | 125.8 | 138.3 |
| Prosthetic | 31.7 | 35.9 | 40.9 | 105.8 | 114.7 | 122.0 |
| Surgical support | 18.3 | 20.0 | 21.7 | — | — | — |
| Therapeutic (except X-ray) | 22.7 | 25.0 | 26.8 | 62.7 | 67.1 | 73.1 |
| X-ray equipment, diagnostic and therapeutic | 330.0 | 357.5 | 385.0 | 699.9 | 719.2 | 740.0 |
| **POWER SUPPLIES, TOTAL** | **107.3** | **128.5** | **158.8** | **281.3** | **298.9** | **319.6** |
| Bench and lab | 25.0 | 35.0 | 45.0 | 28.3 | 31.2 | 33.6 |
| Industrial heavy-duty | 21.3 | 23.0 | 25.8 | 90.8 | 96.4 | 103.6 |
| OEM and modular | 61.0 | 70.5 | 88.0 | 162.2 | 171.3 | 182.4 |
| **ANALYTIC INSTRUMENTS, RESEARCH OR CLINICAL, TOTAL** | **386.2** | **440.9** | **517.1** | — | — | — |
| **TEST AND MEASUREMENT, TOTAL** | **309.5** | **332.7** | **340.6** | **744.7** | **817.0** | **898.8** |
| Amplifiers, lab type | 8.6 | 9.5 | 10.4 | 11.1 | 11.5 | 12.2 |
| Analog voltmeters, ammeters, and multimeters | 35.0 | 36.0 | 37.4 | 51.2 | 54.8 | 57.6 |
| Automatic test equipment (IC, component, and board) | 22.0 | 24.1 | 27.0 | 61.4 | 74.1 | 91.5 |
| Calibrators and standards, active and passive | 10.0 | 10.3 | 10.8 | 14.8 | 15.5 | 16.5 |
| Counters and timers | 16.3 | 17.8 | 19.4 | 42.4 | 46.2 | 49.8 |
| Digital logic analyzers | 3.3 | 4.3 | 5.7 | 19.8 | 24.9 | 31.0 |
| Digital multimeters | 13.9 | 15.1 | 17.2 | 40.1 | 43.4 | 46.9 |
| Microwave test instruments | 7.2 | 7.4 | 7.6 | 63.5 | 69.0 | 76.0 |
| Oscillators | 22.8 | 24.0 | 17.8 | 22.1 | 23.6 | 24.3 |
| Oscilloscopes and accessories | 56.9 | 61.1 | 65.6 | 132.5 | 144.4 | 158.4 |
| Panel meters | 34.6 | 36.1 | 37.1 | 93.7 | 101.9 | 109.3 |
| Phase-measuring equipment | 2.4 | 2.7 | 3.1 | — | — | — |
| Power meters | 2.8 | 3.1 | 5.8 | 2.7 | 3.4 | 3.7 |
| Recorders | 28.6 | 32.3 | 37.1 | 89.4 | 95.3 | 102.1 |
| Signal generators, analog | 22.7 | 24.2 | 26.1 | 42.5 | 45.2 | 48.7 |
| Signal generators, synthesizer | 7.0 | 7.4 | 7.8 | 20.9 | 24.0 | 26.6 |
| Spectrum analyzers (audio to 1 GHz) | 12.9 | 14.5 | 1.6 | 36.6 | 39.8 | 44.2 |
| **AUTOMOTIVE, TOTAL** | **99.0** | **121.7** | **160.1** | — | — | — |

[1]Electronic or semielectronic. [2]Includes stand-alone minicomputers but not computers that are integral parts of process-control and similar systems. — No estimate available.

Figures in this chart are based on inputs obtained from an 11-country survey made by *Electronics* in September and October 1978. They show consensus estimates for consumption of components, valued at factory prices, used to produce equipment for both domestic and export markets and for consumption of electronic equipment, with domestic hardware valued at factory sales price and imports at landed cost.

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**Static Read Only Memories.**

| | |
|---|---|
| SY4600 | 2048x8 or 4096x4, 550nsec |
| SY2316A | 2048x8, 550nsec |
| SY2316B | 2048x8, 450nsec (2716 compatible) |
| SY2316B-3 | 2048x8, 300nsec (2716 compatible) |
| SY2332 | 4096x8, 450nsec (2716 compatible) |
| SY2364 | 8192x8, 450nsec, 24 pin |

**Synertek, Inc.**

# 64-pin QUIP keeps microprocessor chips cool and accessible

Three-part design has low thermal resistance; readily removable chip-carrier has exposed contacts to ease testing

by William Lattin and Terry Mathiasen
*Intel Corp. Aloha, Ore.*
and Steven Grovender
*Minnesota Mining and Manufacturing Co., St. Paul, Minn.*

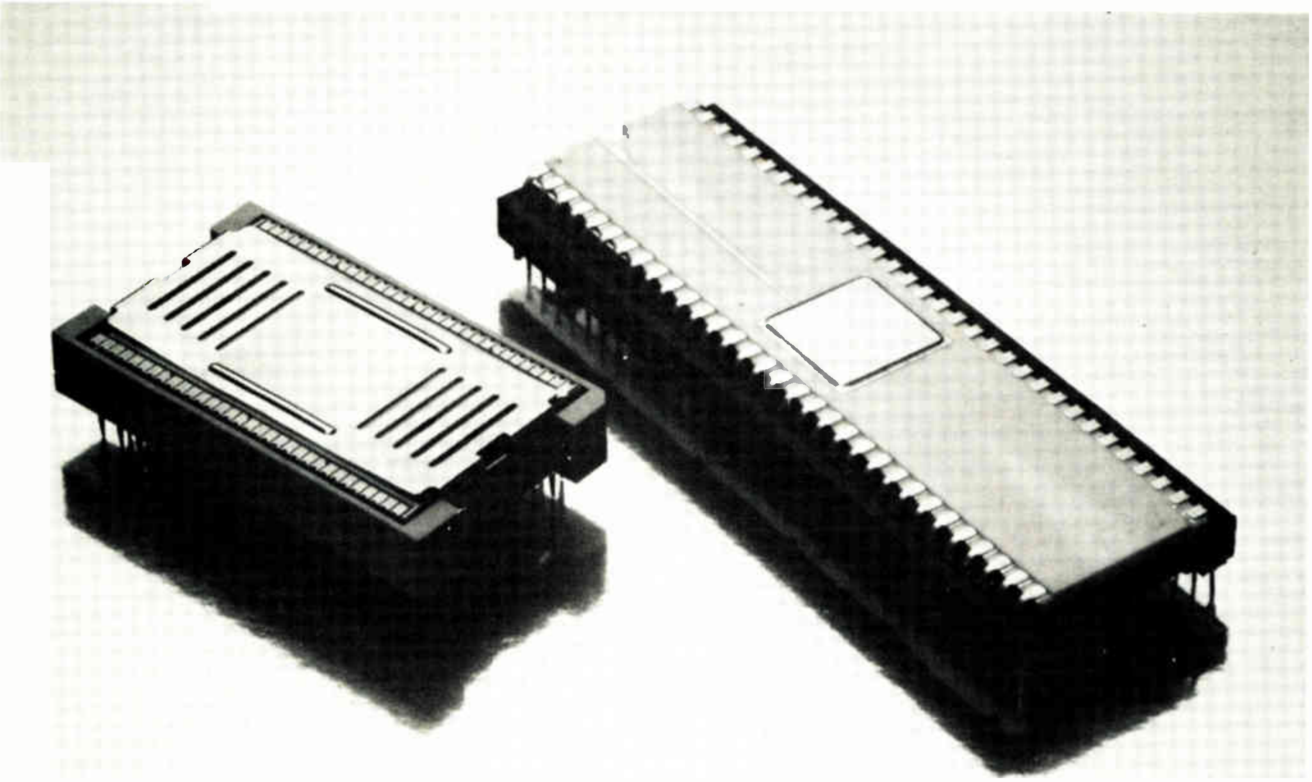
☐ Now that a single silicon chip may contain up to 100,000 transistors and have well over 60 input/output pads, both semiconductor and system manufacturers have been forced to reconsider how to package such large-scale integrated circuits. The need for a change is particularly pressing in the case of microprocessors, which are now appearing as complex, 16-bit units.

The 64-pin quad in-line packaging system developed jointly by Intel Corp. and 3M Co. meets all the requirements of these increasingly powerful microprocessors. Compared with the 40-pin ceramic dual in-line package that has been standard for most commercial microprocessor applications, the QUIP is much smaller yet has a larger chip cavity—400 mils square. Its thermal resistance (35°C per watt) as well as its pin-to-pin capacitance (5 picofarads) and lead resistance (0.5 ohm) are so low as not to limit chip density, speed, or ability to interface with transistor-transistor logic.

As for manufacturability and testability, the QUIP is sturdier than the 64-pin DIP and capable of being probed while actually mounted on the printed-circuit board. And that board can be the low-cost, two-sided kind because the QUIP's pins are on 100-mil centers.

Structurally, as shown in Fig. 1, the QUIP is a three-part system, consisting of a leadless ceramic chip-carrier, a leaded socket, and a metal clip. This metal clip holds the carrier in place face down in a 64-pin socket and dissipates heat generated by the LSI device.

The QUIP is shorter than the 64-pin DIP, 1⅝ inches versus 3⅛ inches. This results in shorter internal metal-



ized conductors on the chip-carrier surface.

The 64 metalized contact pads do not terminate on the socket-interface (bottom) surface of the chip-carrier but extend up the side to the carrier's top surface, where they can be probed during operation of the device.

The chip-carrier contact pads make a gas-tight connection with the spring-loaded contacts of the socket by making a wiping motion against the gold-plated chip-carrier pads. This occurs during carrier-to-socket assembly via pressure supplied by the retaining clip (Fig. 2). Both the carrier contact pads and the 64 socket contacts are situated in two rows of 32 on 50-mil centers, but they emerge as four staggered rows of 16 pins on 100-mil centers to facilitate use with standard pc boards.

None of these design details is arbitrary. All solve specific packaging problems, perhaps the most important of which is the need for low thermal resistance ($\Theta_{AJ}$).

#### Thermal and electrical considerations

Semiconductor designers are restricted by a package's thermal resistance because it boosts junction temperature but must not do so beyond a maximum consistent with chip reliability requirements. Junction temperature is determined by the ambient temperature plus the product of the chip's power dissipation and the package's thermal resistance. But the denser the chip circuitry, the more power it needs to dissipate, and the more heat its package needs to dissipate.

DIPs require heat from the chip to flow through the base of the chip cavity and up round its sides before it can leave the package. In contrast, the QUIP inverts the chip-carrier so that the LSI chip is mounted directly adjacent to the metal retaining clip. This allows heat from the chip to flow straight from the carrier into the metal clip. The chip can easily dissipate 2 W without exceeding an operating junction temperature of 170°C. The nominal thermal resistance of carrier and socket is, as mentioned, 35°C/W.

The reduced lead resistance and lower pin-to-pin capacitance of the 64-pin QUIP, as compared with the 64-pin DIP, are due to its shorter length: the metalized traces on the chip-carrier traverse a shorter distance before connecting with the socket contact.

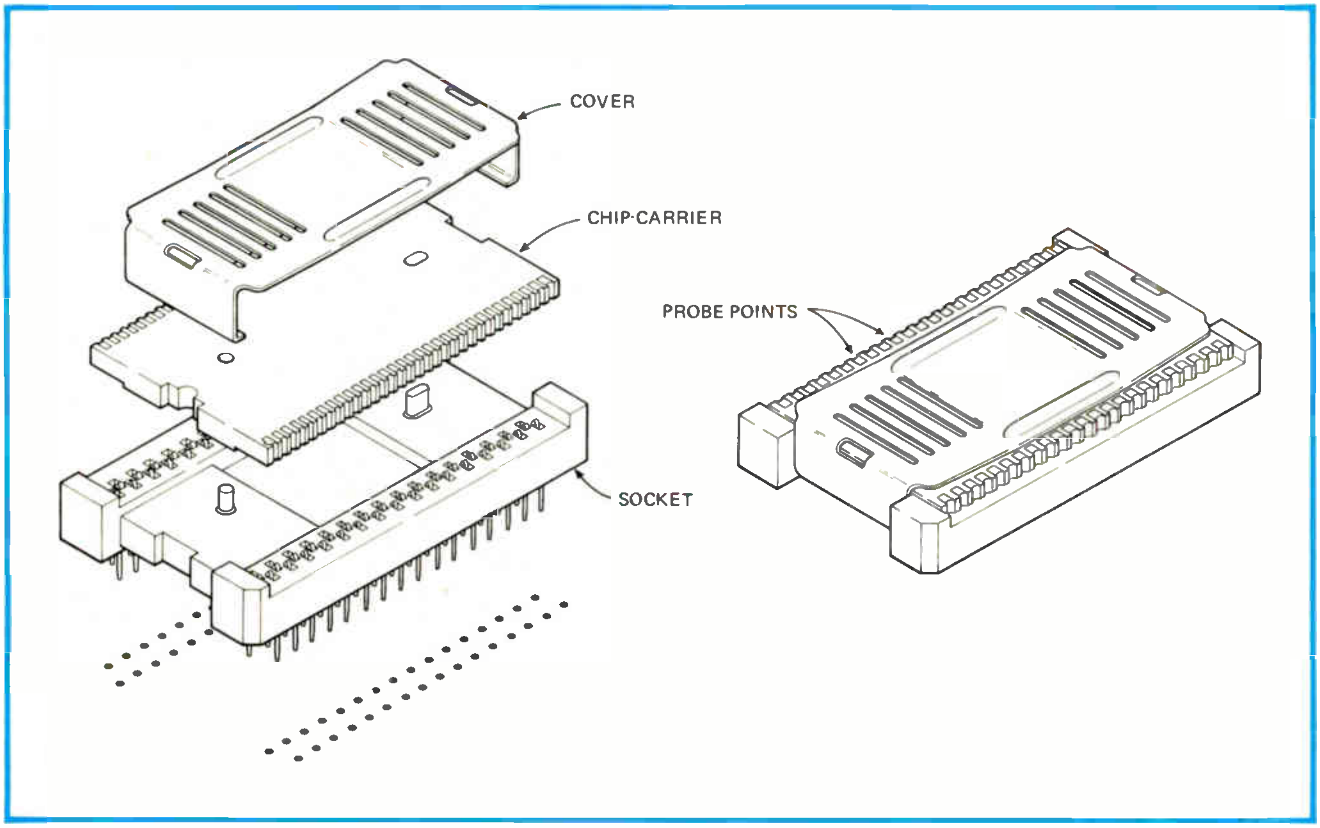
Too high a lead resistance would affect the 0 level of transistor-transistor logic. When a chip has to drive TTL interface circuitry, the interface will see any voltage drop between the chip and the pc board. The standard TTL 0 level is defined as 400 millivolts; so for convenient interfacing the lead resistance of the package must be less than 0.5 ohm—the 64-pin QUIP's specification.

Lead-to-lead capacitance can degrade the performance of metal-oxide-semiconductor microcomputers when driving large off-chip capacitance loads. To minimize this problem, the QUIP's pin-to-pin capacitance is less than 5 pF.

Besides improving electrical performance, the shortness of the leadless chip-carrier increases its mechanical strength. This plus the lack of leads to be damaged ensures higher yields from the packaging process.

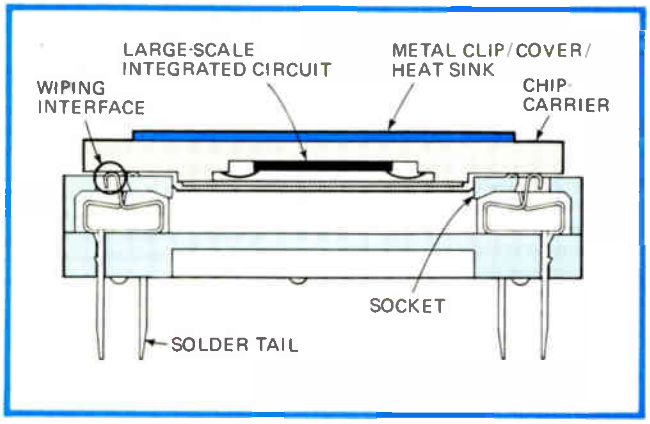
Another physical characteristic of the carrier—its

**1. QUIP.** A combination metal clip and heat sink, a leadless rectangular ceramic chip-carrier, and a zero-insertion-force socket are the three components of the Intel/3M quad in-line package. The carrier I/O pads are on 50-mil centers, the socket pins on 100-mil centers.



THREE LSI PACKAGING SYSTEMS COMPARED

| System | 64-lead dual in-line | | | 64-lead quad in-line | | |
|---|---|---|---|---|---|---|
| | Chip-carrier 3M #ST 80232TA | Socket RN #ICN649S5G | Combination | Chip-carrier 3M #ST 88364BC | Socket 3M #3534000 | Combination |
| Board area | | | 3.5 in.$^2$ | | | 2.1 in.$^2$ |
| Approximate height above board | | | 0.300 in. | | | 0.350 in. |
| Circuit-board pad spacing, center to center | | | 0.100 in. | | | 0.100 in. |
| Method of attachment to board | | solder | | | solder | |
| Package removal from socket | | | difficult | | | simple |
| Nominal thermal resistance in still air ($\theta_{JA}$) | | | 35°C/W | | | 35°C/W |
| Nominal resistance of longest lead | | | 1.1 Ω | | | 0.3 Ω |
| Nominal capacitance of longest lead at 1 MHz | | | 7 pF | | | 3 pF |
| Die cavity size | 0.325 x 0.325 in. | | | 0.400 x 0.400 in. | | |
| Gold thickness | 60 μin. | 30 μin. | | 60 μin. | 30 μin. | |
| Approximate cost per lead in 10,000-unit quantity | 8.1 ¢ | 3.8 ¢ | 11.9 ¢ | 5.2 ¢ | 5.3 ¢ | 10.5 ¢ |
| Availability | special order | readily available | | readily available | readily available | |
| Burn-in socket information | RN #SB-25-HT burn-in strips, not zero-insertion-force | | | 3M #3.62-0000 zero-insertion-force socket, available | | |




**2. Chip down.** This sectional view illustrates how the spring-loaded contacts of the zero-insertion-force socket wipe against the carrier's pads. The chip-carrier is mounted face down in order to make a shorter thermal conductive path between chip and metal heat sink.

large chip cavity—means it can cope with the larger microprocessor chips that are becoming common. Measuring 25 mils deep as well as 400 mils square, it accepts the thicker die made from 4-inch wafers.

Being leadless, the chip-carrier makes a zero-insertion-force socket possible. In the past, chip packages with high pin counts suffered from the force required to insert them into their sockets. Only a few insertions could be made before the board, socket, or carrier was damaged. In the 64-pin QUIP, however, the socket has spring-loaded pins, and these simply push hard against the carrier's pads when under pressure from the metal clip. Levering the clip off with, say, a screwdriver is enough to release the carrier and allow it to be replaced with another (Fig. 3).

For ease of manufacture the system is completely polarized. The carrier cannot be inserted in the socket without proper orientation, having been mechanically keyed to prevent this. The socket is also keyed by the staggered pins, so that it cannot be reversed when being inserted in the pc board.

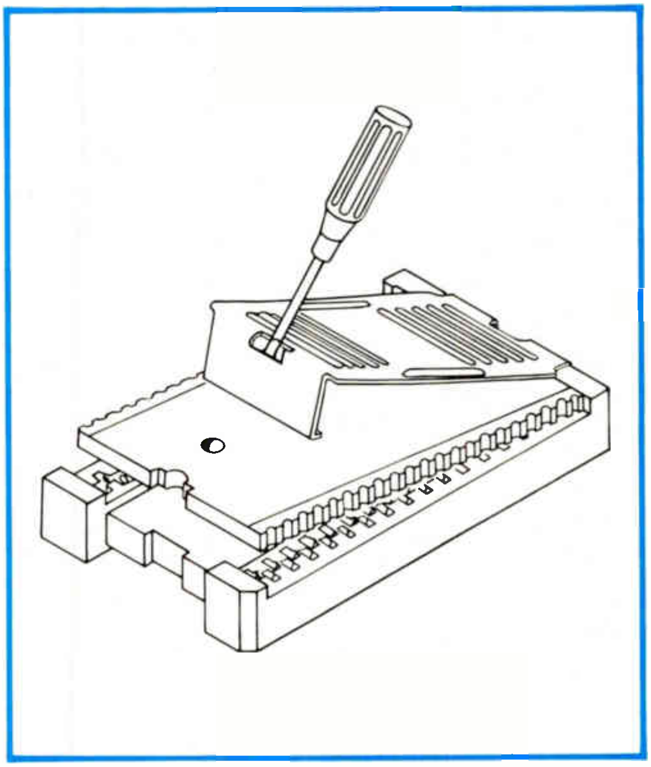
The staggering of the socket's leads on 100-mil centers optimizes layout even on low-cost two-sided boards. The carrier's two rows of 32 leads on 50-mil centers are converted through the socket into four rows of 16 leads on 100-mil centers. Thus copper traces of standard width pass easily between the pins, yet the board has a package density of one using 50-mil centers.

## Easy to test

Finally, for test purposes, the chip-carrier is provided with a special set of probe contacts on the top side, to supplement the ones on the bottom that make contact with the socket. These probe contacts are left exposed by the metal clip, so that the engineer can make electrical measurements on the chip while it is operating in its socket—an impossibility with other leadless packages.

From a semiconductor manufacturer's point of view, the 64-pin QUIP has two outstanding advantages. First, the carrier has no leads that can be bent or broken during the difficult handling and testing stages of manufacture—and incidentally, this leadlessness also elimi-

| 68-lead Jedec standard square | | |
|---|---|---|
| Chip-carrier 3M #SR 88568AA | Socket AMP #P771506 | Combination |
| | | 1.4 in.$^2$ |
| | | 0.500 in. |
| | | 0.050 in. |
| | screw | |
| | | simple |
| | | 50° C/W |
| | | 0.1 Ω |
| | | 2 pF |
| 0.350 x 0.350 in. | | |
| 80 μin. | | |
| 4.4 ¢ | ≈3 ¢ in prod. quant. | ≈ 7.4 ¢ |
| special order | prototype stage | |
| unknown | | |



**3. Dismantling.** Only an ordinary small screwdriver is needed to lever off the retaining clip of the QUIP. The leadless carrier can then be slipped off two keyed posts molded into the socket. A microprocessor emulator or tester may be plugged into the empty socket.

nates all the manufacturing steps associated with lead frames. Second, the carrier is mechanically very strong, being about half the length of a 64-pin DIP yet made of the same high-quality ceramic.

Being both leadless and inherently strong, it lends itself to automatic gold-ball bonding, which increases productivity by a factor of three over manual ultrasonic aluminum-wire bonding. Also, the alloy seal between the carrier and the cavity lid provides hermeticity and takes place at a much lower temperature than the glass-seal interface used with such package as Cerdips.

### Chip users benefit, too

From a chip user's point of view, it is best to compare the QUIP with both the DIP and the leadless ceramic chip-carrier (see table). Evidently, its major competition will come from the square leadless ceramic chip-carrier known as the Jedec type, which occupies an even smaller board area and has slightly better lead resistance and capacitance specifications.

However, the Jedec carrier was originally designed for reflow-soldering to ceramic substrates, so that it is hard to solder to a pc board having a very different thermal coefficient of expansion. So a special socket is made for it by AMP Inc. A screw and nut hold this socket's contacts against the pc board's pads, both being on 50-mil centers. This contact density, plus the carrier's smallness, makes the Jedec package excellent for large-high-density multilayer boards. But it requires specially designed boards and as yet no automatic handling equipment is available for it.

The QUIP, on the other hand, can be used for either complex multilayer boards or low-cost two-sided pc boards. Moreover, since it has an integral socket with wave-solderable leads, it is directly applicable to a two-sided board and can use much of the computer-aided-design board-layout and automatic-insertion equipment developed for applying DIPs to such boards. In addition, the QUIP will use 40% less board space in two-sided pc board applications.

It appears the microprocessor will be the ubiquitous computing element of the future, and the new QUIP has been designed specifically for microprocessor applications. It will let relatively unsophisticated users construct microcomputer systems on low-cost pc boards for such applications as home computers and appliance controls.

For instance, releasing the retaining clip is enough to remove the leadless chip-carrier. Then a cable and connector from a microprocessor emulator or tester may be plugged into the socket for either control or diagnostic purposes. For debugging and maintenance, there is access to all the pins of the LSI microprocessor from the top of the pc board via the probing pads.

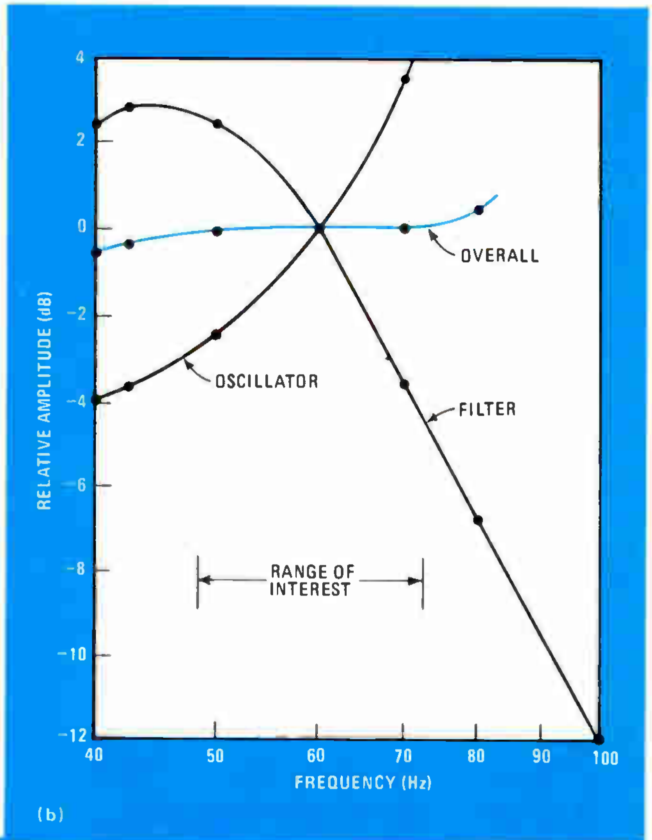
The QUIP is already available from one of its co-developers, 3M Co. [*Electronics*, Oct. 26, p. 309]. The other co-developer, Intel Corp., plans to market a device packaged in a 64-pin QUIP some time in 1979 [*Electronics*, Aug. 31, p. 41]. Also available from 3M are high-temperature burn-in sockets that will allow the 64-pin leadless carriers to be placed on burn-in boards. To be developed soon are cables and connectors for mating an empty QUIP socket to an emulator or tester. □

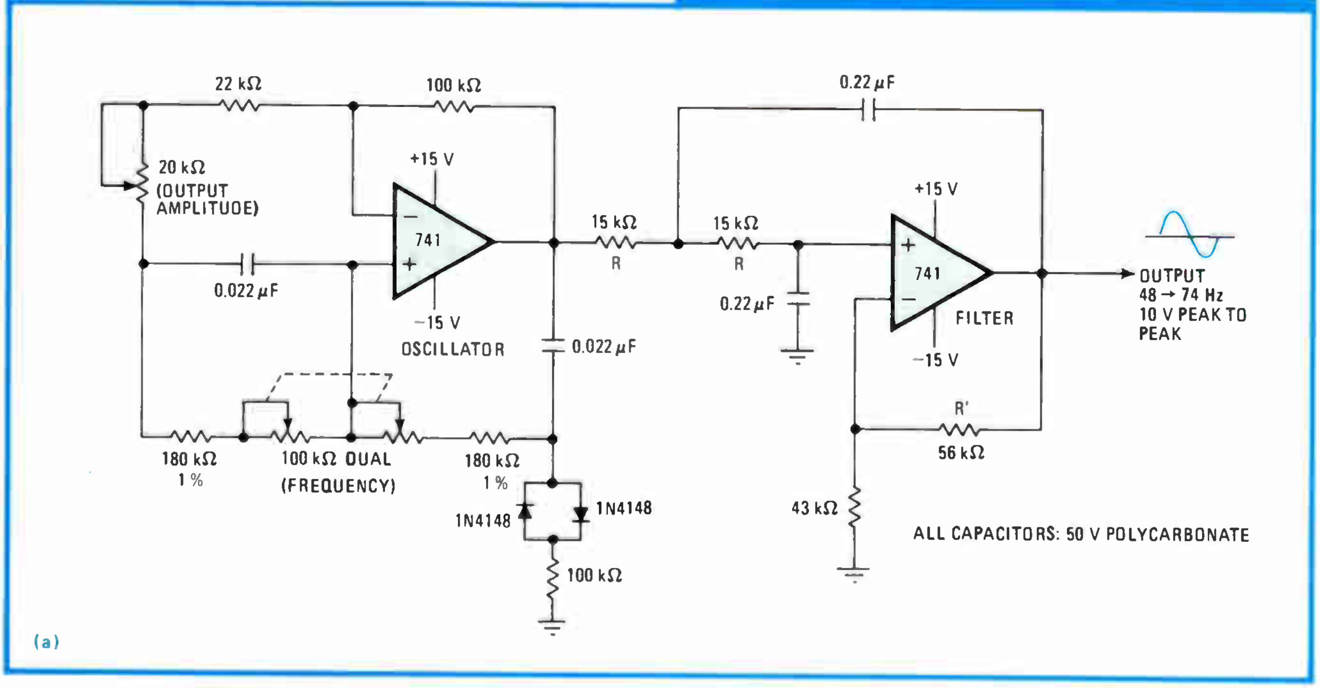
# Filter levels output swing of Wien-bridge oscillators

by Maxwell G. Strange
*Goddard Space Flight Center, Greenbelt, Md.*

Although the output of a tunable Wien-bridge oscillator normally exhibits a large change in amplitude as a function of frequency, a standard active filter will hold it to within ±0.2 decibel over a ±20% frequency range. In this application, the filter's response is set to compensate for the amplitude variation of the oscillator. Most alternative amplitude-stabilization circuits tend to draw high power, create appreciable sine-wave distortion, or stabilize slowly.

The technique can be easily implemented at any frequency over the operating range of the oscillator, since the filter's component values are easy to calculate, being inversely proportional to frequency. The circuit shown was designed to control the speed of a 60-hertz




**Stability.** Active filter's roll-off characteristics compensate for oscillator's inherent amplitude change with tuning, keeping output level within ±0.2 dB in range of interest. Sine-wave distortion is also dramatically reduced—from 1% at oscillator output to 0.1%.

synchronous motor over a range of 48 to 74 Hz. It is used to adjust the tape speed of a recorder in the lab to that of an airplane's recorder so that the data can be recovered from airborne equipment that lacks a frequency-regulated power source.

Two diodes and a resistor at the oscillator's output provide soft limiting in order to confine the amplitude swing of the sine wave. The signal is then passed through the low-pass filter. To flatten the output amplitude, the filter's cutoff and its damping factor, adjusted by R and R′, respectively, are set to compensate for the oscillator's amplitude variations. In general, the slope of the filter's amplitude response is made equal in magnitude but opposite in sign to that of the oscillator's response.

The graph shows the overall output to be expected compared with the individual oscillator and filter responses. In addition to amplitude compensation, the filter provides good rejection of harmonics. Third-harmonic distortion is an order of magnitude below that achieved by the oscillator alone. □

# Smoke-detector chip generates long time delays

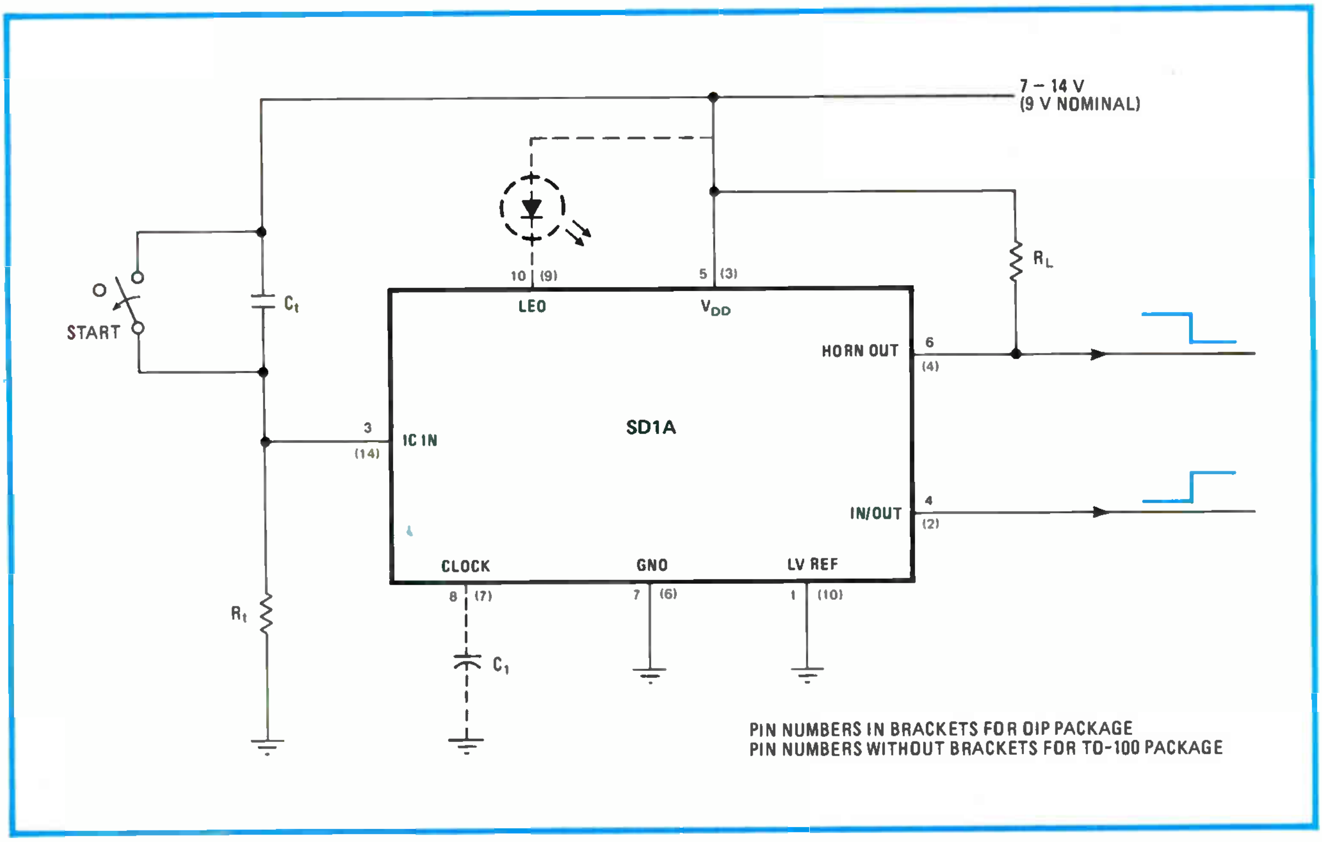
by J. Brian Dance
*North Worcestershire College, Worcs., England*

Long, repeatable time delays are attained with this circuit, which uses a single low-power complementary-metal-oxide-semiconductor chip usually found in smoke-detection systems. A small number of additional passive elements are used, though only three of them—the timing components and a load resistor—are actually required for operation.

Unlike more popular timers such as the 555, the Supertex SD1A can provide long time delays because it does not load down the timing components. The input impedance of its comparator input, to which the timing components are connected, is $10^{13}$ ohms, enabling timing resistors of up to $10^{12}$ Ω to be used. To avoid problems associated with capacitor leakage, however, resistor values of up to $2.5\times10^{10}$ Ω and a 10-microfarad non-electrolytic capacitor have been used to yield time constants of 10 hours or more.

When the start switch is opened, capacitor $C_t$ charges through resistor $R_t$ (see figure). The timing period ends when the potential at the junction of $R_t$ and $C_t$ has fallen to half the supply voltage. The period is approximately $0.69R_tC_t$. This time can be varied by placing a potentiometer (50 kilohms to 50 megohms) between pin 2 (pin

**A smoking timer.** Special-purpose chip, for smoke detectors, can serve as one-shot, providing longer delays than popular timers, such as the 555. SD1A's input does not load timing network, enables setting of time constants to more than 10 hours. Versatile chip also has provisions for flashing LED to check chip operation during long time intervals and for sounding alarm ($R_L$) if battery voltage is low.



12 of the dual in-line package) and the supply.

At the end of the timing period, the voltage at the input/output port rises to $V_{DD}-0.5$ volts. The horn output falls to near zero, serving as a current sink for the load, $R_L$, which may be an alarm or just a resistor. The horn output can sink at least 300 milliamperes.

A light-emitting diode connected to the appropriate port of this versatile chip can be made to flash every 40 seconds during the timed period if a 10-microfarad capacitor is connected to the clock pin. The flashing provides a useful indication that the circuit is operating during long timing periods. The frequency of the flashing is controlled by the value of $C_1$ or can be adjusted by connecting a potentiometer between the clock pin and $V_{DD}$ for decreasing the period or between the clock pin and ground for increasing the period.

The SD1A also includes a circuit for sounding the alarm every 40 seconds if the supply voltage is low (below 7 V). Here the low-voltage reference pin, LV REF, has been grounded so as to disable this feature.

The cost for the SD1A is $2.50 in the TO-100 package version, and $2 in the DIP. The manufacturer does not yet have authorized distributors for the device, however, and thus at this time the SD1A can only be purchased in lots of 50 or more directly from Supertex, 1225 Bordeau Dr., Sunnyvale, Calif. 94086. □

# Opto-isolated detector protects thyristors

by Charles Roudeski
*Ohio University, Athens, Ohio*

Although gating a thyristor with short pulses greatly reduces the gate and driver dissipation, failure of the driving logic can turn on the thyristor full time, possibly destroying it, the driver, and their supply. Described here is an opto-isolated zero-crossing detector that generates a 100-microsecond pulse each time its 60-hertz power-line input traverses through zero. Besides isolating for the logic element, the circuit terminates the generation of pulses if almost any detector component fails.

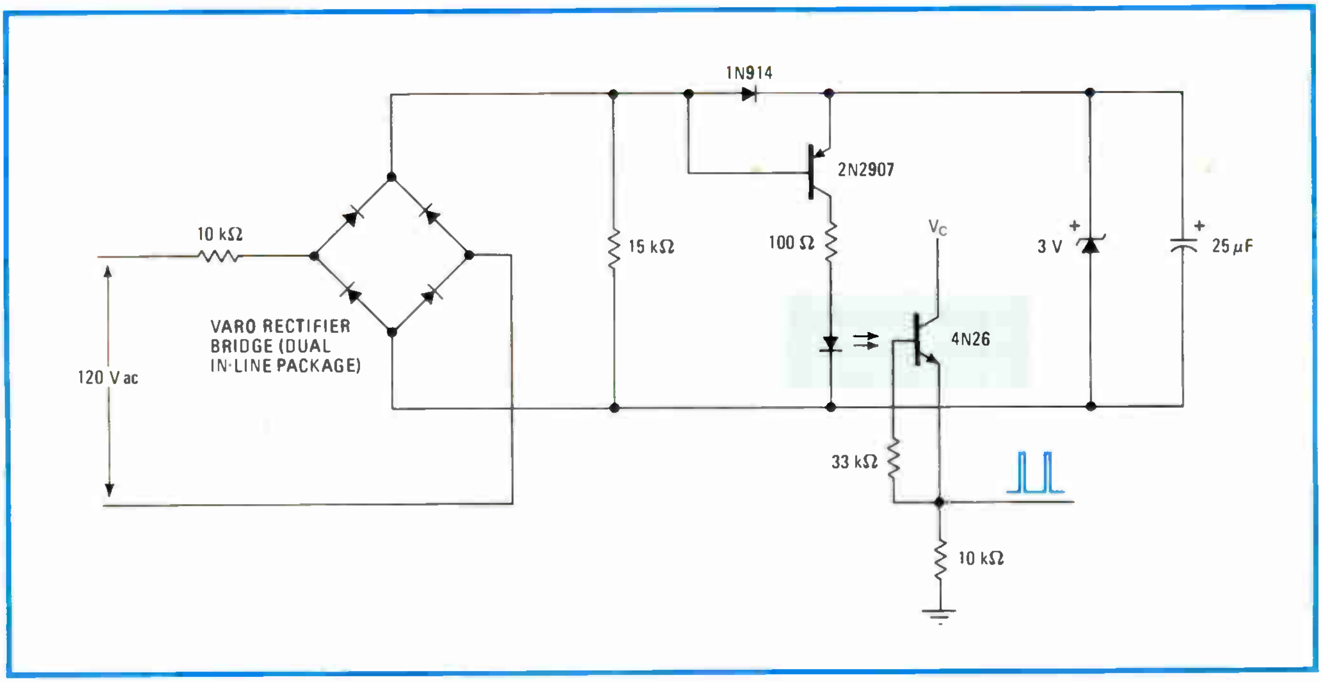
Most of the line voltage (see figure) is dropped across the 10-kilohm input resistor before it is rectified. The 25-microfarad capacitor charges during most of the 60-Hz cycle, but the 2N2907 transistor is held off by any full-wave rectified voltage above 2.3 V.

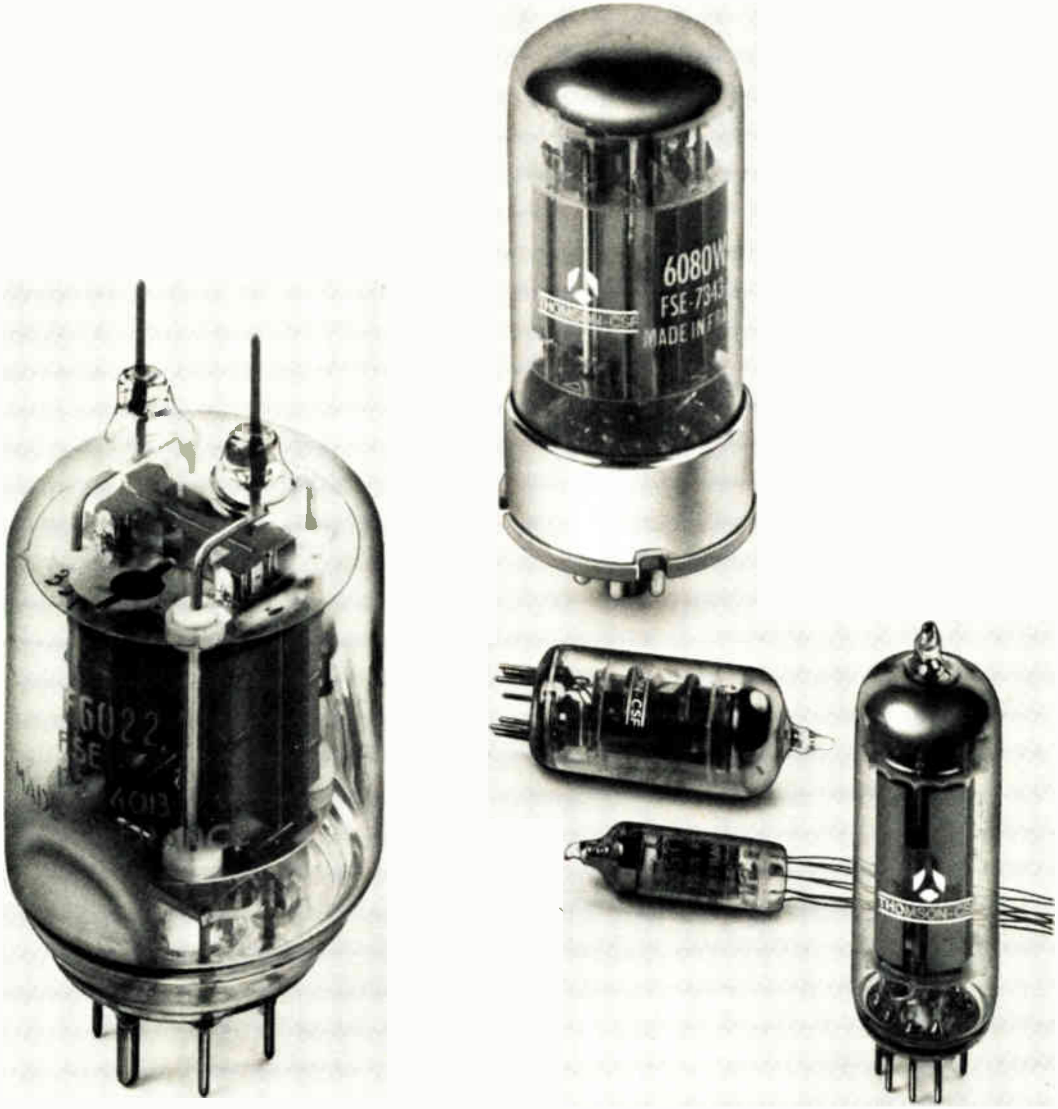
As the line voltage drops to about 4.5 V, the transistor begins to turn on and the capacitor discharges through the 4N26's photodiode, sourcing about 14 milliamperes. This produces a pulse centered about the zero crossing. Wider pulse widths are obtained by reducing the value of the 15-kΩ resistor. If a longer rise time is tolerable, the 33-kΩ resistor in the base lead of the optocoupler's phototransistor can be eliminated.

The 3-V zener establishes the reference voltage for the circuit. □



**Protection.** Zero-crossing detector uses optocoupler for gating of thyristors by power line. Output pulses, produced 120 times per second as input voltage traverses through zero, last 100 μs. Output of 4N26's phototransistor will be zero if most any element in detector fails, thereby protecting thyristor, driver, and supply from damage that would be caused by activating the thyristor continuously.





# Designing fail-safe microprocessor systems

In critical applications, hardware or software can be added to put the finger on faulty components

by Dan R. Ballard, *Telex Computer Products Inc., Tulsa, Okla.*

☐ The microprocessor is finding itself in some tough spots these days—high-reliability space and military equipment, nuclear power plants, and medical life-support systems, to name a few. In such applications, the microprocessor system is required to detect a failure so that it can shut down all or part of the system, provide warnings or alarms, and possibly switch in back-up systems. The designer can choose from among several methods of fault detection, including self diagnosis, external detection hardware, and redundant systems.

Which scheme is to be preferred depends on system architecture, system size (including cost and power requirements), and how critical an undetected fault will be. For systems using a single microprocessor where cost, size, and power must be minimized and where additional memory is available, a self-diagnostic approach may be the best solution. Self-diagnosis has the advantage of allowing system fault detection, with the memory required for diagnostic programs being the only additional financial overhead.

## Self-diagnosis

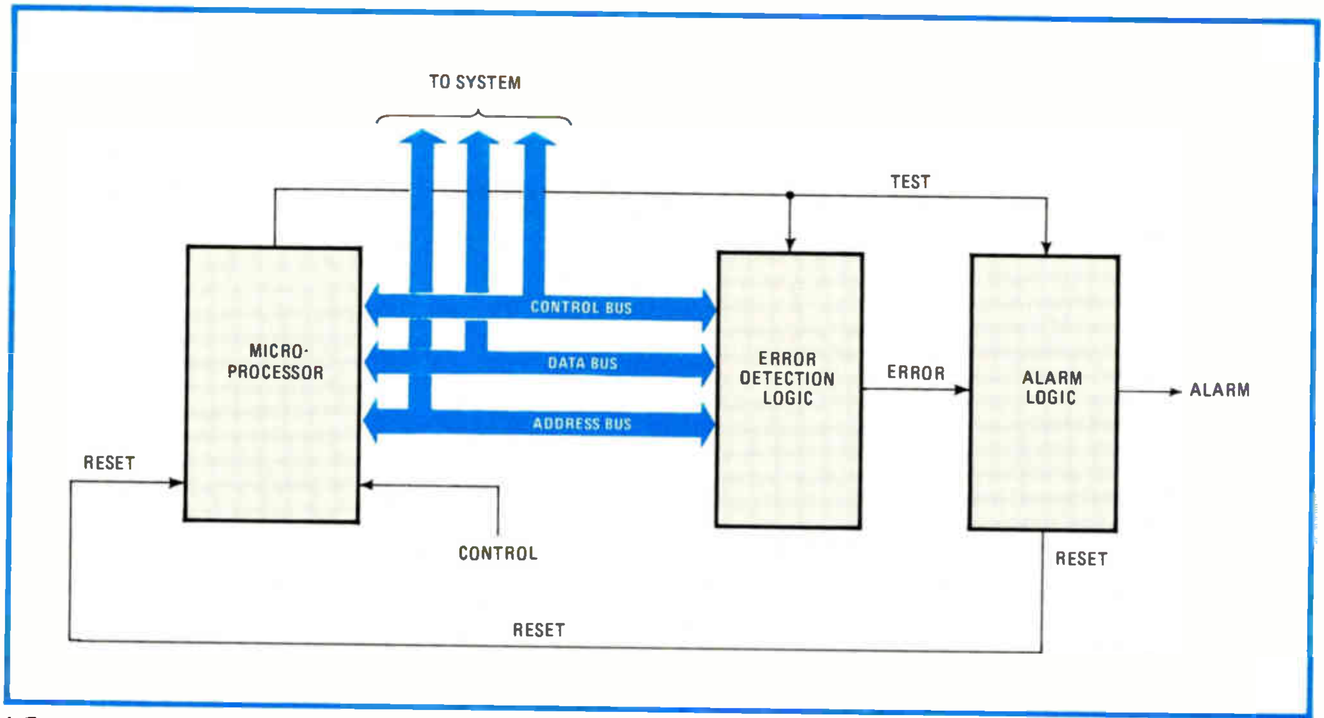
In self-diagnosis, the microprocessor checks itself using diagnostic software. Diagnostic programs should test or exercise as much of the microprocessor system as possible, and they should provide a high level of confidence for a fault-free system. Each functional block in the microprocessor system should be tested with a dedicated diagnostic program. When the diagnostic routines for the microprocessor central-processing units have been completed successfully, diagnostics for random-access and read-only memory, programmable input/output ports and peripheral devices should be performed. In more sophisticated systems, diagnostic programs may be stored off-line in mass storage devices and loaded for diagnostic testing. In such systems, the diagnostic software can be used to locate a faulty large-scale-integrated device, memory chip, input/output port, and so on.

As a minimum, the diagnostic software should detect single bits stuck at a 1 or 0 on address and data lines, the system control and decoded chip-select lines, the microprocessor internal registers, and the microprocessor arithmetic-logic unit. Once the processor has successfully performed these minimum tests, more exhaustive tests for multiple failures, timing problems, intermittent faults, and RAM pattern-sensitivity faults can be attempted. These kinds of tests will require larger amounts of program memory and may have to be stored externally to the system in a mass storage unit.

Self-diagnostic programs are normally executed

INSTRUCTION WEIGHT MATRIX (8080)

| Instruction | Attributes | | | | Weight |
|---|---|---|---|---|---|
| | Register-immediate | Register-memory | Timing cycles; address, data and control lines; other flags | Carry flag | |
| Move immediate (MVI) | 1 | 0 | . . . | 0 | $W_1$ |
| Store indirect (STAX) | 0 | 1 | . . . | 0 | $W_2$ |
| Input (IN) | 0 | 0 | . . . | 0 | $W_3$ |
| Output (OUT) | 0 | 0 | . . . | 0 | $W_4$ |
| Add memory (ADD, M) | 0 | 1 | . . . | 1 | $W_5$ |
| Save program-status word (PUSH PSW) | 0 | 0 | . . . | 0 | $W_6$ |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | $W_i$ |
| Call subroutine (CALL) | 0 | 0 | . . . | 0 | $W_n$ |
| | | | | Total weight | $W_t$ |




**1. External hardware.** In those instances where software alone cannot be used to test a microprocessor system, hardware must be added. In this simple example, the error-detection logic warns the alarm logic if a line in the system bus is stuck high or low.

following a power-on, start-up, or reset of the microprocessor system. During normal operation, a timer or other external event may be used to interrupt the microprocessor, possibly suspend operation, and perform the diagnostic test. It is possible to have some tests running continually in a background mode while the microprocessor is not doing any other useful work. For example, a program performing a check on the contents of ROM could be allocated the lowest interrupt priority. A memory self-check would then be performed continually unless interrupted by a higher-priority request for the microprocessor to perform other tasks.

There is one fundamental problem with self-diagnostic programs, and the system designer must continually beware of it. Simply stated, a fault may prevent a microprocessor from detecting another fault. The system designer must recognize this problem and attempt to design or program around it. The best way of doing this is to determine the most reliable instruction and the most reliable functional unit of the microprocessor. These most reliable instructions and functional units are then used to test the less reliable instructions or functional units. When a less reliable instruction or functional unit has been successfully tested, this instruction or unit may be used in further system testing. Using this approach, one can proceed to test the entire microprocessor system.

To determine the most and least reliable instructions for a given microprocessor, a weight matrix is developed as shown in the table. Each row of the test matrix represents a microprocessor instruction. Each column will represent some attribute of the microprocessor; there should be a column for each instruction type. Some examples of instruction types are:

- Data transfer instructions—register to register, register to memory.
- Arithmetic instructions—add, subtract, increment or decrement register or memory.
- Logical instructions—AND, OR, shift, rotate, complement register or memory.
- Branch instructions—conditional or unconditional jump, call, return.
- Stack, input/output instructions—I/O, stack control.

There should be a column for each address, data, and control line, and one for each timing cycle ($T_1$, $T_2$, $T_3$ . . . $T_n$). Each flag bit should also have a column.

For each instruction, a 1 is entered in the weight matrix under a particular attribute if that attribute is used or altered by a particular instruction. The number of 1s in a row determines the weight of that particular instruction. The instruction with the least weight is then the most reliable.

## Weigh out

After constructing a weight matrix for each instruction, a similar matrix can be generated for each functional unit in the microprocessor. Functional units, which will form the matrix rows, include adders, incrementers, registers, program counters, stack pointers, index registers, and the like. The matrix will have four columns to include the number of gate levels, feedback paths, instructions, and clocks used per device. Once again, the sum of a particular row then determines the weight of the corresponding functional unit. The largest weight indicates the most complex and thus the least reliable functional unit. Using the most reliable instruction and functional unit, the CPU may be exercised from the most to the least reliable of its elements, until the chip is found to be working.

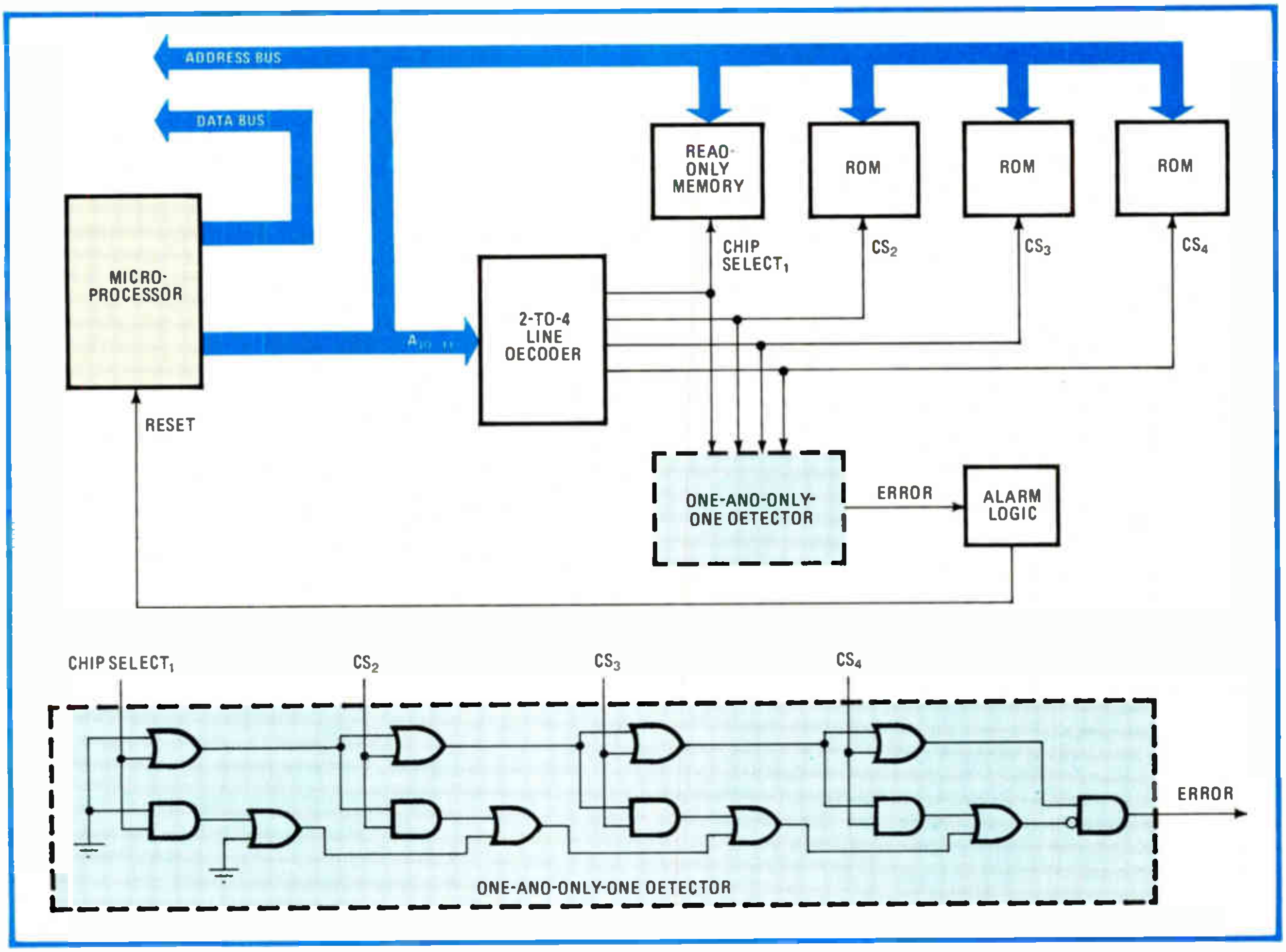
If the microprocessor is found fault-free after testing, the next step is to test the system memory. Memory faults can be detected by a number of different techniques including parity check, check sum, and pattern checking methods.

A parity bit appended to a memory word can be a valuable aid in diagnostic testing. A parity error will indicate that a bit has been dropped or added. There are two problems that restrict the use of parity checking in microprocessor memory systems. First, a parity check may not detect multiple dropped or added bits in a memory word. Also, most off-the-shelf microprocessors have no provision for parity bits in the instruction coding. Thus, a parity check cannot be used to test the ROM containing the microprocessor's instructions. For a custom or microprogrammed microprocessor, parity checking provides a good fault-finding tool.

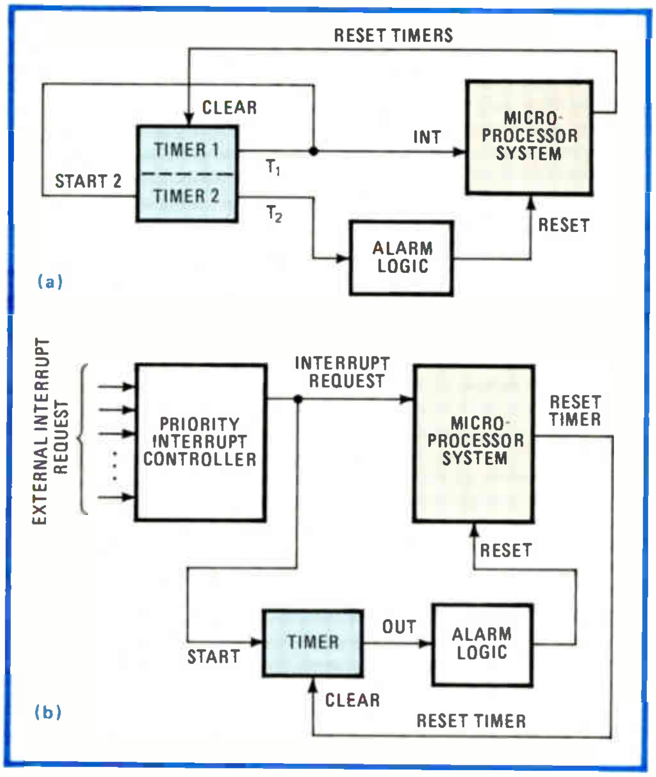
An extension of the parity check is the concept of a check-sum word for testing a block of system memory. The check sum is calculated by performing some arithmetic operation (like addition) on each of the words of program memory in the particular block of program memory under test. This result is stored in a predetermined memory location that is the check sum for that memory under test. This result, called the check sum, is stored in a predetermined memory location for that previously calculated check sum. This method will detect all single-bit errors as well as some multiple failures.

More complex tests can be used to evaluate memories. Cyclic redundancy checks (CRCs) are one such class of tests. One example of a CRC is to perform a mathematical calculation on the data using a special generator polynomial. The result of this manipulation is then stored in a known location, as is the check sum. When the memory is tested, the same polynomial is applied to the data and the result is compared to the previous value. This technique is useful for checking ROM and can be adapted for use with RAM when a known test pattern is loaded into the memory.

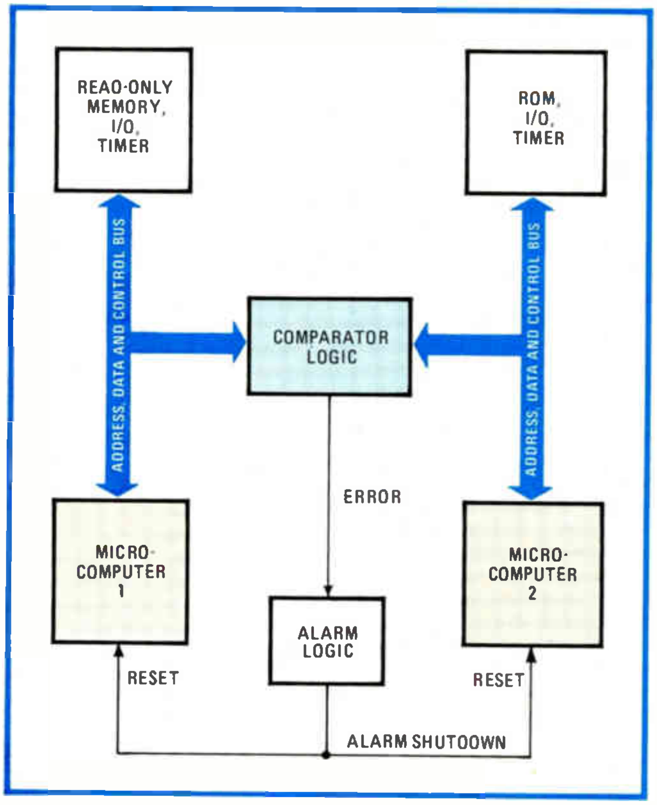
The third and most common method of memory testing generates a pattern of 1s and 0s, writes these in the memory, and then reads the contents of the memory to detect bad lines or cells and dropped bits. Current literature on RAM testing contains a number of algorithms for RAM testing. The following example is a simple test algorithm for RAM chips having square memory arrays. First, write a test word (111 . . . 1 or 000 . . . 0) in location (i, i) which corresponds to the address of a diagonal element in the storage array. Then write the binary opposite into all other locations in the memory. Read the RAM data output and repeat this with a new value of i until all data read back is different from the data put in. Since diagonals are used, the addresses are easy to generate and remember. This test will detect 1s




**2. One at a time.** Often in a microprocessor system the high-order address lines are decoded to select memory or input/output devices. Here, four read-only memories are chosen in this way. The one-and-only detector shows the gating necessary to insure uniqueness.




**3. Time for a test.** As a microprocessor executes a given instruction in a specific amount of time, this period can be measured to check the processor's operation. Timer 1 interrupts the CPU (a). If the CPU does not reset both timers in time, timer 2 triggers the alarm. The last instruction of the service routine (b) is used to reset the timer.




**4. Redundant.** In very critical applications, one can often afford to use duplicate hardware. In this scheme, the microprocessor, memory and I/O chips are identical. The comparator makes sure both sides do the same thing. The CPUs must be synchronized at startup.

or 0s stuck on data-in and -out lines, address lines, row and column decoders of the RAM, and faults in the RAM storage elements.

### External hardware

In some cases, it may be undesirable to use exhaustive diagnostic programs for fault-finding. An alternative is to use additional external circuitry for error detection. This approach will negate the requirement for additional memory to run diagnostic programs, decrease the time required to detect a fault, and lessen the dependence on correct microprocessor operation for fault detection.

A microprocessor system incorporating external hardware for error detection is shown in Fig. 1. The error-detection logic monitors the various address, data, and control signals of the microprocessor. When an error is detected, the error signal is latched into the alarm logic. In a typical application, the alarm logic might inform an operator of a system error and shut down the processor. In this example, the alarm logic forces the microprocessor into its reset state.

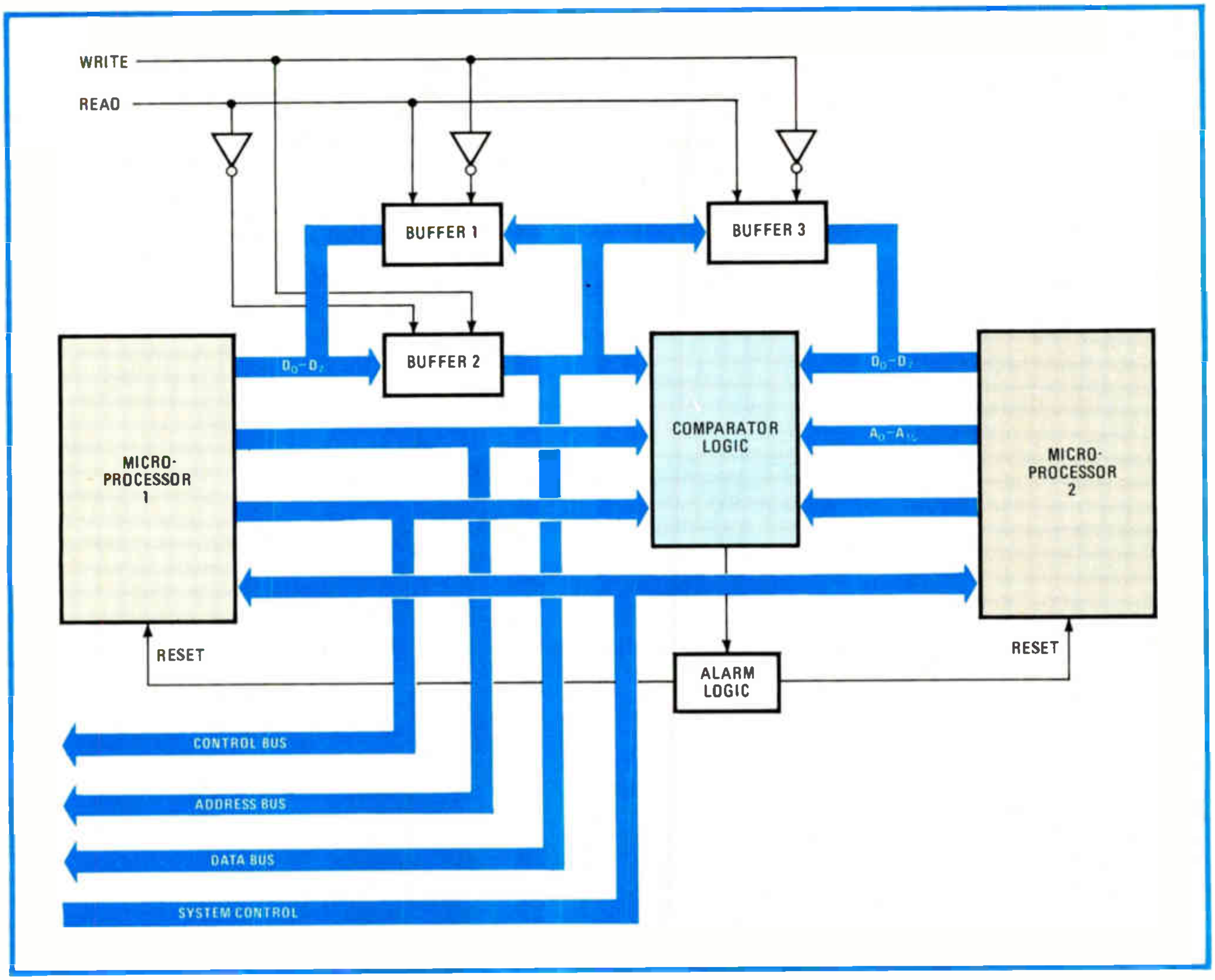
Figure 2 is a block diagram of a microcomputer system that uses a two-to-four-line decoder to select one of four ROM devices. In this case, the error detection logic will detect more than one chip select (CS) activated at any one time. A logic diagram of this one-and-only-one detector is shown in the shaded portion of Fig. 2. The error signal generated by the error detector is used to reset the microprocessor. Other types of error detection circuits for microprocessors include clock monitors to insure that the system clock is running, bus integrity checkers to detect a 1 or 0 stuck on the address or data bus, and various combinational and sequential circuits for checking memory and I/O peripheral devices.

In some critical applications, it is necessary to test the error detection circuitry itself. The system designer must provide a method of injecting faults into the error detection logic and monitoring the alarm logic to insure that the fault was detected and the alarm activated. Under test conditions, it is necessary to block the output of the alarm circuit since it is undesirable to shut down the microprocessor.

### Time out

Since microprocessors require a certain amount of time to perform a particular task, the time elapsed during the performance of an operation can be measured to determine if the processor is functioning properly. With timers and time-out counters now available as part of peripheral I/O devices and single-chip microcomputers, this type of error detecting is easy.

The simplest use of a timer is shown in Fig. 3a. In this application, the programmable timer generates an interrupt periodically after some relatively long time interval, $t_1$. Timer $T_2$ will generate an alarm and shut down the microprocessor system if timers $T_1$ and $T_2$ are not reset by the end of time interval $t_2$. The timer is checking to see if the microprocessor is "awake" and capable of responding to interrupts. Figure 3b depicts a slightly more sophisticated monitoring circuit. Any interrupt




**5. Two CPUs.** In large systems, duplication of all the hardware may not be possible. This figure shows a system where only the CPUs are redundant. The bus paths, however, must be controlled. In this example, three-state buffers do that job.

appearing on the interrupt request line of the microprocessor starts the timer. The last instruction of each interrupt service routine is used to reset the timer. If the last statement in the service routine is not executed before the terminal count of the timer is reached, the alarm circuitry is activated and shuts down the microprocessor system. Care must be taken in initially setting the timer if nested interrupts are allowed.

The programmable timer can be teamed with system software to provide error detection. Upon entering a routine or subroutine, the programmable timer is loaded with a value that will allow it to reach its terminal count slightly after completing the routine. The last instruction in the routine should be used to reset the timer.

With the decreasing cost of microprocessors and single-chip microcomputers, it becomes more attractive to build redundant systems. In a redundant system, two identical logical units operate in parallel. For error detection, the outputs of the two units are compared. If a comparison error is detected, an alarm is given and both units are shut down. Figure 4 is a block diagram of a redundant microcomputer system consisting of single-chip microprocessors and a device which represents ROM, I/O, and timer functions. In this case, the processor, memory, and I/O are identical and comparators provide error signals to the alarm logic. Care must be taken to synchronize the two processors during a restart.

## Redundancy

In larger systems, it may not be feasible to duplicate all memory and I/O devices. Figure 5 is a block diagram of such a system, where only the microprocessors are redundant. This approach is attractive since it is much easier to test memory and I/O rigorously than it is to test microprocessors. The microprocessor's requirements for self-diagnostics are removed since the two microprocessors are checked by the comparator logic. In Fig. 5, the three-state buffers $B_1$, $B_2$, and $B_3$ are controlled by the read/write logic of the microprocessor.

While redundant systems will ensure detection of most faults, there remains one class of faults that is undetectable. Since programs are common to both microprocessor systems, a software fault (where the system performs in an unexpected or undesirable manner) can still occur. Therefore, reliable software is as necessary for a redundant system as for any other. □

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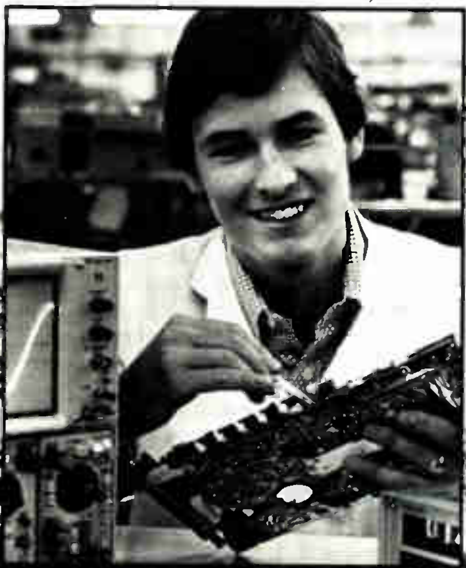

Kieran Fitzpatrick works. An apprentice for the past year, he's building a career in electronics with Grundig.

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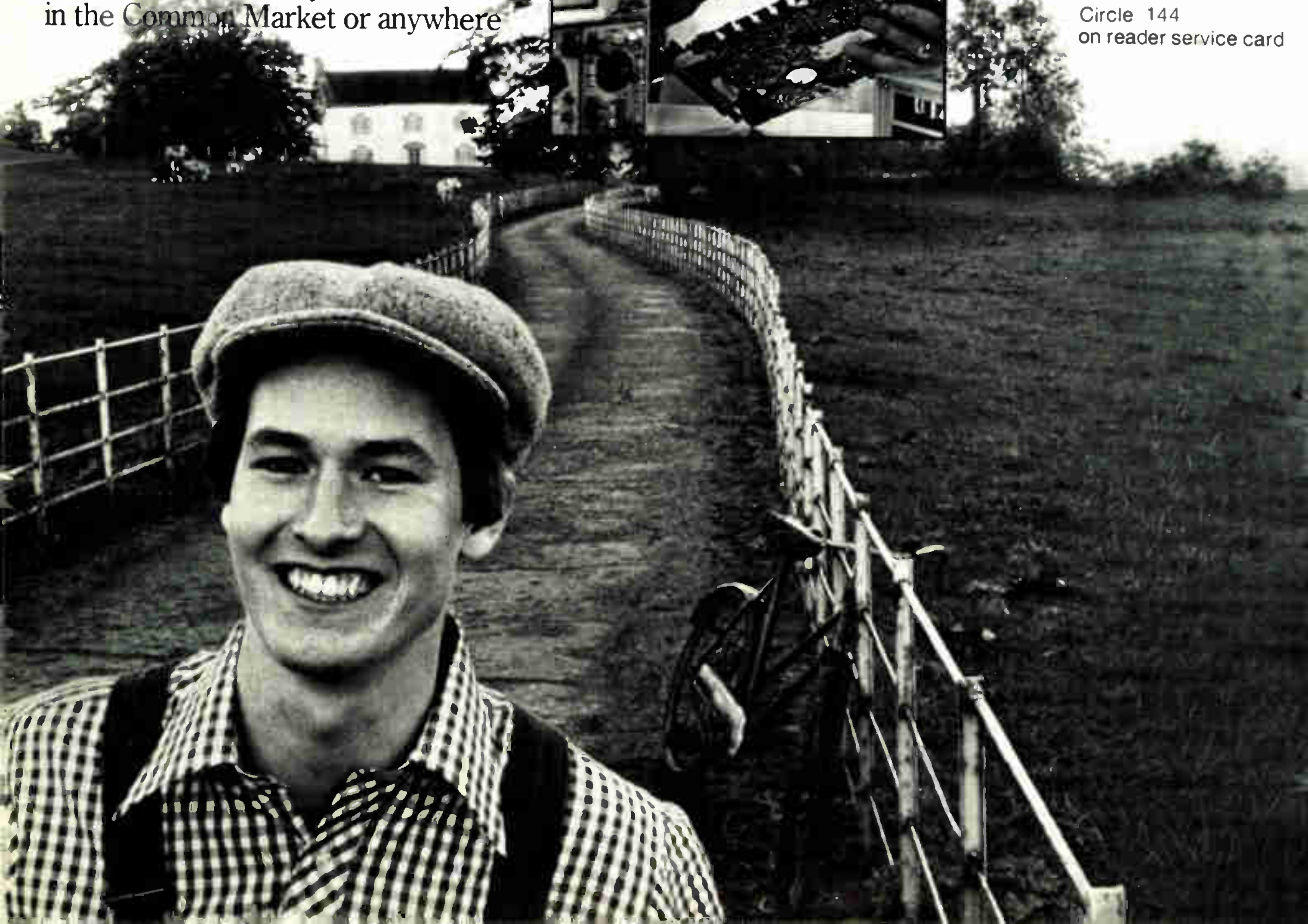
Circle 144 on reader service card



# The 64-K RAM: which way to refresh?

A 256-cycle scheme halves the number of sense amplifiers, but breaks ties with the present generation of 16-K RAMs

by Bill Johnston, *National Semiconductor Corp., Santa Clara, Calif.*

☐ Now that the 64-K level for random-access memories has been reached, several such devices will be on the market within a year and more will follow soon after. Besides quadrupling memory density over 16-K RAMs, these new parts will have a lower cost per bit—0.05 cent or less—but they will demand careful thought in providing for refreshing, since manufacturers are divided on this key aspect.

Some will use 512 sense amplifiers to refresh the memory array; that means a 128-cycle, 2-millisecond refresh, the scheme that present 16-K parts use. Others will halve the number of sense amplifiers, thereby doubling the number of refresh cycles and the refresh period. (Texas Instruments uses this scheme in its recently unveiled TMS 4164.) But system designers can cope with this variation by thinking through the problems of dynamic-RAM refreshing thoroughly and providing for the alternatives.

## Sense and refresh

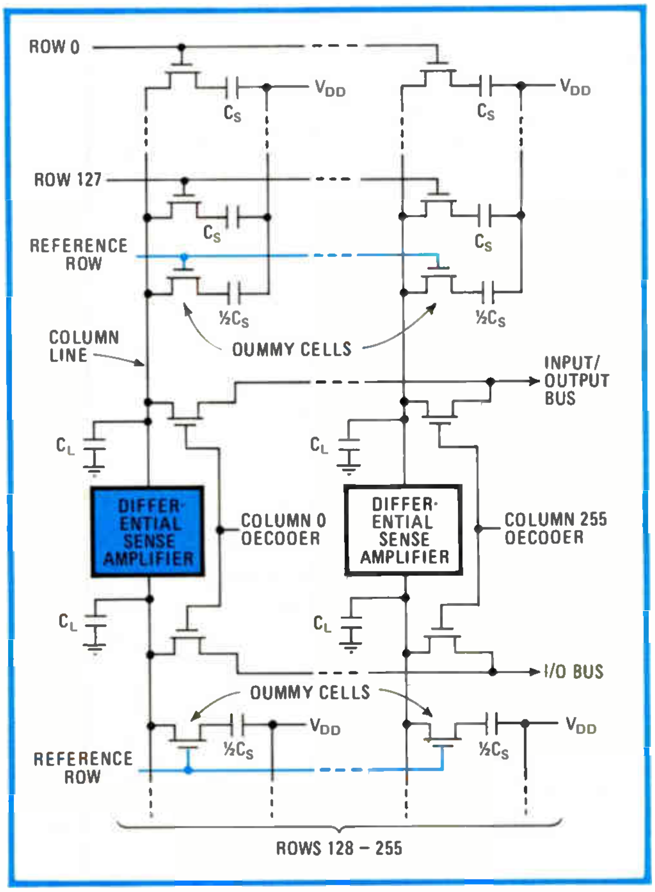
Dynamic-RAM refreshing is accomplished by sensing and restoring the voltage levels present on each cell in the memory array. This is done a row at a time, so that the number of cycles required is equal to the number of rows. Referring to Fig. 1, first a column line is precharged to the drain-supply voltage, $V_{DD}$, and the reference, or "dummy," cells are discharged to ground (the circuitry responsible for charging and discharging is not shown).

After the column has been selected, a row is chosen through address multiplexers. With a 256-cycle 64-K device, this means the storage capacitors ($C_S$) of 256 cells are connected to the 256 column lines. At the same time, a row of the dummy cells is selected on the opposite side of the differential sense amplifiers. The sense amps amplify the signals on the column lines, thus restoring the data on each cell of the selected row.

The signal detected results from the voltage division between the cell capacitor, $C_S$, and the column-line capacitance, $C_L$. This signal is differentiated from the level established on the opposite side of the sense amplifier by the voltage division between $\frac{1}{2}C_S$ and $C_L$. The sense amplifier detects a difference of $\pm\frac{1}{2}V$, depending on whether a digital 1 ($+\frac{1}{2}V$) or a digital 0 ($-\frac{1}{2}V$) is stored on $C_S$, where V is the voltage change on the column line due to the transfer of charge between $C_S$ and $C_L$ and is inversely proportional to $C_L/C_S$, which is called the attenuation ratio.

During a read or write cycle, the column decoder selects one column. The cell chosen by the coincidence of this column and the selected row has its data switched onto the input and output buses during a read operation or has new data written in from the I/O buses during a write operation.

This technique of refreshing a row at a time requires a minimum of one sense amplifier per column. Of course,




**1. Refreshing.** To refresh a 256-cycle 64-K RAM, the column lines are precharged to $V_{DD}$ and the dummy cells are discharged to ground. A row is chosen through multiplexers and a reference row is selected on the opposite side of the sense amps. Column-line signals are then amplified, thus restoring the data on each cell in that row.

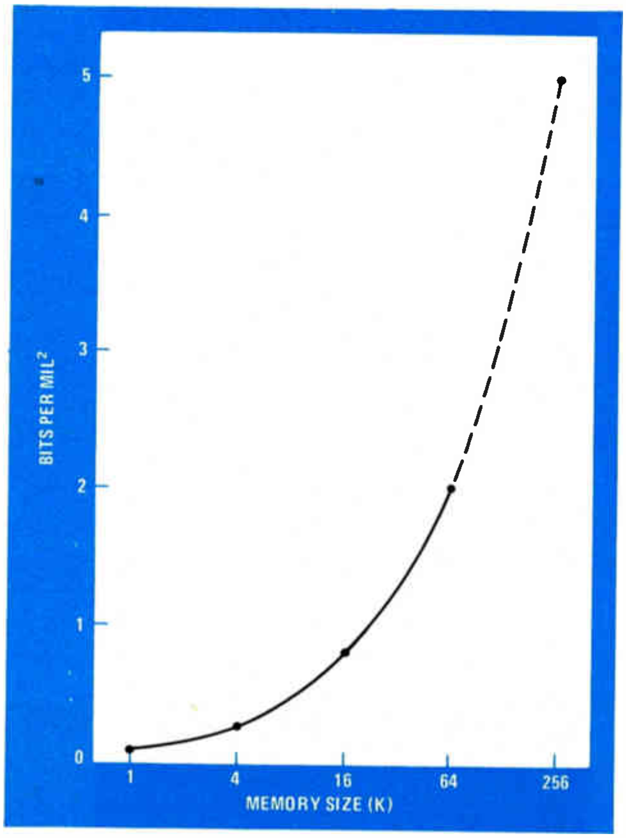
## Refreshing changes

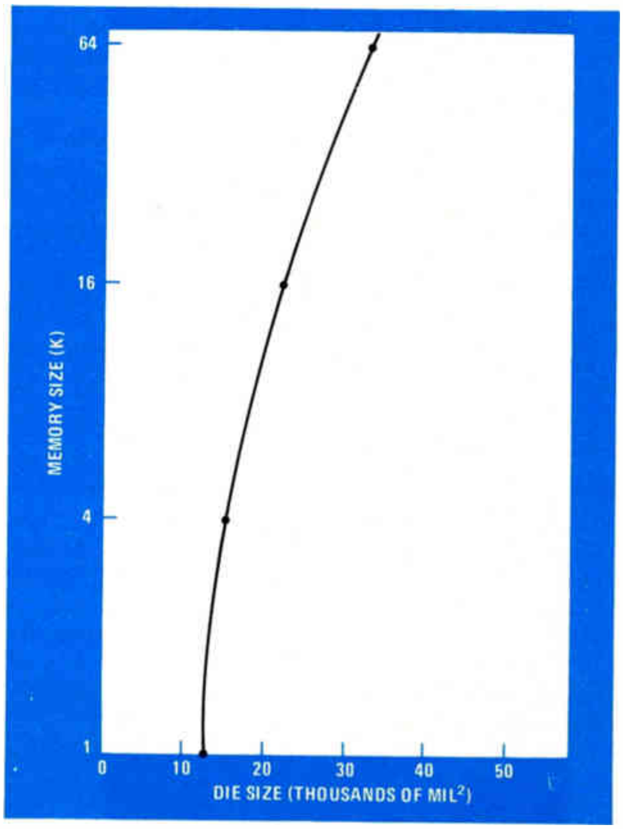
The first significant breakthrough in reducing the cost of metal-oxide-semiconductor random-access memories was the development of dynamic memory storage, which allows a digital 1 or 0 to be stored via a high or low voltage on a capacitor. But since charge eventually leaks off a capacitor, data must be sensed before it is lost and then restored, to provide a useful memory.

Initially, dynamic RAMs used a capacitor in a three-transistor cell as the storage vehicle. The next major innovation was the single-transistor cell. (The three-year lapse between the three- and the one-transistor cell was primarily due to the lack of a sense amplifier capable of detecting millivolt signal levels from the memory matrix.) This cell consists of one transistor and a capacitor and occupies less than half the area of the three-transistor cell. It resulted in a memory matrix that did not have an amplifier built into every cell, which was the case with earlier MOS memory configurations. This allowed 4,096 bits per chip and required 64 refresh cycles every 2 milliseconds.

No single breakthrough accounted for the integration of 16 or 64 kilobits per chip. Improved input/output buffers, clocks, sense amplifiers, and so on, have simplified support circuitry and enhanced performance. Process advancements like ion implantation, multiple levels of polysilicon, and other refinements have reduced the die size. Furthermore, developments in photolithography, such as electron-beam-mask making and projection alignment, have allowed the number of bits per square mil to increase by a factor of 64. The curves in both graphs will shift to the left in the next few years, probably to the point where a 64-K RAM will be only twice the size of a 1-K part.

The 16-K MOS dynamic RAM resulted in a refresh of 128 cycles every 2 ms, twice that of the 4-K RAM. The refresh requirement of the new 64-K parts, however, is yet to be firmly established.



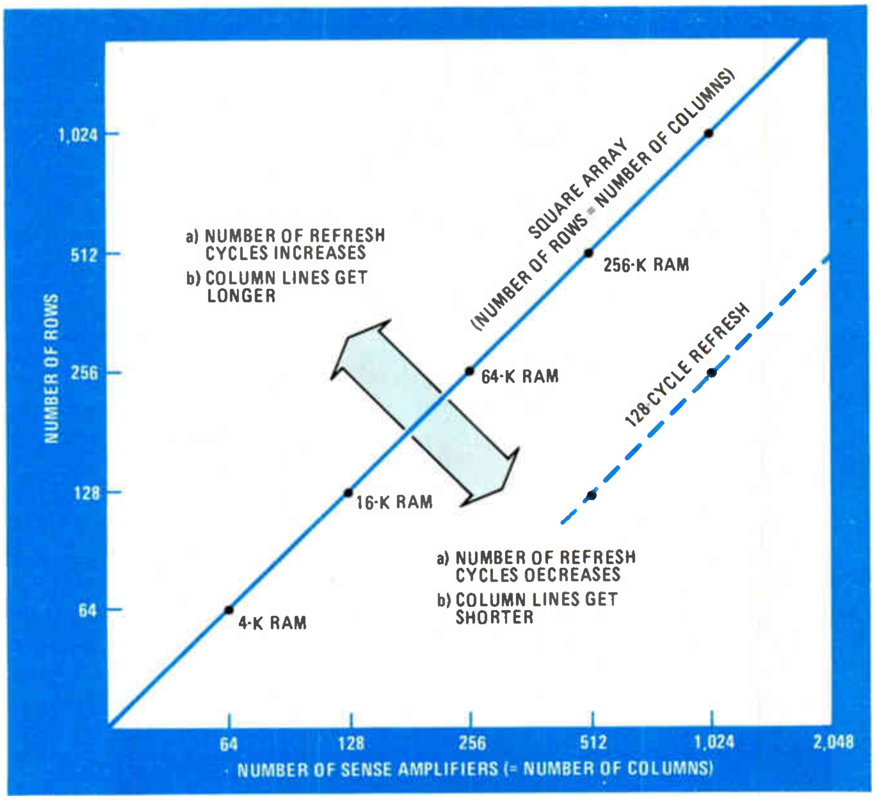




the column lines can be arbitrarily divided into segments, but each segment then requires a separate sense amplifier. Or the number of rows could be increased, but the number of cycles required to refresh the memory increases linearly with the number of rows, and more cycles means more system time is lost to refreshing the memory.

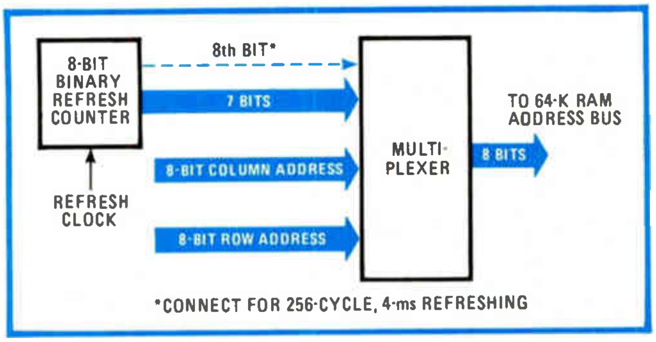
Figure 2 shows the effects of memory organization on refreshing. It also shows how the length of the column varies with organization. This is an important consideration because the column-line capacitance is directly proportional to the length of the column line. As a result, the attenuation ratio must be consistent with the sense amplifier's ability to reliably detect the charge stored on an individual cell.

### The 64-K dilemma

The 64-K dynamic-RAM designs currently in process (samples of some are already available) use either a 128-cycle, 2-ms refresh or a 256-cycle, 4-ms refresh, depending on the technological capability and the design and processing expertise of the individual company. As far as system utilization is concerned, there is no difference between the two, since the percentage of time the




**2. Organization.** The number of refresh cycles and the length of the column lines in a dynamic RAM vary with the chip's organization. The column-line capacitance is directly proportional to the length of the column line, and this capacitance dictates the sensitivity of the sense amplifier.




**3. Easy.** Identical circuitry can be used for either 128-cycle, 2-ms or 256-cycle, 4-ms refreshing for the 64-K RAM, provided a single trace is added to the printed-circuit board (dashed line). The 8th bit from the counter is unconnected for 128 cycles and attached for 256.

memory is being refreshed is the same for both.

For example, a 128-cycle refresh every 2 ms with a 375-nanosecond cycle means refreshing 2.4% of the time, since:

$$\frac{128 \times 375 \times 10^{-9}}{2 \times 10^{-3}} \times 100\% = 2.4\%$$

The same percentage of time is required for a 256-cycle, 4-ms scheme with a 375-ns cycle:

$$\frac{256 \times 375 \times 10^{-9}}{4 \times 10^{-3}} \times 100\% = 2.4\%$$

This means that die size, which is directly affected by the way the chip is organized and therefore refreshed, will be the overriding economic consideration, just as it has been for all metal-oxide-semiconductor RAMs. Process improvements, test innovations, and so on, will lead to the smallest die in volume production. But users cannot wait for the 64-K dynamic RAM to mature. The problem they face is how to design the refresh into their systems without having to redesign later around the most cost-effective product.

No semiconductor manufacturer will provide both 128-cycle and 256-cycle refreshing on the same chip. That would require the larger die of the 128-cycle approach and would further complicate the design to allow selection of either scheme.

## No problem

Fortunately, the solution is not only simple, it is also in effect free, since it does not add to system costs. Identical circuitry can be used for either the 128-cycle, 2-ms or 256-cycle 4-ms refresh for the 64-K RAM, provided the designer adds a single trace to the printed-circuit board. This solution is shown in Figure 3. The first seven outputs of an 8-bit binary counter are used for refresh addressing. The eighth output (the most significant bit) is unconnected for 128-cycle refreshing and attached for 256-cycle use.

The refresh counter is clocked 128 times during a 2-ms period. The most significant bit of the counter could be connected to the multiplexer or to the RAM with no change in operation. The state of this line is a "don't care" for 128-cycle refreshing. When the connection is made, the implementation is exactly that needed for 256-cycle refreshing. In both cases, the counter is clocked 128 times every 2 ms, for a total of 256 times in 4 ms. The refresh function is identical and independent of the mode of refreshing required by the 64-K RAM. Either distributed (transparent) or burst (bursts of 128 cycles every 2 ms) refreshing can be accomplished with this design. □

# Digital strain gage eliminates a-d converter

by N. Bhaskara Rao
*U.V.C.E., Electrical Engineering Department, Bangalore, India*

An up-down counter and several logic elements are used here to transform signals from a strain-gage transducer into a corresponding digital output suitable for driving a display. Replacing the analog-to-digital converter normally required for this application, the counter circuit not only costs less but, more importantly, uses standard logic devices normally found at hand in the lab.

A 555 timer, $A_1$, is used as an astable multivibrator (see figure) whose on time is $T_a = 0.685(R_1 + R_2)C$ and whose off time is $T_b = 0.685R_2C$, where $R_1$ and $R_2$ are the resistances of two discrete transducer elements mounted on a common surface. Their values vary directly with the amount of strain applied. In this case, the nominal values of $R_1$ and $R_2$ are 120 ohms. Resistor r is a 2-Ω potentiometer that is used to zero the circuit (no output from the 555) under no-strain conditions.

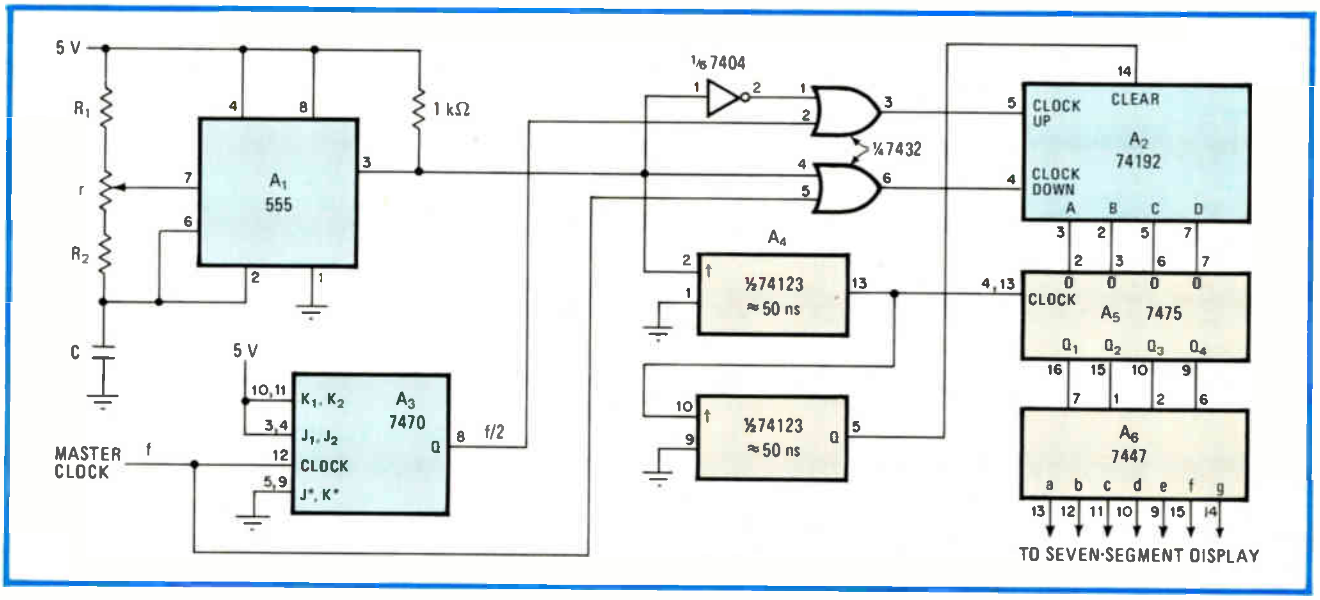
$R_1$ and $R_2$ are wired so that $R_1 - R_2$ becomes a positive value when a strain is applied to them. When the output of $A_1$ is high, the 74192 counter ($A_2$) advances up at a rate of f/2, where f is the circuit's master clock frequency and f/2 is derived from flip-flop $A_3$.

When $A_1$ is low, the 74192 counts down at a rate of f. Thus, at the end of one cycle, the net counter reading will be $N = T_a(f/2) - T_bf$, or:

$$N = 0.685f(R_1 - R_2)C/2 = K(R_1 - R_2)$$

where the scale factor, K, equals 0.3425fC. Therefore the amount of stress becomes known when $R_1 - R_2$ is determined. K can be set to any value by the proper choice of f and C. As seen from the equation, the sensitivity of the circuit increases as K is made larger.

As $A_1$ moves high at the start of the next cycle, one half of the 74123 dual one-shot, $A_4$, is triggered and clocks the 7475 quad latch, $A_5$. Thus the latch stores the contents of $A_2$. $A_6$ converts the 4-bit binary input into a seven-segment output for the display. The other one-shot in $A_4$ then clears $A_2$, and the new count cycle begins. ☐




**Stress test.** Digital circuit transforms resistance change of strain-gage transducer $R_1$–$R_2$ into corresponding index without need for standard a-d converters. Number displayed represents $R_1 - R_2$ scaled to a factor, K, that is equal to 0.3425 fC.

# C-MOS tester checks for assembly errors

by Joseph G. Gaskill
*Solid State Scientific Inc., Montgomeryville, Pa.*

Detecting most faults in complementary-metal-oxide-semiconductor devices due to errors in packaging or because of burnout while in actual operation, this tester can check virtually all the elements in the present C-MOS logic family. The unit needs only to perform a set of simple open and short tests at each pin of the device to quickly check for chip failures.

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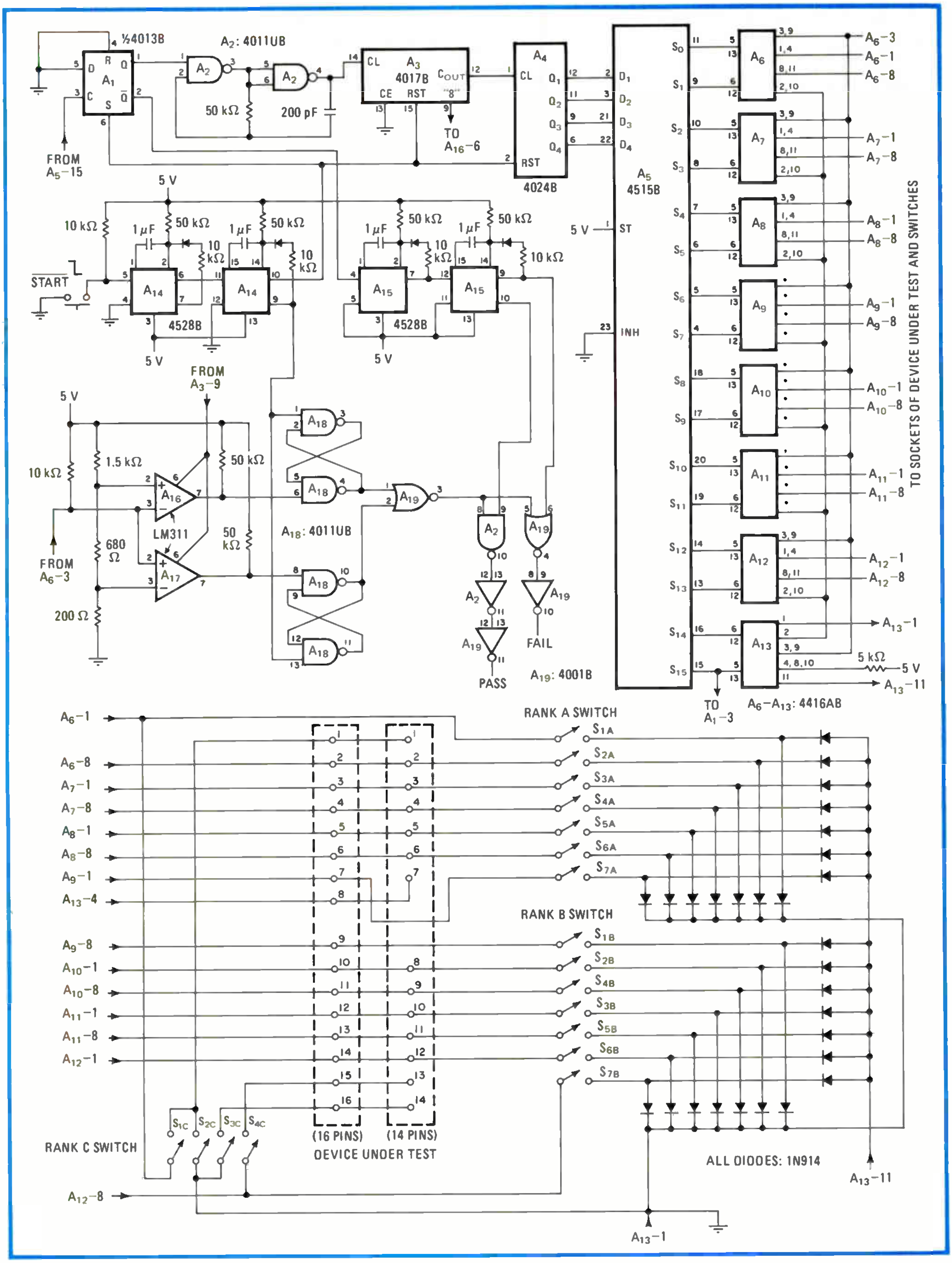


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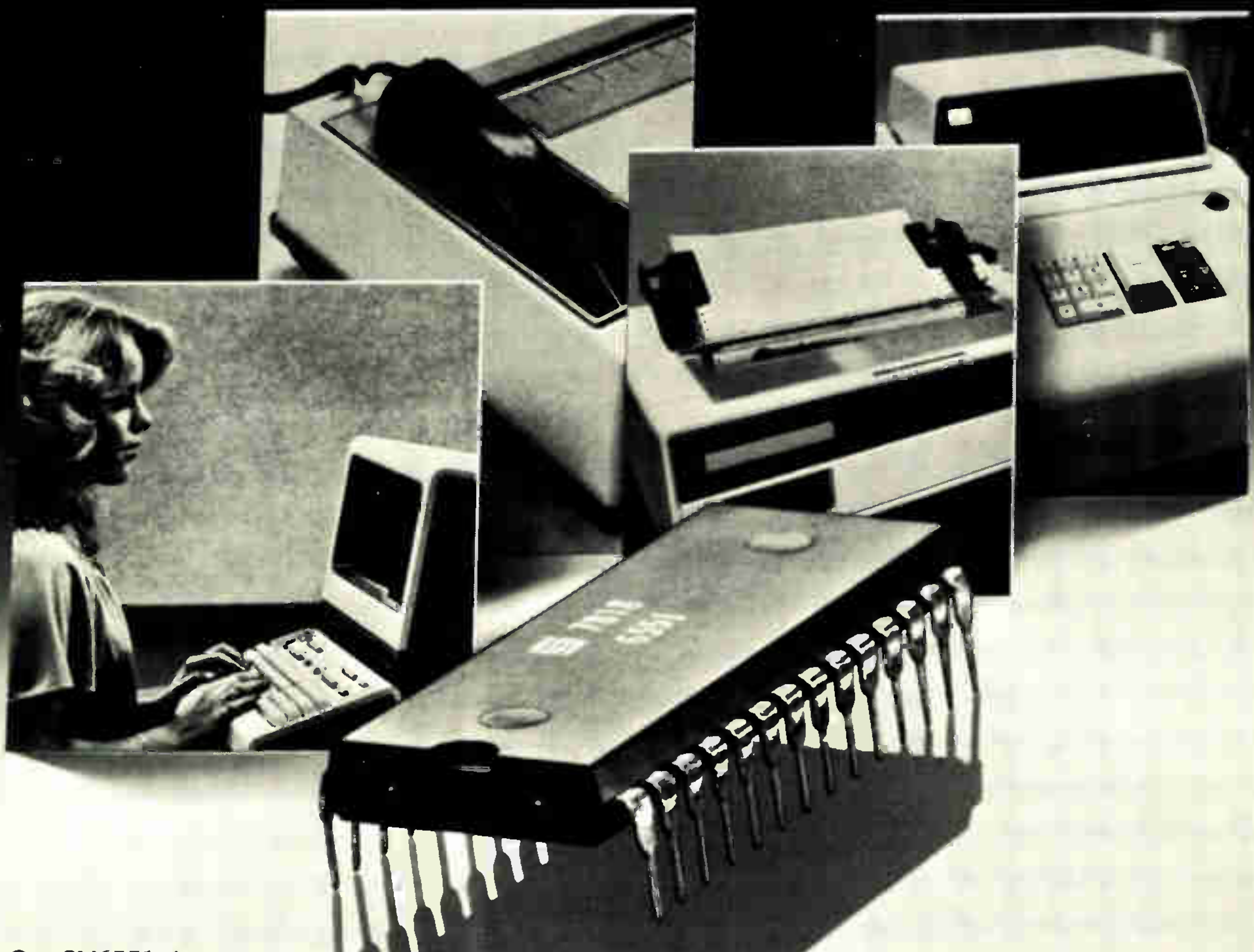

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| | Switch rank A | | | | | | | Switch rank B | | | | | | | Switch rank C | | | |
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| 4520B | | | | | | | | | | | | | | | ■ | | ■ | ■ |
| 4522B | | | | | | | | | | | | | | | ■ | | ■ | ■ |
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predominately caused by or result in internal shorting of wires between leads or open bonds to device pads and packaged posts. The detection of these failures is relatively simple for C-MOS chips because each input and output port is connected to two diodes internal to the device, one forward-biased with respect to the positive supply voltage and the other back-biased with respect to the negative supply. Hence it is necessary only to check whether each diode is opened or shorted. This, in principle, is simple to do.

Most C-MOS devices have at least 10 active ports, however, and consequently it becomes a problem to detect failures in many diodes while performing the minimum number of measurements. The proposed solution arrived at for testing C-MOS devices having up to 16 pins is shown in Fig. 1.

Briefly, $A_2$ serves as a gated oscillator operating at 100 kilohertz for stepping $A_3$, the 4017 decade counter, when the start button is pressed. $A_3$ generates a strobe for circuit timing and also advances $A_4$, the 4024 binary counter, so that each location of the 4515 1-of-16-line decoder can be addressed.

The decoder sequentially steps once through $A_6$–$A_{13}$, the quad analog gates, each of which is wired as a double-pole, single-throw switch. The output ports of the 4515 can thus provide a voltage for testing the diodes at all pins of the device under test.

Any transmission-gate output port connected to a shorted diode will move low. Open diodes will cause the output to float. The results of each individual diode test are monitored by window comparator $A_{16}$–$A_{17}$. The comparator's output is then latched by $A_{18}$ and passed into either the pass or fail gate at the output.

Switches $S_{1A}$–$S_{7A}$, $S_{1B}$–$S_{7B}$, and $S_{1C}$–$S_{4C}$, the so-called rank switches, which are connected to the test-socket pins, must be set accordingly to check the particular device desired. Required switch closures are presented in the table for all 14- and 16-pin 4000-series devices produced by Solid State Scientific Inc.

Note that the 28-diode matrix connected to the rank switches must be individually switched into the circuit of the particular device under test. The matrix is wired so that if there are any unused (inactive) pins in the device, the diodes will simulate the device's diodes; the open-short test may therefore be performed at each pin of the device without generating an erroneous response (that is, an open-circuit indication). □

# Engineer's newsletter

**Learn to write right**

It is difficult enough to communicate engineering information to engineers who are not expert in the field, but communicating it to nontechnical audiences is an order of magnitude worse. Just this problem will be addressed in a two-day seminar sponsored by the Communications Skills Center, Box 74, Newfield, N. J. 08344. And while the center does not claim that it will make you a best-seller writer in 15 hours of class plus an overnight assignment, its staff feels that it can transfer basic skills and progress at a more rapid rate than is possible in conventional courses. Quick information on cities and dates is available by calling (800) 448-4511, ext. 696, or (800) 962-1480, ext. 696, in New York.

**Prose lovers, unite**

The general-purpose calculus-level language Prose (Problem Solving Executive) has become so popular that a users' group is being formed. Interested persons use the language to solve numerical problems in many different areas because it does not require specific solution methods or algorithms—they're already built into the system. Frank Pfeiffer notes that "while Prose cannot compete with specific languages for the simulation of electronic circuits or devices, they cannot compete with Prose in optimizing models of circuits or in fitting models of circuits or devices to experimental data." Contact Frank at Bechtel Power Corp. 12400 East Imperial Highway, Norwalk, Calif. 90650 if you're interested, or call him at (213) 864-3567.

**HP offers show-and-tell on scopes**

Whether used for a refresher course or initiation into oscilloscope operation, technicians and engineers will find the going a little easier with a brand new series of video tapes from Hewlett-Packard. Three ¾-inch tapes, entitled "How to Use an Oscilloscope," cover theory and practical applications of the latest equipment, including variable-persistence and storage scopes, among other topics. Cost considerations ($900 for the series) suggest classroom or library use. For more information ask for the brochure from the company at 1507 Page Mill Rd., Palo Alto, Calif. 94304.

**Guide lists off-beat items**

Working electrical engineers will welcome the Guide to Scientific Instruments sponsored by the American Association for the Advancement of Science. This catalog of laboratory instruments and equipment and names and addresses of manufacturers includes those uncommon gadgets that are needed only occasionally and not covered by the better-known directories. Typical categories range from stereo microscopes and crystal slicers for the semiconductor-fabrication laboratory to space simulators for satellite testing and spectral-emission charts for laser designers. The 193-page guide is available from the Association at 1515 Massachusetts Ave. NW, Washington, D. C. 20005, either as part of yearly membership privileges or for $6.00.

**Harvey Hindin**

# Why buy a technical computer from a stranger...

# when you can buy one

There are a lot of technical computer manufacturers, but none has created so many measurement and computation products for the factory and lab as Hewlett-Packard. From audio oscillators and spectrum analyzers to computerized systems for satellite checkout, HP equipment has been doing the job for engineers and scientists since 1939.

This experience pays off for you with the HP 1000 computer family. Our HP-IB interface bus, for example, makes it easy to use data from our instruments for sophisticated computations and control. And our experience with computer links on our own factory floor helped us develop powerful networking software for yours.

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## Cutting the cost of capturing data.

Whether setting up a full-scale factory information system or a one-computer test station, you want to collect your data as easily and inexpensively as possible. That's why we wrote IMAGE/1000, our DBM capability, and DS/1000, our networking software. And that's why we designed the HP 2240A Measurement and Control Processor and HP-IB, our IEEE-488 standard

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interface, for use with 200 HP instruments. As well as a wide variety of general purpose interface cards, ranging from A/D converters to a 16-bit relay output register.

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## The HP 1000: a family that grows on you.

Your search for compatibility is further simplified by our wide range of peripherals. You can build systems with printers and printing terminals, CRTs and data input devices, disc and tape drives—all manufactured by HP. They work together smoothly, without making you do a lot of interfacing work. And you can be sure of quick single-source service whenever you need it.

So why don't you get together with a company that has 25,000 technical computer installations to its credit? We're listed in the White Pages of your phone book. Or write for complete information about the HP 1000 family to Hewlett-Packard, Attn. Bob Puette, Dept. 642, 11000 Wolfe Road, Cupertino CA 95014.

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Circle 155 on reader service card

# Here's a miniature 3½ digit portable multimeter that delivers extraordinary performance and value for only $189.

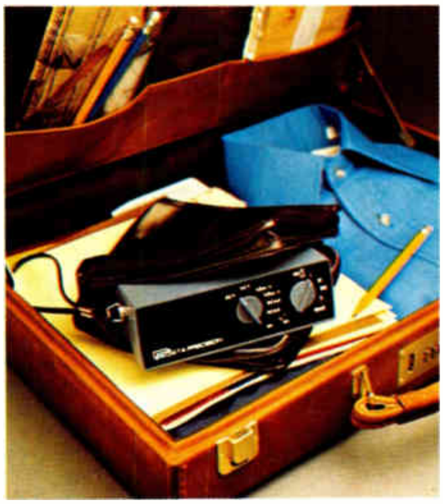
Data Precision proudly presents a 0.1% accuracy multimeter that brings the same high performance and value to 3½ digit portable instruments that our Model 245 brought to 4½ digit multimeters. The same levels of reliability, the same small size, the same great convenience and flexibility. The Model 175 has it all... and more for just $189.00.*

## High performance

The Model 175 gives you 32 ranges of measurement capability, six functions, 0.1% DCV accuracy guaranteed for one year, and 100 microvolts resolution. You can measure DCV from ±100 microvolts to ±1000V, ACV from 100 microvolts to 500V with a frequency response of 30Hz to 50kHz, DC Current from ±100 nanoAmps to ±2A, AC Current from 100 nanoAmps to 2A with a frequency response of 30Hz to 50kHz, Resistance from 100 milliohms to 20 Megohms **in two excitation voltages.**

## Real miniature portability

Here is true miniature portability that delivers lab performance wherever you take it. And you can take it **anywhere.** The 175 operates from AC line, or rechargeable NiCad batteries for 6 hours of in-spec operation. Add this to the remarkably small size 1¾"H x 5½"W x 3½"D, 34 cu. in., weight 22 oz. (4.45 x 13.97 x 8.89cm, 552cc, .63kg.) exceptional operating temperature characteristics, rugged construction... and you can see that this is **real** portability.



## Right at home in the lab

Connect the 175 to an AC line and you have a great bench instrument. It's always recharging when line connected and ready to go into the field whenever you need it.

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# System cuts cost of LSI testing

## Fairchild's medium-priced Sentinel tester can work with programs originally developed for its large Sentry system

*by Robert Brownstein, San Francisco regional bureau*

**Basically, there are** two types of equipment for testing large-scale integrated circuits: very expensive engineering-oriented systems, which are not really suitable for high-volume testing; and much less costly dedicated benchtop units, whose main drawback is lack of flexibility. The large gap in price and performance between the two is one that Fairchild Camera and Instrument expects to fill with its new Sentinel test system.

The general-purpose tester sells for considerably less than the Tektronix S-3280 and Fairchild's own $200,000-plus Sentry system. At the same time it is better suited to high-volume applications, according to the company. "That's where IC manufacturers are feeling some pain," says Gary Ure, Sentinel marketing manager. "They have to keep increasing the scale of integration and productivity, but keep prices low because of competition. Therefore, they have got to reduce their testing costs."

"The $30,000 benchtops look good at first because of their low initial price, but there are hidden economics that crop up—like the lengthy development time," Ure claims. "For a single device like an 8080, a benchtop provides a valid turnkey test solution. But if a user wanted to test another device with it, he would have to go through a lengthy development sequence again."

Whereas Sentinel's base price of $85,000 is significantly higher than that of benchtop testers, Ure feels the system's development and device-flexibility strengths more than compensate. "Fairchild has more than 75 percent of the LSI market using its Sentry testers, and those users have spent millions of dollars developing programs for Sentry. That investment remains intact because nearly all of those programs can be used for Sentinel with very minor changes. That has an enormous effect on development time and test cost."

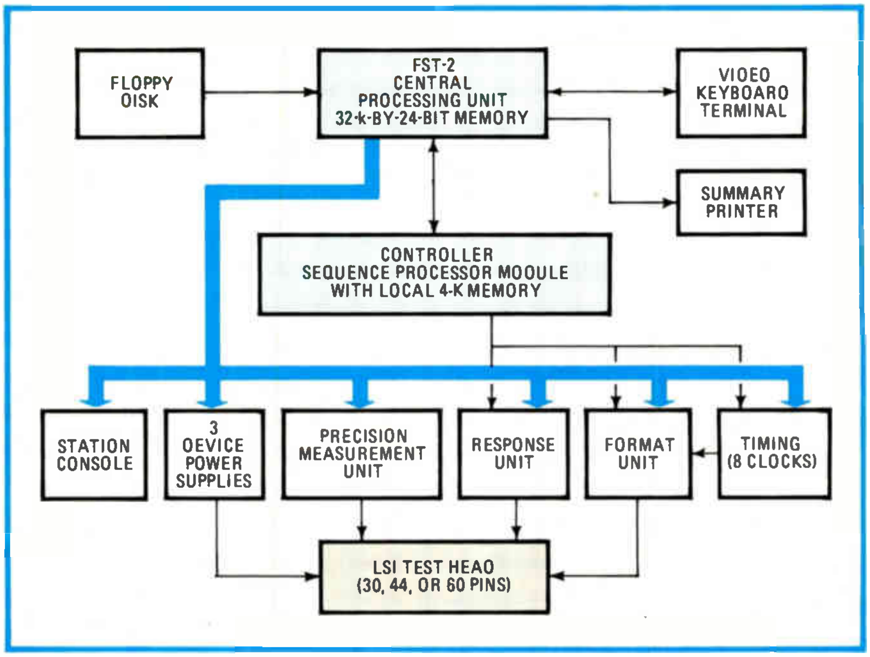
Sentinel's flexibility comes from its kinship with the general-purpose architecture of the Sentry system. To change from one device to another, the user changes the program, but needs to make little if any change in hardware other than swapping performance boards.

Sentinel's operating system, a subset of Sentry's Mastr multitask operating system, has been streamlined for production testing. New programs are developed on Sentry using Fairchild's Factor high-level language and then loaded onto flexible disk.

Older Sentry programs are revised with the support of Sentnl utility software, which denotes any statements that Sentinel will not support. Once the programs are on disk, they can be loaded into Sentinel via its flexible-disk drive.

Identical nucleii in both Sentry and Sentinel (see diagram) ensure software compatibility. Each has the FST-2 general-purpose central processing unit arranged in 24-bit word widths. Sentinel's CPU comes standard with 32 kilowords of memory and can be expanded to as much as 196 kilowords.

The high-speed Schottky logic




**Compatible.** Because the CPU and controller of the Sentinel are the same as those of the older Sentry system, existing programs can be run on the new machine with few changes.

microcode embedded in Sentinel's controller also mirrors similar circuitry in the Sentry system. The rest of the hardware, however, was completely redesigned with low cost and high performance as primary objectives, according to Ure.

The test head and test control console are housed in a table separate from the FST-2, assorted power supplies, precision measurement unit, and high-speed controller. Two types of test head are available: an LSI unit for wafer sorting or final-test operations, and a high-speed head for more stringent quality-approval or final-testing tasks. Each can be ordered with 30, 44, or 60 pins, and Sentinel will interface with one or two; however, they must be of the same type.

Sentinel can perform functional tests at up to a 10-MHz rate as well as carry out dc parametric tests at up to 1,000 per second. Its controller is the key to the rapid functional test rate because it performs on-the-fly changes in definition, reference voltage, and data drive modes while keeping failure records and inverting data patterns where formats dictate. The controller's eight registers and sequence processor module carry out those changes. Moreover, this module can nest subroutines up to 16 deep and can supply clock bursts.

Controlled by four registers loaded by the FST-2, Sentinel's precision measurement unit carries out dc parametric tests by applying voltages or forcing currents at a pin location and sensing the current or voltage reactions at the same pin. In addition, when called upon by self-test diagnostic software, the measurement unit performs tests on Sentinel itself.

The basic $85,000 system includes CPU, controller, the measurement unit, power supplies, station console, a standard 8-in. flexible diskette drive, video keyboard terminal, and 150-line-per-minute 80-character-per-line electrostatic printer. Added CPU memory options and interface to Fairchild's Integrator II host computer can run the tab up to $200,000.

First demonstration of Sentinel is scheduled for this month with first system delivery slated for April.

Fairchild Camera and Instrument Corp., Test Systems Group, 1725 Technology Dr., San Jose, Calif., 95110 [338]

# "Committing yourself holding your breath for

For all the dramatic success stories, the idea of custom LSI still scares the pants off a lot of people. How can they be sure of getting delivery in time to meet their marketing deadlines? Why should they trust the future of a new product to a single supplier? Why not play it safe with microprocessor systems? What about cost?

In the twelve years since making our first custom MOS chip, AMI has heard it all. And we've turned many hard-nosed skeptics into true believers, with scores of extremely successful products to show for their conversion.

Still, the questions are asked. And, as the leader and chief innovator in this complex field, we'd like to answer them.

**"Why take chances on a single supplier?"** There have been cases where two MOS companies were hired to work on the same project. But that kind of expense really isn't necessary if you pick the right MOS company in the first place.

To begin with, their engineers should be able to assess your application to see whether custom is the most cost-effective approach. As AMI makes a variety of standard parts, too (4, 8 and 16-bit microprocessors, memories, telecommunication and consumer circuits), we're in a good position to make an unbiased appraisal. We can show you whether pure custom would give you the most for your money. Or whether a standard system would do the job. Or maybe a system based on a standard microprocessor with custom peripherals would give you the best of both worlds.

If custom's the answer, we can design your proprietary circuit from scratch. Or, if you have the know-how, you can do the design and we'll do the manufacturing. (This "customer tooling" approach can satisfy your second source requirements, if you have any.) A third option is a joint development venture where a team from your company and a team from ours work together to build LSI circuits for families of products.

# to custom LSI is like nine months."

In a technology this complicated, all MOS companies sometimes run into design or production problems. But keep in mind that AMI has far more experience than anyone else. With more than 1200 different circuits under our belt, we know what will work and what won't. That's one reason we average less than seven months from firm specification to fully-tested LSI circuits—the fastest turnaround in the industry. As we work in 25 variations of four major processes, we don't have to bend your application to fit any production limitations. And we have plants in California, Idaho and Korea to build you all the product you need. (Some of our custom clients use more than a million circuits a year.)

**"Custom's too damn expensive."**

This is one of the great LSI myths. Obviously, the front-end engineering costs are higher than pulling standard parts off the shelf. But there are several reasons why custom can end up cheaper in the long run.

First, you're only paying for what you need. As opposed to a microprocessor system where you often have to buy more capability than you'll ever use. That makes custom more cost-effective in your system. And remember, quantity prices of custom circuits follow a similar volume curve as standard products.

But, when you get right down to it, the value of a custom circuit lies in its uniqueness. Its ability to give your product features that nobody else has. That advantage is priceless.

**We wrote the book on custom LSI.**

And, as the pioneer in this field since 1966, we keep rewriting it. We've now published a comprehensive new brochure on the subject titled "AMI's Six Step Program for Success in Custom LSI."

These six steps are: 1) Considering all the factors; 2) Looking at the custom options; 3) Selecting the right MOS/LSI process; 4) Designing the best circuit; 5) Fabricating the optimum device; 6) Testing for reliable performance.

If you think just any custom company could have written this book, think again. It touches on several areas that set AMI apart from the rest. The number of options. The shortening (by about a third) of the design cycle using our SLIC method (Symbolic Layout of Integrated Circuits). And an advanced project management system that allows us to track your circuits from initial logic to computerized testing of every chip.

It also touches on some of AMI's applications' history, showing how far we've come in the past decade. We've made anti-skid and miles-to-empty circuits for the auto world. Sewing machine, kitchen range, washer/dryer and microwave oven controls for the appliance industry. Chips for phones, video games, televisions and electronic organs. And a broad spectrum of EDP applications, from keyboards and displays to memory management systems.

The list goes on and on. But, compared to the potential uses of custom LSI, it's a fairly brief prologue. Every day we come up with exciting new solutions to antiquated electromechanical or MSI problems.

Why don't you come and explore these possibilities with us? Write or call AMI Custom Marketing, 3800 Homestead Road, Santa Clara CA 95051. Phone (408) 246-0330. Or at one of these regional sales offices: California, (213) 595-4768; Florida, (305) 830-8889; Illinois, (312) 437-6496; Indiana, (317) 773-6330; Massachusetts, (617) 762-0726; Michigan, (313) 478-9339; New York, (914) 352-5333; Pennsylvania, (215) 643-0217; Texas, (214) 231-5721; Washington, (206) 687-3101.

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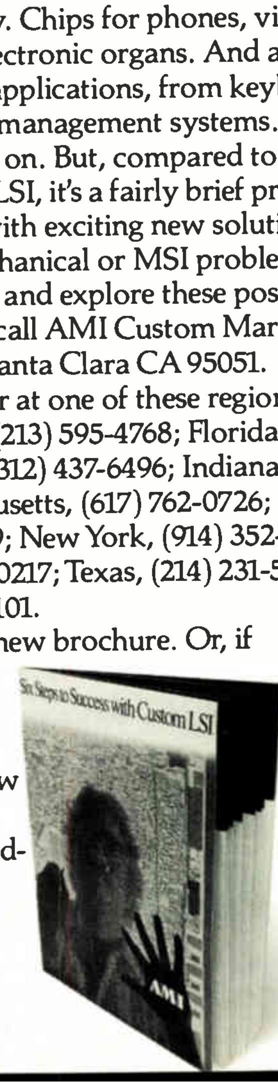


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# 5-V board controls minifloppies too

## Compatible with SBC 86/12 controller supports soft-sectored diskette drives

Intel's iSBC 204 universal flexible-diskette controller is the first board to exploit the features of its 8271 programmable floppy-disk controller chip. It is also Intel's first rotating memory controller compatible with mini-floppy as well as floppy disks. The board will work with the recently announced iSBC 86/12 single-board computer, as well as with other Multibus products.

Because the new board replaces much of the bipolar logic used in previous disk controllers with metal-oxide-semiconductor devices, it requires substantially less power and operates from a single +5-V supply.

The board is capable of supporting virtually any software-sectored, single-density standard or mini-floppy diskette drive. It can control two drive surfaces (two single-sided or one double-sided drive). With the addition of a second Intel 8271 controller chip, as many as four drives can be supported.

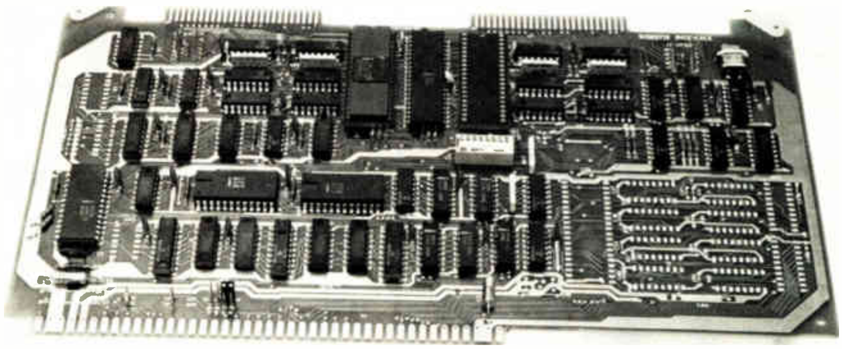
In addition to IBM's standard 3740 formats, the iSBC 204 controller can accommodate sector lengths of up to 4,096 bytes, as well as minifloppy formats. The operating characteristics (track-to-track access and head-loading and head-settling times) are programmable by the user. Moreover, the controller can read, write, verify, and search on either a single- or multiple-sector basis.

The heart of the board is the 8271 chip. On-board data-separation logic performs standard frequency-modulated encoding of the data. This eliminates the need for external separation circuitry at the drive itself. Data transfers may be of a direct-memory-access or non-DMA variety. Another Intel device, the 8257 DMA controller, manages DMA transfers and signals the master iSBC processor when a transfer is completed.

The 8271 is capable of executing high-level commands, which simplify software development for the system. Cyclic-redundancy-check characters are also generated and checked automatically. As a result, two tracks on each surface may be designated bad and logically removed (ignored) from the diskette.

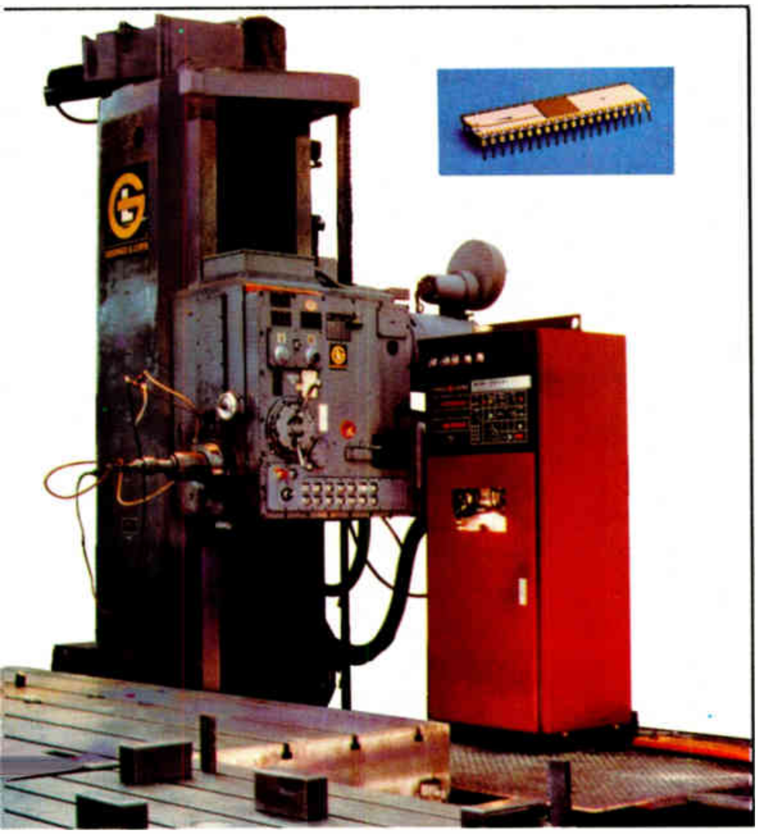
All diskette operations are initiated via standard input/output port operations through an iSBC single-board computer. In a typical sequence of events, the controller is first programmed with system software to be compatible with the operating characteristics of the selected drive. The diskette is then formatted under program control. If DMA is to be used, the starting memory address and the mode of transfer are specified. Finally, data transfers occur in response to commands from the central processing unit.

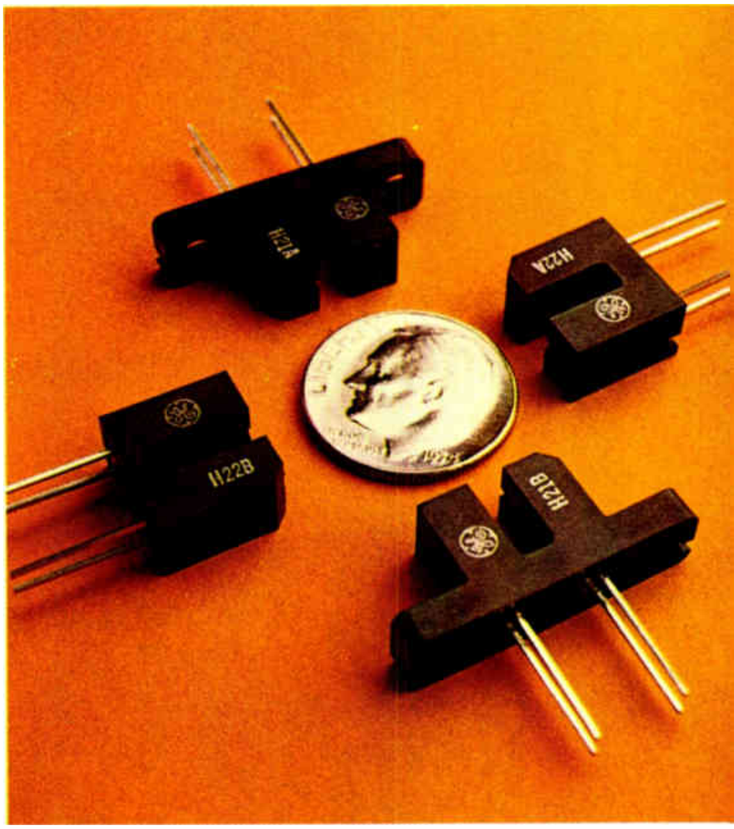
Once a diskette-transfer operation is under way, the 204 plays the role of a bus master and sends data over



# What brings μ processor precision performance to your workhorse?

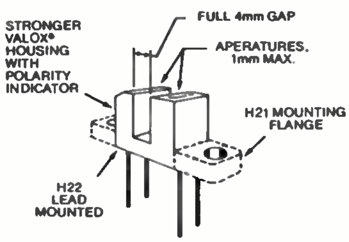
# GE's new supersensitive interrupter module.






Equipment from computer peripherals to machine tools can now take advantage of precision μ processor performance with General Electric's H21 series interrupter modules. Compatible with popular logic systems from CMOS to relays, these new high current, high voltage modules have been optimized to improve resolution and accuracy, and provide up to 25MA minimum specified output and 55V blocking capability.

The H21 and H22 modules provide a consistent light beam with maximum dimensions of 1 mm x 1.5 mm.




There are 24 types of interrupter modules available, 12 transistor detectors and 12 darlington detectors. Transistors feature low saturation voltage (≤ 0.4V at 1.8 MA) and darlingtons high output current, (≥ 50 MA at 1.5V). All with the high performance you need in measurement systems and mechanical/electronic interfaces.

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the Multibus at high speed. The CPU need not be involved until the transfer is complete. Termination can be indicated by the generation of an interrupt on the bus or by the recognition by the CPU of a "done" bit."

The iSBC 204 is supported by the diskette file system available with RMX/80, Intel's real-time executive. Files may be created, deleted, or changed, and file names may be symbolic in nature. Data can be accessed from files either sequentially or directly. An unlimited number of files can be open simultaneously and multiple tasks may be read to the same file at the same time.

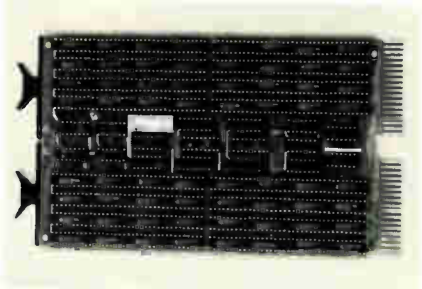
The system can also be used with Intel's high-level languages. Using the structure provided by the RMX/80 Disk-File System, the Basic-80 disk-based interpreter provides facilities for the storing and retrieving of data as well as programs. The formatted input/output capability of Fortran-80 also provides for easy filing and access of data. The iSBC 204 is available now. It sells for $650.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. Phone (408) 987-8080 [381]



## Static memory for LSI-11 uses single 5-V supply

Users who would like to improve the reliability of their LSI-11, LSI-11/2, or PDP-11/03 computers can now do so by using a truly static memory board, which eliminates the extra circuitry required for memory refresh. Configurable for a maximum of 16 kilowords of 16 bits each, the standard dual-size VML1116 fits in a single option slot from which it



draws 2.5 A at 5V, the only power it requires.

Available in 4-, 8-, 12-, and 16-kiloword configurations, it is addressable in 4-kiloword increments. Using TMS 4044 4-K-by-1-bit static random-access memories, the VML1116 provides access times of 250 ns, so that cycle time for the unit is actually faster than the central processing unit requires.

A fully populated low-power board is priced at $950 in single quantities and is available from stock; discounts are available on large orders. It is unconditionally warranteed for one year and has a minimum projected mean time be-



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Every single unit bearing the Power-One label undergoes a full functional test, followed by a 2-hour burn-in, plus a final full functional test. We repeat — *every single unit!* Compare this to other manufacturers who conduct only a single operational test. That's why no other open-frames match ours for long life and overall reliability.

### Talk about selection...we have 84 standard models.

Without a doubt, Power-One has the broadest selection of "off-the-shelf" open-frames in the industry — 84 different models. Single outputs, duals and triples... plus new Floppy-Disk and Microprocessor series. And these are all off-the-shelf *standards*, ready for delivery when you need them. Last year alone, we delivered over 100,000 of these standards — on time! That makes Power-One the largest producer of open-frames in the world.


### Talk about catalogs... we've got a beauty.

It's all new, and all inclusive. Complete specs, dimensional drawings, and prices on every standard model. So don't delay. Get your free copy now.

Also, for off-the-shelf delivery in your area, call us for the location of your nearest Power-One distributor.

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Circle 169 on reader service card

## New products

tween failures of 50,000 hours.
Computer Extension Systems Inc., 17511 El Camino Real, Houston, Texas 77058. Phone Gary Wagner at (713) 488-8830 [384]

### MOS boards operate at 4-MHz clock rates

Time was when a designer looking for 4-MHz system rates narrowed the field to bipolar-based boards. These days, however, he can look to metal-oxide-semiconductor devices, particularly if he wants to upgrade an existing MOS system.

The latest set of 4-MHz MOS boards includes three cards: a Z80A-based microcomputer board, a floppy-disk controller, and a memory board. The first, appropriately dubbed the Z-80A MPB, contains not only the microprocessor but also the interface for a line printer and two independent full-duplex serial communications channels, as well as a direct-memory-access controller.

Sixteen programmable input/output lines on the card directly interface it with a line printer, and replaceable buffers can be programmed by jumpering for three-state printer control. Communications interfaces are compatible with RS-422, -423, and -232 channels, and they are baud-rate programmable. The DMA function can be used for block transfers and data search control.

The single-board floppy-disk controller, Z80A FDC, provides direct control of up to eight single-density floppy or minifloppy drives. Although designed to mate with Shugart 400, 450, 800, and 850 drives, the control and data ports can be programmed for individual design needs. Functionally compatible with the Z80 MDC, it allows files written on 2.5-MHz systems to be upgraded immediately to 4-MHz operation.

The Z80A RRM can be filled to the chocks with both random-access and read-only memory. Starting at 16 kilobytes, the board can be populated with up to 64 kilobytes of RAM. Four on-board sockets can accept a maximum of 8 kilobytes of 2716-


First, imagine small. Because Statek Crystals are small . . . approximately 1/10 the size of conventional low frequency crystals. They employ the tuning fork crystal technology Statek introduced, then perfected for the watch industry. Thus, the small 68¢* cost . . . the lowest cost, high volume, crystals available for discrete or hybrid use . . . world-wide.

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And you won't have frequency selection problems either . . . 19 standard frequencies, plus Statek's precision laser tuning that lets you pick from over 350,000 others.

If you have an immediate volume application, contact the factory for samples or specific information. Or consult EEM/GOLD BOOK for specifications.

Statek Corporation, 512 N. Main, Orange, California 92668, Telephone: (714) 639-7810 TELEX 67-8394

*100k qty

**STATEK**

INNOVATORS IN FREQUENCY CONTROL

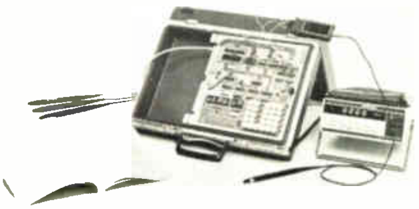
type programmable ROMs. The entire board can be powered from a single 5-V source, thanks to an on-board dc-to-dc converter that supplies −5 and +12V.

In single quantities, the microcomputer, the disk controller, and a 16-K memory are priced at $695, $495, and $850, respectively.

Zilog Inc., 10340 Bubb Rd., Cupertino, Calif. 95014. Phone (408) 446-4666 [383]

## Microcomputer teaches repair as well as use

Besides educating engineers in how to operate it, the 5036A instructs them in how to repair it, which is a much rarer talent among teaching



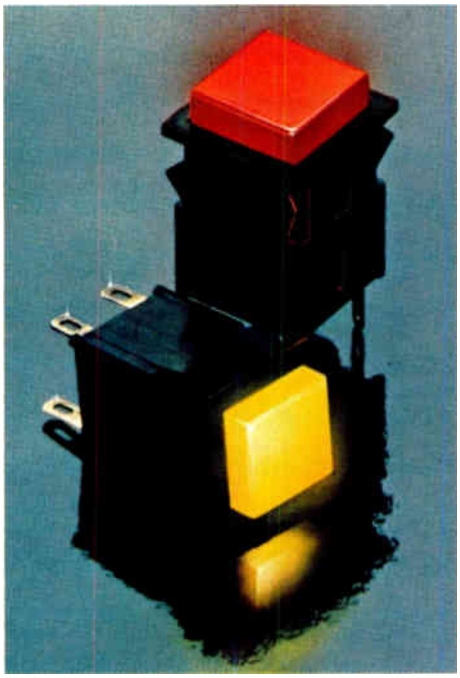
microprocessors.

Called the Microprocessor Lab, the microcomputer is based on the popular 8085. The $800 system has a six-digit light-emitting-diode display, a hexadecimal keyboard, a speaker, and 1 kilobyte of user-programmable storage space.

Individual system components have been laid out on a color-coded block diagram to help users visualize a microcomputer's operations and its functional organization. The clearly marked data, address, and status lines have associated LEDs so that, when the lab is operated in the single-step mode, students will be able to see what each signal line is doing during a machine cycle.

To teach troubleshooting, the 5036A works with a model 5024 troubleshooting kit, which contains a logic probe, a logic pulser, and a current tracer, and a model 5004 signature analyzer. Both the $625 5024 and the $990 5004 are intended for field use, as well as for instruction. Faults can be injected


## Now, all the best features of low cost, low energy, lighted pushbutton switches in a single line.



Licon's Series 05 and 05-6 Series LPB Switches are your most reliable, economical answer to a wide variety of complicated lighted pushbutton switch requirements.

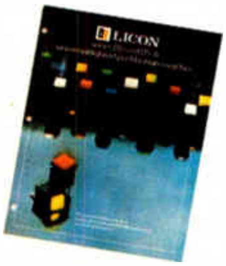
They're the ideal LPB's for applications requiring low level switching and economy. Proven, bifurcated silver plated contacts. Recognized for long, self-cleaning wiping action. No expensive gold contacts.

These amazing little switches are highly versatile. Momentary and maintained action styles plus lighted and non-lighted versions. Maintained action switches offer "dual indication," light and lens position.

And look at our light savers' exclusive design. Smooth, pleasing "feel". Snap-in bezel mounting for rigid retention. .110 quick disconnect or PC board terminals. Rainbow of colored lens cap choices. U.L. Listing.

**05 Series LPB's** fit .625 square panel hole size; accept low cost T 1¾ wedge base lamp. Relamp from front panel. 1 Amp., 125 VAC rating. Compatible L.E.D. version complete with L.E.D. display lens.

**05-6 Series LPB's** mount in .750 square panel cutout. Use versatile front panel replaceable T 1¾ flange base lamp. 1 or 3 Amp. versions, 125 VAC rating. Lens barriers available.




For full details, contact your local Licon Distributor, or call or write for our Switch Catalog: LICON, 6615 West Irving Park Road, Chicago, Illinois 60634. Phone (312) 282-4040. TWX: 910-221-0275.

**LICON**
A DIVISION OF ILLINOIS TOOL WORKS INC.



Circle No. 126 For Full Details
Circle No. 173 To Have Salesman Call

into the system by means of plug-in jumpers.

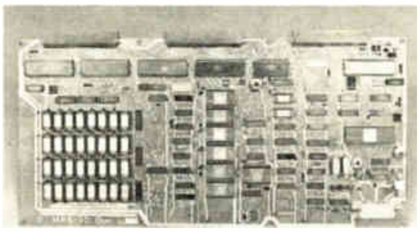
Monitor programs for the Microprocessor Lab reside in read-only memory. They include a self-test program, demonstration programs, and a signature-analysis test program that exercises all system nodes.

The teaching aid comes in a briefcase accompanied by a 20-lesson, 50-hour course. Delivery time is 12 weeks; the 5024 and 5004 are available from stock.

Hewlett-Packard Co., Inquiries Manager, 1507 Page Mill Rd., Palo Alto, Calif. 94304 [387]

## Single-board unit serves four floppy-disk drives

Designers who would rather have their Z80-based computers served on a single board can turn to the 90F/MPS, which can be configured for either 2.5- or 4-MHz operation. Among the smorgasboard of features it offers are up to 65 kilobytes of dynamic random-access memory, 1 kilobyte of static RAM, 14 kilobytes of ultraviolet-light-erasable



programmable read-only memory, and an enticing multidensity floppy-disk controller.

The controller lets users support as many as four floppy or minifloppy single- or double-density drives, providing direct memory access, multiple-track transfers, and data scanning. Also included are a PROM programmer, four programmable input/output ports and counter-timer channels, an RS-232 or 20-mA serial port with selectable baud rates, and a PROM-resident system monitor with debug capabilities.

With 16 kilobytes of dynamic RAM, single boards cost $1,295. Delivery time is 30 to 45 days after



receipt of order by the company.
Quay Corp., P. O. Box 386, Freehold, N. J. 07728. Phone John Lacatel at (201) 681-8700 [385]

## ANSI/ECMA-type recorder tapes 2 megabits quickly

Compatible with ANSI or ECMA recording standards, the model 764-8EU is a high-speed recorder that can provide over 2 megabits of storage on a single cassette. The recorder, whose transport has only two moving parts, simplifies interfacing by responding to command and status words, which control 8-bit parallel data transfers.

Data can be recorded in variable block lengths and, by means of an automatic reversal feature, on both tracks without physically reversing the tape. The unit reads and writes 800 characters per second, has read-after-write capability, and rewinds and searches at rates of 100 in./s. Delivery time for the $865 recorder is two weeks.

Memodyne Corp., 220 Reservoir St., Needham Heights, Mass. 02194. Phone Kevin Corbett at (617) 444-7000 [386]

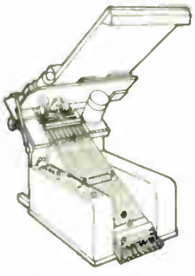
## Software assembles over 1,000 lines per minute

MACRO-80 is an 8080/Z80 assembler that incorporates most of the features commonly found in mainframe assemblers without sacrificing speed or memory space. The 14-kilobyte assembler, which comes packaged with a linking loader, library manager, and cross-reference facility, can assemble over 1,000 lines per minute.

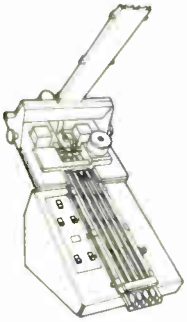
The software supports a complete Intel standard macro instruction facility, with nesting of macros limited only by memory. The package is priced at $200 in single quantities, with discounts available for original-equipment manufacturers.

Microsoft, 10800 N. E. Eighth, Suite 819, Bellevue, Wash. 98004. Phone Steve Wood at (206) 455-8080 [388]

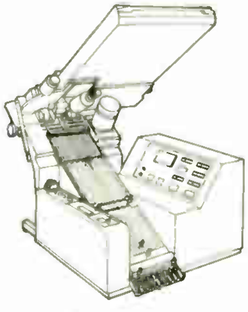

# ...It's MCT's Series 2608



Series 2608M
8,500 DPH
Expanded Input
Ambient Handler



Series 2604
5,000 DPH
Ambient
Temperature
Handler



Series 2608E
7,000 DPH
Elevated Temperature
Handler

The MCT Series 2608 is the answer to reducing the costs of today's high volume DIP handling requirements.

The Series 2608's 10,000 DPH speed (at zero test time) and 8 output categories provide efficient handling of devices with a fast return on investment dollars. Because of its high speed, the Series 2608 will often eliminate the need for additional IC testers and operators. Its increased productivity often justifies the replacement of less efficient DIP handlers.

The Series 2608 is versatile. It handles devices with from 8 to 40 leads. Changeover kits allow you to handle .3, .4 or .6-inch wide devices. You can even purchase an optional 13-track input reservoir for even greater operator productivity.

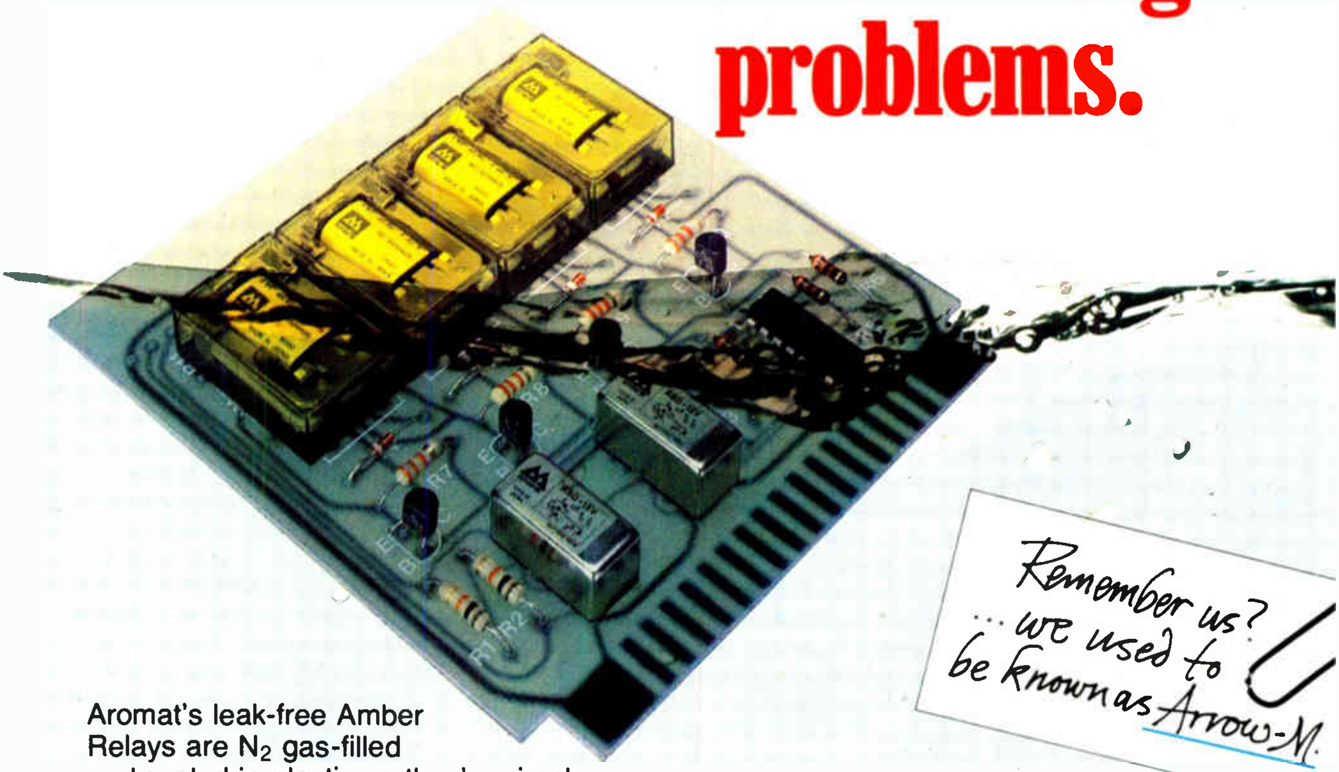
The Series 2608 is reliable. Five-million cycle contact life . . . self-lubricating bearings . . . wear resistant surfaces . . . 'leads up' cycling of devices to virtually eliminate jamming . . . all assure that the 2608 will be up and running so you won't be running to call your serviceman.

The Series 2608 is just one of our many fine IC handlers. It is fully supported with installation, service and operator training programs. Find out for yourself why we're the leader in handling equipment. Contact MCT, Inc., P.O. Box 43013, St. Paul, MN 55164 or call (612) 482-5170.

micro component technology

# Aromat Amber Relays

# solve PC board cleaning problems.




Aromat's leak-free Amber Relays are $N_2$ gas-filled and sealed in plastic so they're simple to clean with most degreasers and detergent cleaners, without affecting the maximum contact reliability of the relays.

In addition, Aromat's vacuum annealing production process completely outgasses all plastic parts, thereby completely eliminating any possible contact contamination.

Aromat can help you substantially reduce your labor costs! Just use Aromat Amber Relays on your PC board in conjunction with automatic wave soldering.

The total savings are even greater when you use Aromat Amber Relays. Aromat Amber Relay prices are right in line with standard non-seal types.

Aromat Amber Relays. When you want maximum reliability and maximum savings. And only Aromat makes them.

| Series | Contact Form | Rating | Style | Size |
|---|---|---|---|---|
| RS | 1 Form C | 1 Amp | Half size | (.787Lx.394Wx.394H) |
| NF2E | 2 Form C | 2 Amp | Flat pack | (1.165Lx.772Wx.425H) |
| NF4E | 4 Form C | 2 Amp | Flat pack | (1.165Lx.953Wx.425H) |
| K2E | 2 Form C | 2 Amp | Cradle type | (.929Lx.748Wx1.181H) |
| K4E | 4 Form C | 2 Amp | Cradle type | (1.157Lx.748Wx1.181H) |
| K6E | 6 Form C | 2 Amp | Cradle type | (1.370Lx.748Wx1.181H) |
| HC1E | 1 Form C | 5 Amp | General purpose | (1.097Lx.827Wx1.280H) |
| HC2E | 2 Form C | 3 Amp | General purpose | (1.097Lx.827Wx1.280H) |
| HC4E | 4 Form C | 2 Amp | General purpose | (1.097Lx.827Wx1.280H) |

***Relays for Advanced Technology***

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Circle 179 on reader service card

Communications

# Optic cables take hard pulls

### Cable construction eliminates strain on fiber elements, prevents microbending losses

To successfully challenge its copper competition overall, fiber-optic cables must take first prize in the long distance run. The fiber challenger must not only be cost-competitive, but must also overcome environmental antagonism and the strains of the long pull. In its latest series of all dielectric, multiple-optic-fiber cables, Siecor believes it has found the great light hope.

The cables are designed in such a way that the optic elements are not subjected to any load, an accomplishment achieved through clever construction. The load-bearing member of the cable is an external jacket of Kevlar or steel. Inside, a central core of steel or glass fiber is surrounded by buffer tubes of Halar 300, a chemically and mechanically nonaging fluoropolymer. This material exhibits the necessary resistance to common solvents, oils, and acids and is nonflammable.

Inside each buffer tube is an optical fiber with an outside diameter much smaller than the inside diameter of the tube. The actual length of this fiber is longer than the buffer tube, and the excess is taken up by spiraling the cable inside the tube. Thus, enough slack is provided so that the cable can be stretched without the fibers' experiencing strain.

If the space between the buffer and the fiber were allowed to remain empty, water would eventually find its way in after the cable was installed. When temperatures dropped below freezing, the ice formed would create sufficient pressure to pinch the fiber, considerably raising its attenuation—a failure mode referred to as microbending. To prevent this, Siecor fills the space with a viscous polyurethane compound of its own devising. The self-healing compound is soft enough to allow necessary fiber movement.

Whereas general-purpose cables that do not have to face harsh environments are usually supplied without the buffer filling, telecommunications-grade cables, available in versions for duct, aerial, and plow-in applications, are. The construction of these cables allows them to survive field conditions, and permits easy installation by typical field workers, rather than engineering personnel. The cables can withstand over 200 lb of pull during installation and a constant load of about 65 lb during active life.

At 820 nm, the optic fibers have a maximum attenuation of 6 to 8 dB/km, depending on type. They are available with 3-dB bandwidths of from 200 to 600 MHz at 1 km. The cables are priced at approximately $1.50 per fiber per meter.

Siecor Optical Cables Inc., 631 Miracle Mile, Horseheads, N. Y. 14845. [401]

### GaAs-GaAlAs laser diode has extremely long lifetime

The fundamental principles for the fabrication of double-heterostructure injection laser diodes have been known since the early 1970s, yet conquering unreliability in the devices has proven difficult.

Armed with refined production processes, a newly formed New Jersey company, General Optronics, is producing a single-mode gallium-arsenide–gallium-aluminum-arsenide device, called GOLS-1, that has a projected operating life of over 100,000 hours.

That projection was the result of more than 26,000 hours of ambient-temperature testing at 5-mW continuous-wave output, which also provided the statistical knowledge that 99.7% of all device failures occur within the first 100 hours. Thus all units receive a 100-hr burn-in.

In addition to lifespan, the diode exhibits improvements in threshold

# TM 500 Pulse Generators give you the capabilities you need and the flexibility you want...

## from Tektronix.

Look around, you'll find our TM 500 Pulse Generators used in just about every application—including radar, biomedical research and digital design.

And because they're part of the TM 500 family of configurable instruments, you can mix and match these generators with over 40 other compatible instruments including scopes, DMMs, counters, and even a digital delay. They slip into the TM 500 mainframe of your choice: rackmount, benchtop or travel lab.

And there's something else of value that comes with these TM 500 packages: a sophisticated array of control functions that let you handle complex pulse requirements with ease. For instance, the 50 MHz PG 508 features double and delayed pulse control. Independently variable rise and fall times. Independent pulse top and bottom level controls. Plus, a true 50Ω output impedance for clean waveforms into high impedances, ideal for CMOS applications.

From the powerful PG 505, you can get up to an 80 V output from a 4kΩ surce. And when you add the capabilities of our 250 MHz PG 502 and our 50 MHz PG 501, you can choose a TM 500 Pulse Generator to tackle almost every electronic measurement application. And, to generate complex waveforms, two or more TM 500 Generators can be combined in a single mainframe.

How can we help you? Call the Tektronix Field Office nearest you. To request a copy of the TM 500 Catalog, call our automatic answering service (toll-free) number: 1-800-547-1512. In Oregon, call collect: 644-9051. In Europe: Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

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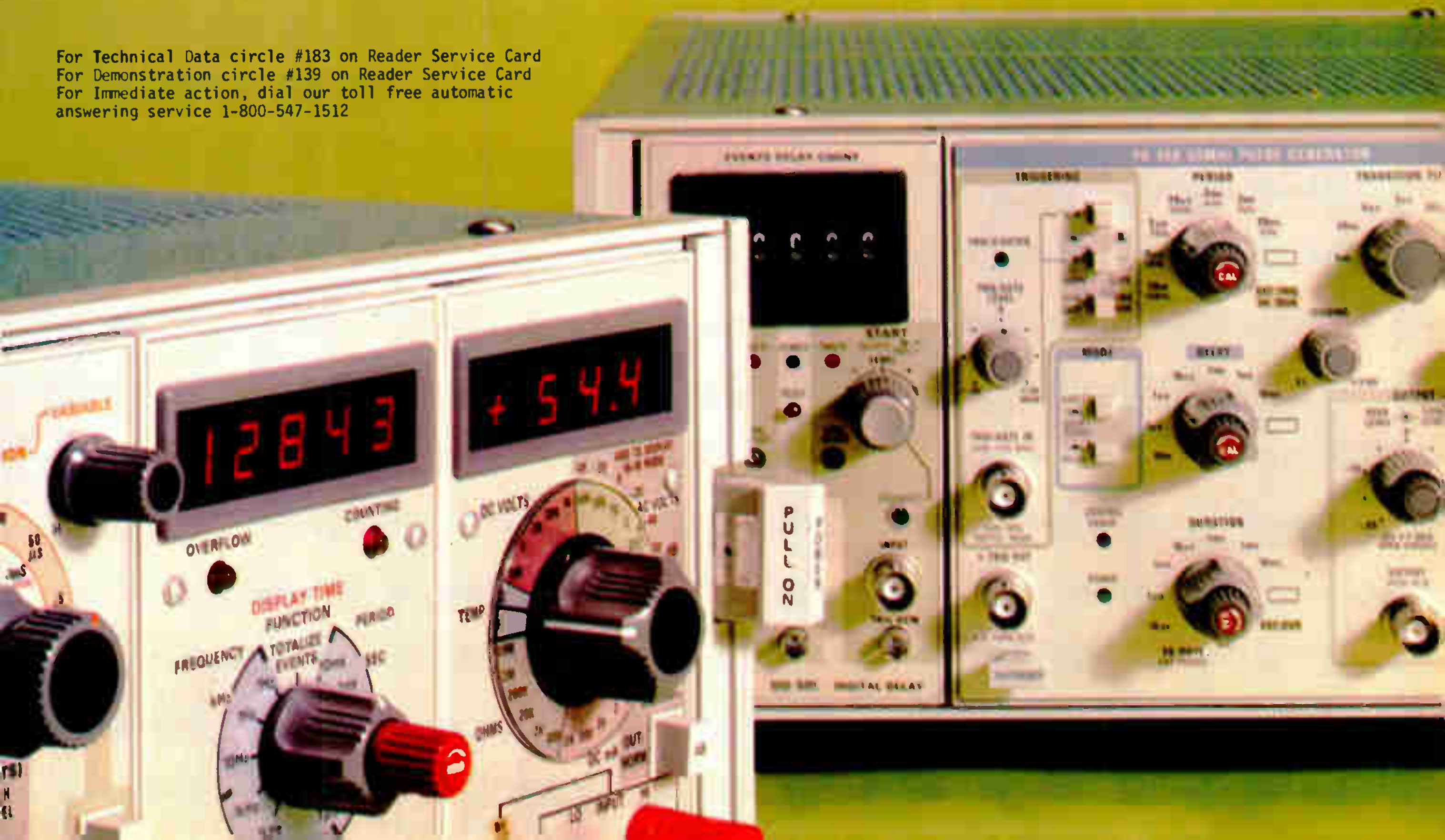


current, turn-on sharpness, and mode stability. Essential to these improvements is the carrier confinement technique used. Other devices have used an oxide mask to create a confining channel, which allows electrons to spread in the crystal area directly below it. The new laser diode instead saturates the region surrounding the channel with deeply implanted protons, creating well-defined confinement channels.

The stripe-geometry laser's cavity measures only 8 microns in width by 380 microns long and, at 25°C, its threshold current is in the 80-to-100-mA range. Boosting the current to between 100 and 120 mA produces a continuous-wave output power of at least 5 mW at each specially coated mirror. There is access to both mirrors, so that the output of one can be used as the input to a current-regulating circuit that can stabilize both outputs.

The wavelength of the output is nominally 830 nm (800 to 870 nm on special order), and operating voltage is 1.5 to 2 V. At 5mW continuous-wave output, the GOLS-1 is guaranteed for a minimum of 10,000 hours.

With differential quantum efficiencies of 40% to 50%, the unit performs with a bandwidth of better than 1.2 GHz. Second-order harmonic distortion is below 40 dB at 70% modulation biased at 2.5 mW output per mirror.

The $1,000 chips come on a $^3/_{16}$-by-$^7/_{32}$-by-$^1/_8$-in. specially plated heat sink that allows access to both mirrors. Coupled with the chip geometry, the heat-sink design provides a thermal resistance for the unit of 20°C/W.

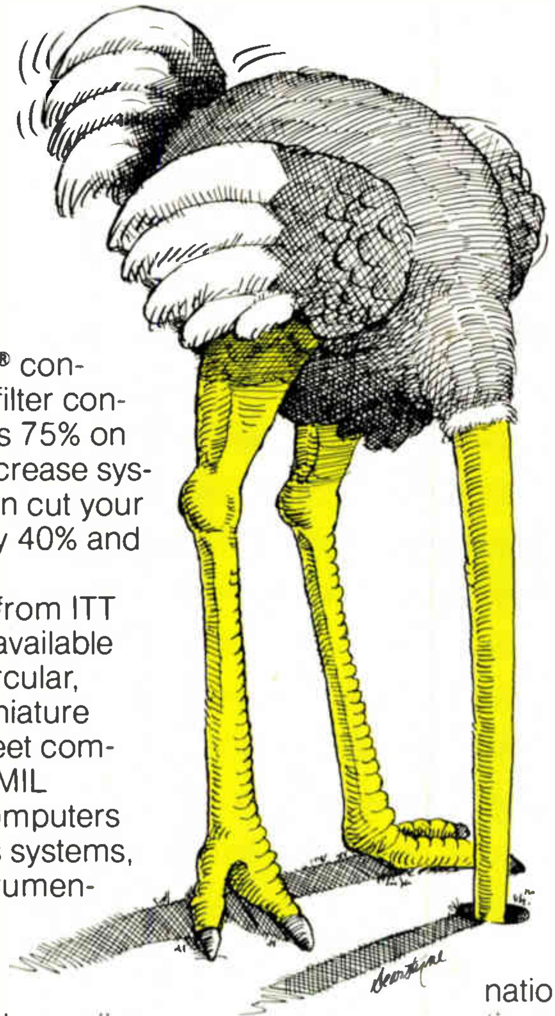
Delivery time for the GOLS-1 is from stock to two weeks.

General Optronics Corp., 3005 Hadley Rd., South Plainfield, N. J. 07080. [403]

## Mixer-preamplifier lowers noise to hear smaller signals

Designed as front ends for monopulse receivers in new or existing radar systems, three-channel versions of the Quiet series of mixer-

# It has come to our attention that some designers are still using discrete EMI/RFI filters

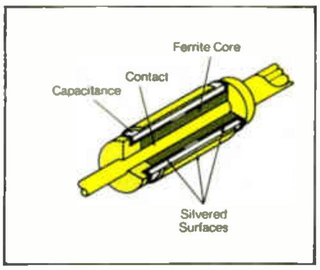


And that's a shame.

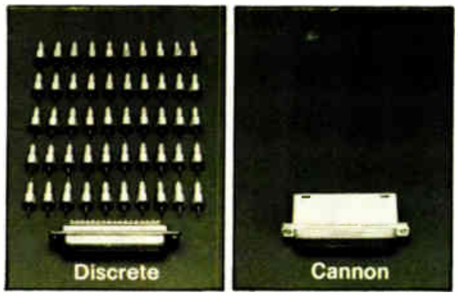
Because Cannon® connectors with integral filter contacts save as much as 75% on space and weight. Increase system reliability. And can cut your total installed costs by 40% and more.

Filter connectors from ITT Cannon Electric are available in rectangular and circular, miniature and subminiature configurations. To meet commercial, ARINC and MIL specifications. For computers and communications systems, medical and test instrumentation, aerospace and automotive applications.

Filtering is available on all or any contacts within the connector. A ferrite tube surrounding the contact forms a series inductor within a concentric, selectively-coated ceramic tube which forms the capacitors of a pi-filter.




Completed connectors, like the computer I/O configuration shown, aren't much larger than the standard connector, yet provide typical attenuation of 70 dB. They eliminate the components, wires and "dog box" that you've had to deal with,




**Computer I/O filters**

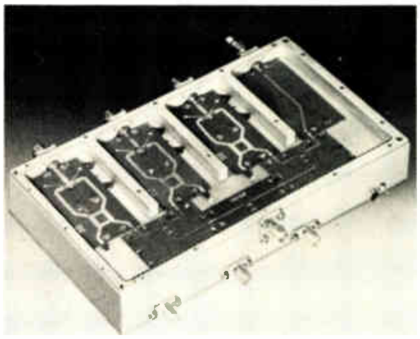
and all the engineering, assembly and testing that go with them.

And Cannon filter connectors can reduce your total installed costs by 40% or more. Now that you know, there's no excuse not to use them, so contact your nearest ITT Cannon field office today.

ITT Cannon Electric, International Telephone and Telegraph Corporation, 2801 Air Lane, Phoenix, AZ 85036, telephone (602) 275-4792.

CANNON ITT

**Six decades on the leading edge of interconnect technology.**



preamplifiers provide noise figures as low as 5 dB. Coupled with the mixer-preamps' low standing-wave ratios, typically about 2:1 in their operating bands, the noise figure reduces the minimum discernable signal level.

The gain- and phase-matched models are available for use in C- or X-band systems; for example, the IRRDM5.9/30-3C covers the 5.4-to-5.9-GHz band. That mixer's intermediate-frequency output has a bandwidth of 10 MHz centered at 30 MHz and is 20 dB above the radio-frequency input.

Isolation of its 13-dBm local oscillator's signal from the rf input, typically 25 dB, is guaranteed to be greater than 20 dB, as is the device's image rejection. Furthermore, gain and phase drift are within ±0.5 dB and ±5°, respectively. The $5,200 C-band unit is deliverable in about 11 weeks.

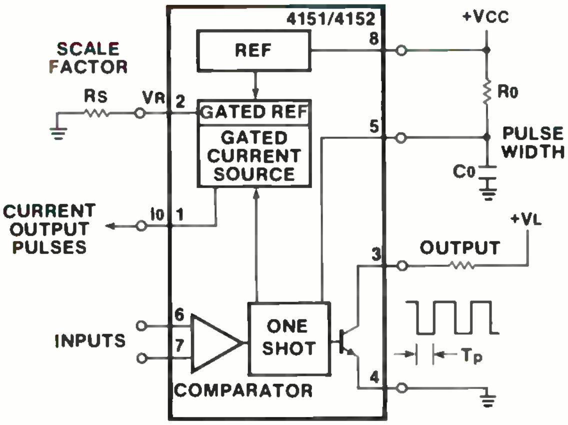
Both multichannel and single-channel members of the Quiet series can be supplied for frequencies in the 1-to-10-GHz range. Units with higher power output and i-f gain control are also being offered.

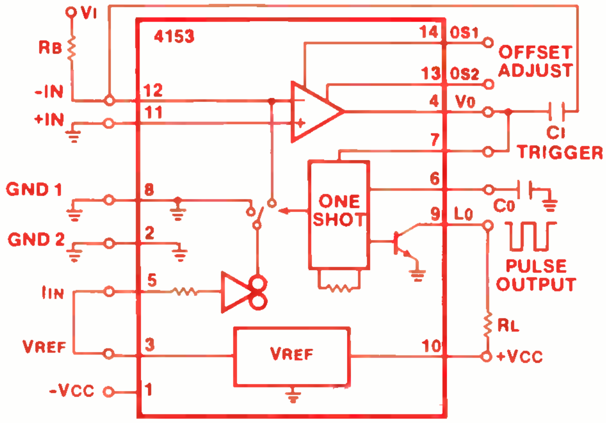
RHG Electronics Laboratory Inc., 161 E. Industry Court, Deer Park, N. Y. 11729. Phone (516) 242-1100 [404]

## 40-dB power divider covers 2 to 26 GHz

Designers working in the super-high-frequency range can now turn to a single unit, the model 2090-6202-00, to divide power over most of that band. The 2-to-26-GHz divider, with a maximum input power of 40 dBm,

# VFC's . . . We've done one better, better.





$ .65
(100+)

The 4151 was the first multi-function VFC offered by Raytheon. It's a low-cost accurate means of converting an analog signal to a pulse train of proportional frequency.

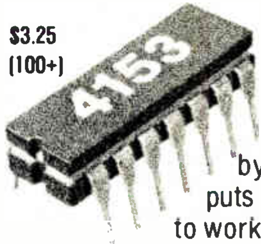
The 4151 gives you the option of connecting it up the way you need. Make a VFC, FVC, or a voltage-controlled pulse generator. Combined with a little external logic, the possibilities are endless.


$ .95
(100+)

The 4152 was the next generation of VFC to come from Raytheon. It's a 4151 and more. It has a linearity capability of ±1% max. Both current source and voltage references have guaranteed maximum temperature coefficients of ±100ppm/°C and a maximum one-shot stability rated at ±50ppm/°C. Add an external op amp and you get linearity of ±0.05% max. and a total gain T.C. of ±150ppm/°C.

The 4152 has a wide bandwidth of greater than 100 kHz, and is DTL, TTL and CMOS compatible, making it an economical answer to your data conversion needs.

$3.25
(100+)




The 4153 is the latest improvement on VFC's offered by Raytheon. It puts LSI technology to work for you. It has a high linearity capability of ±0.01% max. at 10 kHz operation and is high speed, 250 kHz min. All you need to make it work are 2 resistors and 2 capacitors. It has fully contained buried zener reference and on chip op amp.

The 4153 has a total gain T.C. of ±150ppm/°C (including reference, one-shot and current source T.C.'s). The 4153 now makes precision analog-to-digital interfacing an economic reality.

See for yourself. Use the handy coupon, or give us a call today. We'll do the rest. Raytheon Company, Semiconductor Division, 350 Ellis Street, Mountain View, CA 94042, (415) 968-9211.

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## Tell me more . . .

☐ 4151 VFC ☐ 4152 VFC ☐ 4153 VFC

**Other Products** ____________________

Name ____________________

Title ____________________

Company ____________________

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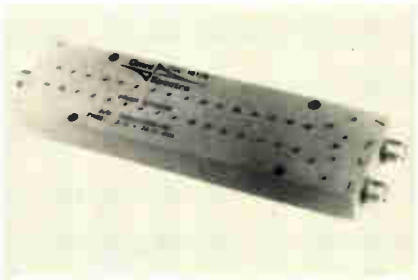
City/State/ZIP ____________________

E010879



has a minimum 20-dB isolation between output ports, which are arranged in a tapered strip-line configuration that provides two-way isolation.

The maximum insertion loss varies linearly with frequency: 0.4 +0.1f dB, where f is the frequency in GHz. Moreover, the voltage-standing-wave ratios are quite low: only 1.35:1 from 2 to 11 GHz and just 1.70:1 from 11 to 26 GHz. Also, the device is relatively small, about 4 by 1 by 0.4 in., and lightweight, 2.9 oz.

The 2090-6202-00 costs $350 in quantities of one to nine pieces and is deliverable from stock to four weeks. Similar devices that provide octave, multi-octave, and decade frequency coverage also are available.

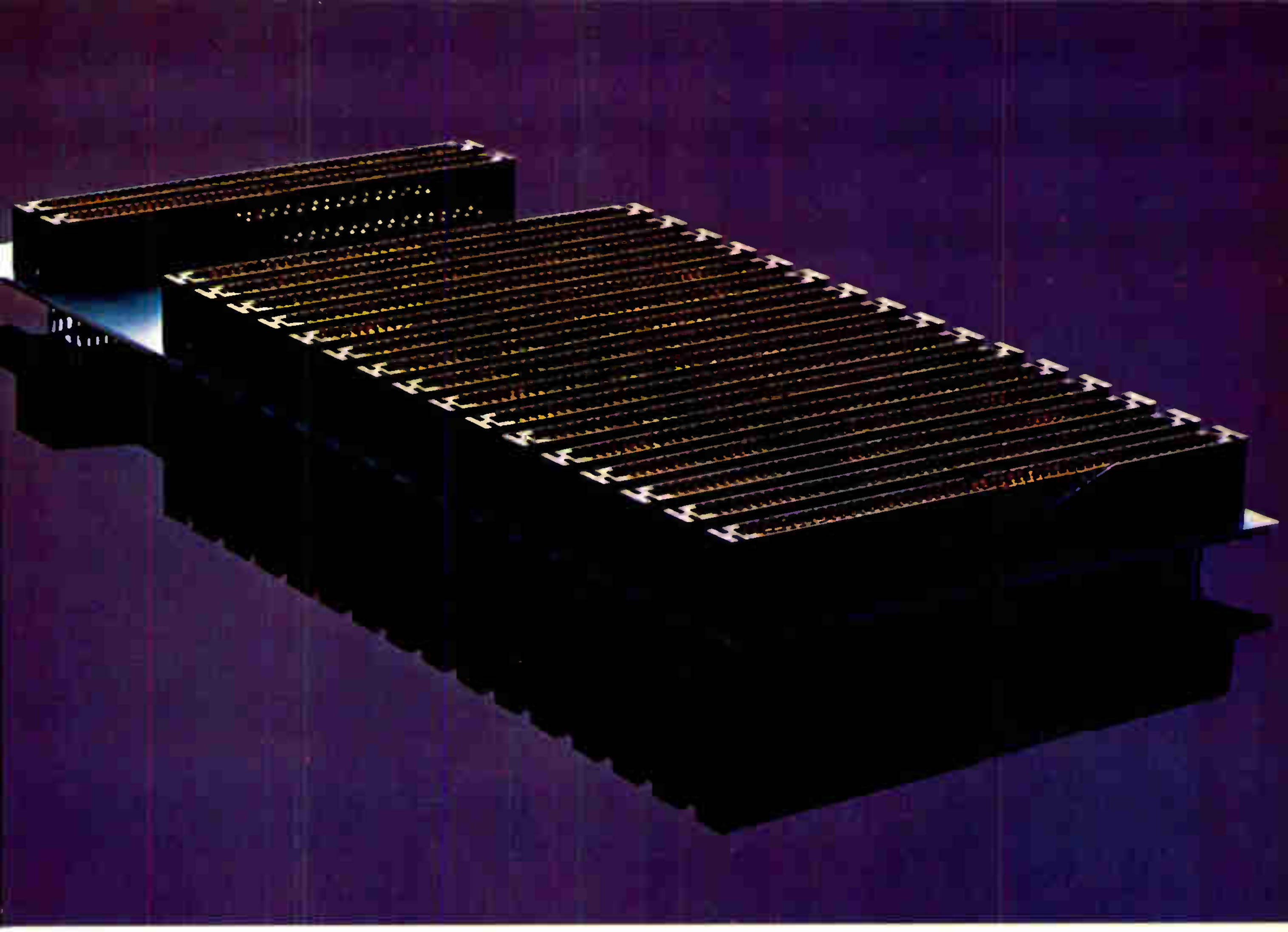
Microwave Component Division, Omni Spectra Inc., 21 Continental Blvd., Merrimack, N. H. 03054. Phone (603) 424-4111 [406]

## 10-piece kit dials 44 12-digit numbers

A kit consisting of 10 semiconductor components in dual in-line packages can be used to construct a telephone repertory dialer capable of storing up to 44 12-digit numbers. Called the Fairdial component set, it is based on the CET 200 telephone controller circuit, built with planar n-channel metal-oxide-semiconductor technology, and includes two 1-kilobit random-access memories, two complementary-MOS gate circuits, and five transistor-transistor logic chips.

The set allows dialing of 10 or 20 pulses per second or 12 digits in less than 1 s. In single quantities it sells for $35.

Fairchild Camera and Instrument Corp., 464 Ellis St. Mountain View, Calif. 94042 [407]



# Remember DEC's® RK05®?

**DEC doesn't:**

The old RK05 was recently replaced by the new RL01® and as disc drives go, the price is nice.

Until you figure in the cost of converting all your media (to media that you can get from only a single source), and the cost of the new controller, new software and the entirely new support situation that you'll be facing.

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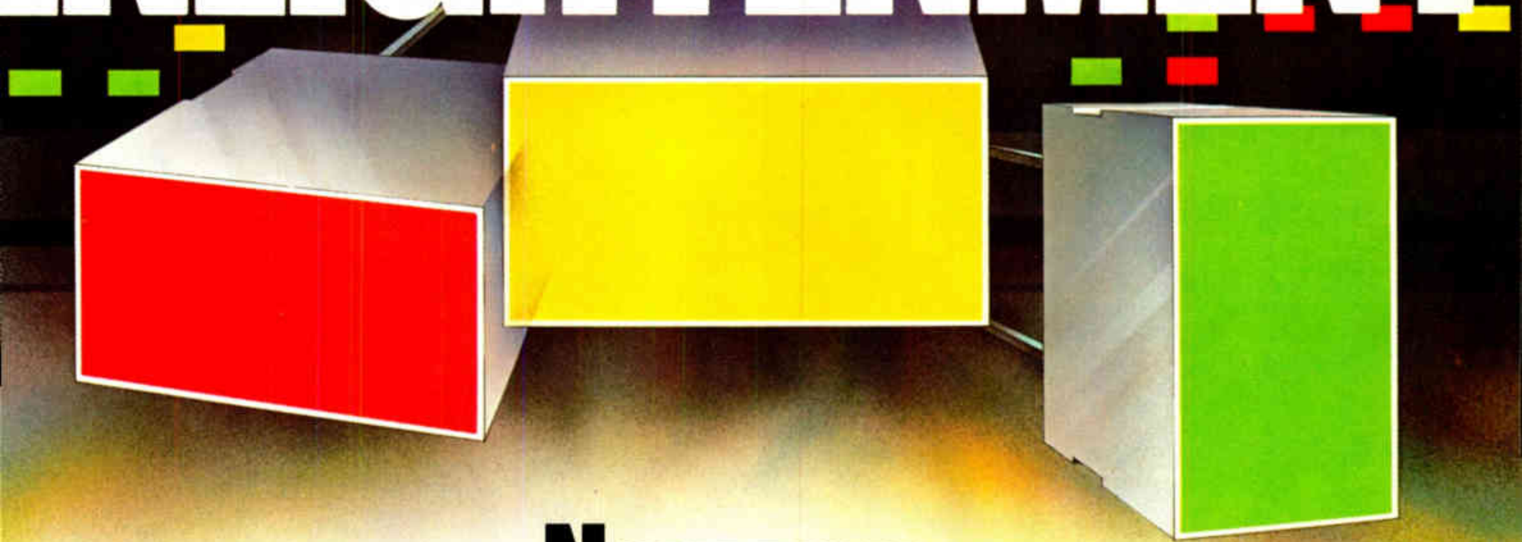
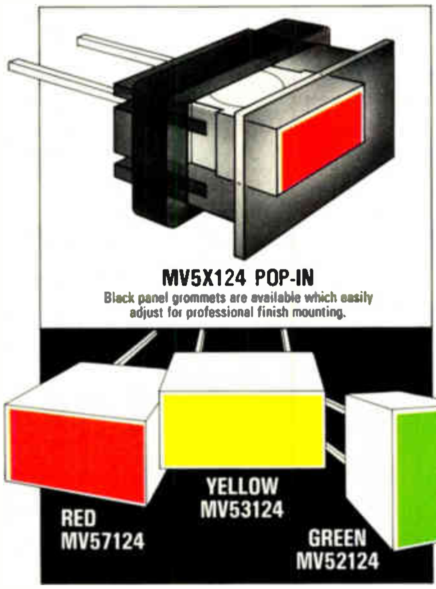


# Now you don't have to approach panel design in a roundabout way

**OUR REVOLUTIONARY NEW RECTANGULAR LED GIVES YOU A CHOICE OF HIGH EFFICIENCY COLORS.**

The "Legend Lamp" series of indicators from Monsanto brings you a new shape for modern industrial panel design . . . plus a selection of three high efficiency colors (red, yellow, and a new, brighter green). It's the perfect design answer for a legend backlight, a panel indicator or a bargraph meter.

**You can add symmetry and efficiency to panel design without crosstalk problems.** The unique design of our Legend Lamps utilizes a special plastic to house the LED assembly, so that no light is emitted from the sides or edges of the unit. All of the light is concentrated on the viewed surface. Lamps can be stacked, side-by-side in an X or Y direction without light interference between units. And mounting becomes a simple operation with a special 2-piece grommet.




**A new dimension in light output.** You're assured of uniform illumination across a large emitting area (.15" x .25"). This new package makes maximum use of emitted light, minimizing unusable light. Light output is a very bright 4 millicandelas at 20 mA (red and yellow) and 3 mcd for green. That's up to 3 times the output of other rectangular lamps.

**We'll send you a free sample.** Write today, on your company letterhead, for a free sample. Please indicate desired color. We'll also send you full specifications.

Monsanto Commercial Products Co.,
Electronics Division,
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Palo Alto, CA 94304.
Telephone: (415) 493-3300.

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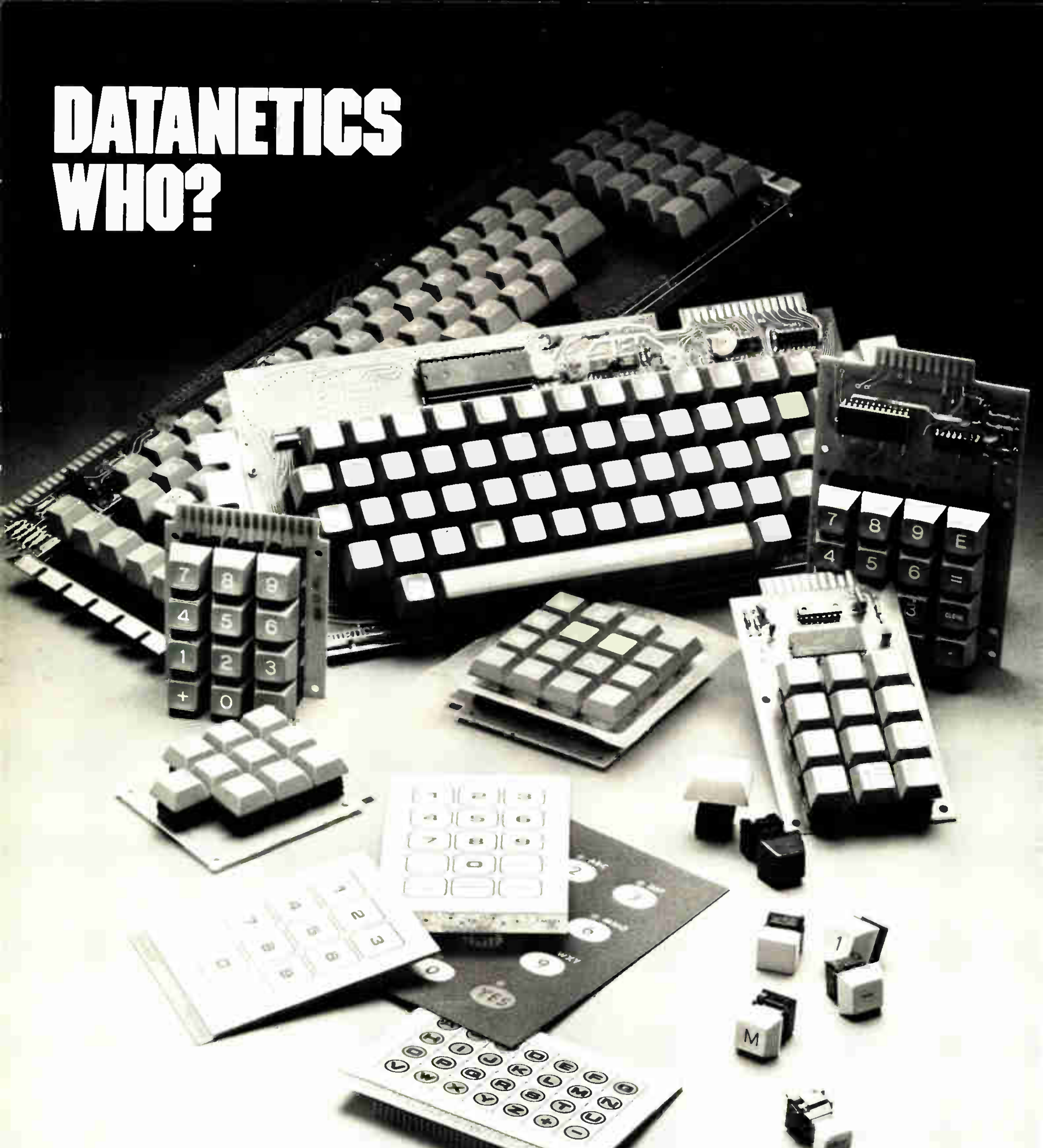
Circle 191 on reader service card

# DATANETICS WHO?



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We have the best line of keyboard products around. From standard 75 key keyboards stuffed with innovative features at low prices...to custom keyboards...to key switches...to our unique, ultra-thin touchboard.™
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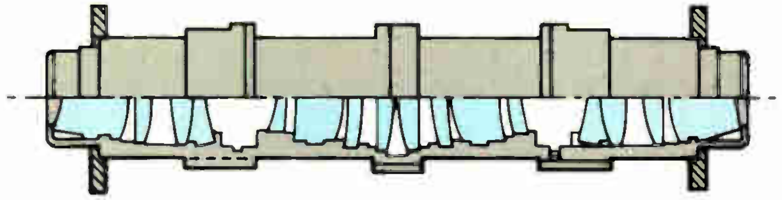
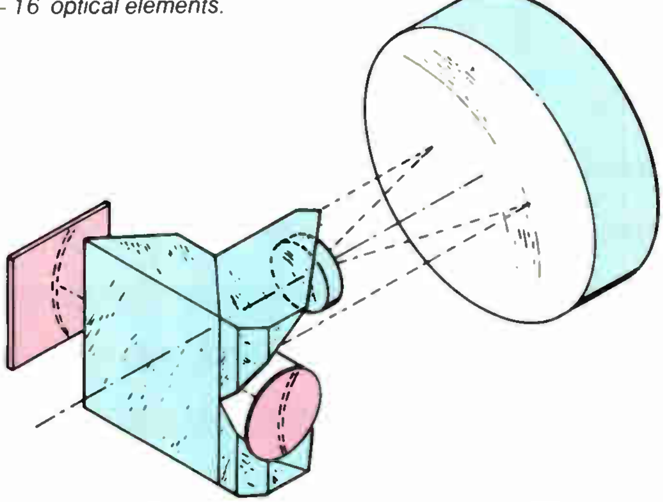


*Typical refracting system lens arrangement — 16 optical elements.*



*The MICRALIGN all-reflecting folded projection system — three optical elements.*

Compare these two lens systems. Until Perkin-Elmer introduced the Micralign Projection Mask Alignment System five years ago, all manufacturers of projection systems used refracting optics. Most still do.

**Complex refracting optics**

Refracting optics can involve as many as 16 separate lenses. Such complexity has several drawbacks. In spite of antireflection coatings, the individual lenses scatter light. Imperfections in the glass scatter light. And all this scattered light affects image quality. It limits the use of negative photoresist. In addition, standing wave effects make the system hard to use.

**Simple reflecting optics**

Note the contrast with the Micralign reflecting optical system. Its simple design employs only three reflective elements, no refracting lenses. Scattered light is near zero. Ghost images are eliminated, image quality is enhanced.

This all-reflecting system has no chromatic aberrations. The optics are telecentric, maintaining magnification at 1:1 even if the focal planes shift. Either positive or negative photoresist is practical.

Reflecting optics combined with advances in electronic and mechanical designs have made the Micralign instrument the choice of 65 semiconductor manufacturers at 100 sites worldwide. Learn more about how the Micralign instrument can bring efficiency and economy to your operations. Write Electro-Optical Division, Perkin-Elmer Corp., 50 Danbury Road, Wilton, CT 06897. Or phone 203-762-6057.

# REFLECTING OPTICS. WHY YOU GET BETTER PERFORMANCE WITH A Micralign™ SYSTEM.

*Model 140— the third-generation MICRALIGN instrument.*

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Industrial

## System profiles temperatures for processes

Generating temperature profiles for thermally critical processes by traditional means—taking readings at various points in the process and plotting them—is a time-consuming chore. Furthermore, this task generally has to be repeated whenever a change is made at one point in the process so that its downstream effects can be seen. Thus, fine-tuning a system and monitoring its performance requires an inordinate amount of costly effort.

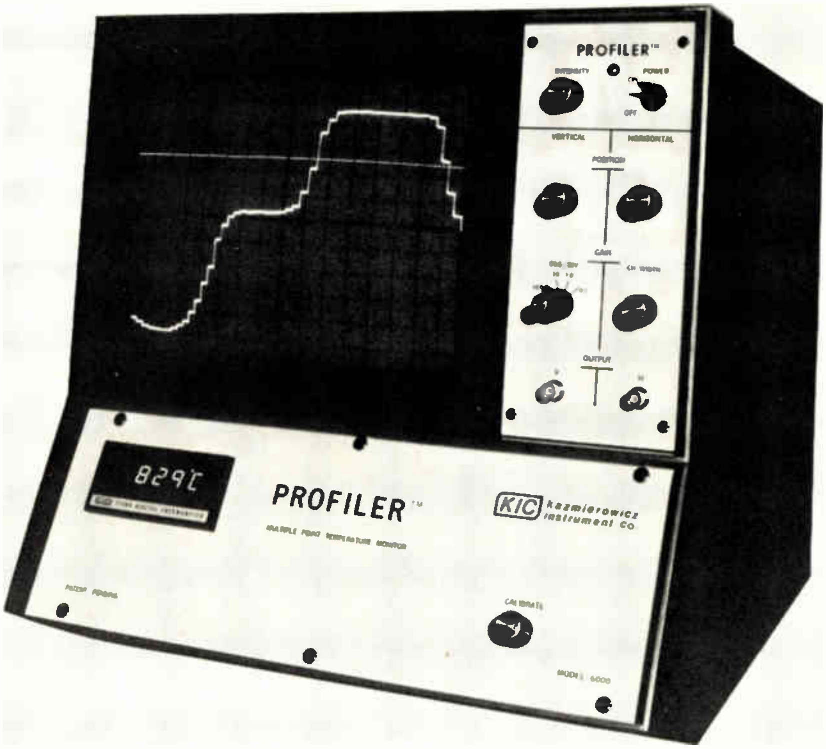
A simpler, real-time means of performing this function is offered by the Profiler, a temperature-monitoring system that can simultaneously display the temperature at up to 60 points in one or more processes. Outputs from type J, K, T, R, S, E, B, or C thermocouples are multiplexed to one of the unit's four possible connectors, each of which can handle 15 channels. These inputs, which can cover the range from −200° to +2,328°C, are displayed simultaneously on a 12-in. cathode-ray screen with 12 vertical divisions, giving a thermal profile.

The green-phosphor screen's vertical sensitivity can be set for 100°, 10°, 1°, or 0.1° per division; it is continuously variable by vernier and provides a resolution of 0.2°. Horizontal sensitivity, or channel width, is adjustable continuously, allowing users to set the display for the required number of channels.

A calibration knob moves the profile vertically with respect to a reference line, and the temperature at the point or points of intersection is displayed on a four-digit light-emitting-diode thermometer; users can calibrate the Profiler to an accuracy of within ±1° C or F. The vertical-position knob shifts both the reference line and the profile in unison.

The system's vertical and horizontal outputs allow permanent records to be made with an external plotter or alarms to be triggered when limits set by the reference line are exceeded. The Profiler can also be configured in a dual-trace version to display a synthesized profile with the measured one.

The unit, 17.5 by 16.5 by 18 in., requires 115-V, 60-Hz power and weighs



# The last time you saw a really new bench/portable DMM was 1972.

That's the year our 8000A was introduced. Its custom LSI and solid owner benefits quickly established it as the world's leading DMM.

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

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

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Circle #195 for literature
Circle 164 for demonstration

2509-8020

approximately 44 lb. Without thermocouples, a 15-channel Profiler is priced at $6,000 and a 60-channel system costs $7,150. Delivery time is presently six to eight weeks.

Kazmierowicz Instrument Co., 26546 Aracena Dr., Mission Viejo, Calif. 92691. Phone (714) 770-9891 [371]

## Sources calibrate IR thermometers to 2,200°C

A line of temperature-calibration sources for infrared thermometers and optical pyrometers covers the range from 20° to 2,200°C. Three basic units cover the full temperature span. A liquid bath is used from 20° to 200°C, two types of blackbody furnace operate from 200° to 1,450°C, and a tungsten strip lamp with an optical bench serves from 800° to 2,200°C.

The liquid-bath source has a total temperature uncertainty of ±2°C. The tungsten-lamp system has a maximum error or ±0.5% of temperature. Various versions of the black-body furnaces have uncertainties ranging from ±4° to ±7°C.

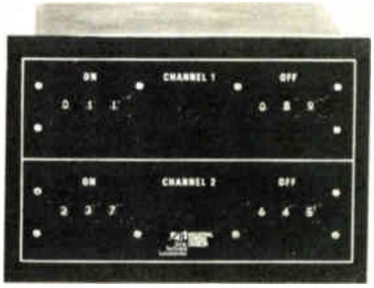
Land Instruments Inc., P. O. Box 1623, Tullytown, Pa. 19007. Phone (215) 943-7882 [374]

## Programmable limit switch speeds assembly lines

With three-digit thumbwheel switches, users of the Z-237 programmable limit switch can set the on and off limits for two processes on an automated production line. The switch-programmable limit controller can replace such devices as cam limit switches with semiconductor logic, thus eliminating failures due to mechanical wear while increasing the speed at which assembly lines can be made to operate.

Adjustable from 0 to 60 v ac, the optically isolated output derives from an open-collector transistor. (Output load is specified at time of order.) The pulse width of the output can vary from 50 ms to 15 s and duty

## New products



cycle can be specified from 30% to 70% of the operating cycle.

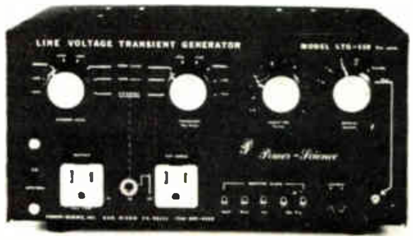
Supplied with an internal timer-clock, the Z-237 can also use an external clock with a rate of up to 30 kHz. The Z-237 takes power from either 110- or 220-V lines and is priced at under $1,000.

Zonic Technical Laboratories Inc., Industrial Systems Division, 8927 Rossash Rd., Cincinnati, Ohio 45236. Phone (513) 891-6390 [373]

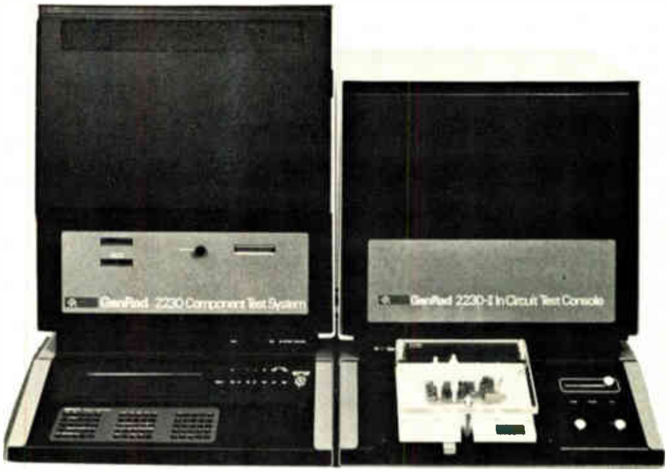
### Transient generator disturbs line for up to six cycles

The model LTG-110 is a solid-state line-voltage transient generator that can produce typical power-line disturbances such as sags, surges, and drop-outs for periods of from one-half to six cycles. Sags and surges of 10% and 20% can be selected by switch, as can total drop-outs. The LTG-110 can also be connected to an autotransformer to generate other transient levels.

Transients can be repeated at intervals from 0.3 to 10 seconds or at random using a push button. The start of the transient is synchronized with either the positive or the negative half of the power-line cycle. An advanced trigger pulse for an external oscilloscope's sweep lets users monitor line voltage starting a single



# Identify assembly faults on small PC boards FAST with GenRad's 2230I In-Circuit Test System

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Circle 199 on reader service card

## New products

cycle before the transient is introduced.

The generator can drive loads of up to 1 kW and is priced at $1,150. Delivery time is six weeks.

Power-Science Inc., 7571 Convoy Ct., San Diego, Calif. 92111. Phone Edward Cooper at (714) 292-4322 [375]

### Line monitor senses under- and over-voltages

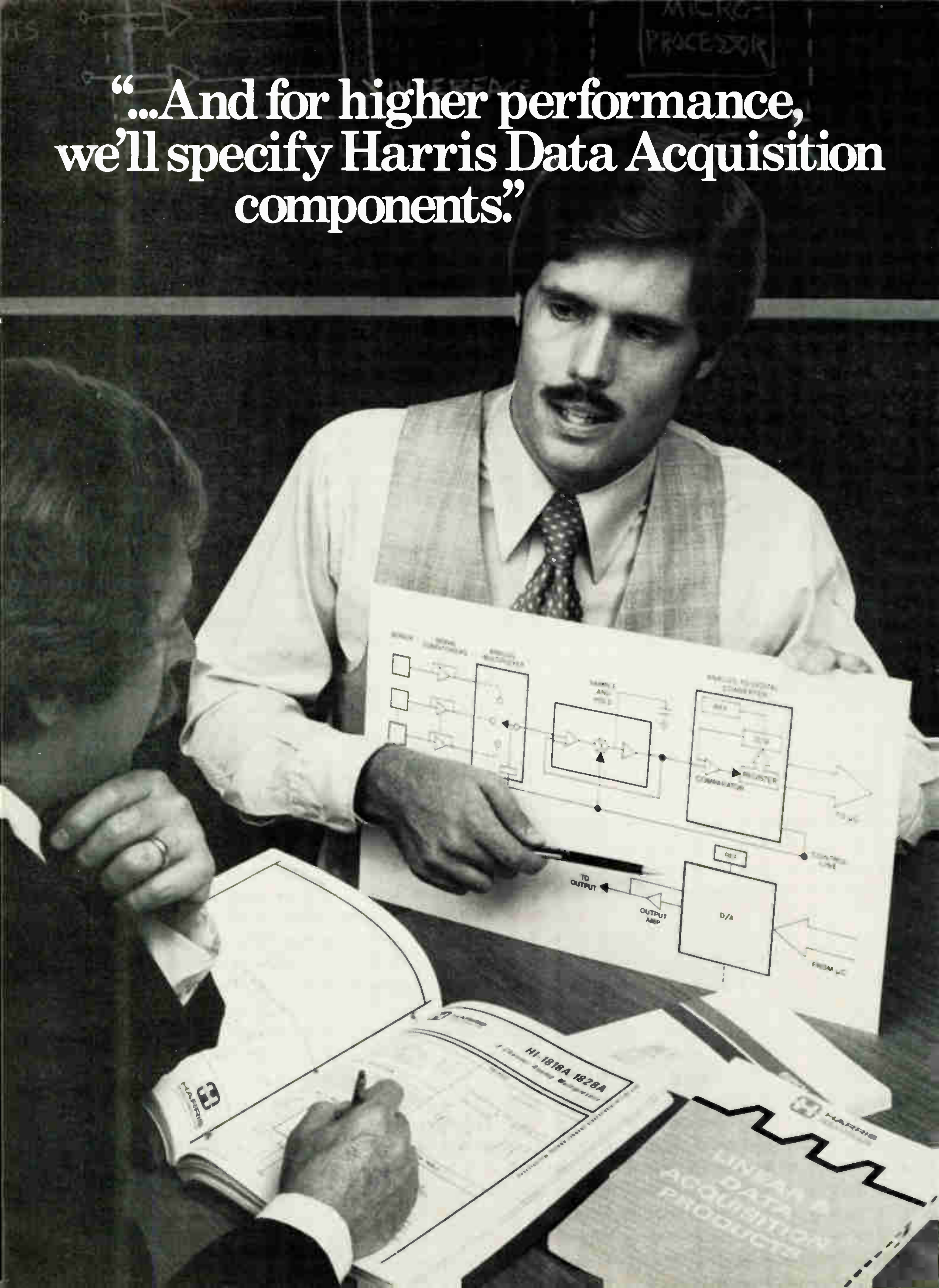
Two line monitors—the models 829R and 829T—directly sense the voltage on the ac line and react when it exceeds upper and lower limits, which are adjustable by means of potentiometers molded into the monitor cases. The model 829R reacts by switching a single-pole, double-throw relay, whereas the 829T activates an optically isolated open-collector transistor. The transistor can be connected to any voltage from +4 to +32 V dc. Principal applications of the Linesensors are in the protection of computers and instruments from brownouts and high-voltage surges. The 829R and 829T are priced at $68 and $89.

Calex Mfg. Co., 3355 Vincent Rd., Pleasant Hill, Calif. 94523. Phone Ron Kreps at (415) 932-3911 [376]

### Transmitter measures liquid level in tanks

Designed specifically for the dairy and food-processing industries, the model LL liquid transmitter uses a flush-diaphragm strain-gage transducer to produce a 4-to-20-mA signal proportional to its hydrostatic head pressure. The unit can be used in liquids as hot as 425°F and is offered with either clean-in-place fittings or a hot-tap installation package. The price of the model LL, including a companion digital indicator that can be calibrated for direct readings in liquid height, volume, or weight, is $1,500.

Sensotec Inc., 1200 Chesapeake Ave., Columbus, Ohio 43212. Phone Jack A. Feil at (800) 848-6564 [377]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**CMOS ANALOG MULTIPLEXERS**
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- HI-506/7 —16-channel
- HI-508A/9A — 8-channel, overvoltage protected
- HI-1818A/28A— 8-channel
- HI-1840 —16-channel, high Z, overvoltage protected

**CMOS ANALOG SWITCHES**
Two popular series feature several latch-proof configurations with high-speed, low-on-resistance, and low-power versions.
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- HI-5040 series—370 ns, 25 ohms, 1.5 mW

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Low droop rate coupled with fast acquisition time furnishes the speed and precision needed for 12-bit systems.
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New precision BIFET op amps to complement the Harris high-performance line. Laser trimmed for low offset voltage.
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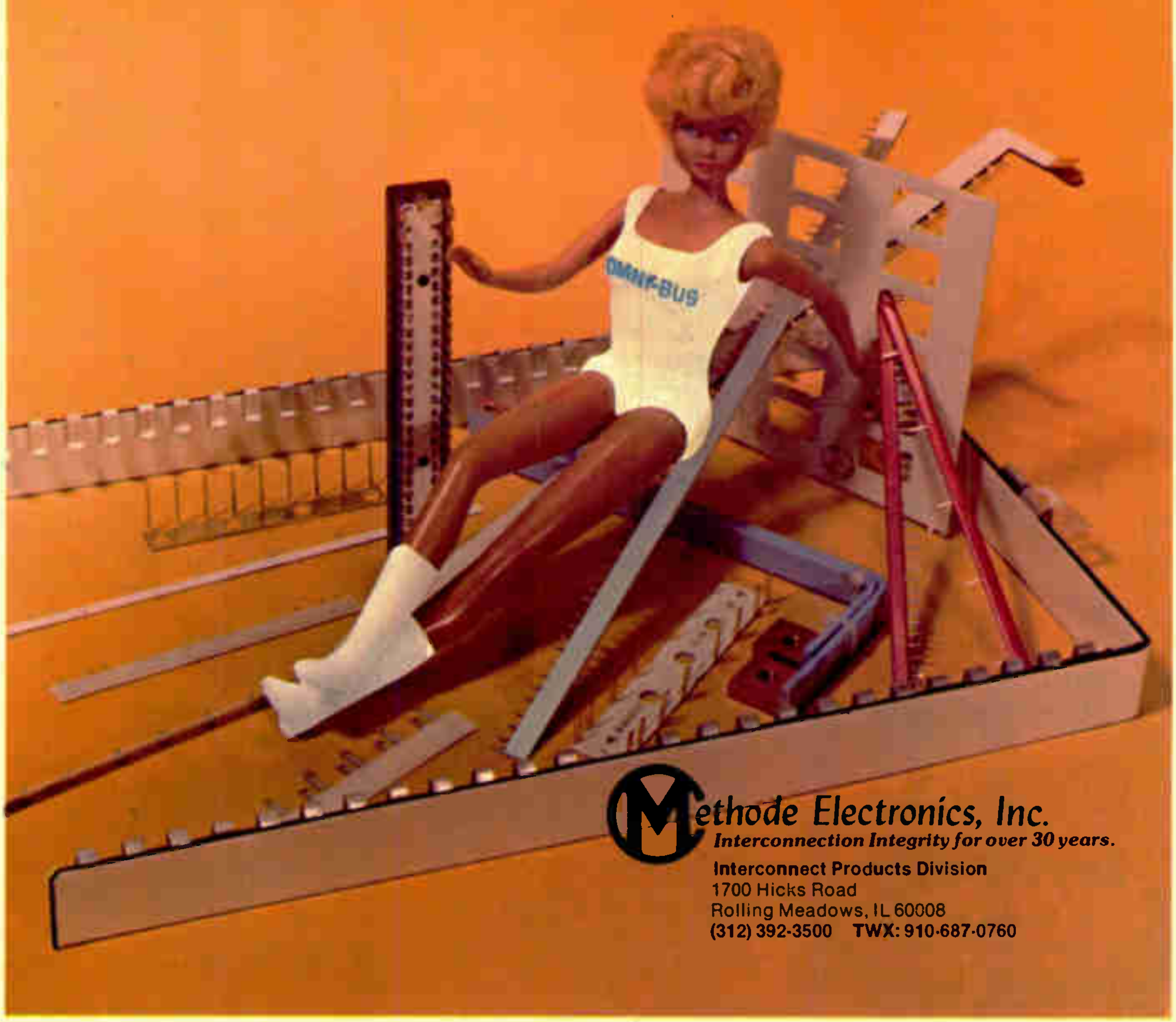


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Computers & peripherals

# New Novas cut costs

## Three minicomputers use bipolar technology to increase speed up to 50%

Last month's announcement of a family of three Nova 4 computers by Data General Corp. [*Electronics*, Dec. 21, p. 26] should serve notice of three facts to customers and competitors alike. First, where recent Cobol-based Eclipse system introductions from the company have been targeted mainly at end users in business data processing, there is no intention to overlook the strong base of original-equipment makers for the Nova line, who have so far installed more than 25,000 units.

Second, with the price structure for the three models, Data General has shown that it intends to be among the most aggressive vendors of small computers. Finally, the move shows that the firm will not stand idly by while companies with machines that emulate the older Nova 3 but cost less chip away at a market Data General created.

The entry-level machine is the 4/C, which puts on a single board what previously required three in the Nova 3: 16 kilobytes of metal-oxide-semiconductor main memory, hardware for automatic restart and automatic program-loading on power failure, and a console interface, but no console. The price of the basic version is $2,500, compared with $4,350 for a similarly equipped Nova 3.

There is also a Nova 4/S and 4/X, with prices ranging to $14,300 for small configurations of the latter, or to almost $57,000 for a large 4/S that includes a 20-megabyte disk and a 180-character-per-second printer.

John Scanlon, manager of product marketing programs, says the Nova 3 model 4, the least expensive entry in the Nova 3 family with 64 kilobytes of main memory, sells for $7,550. The comparable Nova 4/C is $3,500.

Of the higher-level new machines, he says, "Up until a month ago, a Nova 3/D with 256 kilobytes of main memory sold for $27,000. A Nova 4/X with same features is $14,300 with 14 input/output slots, whereas the earlier machine has 6. The new one is also 50% faster." He says the Nova 4 line can perform a register-to-register operation such as an addition, a move, or a comparison in 200 ns.

These are bipolar machines, built around the 2901A bit-slice processor—which accounts for the speed improvement—and transistor-transistor logic. All three models are available in either a 5¼-inch-high, 5-slot chassis or a 10½-inch-high, 16-slot chassis.

All incorporate popular features of the Nova 3, including microprogramming, 16-bit architecture, hardware stack and frame pointer, high-speed direct memory channel, and a 16-level priority interrupt structure. All three have extensive internal diagnostics initiated when power is turned on or restored.

Scanlon expects the new models to compete with Digital Equipment Corp.'s PDP-11/03 and -11/04 at the low end and with some members of the PDP-11/34 family at the high end. As for the market, he sums it up this way: "The Nova has typically been an OEM machine, and these will be, too. But we move a lot of Novas

  


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Circle 207 on reader service card

through systems houses to end users for small-business applications because they can use Fortran and business Basic languages." He looks for high-end Nova 4s to find similar applications using the same languages.

Deliveries of the 4/S and 4/X begin in 90 days, with 4/C deliveries in 180 days.

Data General Corp., Route 9, Westboro, Mass. 01581. Phone (617) 366-8911 [361]

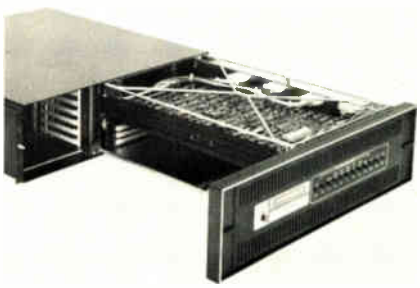
## Fast array processor sells for only $7,500

Array processors are usually costly special-purpose computers that can perform certain specialized computations much more rapidly than general-purpose computers can. Typically, they are used in conjunction with host computers for which they handle such tasks as fast Fourier transforms for radar and sonar signal processing.

Because their price tags range from about $30,000 well into six figures, array processors are not generally regarded as high-volume items. Officials at Analogic Corp., however, think there is a large, untapped market among original-equipment makers for versatile, relatively inexpensive array processors. They have done something about it with the introduction of the AP400.

Fully programmable, the AP400 comes in a standard rack-mountable cabinet that stands only 5.25 in. high. It can perform 10 million complex floating-point, high-precision computations per second and will cost just $7,500 to $9,000 in original-equipment quantities.

As one performance benchmark,



the unit can perform a complex, 1,024-point fast Fourier transform in 7.4 ms. Chairman Bernard Gordon says that is faster than the same computation done by array processors priced at $40,000 or more. Adding to its attractiveness, the AP400's arithmetic section can also be quickly reprogrammed to do various other functions, such as logarithms, exponentials, or an FFT followed by a logarithm.

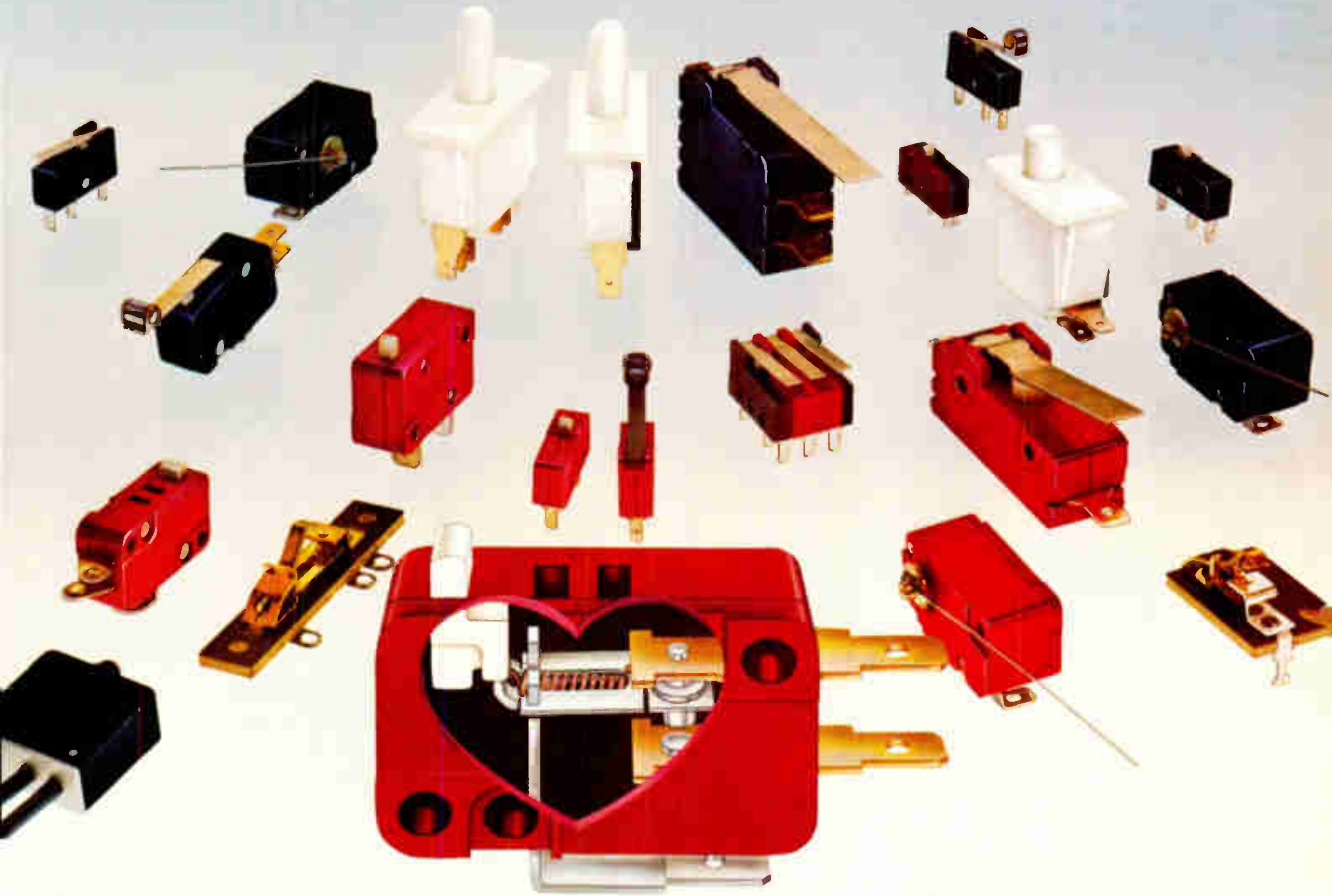
"Most people in the array processor business don't have analog backgrounds, as we do," Gordon asserts. "So we decided there was a major untapped market waiting for us if we could develop a powerful machine that would sell for less than $10,000 and include an analog capability." Users may order wide-dynamic-range, low-noise multichannel data-acquisition circuitry, of which Analogic is a leading supplier, plus substantial data-memory expansion beyond the basic 4,096 words of 24-bit bipolar random-access memory.

The processor employs a 24-bit mantissa and 16-bit exponents, and typically operates in a block-floating-point configuration. Gerald Shapiro, technical director for array processors, says most other array processors have some pipelining in the arithmetic sections to boost throughput, such as pipelining the multipliers and adders on a bus. "We're different in that the whole arithmetic section is a pipelined structure," he notes.

This architecture, combined with a control processor, command and address buffer, and a pipelined command decoding section, provides the speed and flexibility to handle various arithmetic functions, instead of the usually limited, repetitive functions of most other array processors currently available.

In a single 1.92-μs period, the AP400 can carry out four multiplications and 12 additions, while simultaneously doing several table look-ups and logic operations. The processor is supported with software that includes an extensive library of host computer function calls, an assembler for additional software development, and a virtual front-

# Behind all these pretty faces...



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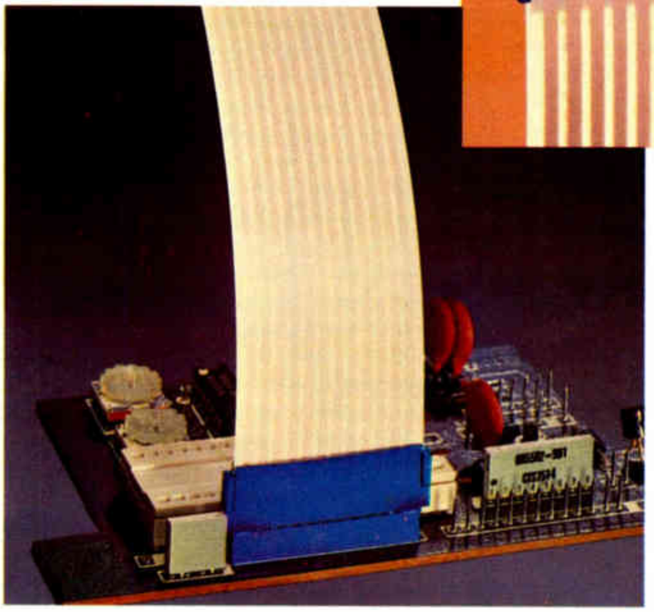
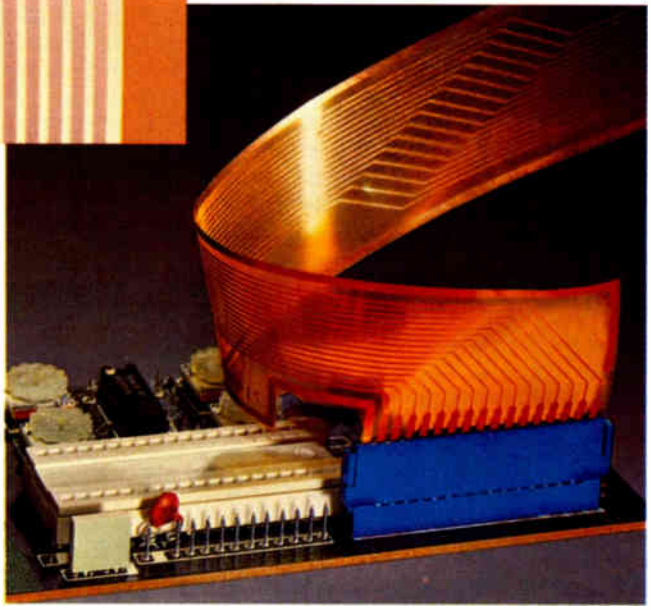
Circle 211 on reader service card

# Berg's Clincher* connector mass terminates flat conductors quickly and reliably.



The "Clincher" on flat conductor, flat cable.



The "Clincher" on flat conductor, flex circuitry.

The "Clincher" is a superior connector system for flat conductor, flat cable or flex circuits. It offers high reliability and the lower applied cost of mass termination.

With the "Clincher," all of the flat conductors are terminated simultaneously, within 15 seconds. Cable stripping is not required. The "Clincher" system offers a substantial reduction in total installed cost over individually terminated conductors.

The "Clincher" design uses Berg's proprietary PV* receptacle, a connector of proven reliability for over a decade in data processing and telecommunications applications. The dual-metal construction of the "PV" provides a high normal force to assure highly reliable mechanical and electrical performance.

Berg's "Clincher" accepts a 1 to 2 oz. copper 0.062" wide cable. It is stackable on 0.100" centers in double-row configurations for dense packaging. The "Clincher" mates with 0.025" pins or standard Berg headers to form a complete interconnection system.

Rely on Berg for quality performance to meet your most demanding application needs. For a brochure describing the "Clincher" system, write or call:

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*Du Pont Trademark

panel handler for interactive software diagnostics. Deliveries will begin March 1st.

Analogic Corp., Audubon Road, Wakefield, Mass. 01880. Phone (617) 246-0300 [362]

## Lower-cost 303X memory adds up to 16 megabytes

With the ARM-303X, Ampex Corp. has entered the latest round of the IBM-compatible memory competition. Designed and manufactured by the company, the expandable memory for IBM's 303X systems sells for $50,000 per megabyte, a third less than IBM's own recently announced add-on memory.

The addition of this plug-compatible system rounds out a line that already includes add-ons for the 360 and 370 systems. The new single-cabinet memories are field expandable to 16 megabytes in 1-megabyte increments using 256-kilobyte boards. They come in 3031 and 3032 versions, which have four-way interleaving, and a 3033 model which uses eight-way interleaving.

All units consist of a frame, power supply, cooling units, error-detection panel, and boards for interface logic, memory timing, control logic, and memory. The initial 2-megabyte systems consume 0.9 kVA and each incremental megabyte pulls an additional 0.4 kVA. The systems can be leased for a monthly charge of $2,400 per megabyte including round-the-clock service.

Ampex Corp., 200 N. Nash St., El Segundo, Calif. 90245 [363]

## Tailorable computer offers greater processing power

Engineering and laboratory research personnel attracted to the configurational concepts of the recently introduced MINC [*Electronics*, Nov. 9, p. 175] but whose applications require greater computational power may find their needs fulfilled by the DEClab-11/MNC system.

Like its smaller sibling, the top-of-the-line system permits users to customize a computer to their needs by using as many as eight modules of seven different types. It, too, offers a VT101 video display terminal, or purchasers may choose a LA36 DECwriter II for data display.

The DEClab-11/MNC, however, uses twin R101 disk storage units to provide a standard 10-megabyte storage capacity. Its PDP-11/03 comes with 64 kilobytes of semiconductor storage capability. In addition, software for the system includes ANSI-standard Fortran IV and a package of Fortran subroutines such as peak and envelope processing, fast Fourier transform, and power spectrum analysis.

The DEClab-11/MNC is priced from $21,000, and delivery time is approximately 60 to 90 days.

Digital Equipment Corp., Maynard, Mass. 01754 [365]

## Thermal printer for OEMs sells for $595 or less

The T-80M is a dot-matrix thermal printer that prints at a speed of 80 characters per second. Intended for incorporation in terminals produced by other manufacturers, the unit includes the print head assembly, servomechanisms, and servoelectronics. It requires only an external transistor-transistor-logic control signal and power to become operational.

The unit can print graphics with 70-dot/in. resolution as well as 5-by-7-dot–matrix characters. Typical character format is 80 columns per line, 6 lines/in. The printer uses 8.75-in. thermally sensitive paper—a standard size available from a number of commercial chart paper suppliers—and its print head can be replaced by an operator.

In lots of 100 or more, the 10.5-by-4.75-by-7.09-in. printer sells for $595, and further discounts are available in larger quantities. Delivery time is 30 days after receipt of order.

Dataproducts Corp., 6219 DeSoto Ave., Woodland Hills, Calif. 91364. Phone Al Erikson at (213) 887-8451 [369]

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**Circle Card Number 260**

**Industrial Power Supply Catalog** — Some 279 of our low cost, high quality OEM power modules are detailed in this 16-pager. Includes covered/open frame, AC to DC single, dual and triple output versions, with outputs from 5 to 36VDC, 0.5 to 320 Watts. Plus DC to AC converters with 50 and 60Hz outputs. Priced as low as $35 for up to 24 units.

**Circle Card Number 261**

**Transformer Catalog** — We specialize in custom transformers, and this 20-pager gives you detailed information on how to specify for your exact requirements. It also covers over 800 standard military, industrial and miniature pcb transformers, including 60 and 400Hz, single phase input units. Prices for standards start as low as $5.10 for up to 9 pieces.

**Circle Card Number 262**

***See Power Supply Section 4000, and Transformer Section 5600, Vol. 2, of your EEM catalog; or Power Supply Section 4500, and Transformer Section 0400, Vol. 2, of your GOLD BOOK for complete information on Abbott products.***

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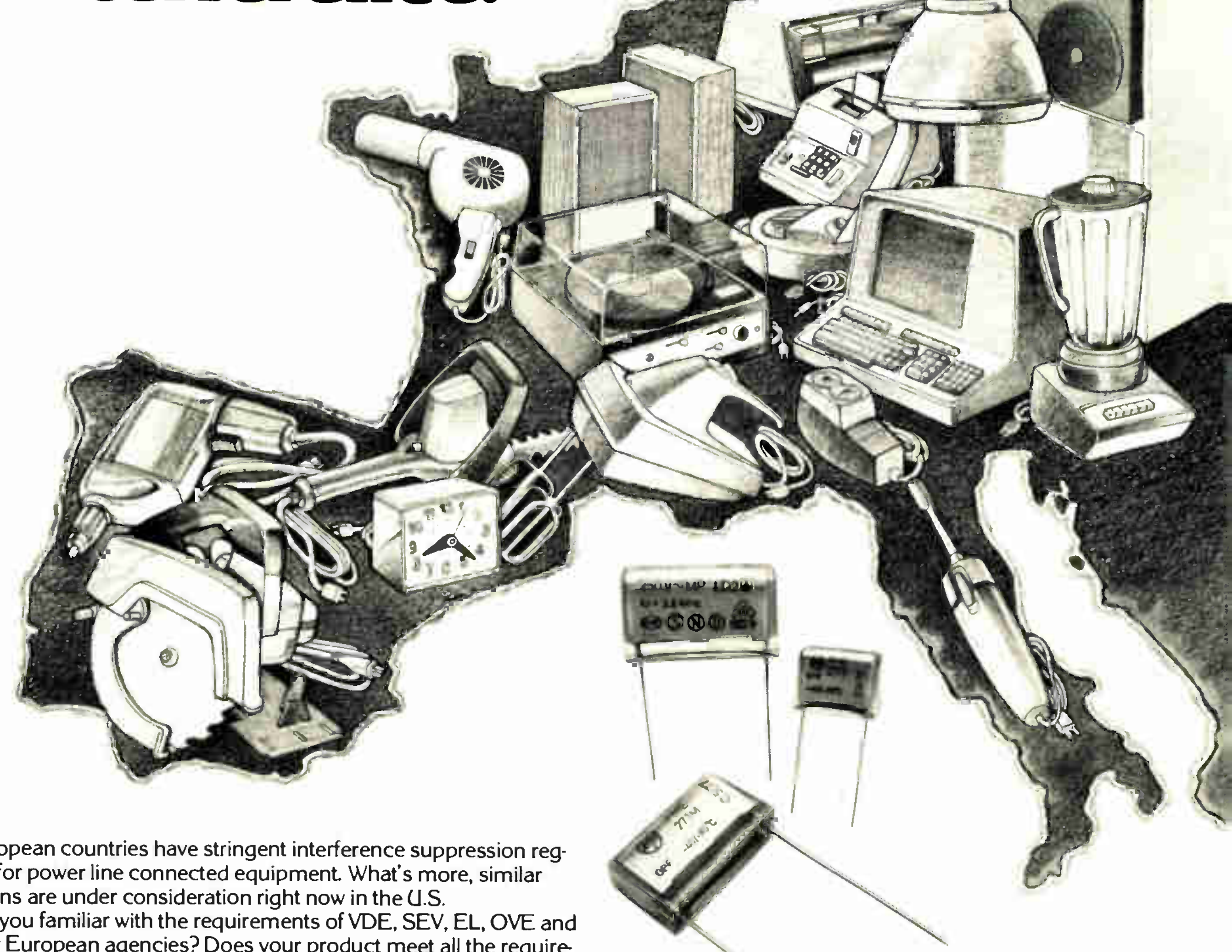
# How to meet European suppression regulations without getting a lot of interference.



PME 271 SERIES interference suppressor capacitors shown actual size.

European countries have stringent interference suppression regulations for power line connected equipment. What's more, similar regulations are under consideration right now in the U.S.

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If you want your product to meet all the European suppression requirements, go with the capacitor line that's number one throughout Europe.

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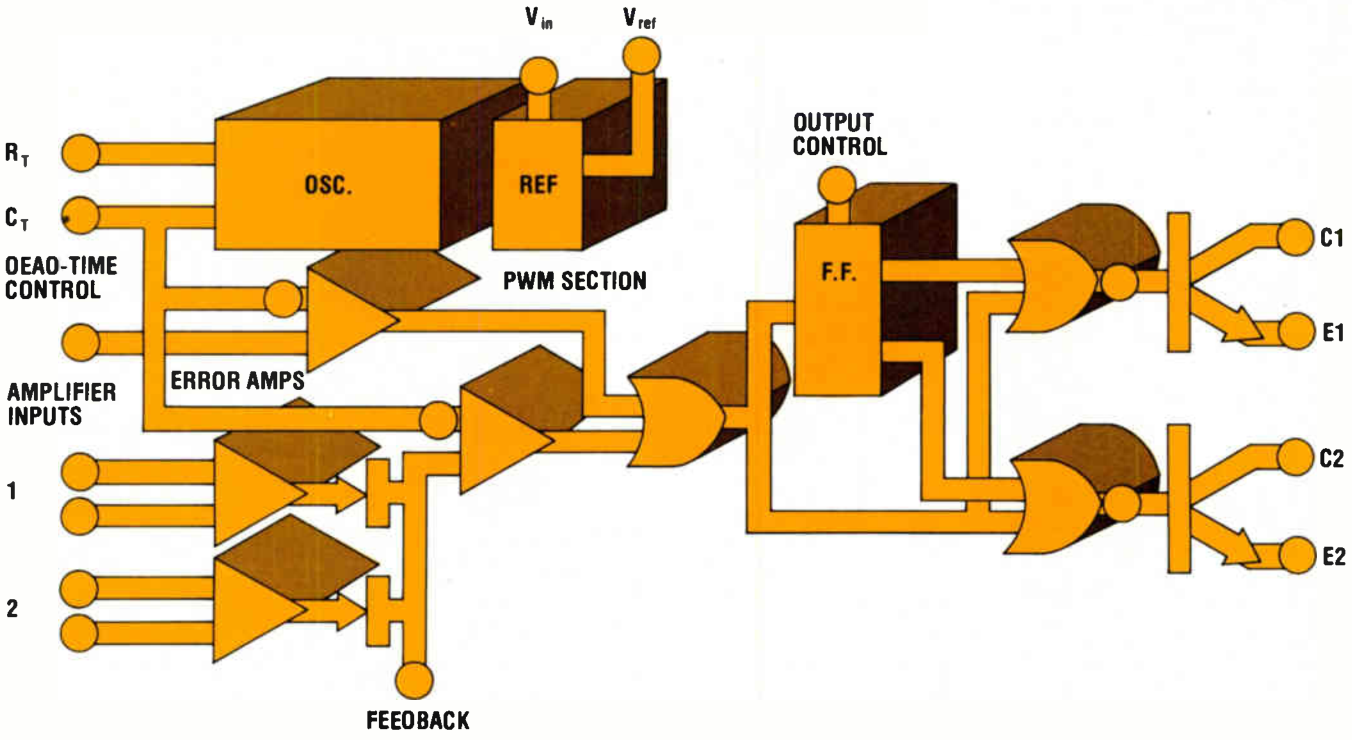


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In addition to all the outstanding features of the TL494, the new TL495 includes an on-chip zener for applications where input voltage exceeds 40 volts.

For extended applications, an output steering control provides external control of the pulse steering flip-flop.

### TL496 power controller for battery-powered products

This new monolithic controller contains both a switching regulator and a series regulator to provide a 9-volt output with only two external components (inductor and capacitor). It can operate from either a 2-cell battery or a-c input. Features include:

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- 9-volt output
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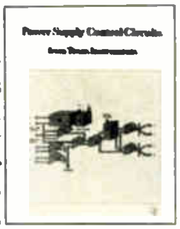
### And there's more...

The TI line of switching voltage regulators also includes the TL497A and SG3524. These circuits are complemented by the overvoltage sensing circuit MC3423 and the temperature compensated voltage reference TL431.

### Free brochure



A new 16-page brochure (CL-366) gives full information on all TI's power supply control circuits. For your copy, write Texas Instruments Incorporated, Post Office Box 225012, M/S 308, Dallas, Texas 75265.

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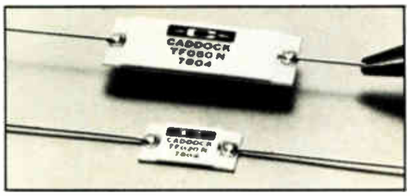
Circle 219 on reader service card

## New film resistor replaces precision wire-wounds.



### Caddock's Type TF Low TC Ultra-Precision Film Resistors.

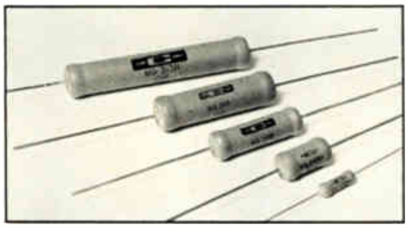
Utilizing Tetrinox™ film technology, the Model TF 050 N resistors combine TCs as low as 5 ppm/°C, values from 2 Megohms to 10 Megohms and tolerances to ±0.1% to surpass the performance of high-value wire-wound resistors.

Caddock's monolythic design and non-inductive resistance patterns eliminate fragile, 'high-L' coiled-wire construction.

Laser production techniques keep these Type TF resistor prices *below* the basic material cost of fine resistance wire!

For Type TF data, circle Number 101.

## Non-inductive precision resistors for power switching circuits.



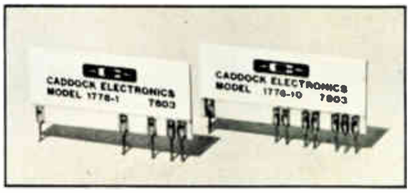
### Caddock's Type MS Power Film Resistors.

Caddock's patented Non-Inductive Design in power ratings from 2 watts to 15 watts assures minimum voltage transients in all types of power switching circuits.

High stability Micronox® resistance films operate to +275°C and years-long load-life tests demonstrate extended-life stability better than 0.05% per 1000 hours.

For Type MS data, circle Number 103.

## Off-the-shelf precision decade voltage dividers.



### Caddock's Type 1776 Precision Decade Resistor Voltage Dividers.

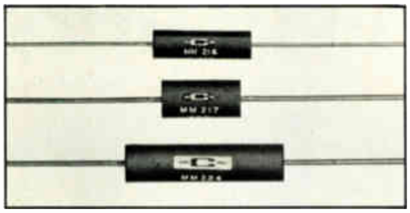
When used as a 10 Megohm input voltage divider, the Type 1776 family can provide high accuracy voltage division in ratios of 10:1, 100:1, 1000:1 and 10,000:1.

The Type 1776 is available in 14 standard in-production models, and OEM quantity prices are low.

For Type 1776 data, circle Number 105.

# CADDOCK Resistor Technology solving problems across the board!

## High temperature, miniature axial-lead resistors.



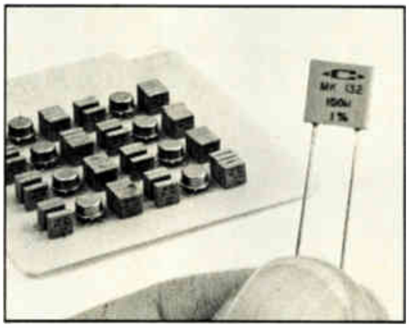
### Caddock's Type MM Precision Film Resistors.

The Type MM is a family of precision film resistors in a molded silicone case that is rated at .12 to 3.0 watts and at operating temperatures as high as +275°C.

Many years of use and testing have demonstrated outstanding reliability in geophysical 'down-hole' instruments, heart pacemakers and advanced aerospace systems.

For Type MM data, circle Number 102.

## 100 Megohms in a miniature package.



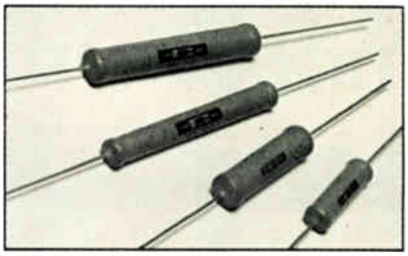
### Caddock's Type MK Precision Film Resistors.

Precision values to 100 Megohms in a miniature CK 06 case make the Type MK ideal for low current designs.

These non-inductive resistors find wide application in high-impedance analog circuitry.

For Type MK data, circle Number 104.

## High stability resistors for very-high voltage control and measurement circuits.



### Caddock's Type MG High Voltage Resistors.

High voltage probes and control circuits make wide use of Type MG resistors for precision high voltage regulation and high voltage measurements.

Long-term stability—plus proven reliability—have also made these precision resistors first choice in communications satellite voltage control circuits.

For Type MG data, circle Number 106.

Caddock's latest General Catalog provides complete performance data and specifications on over 100 models of these outstanding 'problem-solving' resistors.

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## Unit increases yields by cleaning wafers

An important cause of rejects in semiconductor manufacturing is particles that remain on semiconductor wafers after sawing or scribing. To eliminate this cause of bad circuits, Laurier Associates has developed its model WS-180 wafer scrubber. The unit not only increases yields by cleaning the wafers, it also reduces manual handling of the wafers during cleaning—a potential source of damage.

A typical operation of the WS-180 goes as follows: a wafer is mounted on the machine's turntable, which begins to rotate. Then deionized water is sprayed onto it and a brush begins to scrub the surface. Next detergent is fed into the water to assist in the removal of debris. Finally, the wafer is rinsed and spun dry.

At the end of the cleaning cycle, air pressure elevates the wafer for easy, safe removal. The exact sequence of events is programmed and can take from 30 seconds to 6 minutes.

The WS-180 can handle both taped and untaped wafers with diameters up to 5 in. It comes with a micrometer adjustment for varying the brush height and a plexiglass cover for visual monitoring of the cleaning process. Lifting the cover during a cycle automatically shuts down the machine.

Designed to be bench-mounted adjacent to sawing or scribing equipment, the WS-180 measures 21 in. long by 20 in. deep by 17 in. high and weighs 85 lbs. It draws 1 A from a standard 115-V, 60-Hz line. Delivery time is eight weeks after receipt of order, and the price is $5,300 each.

Laurier Associates Inc., Executive Drive, Hudson, N. H. 03051. Phone (603) 889-8800 [391]


### Laser scribes substrates up to 0.4 in. thick

The 1080S computer-controlled laser system can scribe ceramic substrates as thick as 0.4 in. Moving at speeds of up to 10 in./s, its motor-driven table can be positioned to within ±0.1 mil/in. of travel. The fixed yttrium-aluminum-garnet laser can scribe straight cuts parallel to

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Mallory Capacitor Company, a division of P. R. Mallory & Co., Box 1284, Indianapolis, Indiana 46206.


# MALLORY

Circle 222 on reader service card

two perpendicular axes, straight cuts at 45° to these axes, and circular cuts of specified center and radius. The table comes in sizes from 4 to 12 in. square.

Quantrad Corp., South Normandie Avenue, Torrance, Calif. 90502 [393]

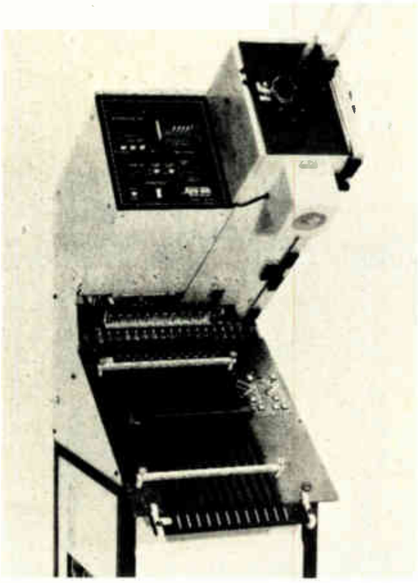
## Dual handler tests

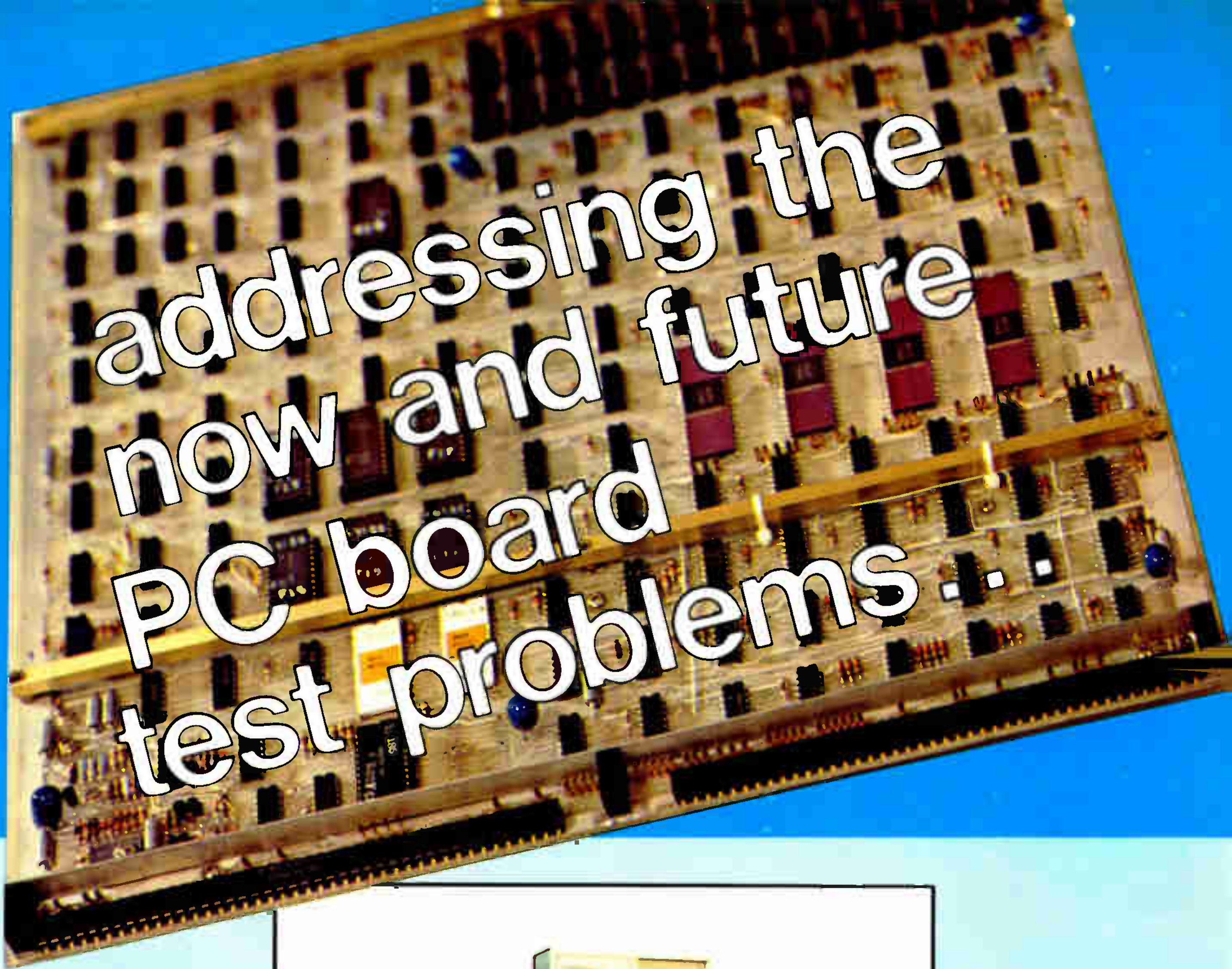
### 0.3-, 0.4-, 0.6-in. DIPs

Actually two independent handlers in one housing, the 346 Twin Magnum dual environment handler has two inputs that feed devices in dual in-line packages into a temperature-controlled chamber. There, the components' temperature is controlled to within ±1°C from −55° to +150°C by a microprocessor-based controller. The soak time, or time required for a device to reach test temperature, is selectable from 1 to 99 s.

When the DIPs reach the correct temperature, they are tested and moved into a common sorter assembly for separation into five categories. There are two reservoirs for each of the categories and two additional reservoirs for parts to be retested. The handler can also be operated in a single-track mode with 11 sorting categories and one retesting category.

Also available is the model 7830,



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Circle 224 on reader service card

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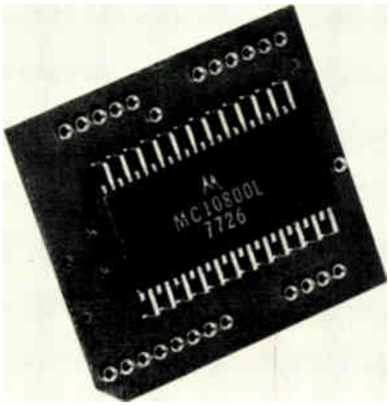
## New products

which tests 0.3-in. devices and can handle 6,500 DIPs per hour at zero test time. Its temperature range is from −73° to +150°C, and the soak time is the same as for the 346.

Sym-Tek Systems Inc., 4140 Morena Blvd., San Diego, Calif. 92117 [395]

### Adapters offer aid in packaging ECL systems

A family of adapters for medium- and large-scale integrated emitter-coupled-logic devices, when used with Mupac's line of ECL panels and rack assemblies, offers design engineers a complete high-frequency




packaging system. Adapters with provisions for decoupling 48-pin quad in-line and 24-pin MSI packages plug directly into a group of 16-pin socket locations and appropriate power pins. Delivery is from stock to three weeks; in quantities of 1 to 99, they sell for $5.50 each.

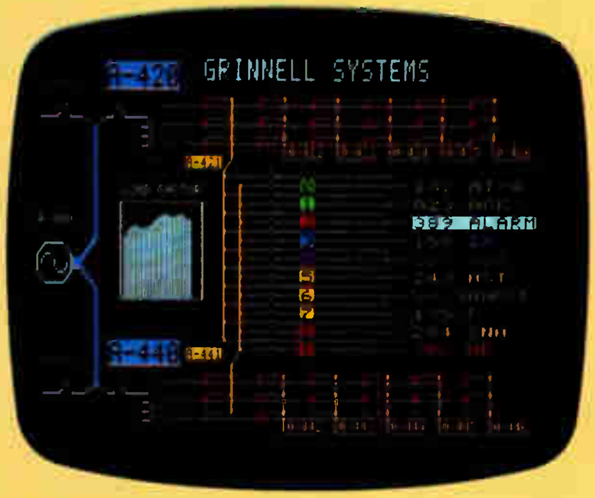
Mupac Corp., 646 Summer St., Brockton, Mass. 02402 [394]

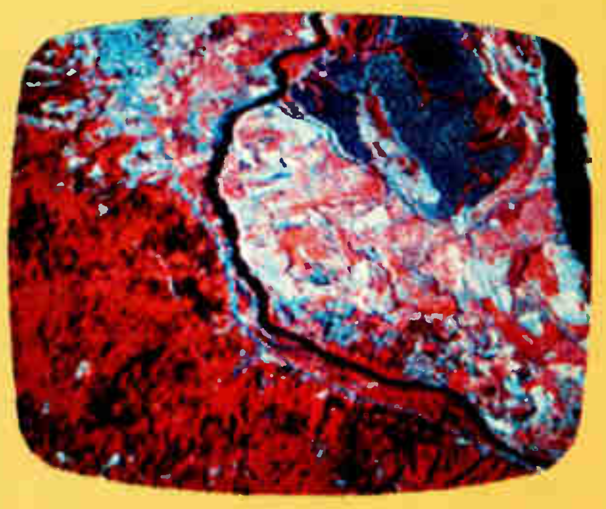
### Thermal-cycling system works without large ovens, hot plates

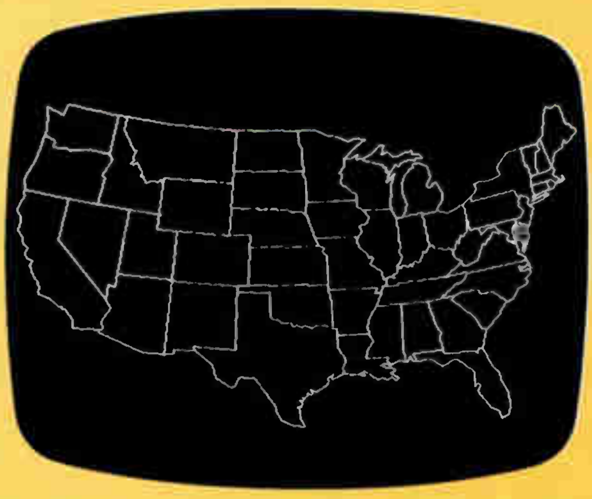
Design engineers who perform benchtop tests of components to military specifications usually use large ovens, hot plates, or probes for thermal cycling. The T-2100H high-temperature forcing system eliminates these auxiliary units.

To test a device, the user need

# Grinnell has your display...





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Circle 226 on reader service card

## New products


only plug it into a socket and place a Thermotest fixture over it. A stream of dry air or nitrogen is forced through the hose to the fixture and over the component. The system first raises the temperature of the gas to a selected temperature between 0° and 150°C and then sustains it in the fixture to within ±1°C. The flow rate of the gas is manually adjusted by turning a knob on the front panel of the T-2100H.

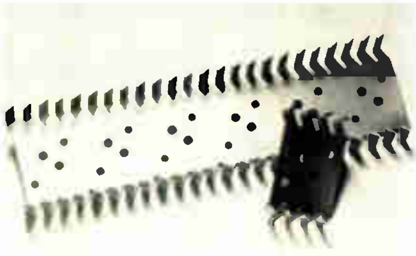
Thermotest fixtures accept devices regardless of configuration. A standard fixture, the PF-1, measures 3.2 in. diagonally and 1 in. high. Prices range from $70 for the PF-1 to under $1,000 for custom units. The T-2100H sells for $3,250, weighs 30 lb, and measures 17 by 17 by 9 in.

Thermonics Inc., 528 Weddel Dr., P. O. Box 60284, Sunnyvale, Calif. 94088. Phone (408) 734-4490 [396]

### Slant-fin heat sinks come in strip form

The 5700 slant-fin heat sink is available in strips of 1 to 39 units and can be used with devices housed in TO-3 and -66 packages. Individual sinks are 2.43 in. wide by 1.5 in. long. Delivery time is three to four weeks after receipt of order.

Aavid Engineering Inc., 39 Cook Ct., Laconia, N. H. 03246 [397]

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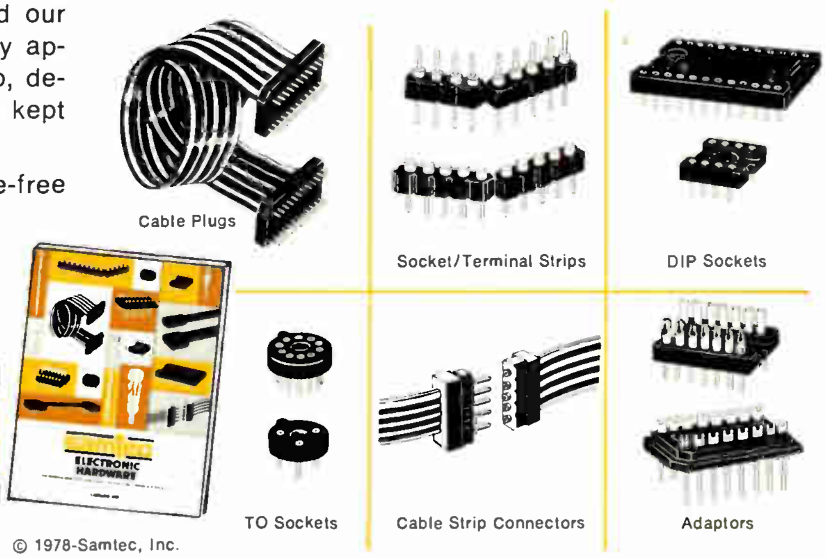
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Circle 230 on reader service card

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**8804 ANY DIP**, $21.95. Accepts all DIPs. Offset power and ground planes, 50/100 contacts spaced .125." S-100 size.*

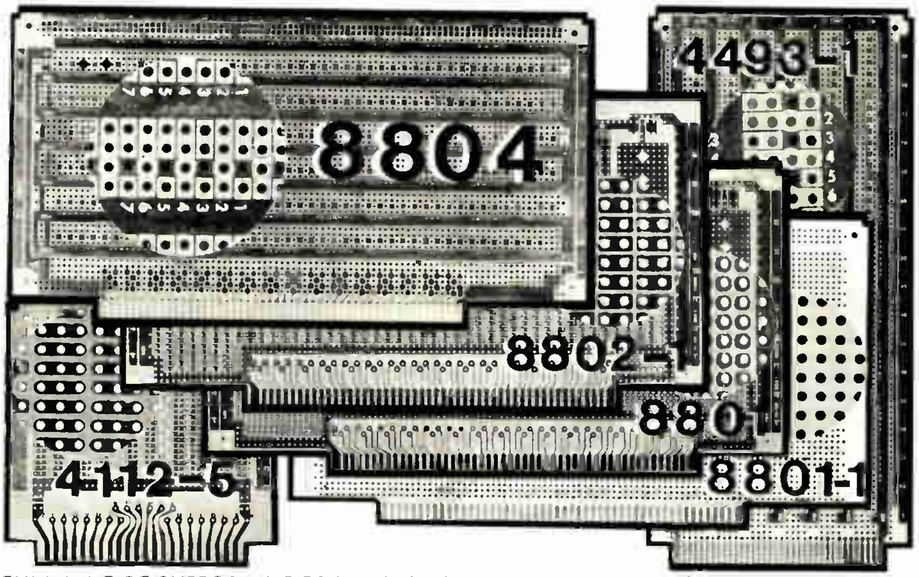
**4112-5 PAD BOARD**, $12.23. Pad per 3 holes. Ground plane on backside. 4.5" x 4.5" or 4.5" x 6.5" or 4.5" x 9.6". 22/44 contacts spaced 0.156".

**8802-1 PAD BOARD**, $21.95. Pad per 2 holes, each side, peripheral buses. 50/100 contacts spaced at .125", S-100 size.*

**8801 PAD BOARD**, $19.95. Pad per each hole, each side, peripheral buses. 50/100 contacts at .125". S-100 size.*

**8801-1**, $14.95. No pads — just holes. 50/100 contacts at .125". S-100 size.

*S-100 size is 5.3" high by 10" wide.

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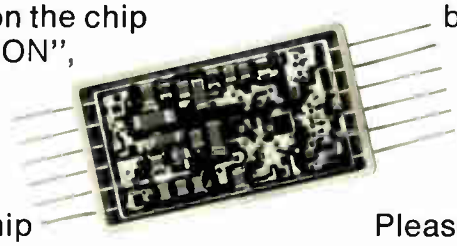

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# 20KHz WIDE RANGE
# SWITCHING POWER SUPPLIES

## For use in laboratory, systems and test equipment


45% smaller by volume and 46% more amps per dollar than an equivalent SCR switching power supply.

## Guaranteed 5 Years

OUTPUT RATINGS FOR LES-F SERIES

| MODEL | REGULATED OUTPUT VOLTAGE | MAX. OUTPUT CURRENT AT T AMB 40°C | 50°C | 60°C | 71°C | PRICE |
|---|---|---|---|---|---|---|
| LES-F-01-OV | 0 TO 7.5V | 100A | 83A | 66A | 47.5A | $1200 |
| LES-F-02-OV | 0 TO 18V | 47.5A | 41A | 32.5A | 23.5A | 1100 |
| LES-F-03-OV | 0 TO 36V | 24A | 20.4A | 16.5A | 12A | 1000 |
| LES-F-04-OV | 0 TO 60V | 15A | 12.8A | 10.3A | 7.5A | 1200 |

Note: Maximum output current applies over entire output voltage range.

## Outstanding Features

**Designed to meet military environment MIL-STD-810C**

**Digital Meter Readout**

**Convection cooled, no fans or blowers**

**Constant voltage/constant current**

**Overvoltage protection — built in on all models**

# SPECIFICATIONS OF LE SERIES

## DC output and rating
Refer to the table.

## Regulated voltage
regulation line .............. 0.02% + 2 mv for line variations from 105 to 132 vac (or 187 to 242 vac on 'V' options, 205 to 265 vac on 'VI' options).
regulation load .............. 0.02% + 2 mv (LES-F-01, 02) 0.02% + 4 mv (LES-F-03, 04) for load variations from 0 to full load.
remote programming resistance .............. 200 Ω/volt nominal
remote programming voltage volt/volt
ripple and noise .............. 10 mv-rms; 50 mv pp for LES-F-01 15 mv-rms; 100 mv pp for LES-F-02,03,04
temperature coefficient ...... (0.02% + 50 μv)/°C

## Constant current
(current regulated line and load)
automatic crossover.
voltage range .............. As shown in table.
current range .............. 5% to full load current.
regulation line .............. 0.5% + 50 mA (LES-F-01, 02) 0.5% + 20 mA (LES-F-03, 04) line variations from 105 to 132 vac (or 187 to 242 vac on 'V' opts, 205 to 265 vac on 'VI' opts).
regulation load .............. 0.5% of $I_{(max)}$ for load changes from 5% to rated DC voltage.

## AC input
line .............. 105-132 vac (47-63 Hz) standard input (derate output current by 5% at 50 Hz)
power .............. 1250 watts max at 0.6 P.F. at maximum output voltage, high line.
efficiency .............. Minimum 60% at maximum output voltage.
soft start circuit .............. Limits inrush current at turn on to 200% of full load peak current.
input current .............. 25A rms max.

## Ambient operating temperature
Continuous duty from 0°C to 71°C with appropriate deratings (40°C to 71°C—see table).

## Storage temperature range
−55°C to +85°C

## Overload protection
**Thermal**
By self resetting thermostat
**Electrical**
External overload protection—adjustable, automatic, electronic current limiting circuit limits output current to preset value. Current limiting settability to 105% of rated current via front panel adjust.

## Overvoltage protection
Built in, adjustable overvoltage protection standard on all sets. When preset voltage is exceeded, the overvoltage protector crowbars the output and removes the inverter drive. See table for OV range on each unit.

**OVERVOLTAGE PROTECTION ADJUSTABLE RANGES - LES-F SERIES.**

| MODEL | $V_{OUT}$ | ADJUSTABLE OVERVOLTAGE PROTECTOR RANGE $V_{OV}$(min) | $V_{OV}$(max) |
|---|---|---|---|
| LES-F-01-OV | 0 TO 7.5VDC | 3V | 10V |
| LES-F-02-OV | 0 TO 18 VDC | 6V | 24V |
| LES-F-03-OV | 0 TO 36VDC | 9V | 47V |
| LES-F-04-OV | 0 TO 60VDC | 12V | 70V |

## EMI
Conducted EMI conforms to MIL-I-6181D.

## Cooling
Convection cooled—no fans or blowers.

## Input and output connections
Heavy duty barrier strip and output studs on rear of chassis.

## Meters
Digital panel meter standard on all sets monitors output voltage/current by means of a volt/amp selector switch.

## Controls
**DC output controls**
coarse and fine voltage adjust and coarse current adjust on front panel.
**Overvoltage protection**
overvoltage trip point set by screwdriver adjust on front panel.
**Power**
on-off switch on front panel.

## Remote sensing
Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation.

## Fungus proofing
All units are rendered fungi inert.

## Options
**AC input**

| Add Suffix | For Operation at: | Price Qty. 1-14 | Price Mixed Models Qty. 15 and up | Price Single Model Qty. 15 and up |
|---|---|---|---|---|
| -V | 187-242 VAC (47-63 Hz*) (derate current 10%) | 12% | 12% | 10% |
| -V1 | 205-265 VAC (47-63 Hz*) | 12% | 12% | 10% |

*derate 5% at 50 Hz operation

## Accessories
Chassis slides (KHT-34-003)

## Weight
net: 40 lbs
ship: 50 lbs

## Size
Standard F package size 3 15/32" x 19 x 16 1/2" (H x W x D)

## Guaranteed for 5 years
5 year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of 5 years.

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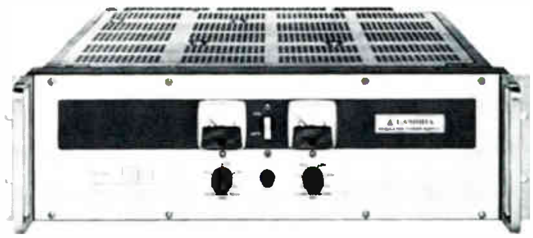
## LK SERIES USING SCR SWITCHING

3 5/16"

LES-F-02-OV



5 3/16"

LK-350-FM

| LES-F-02-OV | | LK-350-FM |
|---|---|---|
| 0-18V | VOLTAGE | 0-20V |
| 47.5A | CURRENT | 35A |
| 3 15/32 x 19 x 16½ | SIZE | 5 3/16 x 19 x 16½ |
| 40 LBS | WEIGHT | 95 LBS |
| CONSTANT I/CONSTANT V | MODE | CONSTANT I/CONSTANT V |
| DIGITAL METER STD | METERS | ANALOG METER STD |
| OV BUILT IN | OV PROTECTOR | OV OPTIONAL |
| $1100 | PRICE | $1181 (WITH OV) |

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- Constant voltage/constant current

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Wear-free brushless dc servo motors (Type 3056).
Fully-modular construction based on a motherboard.

**Ease of use**
The world's easiest-to-load chart recorders...... U.S. Patent No.3,946,406 (Type 3061).
High-quality disposable pens... replace in seconds with no mess.
Versatile remote control options.

**Portability**
Durable, yet compact and lightweight. The largest, the 9-pen Type 3061, weighs only 25kg and measures less than 38×57×28cm. Type 3056 is half the weight, half the volume.

Choice is yours:

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Recording width: 250mm, Accuracy: ±0.25%, Pen speed: 800mm/s, Voltage ranges: 5μV/cm to 5V/cm in 19 ranges or 0.5mV/cm to 5V/cm in 13 ranges, Chart speeds: 60cm/min to 2cm/h in 8 speeds (controlled by built-in fork oscillator), CMR: 140dB.

**Multi-channel tracing versatility from 6- or 9-pen flatbed recorders (Type 3061)**
Recording width: 250mm, Accuracy: ±0.25%, Pen speed: 800mm/s, Voltage ranges: 0.5mV/cm to 5V/cm in 13 ranges, Chart speeds: 60cm/min to 2cm/h in 14 ranges (controlled by built-in fork oscillator), CMR: 140dB

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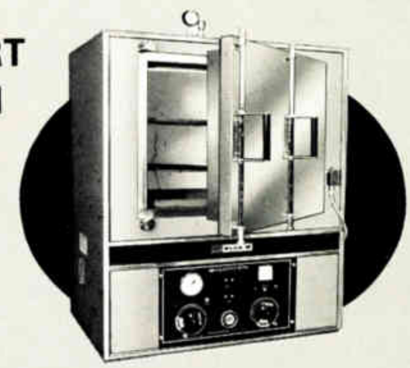

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 Circle 240 on reader service card

Circle 348 on reader service card

# Products newsletter

**Amplifiers use new error-cancellation technique**

Watch for Intersil Inc., Cupertino, Calif., to introduce a pair of monolithic CAZ amplifiers. **CAZ, which stands for commutating auto zero, is a novel technique for cancelling errors caused by noise, temperature effects, and long-term drift,** according to Skip Osgood, marketing manager for the company's data-acquisition products group. One of the new chips, the ICL7600, is a 14-pin operational amplifier. The other, the ICL7605, is an instrumentation amp in an 18-pin package. Both will be available this quarter. The op amp will be priced at $6.50 each in hundreds; the instrumentation unit will go for $15 in the same quantities.

**Tektronix adds Basic to 8002**

Users of the model 8002 microprocessor development lab by Tektronix Inc. can now develop code for the 8080, the 8085, and the 8080 subset of the Z80 using Basic high-level language instead of assembly language [*Electronics*, Oct. 26, p. 147]. **A Basic compiler on a flexible disk is now available for $900,** according to Roger Hokanson, product marketing manager at the Beaverton, Ore., firm. Tek's Basic is a subset of ANSI minimal Basic with high-level language addressability of input/output ports and registers. What's more, it adds an extra 35 error messages to the 8002's list of 90, Hokanson says.

**Analog Devices shrinks temperature sensor . . .**

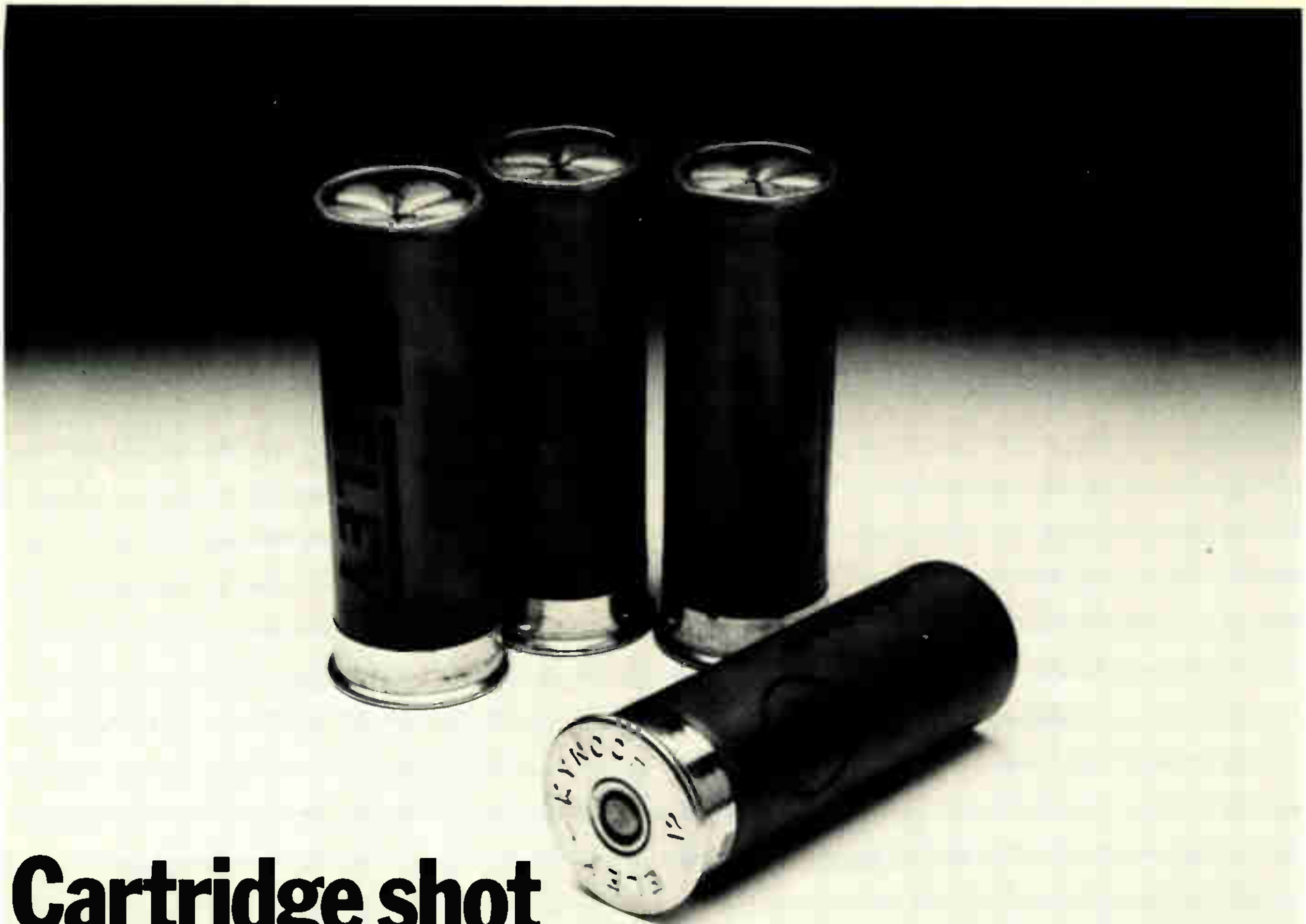
A newly packaged temperature sensor from Analog Devices Inc.'s Semiconductor division, Wilmington, Mass., fits into places a TO-52 can could never hope to make. **The AD590 is now available in a flat pack that measures 0.23 by 0.105 by 0.056 in.** Designated the AD590F, it has a maximum error of 5°C at 25°C and is typically linear to within 0.02°C over the range from 0° to 100°C. The fast-responding device sells for $3.50 and is available from stock.

**. . . and second-sources the DAC85**

Also new from the division is a three-chip second source for Burr-Brown's DAC85—the military version of the popular DAC80. **The new ADDAC85 is linear to within ¾ least significant bit over its full range.** The digital-to-analog converter sells for $52 each in hundreds in its current-output form and for $54 each for the voltage-output version, which contains an output operational amplifier.

**34 opto-isolators second-sourced by Motorola**

An extensive series of popular opto-isolators is being second-sourced by Motorola Semiconductor Products Inc., Phoenix, Ariz. **Both phototransistor and photodarlington types are included in the list of 34 devices,** all of which are housed in standard six-pin plastic dual in-line packages. The devices, which were originated by General Electric, Litronix, Monsanto, and Texas Instruments, are all tested to a peak ac isolation voltage of 7,500 V for 5 seconds—considerably higher than the originators' specifications. All other parameters are tested to the originators' specifications, conditions, and limits. Small-quantity prices for the Motorola units range from 90¢ to $1.90; for quantities of 100 to 999, the range is 75¢ to $1.60. Delivery time varies from immediate to eight weeks.



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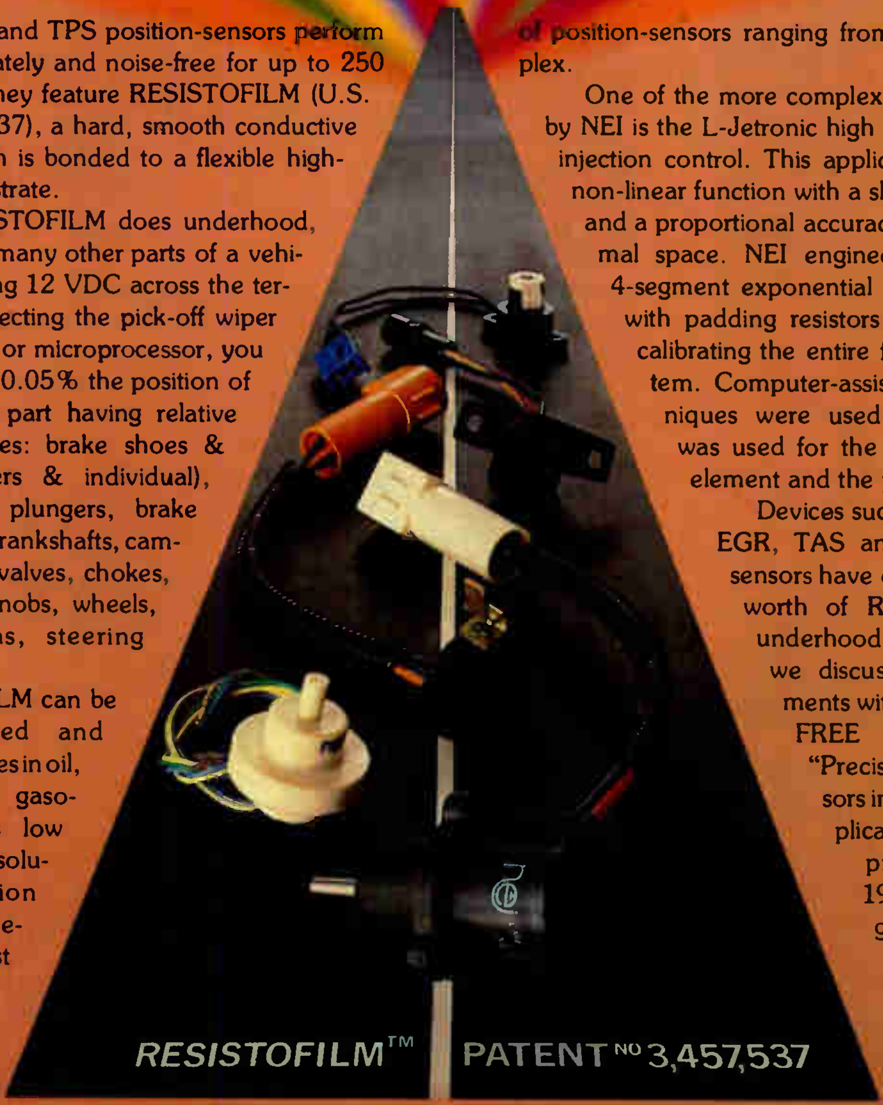
RESISTOFILM can be flexed, punched and bonded. It operates in oil, diesel fuel, and gasoline. It features low noise, infinite resolution, multi-million cycle life, tight linearity, and low cost in volume production. It can improve the performance of position-sensors ranging from simple to complex.

One of the more complex devices supplied by NEI is the L-Jetronic high performance fuel injection control. This application required a non-linear function with a slope ratio of 40:1 and a proportional accuracy of 1% in minimal space. NEI engineers developed a 4-segment exponential function element with padding resistors which allow for calibrating the entire fuel injection system. Computer-assisted design techniques were used. RESISTOFILM was used for the variable resistive element and the padding resistors.

Devices such as this and our EGR, TAS and TPS position-sensors have demonstrated the worth of RESISTOFILM in underhood applications. May we discuss other requirements with you?

FREE ON REQUEST: "Precision Position-Sensors in Automotive Applications," a paper presented at the 1978 SAE Congress & Exposition by William Wheeler, Laboratory Manager, NEI R&D Dept.

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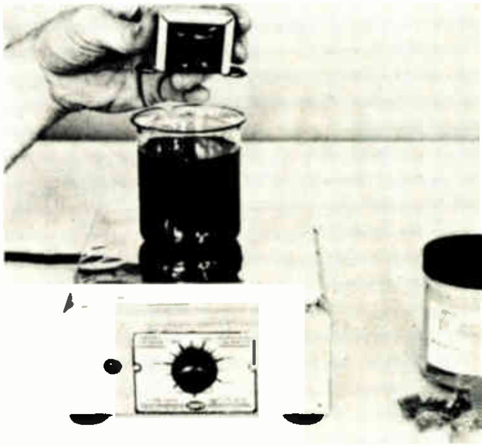
## New products/materials

**A meltable protective coating** is suitable as a masking material for terminals and stand-offs and similar applications before potting, dipping, and impregnating. Based on a modified and stabilized cellulose acetate butyrate, Eccocoat MH-10 can also be used as a removable protective coating on tools and other items. The material is nontoxic and noncorrosive to such metals as brass, lead,



steel, and zinc. Eccocoat MH-10 will melt at temperatures from 340° to 350°F (171° to 177°C); at 350°F, it has a life expectancy of 300 hours. Tensile strength is 1,400 lb/in.$^2$ The melt can be easily stripped away with a sharp knife. It sells for \$3.25/lb in quantities of 25 lb and is available from stock.

Emerson & Cuming Inc., Dielectric Materials Division, Canton, Mass. 02020 [476]

**Ceramic wear parts,** after curing, exhibit a hardness of 6 on the Mohs scale, which is comparable to tool steel. They can be polished to a 6-$\mu$in. finish and are good for such applications as computer tape

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**SWITCHCRAFT INC.**

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Aremco Products Inc., P. O. Box 429, Ossining, N. Y. 10562 [478]

**A silver epoxy**, Epo-Tek H20F is a good electrical conductor and can be flexed through 180°. It has a volume resistivity of 0.07 to 0.09 mΩ-cm when cured at 150°C and a sheet resistivity of 1.3 mΩ/sq/mil. The two-component material can be cured at 150°C in 10 min or at 100°C in 60 min. Pot life of the mixed epoxy is four days at room temperature; storage life of the unmixed materials is one year at room temperature. One-ounce evaluation kits sell for $27, and delivery is from stock.

Epoxy Technology Inc., Marketing Department, P. O. Box 567, 14 Fortune Dr., Billerica, Mass. 01821 [477]

**Foam microwave absorbers** can be used outdoors or where the absorber will be in contact with fuel, lubricants, or hydraulic fluids and is particularly useful in airborne applications. The material can be made into large blankets that can be draped or wrapped around radomes, antennas, or other structures. Standard-size sheets of Eccosorb AN-W are 2 ft by 2 ft (0.6 m by 0.6 m) and from ¼ to 4½ in. thick. The fabric is a self-extinguishing material and complies with MIL-C-20696. When used with Eccobond 87H, the absorber can be bonded to itself, metallic surfaces, or fiberglass laminate radomes.

Emerson & Cuming Inc., Microwave Products Division, Canton, Mass. 02021 [480]

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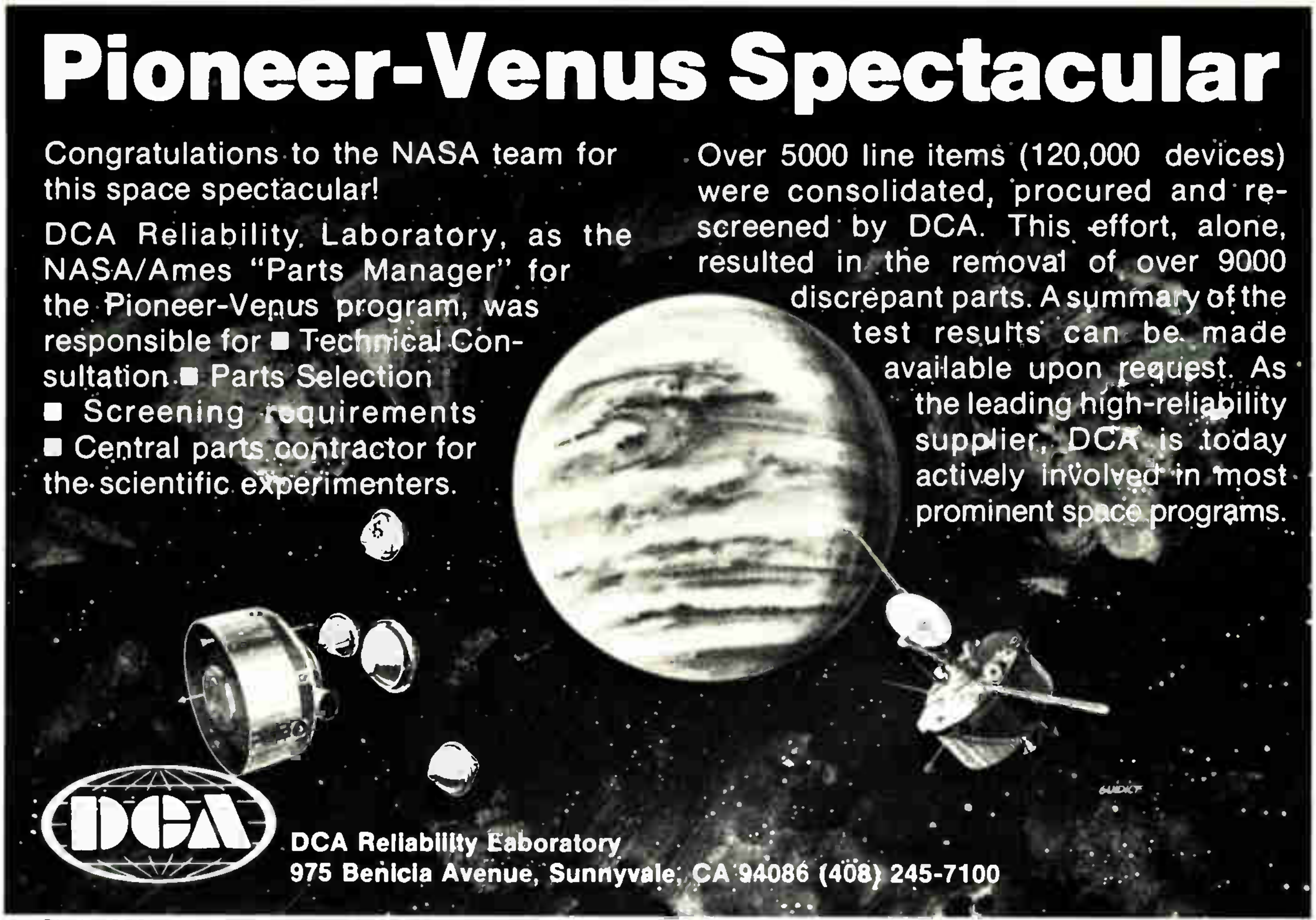


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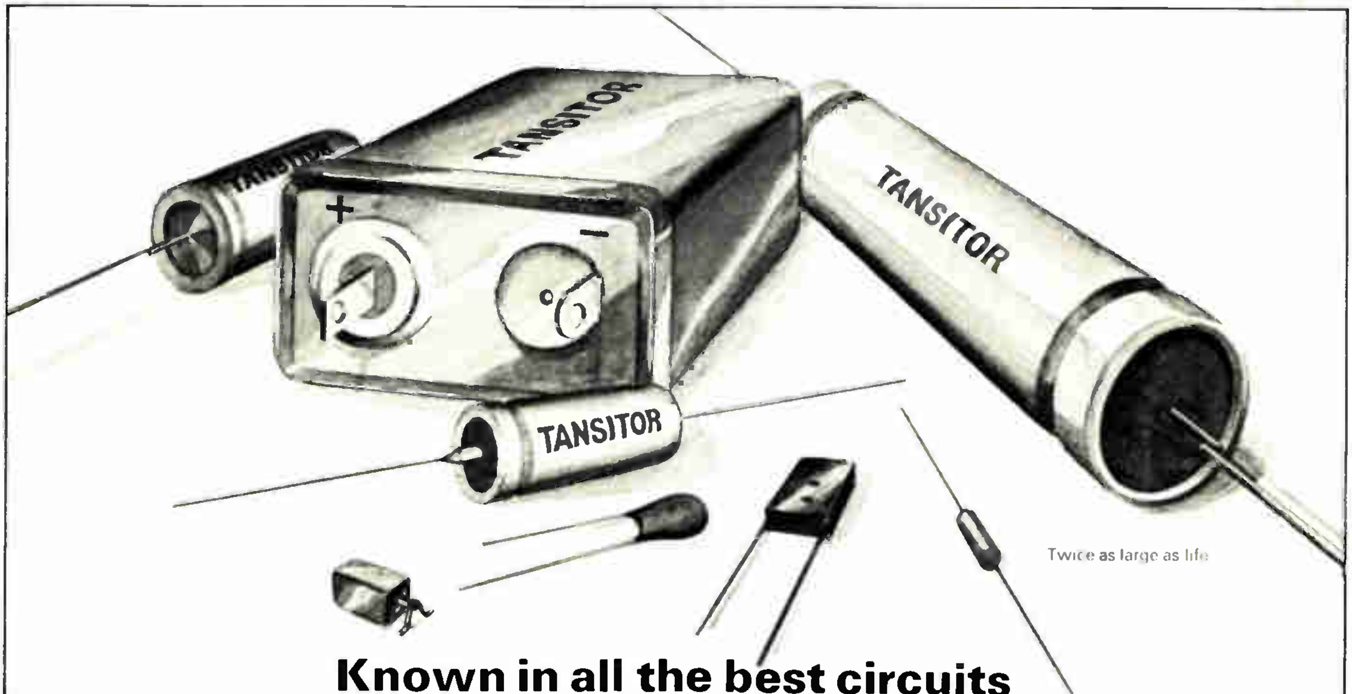


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## New literature

**Materials.** "Advanced Materials for Electronics," a 132-page catalog, describes, lists the properties of, and explains how to use such products as adhesives, cleaning preparations, conformal coatings, diffusants, cathode coatings, etchants, microwave materials, plating solutions, potting compounds, and junction coatings. Transene Co., Route One, Rowley, Mass. 01969. Circle reader service number 421.

**Microcomputers.** Designed for laboratory, educational, and home use, the TRS-80 microcomputer is the subject of a 20-page "TRS-80 Microcomputer Catalog." It gives the specifications and explains Level I and Level II Basic languages. The brochure also contains information on the TRS-80 expansion interface, TRS-80 minidisk system, and TRSDOS, which is the software


needed to operate the disk system. Radio Shack, a Division of Tandy Corp., 1400 One Tandy Center, Fort Worth, Texas 76102 [422]

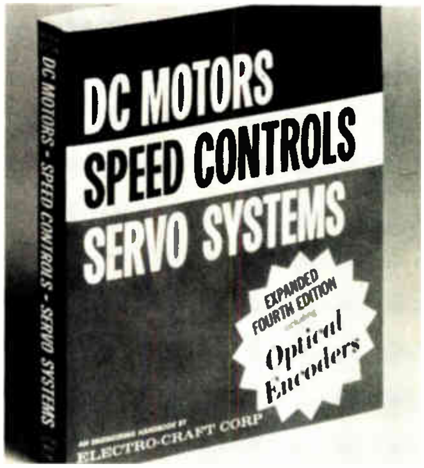
**Thermal shock chambers.** Described in an eight-page brochure are 64 standard test equipment models designed to transfer test specimens automatically between hot and cold zones with either air or liquid as the medium. Three different test equipment types are discussed and compared: vertical thermal, rotary thermal, and liquid-to-liquid thermal shock chambers. Topics that are covered include the requirements of military standard testing, the difference between thermal shock and temperature cycling, the economics of gas versus mechanical refrigeration, and the advantages of air-to-air and liquid-to-liquid testing. Safety and construction features are given. Ransco Industries, 2221 Statham Blvd., Oxnard, Calif. 93030 [423]

**Personal computer components.** More than 100 components, including microprocessors, memories, cathode-ray-tube controllers, light-emitting-diode displays, floppy-disk interfaces, serial and parallel interfaces, sound synthesizers, analog interfaces, and printer interfaces, are discussed, along with diagrams for each, in a 29-page brochure, "Semiconductor Components for the Personal Computer Industry." National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051 [424]

**Packaging and production.** Several brochures contain specifications and technical information on different types of electrical and electronic terminations. The brochures include "Plugs and Sockets," "Standard Rail-Mounted Terminal Blocks," and "Moduflex Crimp Pin Terminal Systems." Weidmuller Terminations Inc., 4326 Eubank Rd., Richmond, Va. 23231 [425]

**Components and power-supplies.** Useful for design engineers, the fourth edition of "DC Motors, Speed Controls, Servo Systems" contains technical information on these products and discusses optical encoders in depth. To order the handbook, send $1, along with a business card or company letterhead, to Electro-Craft Corp., Box 664, Hopkins, Minn. 55343

**Circuit protection.** "The Choice of Protection" is a 24-page technical booklet that discusses various techniques for protecting circuits. It features a section on magnetic circuit breakers and also contains information on fuses and thermal breakers. Topics in the magnetic-circuit section include short-circuit capacity, battery let-through currents, transient tripping, motor protection, SCR motor drives, measuring




inrush currents, and environmental conditions. The publication also has numerous graphs, tables, and illustrations. Airpax, Woods Road, Cambridge, Md. 21613 [426]

**Rubber.** "Precision Extruded Rubber

## New literature

Shapes," a 208-page catalog, contains profiles of both solid and cellular materials and is available from Minor Rubber Co. Inc., 49 Ackerman St., Bloomfield, N. J. 07003 [427]

**Test and measurement equipment.** A directory lists 912 of the leading manufacturers of test and measurement equipment. It is separated into three major sections: a product section, which lists the names of the major manufacturers by product area; company profiles of the 30 top manufacturers of test and measurement equipment; and information on each of these 30 companies. There are 84 different product categories covered, including spectrum analyzers, frequency synthesizers, signal generators, oscilloscopes, counters, panel meters, and printed-circuit-board testers. The directory sells for $75. Marketing Development, 402 Border Rd., Concord, Mass. 01742.

**Industry standard.** "Electromagnetic Susceptibility of Process Control Instrumentation," PMC33.1-1978, is a guide for establishing a common reference to evaluate the performance of industrial process-control instruments when subjected to electromagnetic fields such as those generated from radio transceivers. A classification of environments for anticipated electromagnetic fields and test methods for evaluating the instruments when used in these environments is included. The standard sells for $2 a copy. It can be obtained from Process Measurement & Control Section Inc., 370 Lexington Ave., New York, N. Y. 10017

**Microcomputer analog I/O systems.** A 74-page catalog gives technical specifications, prices, and ordering information for Data Translation's line of products. Described are the microcomputer analog input/output systems for Digital Equipment Corp.'s LSI-11/2 and LSI-11; Intel's SBC-80; Computer Automation's LSI-1, -2, -3, and -4 series; Zilog's Z80 MCB and MCS series, and National Semiconductor's BLC-80, IMP, and PACE families. A

## New literature

family of busable data-acquisition modules, special-purpose digital-to-analog converters, a programmable real-time clock for DEC's LSI-11,


and a selection of dc-dc converters are also described. Data Translation Inc., 4 Stathmore Rd., Natick, Mass. 01760 [428]

**A-d and d-a peripherals.** Highlighted in a 12-page brochure is the Sine-Trac series slide-in analog-to-digital and digital-to-analog peripheral boards for minicomputers and microcomputers. The brochure outlines the SineTrac concept and gives performance specifications common to all models. A block diagram for the ST-PDP is also provided, along with a user-oriented selection guide for each series. Ordering information is given. Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021 [429]

**Silicones.** "Guide to Dow Corning Products" summarizes silicones used in 21 major industries for such applications as appliance design and maintenance, chemical and petroleum processing, and metal fabrication. The 40-page guide also contains product-selection tables that contain descriptions, benefits, and applications. Dow Corning Corp., Midland, Mich. 48640 [430]

**Switches.** Information on more than 300 different switches is contained in a 32-page catalog. Some of the products include slide, snap-action, rotary, rocker, and paddle switches, as well as klipsocket lamp holders, and panel indicator lights. Chicago Switch Inc., 1714 N. Damen Ave., Chicago, Ill. 60647 [431]

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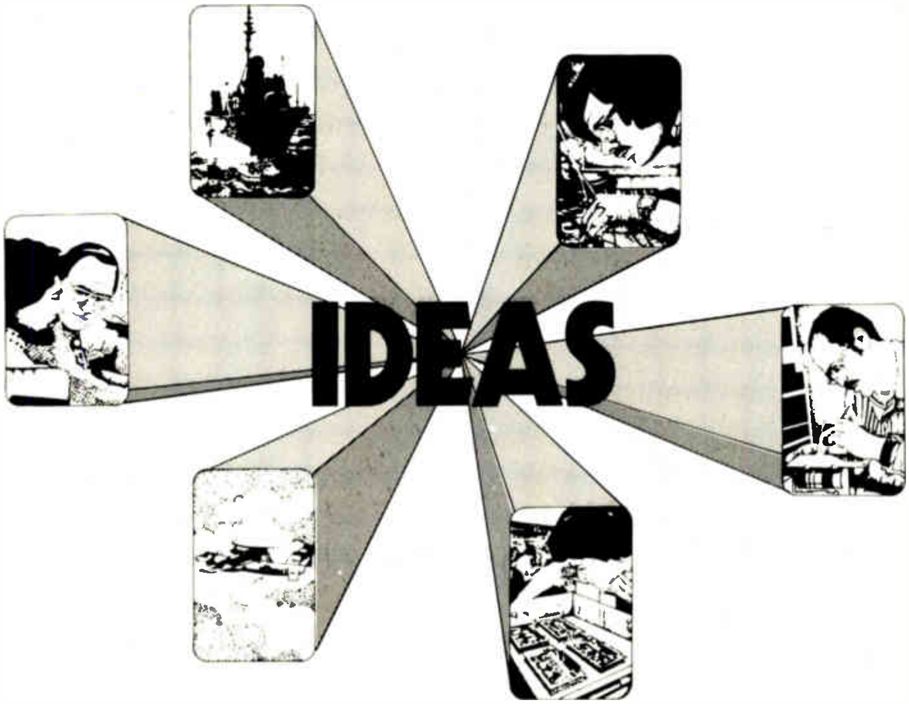


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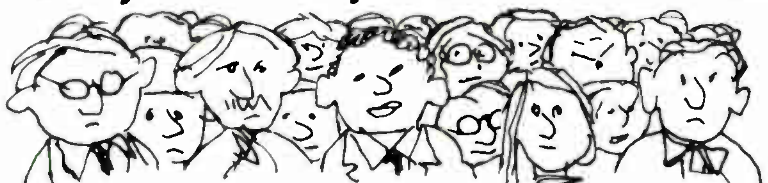

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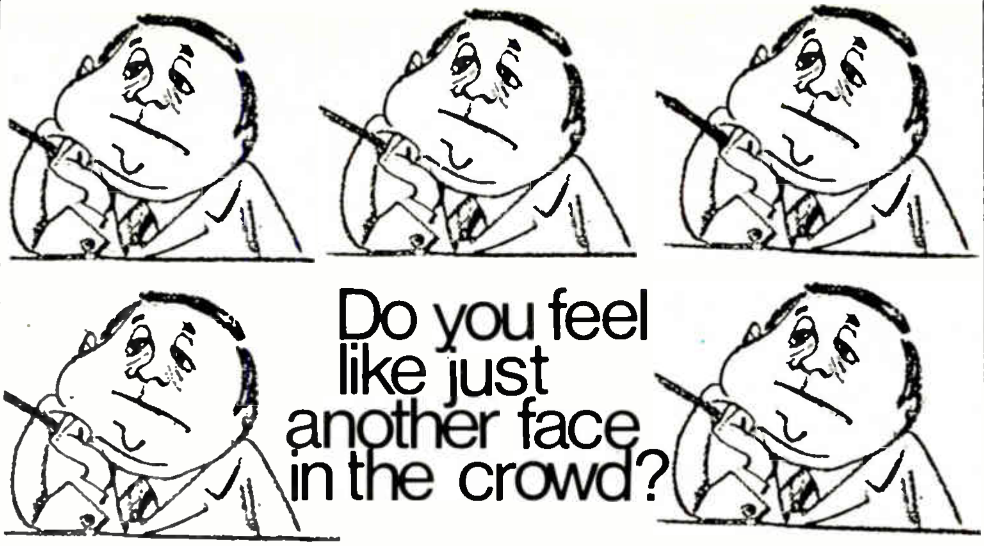


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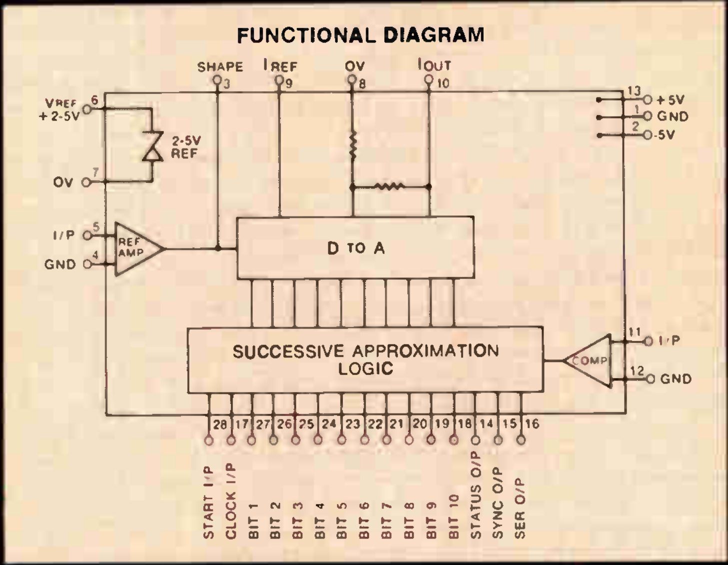


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**Your principal job responsibility** (check one)

- **t** ☐ Management
- **v** ☐ Engineering

**Estimate number of employees** (at this location): **1.** ☐ under 20 **2.** ☐ 20-99 **3.** ☐ 100-999 **4.** ☐ over 1000

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 16 31 46 | 61 76 91 106 | 121 136 151 166 | 181 196 211 226 | 241 256 271 348 | 363 378 393 408 | 423 438 453 468 | 483 498 703 718 |
| 2 17 32 47 | 62 77 92 107 | 122 137 152 167 | 182 197 212 227 | 242 257 272 349 | 364 379 394 409 | 424 439 454 469 | 484 499 704 719 |
| 3 18 33 48 | 63 78 93 108 | 123 138 153 168 | 183 198 213 228 | 243 258 273 350 | 365 380 395 410 | 425 440 455 470 | 485 500 705 720 |
| 4 19 34 49 | 64 79 94 109 | 124 139 154 169 | 184 199 214 229 | 244 259 274 351 | 366 381 396 411 | 426 441 456 471 | 486 501 706 900 |
| 5 20 35 50 | 65 80 95 110 | 125 140 155 170 | 185 200 215 230 | 245 260 275 352 | 367 382 397 412 | 427 442 457 472 | 487 502 707 901 |
| 6 21 36 51 | 66 81 96 111 | 126 141 156 171 | 186 201 216 231 | 246 261 338 353 | 368 383 398 413 | 428 443 458 473 | 488 503 708 902 |
| 7 22 37 52 | 67 82 97 112 | 127 142 157 172 | 187 202 217 232 | 247 262 339 354 | 369 384 399 414 | 429 444 459 474 | 489 504 709 951 |
| 8 23 38 53 | 68 83 98 113 | 128 143 158 173 | 188 203 218 233 | 248 263 340 355 | 370 385 400 415 | 430 445 460 475 | 490 505 710 952 |
| 9 24 39 54 | 69 84 99 114 | 129 144 159 174 | 189 204 219 234 | 249 264 341 356 | 371 386 401 416 | 431 446 461 476 | 491 506 711 953 |
| 10 25 40 55 | 70 85 100 115 | 130 145 160 175 | 190 205 220 235 | 250 265 342 357 | 372 387 402 417 | 432 447 462 477 | 492 507 712 954 |
| 11 26 41 56 | 71 86 101 116 | 131 146 161 176 | 191 206 221 236 | 251 266 343 358 | 373 388 403 418 | 433 448 463 478 | 493 508 713 956 |
| 12 27 42 57 | 72 87 102 117 | 132 147 162 177 | 192 207 222 237 | 252 267 344 359 | 374 389 404 419 | 434 449 464 479 | 494 509 714 957 |
| 13 28 43 58 | 73 88 103 118 | 133 148 163 178 | 193 208 223 238 | 253 268 345 360 | 375 390 405 420 | 435 450 465 480 | 495 510 715 958 |
| 14 29 44 59 | 74 89 104 119 | 134 149 164 179 | 194 209 224 239 | 254 269 346 361 | 376 391 406 421 | 436 451 466 481 | 496 701 716 959 |
| 15 30 45 60 | 75 90 105 120 | 135 150 165 180 | 195 210 225 240 | 255 270 347 362 | 377 392 407 422 | 437 452 467 482 | 497 702 717 960 |

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**Electronics** January 4, 1979 This reader service card expires April 5, 1979

NAME ______________________ TITLE ______________________

PHONE ( ______ ) ______________ COMPANY ______________________

STREET ADDRESS (Company ☐ or home ☐ check one) ______________________

CITY ______________ STATE ______________ ZIP ______________

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- **a** ☐ Computer & Related Equipment
- **b** ☐ Communications Equipment & Systems
- **c** ☐ Navigation, Guidance or Control Systems
- **d** ☐ Aerospace, Underseas Ground Support
- **e** ☐ Test & Measuring Equipment
- **f** ☐ Consumer Products
- **g** ☐ Industrial Controls & Equipment
- **h** ☐ Components & Subassemblies
- **j** ☐ Independent R&D Organizations
- **k** ☐ Government

**Your design function** (check each letter that applies):

- **x** ☐ I do electronic design or development engineering work.
- **y** ☐ I supervise electronic design or development engineering work.
- **z** ☐ I set standards for, or evaluate electronic components, systems and materials.

**Your principal job responsibility** (check one)

- **t** ☐ Management
- **v** ☐ Engineering

**Estimate number of employees** (at this location): **1.** ☐ under 20 **2.** ☐ 20-99 **3.** ☐ 100-999 **4.** ☐ over 1000

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 16 31 46 | 61 76 91 106 | 121 136 151 166 | 181 196 211 226 | 241 256 271 348 | 363 378 393 408 | 423 438 453 468 | 483 498 703 718 |
| 2 17 32 47 | 62 77 92 107 | 122 137 152 167 | 182 197 212 227 | 242 257 272 349 | 364 379 394 409 | 424 439 454 469 | 484 499 704 719 |
| 3 18 33 48 | 63 78 93 108 | 123 138 153 168 | 183 198 213 228 | 243 258 273 350 | 365 380 395 410 | 425 440 455 470 | 485 500 705 720 |
| 4 19 34 49 | 64 79 94 109 | 124 139 154 169 | 184 199 214 229 | 244 259 274 351 | 366 381 396 411 | 426 441 456 471 | 486 501 706 900 |
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