NOVEMBER 13, 1975

DATA ACQUISITION WITH HIGH SPEED AND RESOLUTION, PART 1/114

How time-base accuracy affects scope measurements/124

Development profile: tomorrow's computer with today's components/130

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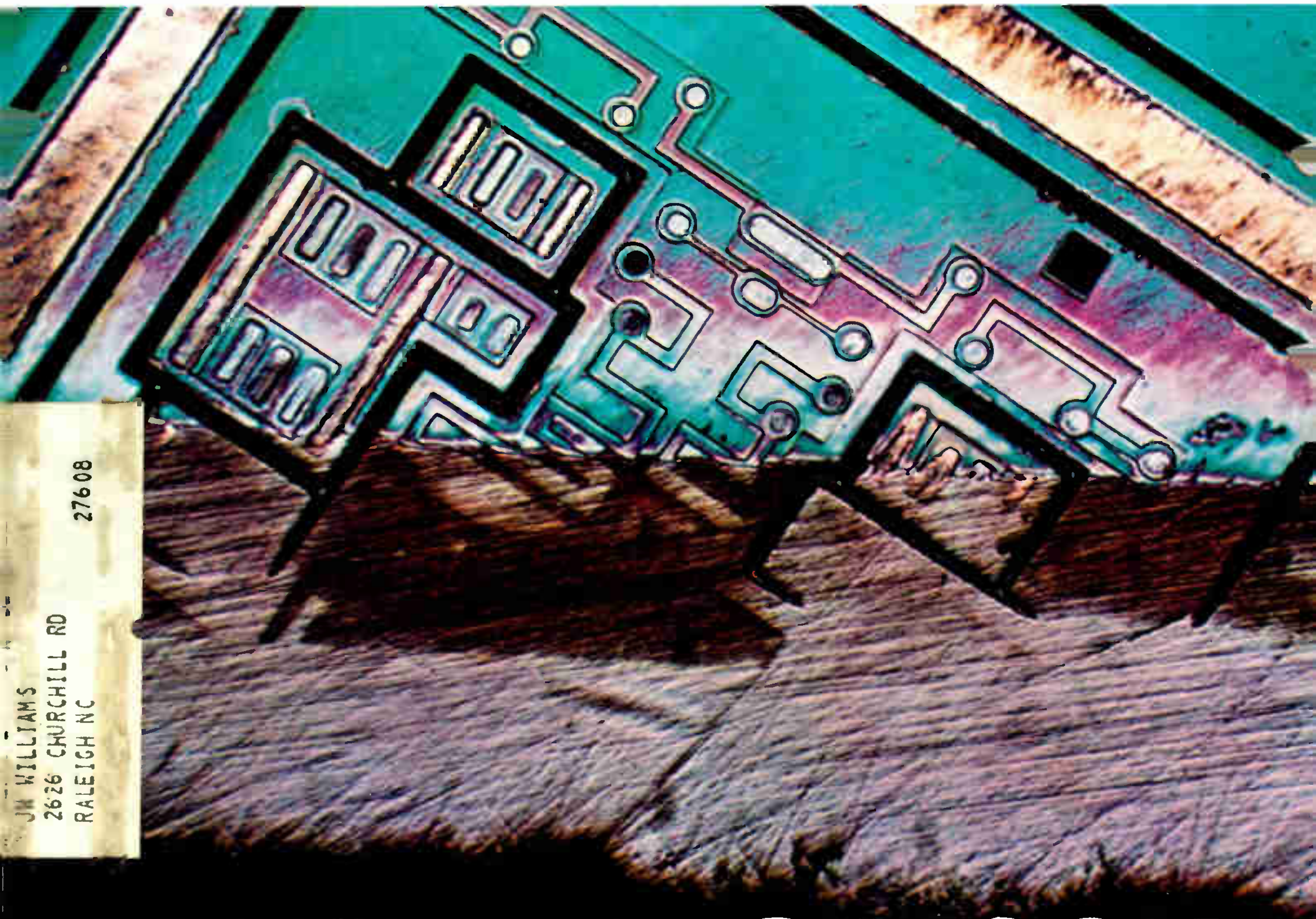

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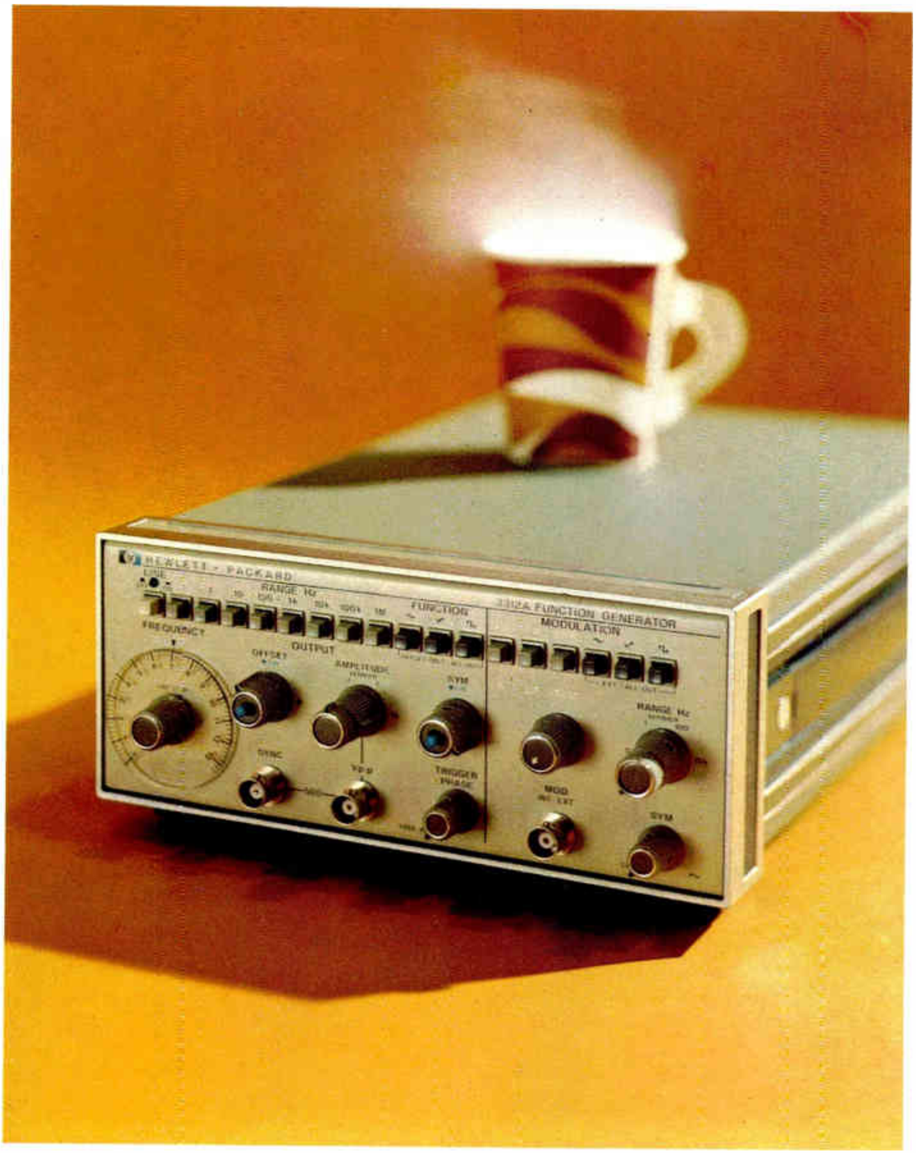

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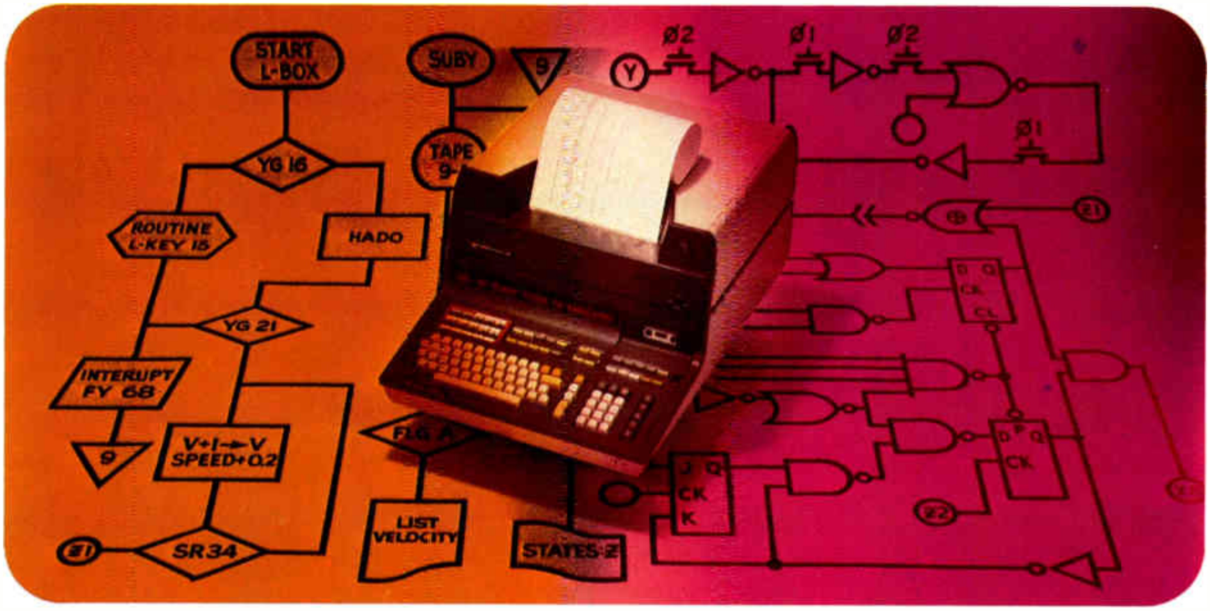

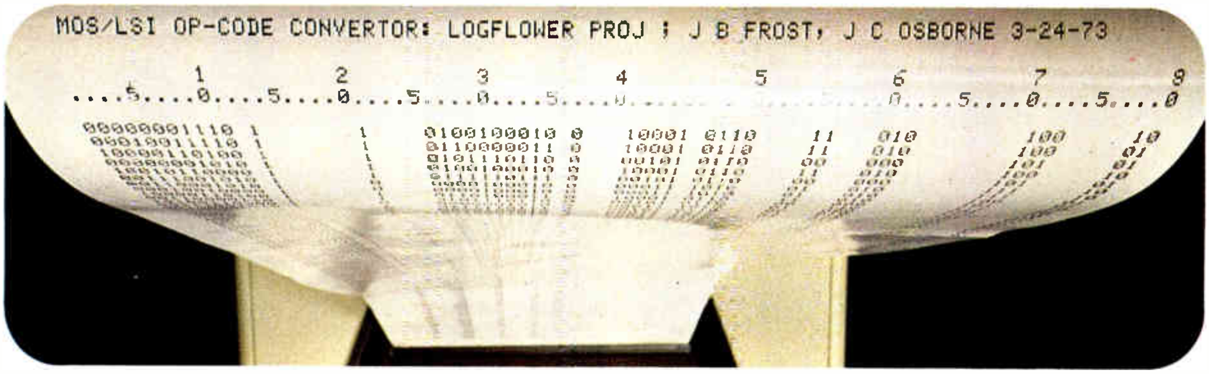

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Electronics

The International Magazine of Electronics Technology

Vol. 48, No. 23 • November 13, 1975

Highlights

Cover: The boon of silicon anodization, 109
Anodizing silicon turns it into a dielectric that can be used to isolate the active elements in both bipolar and MOS integrated circuits. The economical process also increases chip density and performance, particularly in the case of injection logic.

More firms enter auto diagnostics, 87
To meet the need for more precise engine tuning and emission control, more owners of automobile repair shops are expected to buy electronic equipment. The market has already attracted three newcomers.

Optimizing a data-acquisition system, 114
If the designer of a data-acquisition system is to capitalize fully on today's high-performance hardware, he must relate each system element carefully to his over-all design. But first, says Part 1 of this two-part article, he must understand each component's capabilities in detail.

Unusual computers use standard parts, 124
As this Product Development Profile of the Eclipse computer family shows, a system need not use state-of-the-art components to attain high performance. A clever architecture plus standard devices does just as well and should yield as long a market life.

And in the next issue . . .
Software considerations in circuit-board testing . . . how to design the optimum data-acquisition system, Part 2 . . . a preview of the International Electron Devices Meeting.

Electronics

Publisher's letter

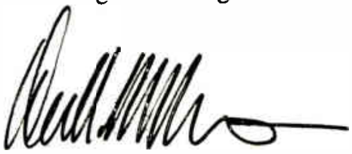
Executive editor Samuel Weber (second from left) and McGraw-Hill Publications Co. president John R. Emery (right) congratulate Achievement Award winners Horst H. Berger (left) and Siegfried K. Wiedmann of IBM's research labs in Boeblingen, West Germany.

In our October 16 Technology Update issue, we named the winners of our Award for Achievement and, in this space, ran a photograph of two of the four winners being interviewed by *Electronics*' staff members. Here, to more or less balance things out, are the other two winners, IBM's Horst H. Berger and Siegfried K. Weidman. They are shown as they, during a trip to New York, received their awards.

Interviewing Tadashi Sasaki is always a challenge, says associate editor Jerry Walker about his most recent meeting—his fourth in four years—with the Sharp Corp. executive in Japan (see p. 94). "They don't call him "The Rocket" for nothing," Jerry marvels.

"Sasaki leaves and arrives like a rocket. His staff is usually exhausted by the pace he sets. In our more-formal conversations, Sasaki switches between English and Japanese, causing fits for the interpreters. In fact, you don't so much interview Sasaki as absorb information during hours of conversation, which ranges from consumer electronics to Japanese cuisine, how to do business with the Russians, semiconductor development, enjoying Kyoto, medical electronics, point-of-sale systems, electronic watches, and music.

"After continuing our discussion during a late evening drive from his offices in Nara back to Osaka and then over dinner, Sasaki ended my interview with him by taking *my* picture with a pocket camera. The impression he gave when we parted was that he was rocketing off to another all-night meeting."



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Readers' comments

On organ music

To the Editor: I would like to express my disappointment over "The sound of organ music inspires new bipolar efforts" [Sept. 4, p. 110]. Superficially, the article contains many inaccuracies and even contradictions; it promises many things (such as tremolo) that it does not deliver.

Of greatest concern, however, is that it completely omits the one question which must be answered before a designer can decide whether even to send for a spec sheet—how does it sound? Forget about the comparison of the new method with relaxation oscillators—they are an archaic method of tone generation no longer widely used. The modern method of tone generation is to divide a high-frequency signal (generally near 2 megahertz) with twelve mod-n counters to generate the top octave, and then use twelve binary counters to produce the lower octaves. This method yields square waves of extremely high purity. Philips' method, on the other hand, generates square waves with substantial amounts of jitter. A short discussion of spectral purity and how it all sounds would have been appropriate.

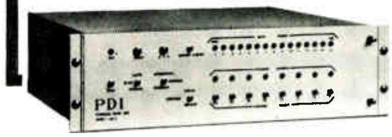
In short, I found this article to have a lot of gravy and very little meat.

Peter A. Stark
Mt. Kisco, N.Y.

The author replies: In our opinion, Mr. Stark misses the whole point of the article, which introduces the Philips system in a general way without attempting to give detailed information. The latter is certainly available to designers, who can then develop peripheral circuitry to provide such features as they require.

On the question of pitch, we agree there is a jitter but, with a master oscillator frequency of over 8 MHz, it is normally inaudible. And, as the article pointed out, the total frequency deviation is under 50 parts per million over a whole octave.

W. Adriaans
Philips N.V.
Eindhoven, the Netherlands



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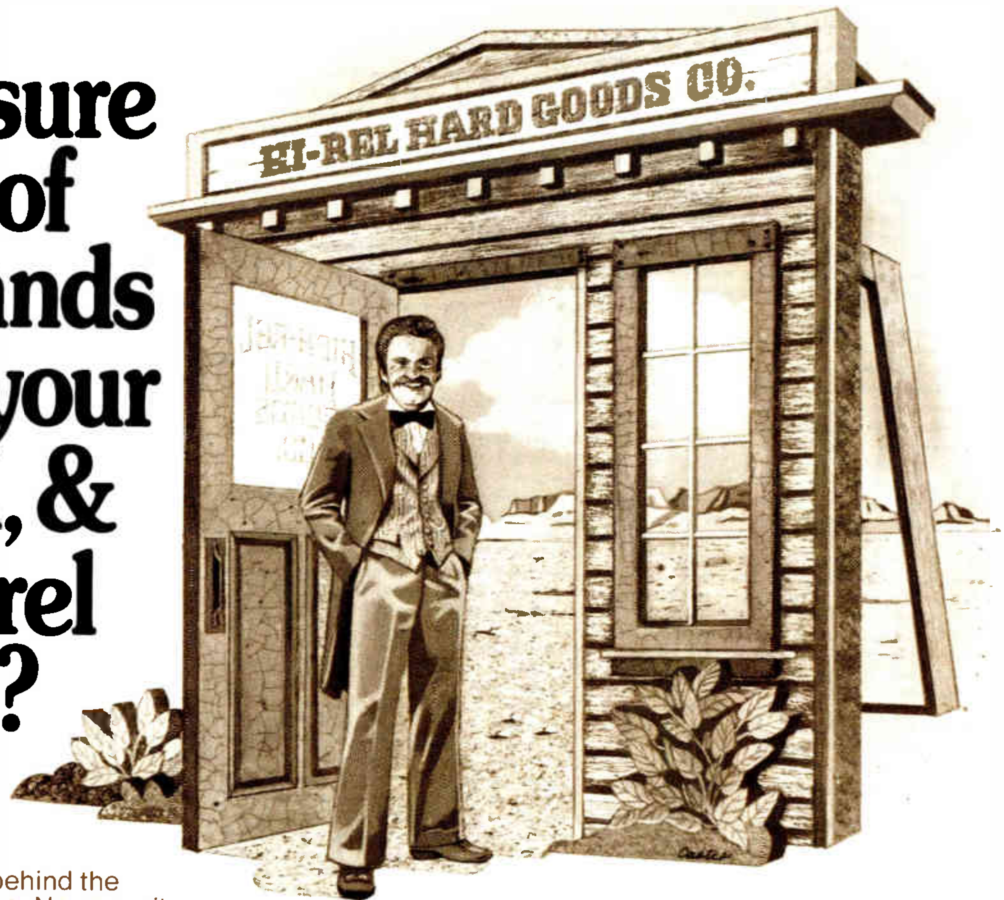

Many times when you get behind the facade, there's nothing there. No commitment to stay in the hi-rel business, no strict conformance to DESC processing regulations, no commitment to delivery, no broad product line. That's why buyers of both custom hi-rel and standard JAN, TX and TXV devices who want certainty buy from Teledyne.

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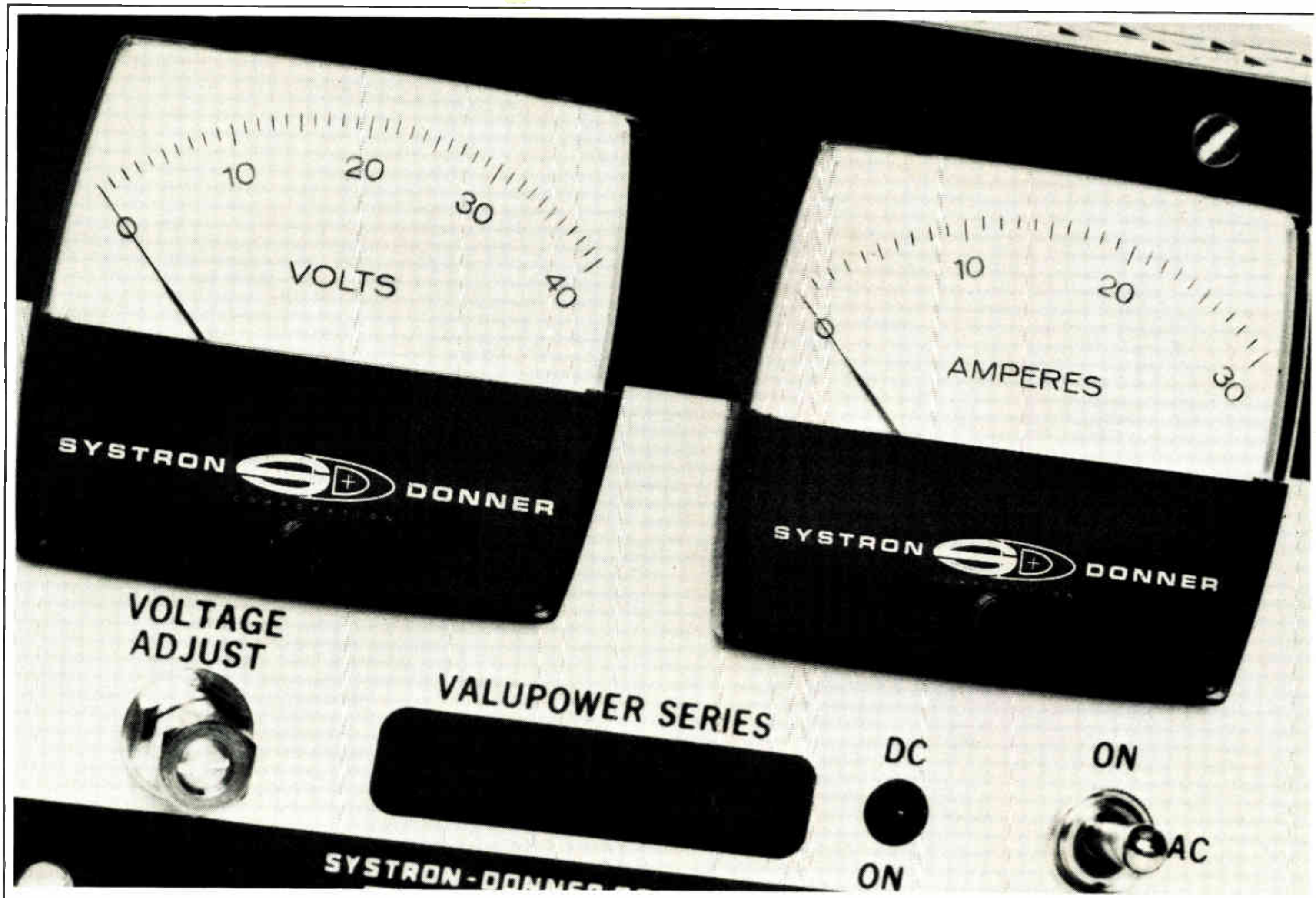
News update

■ Picturephone never quite reached the market potential that AT&T had hoped for. One of its main problems, for instance, was bandwidth, an obstacle that might be overcome when fiber-optic transmission becomes a reality. Meanwhile, phone company marketers have taken a new tack: selling Picturephone as an intercity video-conference tool. Last month, two lawyers in a small room in New York presented oral arguments via Picturephone to three judges sitting in Washington. According to officials of the Appellate Judges Conference, which sponsored the event, it was the first time such a system was used in actual court proceeding and the first time oral arguments had been held in a different city from where judges were sitting. AT&T paid transmission costs, estimated at $150 an hour.

■ Precision Instrument Co.'s $400,000 Model 190 memory system, which has a capacity of 16 billion bytes [July 25, 1974, p. 30], was installed last month at Ft. Meade, Md., for the Defense Department; the next installation is scheduled for a facility of the Energy Research and Development Agency in Tennessee. The Santa Clara, Calif., company says it has four contracts for the 190 plus "numerous" letters of intent from companies waiting to see how the first few installations fare. Meanwhile, Precision Instrument is expanding the 190's software to make the system almost completely transparent to the user.

■ The assets of Ohmtec Inc.'s Econostrate division have been bought by Christos G. Alex and he has formed a new company, Econostrate Corp., in Andover, Mass. Econostrate is producing printed-circuit boards by silkscreening the conductor and resistor pattern [July 25, 1974, p. 33]. Alex says that there has been some resistance by companies to the new method, "but things are moving to the production level."



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The future of funds-transfer policy and technology

The National Commission on Electronic Funds Transfer is off to a slow and shaky start, one that bodes ill for data processing equipment makers, who view the commission's success as critical to the successful evolution of "the cashless society."

The commission has several obvious problems. First, President Ford, without explanation, waited a year between the commission's creation and his October nomination of former New Jersey Congressman William B. Widnall as its chairman. That delay leaves the commission, which was given $2 million to start, only one year to come up with its report, rather than two years.

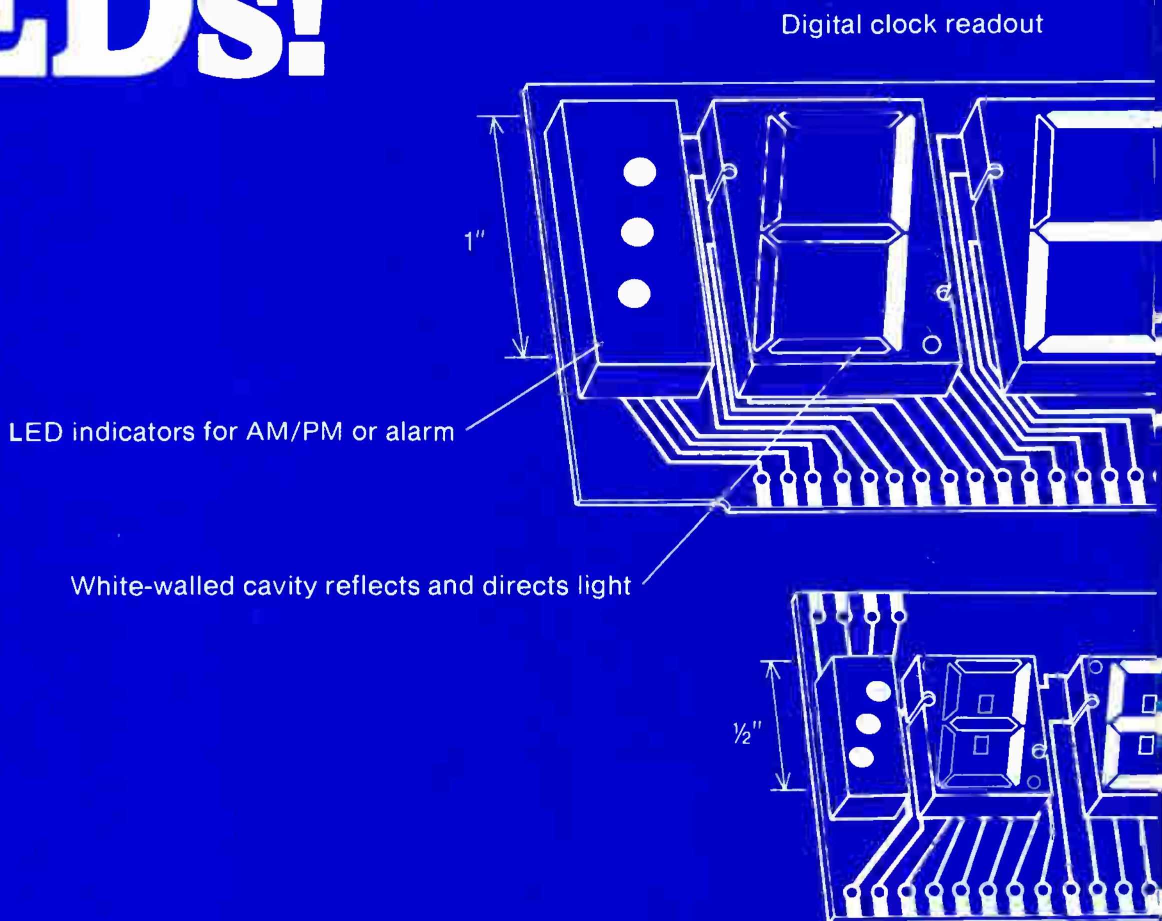
More critical to the commission's success is the absence, thus far, of any data processing or communications industry specialists among its 26 members, a dozen of whom are selected by Congress. Mandatory members include such figures as the Comptroller of the Currency and the chairmen or delegates of the Federal Reserve Board, Federal Home Loan Bank Board, and similar government specialists in monetary policy. The remaining 14 must include two involved state officials, such as banking regulators, seven representatives of banking interests, and five individuals with no ties to any institution.

The computer and communications industries clearly had a stake in those last five openings, but President Ford chose to ignore them. They also have a stake in the pending appointment and Senate confirmation of the commission's executive director. In view of the president's proclivity for giving such chairmanships to persons whose principal qualification seems to be that they lost their last election—plus 70-year-old Widnall's advanced age—the executive director is likely to have more authority than many of his counterparts. At best, however, the electronics industries can only hope for the appointment of someone with a knowledge of, and a sympathy for, the problems of applying technology.

National commissions to study this or that regularly come and go in Washington, leaving behind one or more volumes thick with conclusions and recommendations, and the charts, graphs, and footnotes that support them. A commission's delivery of its report to a President, the Congress, or its sponsoring agency is usually good for no more than one press conference before the volumes begin collecting dust. Sometimes the report is massaged into law a year or so later, sometimes not. The latter fate could easily befall the commission on electronic funds transfer—hardly a burning issue in the public eye—if those within the communications and computer industries fail to participate.

"A national commission," opines one congressional cynic, "is a convenient device. It gives burning issues a chance to cool so they may be more easily handled. If they burn out, so much the better. The ashes are easily disposed of." But, this should not and need not be the case with electronic fund transfer. New technology applications have suffered from time to time when ineptly applied by poor managers. Whether or not this happens again with EFT will depend on how hard technologists try to influence national policy while they still have the chance.

Let's hear it for 1" high LEDs!



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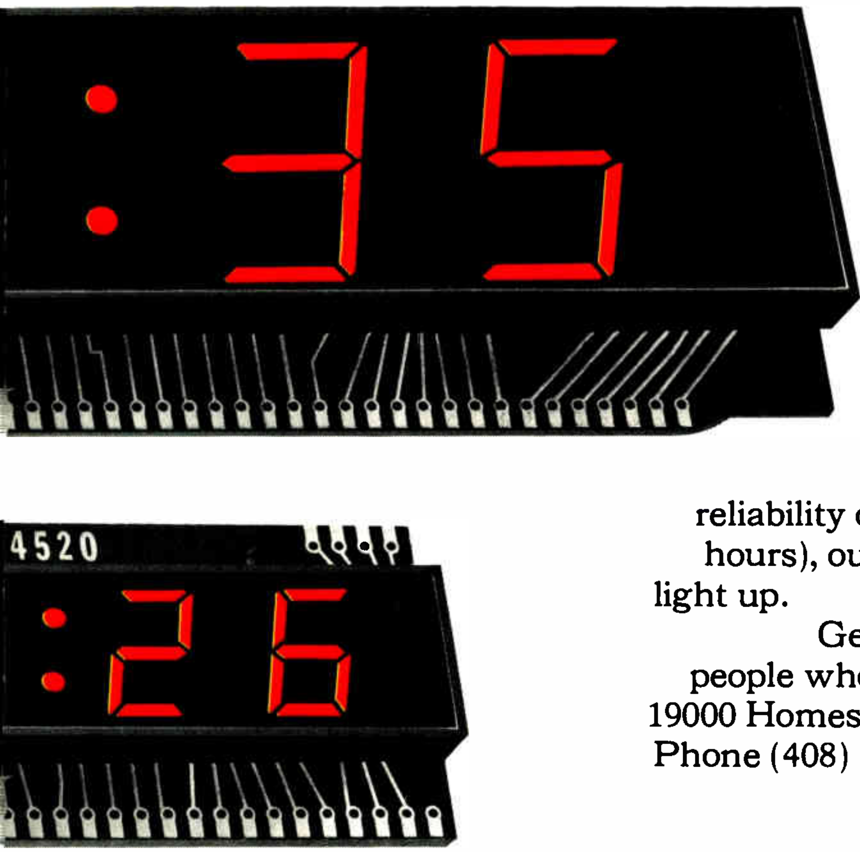

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People

Challenging IBM in the 1980s is Shattuck's task at Amdahl

Thirty-eight-year-old Harold Shattuck is breathing a little easier these days. He has survived, as has the company he joined shortly after its founding in 1971—the Amdahl Corp. of Sunnyvale, Calif. And as its new vice president of engineering, he's concentrating on Amdahl Corp.'s "rather bright future."

Challenger. With production in hand, Harold Shattuck is boosting performance.

The company manufactures what Shattuck calls the first "fourth-generation computer system," the 470V/6, which has an internal speed twice as fast as the IBM 370/168 and requires one-third the floor space because it's designed with 80% fewer interconnections and components [*Electronics,* March 29, 1973, p. 51].

Markets. Amdahl will be directly challenging IBM in two of its most lucrative markets involving users of multiple central processors such as the 370/155 and 370/158 and those customers developing the requirement for an IBM top-of-the-line 370/168, according to Shattuck. As engineering vice president, he sees his job as "improving Amdahl's hand" in its head-to-head battle with IBM.

"Over the short term this means improving the current designs," Shattuck says, perhaps eyeing the possibility of increasing his computer's speed and storage capacity. Specifically, this includes the possibility of a shift from 1,024 to 4,096-bit n-channel MOS random-access memories and improving the system's diagnostics software.

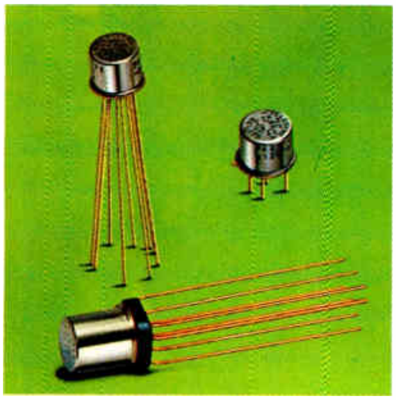
With Amdahl since the beginning, he had 11 years of experience at IBM, which he joined directly out of college in 1960. First a diagnostics engineer on the Stretch computer project, forerunner of the IBM 360 series, Shattuck held a variety of engineering, scientific and marketing positions. He joined Amdahl as manager of advanced planning and then got involved in the international marketing strategy. He shifted to engineering almost two years ago, as senior director, at a time Amdahl was having a hard time getting off the ground [*Electronics,* Nov. 28, 1974, p. 39]. But now, says Shattuck, Amdahl is well on its way to financial stability and "explosive growth."

By the end of this year, six of the $4.5-million systems will have been delivered, an average of one a month since June. "And our momentum is still building," he says. Financially, the company is in good shape, with a $25 million line of credit from one of its major backers, Fujitsu Ltd. of Japan, as well as $160 million in lease financing. This, says Shattuck, "assures us of adequate resources."

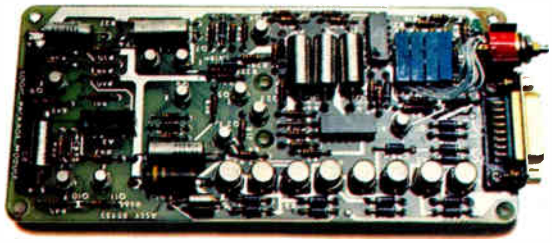
For Stadin, electronic watches are pieces of jewelry

By hiring its second experienced executive from a conventional-watch manufacturer, National Semiconductor Corp. is intensifying its drive for massive sales to try to become the Timex of the digital electronic-watch industry. Perhaps not so coincidentally, Richard Stadin, the new watch-marketing manager at Novus, the consumer-products division of the Santa Clara, Calif., semiconductor manufacturer,

A big hit: Teledyne TO-5 relays.



Improve shallow depth operation. Counter target decoys. Enhance rejection of false echoes. Tough goals for any torpedo acoustic guidance/control system. But Northrop did it — turning misses into hits — with a little help from Teledyne TO-5 relays.



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comes from Timex. Stadin is joining Novus' product manager for timepieces, Pierre Essig—formerly with Waltham Watch Co.—making Novus one of the few consumer-electronics firms with former watch-company executives in key management positions.

Dominant. Stadin asserts that Novus is well on its way to being a dominant force in the electronic-watch business because it has learned a lesson that few semiconductor companies have really taken to heart, that "the electronic-watch business is a watch business and not an electronics business."

This means at least two things, he says. Foremost is the provision for financial and management backing for a long-term commitment to staying in the watch business. The other is concentration on a policy of distributing electronic watches through jewelry wholesalers and retailers.

Many electronics firms are ignoring the jewelry trade and looking for non-traditional ways of distribution, asserts Stadin, whose positions at Timex included stints as a sales manager for exports and at division level. "Watches are jewelry," he says, "whether they are low-, medium-, or high-priced. And electronic watches are no exception."

Novus is going after the broad middle range of the market by pricing its solid-state light-emitting-diode digital watches from $80 to about $170, says Stadin. This positions the company in a buffered area between "the chaotic discounting trade and the slower-moving upper end" of the electronic-watch market.

Processes. In terms of technology, National is looking at several new processes for reducing the size and extending the lifetime of its watches. Among them are silicon-gate, complementary-MOS and integrated injection logic. But the crucial parameters, Stadin says, will be reliability and cost.

"The company that will dominate will not be the one with the cheapest or the flashiest modules, but the one that offers dependable, moderately priced products," he maintains.

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Start by replacing hundreds of TTL packages with the three LSI circuits in the MCS-80™ CPU Group—the 8080A CPU, 8224 Clock Generator and 8228 System Controller. Built into the Intel 8224 and 8228 are many of the extra functions that most designs require, such as TTL & MOS clocks, auxiliary timing functions and current sinking capability that keeps memory and I/O interfaces simple.

MCS-80™ SYSTEM COMPONENTS

	Part No.	Description
CPU GROUP	8080A	8-bit Central Processor Unit, 2μs cycle
	8224	Clock Generator
	8228	System Controller
CPU OPTIONS	8080A-1	1.3μs cycle
	8080A-2	1.5μs cycle
	M8080A	2 μsec cycle (−55 to +125°C)
I/O	8212	8-bit I/O Port (15 mA drive)
	8251	Programmable Communication Interface
	8255	Programmable Peripheral Interface
PERIPHERALS	8205	1 out of 8 Binary Decoder
	8210	Dynamic RAM Driver (8107B)
	8214	Priority Interrupt Control Unit
	8216	Bidirectional Bus Driver, Non-Inverting (50 mA)
	8226	Bidirectional Bus Driver, Inverting (50 mA)
	8222	Dynamic RAM Refresh Controller (8107B)
	8253*	Programmable Interval Timer
	8257*	Programmable DMA Controller
	8259*	Programmable Interrupt Controller
PROMs	8604	512 x 8, 100 ns
	8702A	256 x 8 Erasable, 1.3 μs
	8704	512 x 8 Erasable, 450 ns
	8708	1K x 8 Erasable, 450 ns
ROMs	8302	256 x 8, 1μs
	8308	1K x 8, 450 ns
	8316A	2K x 8, 850 ns
RAMs	5101	256 x 4 Static CMOS, 650 ns
	8101-2	256 x 4 Static, 850 ns
	8102-2	1K x 1 Static, 850 ns
	8102A-4	1K x 1 Static, 450 ns
	8107B	4K x 1 Dynamic, 420 ns
	8111-2	256 x 4 Static Common I/O, 850 ns

*Available 1st quarter 1976.

A dozen I/O and peripheral circuits that attach directly to the system bus make it easy to add on peripheral subsystems. Five are programmable LSI devices. These operate under software control in numerous modes and can often replace up to 75—or more—TTL packages each. For example, the Intel 8251 Programmable Communication Interface provides virtually all serial data transmission protocols in use today, including IBM Bi-Sync. Or, for easy interface to printers, keyboards, displays and motor drives, use the 8255 Programmable Peripheral Interface. You can reorganize its 24 I/O lines with software as your needs change.

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You also get four CPU choices, including the M8080A for operation

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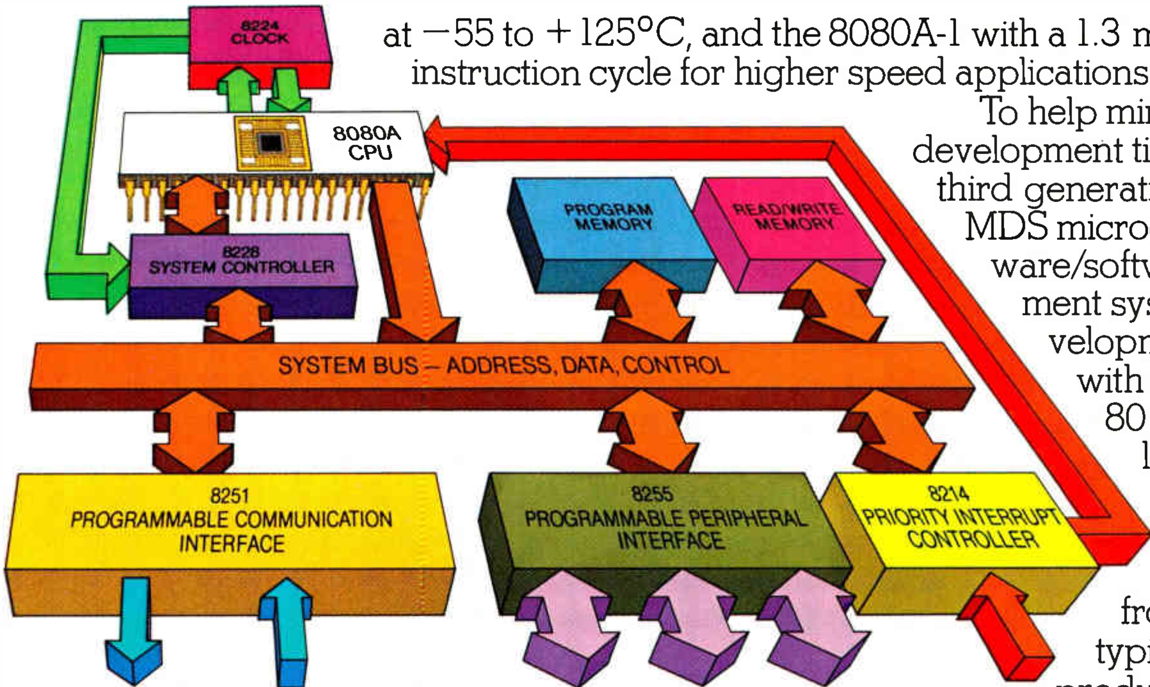

at −55 to +125°C, and the 8080A-1 with a 1.3 microsecond instruction cycle for higher speed applications.

To help minimize system development time use the third generation Intellec® MDS microcomputer hardware/software development system. This development system with its unique ICE-80 in-circuit emulator lets you simultaneously debug software and hardware, from initial prototyping right through production. The Intellec MDS is supported by six comprehensive software packages including a macro-assembler, ICE-80 interactive software driver and a diskette operating system.

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Meetings

International Electron Devices Meeting, IEEE, Washington Hilton Hotel, Washington, D. C., Nov. 30–Dec. 3.

National Telecommunications Conference, IEEE, Fairmont Roosevelt Hotel, New Orleans, Dec. 1–3.

Conference on Loran-C, U.S. Coast Guard and Sea Grant Advisory Program of Oregon State University, Sheraton Inn, Portland, Dec. 2–3.

Conference on Government Computer Applications, American Institute of Industrial Engineers, International Inn, Washington, D. C., Dec. 3–5.

Electronic Components Exhibition, U. S. Department of Commerce (Washington, D. C.), U. S. Trade Center, Paris, France, Dec. 8–12.

Magnetism and Magnetic Materials Conference, IEEE, Benjamin Franklin Hotel, Philadelphia, Dec. 9–12.

Third Annual Symposium on Computer Architecture, IEEE, Fort Harrison Jack Tar Hotel, Clearwater, Fla., Jan. 19–21.

Reliability and Maintainability Symposium, IEEE, et al., MGM Grand Hotel, Las Vegas, Jan. 20–22.

Design and Finishing of Printed Wiring and Hybrid Circuits Symposium, American Electroplaters' Society (East Orange, N.J.), Fort Worth Hilton Inn, Fort Worth, Texas, Jan. 21–22.

Power Engineering Society Winter Meeting, IEEE, Statler Hilton Hotel, New York, Jan. 25–30.

Twelfth Modulator Symposium, IEEE, Statler Hilton Hotel, New York, Feb. 4–5.

ISSCC-76, International Solid State Circuits Conference, IEEE, Sheraton Hotel, Philadelphia, Feb. 18–20.

Compcon Spring, IEEE, Jack Tar Hotel, San Francisco, Feb. 24–26.

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Intersil's IM55S08/18 is a 1024 x 1 TTL Schottky RAM in a 16 pin CerDIP. Pin for pin and totally compatible with the 93415/25, it's ideal for high speed scratch pad, buffer and main frame memories. Maximum access time from 0° to +75°C is 70nS, and 75nS from −55° to +125°C. An "A" version guarantees 45nS.

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IM55S08/18 Schottky RAM	1024 x 1	70nS	$22.00	57
IM6508/18 CMOS RAM	1024 x 1	200nS	$ 8.95	58
IM7505 dynamic RAM	4096 x 1	300nS	$16.70	59
IM7505-1 dynamic RAM	4096 x 1	150nS	$24.70	60
IM7505-2 dynamic RAM	4096 x 1	200nS	$20.50	61
IM7507 dynamic RAM	4096 x 1	300nS	$21.95	62
IM6312 CMOS ROM	1024 x 12	350nS	$36.00	63
IM53S10 Schottky ROM	1024 x 10	100nS	$49.50	64
IM53S09 Schottky ROM	1024 x 9	100nS	$45.00	65
IM53S08 Schottky ROM	1024 x 8	100nS	$36.00	66
IM5605/25 bipolar P/ROM	512 x 8	70nS	$24.70	67

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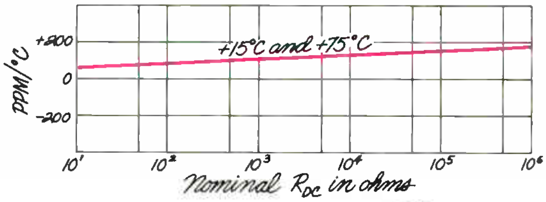

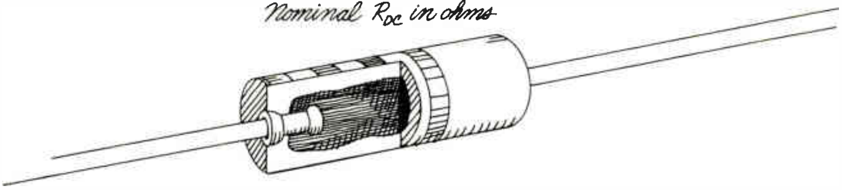

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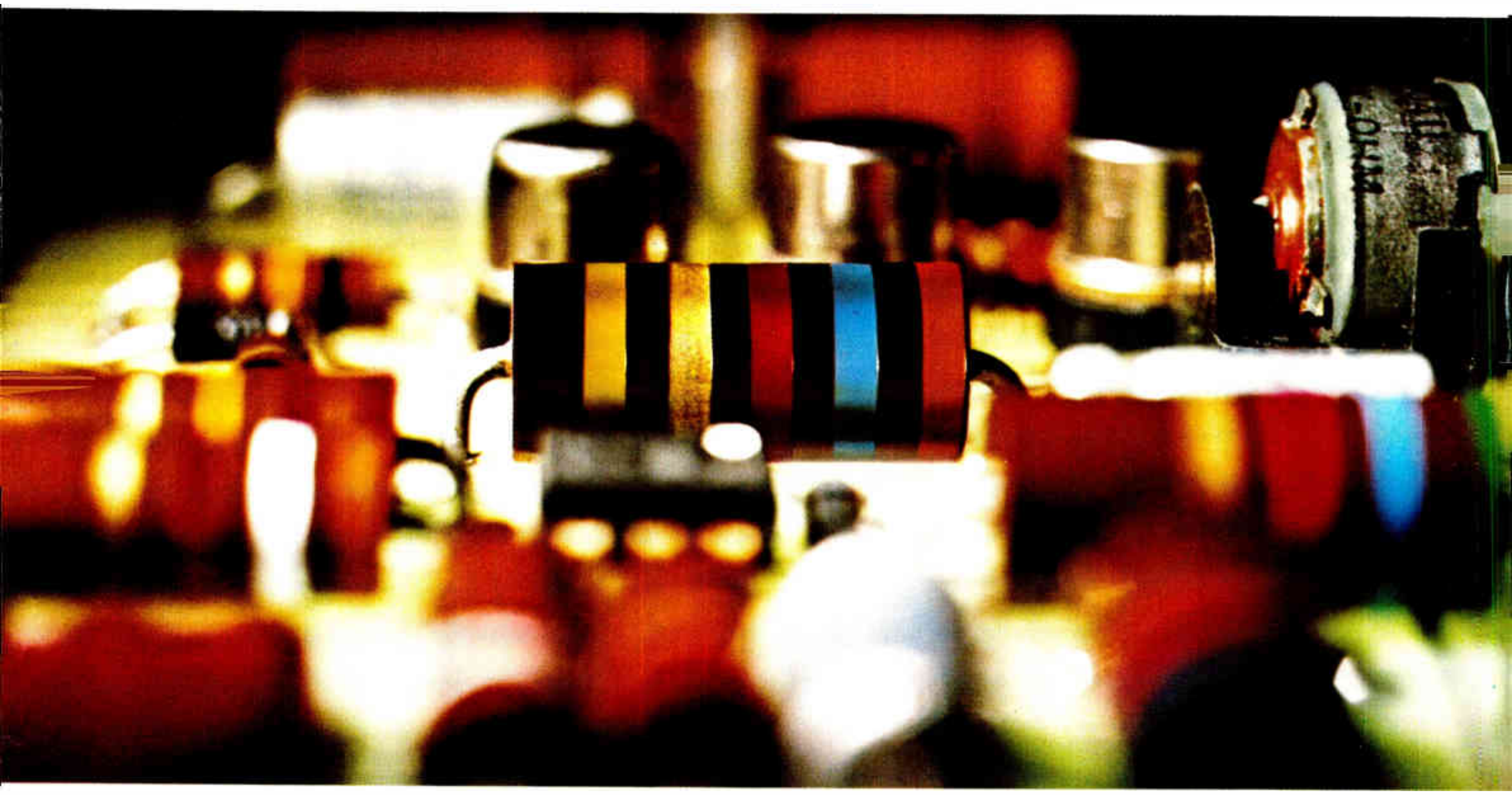

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Electronics newsletter

Army seeking to replace radios

The Army is planning to replace all of its aging single-channel AN/VRC-12 vehicular, AN/PRC-77 manpack, and AN/ARC-114 airborne vhf-fm radios during next several years. Col. James E. Wyatt, who will be project manager at the Army Electronics Command, Fort Monmouth, N.J., says that **a request for proposals for competitive advanced development will be issued to industry in January 1976,** pending final approval of the Defense Department.

Wyatt says the Army wants the latest electronics technologies for communications security and electronic counter-countermeasures in a system to be deployed in the 1980s.

Process controller from Honeywell uses microprocessor

Most process-control manufacturers admit there's a microprocessor in their future, but only Acco Bristol of Waterbury, Conn., has used one in a system. **Now Honeywell Inc. has taken the plunge with the introduction of its TDC 2000 system.**

A joint offering of the Phoenix and Ft. Washington, Pa., Process Control divisions, the TDC 2000 is the end result of the company's development program with General Instrument Corp. that led to GI's CP 1600 [*Electronics*, Feb. 20, p. 25], a single-chip, 16-bit processor. Honeywell's allows the user to combine microprocessor-based controllers and stand-alone cathode-ray-tube displays into a modular distributed-control system together with a data highway for information transfer. While suitable for controlling only a few loops, a number of modules can be linked to a minicomputer for advanced applications in the chemical, petroleum, metal, and electric utility industries. The controller design saves the user money by using one microprocessor to handle eight controllers.

Fairchild maps counterattack on Intel's 2115

Fairchild Camera and Instrument Corp. is attempting to counter the threat to its market dominance represented by Intel Corp.'s 2115 family of static, 1,024-bit n-channel random-access memories. The Intel parts feature 525-milliwatt, 60-to-120 nanosecond operation. **Fairchild has started producing its own 1-k static n-MOS RAM,** the 3542, a 250-to-300 mw device with speeds of 100 to 150 ns. It will sell for $2 to $2.50 in large quantities.

According to Thomas Longo, vice president and general manager of Fairchild's IC group, the marketing strategy will be to block Intel's parts, which sell for $10 to $15 in quantities of 100 to 999, on three sides. This will be done with the 3542 on one side, Fairchild's 93415 standard 1-k bipolar RAM (600 to 800 mw 35 to 45 ns) on another, and its low-power 931415 device (250 mw, 80 to 90 ns) on the third.

Semiconductor buys down 19% in '75, Motorola estimates

With the year almost over, Motorola Inc. estimates that worldwide semiconductor consumption fell 19% from 1974. The U.S. and European segments dropped 21% and 22% respectively, while Japan was down only 10%. On a brighter note, **Motorola expects 1976 to see a 20% increase over-all** with Europe recovering slowest to climb only 14%. The U.S. should climb 22% and Japan 25%, according to the forecast.

Leading the '76 upsurge, Motorola predicts, will be the MOS lines, which are looking at a 38% jump worldwide after a 7% decline this year. In fact, the only plus figure for 1975 is Japanese consumption of MOS ICs, up 4%, Motorola estimates.

Electronics newsletter

Sarnoff departure unlikely to change RCA's course

The surprise resignation of Robert W. Sarnoff as chief executive officer and chairman of RCA has accomplished at least one thing: it put an end to rumors that the board of directors has been pressing him to quit. The rumors started in September 1971 when RCA decided suddenly to get out of the computer business and absorb a $490 million loss, reportedly leaving some board members determined to force him out. But Sarnoff survived.

One Wall Street observer, James I. Magid, vice president for research at Drexel Burnham & Co., believes that **Sarnoff has been preparing to leave.** Only last Sept. 19, Sarnoff announced formation of a new office of the chairman consisting of himself, Anthony L. Conrad, and executive vice presidents Edgar H. Griffiths and Howard R. Hawkins. Conrad, who has been president and chief operating officer, succeeds Sarnoff as chief executive officer. And as Kent A. Logan, a partner in H. C. Wainright & Co., sees it, Sarnoff's departure will have miniscule effect on RCA. He says, **"RCA is so big, so diversified—how dramatically can it change?"**

Fairchild markets ignition kit

After testing the automotive aftermarket for about six months with a $39.95 transistorized breaker-point electronic-ignition kit, Fairchild Camera and Instrument Corp. of Mountain View, Calif., is feeling confident enough to jump in all the way with a variation: **a breakerless system using an inductive, rather than capacitive, storage approach.** The points are replaced by a magnetic pickup that senses the passage of the cam lobes and then generates the voltage needed. Sold as a standard product under the Fairchild name through auto parts stores, department stores, and service stations, the 12-volt negative-ground system will sell for $59.95 and come in three models, the E-300 for all U.S. six- and eight-cylinder cars, except Chrysler; the E-400, for all four-cylinder cars; and the E-500, for Chrysler autos. Fairchild estimates the size of the market it's entering at $220 million annually, shared by dozens of suppliers.

Dillard elected IEEE president

With 36% of the eligible members voting, Joseph K. Dillard, manager of advanced-systems technology for Westinghouse Electric Corp., Pittsburgh, has beaten Irwin Feerst to become president of the IEEE. **Dillard's margin of victory was approximately three to two, or** around 30,600 to 20,400.

Feerst, who got on the ballot by petition, has stated that he will carry on his newsletter reporting on IEEE activities, but has not decided whether or not he will go after the presidency again next year. This election was the first contested race for the office.

This year's 36% turnout compares with the 32.5% of the eligible members who voted in the 1974 election. The highest percentage of members ever to send in ballots was 36.6% in 1971. However, because membership has increased since then, some 3,000 more ballots were received this year than in 1971.

Meet the 1500W zener.

The zener with the specs of a transient suppressor.

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Manufacturers replace defective antilock braking systems

More than 18,000 units are being pulled from vehicles in retrofit; truckers want delay in safety mandate

Rockwell International and B.F. Goodrich Co. are replacing more than 18,000 controllers and other electronics making up new antilock braking systems supplied for trucks, buses, trailers, and other heavy-duty road vehicles. The two companies may have to absorb a loss of $2 million, it was revealed during testimony late last month at a special hearing before the National Highway Traffic Safety Administration. In addition, Kelsey-Hayes Co., Romulus, Mich., has had to replace a much smaller number of systems because of malfunctions caused by radio-frequency interference.

Faulty. At the hearing, both drivers and operators of truck and bus fleets continued to charge that far too many of the Government-mandated antiskid control systems are faulty [*Electronics*, July 24, p. 63]. The defects include jerky decelerations, air-brake valves being released by rfi, and dashboard warning lights signaling phantom malfunctions.

Accidents. All told, 24 accidents and hundreds of near misses have been counted by the operators. In fact, Rockwell's bus systems have performed so poorly that NHTSA has permitted operators to disconnect the units. For these reasons the operators continue to urge that NHTSA postpone for one year implementation of Federal Motor Vehicle Safety Standard 121, which requires the controls, while the electronics manufacturers work out the bugs. Officials at the safety agency say a decision on the fate of the regulation will be made by the end of the year.

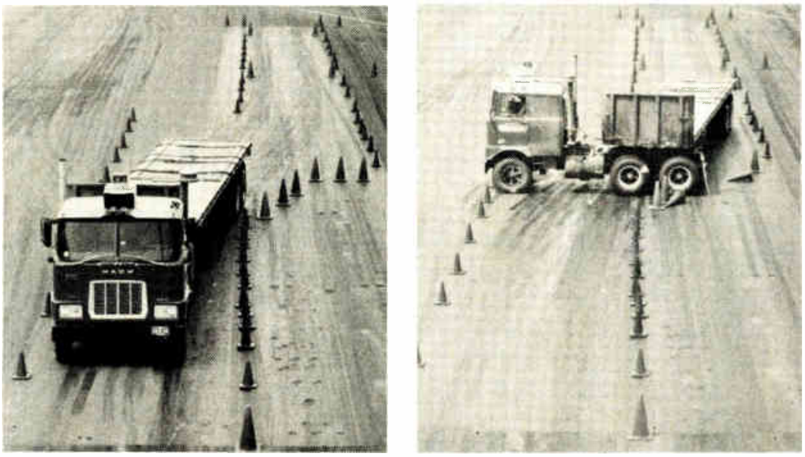
At stake is $375 million a year in sales of approximately 500,000 axle sets, including hard-wired controllers, wheel-rate sensors, wiring, hardware, and test systems. Fleet operators also complain that the systems add as much as $500 million a year to operating costs.

Other manufacturers that have fared better than Rockwell and Goodrich are suffering only what officials say were "typical start-up problems." Among them are General Motors Corp.'s AC Spark Plug division, Flint, Mich., Berg Manufacturing Co., Iola, Kan. and Wagner Electric Co., St. Louis.

Retrofit. Rockwell began this month to deliver replacement controllers and sensors to retrofit its entire 10,000-plus shipment of vehicle axles, report officials at the company's Automotive Operations division, Troy, Mich. Indeed, drivers say Rockwell and Goodrich systems often malfunctioned within hours of delivery. Rockwell cites an inadequate sensor housing that caused misalignment of the wheels and wheel-rate sensors, leading to frequent fuse blow-outs and erratic braking. Inadequate quality control during the manufacture of Rockwell's MOS-LSI digital controller also caused frequent failures.

"Better quality-control is solving this problem," says Gerald J. Flannery, Rockwell's director of Government relations. Rockwell is also shipping a redesigned sensor protected by a new cast-metal housing that should prevent misalignment. The company is also adding a solenoid circuit breaker equipped with a dashboard-mounted reset switch for checking false alarms.

Of 18,000 controllers shipped, by the Engineered Systems Co., in Akron, Ohio, a Goodrich division, more than 8,200 have been replaced, says



No skidding. Electronic braking systems prevent the brake locking that can lead to jackknifing and other dangerous skids. But some systems are proving faulty.

Richard Brandewie, antilock-program manager. Early units failed when potting compounds, used to protect discrete devices in the controllers, shrank and pulled components out of the printed-circuit boards, he explains.

Disruptions. Radio-frequency interference is also causing problems. Rockwell, Goodrich, and Kelsey-Hayes have verified that rfi sometimes disrupts both analog and digital controllers, causing erratic braking. "Rf fields encountered are more intense than had been anticipated," says Flannery of Rockwell, which has not yet determined the extent of its problem. But its new controllers have additional rfi filters and heavier metal cabling and shielding, Flannery says. Goodrich has had two reports of rfi, at the 1-megahertz level and from sources with more than 150 watts of output, notes Brandewie. Its controllers had been shielded to the 100-watt level.

Kelsey-Hayes has boosted its rfi protection to transmitter outputs of more than 50 watts in the 35–45-MHz range. A recall of an unspecified number of affected units, to add rfi filters, has been completed. □

Military

Aircraft may use IR transceivers

How does the crew of one Navy P3 antisubmarine-warfare aircraft coming off duty communicate covertly with the crew of another P3 coming on station to replace it? Very carefully, as it turns out, or not at all. "There are ways of communicating," says Rudolph A. Stampfl, director of the Aero Electronics Technology department at the Naval Air Development Center, Warminster, Pa., but apparently they're not very satisfactory for reasons Stampfl declines to discuss.

To make it easier to achieve security and communicate, Stampfl's Electro-Optics section has developed a relatively simple hand-held optical voice and data-communications system that it claims is virtually impossible to intercept.

Stampfl says that most of the system was made with off-the-shelf items. The optical transceiver, for instance, uses a Bell & Howell Co. combined silicon-diode-detector operational amplifier and a Texas Instruments XL-16 infrared light-emitting-diode radiator operating in the 9,300-angstrom range. The only unique feature—the circuitry for interfacing the airborne minicomputers with the optical transceivers—was designed in-house and is integrated into the communicators, says Larry Ott, Electro-Optics section chief.

Testing. The system has already flown at least one mission and Lt. Cmdr. Joseph Kiel, a member of the P3 program office in Washington, D. C., who is responsible for P3 systems upgrading, says that, although "there are other possibilities open to us to perform covert communications, the optical communicator definitely is something we're looking at very strongly." He indicated that more flight tests will be scheduled.

During a mission, the crew of one P3 aircraft could talk to or transmit data to another P3 covertly via the optical transceivers by flying in a tight circle, within a few thousand feet of each other, one plane directly above the other. The communicators are aimed at each other through an optical peepsight mounted on the unit, but aiming accuracy does not have to be very precise, Ott says. Also, the system transmits on low power to further ensure that the communications will not be intercepted.

Ott estimates the communicators could be produced for about $10,000 per system. The Navy now has 36 squadrons of land-based, long-range ASW aircraft—24 active and 12 reserve—with nine P3 aircraft in each squadron. At least three quarters of the total number of operational P3s are the newer P3Cs, says Commander Kiel. The P3Cs are fitted with computer-integrated avionics and acoustic processing systems to improve over-all ASW effectiveness. □

Solid state

Holes in CCD yield FET amplifiers

Although promising for mass storage and signal processing, the serial structure of conventional charge-coupled devices is unsuitable for use in main random-access memories. To make it randomly accessible, Mullard Research Laboratories superimposed an array of field-effect transistors onto the basic structure, allowing each storage site, or bit, to be directly addressable.

The technique is also useful for tapped delay lines in complex signal processing where access to each element is also desirable, says John M. Shannon, leader of the semiconductor physics and devices group.

Mullard, in Red Hill, Surrey, builds the array by etching holes in the top of the CCD and forming transistor gates in the aluminum electrode layer. This changes the CCD line into a line of FETs. Besides nondestructive readout, the charge-coupled FETs feature high charge gain and a capability, like other CCDs, for processing analog signals. Moreover, the punchthrough effect can be used to introduce new charges at the source and to reset the whole array to reduce gain variations across the array, Shannon says.

Edge sensing. Usually, charge packets are sensed at the edge of the CCD either at the surface or in the semiconductor bulk. Instead, the Mullard device exploits the fact that the surface potential under any CCD electrode and consequently the depth of the depletion layer reflects the amount of charge stored there, explains Shannon.

Each FET gate has access to the current flowing in the semiconductor bulk. Since the gates can access every stored charge in the CCD, the charge-coupled FET becomes an amplifier array, unlike conventional charge-coupled devices in which the charge out approximately equals charge in, Shannon says.

To be described at the International Electron Devices Meeting, Washington, D.C., on Nov. 30, the surface-channel device is an ion-implanted two-phase CCD having an n-type layer on a p substrate. Into each electrode is etched an FET gate with a central drain. Drain current is directly related to the size of a charge packet held under a particular electrode.

"It's a surface CCD with a bit of difference," Shannon comments. And the difference shouldn't make the device much harder to manufacture, he says.

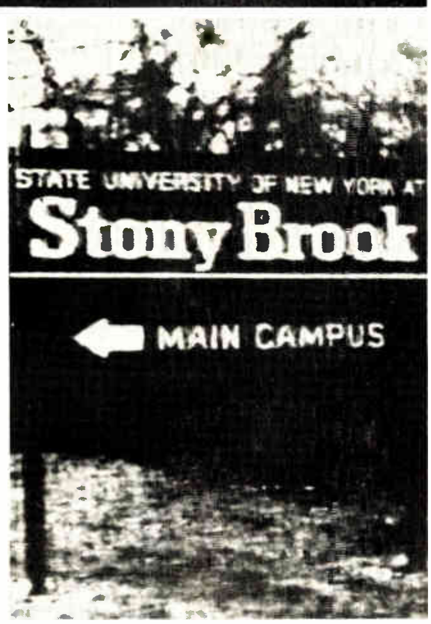
Four-bit chips. Mullard currently is using 4-bit chips and rather large gates, 15 micrometers long and 460 μm wide. Shrinking gate size should increase speed, Shannon says.

In one of Mullard's development devices, the charge-coupled FET was operated above pinchoff, where the drain current was insensitive to drain voltage, and was read for 40 microseconds. This read time can be increased up to the limit where internal generation adds significantly to the charge packet, Shannon says. In what the company terms experimental devices, the maximum read time was 10 milliseconds, yielding a maximum charge gain of about 280,000. But a read time of 10 ms would diminish the gain by a thousand times, according to Shannon. □

Holography

Holograms sharpen images from space

Soviet scientists are using a U.S.-developed image-focusing technique to detect possible oil and natural-gas reserves from blurred photographs taken by earth-resources satellites. George W. Stroke, a physicist at the State University of New York at Stony Brook, developed the technique. He believes the Soviet application, reported in a recent proceedings of the USSR Academy of Sciences, opens an important area of refinement in the aerial mapping of earth resources by satellite.



Sharp. Photo blurred by camera movement is focused using holography. Russians apply technique to photos from satellites.

Retrievable. The method uses the principles of holography to encode the image in a retrievable form, "just as a long-playing record encodes music in the seemingly illegible wavelike pattern of its grooves," says Stroke. The required mathematical operations can be performed either by digital computations or by optical analog computations based on the use of lasers and holography.

NASA generally has been more interested in digital rather than optical techniques for image-deblurring, although Stroke says that better results are being attained with the optical method. However, NASA has used only the digital method with its earth-resources satellites, notes Stroke. He indicates that NASA's renewed interest in the optical system may be related to reports of the Soviets' success with this technique. He says the Soviets became aware of his work in the field by following several papers he delivered in recent years and through discussions at international technical conferences.

Stroke, director of the university's Electro-Optical Sciences Laboratory, says the technique enhances details of valuable space photos which might otherwise be unreadable because of blurring caused by random movement of the camera-carrying satellites. Indeed, notes Stroke, "Almost half of the photographs taken during the first American lunar-orbiter satellite mission to learn more about the moon's surface were spoiled by camera movement and blurring." Similarly, he says, images were blurred in photos of the back of the moon by Russia's Lunik III.

The image-deblurring method, conceived by Stroke in 1965 has been perfected in recent years in collaboration with Maurice Halioua, an assistant. Stroke's research has been supported in part by the National Aeronautics and Space Administration's Physics, Geophysics, and Astronomy division in Washington, D. C.

Transform. The advantage of the holographic process, he adds, results from the natural capability of lenses to carry out the fundamental Fourier-transform operations involved in image-deblurring. In practice, deblurring produces the spectrum analysis (or architecture) of the blurred photograph in the focal point of a lens by illuminating it with a laser. The spectrum of the blurred architecture of the photo is recorded holographically and is used to create a compensating holographic filter, consisting of a sandwich of two photographic transparencies—the amplitude-intensity component and the holograph. Deblurring is achieved by using the holographic filter and allowing the laser light to pass through a second lens to sharpen the blurred image.

Stroke believes the Soviets are the first to use the deblurring method in search of oil and natural-gas reserves. □

Military

Navy adapting commercial concepts in interim standard avionics computer

While many military programs are racing ahead in cost but falling behind in performance, the Naval Air Systems Command is going off on a different tack with its interim standard airborne digital computer. Rather than initiate costly new research and development, it's using available technology like core memories, at least to start with, and support software in Fortran. "We will work with commercial concepts as closely as we can," says Ronald S. Entner, who directs the ISADC effort in Navair's avionics division.

The first 10 test machines are scheduled to be bought between January and March 1976. But as of now, a formal Navair project office has yet to be established—it will take another several weeks before the necessary funds can be transferred from this fiscal year's budget.

When that's done, though, Navair will move ahead with development of three basic packages—an extended minicomputer with 32,000 words of 16-bit core memory and a forecast unit price of $45,000; a smaller minicomputer in the $30,000-$35,000 range, and a $10,000-$15,000 microcomputer. The interim system is to be available before the all-avionics digital computer, currently in the hands of the Naval Electronic Systems Command, from which it evolved.

Market. Partly from the use of common software and logistics, but partly also from large-scale procurement, the Pentagon expects substantial savings from the program. The potential market is a minimum of 1,600 computers—two per plane for the 800 Navy F-18 fighters if the computer becomes Government-furnished equipment for the McDonnell Douglas plane. But the family could find use in an estimated 12 different Navy airborne systems, plus a minimum of 20 more air and ground systems of the other services. The Directorate of Defense Research and Engineering is beginning to encourage Army interest in the system, and the Air Force is monitoring the program.

Hardly surprisingly, therefore, military computer makers see a major sales opportunity. Already in line for the bidding, say industry sources, are Sperry Rand's Sperry Univac division, General Motor's Delco division, International Business Machines Corp., Singer Co.'s Kearfott division, and Lear Siegler Inc.

What Navair wants for ISADC is a processor weighing no more than 30 pounds that will occupy half a cubic foot and initially use 16-bit core memories already produced for other systems by a variety of vendors. While noting that the price of the core memories is "very reasonable," Entner is quick to add that a compatible semiconductor memory is proposed for later use in the computer that would have double the density of the core system.

ISADC's operating software will use the Navy's CMS-2 higher-order language, a variation of that used by the AN/UYK-20 small shipboard system. But its support software will be Fortran, which offers "ease of software handling and system logistics," Entner explains. "It is a means of unifying the market for software development using the same equipment"—either the vendor's own large, ground-based computer or one of the new model 732 minicomputers just ordered from Interdata Inc. by the Navy's Automatic Data Processing Equipment Selection Office.

Choices. The decision to begin with commercially available core memories and use Fortran for system support software came after the solicitation of the views of computer makers as well as those of multiple Naval laboratories and prospective user commands. For example, the original specification called for 375,000 operations per second using 32-bit arithmetic with a 16-bit machine. "This was rejected as poor design practice," according to Entner. "We just couldn't make 16-bit machines meet those performance specifications."

With much of the preliminary Navy work nearing completion and the specifications for next year's RFP being drafted, the program may be out of the hangar. But it has yet to begin its takeoff roll. That will come when the 10 "first buy" machines start preproduction testing at the contractor's plant. This, Entner says, is expected to produce over a period of six to nine months "a best and final" configuration on which to establish an ISADC baseline—a minimum capability with options. □

Automotive

Spark advance hits snag

Both Chrysler and Ford have run into snags on their electronic spark-advance programs. Both have delayed equipment introductions, pending certification by the Environmental Protection Agency of new versions. It's believed that the first engines equipped with the sophisticated control of spark advance and retard presented to the EPA won gains in fuel economy of only 1% to 2%, instead of the 5% to 7% projected by the auto makers.

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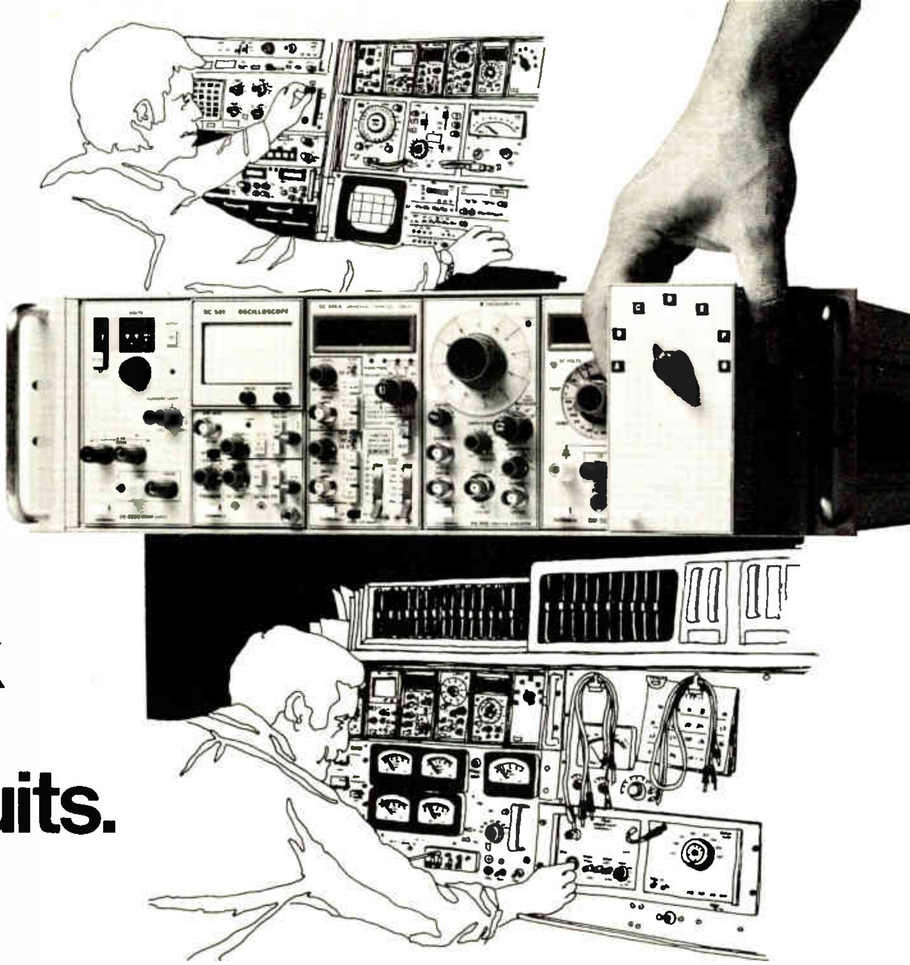

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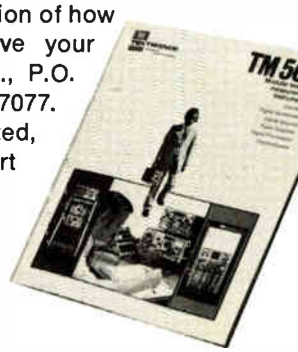

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For a demonstration circle 32 on reader service card

Circle 33 on reader service card

[*Electronics*, Oct. 2, p. 42] that the new computer-controlled timing (CCT) feature would be introduced as standard equipment on the 1976 Continental Mark IV, it was estimated that the system would improve fuel economy in the vehicle by about one-half mile per gallon, or about 5%," states Howard P. Freers, chief power-train and chassis engineer at Ford Motor Co., Dearborn, Mich. However, fuel-economy objectives for the car were met without CCT, "so we now have decided to work on the system further to determine if additional fuel-economy gains are possible," he continues.

Later delivery. The system, built by Aeronutronic Ford and Motorola Inc.'s Automotive Products division, was originally slated for October introduction and then slipped to November delivery. The firm will not rule out a debut of the system in 460-cubic-inch engines later in the model year.

Chrysler Corp., on the other hand, has never publicly promised an introduction date, except some time during the 1976 model year [*Electronics*, April 3, p. 38] on cars equipped with 400- and 440-in.^{3} engines. Since then, Chrysler has decided not to implement the system on 440-in.^{3} engines and will make its so-called lean-burn system optional on all standard-size, as well as intermediate cars. As many as 60,000 cars could have the device, which costs between $20 and $25, installed, according to Chrysler.

Certified. The 400-in.^{3} engine, with electronic spark advance has been certified by EPA, notes Earl W. Meyer Jr., assistant chief engineer for engine electrical systems at Chrysler, "but we've gone back to the EPA with further improvements. We expect to have the new ones certified within a month and should go into production in January." The firm has already submitted the engine with six different calibrations to the EPA for city/highway dynamometer testing. The differences are largely changes in resistor values that change the output waveforms of the analog computer, he says.

"This change to electronic spark advance is more significant than most people thought it would be," Meyer points out. "It's taken longer than we thought to optimize the programing of the device, and I would anticipate that optimization of the programing of the spark computer will go on for the next 50 years, just as programing the conventional distributor has gone on for the past 50 years," he continues.

Despite the weak performance thus far, the firm is still sticking to its estimate of 6% to 7% improvement in fuel economy when the system is finally introduced, compared to ratings for comparable engines equipped with conventional spark advance and a catalytic converter. Another improvement: "We're running close to zero deterioration—emission levels are not changing over 50,000 miles," Meyer says. "Typically, most other systems see a deterioration of some sort, and that has to be allowed for in EPA certification." □

Consumer

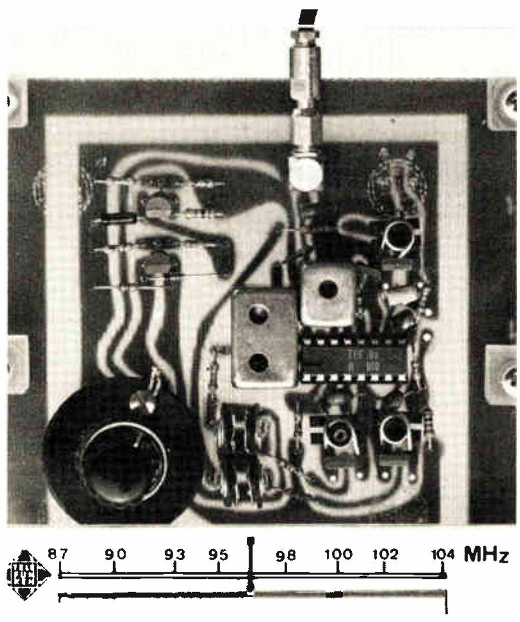
Fm function joins a-m on radio chip

Integrating their efforts, a pair of West German and American companies have succeeded in putting all the active-component functions of an a-m radio and a major section of an fm radio on a single silicon chip. The aim is to use the IC in low-priced a-m/fm radios which the American firm will market in the U.S. early next year for under $20.

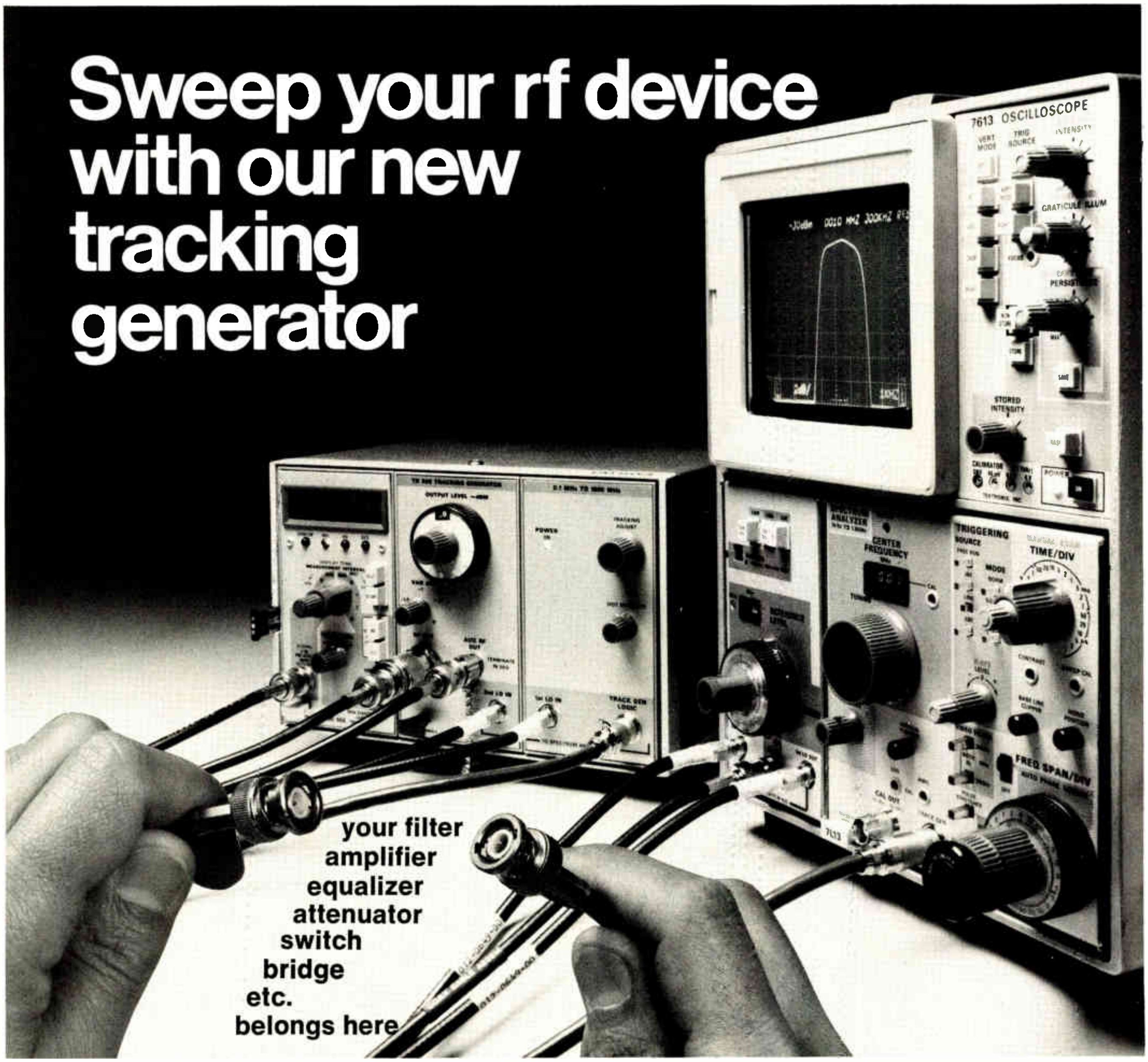
The analog "one-chip radio" circuit, developed by AEG-Telefunken, is now in large-scale production at the company's semiconductor facilities in Heilbronn, West Germany. First deliveries to the American partner, which Telefunken describes as a large U.S. electrical/electronics producer but declines to name, have just begun, and follow-up shipments "will be in the hundred thousands of circuits per month" range, says Reinhard Gereth, deputy director of production. About a year after the radio's introduction in the U.S., German set makers may follow suit with radios for European markets.

An fm demodulator. The new chip, designated the U115B, integrates into a 2-by-2-millimeter area all functional units for an a-m receiver plus an fm demodulator. External to the chip are only the passive components for the resonant circuits, a potentiometer for volume control, and discrete devices for the remaining fm circuitry. Efforts by other manufacturers to integrate radios on an IC chip have stopped at the a-m portion [*Electronics*, July 17, 1972, p. 25].

The U115B is a medium-scale IC that packs about 100 transistors, diodes, and resistors onto the chip. It contains the tuner, oscillator, mixer and demodulator for a-m reception, an intermediate-frequency stage, an audio-frequency amplifier, and the fm demodulator. Operation is over a 3-to-11-volt range. The device delivers a maximum of 0.8 watt to an 8-ohm loudspeaker. "For the set maker the one-chip solution spells more economical radio production," Gereth says. "The producer can fabricate dif-



Fm radio. Integrated H810 tuner developed by AEG-Telefunken will be made available by the West German manufacturer next year.



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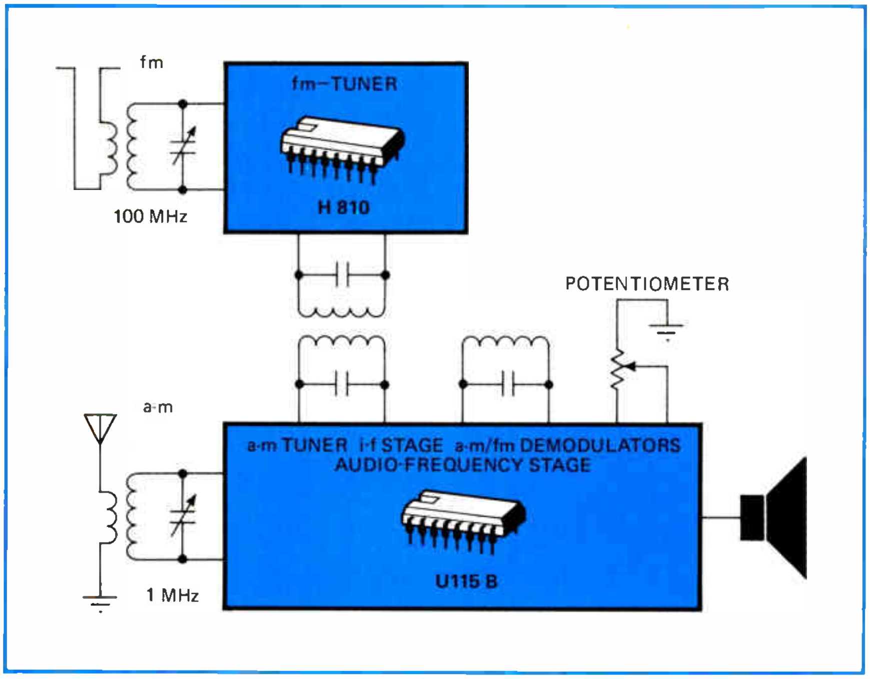

Radio pair. Active functions of a-m/fm radio are performed by two ICs being built by AEG Telefunken. U115B chip was developed jointly with an American company.

ferent receiver models by merely varying the peripheral circuitry around that chip."

Second circuit. AEG-Telefunken engineers have also designed a circuit that integrates the fm tuner on a single chip. But as the diagram above shows, such a radio is based on two chips, rather than one chip.

As Gereth sees it, a single chip incorporating both the uhf tuner and the a-m portion "would not make economic sense." For the tuner's mixer stage to have optimum large-signal-handling capability its transistors must be designed for transit frequencies of 3 to 4 gigahertz, he explains. This requires pn junctions as flat as 0.1 micrometer and lateral structures of from 2 to 4 μm. Such high-frequency components call for self-aligning structures, ion-implantation and steep doping profiles—a more complex technology than is needed for the a-m portion. Mixing complex and less complex steps on the same chip, though technologically possible, would result in higher production costs than putting them on two separate chips.

AEG-Telefunken's second chip is called the H810 integrated tuner. It incorporates four frequency-tuning diodes, a preamplifier stage, a mixer, a low-level oscillator, a control-signal generator and a low-pass filter at the mixer output. The IC has high large-signal stability, low noise (5.5 decibels), and high (30-dB) amplification. The H810 will be available some time next year. □

Solid state

TI offers 16-bit microprocessor

The announcement by Texas Instruments' Digital Systems division of a new series of 16-bit minicomputers [*Electronics,* Oct. 30, p. 38] included news of something else that may have far greater significance for electronic-design engineers—a full parallel 16-bit processor built in n-channel MOS, the TMS 9900.

The chip, TI's first proprietary n-channel silicon-gate microprocessor (it second-sources Intel Corp.'s 8080), operates with a 3-megahertz, four-phase clock and does 16-bit register-to-register additions in 4.67 microseconds, according to TI. The key to the operation is its full 16-bit data bus and 16-bit arithmetic-logic unit, which can also operate on two 8-bit bytes in parallel.

For TI, the TMS9900 adds to its family of microprocessor chips: the TMS1000, a 4-bit p-channel MOS device, and the SBP0400, a 4-bit-slice bipolar chip. In the over-all microprocessor picture, the 9900 joins General Instrument Corp.'s CP1600 as the only American-made 16-bit n-channel microprocessor chips. National Semiconductor Corp.'s 16-bit PACE chip uses p-channel technology.

Registers. Unlike most microprocessors, the chip contains no general-purpose registers. Instead the user assigns these functions to locations in the random-access memory. The chip does have three "housekeeping" registers—program counter, status register, and a work-space pointer that points to an address in one of the registers assigned to the RAM. This allocation of registers to external memory saves space on the chip—space required by the full 16-bit parallel buses on the chip—and also allows the user greater flexibility in programing, according to TI. Addresses are designated by 15 bits plus one extra bit to show whether the contents of that address are to be interpreted as a full 16-bit word or two eight-bit bytes.

The chip handles up to 15 external interrupts, while four bits in the status register store the priority of the interrupt currently being serviced and only an interrupt with a higher priority can be serviced by the device.

Instructions. The chip has a set of 69 instructions, including hardwired multiply and divide, which speed up those operations. Seven addressing modes are available: work space register, indirect, indirect with auto increment, indexed, immediate, symbolic (direct), and program-counter relative.

One advantage of introducing the chip simultaneously with the minicomputers, says TI, is that the one-board minicomputer, model 990/4, which uses the 9900 as its central processing unit, will serve as the

T921

T912

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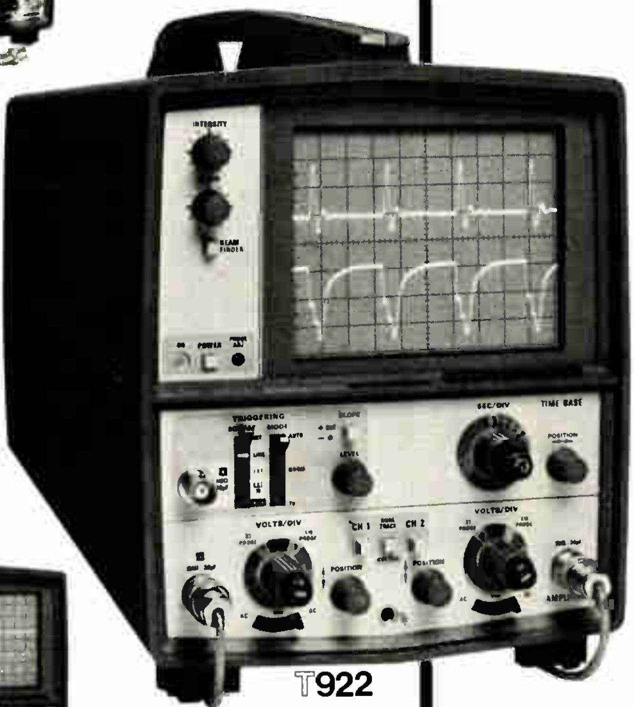

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Banking

IBM's funds transfer gets high marks

Electronic switching systems to automate currency transfer among the nation's savings-and-loan associations look like a $10 million market—and International Business Machines Corp. looks like the front runner in that market.

IBM's advantage became clear with the Federal Home Loan Bank Board's issuance of a report to its 13 regional members in late October. The 171-page document assessed technologies available for funds-transfer tasks in metropolitan areas with five million residents.

The cost per transaction is the figure that means most to bankers. IBM's two proposals, a System/370 for both accounting and switching or a System/7 for switching only, projected a cost of 87 and 41 cents per 100 transactions and were cheaper than the competition. Nine other companies submitted system proposals to the Federal bank group's solicitation for qualified vendors to guide its members. Included were Burroughs Corp., Compata Inc., Concord Computing Corp., Control Data Corp., Financial Industry Systems Inc., Honeywell Information Systems Inc., NCR Corp., System Development Corp., and Sperry Univac division.

Issues. Before the regional savings-and-loan groups can implement systems of their own, however, key policy and operational issues dealing with system security, standards, and software for monetary settlement remain to be resolved "With few exceptions," the Federal board said, "vendor responses shed little light" on these subjects, adding in the report to the regional banks that "a considerable amount of

News briefs

Motorola seeks to stop microprocessor foe
Motorola said last week it would seek an immediate injunction to stop MOS Technology Inc., Norristown, Pa., from making and selling microprocessor products, including its MCS6500. The action would be a stopgap measure, pending trial of a suit filed in Federal Court in Philadelphia. Motorola, which charges its rival with patent infringement and misappropriation of trade secrets, is asking triple damages plus all profits MOS Technology has made on the devices. The suit, which cites Motorola patents that led to development of its own MC6800 microprocessor, alleges that seven former employees of Motorola Semiconductor Products division joined MOS Technology and helped establish that company's microcomputer line. MOS Technology says Motorola's claims are unfounded.

GI sues Mostek on processing patent
General Instrument Corp. has filed suit against Mostek Corp. for allegedly infringing eight of GI's metal-oxide-semiconductor processing and device design patents. The most significant of these involves GI's patented (3,388,009) process for forming a pn junction with an ionic beam. Robert Shapiro, GI's director of legal affairs, says Mostek is a "substantial practitioner" of the process and that GI has been unsuccessful in negotiating a patent agreement with Mostek. Mostek has declined to comment.

Mini maker to introduce POS system
Data General Corp., Southboro, Mass., says it will introduce its 9036 point-of-sale system for supermarkets before May, 1976. The company, in addition to making key system components like the processor and disk memory, has also developed and will produce its own laser scanner to read labels. The 9036 is a dual parallel system, with two central processing units and two disk memories connected by interprocessor buses.

Du Pont signs Soviet trade deal
The Du Pont Co. has signed an agreement with V-O Techmashimport, a Soviet trade organization, to sell Du Pont technology for making chromium dioxide used in audio and video magnetic tape. Du Pont also has concluded negotiations with Sumitomo Shoji America Inc. and the Soviet trade agency for the sale of chromium-dioxide manufacturing equipment.

GE's microwave headaches continue
The Food and Drug Administration has ordered General Electric Co. to inspect 36,000 more microwave ovens for radiation leakage and make free repairs where necessary. But GE, which was earlier directed to recall about 17,800 older Versatronic and Hotpoint microwave-thermal ranges, is resisting the order. FDA also advised GE to stop distributing the two models.

Medical-device standards due
Almost all electronic medical devices will be subject to minimum performance standards, the Federal Food and Drug Administration recently announced. A new list of device standards to be developed in the next three to five years includes high- and low-voltage generators for the $500 million annual X-ray equipment market and products in the $61 million hearing-aid market. Other systems are shortwave and microwave diathermy (heat treatment) apparatus, ultrasonic body scanners and electrocardiograms.

Interconnect rule to be set by FCC
April 1, 1976, is the effective date of the Federal Communications Commission's decision on Oct. 31 to permit AT&T customers to interconnect data modems and data terminals to telephone lines without an AT&T interconnection device. If the modem or terminal is equipped with an FCC-registered protective circuit, the user will avoid installation and rental fees for an AT&T protective module [*Electronics*, Oct. 31, 1974, p. 20].

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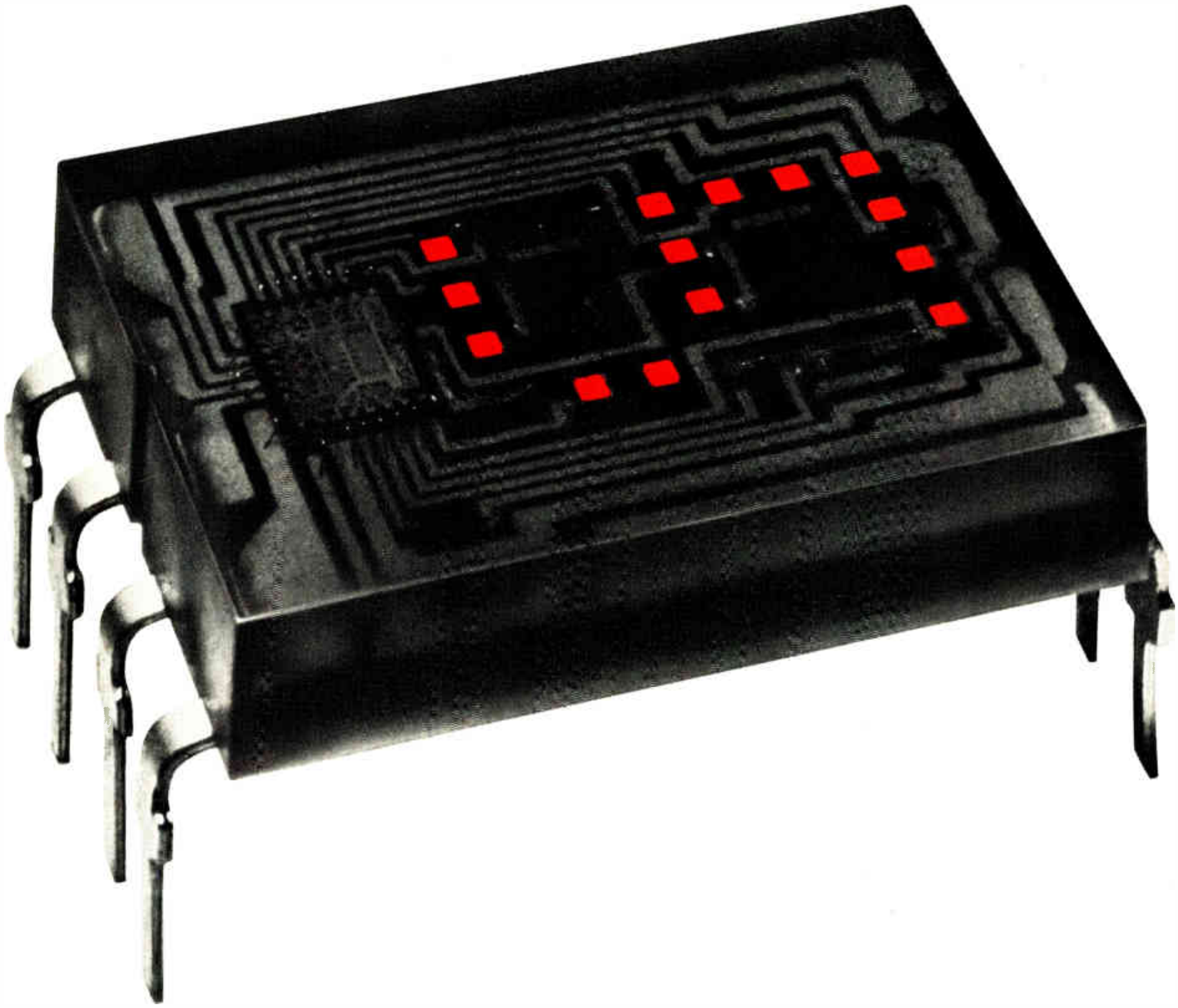

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work remains to be done."

IBM's hardware costs of $465,000 for a System/370 installation and $226,000 for a System/7 installation are not far under the $237,000 of System Development Corp., its nearest competitor. However, the SDC proposal, which features three Hewlett-Packard 21MX-M/30 minicomputers, projects a cost of 90 cents per 100 transactions.

IBM's edge comes from its previously developed communications control application program "which provides message-handling capabilities . . . in a network of remote terminals," notes the FHLBB review team. IBM can sell its software package for $22,000, while the FHLBB says the SDC software cost is $402,500. IBM's switching system consists of a model 5010 processor,

ERDA's photovoltaic-cell effort kicks off with procurement, research

By announcing late last month that it will procure $1 million worth of photovoltaic solar cells, the Energy Research and Development Administration is heating up silicon-cell production for terrestrial use. The cells, to be delivered in four to six months, will be capable of a peak output of 40 kilowatts [*Electronics*, March 6, p. 29]. Annual output is now 100 kw. Moreover, ERDA should order an additional 130 kw of cells by the end of December.

Five companies have been selected to provide off-the-shelf devices in panels measuring up to 4 by 6 feet and supplying up to 5.6 watts per square foot, depending on the vendor. An estimated 90% of the total are being shipped by Solarex Corp., Rockville, Md., and Spectrolab Inc., Sylmar, Calif., a subsidiary of Hughes Aircraft Co. The other three firms are relative newcomers: Sensor Technology Inc., Chatsworth, Calif., M7 International Inc., Arlington Heights, Ill., and Solar Power Corp., Wakefield, Mass.

Most of the modules will be used in photovoltaic systems in remote, battery-operated equipment on which ERDA is running a series of tests in cooperation with the Department of Defense. The remainder will be devoted to applications in the civil sector by NASA-Lewis Research Center, Cleveland.

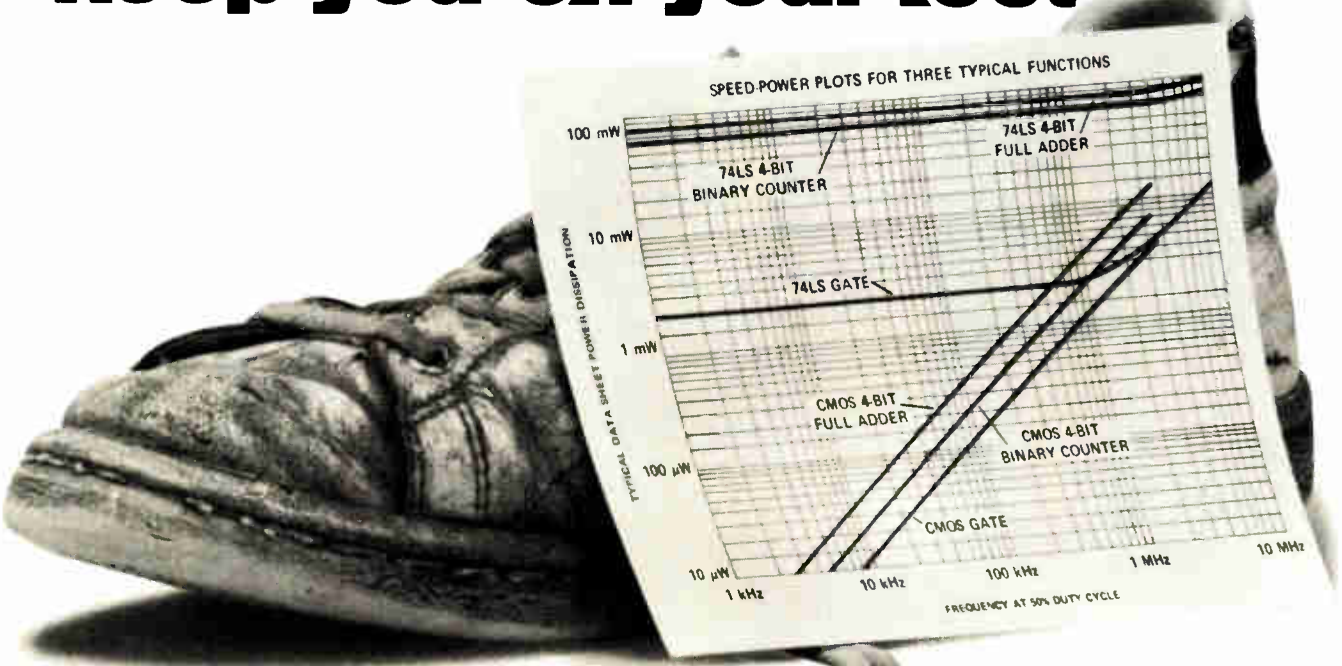
ERDA's photovoltaic program, being managed by Jet Propulsion Laboratory, Pasadena, Calif., seeks to reduce the cost of photovoltaic power to $5 per peak watt by 1979, down from the present $17 to $20, and to demonstrate the feasibility of 50-cent cells by 1980 [*Electronics*, June 12, p. 75]. For these goals, ERDA has allocated $12 million to 16 contractors for four research tasks to last up to 18 months.

Thus, seven organizations will investigate developing less expensive but sufficiently pure silicon materials. They are: Battelle Memorial Institute, Columbus, Ohio; Dow Corning Corp., Hemlock, Mich.; Monsanto Research Corp., St. Louis; Motorola Inc., Phoenix; Texas Instruments, Dallas; Union Carbide Corp., Sisterville, W.Va., and Westinghouse Research Laboratories, Pittsburgh.

Also under study will be methods of producing silicon in large sheets, among them vacuum deposition, dendritic web, and Czochralski growth. Nine organizations being funded for this are: Crystal Systems Inc., Salem, Mass.; General Electric Co., Schenectady, N.Y.; Honeywell Corp., Bloomington, Minn.; Mobil-Tyco Solar Energy Corp., Waltham, Mass.; Motorola; RCA Laboratories, Princeton, N.J.; Rockwell International, Anaheim, Calif.; University of South Carolina, Columbia, S.C., and Varian Inc., Lexington, Mass.

Still another task is to develop automated equipment to assemble the cells into arrays, and this will be studied by Motorola, RCA Laboratories and Texas Instruments. Finally, techniques must be perfected for encapsulating and weatherproofing the arrays, and Battelle, Rockwell, and Solar Power are being funded for these tasks.

"Old Shoe" logic won't keep you on your feet



We hear it all the time. "I'd rather use TTL because I'm used to it. It's comfortable . . . comfortable as an old shoe."

Most of us are inclined to operate that way on occasion, but can you afford it in competitive times like these, with more and more people scrambling for a piece of your action?

There's no denying that TTL is the most appropriate logic form now available for a very large number of systems. But it's also true that it's used for more systems than it ought to be. Because:

For ☑ Lower power
- ☑ Noise immunity
- ☑ Supply voltages above and below 5 V
- ☑ Wider commercial product temperature range
- ☑ Money savings*

CMOS beats any TTL

Not only does CMOS beat TTL in the areas critical to many systems, but it does better on the speed/power plot than some folks would have you believe. Just look.

The graph reiterates something we've probably all taken for granted, that single gate vs. single gate, CMOS is tops below 1 MHz. Look closely and it indicates something far more revealing. When complex functions, MSI, are compared, CMOS more than holds its own to the end of its frequency range.

After thinking this over, if that old TTL shoe looks like it might pinch your system, then think about this.

For ☑ MSI
- ☑ Full line 3 V to 18 V supply range
- ☑ Reliability

Motorola's CMOS, McMOS, leads the rest

McMOS† puts more CMOS MSI at your disposal than any other brand, with complete coverage for CMOS logic system requirements, and there's also a plus in MPU and data comm systems MSI.

McMOS reliability has climbed steadily to the top while prices have dropped into direct competition with TTL, reflecting benefits of the ultra-modern Austin, Texas facility. Naturally, McMOS provides all inherent CMOS cost savings.

Don't make systems rely on an "old shoe." For McMOS information and a thorough analysis of CMOS vs. bipolar, circle the reader service number or write to Motorola, P.O. Box 20912, Phoenix, AZ 85036. Give your Motorola sales office or authorized distributor the business . . . McMOS business.

**Saves money by using smaller, less expensive power supplies, wire and connectors. Dispenses with cooling equipment. Saves money because the system needn't operate in such a tight voltage range. In battery systems, batteries last longer two ways . . . drain is slower and CMOS continues operating properly after the voltage drops below TTL levels. Saves money because TTL noise suppression requirements needn't be met. CMOS not only resists greater levels of noise, but generates less on its own because it switches at lower current levels.*

†Trademark of Motorola Inc.

MOTOROLA McMOS
– *complementary MOS for contemporary systems*

new market opportunity spurred by the desire to conserve energy. The automated central stations could monitor and control heating and air-conditioning systems, sending signals to on-site actuating devices and control equipment and matching the energy supplied to actual requirements. And down the road, Ditch says, ADT anticipates moving into monitoring conditions relating to Federal OSHA (Occupational Safety & Health Administration) standards.

"We're doing some market research in this area now," adds Ditch, "and while it may be too early to speculate as to what kinds of things we might look for, the monitoring of fumes or even the effluent in certain types of industrial facilities seem to be likely applications."

Alarm. In the Houston system, incoming alarm signals flash onto a CRT screen and are recorded by a high-speed printer. Simultaneously, emergency information retrieved from the computer's memory is displayed and recorded. This information tells the ADT operator, among other things, where the endangered premises are, whether the emergency is a fire, burglary, or holdup, and what remedial action ought to be taken. The display also lists numbers of police and fire departments, as well as such information as home-telephone numbers of bank managers, merchants, or others responsible for the alarm-protected location.

Unlike the other 157 ADT central stations across the country, the Houston station handles all routine scheduled signals, such as when an alarm-protected bank vault is opened in the morning and closed at night, without the aid of an operator. According to Ditch, the routine procedures account for well over 90% of activity at the ADT security operations center.

The computer also is programed to assign priorities to incoming alarm signals. For example, a burglar alarm would take precedence over a signal indicating a problem on the signal-transmission line. □

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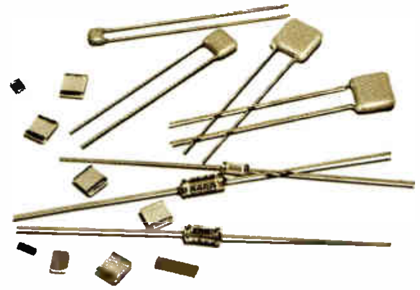

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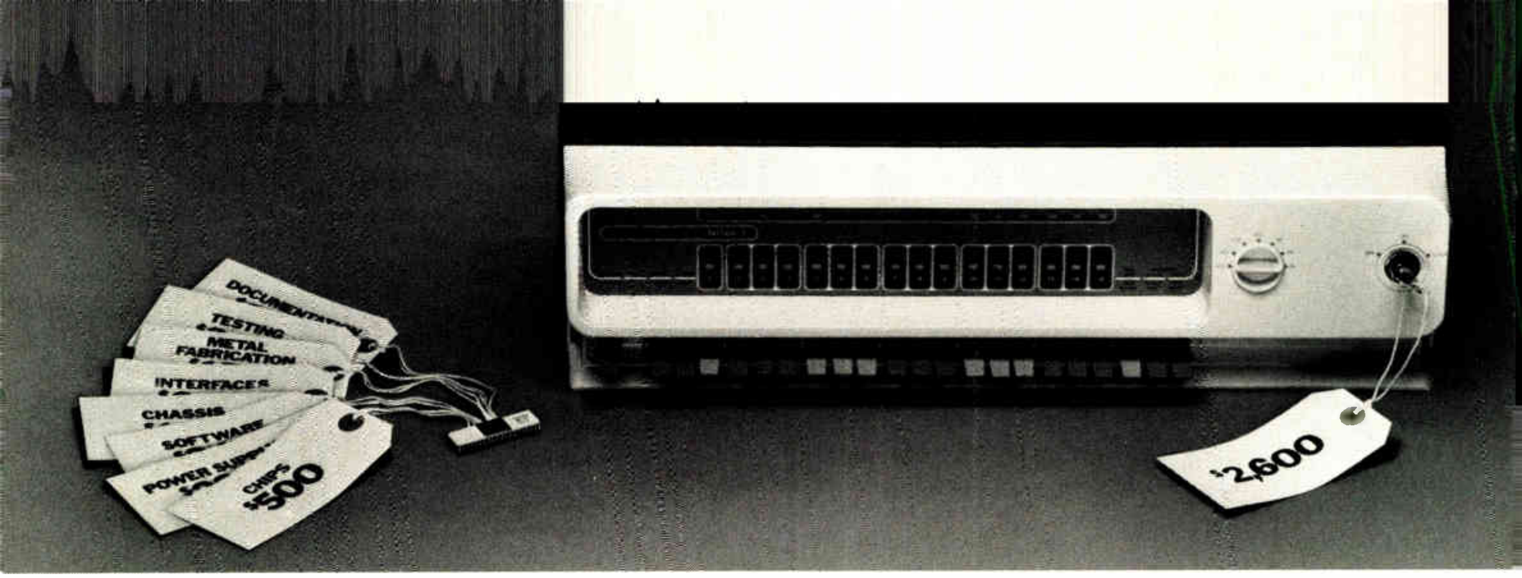

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Justice urges delay of BFT switch buys

The Justice Department has thrown cold water on the San Francisco Federal Home Loan Bank Board's (FHLBB) plan to buy an electronic system to channel deposit and withdrawal information among 195 saving and loan associations in its region [*Electronics*, Oct. 2, p. 59]. **The antitrust division says the FHLBB decision to buy a system, at a cost of up to $700,000, was premature.** "Competitive pressures have already generated a wealth of private BFT systems [but] a Federal EFT system could deter private competitors," says Assistant Attorney General Thomas E. Kauper.

Bank board officials have "indefinitely postponed" the contract award and the procurement may be cancelled. Bankers insist, though, that the Federal agencies responsible for transferring currency among banks—the regional bank boards for S&Ls and the Federal Reserve system for commercial banks—should develop regional switching systems. But the new challenge from Justice has stalled both agencies. Many national banks have organized independent corporate entities to develop their own switching systems [*Electronics*, April 17, p. 38] and industry observers suggest that S&Ls may be forced to do the same thing. (See related story, p. 38).

Navy orders 100 Interdata minis in $12 million pact

Minicomputers have intrigued the Navy sufficiently for it to award a $12 million, three-year contract for 100 Interdata 732 systems, plus a wide variety of peripherals, with C3 Inc., a Fairfax, Va., systems house. **The annually renewable contract guarantees the purchase of at least 10 systems by the Navy's automatic data-processing equipment selection office.** Prospective users within the service "will be able to place orders against the contract," says selection-office deputy Raymond Huber, for a system that meets their particular requirements. The 16-bit Interdata minis have a cycle time of three quarters of a nanosecond and a memory capacity of up to 1 million 8-bit bytes. The large order size, Huber explains, was designed to hold down the Navy's costs of internal competition "every time someone needed a small machine" as well as shorten the time lag between a user's determination of need and the delivery of operational hardware. Included in the C3 order for peripherals are three different types of printers and disk drives, two different card readers, tape units, CRT displays, and terminals.

$NiOH_2$ batteries seen as standard for next decade . . .

The next-generation battery for commercial and military satellites will get its first flight test late next year when the Navy's Navigation Technology Satellite 2 is launched with nickel-hydrogen ($NiOH_2$) batteries developed by Comsat Laboratories, Clarksburg, Md. With a power density level of "at least 15 watt-hours per pound and a potential density of WH/lb.," the new cells have 2.5 to 4 times the 6-WH/lb. density of state-of-the art nickel-cadmium cells, Comsat officials say. **Officials estimate that the $NiOH_2$ battery can save more than 100 pounds, or 10% of the gross**

weight of a typical communications satellite. And the batteries' 10-year lifetime will permit their use as storage batteries for terrestrial photovoltaic cell arrays.

... as Lockheed and Hughes propose $NiOH_2$ to Intelsat

Enthusiasm for the $NiOH_2$ battery is so great that California's Lockheed Missiles and Space Co. in Sunnyvale and Hughes Aircraft Co. in El Segundo have included it in their proposals to supply the International Telecommunications Satellite Organization (Intelsat) with up to 15 new satellites worth $250 million. The new Intelsat V satellites would replace units now currently relaying voice and television signals around the world [*Electronics*, Oct. 16, p. 34]. Industry officials say **the battery may be exempted from Intelsat's policy against flying unproven technology if the Navy tests are successful.** But Lockheed and others are hedging their bets by suggesting NiCd cells if the $NiOH_2$ units fail the Navy test.

Roles of OTP and Eger are boosted by White House

Speculation that the White House Office of Telecommunications Policy was about to go out of business and its role absorbed by the Commerce Department has been put down by President Ford. "No consideration is being given to the elimination of OTP or to its transfer from the Executive Office of the President," Ford says in a written reply to a query from Sen. Howard H. Baker Jr. (R-Tenn.). **But the President's statement leaves open the prospect that OTP could become part of a reactivated Office of Science Adviser to the President,** which the White House has said will be revived and given larger responsibilities than it had before it was dissolved by Richard Nixon.

At the same time, OTP's acting director John Eger gained a measure of job stability as the White House pulled back from nominating former Federal Communications Commissioner Robert Wells to succeed him. Wells' long service and close ties in the broadcasting industry were considered a major liability. Discussion of a successor to Eger is now dormant.

ERDA is urged to build thin-film photocell systems

The Energy Research and Development Administration's plan to demonstrate power systems using silicon photovoltaic cells while keeping advanced thin-film technologies such as cadmium sulfide on the back burner has been challenged on Capitol Hill. **The congressional Office of Technology Assessment has questioned the decision and given a vote of confidence to the advanced concepts.**

"A number of other materials, such as gallium arsenide and cadmium phosphide, are receiving considerable attention from the private sector, and some of them appear quite interesting," OTA says. Congress should also require ERDA to include more photovoltaic demonstration projects than currently planned, OTA adds.

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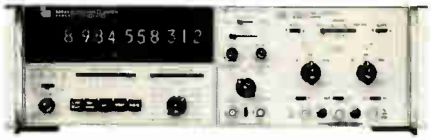

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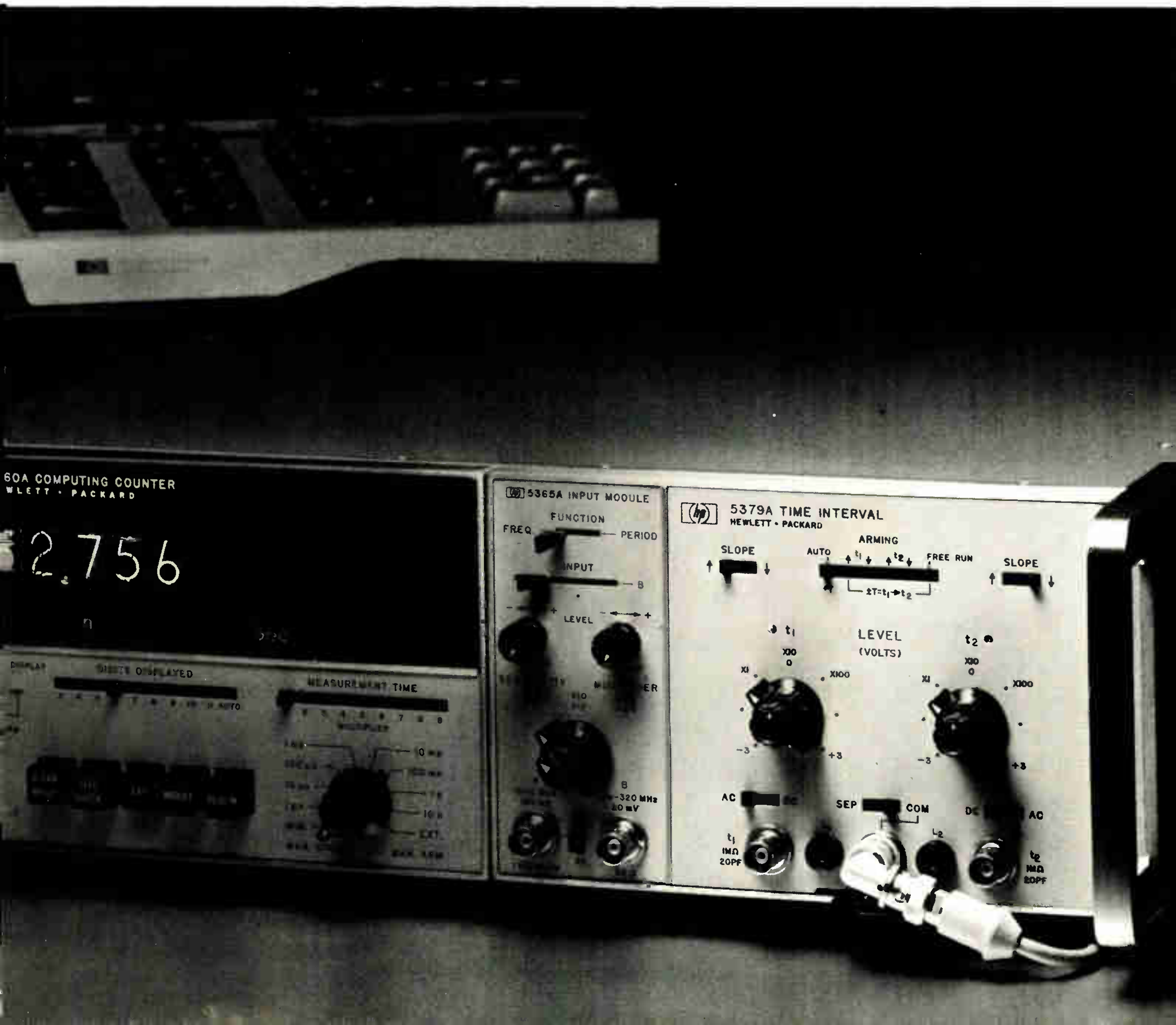

Color-facsimile signals multiplexed on TV broadcasts in Japanese system

In an experimental system, facsimile signals ride piggyback on a color-television broadcast so well that a home TV set can in two minutes receive a letter-size page of copy in four colors. Matsushita Electric Industrial Co., which developed the system with NHK, Japan's public-service broadcasting network, estimates that a color-facsimile adapter could be made at less than the cost of an ordinary color-TV set. However, some obstacles must be overcome first.

Government approval must be obtained, and broadcasters have to figure out how to tie facsimile in with their programing and how they would be paid for their service. Facsimile copy could either be related to the TV programs or differ completely.

But before the system goes into broadcasting service, it is likely to be used for such applications as facsimile transmission on private lines and computer output. Neither of these tasks would require strict standardization or licensing.

Innovations. To make the system possible, a new type of head was developed to shoot ink jets, and a technique was developed to transmit facsimile signals on a subcarrier modulated on the sound-signal carrier in a dot-simultaneous mode. The color-printing process is based on the absorption of portions of incident white light as it passes through successive layers of subtractive primary-color pigments; conversely, color-television transmission forms colors by adding the light of the three additive primary colors. However, black ink must be added in the printing process to give the primary colors enough brightness contrast.

An assembly of four heads shoots the ink in the four colors on plain uncoated paper. Signals to the laterally displaced jets are delayed by successive 8-millisecond intervals. The yellow head writes first in real time, the magenta head writes next, then the cyan, and the black comes last, 24 ms later. Resolution is six lines per millimeter.

The ink streams, which print without odor, are not deflected, as in conventional systems. The size of the droplets, which are produced only when needed, is proportional to the desired printing densities at the points being written. This technique, which permits printing in varying tones, also prevents circulation of excess ink.

Analogous to the intensity modulation of electron guns, the droplet size is regulated by the magnitude of driving pulses to piezoelectric elements that actuate movable diaphragms to eject the ink. The horizontal scan comes from rotation of the paper wrapped around the facsimile drum, and the vertical scan comes from motion of the heads along the axis parallel to the drum.

Delaying. The ink-color signals are delayed by the same kind of bucket-brigade devices Matsushita uses in its recently announced variable-speech-control tape recorder. The applications are surprisingly similar because the highest frequency in the facsimile system is below 10 kilohertz.

The basic format of the multiplexing system is similar to that used for multiplexed fm broadcasting in the U. S., except that facsimile replaces the subsidiary communications-authorization channel on the second subcarrier of the sound signal. However, the frequencies differ because of the need to space the pilot frequency at an odd multiple of half the television horizontal-scan frequency.

For transmission, a color-facsimile signal similar to the NTSC color-television signal used in Japan and the U. S. is modulated on the second subcarrier. The luminance signal, which occupies the frequency range from 0 to 10 kHz, can be used alone for black-and-white reception. The I color-difference component of the chrominance signals is transmitted between 10 and 15 kHz, and the Q component is transmitted between 15 and 20 kHz. Since these signals are discrete, they can be separated by tuned filters. In contrast, the I and Q signals for color-television transmission are combined in phase quadrature, and fairly complex circuits are required to reconstitute them. □

West Germany

X-ray system provides real-time view of semiconductor devices on TV screen

Both the yields and the reliability of semiconductor devices are likely to improve, once an X-ray/television system now in the final stages of development becomes available. The equipment presents pictures of crystal growth on a TV monitor for direct viewing in real time, in contrast to hours-long exposure of photoplates that is necessary in other methods. The system, being developed at West Germany's Max Planck Institute for Solid State Research in Stuttgart, is being funded by Bonn's Ministry for Research and Technology.

The new equipment can be used in semiconductor research as well as industry for nondestructive investigations of crystals and devices during component manufacture. In device production, for example, crystal layers can be viewed after high-temperature diffusion steps or before the various masking steps.

Werner Hartmann, whose group devised the technique, says that the system has already aroused much interest among semiconductor manufacturers. When development is completed, the equipment will probably be manufactured by Garching Instrumente GmbH, a subsidiary of the Max Planck Society. Production may also be licensed.

Viewing. The crystal to be examined is oriented so that its atomic lattice planes reflect light from X rays of constant wavelength. The crystal in front of the X-ray beam is shown on the monitor as a topographic image of the crystaline body and its structural imperfections, such as unwanted grain boundaries and dislocations.

These imperfections adversely affect the mechanical stability and electrical characteristics of crystal and limit the yield and reliability of semiconductor devices. Perfect planes produced under normal conditions show up as a uniformly gray image on the monitor, but imperfect planes, which reflect the light differently, show up as contrast fields on the monitor.

The TV picture can also be presented in color. For viewing in color, a converter changes light-intensity values into color signals so that lattice imperfections show up in one color and the perfect sections in another. By remote control, any desired section of the crystal can be moved into the field of view. A sequence of crystal pictures can be stored on magnetic film for later evaluation.

Magnification. The equipment can clearly show crystal details less than 10 micrometers wide on the monitor, and viewers can watch any imperfections in lattice structure as they are formed. Hartmann says such high magnification, unattained before in direct image representation, is a prerequisite for basic research on crystal lattices, structures, and imperfections.

The system has a 30-kilowatt X-ray source with a rotating molybdenum anode. The crystal to be examined is placed near this source, and the X-ray image is converted into visible light. The resulting picture is projected through an optical system onto a sensitive television camera, which sends the picture signals to the TV monitor.

The Stuttgart team is now planning to investigate dislocations in semiconductor crystals subjected to high mechanical stress and temperature-loading. Such investigations, Hartmann says, are necessary to understand the aging processes and causes of failure, especially in such devices as laser diodes and integrated circuits. □

Around the world

French company provides nonvolatile SOS memory

Long dependent on U.S. companies for advanced circuit technology, France is now fostering an embryo design company that is aiming at sales in U.S. and West German markets. The French hope that the combination of powerful research resources and a small, market-oriented engineering team will set an example to others in the French semiconductor industry. Efcis (Etude et Fabrication de Circuits Integrés Speciaux) is a spin-off from a large electronics-research establishment, the 500-man Laboratoire d'Electronique et de Technologie de l'Informatique, which handles fundamental, applied-electronics, and computer-technology research for the French atomic-energy commission.

Now, as a separate company, the same design team is completing development of several custom-made silicon-on-sapphire circuits. Next year, the company plans to start selling MIIS (metal insulation insulation semiconductor) SOS memories. The market for MIIS memories, which are nonvolatile, promises to be huge. Although power failures wipe out data on conventional semiconductor memories, MIIS circuits retain data in the form of electrical charges between two layers of insulation and remain independent of an outside power supply. The first 1,000-bit industrial samples will go out next year, and Efcis is pushing ahead to develop a 4,000-bit chip.

But Efcis could hardly move into standard products even if it wanted to. This year, the company will produce about 60,000 circuits and plans an increase to 200,000 next year. At best, the company figures it could expand up to a production of a million chips a year, but so far most of its sales have been for small runs of 1,000 to 10,000 circuits, far below the 200,000 minimum volume set by such big semiconductor makers as Motorola and Texas Instruments.

Norwegians build military-communications gear

Norway's armed forces now are putting into service a new generation of portable field-communications hardware—a manpack transceiver and an electronic-telephone set. The new hardware was designed as well as built in Norway to cope with the severe winters and the 1,100-mile length of the country. Aksjeselskapet Mikro-Elektronikk has a $17 million contract to supply 2,600 of its NO/PRC 111 manpack transceivers over the next three years. A/S Elektrisk Bureau has a $4 million order to deliver 16,000 of its TP-6N field-telephone sets this year and next, plus an option for an additional 10,000 sets in 1977.

The Norwegian army is getting leading-edge hardware from its native suppliers. AME's single-sideband manpack radio can send or receive on any of 285,000 frequencies over a band from 1.5 to 30 megahertz at output power up to 25 watts. In the TP-6N, the Norwegian armed forces are getting—for about the same price—a set that's about one third as heavy and nearly double the range of a conventional field phone. The new electronic hardware can transmit a maximum of 35 kilometers over a standard twisted pair. All the elements are solid state and mounted, along with three special lithium D cells, on one printed-circuit board. All told, the set weighs less than 2 kilograms and can be carried in a field-jacket pocket.

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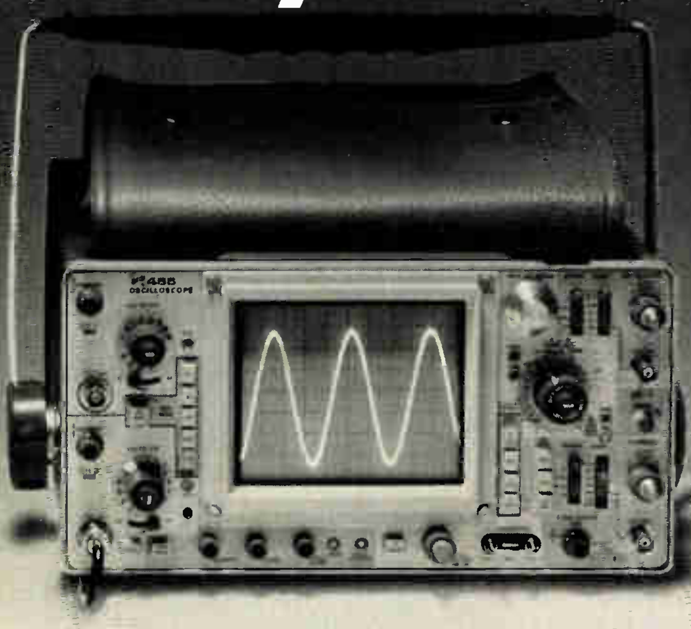

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International newsletter

Intermetall slates three I^2L devices for next year

Two integrated injection-logic devices for electronic organs and one for alarm clocks are to be marketed early next year by Intermetall GmbH, Freiburg, West Germany. **The member of the ITT Semiconductor group will begin sampling the organ ICs this month, and begin delivering large quantities in January. The clock circuit will come along later.**

The organ circuits, the SAA 1004 and SAA 1005, are frequency-divider circuits Intermetall is offering "at the price of conventional ICs." Each chip has an area of 2.4 square millimeters. The clock circuit, the UAA 1007, integrates on a 2.9-mm^2 chip the clock-drive circuitry, a 2-kilohertz oscillator, the output stage for the alarm tone, and the circuitry for the alarm program.

Market hopes rise for electronic gear in Spain . . .

Barring upheaval, electronics markets could grow in Spain next year for communications gear, computers, consumer-electronic equipment, and instruments. That is the consensus of electronics executives who are worrying about what the government would do if Franco should die. Another worry is, however, whether a new government can stimulate the once-booming economy without overheating an inflation rate of at least 17%.

The hope is that investment will return, as public confidence in stability grows, to help rekindle the boom that fizzled in 1975. If that happens, the turnaround could begin by mid-1976, says Jose M. Coronado, assistant to the president of ITT's Standard Electronica, S.A. **Pacing the upturn would be government outlays for communications, increasing business automation, and rising sales of color-television sets as the country expands its *de facto* recognition of the PAL system.**

. . . as Univac helps form Spain's second computer company

Spain will get its second national computer company when papers are signed between the Instituto Nacional de Industria (IRI) and Sperry Univac. The companies are forming what junior partner Univac calls Uniforesa. **To begin full operation by late 1976, Uniforesa plans to make 150 Univac model 90/30 computers, worth $50 million a year.** One third of them are to be exported. Sperry Rand Espanola, which views Uniforesa as a new European-based plant, will independently market Univac 1100-series computers. The new company follows creation of Secoinsa by a consortium created around Japan's Fujitsu to make minicomputers for telecommunications switching.

Toshiba C-MOS chip selects TV fare at preset times

The most elaborate channel-selection device yet developed for color-TV sets is due on the market from Toshiba in February. The viewer programs his selections for the day into the device, and the TV screen displays the time and lists the channels as he chooses them.

Actually a clocked complementary-MOS chip, the device automatically switches a varactor-tuned television set to a desired channel at a preset time. **The circuit, which contains about 8,200 transistors on a chip 5.4 mm square, is furnished in a 42-pin dual in-line package.** Buffers prevent latching that might be triggered by high-voltage surges from a color-television set.

The channel selector can be preset for a maximum of 16 programs, which consist of the on and off times and the channels desired at those times. The device operates at 4.5 megahertz from a 4.5-volt supply, and three dry cells prevent loss of program and keep the clock running in the event of a power failure.

Computers to save British Rail net triple their cost

A new on-line computer system is expected to save British Rail three times its price of $33 million by keeping close tabs on some 300,000 freight cars in the United Kingdom. The system, built around two IBM System/370-168 computers, is expected to save 20,000 freight cars plus $6 million a year in operating costs. The mammoth network, augmented by a phalanx of IBM and Control Data Corp. disk drives, **receives continuously updated information from the 155 area centers on the status of every car in each jurisdiction.** Automatic polling by the TOPS (total operations processing system) reveals the unused cars available for trains, thereby reducing the number of idle cars in marshalling yards.

Sescosem upgrades power transistors for switching

The Sescosem Semiconductor division of France's Thomson-CSF has started to position itself for a strong share of the burgeoning market for switching power transistors in Europe. Officials maintain that their company has pushed its technology to the point where **figures of merit for power transistors in switching applications approach those for signal transistors.** The high performance levels of these switched power supplies should open new industrial applications of all sorts. Sescosem is backing this belief with a heavy development program to boost ratings. The short-term aim: an 800-volt, 60-ampere transistor on the market by mid-1976.

Canon projector reduces line widths for ICs

Sales of a projection-type pattern-exposure unit for extreme reductions of integrated-circuit patterns began this month. Canon Inc., developer of the $107,000 model FPA-141, says **the system can reproduce the submicrometer line widths needed in fabrication of very-large-scale ICs and microwave transistors, as well as magnetic-bubble, charge-coupled and surface-wave devices.** Canon claims that the FPA-141 can resolve line widths down to 0.8 micrometer and that optical-system distortion is less than 0.01%.

When projecting a mask on a wafer, a high-performance optical system can reduce photomask dimensions to 25% of their original linear dimensions. The system was designed for 2-inch wafers, but larger sizes can be accommodated. After reduction, the maximum effective pattern size is 14 millimeters in diameter. **Larger portions of the wafer can be exposed by step-and-repeat operations—an area of a wafer 30 by 30 mm square can be covered in nine exposures.** Both the G line of 436 nanometers and the H line of 405 nm are used for exposure to minimize standing waves.

West Berlin to try fiber-optic net

An experimental glass-fiber-optic communications network that would transmit 480 speech channels over several kilometers is being planned in West Berlin by Germany's Ministry for Research and Technology and the Bundespost. Expected to get under way in 1977, the project is designed **"to test optoelectronic components under actual operating conditions in local trunk lines and to give the industry practical experience with such components,"** says a Bundespost official. Requests for bid proposals have gone out to a number of electronics manufacturers.

THE ONE SOURCE FOR EVERYTHING NEW IN BREADBOARDING

CONTINENTAL SPECIALTIES

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CONTINENTAL SPECIALTIES

Quick Test SOCKETS

They're called "QUICK TEST" because now you can breadboard any circuit faster than drawing. These snap-

Keep going non-stop, from idea stage to final design, using the same components over again without bending, twisting or loading with solder. The fast, reliable Quick Test Sockets and Bus Strips let you try out new ideas or rejuvenate old ones with complete safety to your discrete and IC components and your fingers.

SIMPLE MOUNTING Mounting holes in the plastic housing let you top mount to any flat surface with 4-40 flat head screws, or 6-32F self-tapping screws for behind-the-panel mounting.

ACCEPTS ALL STANDARD COMPONENTS Quick Test Sockets and Bus Strips conform to 1/10'' grid and are DIP compatible. ICs, diodes, resistors, capacitors, transistors, etc. are plugged right into the socket and/or strip, without messy, time-consuming soldering.

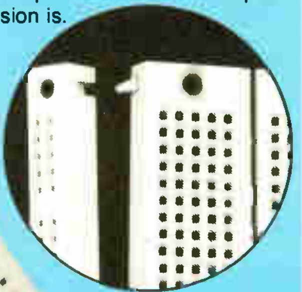
HOOK-UP All you need is a wire stripper and #22 AWG solid hook-up wire. Connect power and ground leads to your bus strip. Plug in your ICs, transistors, resistors, etc. Now interconnect components with #22 wire. Connect a signal source to bus strip or directly to input point of your circuit. Each socket has 5 tie points per terminal; each bus strip has 2 separate rows of interconnecting terminals. Turn on the power and signal source. Hook-up a scope probe, counter, etc. Then, if you have to add a wire, need another IC or component — just plug it in. You'll never burn your fingers or get solder shorts. And you don't need any special patch cords, either.

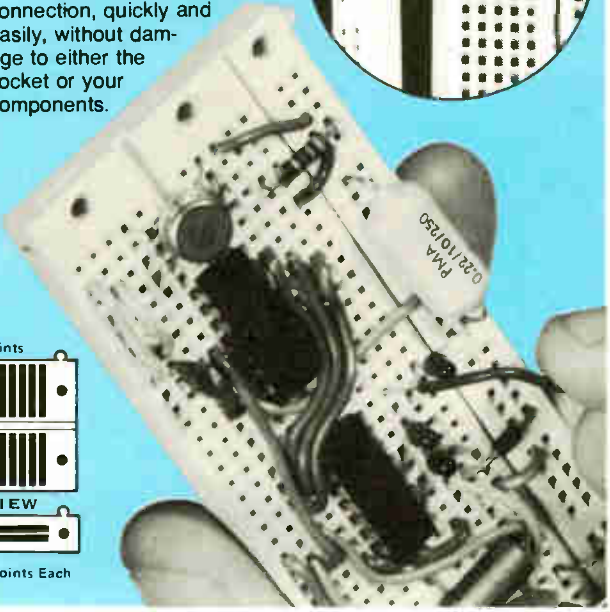
INTERCONNECTIONS Each terminal consists of 5 connected solderless tie points formed from a pre-stressed, spring loaded, non-corrosive nickel silver alloy to insure secure mechanical and low resistance electrical connections. Simply push in your lead, wire or component and you've got a connection, quickly and easily, without damage to either the socket or your components.

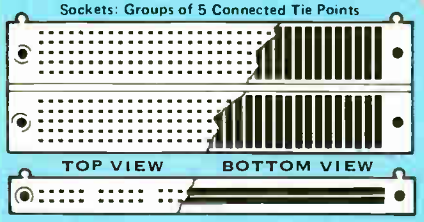
It's that simple!

All Sockets are 1.32'' wide. All Bus Strips are .36'' wide. All Sockets and Bus Strips are .33'' thick. And all are great for high temperature operation — for worst case circuit design to over 100°C.

Exclusive SNAP/LOCK allows you to expand or contract your breadboard by snapping together as many sockets or strips as you need. Look at the picture, and see how quick and simple SNAP/LOCK expansion is.



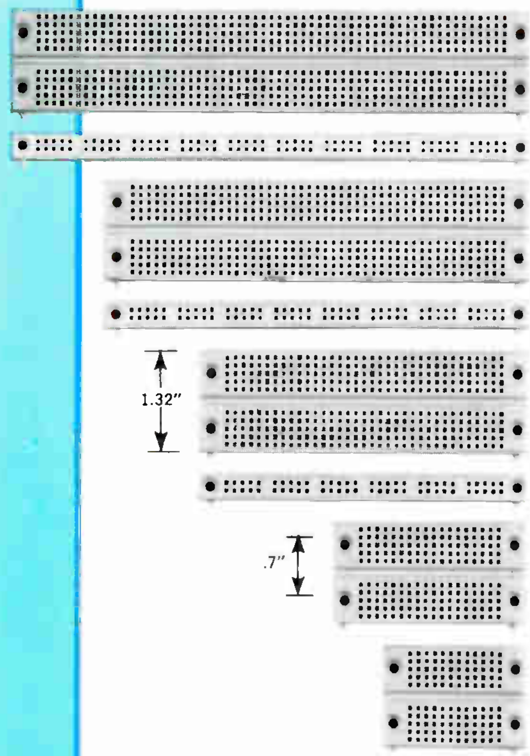




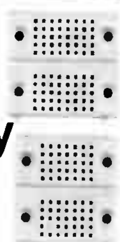
and BUS STRIPS

together, compact breadboards let you plug-in, test, wire, modify, build . . . without solder or patch cords!

10 Modestly Priced Models . . . off-the-shelf . . .



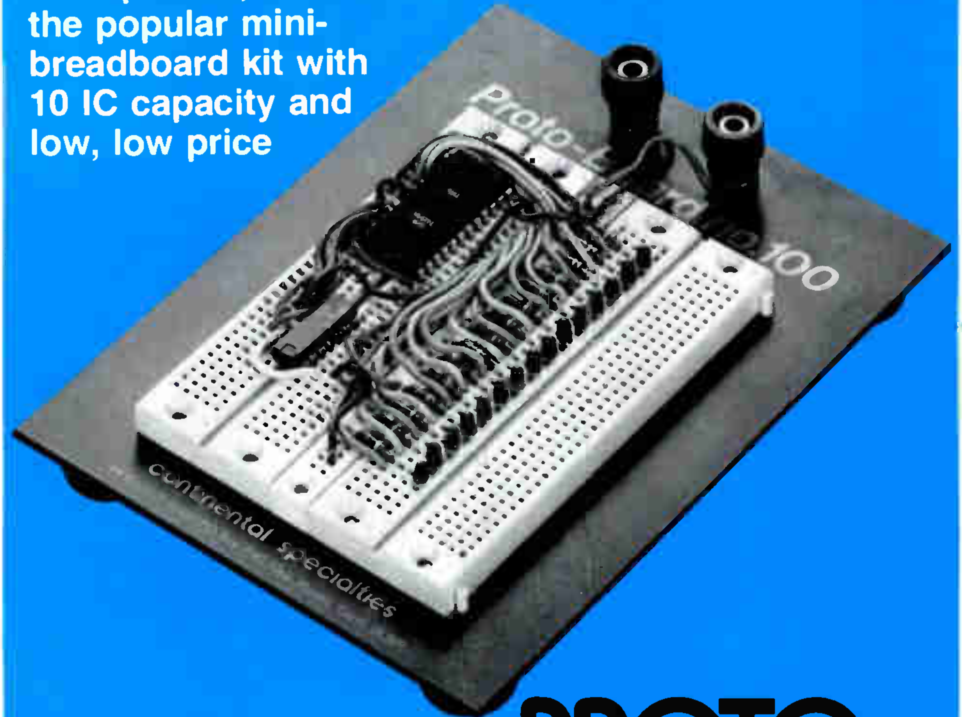
	length	Hole-to-Hole	Terminals	Unit Price $
QT-59S	6.5"	6.2"	118	12.50
QT-59B	6.5"	6.2"	20	2.50
QT-47S	5.3"	5.0"	94	10.00
QT-47B	5.3"	5.0"	16	2.25
QT-35S	4.1"	3.8"	70	8.50
QT-35B	4.1"	3.8"	12	2.00
QT-18S	2.4"	2.1"	36	4.75
QT-12S	1.8"	1.5"	24	3.75
QT-8S	1.4"	1.1"	16	3.25
QT-7S	1.3"	1.0"	14	3.00



Order yours today!
Use the handy order form!

U.S. Patent Design No. 235,554

For openers, here's the popular mini-breadboard kit with 10 IC capacity and low, low price



PROTO BOARD 100

We've put the best together (2 QT-35S Sockets and a QT-35B Bus Strip) . . . 760 tie points (less than 2.7¢ ea.) . . . throw in all the ruts, bolts, screws, binding posts 'n rubber feet . . . even simplified directions . . . and the fun of building your own working ProtoBoard begins. DIMENSIONS: 4.50" (114.3 mm) Wide. 6" (152.4mm) Long. 1.35" (34.3mm) High. Order today. Start building. Start testing. Start saving.

Complete kit . . . only

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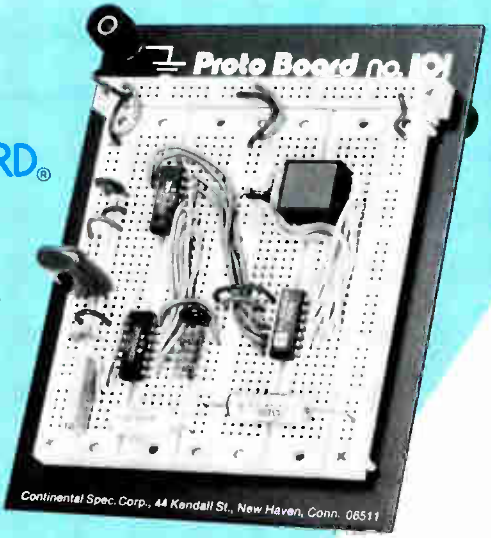
PROTO BOARD® **101**



A compact mini-breadboard at a mini-price, but with expanded 10 14-pin DIP capacity.

29.95

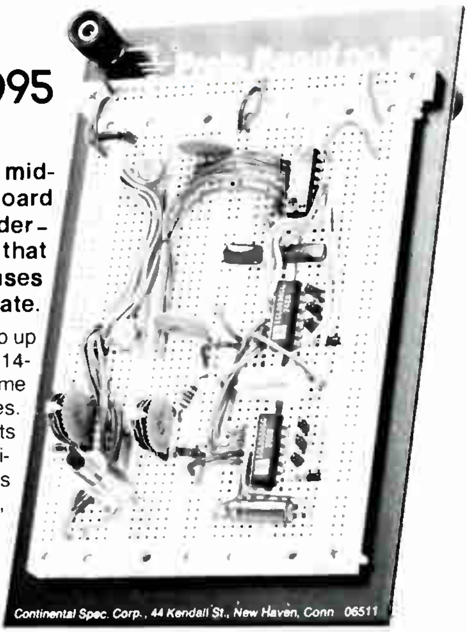
If you're on a budget, here's the ProtoBoard for you. 10 14-pin DIP capacity. 940 solderless tie points (less than 3.2¢ ea.). 8 distribution buses; 2 horizontal, 6 vertical; 30 contacts each. Weighs only 9 oz. (.255 Kg). 5.8'' x 4.5'' (147mm x 114mm). Complete and ready to start testing. And that price. How sweet it is! Order today.

PROTO BOARD® **102**

39.95

A mid-size mid-priced ProtoBoard with 1,240 solder-less tie points that has as many uses as you can create.

The PB-102 is a step up from PB-101, offering 12 14-pin DIP capacity and the same mechanical/electrical features. The 1,240 solderless tie points cost less than 3.2¢ ea. 8 distribution buses on each; 2 horizontals with 30 contacts each. Lightweight, only 11 oz. (.312 Kg). Compact. 7'' x 4.5'' (178mm x 114mm). It's assembled and ready to start testing the minute you open the package. What are you waiting for? Order yours today.

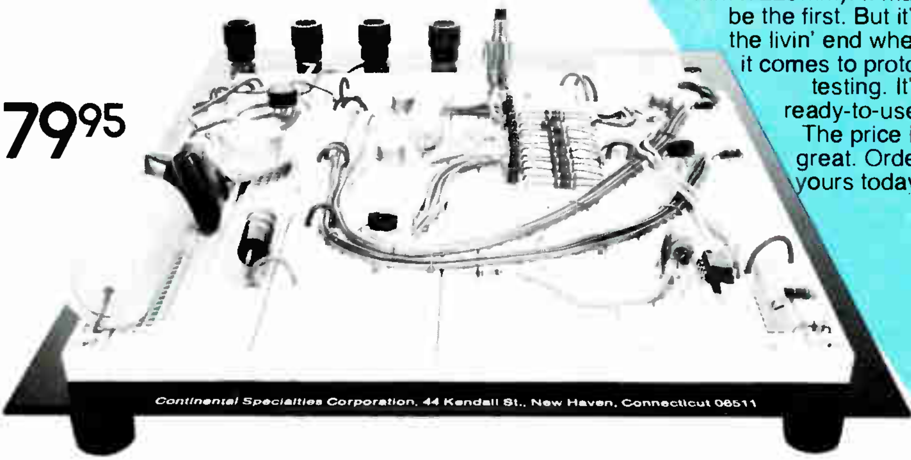


PROTO BOARD® 104

The King Size ProtoBoard that offers it all . . . at a very easy price.

You name it. PB-104 has it. 3,060 solderless tie points at only 2.6¢ ea. 32 14-pin DIP capacity to build an entire system, including power supplies. Four 5-way binding posts; one grounded, three floating. Rubber feet. 14 distribution buses; 4 horizontal with 50 contacts each, 10 vertical with 50 contacts each. Lightweight, only 1 lb. 12 oz. (.794 Kg). Measures 8″x9.76″ (203mm x 248mm). It's all here. Ready to use . . . and reuse. And, the price isn't bad either, when you consider everything you're getting!

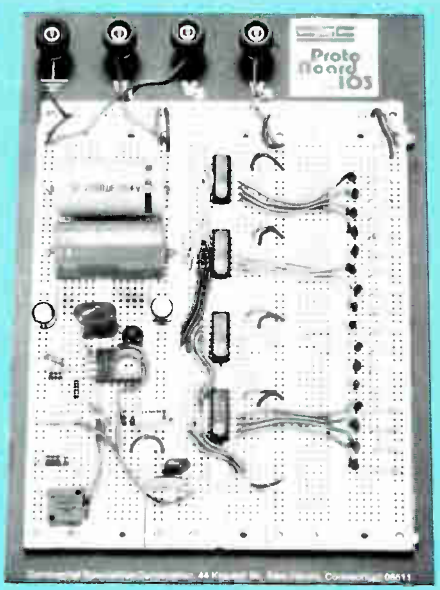
79.95



PROTO BOARD® 103

The versatile, expanded, granddaddy of all the ProtoBoards.

59.95



PB-103 was our first ProtoBoard because (until now) it had just about everything you could need . . . and still does. 2,250 solderless tie points at less than 2.7¢ ea. Four 5-way binding posts; one grounded. 24 14-pin DIP capacity. 10 distribution buses; 2 horizontal with 40 contacts each, 8 vertical with 50 contacts each. Weighs only 1 lb. 4 oz. (.567 Kg). 6″x9″ (152 mm x 229mm). It may be the first. But it's the livin' end when it comes to proto-testing. It's ready-to-use. The price is great. Order yours today.

You asked for them. Now here are two powerhouse ProtoBoards . . . with built-in regulated short-proof power supplies!

Here is the ultimate in prototesting. New PB-203 and PB-203A protopowerhouses are ready to use. Just plug 'em in and start building. The PB-203 offers 2 extra floating 5-way binding posts for external signals. Both are self-contained with power switches, indicator lamps and power fuses. 24 14-pin DIP capacity. All metal, two-tone quality cases. Good looks. Great technology. Fantastic price.

PROTO BOARD® 203

3 QT-59S Sockets
4 QT-59B Bus Strips
1 QT-47B Bus Strip
Fuse . Power Switch
Power-On Light
9.75"Lx6.6"W x3.25"H Weight 5 lbs.
5V, 1 AMP regulated power supply

Output Specifications

Output voltage 5V±¼V
Ripple & Noise @ ½AMP 10 millivolts
Load Regulation Better than 1%

75.00 each

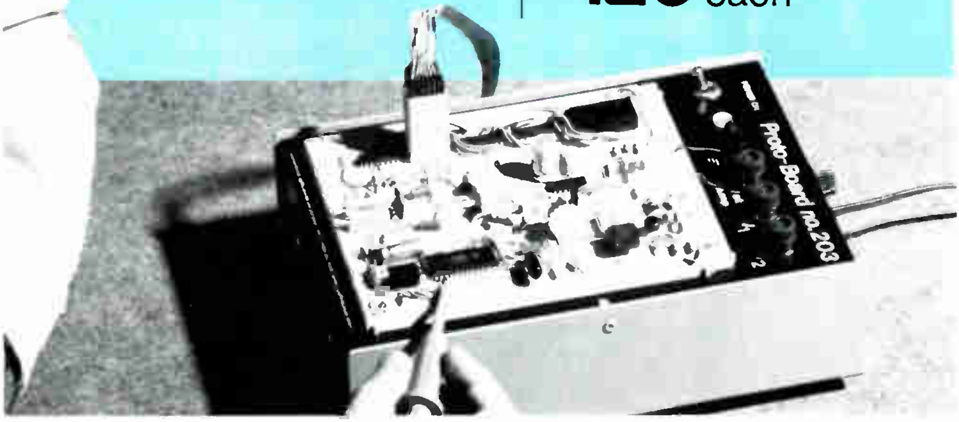
PROTO BOARD® 203A

3 QT-59S Sockets
4 QT-59B Bus Strips
1 QT-47B Bus Strip
Fuse. . Power Switch
Power-On Light
9.75"Lx6.6"Wx3.25"H
Weight 5.5 lbs.
5V, 1 AMP regulated power supply (same as PB203)
+15V, ½AMP regulated power supply
−15V, ½AMP regulated power supply

Output Specifications

Output voltage 15V, internally adjustable
Ripple and noise @¼AMP 10 millivolts
Load Regulation Better than 1%

120.00 each



LOW COST . . . COMPACT . . .

CONTINENTAL SPECIALTIES

PROTO CLIP

*Patent Pending

Test with power on and hands off . . . without shorting leads. All for under $5.

Here's the micro-troubleshooter you've looked for. Its narrow, deep throat brings IC leads up from crowded pc boards for fast signal tracing. Or even injecting signals and wiring unused circuits into existing boards. See those unique gripping teeth (below); scope probes and test leads lock onto them instantly, easily to free your hands for other work. The plastic construction eliminates springs and pivots. And, the molded flexible web* insures thousands of sure operations. Non-corrosive nickel/silver contacts give simultaneous low resistance connections to all your IC leads. If you work with ICs you need these inexpensive CSC ProtoClips. So, order yours today.

PC-14 (14-pin ProtoClip). . . . .$4.50 each
PC-16 (16-pin ProtoClip). . . . .$4.75 each

PRE-WIRED

PROTO CLIPS

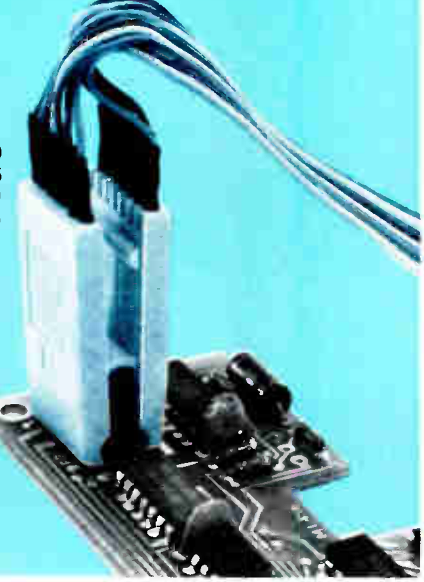
WITH CABLES

. . . a new dimension in interfacing

How easy can you get? Pre-wired ProtoClip Cables simplify IC connections to other ICs, pc boards, test fixtures . . . even interconnecting ProtoBoards. Available up to 36" (914mm), these factory-tested, ready-to-use, cables are rated up to 150V and 105°C. #28 AWG stranded conductors, with vinyl PVC insulation. Here's how to order . . .

	Cable length inches	Price Each Single clip	Dual clip
PC-14	12	7.50	14.50
PC-14	18	7.75	14.75
PC-14	24	8.00	15.00
PC-14	30	8.25	15.25
PC-14	36	8.50	15.50
PC-16	12	8.25	15.75
PC-16	18	8.50	16.00
PC-16	24	8.75	16.25
PC-16	30	9.00	16.50
PC-16	36	9.25	16.75

NOTE: S=Single Clip
D=Dual Clips
When ordering include Part No.-Cable Length-Single(S) or Dual (D) Clips



What the Logic Monitor does

Continental Specialties' Logic Monitor simultaneously displays static and dynamic logic states of DTL, TTL, HTL or CMOS DIP ICs in a compact, self-contained, pocket-sized unit. Never needs calibration or adjustments. Traces signals through counters, shift registers, gating networks, flip flops, decoders. . .entire systems, made up of mixed logic families. Now that's versatility and value from one low cost instrument!

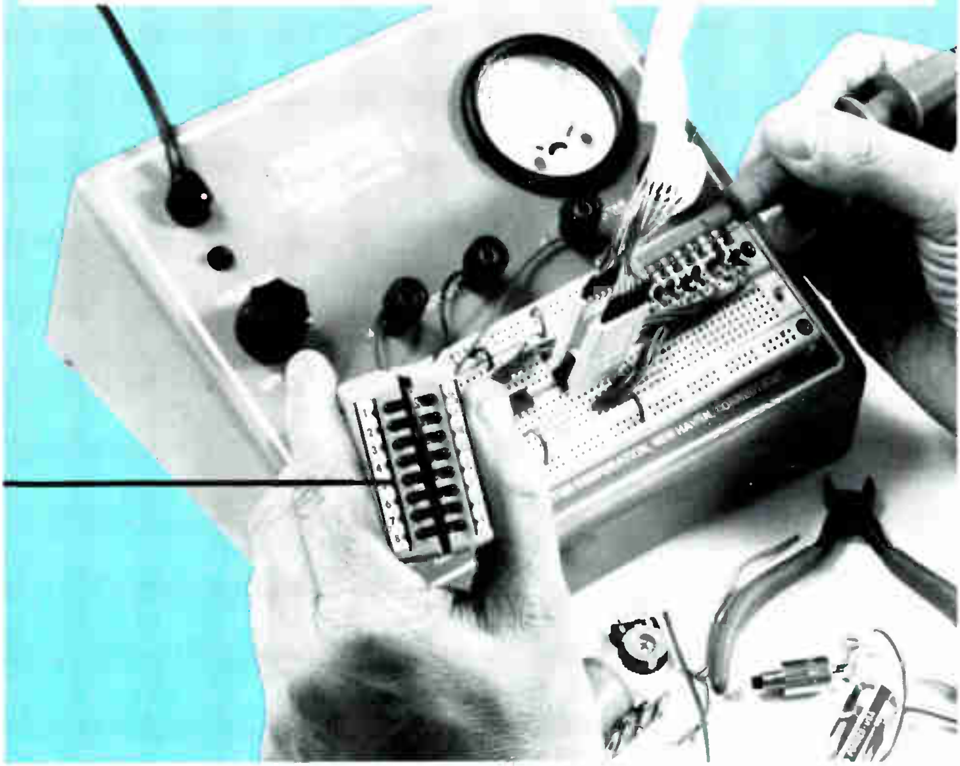
How the Logic Monitor works

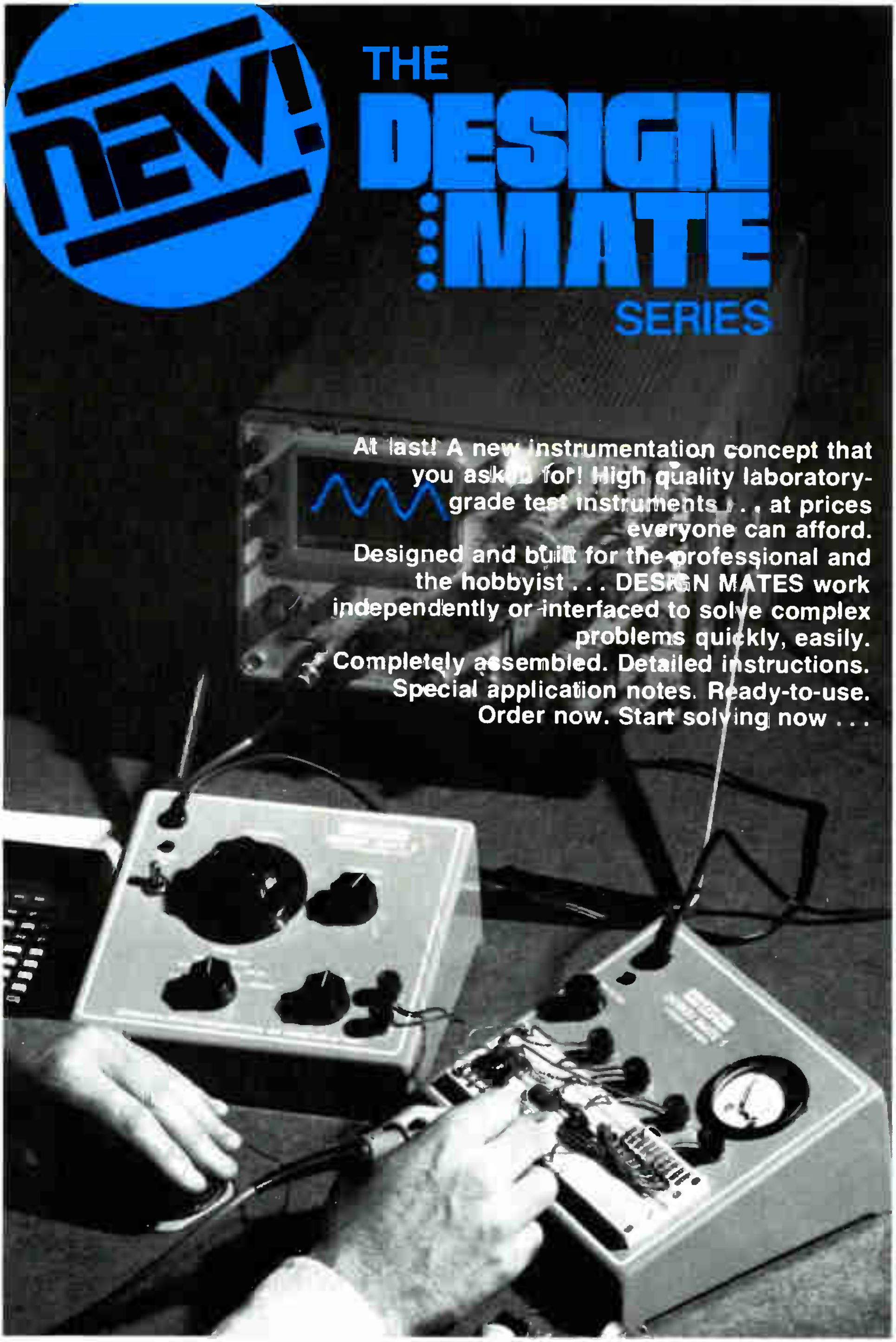
Each of the 16 input contacts are connected to independent single "bit" go/no go detectors with LED readouts. Each detector circuit turns on a high intensity LED when its input voltage exceeds a fixed 2V threshold. A power-seeking gate network automatically locates supply leads and feeds them to the Logic Monitor internal circuits. Simple, but effective . . .and a must for your lab.

It's so easy to use

Simply clip the Logic Monitor to any DIP IC up to 16 pins. Precision plastic guides and the unique flexible web* insure positive connections between non-corrosive nickel/silver contacts and IC leads. Logic levels appear instantly on 16 large (.125" dia.), clearly marked, high intensity LEDs. Logic "1" (high voltage) turns the LED on. Logic "O" (low voltage or open circuits) LED off. Best of all, it fits in the palm of your hand and operates instantly. Order today.

*Patent Pending

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At last! A new instrumentation concept that you asked for! High quality laboratory-grade test instruments . . . at prices everyone can afford.
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A manufacturer of hydraulic cylinders was producing precision parts faster than existing plating facilities could handle them. OMI's Udylite Division installed its Ultrachrome™ ACS process and production capability jumped 70% with no sacrifice in quality.

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Dissatisfied with cost and production levels for critical gold plating processes, a maker of telecommunications devices switched to a new process from OMI's Sel-Rex Division. Plating time was cut in half...gold consumption was reduced by 15%. And the resulting boost in production allowed for a 50% saving in labor cost alone.

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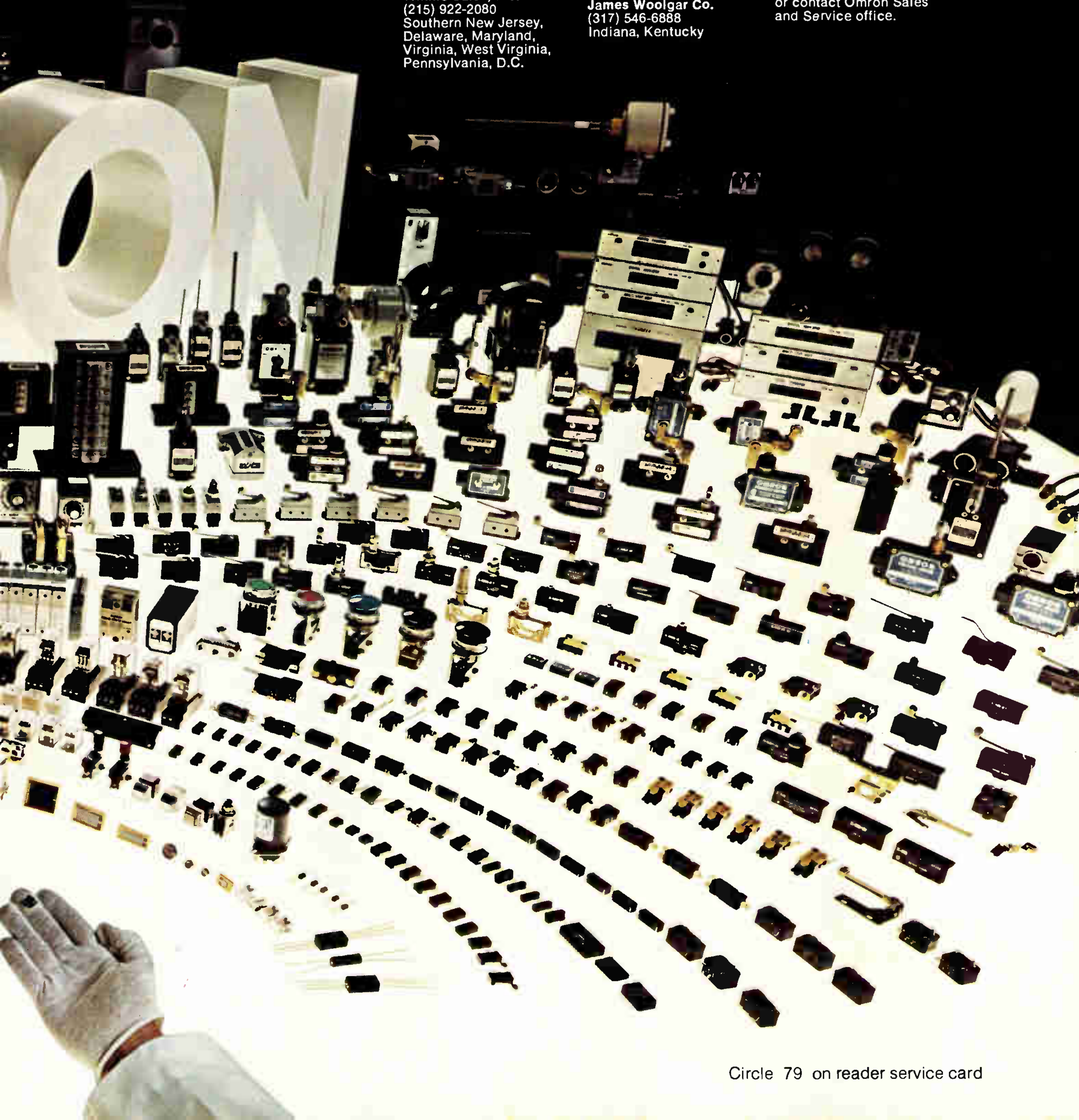

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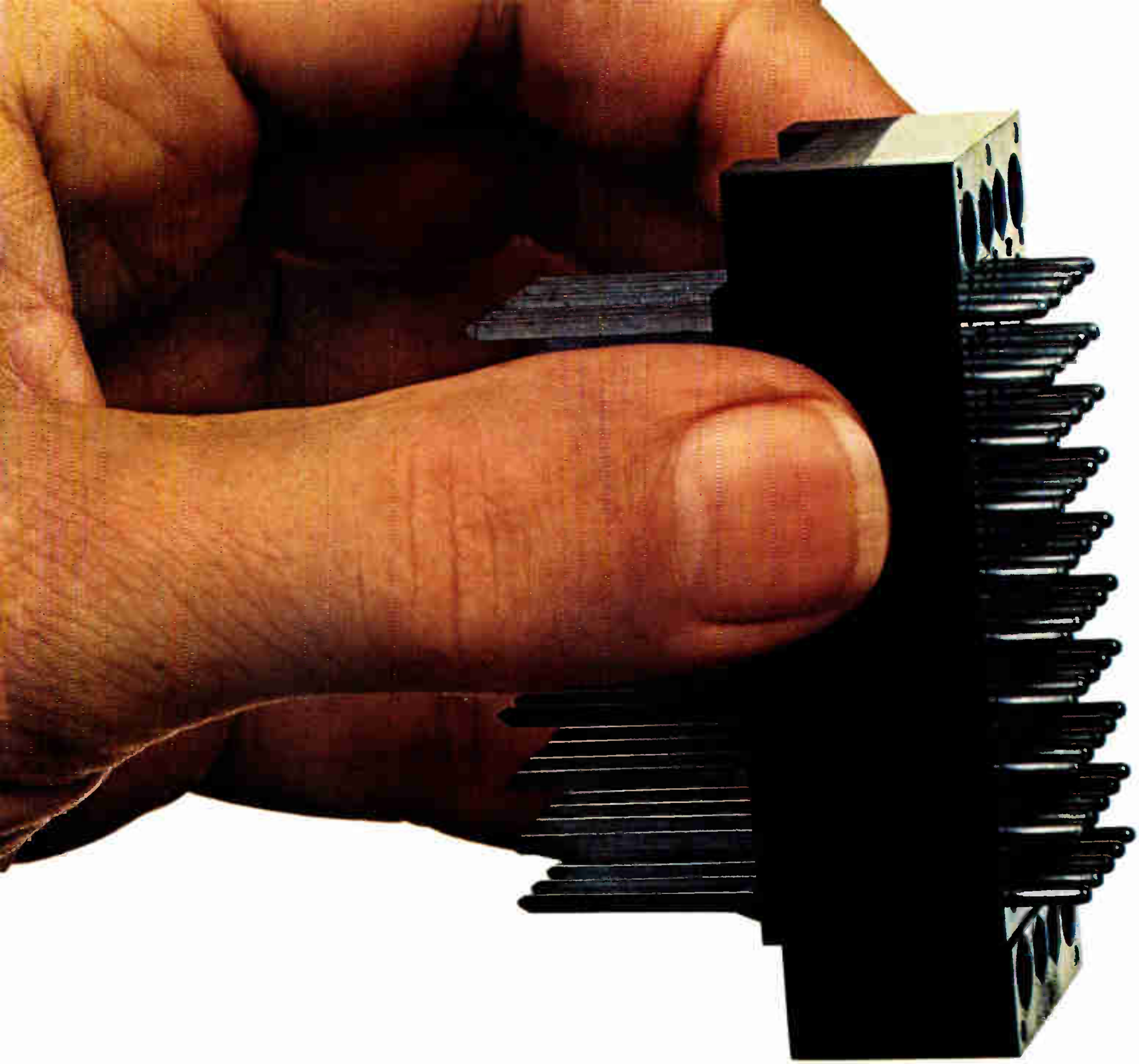


Sylvania gets it all

At some point in your system, all the panels and black boxes must get together, so you can get your system all together.

And Sylvania has that point.

Our new 50-position rack and panel connector.

It's available with either point-to-point or crimp snap-in contacts.

Contacts are on a standard 0.200-in. matrix for automatic wiring applications. The position of each contact is held within a diameter of 0.20-in. of its true position.

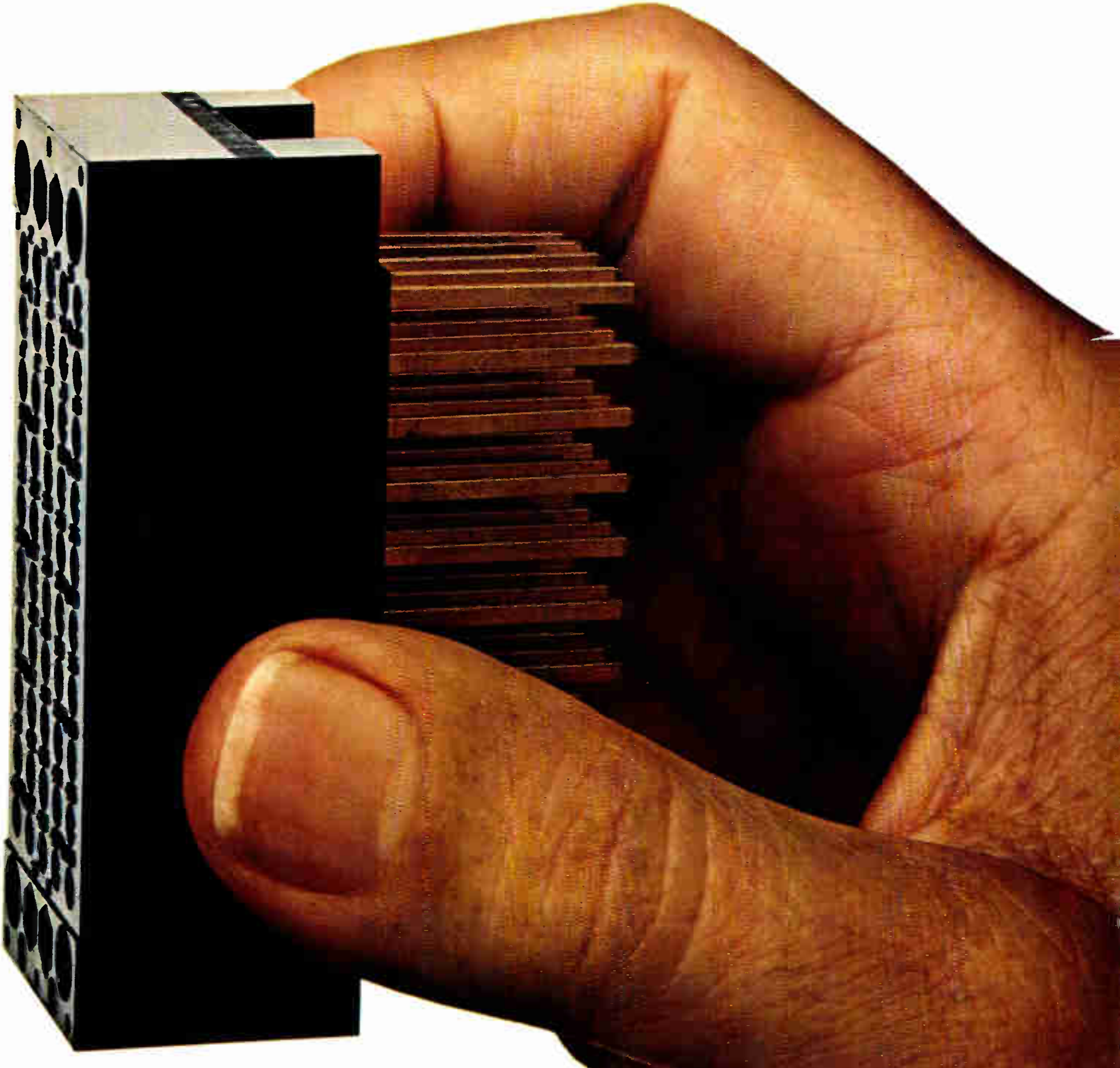
The phenolic molded connector has copper-alloy contacts with gold or tin plating.

The 50-contact model is available now, off-the-shelf, and additional models will be in production soon.

As with all Sylvania connector products, custom modifications or completely new custom designs are available.

We are able to maintain the highest quality control over all of these connector products because we control the complete operation from molding the plastic through stamping, plating and assembly.

Right up to the finished product.



together.

You get the same quality control whether you want our 50-contact connector, your own modification, or something completely special.

We can put it together for you because when it comes to connector technology, Sylvania has it all together.

So get together with us. Call or write: GTE Sylvania, Parts Division, 816 Lexington Avenue, Warren, Pa. 16365, 814-723-2000.

We're helping you make it.

GTE SYLVANIA

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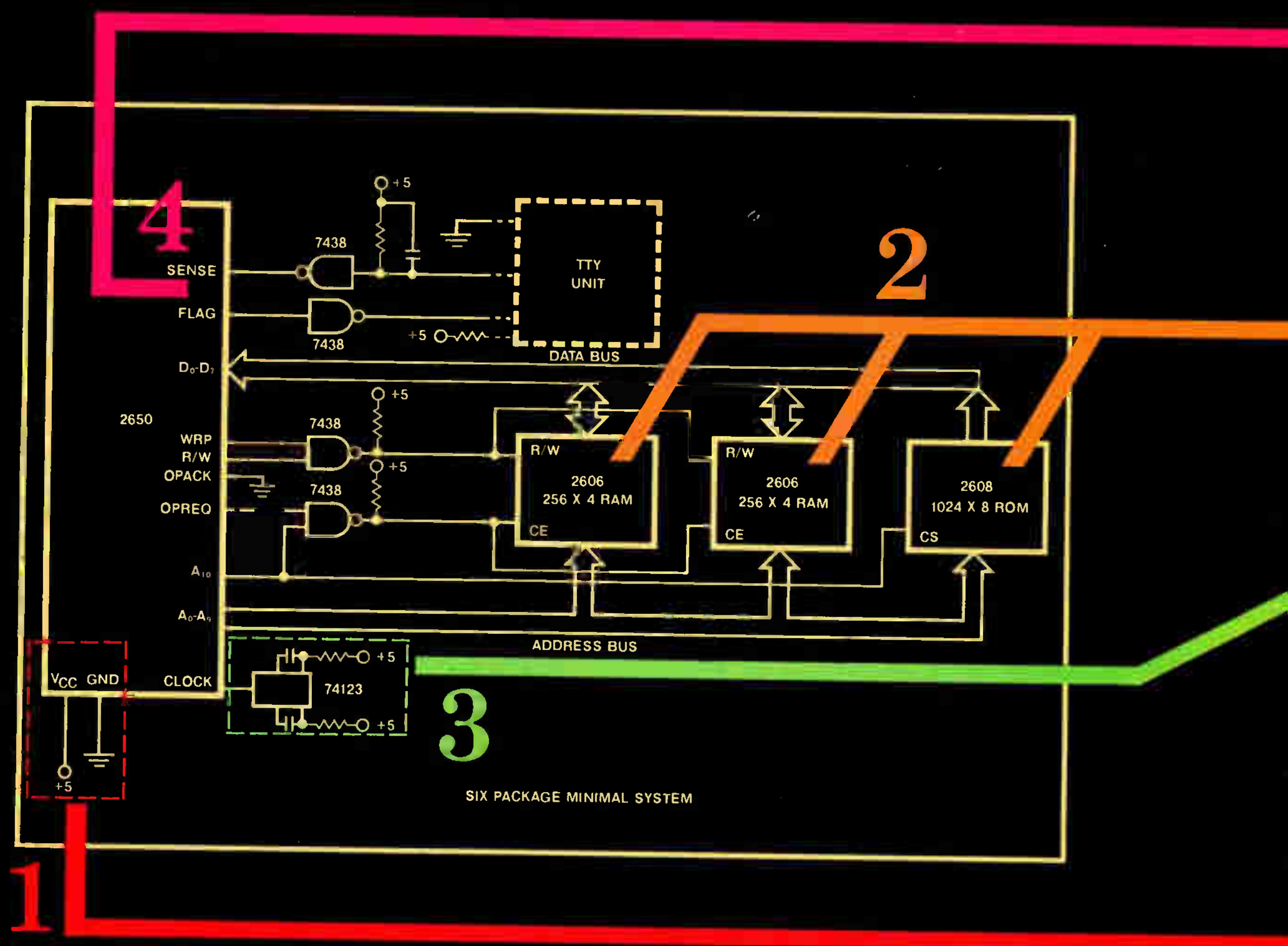
EASIEST-TO-USE



The 2650–static, 5V, TTL compatible, 8-bit μP.

Conceptual simplicity is the key to the 2650's ease of design. This μP is static, not dynamic. Its multiple addressing modes mean fewer instructions. Even the instruction set is extra powerful, to increase coding efficiency. Features that add up to less memory required, less design time. Less parts cost and assembly time. More value.

Illustrated: Parts for 6-package system. Can be purchased for under $100 in quantities of 1.

How much less than $100? In large quantities, the parts could go below $50. But what's most important is that if you build a larger system—perhaps with 5 or 10 times the memory, plus more I/O—you'll do it with the greatest of ease, and increase your savings still further. Because the 2650 won't need the special (and expensive) memory and LSI I/O chips required in other microcomputer systems. What's an outstanding value in small systems becomes an unbeatable value as the systems get larger. Convince yourself by looking at this beautifully simple Teletype system, a typical example.

1 Only one +5V power supply drives everything in the system; and this microprocessor is really low power: just 525mW max.

2 Standard, low-cost memories—your choice. This 6-package system with TTY interface uses only 3 ICs to give you 1024 bytes of standard ROM, 256 bytes of standard RAM. ROM can contain bootstrap loader and I/O driver programs for the TTY, plus operating programs for the system. Other programs plus data can also be in the ROM or written into the RAM by the TTY. Or use a PROM instead of a ROM for maximum flexibility.

3 Single-phase, TTL-compatible clock input eliminates the nest of transistors, crystal and extra ICs some other microprocessors require. Simple. Cheap. Works better.

MICROPROCESSOR.

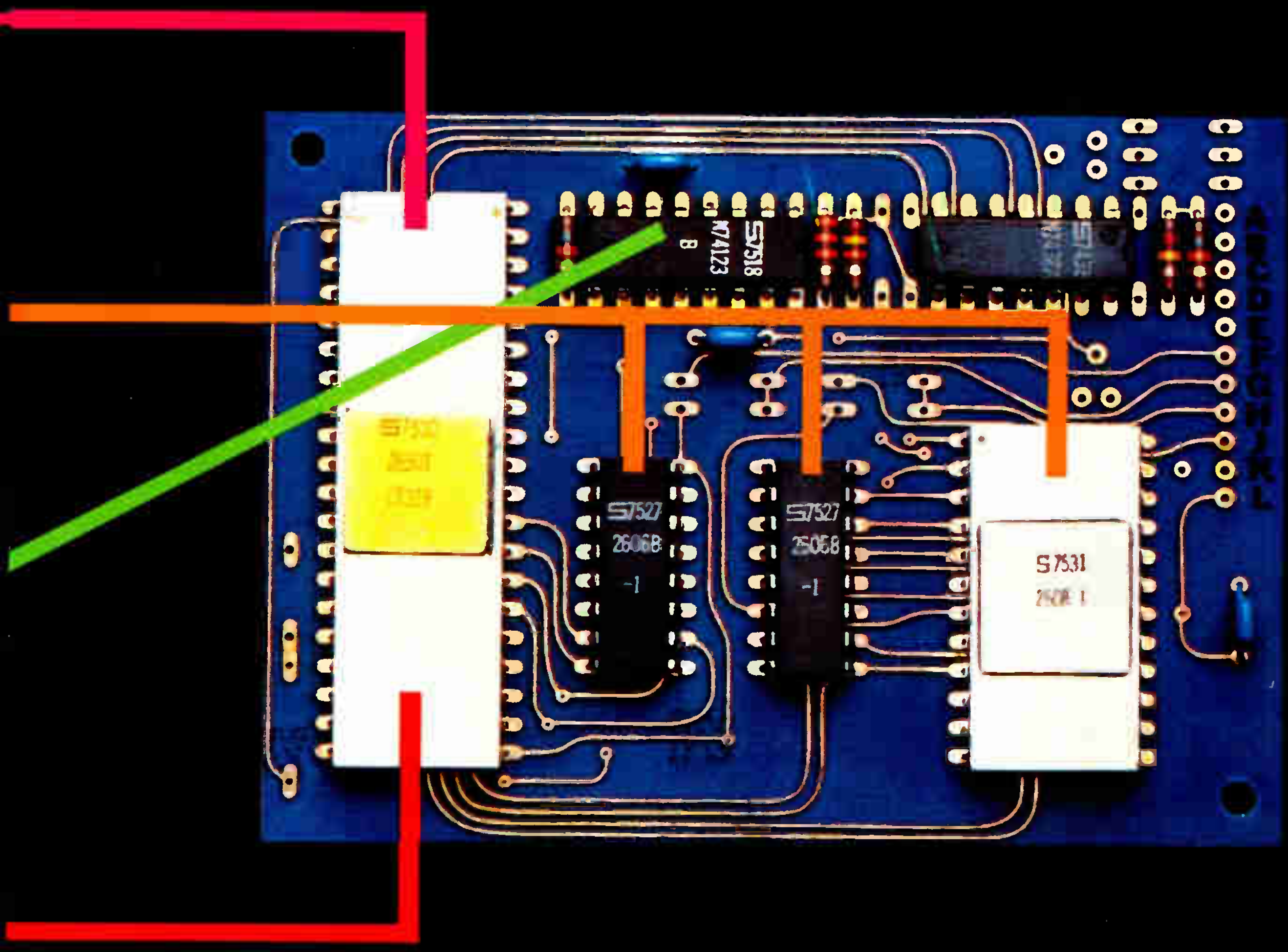


Photo approximately twice actual size.

4 On-chip serial interface eliminates a 24-pin IC. And its cost. And its space. And its connections.

5 Where are the special interface chips? There aren't any in this sample system. And not much in any other system you might design with the 2650. With much of the I/O built into the 2650, you can interface the I/O devices with simple, low-cost, industry-standard 74LS, 7400 and 8T circuits.

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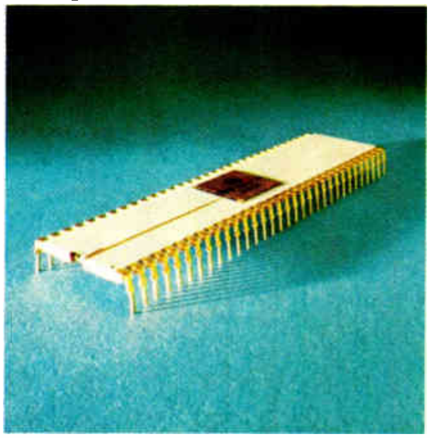

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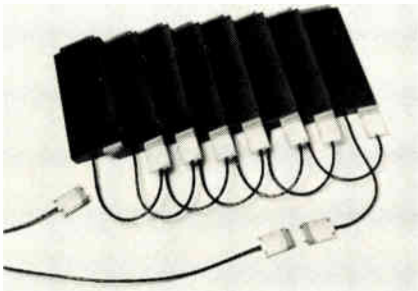

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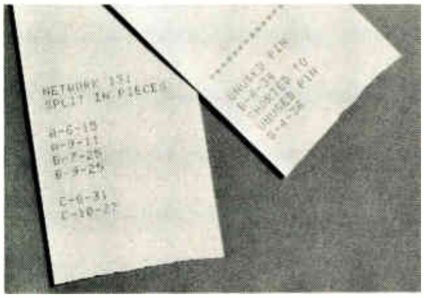

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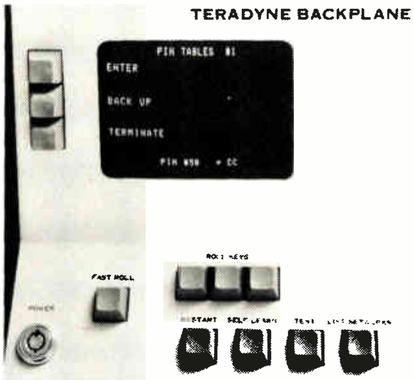

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From the Sun. Model 2001 Diagnostic Computer from Sun Electric will sell for $13,950. It steps mechanic through test procedure.

Auto diagnostics market widens

by Margaret A. Maas, Industrial Electronics Editor; Larry Armstrong, Midwest bureau manager

You used to be able to adjust your car's carburetor yourself: if a nickel stood up on the fender and vibration didn't topple it, you'd be pretty close to doing what a well-equipped mechanic could do.

Now the auto makers' legislated push to drive emissions down and fuel mileage up has dictated a new breed of faster, smaller, and more critically balanced engines. If timing is a degree or two off, nitrogen oxides increase; a 10-to-20-rpm error in engine speed can cause the exhaust-gas-recirculation valve to open prematurely, and the car will idle roughly, or the engine will continue running after the ignition is shut off. Moreover, skilled mechanics are becoming scarce, and the cost of repairs is rising.

As a result, the automotive service industry over the past year has seen an influx of electronic diagnostic equipment ranging widely in sophistication. One, from the industry leader, is even microprocessor-based. Another, from a newcomer, does away with the scopes and meters that auto mechanics have been using since 1954. And some manufacturers are talking about adding calculator chips to low-cost portable instruments.

The big three of the business are Sun Electric, Allen Testproducts division, and Marquette Performance/Safety Test division of Applied Power Inc. But the enticement of 350,000 repair facilities as potential customers has brought new faces into the field they have long dominated. Among the newcomers is a medical and scientific instrument maker, Beckman Instruments Inc., Fullerton, Calif., whose $2,500 entry was announced last month [*Electronics*, Oct. 30, p. 37]. Another, Hamilton Test Systems, a subsidiary of United Aircraft Corp., Windsor Locks, Conn., is known for its aircraft-engine and military test systems. And Heath Co. of Benton Harbor, Mich., is actively soliciting service-station business with a preassembled Professional Ignition Analyzer. "While it's the most expensive automotive unit we've ever sold," says a Heath spokesman, "we can sell it for up to $1,000 less than competitive units because our development costs are absorbed by the kit version. We're aiming at one portion of the market—the small service station who never before could afford this kind of equipment—that has been overlooked by the larger traditional suppliers like Sun Electric and Marquette." The Heath unit, which sells for $695 assembled and $379.95 in kit form, includes a 12-inch oscilloscope and a tachometer/voltmeter and can be used to tune any standard, transistorized, or capacitive-discharge ignition system.

In harness. Hamilton Test Systems has committed itself to the full diagnostic concept with an $11,900 system called Autosense, built around a 16-bit serial minicomputer with a 4,000-word memory plus tape cassettes to load automotive specs and diagnostic sequences into the computer.

To use Autosense, the mechanic connects a harness of 10 connections to the car, then identifies the make and model with a four-digit number entered into the keyboard of his hand-held controller. The computer puts the car through the test sequence, indicating with lights when the mechanic must perform some task, such as revving the engine. Test results are displayed on the controller and printed out, together with the specifications for that car, in hard copy.

The traditional powers in the market aren't sitting back quietly while the newcomers partake of their thunder. The leading company in the field, Sun Electric Corp. of Chicago, has also taken a sophisticated route. It has just started to make its model 2001 "Diagnostic Computer." The $13,950 unit steps the mechanic through a preprogramed, automatic, sequential test procedure. The system's emphasis is on data acquisition—engine parameters digitally displayed on a cathode-ray tube while go/no-go decisions are left to the mechanic.

Though Sun is keeping technical details of the system close to its vest, the 2001 is built around a 16-bit microprocessor using 4,000 words of read-only memory for program storage and at least 1,000 words of random-access memory. Also implemented on the six printed-circuit cards that make up the controller are multiplex circuitry to sample the analog inputs from under-the-hood leads, an analog-to-digital converter, and the electronics needed to drive the 2001's alphanumeric and analog CRT displays.

Automation. Another comment on computerized testing comes from Robert Swarts, manager of special projects at Allen Testproducts of Kalamazoo, Mich. "As long as a computerized tester is going to be used where you need a qualified technician to determine which component to replace, it won't go. But if it develops to the point where it opens diagnostic lanes, it might make it."

All the action is not just at the high end of the test-equipment line. "There's a very big market for low-end hand-held equipment for making rapid diagnoses," says Roland C. M. Beeh, vice president for research and engineering at Peerless Instruments Corp., Niles, Ill. Peerless is the manufacturer of Sears Roebuck's Penske line.

"There's quite a bit of room for improvement in this area," adds Beeh. "In two or three years we'll be going from analog to digital on the smaller equipment. And once we have digital equipment, we could use a calculator chip to lower the price. A digital tachometer reading could be divided by a constant to calculate timing and spark advance, and we could use preprogramed cards, like Hewlett-Packard's programable calculator, for constant data for specific engines."

Frank Hill, marketing executive for Clayton Manufacturing Co., El Monte, Calif., a manufacturer of electronic engine analyzers in the $4,000 to $5,000 range, says auto repair facilities are upgrading their equipment as cars are becoming more complex. Clayton's latest entry is the 5100, a unit designed to interface with a dynamometer as part of an entire system. The 5100 features 12 programed tests. The operator may select the tests and conduct them from the driver's seat, watching the results on the scope and meters arrayed on a console. Changes in auto models are handled by plug-in modules which modify the test circuits primarily to accommodate the rise times of different electronic ignitions.

The automotive manufacturers enthusiastically back the move to better diagnostics and have been working with several suppliers on

Autosense. That's what Hamilton calls its new auto-diagnostic system, built around a 16-bit minicomputer with a 4,000-word memory. It costs up to $11,900.

diagnostic systems for use by their dealers. By 1980 the Big Three will have incorporated a universal diagnostic connector, a terminal through which the mechanic can check the vital signs of the car without breaking any existing connections in the car. The first step in this direction is the newly announced connector which General Motors has incorporated into the 1976 Chevette and in some models of the Chevelle. Through this connector, an appropriate diagnostic system can check ignition, starter, and other electronic circuits. Right now only Kent-Moore, Sun Electric, Allen Testproducts and Hamilton have systems that mate with it. □

Too much, too soon

Allen Testproducts was ahead of its time 10 years ago when it introduced its model 1280—a computerized system with cold-cathode-tube display and printer. It sold for $10,500—or $15,000 with all options, including a radio-controlled remote clipboard that could be tuned to the frequency of the operator's voice so that a shout from him would advance the system to the next step in its sequence. "We sold about 150 of them," recalls Robert Swarts, special products manager, "and there are maybe six or eight still running today. But the quantity of sales didn't justify manufacturing the equipment. We entertain no thoughts of going back into that business."

Even by today's standards, the model 1280 was sophisticated. It ran a series of about 50 tests, including mechanical and vacuum spark advance at 2,000 rpm, average and individual sparkplug-wire resistance, rotor-air gap, fuel-pump pressure, average kilovolts to fire plugs, and kilovolt demand for individual cylinders. The machine did not include an oscilloscope; instead, it accepted a punched card for individual car specifications and compared measured values to the manufacturer's specs. Each test received a good, marginal, or fail rating.

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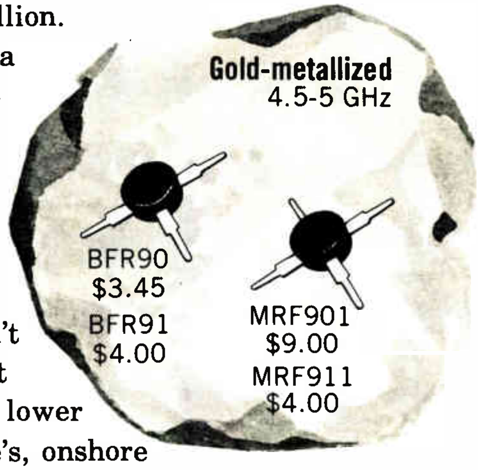

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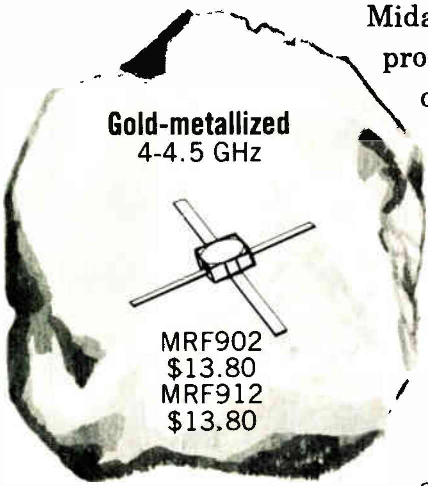

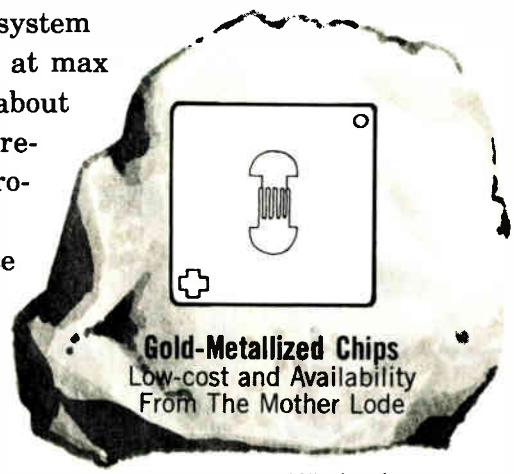

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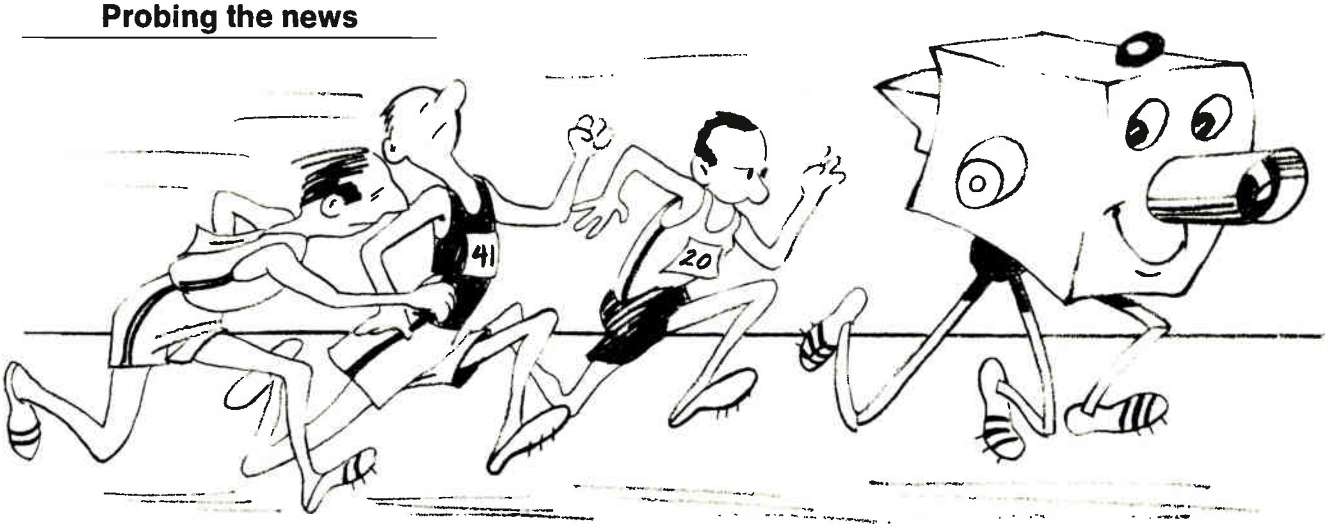

The Olympics: money games

To electronics firms, 1976 winter and summer events are big business; Conrac gets $2.4 million contract

by Ron Schneiderman, New York bureau manager

It was a lot simpler in 776 B.C. Then, pilgrims and envoys from neighboring states traveled to the city of Olympia in the ancient Greek state of Elis for the first recorded Olympic Games. There were few competitors and only one event, a footrace.

But times have changed. The modern Olympiads involve thousands of athletes and officials from well over 100 countries, they require a good deal of advance preparation, and they're big business, particularly for electronics companies. Indeed, athletes' performances at both the winter games in Innsbruck, Austria, and summer Olympiad in Montreal next year will be electronically timed, measured, scored, monitored, and, of course, televised.

"We started about two years ago," says Maurice Louvet, assistant director of construction and technology for Canada's Olympic Organizing Committee, "by sending out requests for proposals for electronic scoreboards to 24 international companies." Although several European firms qualified for the summer games, the big winner is Conrac Corp. The company, which is based in New York, has a $2.4 million contract to provide computer-controlled Telscreen scoreboards at five Olympic sites in Montreal.

The Olympic stadium will have two 33-by-65-foot boards, each consisting of a solid bank of 19,200 light bulbs. Each bulb is individually controlled by the computer, and the boards can display pictures in nine shades of gray. In addition to regular messages, statistics, and timing and scoring information, the Telscreen will provide close-ups of field action, instant and slow-motion replays, and highlights of events taking place at other locations.

Conrac also built the scoreboards for the 1972 Games in Munich, but the Montreal installation will be the first Olympic use of spectator displays having video capability. Conrac will supply indoor Telscreen systems at four other Olympic sites in Montreal, including one installation to be rented. The indoor systems will use Eidophor television projectors to display timing, scoring, messages, and video pictures on 12-by-16-foot screens for spectators at the swimming, diving, boxing, wrestling, and handball events in the Canadian city.

Elektro-Impex, a Hungarian firm, which makes an electronic scoreboard specifically for weightlifting results, will provide the system for that event. Otaco Ltd. of Montreal will supply the scoreboard for water polo. All of these scoreboards will be tied into an IBM Corp. "results" computer, to generate information and statistics for spectators and the news media.

Swiss Timing, a consortium of

Compagnie des Montres Longines Francillon S. A. and Omega, will supply timing devices for both Innsbruck and Montreal. In addition, says Louvet, Swiss Timing plans to use a laser optical system developed by Carl Zeiss of West Germany to measure javelin- and discus-throwing events. A small computer connected to the instrument determines the distance thrown and feeds it directly to a scoreboard for display.

For security purposes, RCA Ltd. (Canada) will spot closed-circuit TV monitors at every competition site. RCA Mobile Communications Systems in Meadow Lands, Pa., also has a $1 million contract from the Canadian organizing committee to provide two-way radio systems for security-force communications during the Games. The uhf system includes 600 Tactec portable two-way radios and 20 Series 700 radio base stations. Joseph P. Ulasewicz, international operations vice president, RCA Commercial Communications Systems division, says more than 400 of the portables in the system will operate on up to six radio channels, and the rest will be single-channel units. To prevent any interference between neighboring channels, the 25-watt RCA radio base stations can be preset to operate at low power, thereby reducing their effective range to only several hundred yards, if required.

Equipment galore. Electronically, broadcasters will, literally, carry the biggest load at both Innsbruck and Montreal. More than 60 television and 110 radio organizations will cover up to 15 of the 20 competition sites in any one day in Montreal. This will require 19 mobile production units, with all the ancillary equipment (88 cameras, 17 videotape recorders, 10 slow-motion videotape recorders, and 16 character generators).

Cable by the mile. To coordinate the broadcasting effort, the host broadcaster, Canadian Broadcasting Corp., formed the Olympics Radio and Television Organization. That group is working with a $56 million budget.

Meanwhile, Bell Canada and its manufacturing arm, Northern Electric, are to install more than 3.5 million feet of cable tubing to transmit the show to the estimated one billion TV viewers throughout the world. Northern Electric officials have estimated that it would require a full year to manufacture and install the 58 miles of video cable for the games—an event that would last no more than two weeks.

The dilemma was solved with Northern Electric's LD-4 coaxial cable, designed for the LD-4 digital communications network now being built to link Montreal, Toronto, and Ottawa. In ordering two modified versions of the standard LD-4 coaxial cable, Bell Canada says it can meet the short-range requirements for Olympic Games transmission facilities and a long-range requirement for digital-transmission facilities for use by telephone customers during the next few years.

At ABC-TV, which is covering both the winter and summer games for U. S. audiences, Phil Levens, the network's engineer in charge of Olympic coverage, says only a few technical problems have to be overcome. At Innsbruck, for instance, the American network will work with ORF-TV, the Austrian broadcast organization, and the British Broadcasting Corp., to convert from the 625-line Austrian TV standard to the U. S. 525-line standard. "Obviously, this won't be a problem in Canada," says Levens.

The ABC official says his crew will be using Philips' LDK-5 cameras (equivalent to the Philips PC-100 models used in the U. S.) at Innsbruck. As for special equipment at Innsbruck, Levens says, "We're taking electric blankets for the cameras. It gets pretty cold up on those hills in Austria." □

Hold high the sensor

How do you get the Olympic flame from Olympia, Greece, to Montreal for the traditional torch-lighting ceremony that opens each Olympiad? You might do it by air or by sea, or you might take the quickest, most reliable, least expensive route—electronics.

Researchers at Canada's Bell Northern Research have come up with a technique that would use a portion of the original flame—or at least the flame's energy—to light the torch at Montreal. They plan to convert a small amount of thermal energy to an electrical current by means of a thermal sensor. That signal would trigger a microwave transmitter, which would send coded tone signals via Intelsat satellite to a receiver in Nova Scotia. From there, a demodulated signal would be sent over conventional telephone lines to Ottawa. It would then be compared to a preset code. If correct, the signal would cause a laser to ignite material in an urn, which would be carried by relays of runners to ignite the large, symbolic torch high in the Olympic stadium at Montreal.

Olymplan task. ABC technicians are building a studio in the U. S. It will then be taken apart and shipped to the site of the games, where it will be put back together again.

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Here's what Harvard professor John Ball wrote about RPN in *Electronic Design* (1/18/75): "In an objective evaluation, based on algorithms for all basic arithmetic operations with four variables, RPN gets the best score." (Of all logic systems tested.)

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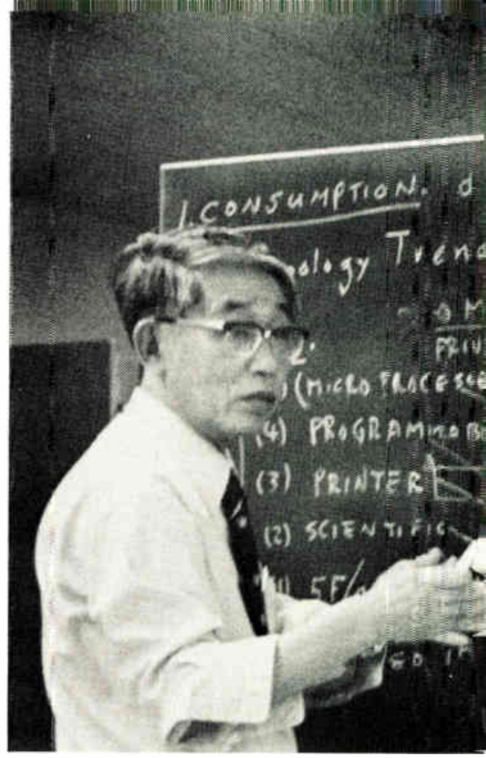
Executive

Calculator pioneer awaits LSI

Sharp's Sasaki also foresees dealer programing of machines to meet special requirements of individual customers



Future map. Tadashi Sasaki, who runs Sharp's Industrial Instruments group, sees microprocessors coming for calculators with programing done by dealers.

Among the first to recognize the potential consumer market for low-priced electronic calculators was Tadashi Sasaki, corporate executive director and managing director of the Industrial Instruments group of Sharp Corp. in Japan. Sasaki has seen the calculator market explode worldwide since the initial joint venture between Sharp and what was then called North American Rockwell that led to the application of integrated-circuit technology to the hand-held calculator.

At each of the calculator market's many mad gyrations, Sasaki has managed to keep Sharp in the running, and, equally important, to sustain its profits. Now having survived what may well be the final major shakeout in this rough-and-tumble business, Sharp and Sasaki are preparing for the next bold venture—microprocessor-based products.

This year, Sasaki turned 60, which is an important birthday to the Japanese. To them, it symbolizes an individual's rebirth, and, in a sense, that is what Sasaki expects for the calculator industry. Other products under his purview include watches, office machines, medical equipment, point-of-sale systems, and semiconductor development and production. Here are some of his views, expressed recently in an interview in Japan with *Electronics*:

Q. What is the condition of the calculator market today in Japan and overseas?

A. In 1975, the estimated number of calculators produced in Japan was expected to be 19 million units. But the industry did better than expected. The actual figure should be around 26 million units—6 million sold domestically, and 20 million exported. However, while the quantity was up, the average selling price was down. In October 1974, the average domestic price was 12,000 to 13,000 yen [$40 to $43.33] for an eight-digit, LED, four-function, no-memory machine. In October 1975, it was 5,500 yen [$18.33].

We estimate production in America this year will be around 7 million units and in Western Europe about 5 million units. Consumption in the United States should be about 19 million units and perhaps 10 million units in Europe.

Q. Will the market's growth rate finally level off? If so, what affect will that have on the industry?

A. I expect world production will peak in 1977 for Japan, the U.S., and Europe at about 40 million to 41 million units. But production in the Far East, emerging nations, and elsewhere will continue to increase from 12 million units in 1977 to a little over 17 million units in 1978. Consumption in the U.S., Japan, and Europe will also level off in 1977 at around 44 million units. Price per function, on a merit scale, will also tend to level out in 1977 for various types of calculators. Average selling price for an eight-digit, four-function, no-memory machine will be approximately $10.95 and for a unit with memory around $14.95.

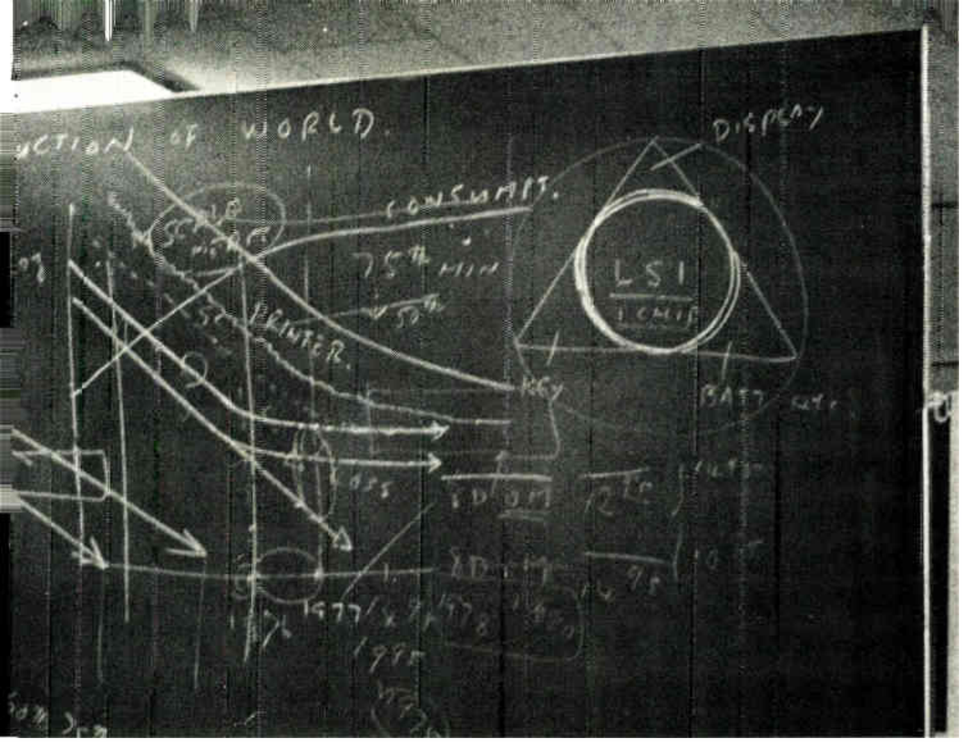
Q. What will happen to calculator technology?

A. By 1977, unless the calculator firms in the advanced countries want the advantage to go to the low-labor-cost countries, there must be technological innovation in LSI. Also, for us, production equipment is now more important than assembly labor because more functions can be designed into the LSI package. Until now, calculator makers have cut costs by using LSI. From now on, prices will stop dropping, but profit margins will rise.

Q. How can you make the distinction between LSI to cut costs and LSI to boost profits? What impact will this change have on the product?

A. In the future, we'll see a great variety of calculators at about the same price level tailored to each user. Yet, from the production side, these calculators will be mainly variations of the same basic LSI chip, programed for the special feature. The manufacturer will make a few basic models, each having a wide range of capabilities and including a programable read-only memory. The dealer will program the calculator at the point of sale to fit the variety of uses requested by the consumer. LSI makes it possible to add these features easily. Automation makes it possible to manufacture with minimum assembly. The result will be more profits, even with low price levels.

Q. Do you anticipate microprocessor-



based calculators? And if so, how will a company like Sharp compete with the microprocessor producers capable of assembling their own calculators?

A. For the present, microprocessors are not adequate for the hand-held calculator market in cost. But, in the near future, there will be two types of companies serving the microprocessor-calculator market—the systems company such as Sharp, and the microprocessor maker such as Intel, Rockwell, Fairchild, and the others. I think there will have to be a return to joint ventures between the systems companies and semiconductor makers.

Q. Why is that so?

A. Because of software. The microprocessor maker must develop operating software, and the systems company must have applications software for individual users. If the microprocessor company goes to market alone, it has the operating software, but it must also develop special-applications software, which is costly. If the systems house goes to market, it has the applications software of its own, and the basic software is obtained from the microprocessor company.

Q. What is Sharp doing about this?

A. We are developing applications software for microprocessors and looking for a joint venture for the operating software.

Q. Has the pendulum swung back to the earliest applications of LSI in consumer products when the semiconductor companies provided the basic technology, and the systems companies provided the applications know-how?

A. That's right. But in microprocessors, the difference is software cost and development. Microprocessor companies may want special relations with systems companies in order to cut out competition for that customer.

Q. Do you plan to enter the digital-watch market directly?

A. Sharp is producing electronic watch modules in Japan for [watchmaker] Orient, which is a good arrangement. I don't think many Japanese companies will enter the watch business directly because the three major producers here—Seiko, Citizen, and Orient—have a strong hold on the domestic market. So far, only two electronics companies in Japan have begun marketing their own watches.

By 1977, new displays will be developed to phase out LED and liquid-crystal displays. A likely combination would be I²L and electrochromic displays. Development effort at Sharp is concentrated on microprocessor CPUs and watch chips, as well as displays. We have a new facility for both I²L and MOS, so we will be in position to follow either, depending on the applications. The Japanese companies are watching the Americans to see which way to go in I²L and MOS. But it is a mistake to do too much watching. □

Companies

Motorola seeks to end skid

Reorganization of Semiconductor Products division, change in approach, and more layoffs follow four losing quarters in succession

by Larry Waller, Los Angeles bureau manager

After carving its Semiconductor Products division into two parts, changing the management philosophy, and laying off 1,000 more white-collar workers, Motorola Inc. executives still face the ultimate challenge. They must put it all together to stop a four-quarter profit plunge that has pushed the division deeply into the red and seriously affected corporate profits.

In admitting to financial-security analysts Oct. 31 at a Phoenix meeting that a formidable list of problems afflicts the semiconductor operation, Motorola corporate and division officials are attempting to clear the air of rumors and speculation and get off to a fresh start.

Although Motorola doesn't break out separate division results from corporate-earnings reports, some financial analysts estimate that those mistakes add up to semiconductor losses for the last four quarters exceeding $30 million before taxes.

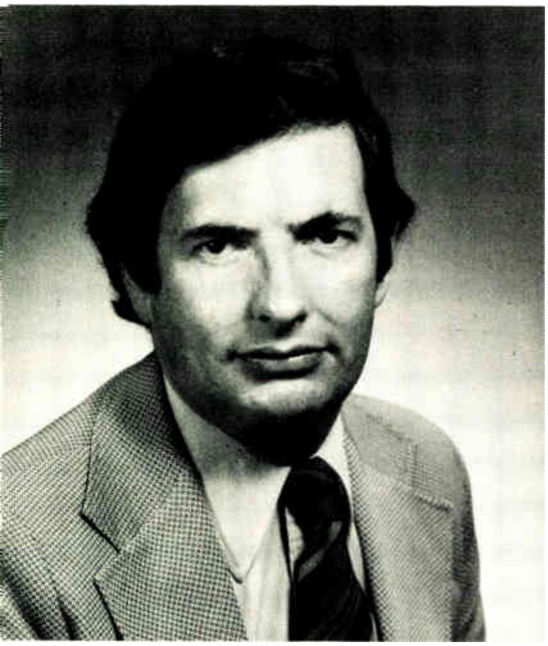
Wrong way. Perhaps the most telling admission comes from chairman of the board Robert W. Galvin, who says, "We did not choose the right leaders in the Semiconductor Products division." However, he gives high marks to the division's present top officials, John R. Welty and Robert Heikes, for previously warning corporate executives on "the wrong way we were going. But we didn't listen."

Discrete and integrated-circuit operations have been split into separate divisions, and Heikes is acting general manager of the IC division. In addition, he has retained his role as assistant to Welty, who has moved up to become vice president and Semiconductor group executive. Both Welty and Heikes confirm that a top-notch outsider eventually will be brought in to head the new IC division. However, the Discrete division, under Gary Tooker, has had relatively little trouble, except selling into depressed markets. Discrete operations have been profitable right through the recession, and are now improving somewhat.

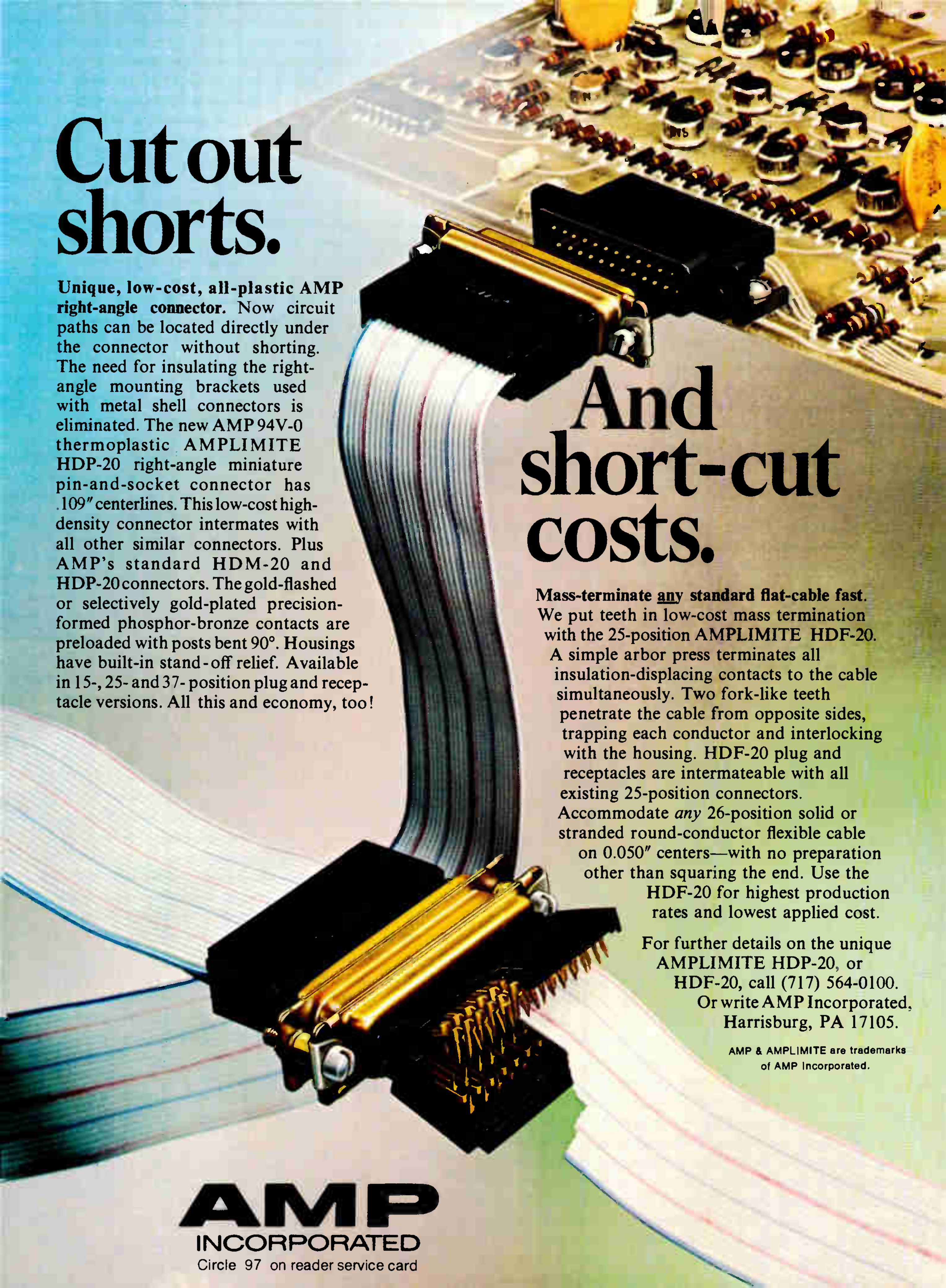
Heikes says his two jobs are complementary while the IC division is in its formative stage, and he is prepared to act as general manager for 10 to 18 months "unless a plum would drop in our laps." Welty believes Heikes's presence there is a decided strength because it is "the first time since 1968 that a technologist is in the top office."

As for the problems to be tackled, Welty spells them out in detail, beginning with a poor job by management in assessing both the over-all economic environment and the related demand for semiconductors. Motorola had misread the signals from the first, expecting a shallow recession and an upturn in mid-1975.

Flabby. Making matters worse, the division's management structure grew flabby and failed to retain its quick, responsive attitude of the 1960s. Welty says the semiconductor sales organization lost its sensitivity to customer needs and couldn't make speedy decisions. Many times, delays in responding to price cuts meant that customers bought else-



Reorganized. With the changes at Motorola Semiconductor in Phoenix, Colin Crook, left, heads the new IC division, while John R. Welty, right, has been named vice president and Semiconductor group executive.



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where. Also, technical problems plagued IC production. Welty's boss, John F. Mitchell, corporate executive vice president, stated that these troubles are "not in design, but in chip and die yields." Welty identified MOS production in the new Austin, Texas, plant as the most recent and critical production problem, but officials say they have been solved.

Now that Welty and Heikes are in control, an evident comer in the group is Colin Crook. When he was named director of LSI systems this fall [*Electronics*, Oct. 30, p. 35], it was his second major promotion in six months; the first was to assistant director of marketing. Crook will supervise all LSI activities from design to sales, except for manufacturing.

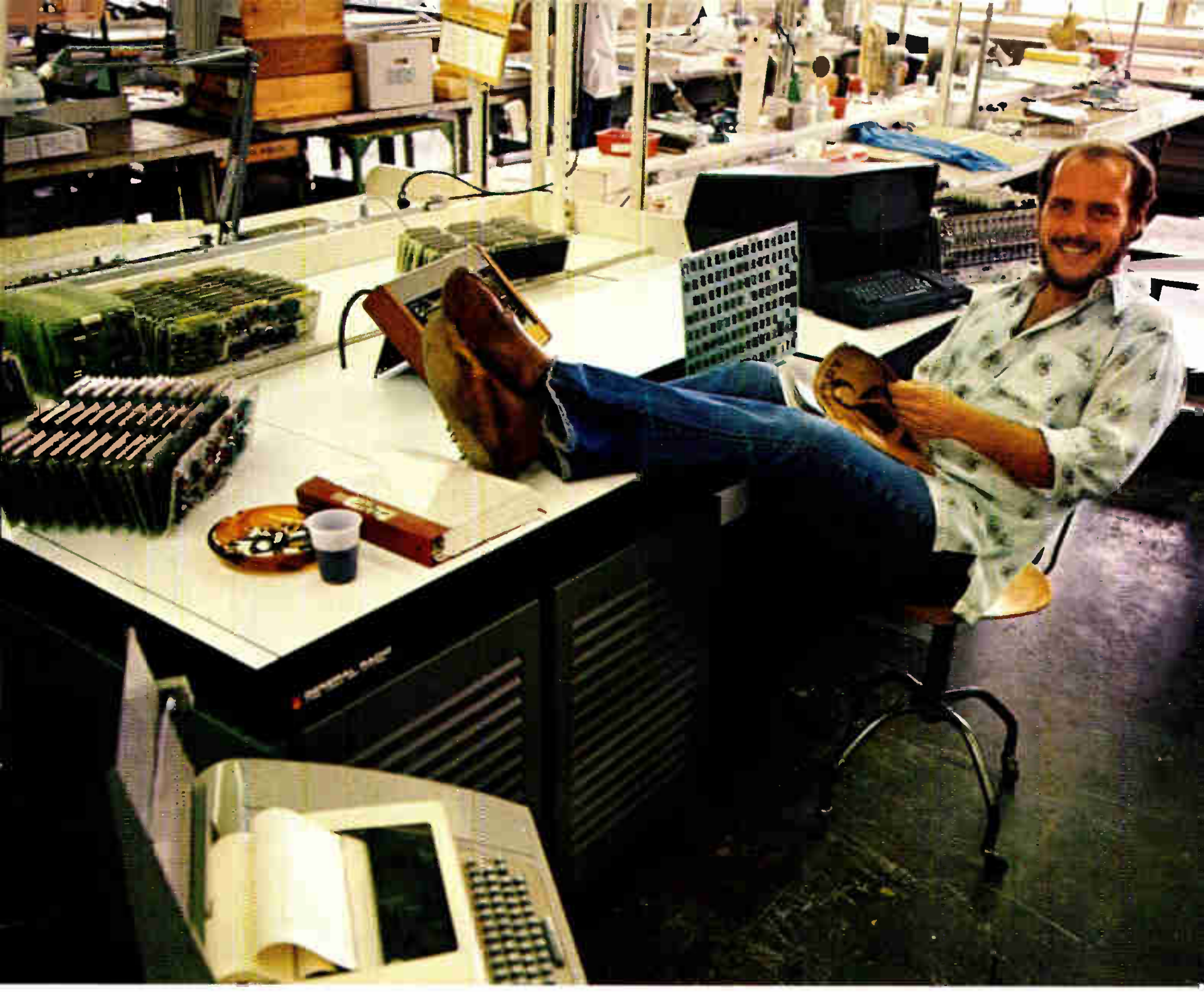
Reduction ahead. But even with all the reorganization and management optimism, there are rumors that Motorola plans to drop or sell entire product lines. Heikes will say only that his division will reduce its number of programs. "We tried too long to be all things to all people, and we can't cover the waterfront."

Against all these woes, what is the bedrock on which Motorola Semiconductor plans to build? For openers, Welty and his men are unanimous in enthusiasm about their 6800-series microprocessor, which arrived in November 1974.

Welty says Motorola has the broadest line of complementary-MOS and ranks second in the world in C-MOS sales. The line of emitter-coupled-logic memory products is also making headway.

Improvements planned. Other product improvements are scheduled for the months ahead, and a major program for increased mechanization of manufacturing is nearing completion. The division is also sampling its 16-pin 4-kilobit random-access memories and expects to go into volume production soon.

Financial analysts who follow the company think operations could near the break-even point in the fourth quarter and may edge into profitability in the first half of 1976 if things go well. After that, the effects of the reorganization will start to show. □



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Standards for Europe?

by Sarah Kemezis, McGraw-Hill World News

Bright hopes. With Unidata dead, this computer is once again carrying the Siemens nameplate—and the European Common Market is moving ahead to prop up Europe's industry.

Unidata or no Unidata, the European Common Market Commission is charging ahead with its effort to save the European data-processing industry. That effort consists of a series of technical and financial aids aimed primarily at the software and peripherals sectors.

The demise of Unidata has made the commission's program the only game in town if IBM and other American computer makers are to be kept from swallowing even more of the European market. Unidata was supposed to have done that, although all it ever became in its short life was a loosely knit sales organization. The blueprint for the tripartite organization—launched in July 1973 by Siemens of West Germany, Philips of the Netherlands, and the struggling Compagnie Internationale pour l'Informatique of France—called for coordination of software and hardware development and negotiation of production contracts for specific machines. But the French government's decision to merge CII with Honeywell-Bull led to Unidata's death [*Electronics*, Sept. 18, p. 55].

Enter the new program. Its first step came last year when the commission proposed five community-funded applications projects, with contracts to be granted to consortiums of European firms [*Electronics*, July 11, 1974, p. 55]. Initial reaction of the national governments has been favorable, and passage by the Common Market's Council of Ministers is expected within the next few months.

Emboldened, the commission has moved beyond its first modest step to issue a new set of proposals designed to prevent IBM from sewing up the software and peripherals businesses. The means is development of a framework of software standards and aids to commonality, with a still more comprehensive program promised for early 1976.

The first of these proposals calls for creation of a standard Common Market language for real-time programing. Commission computer czar Christopher Layton is convinced that development of standards—with acceptance of IBM's the alternative—is a must if any semblance of competition is to be retained. An expert working group on standards set up earlier this year is already drawing up European subsets of Cobol.

"In general terms, we agree with the approach," says a Common Market expert at Philips in the Netherlands. However, the spokesman adds, "Standard languages could be of use if we had a political body to enforce using them, but at the moment we don't." Nevertheless, the Common Market is undeterred.

The second Commission proposal, for five projects to improve software commonality, reflects the same sort of pragmatic thinking.

Of the last two new proposals, one calls for studies of general interest to the industry on data security and confidentiality, programing techniques, and evaluation of database systems. Studies would be done in national research centers; an aim of the program is improved cooperation between such centers. The other would add two new application projects to the five proposed earlier. They would then cover:

- Establishment of computerized records of available human organs and blood.
- A study of data-processing techniques for monitoring agricultural imports and exports.
- Automation of access procedures to legal documents.
- A study of the possibility of developing data-processing techniques for European air-traffic control.
- Economic assessment of the feasibility of developing logic circuits in electronics and management of integrated design systems.
- The specification of a computer-based information storage and retrieval system.
- Experimental application of high-speed data communication. □

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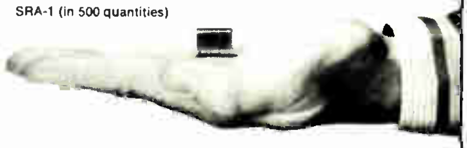

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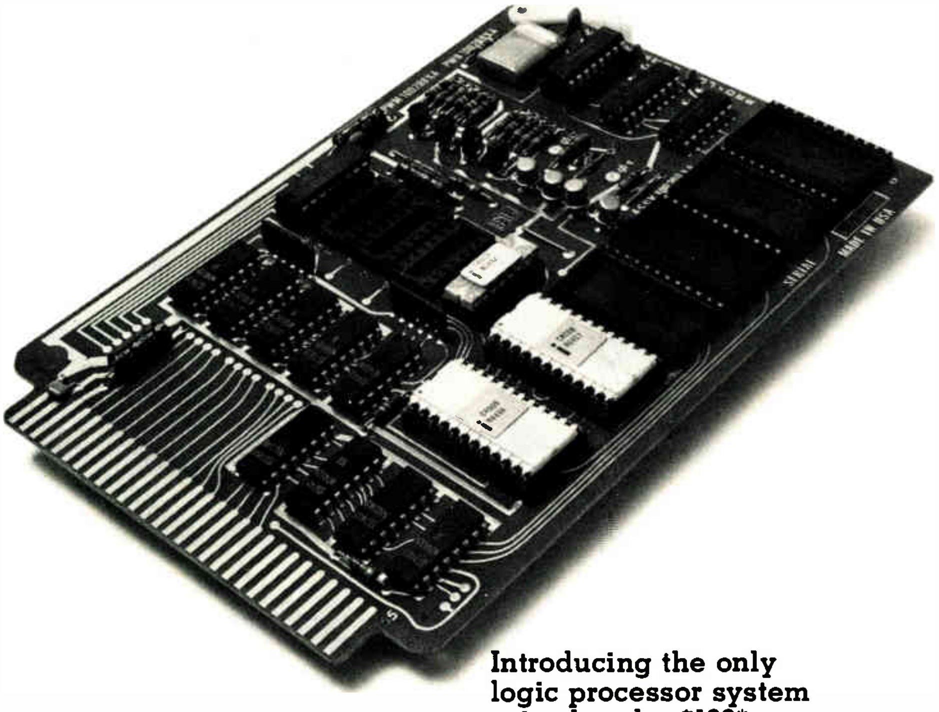

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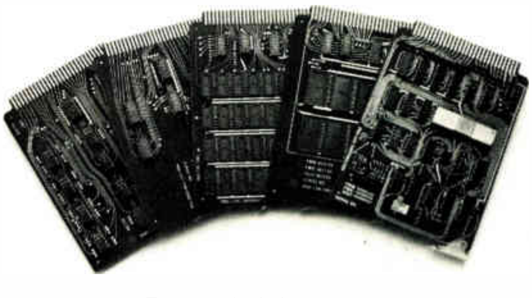

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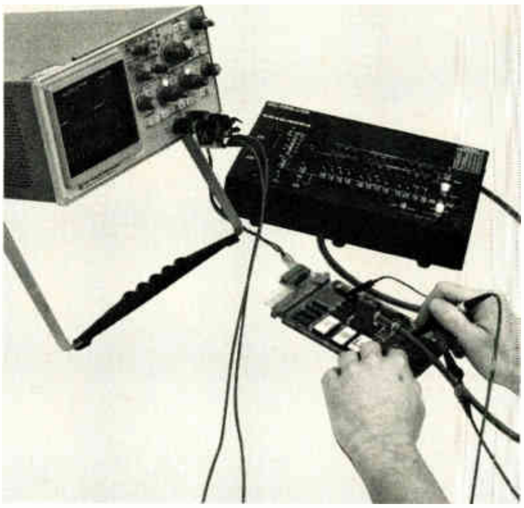

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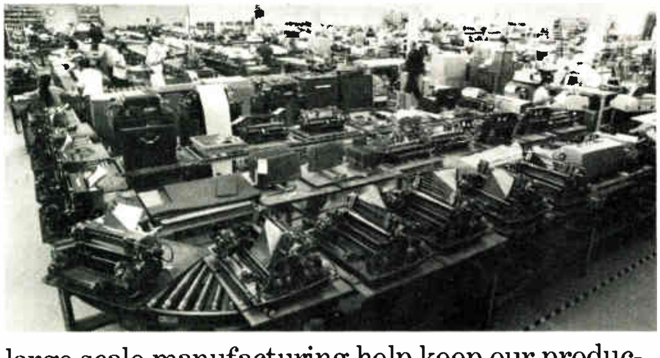

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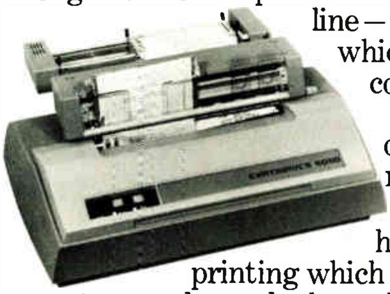

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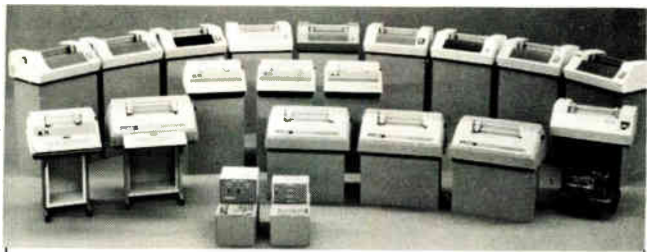

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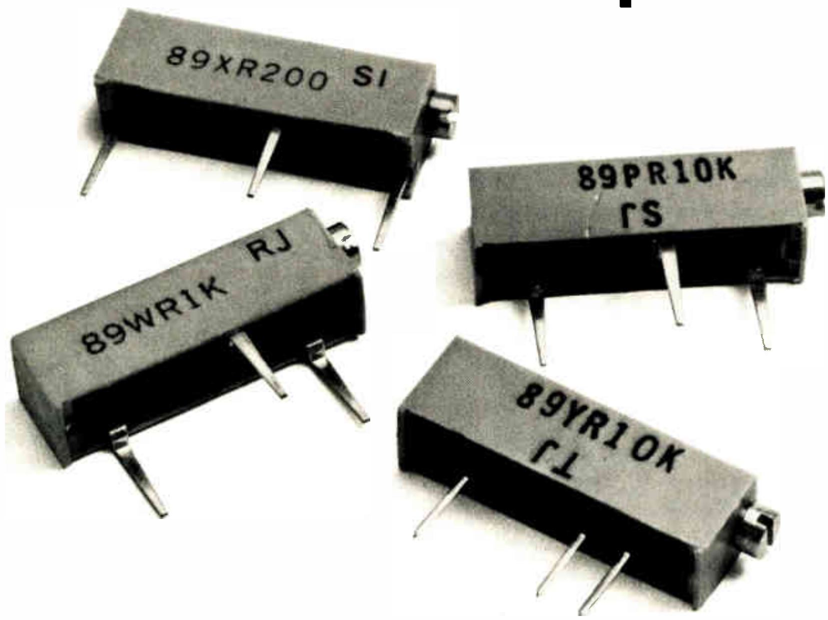

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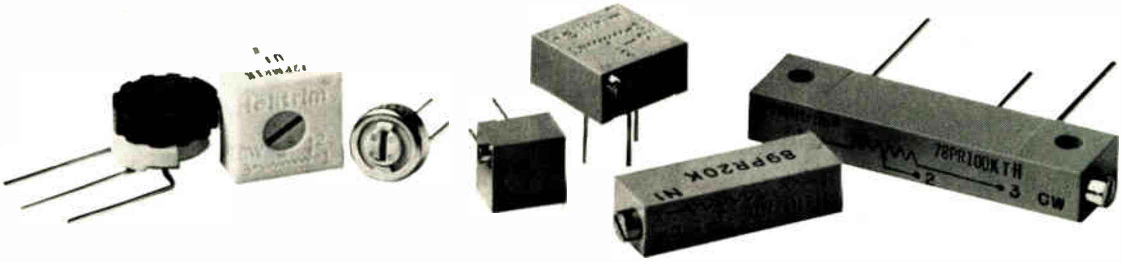

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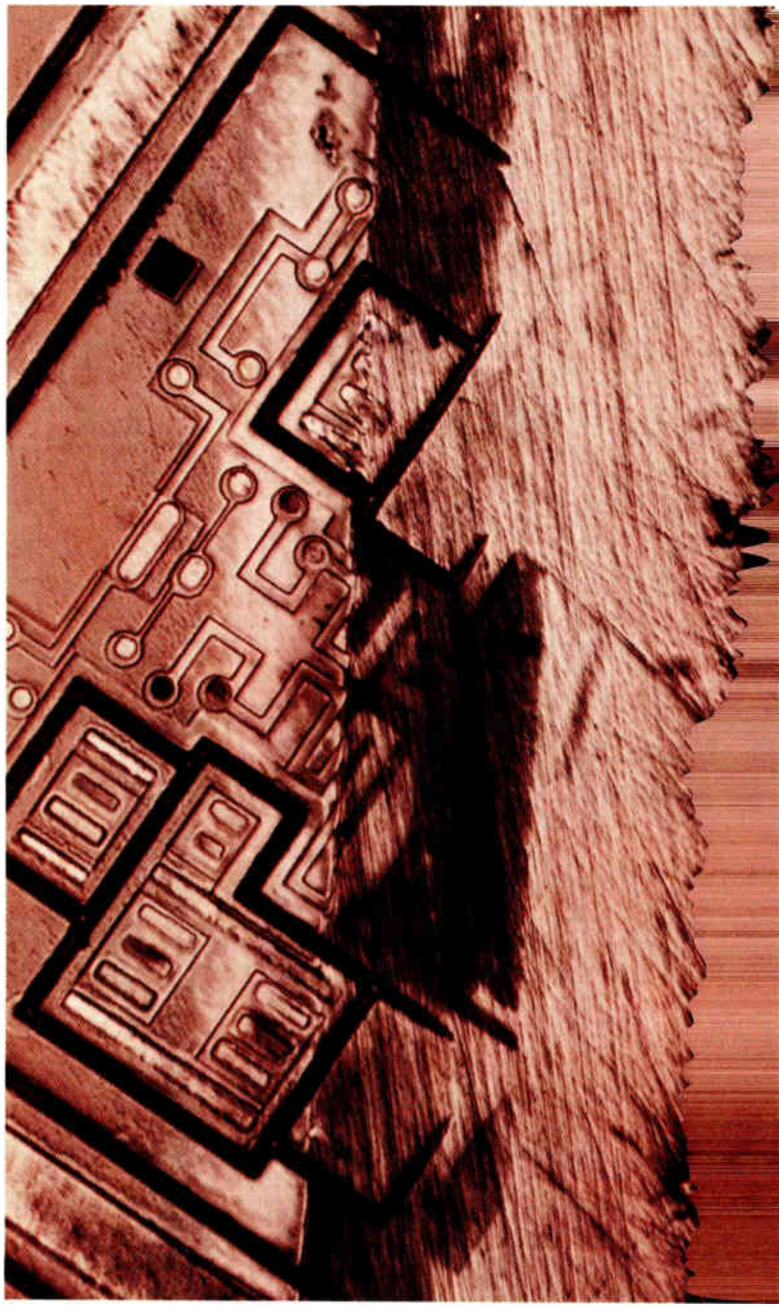
Anodizing silicon is economical way to isolate IC elements

by Bob Cook, *ITT Semiconductors, West Palm Beach, Fla.*



New low-temperature process also increases density and performance of both MOS and bipolar chips

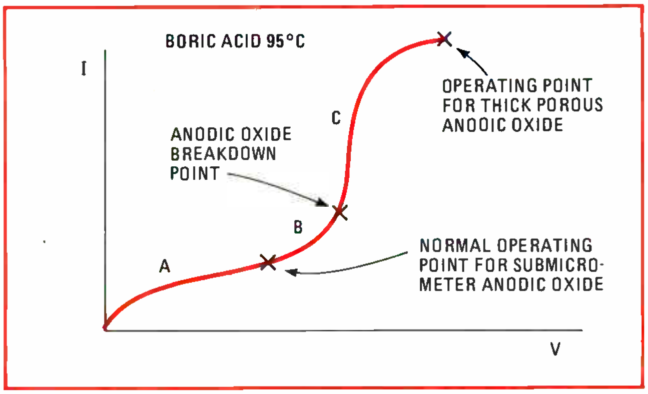
□ The discovery that silicon itself can be anodized opens an unexpected path to cheaper, denser, faster integrated circuits. The low-temperature process produces in one step the dielectric needed to isolate the active elements on a chip, thus adding the advantages of dielectric isolation to any semiconductor technology, whether bipolar or metal-oxide-semiconductor.

Normally, device isolation requires two or three extended oxidizing and diffusion steps at temperatures in excess of 1,000°C. But the new process eliminates one and often two mask applications, depending on the circuit design. It should therefore ultimately reduce the energy consumed in processing as well as cut the front-end wafer cost by 25%. Circuit complexity is also increased: bipolar large-scale ICs can double in density.

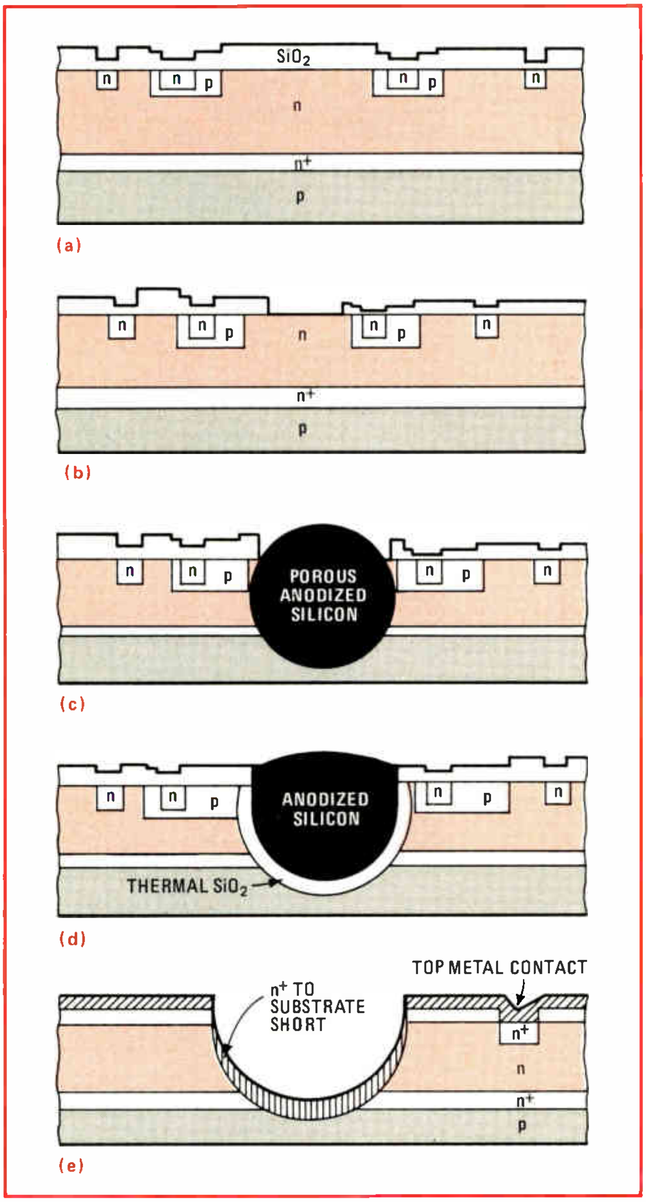
Equally significant, silicon anodization improves performance by lowering the capacitance between elements and increasing transistor gain and speed. The improvement is especially evident in such new bipolar circuit forms as integrated injection logic and low-power Schottky transistor-transistor logic. In improved I^2L circuits, for example, current gains have increased tenfold, and cutoff frequencies have been multiplied by five.

Use of an anodizing process in the fabrication of integrated circuits is not new—in many of today's circuits, buried conductors are built by anodizing aluminum. But silicon itself has never before been anodized and transformed into a dielectric deep enough for IC isolation.

Direct silicon anodization was discovered quite by chance. An anodizing voltage was accidentally increased beyond the point required to anodize aluminum. The aluminum was destroyed, but the silicon substrate beneath the aluminum, when examined under a microscope, was seen to have been transformed into a porous dielectric layer. Further experiment revealed



1. Beyond the limit. The secret of anodizing silicon directly is to operate well beyond the breakdown point for metal. The surface then stays porous, letting acid reach the underlying silicon.



2. Building the dielectric layer. In the key step (c), the oxide has been opened, and boric acid contacts the silicon. The process runs best at 100 volts and 1 to 3 amperes. Unwanted material protrudes above the substrate and is removed (d) before metalization.

that the dielectric on the silicon surface could be tailored to almost any desired thickness simply by adjusting the anodizing process. Evidently, a simple low-temperature anodization technique could now replace the high-temperature diffusion or oxidation that till now had been needed for isolating circuit components.

To the design engineer this process not only offers compact circuit layout because of the self-isolated structures but, most significantly, it virtually eliminates any lateral encroachment of the isolation areas. For the manufacturer any new process must be capable of mass production to keep processing costs down. The anodic process easily satisfies this criterion: very little wafer preparation prior to anodization is required, anodizing equipment is inexpensive, and high-volume production at high yields can be obtained. Moreover, no special masking, such as the use of silicon nitride, is required to protect the wafer during anodization, while control of isolation depth is excellent because of the close relationship between the oxide opening's width and the anodization depths.

The chemical reaction

Figure 1 shows, in terms of the typical voltage-relationships, what happens when silicon is anodized in a boric acid solution. Normal anodization of silicon and other materials occurs in region A, and as the voltage increases into region B, a hard nonporous anodic film less than 1 micrometer thick is produced on the silicon. The trouble is, it can be made no thicker, because the low porosity of the film prevents the electrolyte from reaching the silicon. The current gradually saturates, the process gradually self-limits, and the dielectric surface stays as thin as ever. This is all still happening in region B, below the anodic oxide breakdown point.

The trick, as it turned out, was to operate in region C, well beyond breakdown. There, the strong forces of the chemical reaction produce a porous anodized layer that allows the electrolyte to penetrate it and to maintain a continuous reaction with the underlying silicon until other limits set in.

Boric acid is used because it creates a deep isolation, leaving boron, an inert and electrically harmless substance, as the only impurity. More important, the acid can be masked by a material readily available in the IC process—silicon dioxide. Of course, the masking dioxide must be thick enough to withstand the anodic voltage.

Application of the process to circuit fabrication is straightforward, as Fig. 2 shows for a bipolar circuit. Before anodization, an epitaxial n+n layer is grown on top of a p-type high-resistivity starting substrate (a). Next, base and emitters are diffused, and the oxide opened in the areas to be isolated (b). Then the substrate is anodized, preferably in a boric acid solution at 95°C, using a driving force of 100 volts and 1 to 3 amperes for each 2-inch-wide slice.

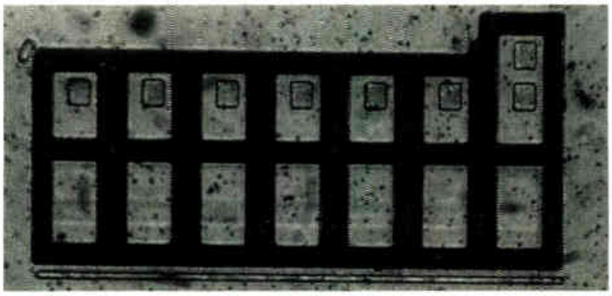
The depth of the anodization is normally about two thirds the width of the oxide opening, but greater depths can be achieved with multiple anodizations—samples up to 1 mil deep have been grown in the laboratory.

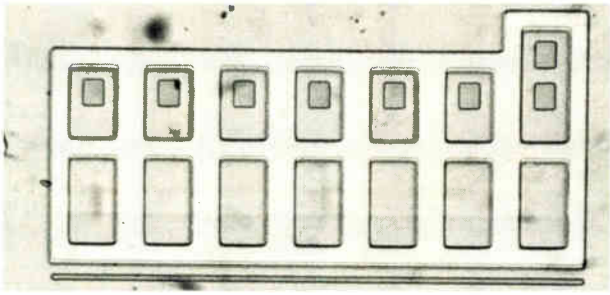
When a thick enough anodized layer has been pro-

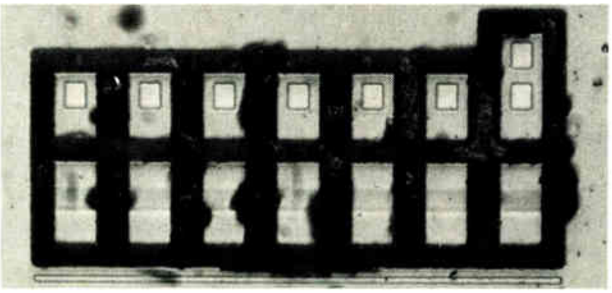
Successful silicon anodization

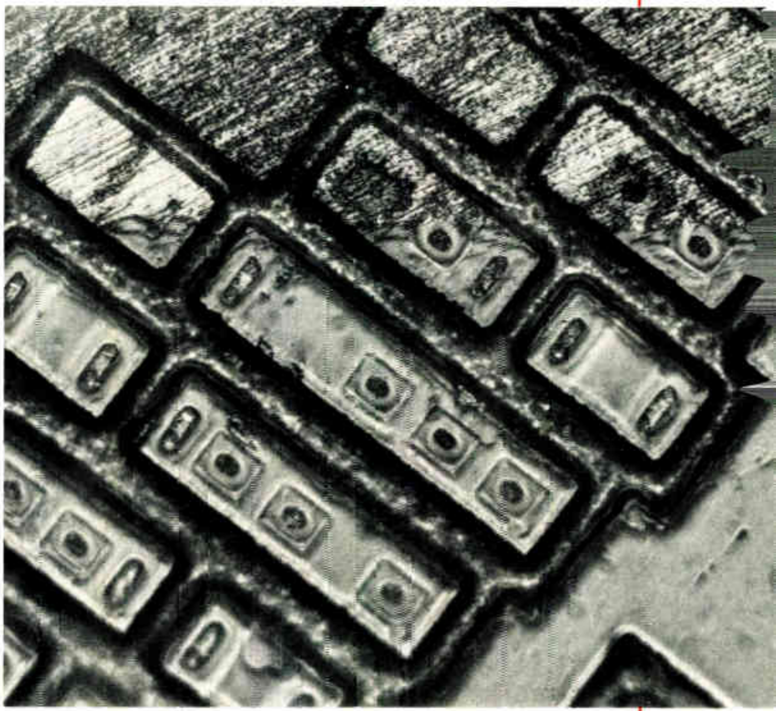
Here are a few tips on how to anodize silicon when processing integrated-injection-logic devices. After the collector diffusion, open the oxide in the isolation areas to a width about one and a half times the depth desired, but leave the oxide on the back of the chip untouched (top left). Now etch down to the substrate on both sides of the slice to create electrode contacts, and lower into a near-boiling solution of 95% boric acid. The reaction must go no faster than 2 A per 2-inch slice—at 100 V, it takes about 10 minutes per micrometer of depth.

Next, use a spinner, swab, and Al_2O_3 powder to remove the surplus anodized material poking above the surface. The cleaned chip is shown top right, the final lapped and polished version at lower right.









duced, a part will rise above the surface of the oxide, as shown in Fig. 2 (c), because anodized silicon occupies more volume than straight silicon. The unwanted material can be easily removed by abrasion or by being etched away in dilute hydrogen fluoride. In fact, the material at the surface is softer than that below and etches away about five times faster. The result is shown in Fig. 2 (d).

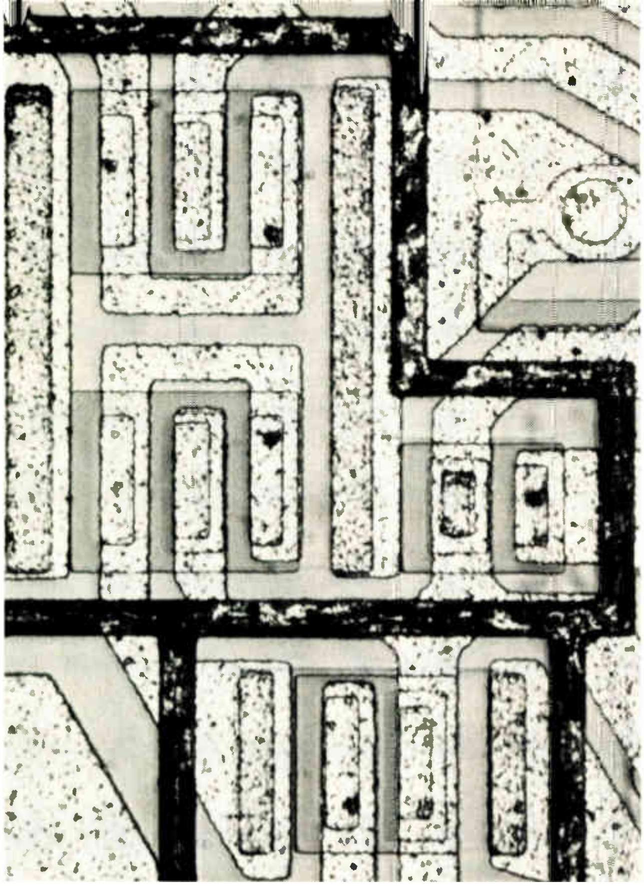
At this point in the process, an additional thermal oxidation may be performed, for the anodized silicon areas will withstand any temperatures normally associated with silicon processing. The last steps in the anodizing process are to fill the pores by spinning a liquid glass-forming material onto the slice and to bake the result at 450°C for 15 minutes.

The remaining fabrication steps are quite conventional. Contact openings are etched and electrodes and connections metalized. Fortunately, metalization through the anodized regions to the substrate presents no problems. A standard 2-minute oxide etch exposes the junction between the epitaxial layer and substrate, and normal aluminum evaporation is used to connect the n^+ region to the p-type substrate for access to the buried collector, as may be seen from Fig. 2 (e).

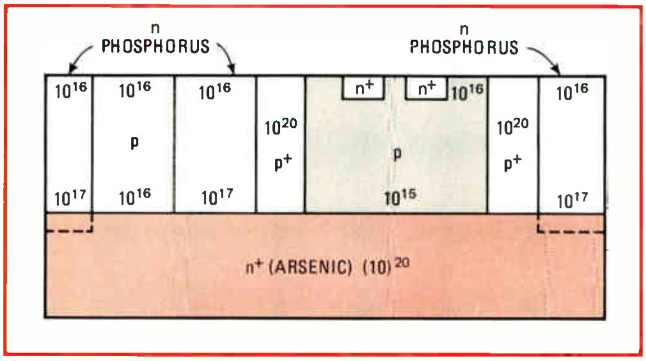
With this process for anodizing silicon directly, the yields of complex logic and memory circuits should rise and their costs fall because two high-temperature steps required in other processes are eliminated. One is the sub-epitaxial n^+ diffusion, normally carried out at 1,250°C, and the other is the isolation diffusion, normally done at 1,200°C. In the anodizing process, no sub-epitaxial diffusion for the buried collector is needed since it is possible to anodize right through the n^+ epitaxial layer. Nor is the isolation diffusion needed because the anodized silicon is itself a strong dielectric.

Anodic isolation also will increase circuit density. No longer compelled to use distance to separate base from isolation walls, designers can make the collector element coincide with the base and emitter. This configuration, called a "walled" structure, also characterizes the latest high-density oxide-isolation techniques, but there it requires high-temperature oxidizing steps.

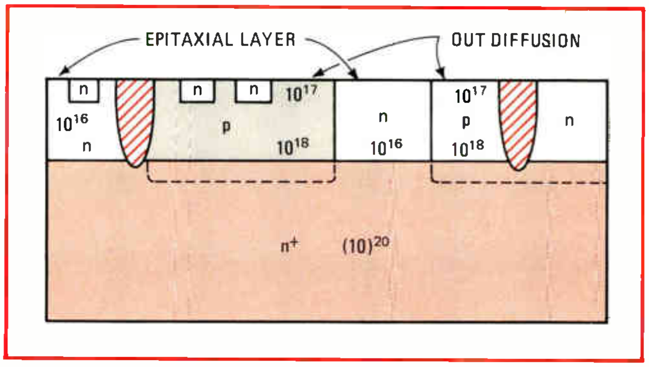
The kind of space savings possible with the anodizing process has already been demonstrated in the labora-



3. The proof. Silicon anodization is an easy way to isolate the buried elements of this integrated-injection-logic structure and to reduce the internal capacitances between them. The process can be applied to other varieties of TTL and MOS circuits.



4. More speed. Because of improved isolation, anodized-silicon circuits can be very fast. This I²L circuit operates in the 5-ns region without the added complication of Schottky clamps.



5. Less space. This extremely small I²L structure is fabricated by depositing boron on the n+ starting material to form the npn and pnp elements. N-type material is then grown, and the boron diffused out.

tory on most of the conventional bipolar-circuit forms, including TTL and low-power Schottky TTL as well as new bipolar forms using integrated-injection-logic techniques. An example of an I²L design is the minimum-geometry, walled structure shown in Fig. 3. Its 4.5-square-mil gate is less than half the size of conventionally fabricated TTL gates.

In relation to I²L

Indeed, perhaps the greatest benefits from the direct silicon anodizing process will occur when it is applied to integrated injection logic. With its inverted transistor structure, I²L requires multiple sub-epitaxial circuit elements, and these are easily accommodated with the anodizing process. Then, too, because of the high gains and lower interelement capacitances, the performance and also the fanout of the new I²L structure are considerably improved.

Actually, I²L runs into difficulties only when pushed to perform in the 5-to-10-ns TTL range. It has a very simple structure, consisting of an inversely operated npn transistor acting as a switch and a lateral pnp transistor acting as a current source.

Most of the improvements made to date, such as adding Schottky clamps to limit logic swings or implanting impurity boundaries to limit junction losses, have improved the speed-power product but have increased processing costs. The new structure shown here is considerably less expensive, yet extends I²L performance to compete with TTL and will allow Schottky clamps to be added if required.

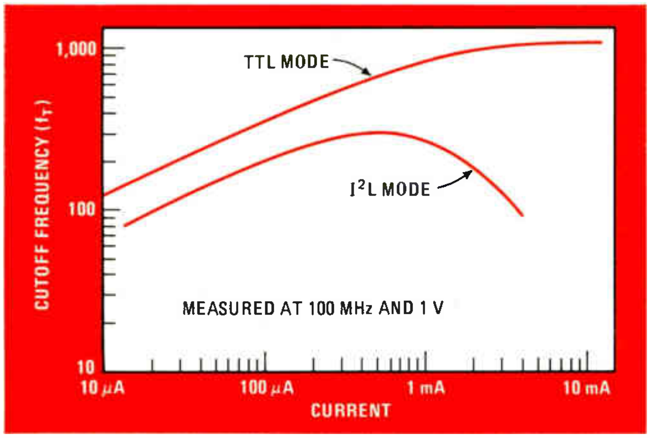
More specifically, early I²L structures had five overlapping limitations:

- The injection efficiency of the inversely operated npn transistor was poor because an existing bipolar process was used that was not optimized for inverse npn gain.
- The impurity gradient in the inverted npn base produced a field that opposed the flow of the injection carriers. To overcome the opposition, a complex ion-implanted gradient has been proposed.
- Too much recombination occurs in the base of the lateral pnp because of its proximity to the n+ region of the npn switch.
- The aspect ratio of the emitter-to-collector area in the npn device gave poor collector efficiency which further limited gain and fanout. The npn inefficiency could be reduced by using a narrow base width, but this put a strain on the process control needed to limit punch-through and defect leakage from collector to emitter.

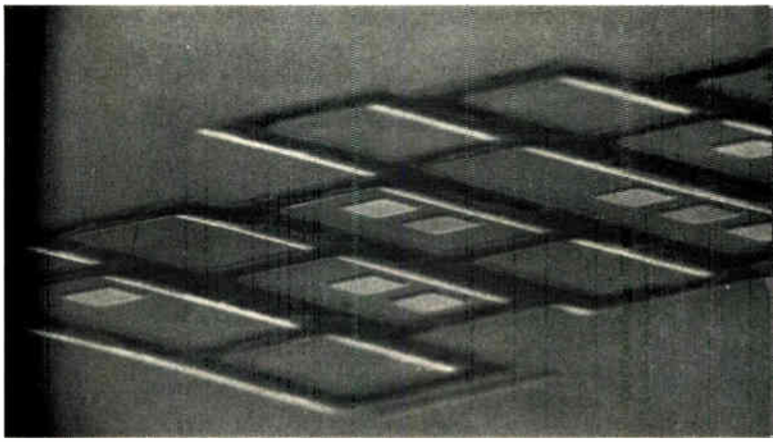
Finally, the unmodified I²L structure generally could not be operated at a high enough current to reach TTL speeds. To be fast, it either had to have extensive ion implantations around the junctions to limit current losses, or it had to use Schottky diode clamps on their collector inputs.

Why silicon anodization helps

The silicon anodizing process attacks all of these limitations because it is a very effective way of isolating the buried multiple collectors from the inverted emitters in the I²L structure. As a result, the parasitic losses at the emitter-collector junction are greatly reduced, and effi-



6. Good form. An I^2L gate built with a dielectric of anodized silicon runs almost as fast as conventionally built TTL structures. Cutoff frequencies of up to 250 megahertz can be expected in the future.



7. Confirmation. The view through a scanning electron beam microscope reveals the integrity and continuity of the anodized-silicon elements in a I^2L structure before it is metalized.

ciencies are increased. The emitter-to-collector aspect ratio can be adjusted for optimum efficiency by walling the collectors. Also, the npn injection efficiency is greatly improved, and to top it off, the base gradient comes out the right way.

Several types of anodized I^2L structures have already been built. One is optimized for high density with grounded emitter npns as shown in Fig. 4, while another has been built with isolated emitters and vertical pnps (Fig. 5).

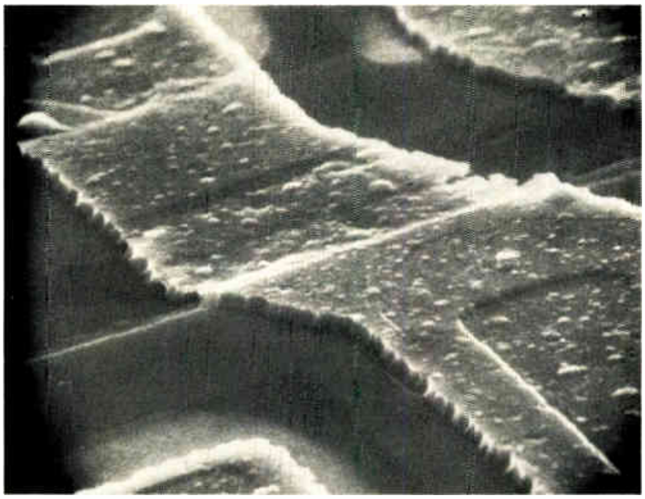
The first device is fabricated by depositing boron into an n^+ substrate. This boron will become the npn base and pnp emitter and collector. Next a 1-to-2-micrometer-thick n-type epitaxial layer is grown for the npn base. Then the boron is diffused out and the collectors diffused in. The anodic isolation is the last step, as described earlier for other products.

To build the second structure, boron is deposited on n^+ starting material to form the npn base and pnp emitter and collector. Over this is grown an n-type epitaxial layer for the pnp base, the boron is diffused out, and the collectors for the npn transistors diffused in. Thereafter the standard anodic isolation procedure is followed.

As for performance, Fig. 6 compares the operation of a typical minimum-geometry anodic I^2L structure with TTL operation. At currents up to about 1 milliampere, the I^2L mode ranks closely with the TTL mode. These anodized I^2L test devices have been built with npn transistors having current gains equal to 250 and cutoff frequencies equal to 250 MHz—figures that translate into a gate delay of less than 10 ns.

The foreseeable future is still brighter. Simple extensions of the process are expected to push I^2L operation into the milliampere current range with cutoff frequencies greater than 500 MHz. This points to gate delays on the order of 2 to 5 ns, well below standard TTL speeds. Yet they would be achieved without the encumbrance of Schottky diode clamps or other expensive process steps.

One final bonus: anodized silicon turns out to provide an excellent surface for metalization. The scanning electron microscope pictures of Figs. 7 and 8 show an I^2L gate before and after metalization. Notice how well



8. Almost perfect. This microphotograph of part of an I^2L gate shows that metalization over anodized silicon is excellent. Metalization in oxide-isolation processes often reduces yields.

the metal interconnection lines adhere to the anodized silicon surface.

As for products, the anodic silicon isolation process is already being applied to existing diode-transistor-logic and 54/74 TTL circuits. Indeed, it may even revive the old hardware logic families by cutting their cost per gate to 10 cents.

Most important are anodized-silicon I^2L designs for high-density memory and logic. A 4,096-bit I^2L RAM with speeds of 100 ns will be no more expensive than MOS RAM types, while microprocessors will have instructions in the 100-ns range. □

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Data acquisition can falter unless components are well understood

First part of two-part article studies relationship between sample-and-hold and multiplexer

by Dennis Santucci, *Teledyne Philbrick, Dedham, Mass.*

☐ High speed and high accuracy are the outstanding attributes of a modern data acquisition system. And manufacturers, while continuously improving on both, have also cut down on component size, weight, and cost. Problems with new data-acquisition systems are therefore seldom the result of poor component performance and commonly the result of a failure to utilize the hardware effectively. The engineer, to get optimum performance from his data-acquisition system, must understand precisely how each device functions and how it affects over-all operation.

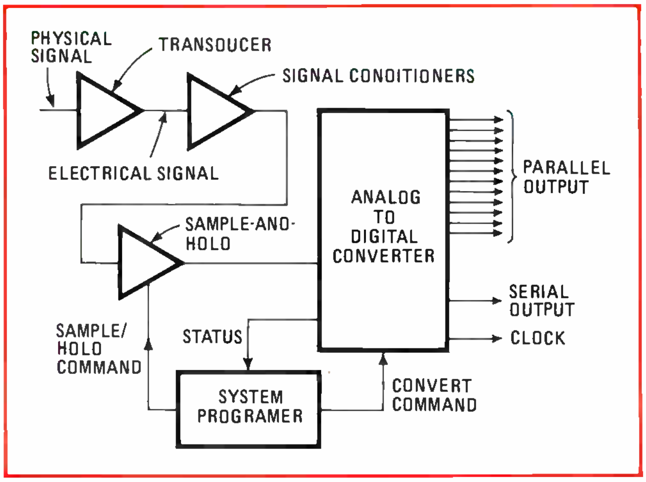
Part 1 of this two-part article will discuss the basics of data-acquisition technology, with the main focus on sample-and-hold circuits and multiplexer modules. Part 2, which will appear in the Nov. 27 issue, will concentrate on the analog-to-digital converter and will include an explanation of how system components can be tied together for optimum system performance.

Collecting the data

A typical application for data acquisition is a large processing plant where numerous temperature, pressure, and flow measurements have to be acquired before control-system calculations can be performed. The data-acquisition system takes the outputs of a number of analog transducers and converts them to digital form prior to transmission to a remote location where they are often manipulated by computer.

In its simplest form (Fig. 1), the digitizing system consists of a signal-conditioning network (usually amplifying and filtering), a sample-and-hold, and an a-d converter. After the transducer signal is conditioned, the sample-and-hold—on command from the system programer—stores the signal and holds it while slower circuits, namely the a-d converter, operate on it.

If many signals must be sampled sequentially, a multiplexer is inserted between the transducer-signal conditioner and the sample-and-hold (Fig. 2). The multiplexer then sequentially connects the input signals to the a-d converter. Only one signal is connected at any time, and both the timing and the sequencing of the in-



1. Acquiring data. In the simplest data-acquisition system, the sample-and-hold circuit stores the conditioned transducer signal and holds it so the slower acting analog-to-digital converter can convert it into a digital output.

puts to the a-d are determined by the system programer.

In terms of hardware costs, multiplexing is economical because many signals can share one sample-and-hold and one a-d converter. But because they must share these components, system speed is sacrificed. Even with identical components and an ideal multiplexer, the speed per channel of the multiplexed system is reduced by a factor equal to the number of channels.

If it is essential that many signals be acquired simultaneously and processed almost immediately, each channel can have its own sample-and-hold and its own a-d converter, which can be quite expensive. Or, time permitting, each transducer can have its own sample-and-hold while the a-d processing occurs "off line." Here, the outputs of the sample-and-holds are sequentially multiplexed to the a-d converter in an order determined by the system programer (Fig. 3). In either case, the serial output of the a-d converter can be used for two-wire (plus ground) transmission.

Finding the limits

Accuracy problems aside, the crucial question pertaining to most systems is speed. Speed, or, in industry jargon, throughput rate, is the maximum rate at which a system can convert an analog signal into a digital word and prepare itself for the next conversion. Throughput rate is expressed in samples per second.

The well-known Shannon theorem on sampling theory defines one of the basic limits on throughput rate. It states that the minimum frequency for sampling must be double the highest significant frequency of the signal, including the noise on the signal. This minimum frequency is necessary, the theorem states, if the sampled signal is to contain all the information needed for undistorted reconstruction. At a lower frequency, a phenomenon known as aliasing can occur. That is, the sampled data derived from a sine wave of frequency f sampled at a rate less than 2f can be fitted to sine waves of a frequency other than f. Aliasing, or frequency folding, is an error that cannot be removed by filtering or digital manipulation. A Fourier analysis of a complex waveform will show that even though filtering can reduce unwanted frequency components, it cannot eliminate them. Their presence will still affect the conditioned signal being supplied to the sample-and-hold, and this must be taken into account by the systems engineer. The insertion of wideband noise into the system is another consideration. To allow for these factors, many systems engineers, as a rule of thumb, sample at five or 10 times the highest input frequency component (after good filter and noise suppression techniques are used).

Thus the sampling of input signals having appreciable frequency components (after filtering) requires an ultra-fast data-acquisition system. This holds true for inputs of high fundamental frequencies or for transient signals with high-frequency components.

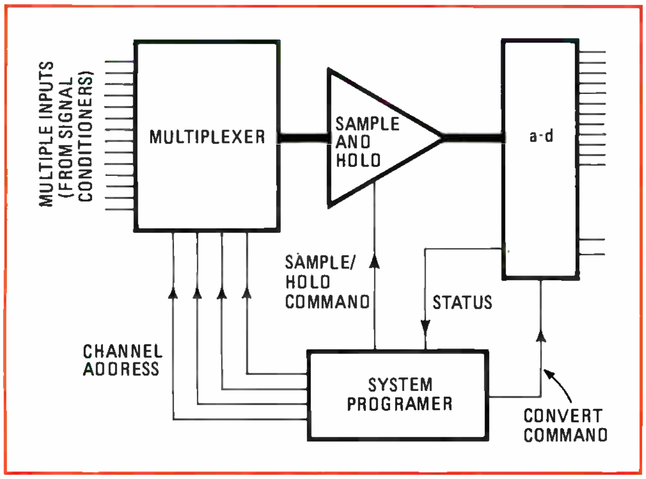
Equipping for accuracy

Also important for the accuracy of a system are the criteria that are set for the sample-and-hold circuits. Degradations in accuracy can occur whenever the input to a system varies appreciably because the input may be changing significantly while the system is still preoccupied with an earlier sample of data. If a system is to convert to within a specified accuracy, then the rate at which the input signal may change must somehow be attuned to the time taken by the a-d converter to examine a given sample. It is the sample-and-hold circuit that acts as the intermediary.

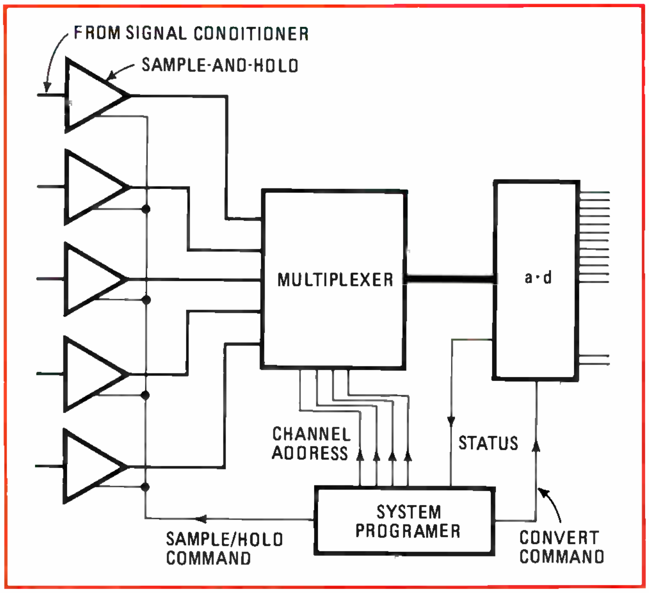
To establish the speed/accuracy relationship, the systems engineer begins with the a-d conversion time, which is expressed as the frequency of a sinusoid: $e(t) = E \sin\omega t$, where e is the amplitude at any given time t, and E is the maximum amplitude.

The rate of change of $e(t) = de/dt = \omega E\cos \omega t$. And this rate is maximum at $\cos\omega t = 1$. Thus, the maximum rate of change is $\Delta e/\Delta t = \omega E = 2\pi fE$.

Now, for an n-bit converter, the magnitude of the



2. Multiple sensors. To reduce the number of components required when a number of transducers must be scanned, the transducers are sampled sequentially, with each input being fed in turn into the sample-and-hold and the a-d.



3. Simultaneous readings. When several transducers must be scanned at one time, each can have its own dedicated sample-and-hold. The sample-and-holds are then sequentially fed into the multiplexer and from there into the analog-to-digital converter.

least significant bit (LSB) is: 1 LSB = $E/2^n$. To obtain n-bits of accuracy, the change in the amplitude of the input, Δe must not exceed the value of its least significant bit or $E/2^n$, so that

$$\Delta e = E/2^n = 2\pi f E \Delta t$$

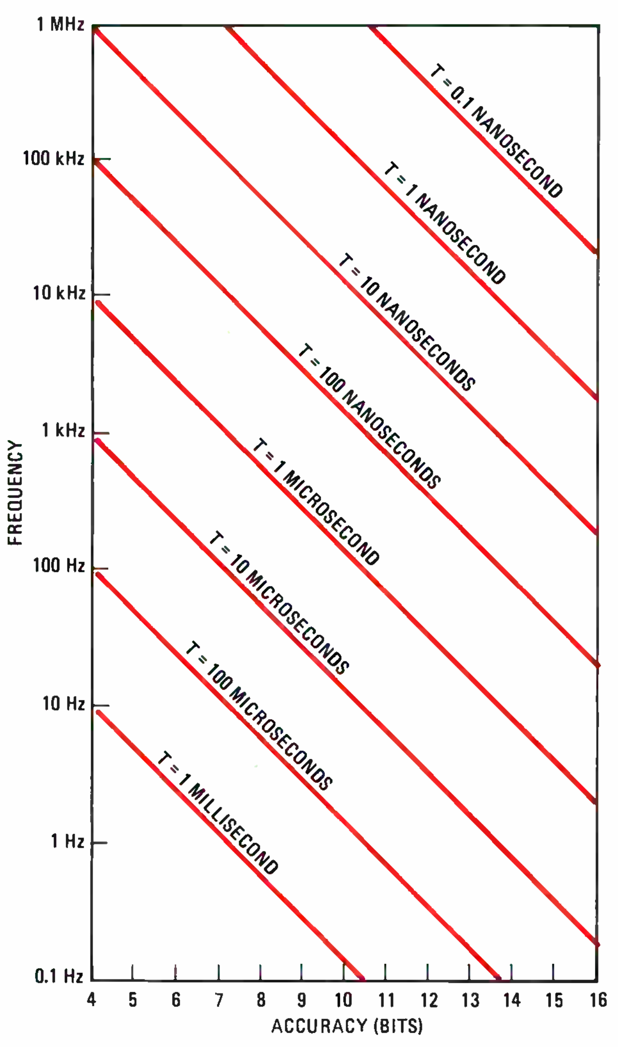
Solving for f_{max}:

$$f_{max} = 1/(2\pi \Delta T 2^n)$$

where ΔT designates the aperture time.

This then is the highest frequency that can be sampled by a data-acquisition system if it is to maintain n-bits of accuracy and if the signal must be observed for ΔT time while the system converts. This equation shows the tradeoff between the highest frequency a system can handle, the aperture time, and the desired accuracy. Figure 4 is a nomograph comparing these three parameters. For a 12-bit a-d converter that has a conversion time of 24 microseconds (its effective aperture):

$$f_{max} = 1/(2\pi)(24 \times 10^{-6})(2^{12}) = 1.6\ Hz$$



4. At top speed. The maximum input frequency a data-acquisition system can handle is a tradeoff between aperture time T and the accuracy of the a-d converter. If the conversion time is too long for the rate at which the signal changes, then in order to maintain system accuracy, a sample-and-hold must precede the a-d converter.

If one were to use the fastest a-d converters available today, the frequency might be improved by a factor of 10 (while maintaining the same accuracy), but the cost would more than quadruple.

However, if a sample-and-hold were placed in front of the a-d, the signal could change at a rate many orders of magnitude higher than that which the a-d is capable of handling. The sample-and-hold could sample the signal at the appropriate time and hold it long enough for the a-d to convert it without error. This is a cheaper solution than going to a faster a-d. The fastest sample-and-hold responds in about one nanosecond, resulting in an f_{max} of approximately 39 kilohertz. Yet such a sample-and-hold costs no more than an a-d converter that operates at only 24 μs.

Basically the sample-and-hold consists of an analog switch, a storage medium (usually a capacitor) and a buffer amplifier (Fig. 5). The voltage across the capacitor follows the input signal until a hold command is received from the system programer. At that point the switch opens, storing the voltage across the capacitor. When the next sample command is received from the system programer, the switch closes and the voltage across the capacitor again tracks the input signal.

In the sample mode, the circuit has the basic transfer characteristics of an operational amplifier. Important parameters therefore are: gain linearity, offset voltages, power-supply rejection ratio, slew rate, and bandwidth. Usually the gain and offset-voltage errors can be trimmed to zero using external potentiometers.

For transition from sample to hold, the important parameters are aperture delay time, aperture uncertainty time, aperture time, sample-to-hold transient, settling time, and hold jump voltage. What these parameters are and how they affect operation is seen in Fig. 6.

Upon receipt of the hold command, a delay occurs before the input switch begins to open. This is the aperture delay time, which in an ultra-fast sample-and-hold is on the order of 2 nanoseconds. This delay, however, is not consistent and has a tolerance (in the best sample-and-holds it is about ±0.2 nanosecond) that is known as the aperture uncertainty time. Therefore the time it takes the switch to open is known as the aperture time and includes the aperture uncertainty. However, a word of warning: these and many other definitions given in this series may differ from manufacturer to manufacturer. The buyer must ascertain what the manufacturer is actually specifying and not just compare numbers.

The aperture delay time can be compensated for by advancing the hold command an amount equal to the delay time. Thus if a measurement were required at precisely T_1, the hold command should be applied at $T_o = (T_1 - \text{aperture delay time})$. This assures that the output sample is held at $T_1 \pm$ the aperture uncertainty time. The switch impedance, during the aperture time, goes from near zero to about 10^{13} ohms. Throughout this period the sample-and-hold acts as an integrator with a varying RC time constant. These effects, while negligible in slower systems, are important in high-speed, high-accuracy systems. If the circuit is sampling, say, a constant-ramp signal (Fig. 7), it begins to integrate the signal over the period T_1 and T_2 (the aperture time). To compensate for this the opening time can be adjusted so that the level of the integrated pulse will exactly equal the ideal sampled level (instantaneous switch opening producing a nonintegrated sample). Once this time is selected, the only variation will be the aperture uncertainty time. This uncertainty time now limits the maximum rate of change in input voltage that can be tolerated if the output is to remain within the specified accuracy.

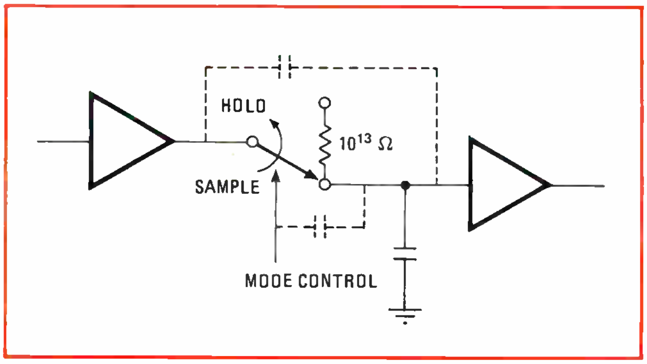
For a sine-wave input, the error incurred is a sinusoid shifted 90 degrees. This is because the maximum error occurs at the zero crossing where the slope is steepest (maximum de/dt) and the minimum error occurs at the peak. Any correction to the timing will only move the sampling period away from the point of minimum error. Therefore no change in timing will compensate for this minimum amount of error.

The most interesting phenomenon appears when the peak of a triangular waveform is to be captured (Fig. 8). The input slope will change direction at the peak causing the integrating curve to change its direction before it is able to reach the peak. Only if the switch could be opened in zero time, which it can't, could the circuit capture the peak by eliminating the integration effects. Yet even an instantaneously acting switch could not be relied upon to catch the peak as there is always the aperture uncertainty time to contend with.

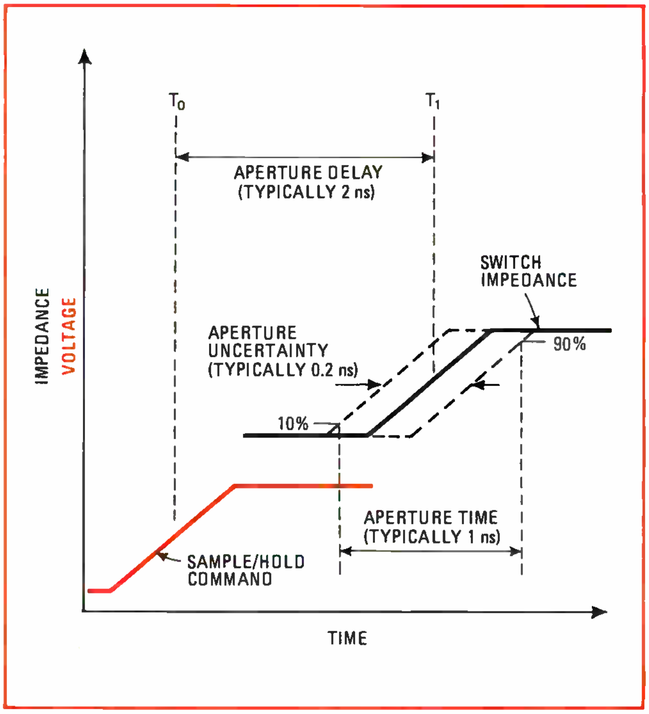
Parasitic coupling also occurs within the sample-and-hold. Coupling from the mode control circuitry causes a spike on the output known as the sample-and-hold transient. While it can be as much as several hundred millivolts, this transient will, in a well constructed device, settle out within 100 ns. Also, when the device is switched from sample to hold, some charge is transferred to the holding capacitor due to the inter-electrode capacitance of the switch. To the output, this adds a constant voltage level known as the hold jump voltage. While the hold jump voltage can be nulled out using an external trimmer, the transient must usually be lived with.

Once in the hold mode, the circuit must retain the level it has stored regardless of changes in the input. But leakages across the switch and into the output amplifier, and leakages across the capacitor and dielectric absorption within the capacitor will cause the voltage on the capacitor to change gradually. The delay (or droop) rate defines how the output voltage will droop during the hold mode. A sample-and-hold with very fast acquisition time has a relatively high decay rate because of the small capacitor used. And it also follows that a device with a low droop rate will have a relatively longer acquisition time. Typically this rate of change averages 25 μV/μs, but it will increase with temperature because the current through the field-effect-transistor FET switch and FET amplifier doubles every 10°C.

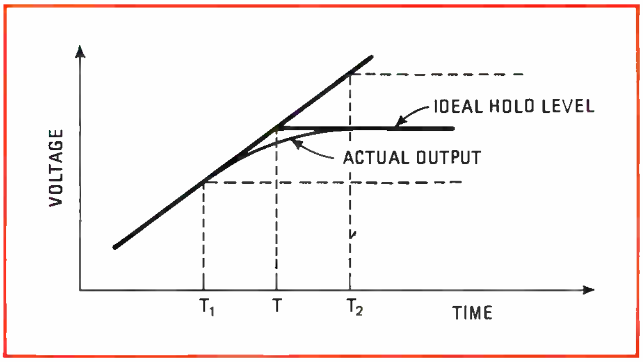
Feedthrough, a term for the amount of signal coupled from the input to the output in the hold mode, is the factor to consider here. In a well designed sample-and-hold, feedthrough can be as low as 1 millivolt peak to



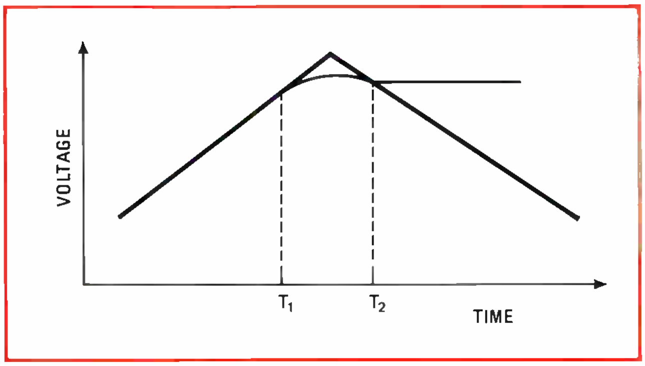
5. Inside the sample-and-hold. When the switch closes, the voltage across the capacitor tracks the incoming signal. On command from the system programer the switch opens and the capacitor stores the instantaneous input signal.



6. Characteristics. Upon receipt of the hold command there is a delay before the switch begins to open, known as the aperture delay time. This delay may vary by an amount referred to as the aperture uncertainty time. The aperture time, which includes the uncertainty, is the time the switch takes to open and store the signal.



7. Integrating a ramp. When the output is a constant ramp, the timing can be adjusted to compensate for the aperture delay time and aperture time so that only the uncertainty limits the bandwidth.



8. Out of reach. Because of the RC time constant, a sample-and-hold can never capture a triangular waveform. The input signal will change direction before the integrating curve can reach the peak.

peak for an input sinewave of 20 V peak to peak at 1 MHz.

As its final task, the sample-and-hold must re-acquire the input signal and commence to track. The time required to re-acquire and remain within a given error band is called the acquisition time. It is usually specified as the time it takes the sample-and-hold to go from holding at one end of its input-voltage range till it acquires the level at the opposite end of the range. For example if the device has an input voltage range of ±5 V, the acquisition time is the time it takes the circuit to go from holding at -5 V till it acquires a signal at +5 V, or vice versa. The acquisition time includes the slew rate and the settling time. Frequently, however, it is important to know the slew rate by itself when maximizing the throughput of the system.

Multiplexer performance

Basically the multiplexer is an array of analog voltage switches that sequentially connects each input signal to the a-d converter. As mentioned, only one switch at a time is closed, and the closing sequence and timing are directed by the system programer. Ideally the multiplexer would switch from channel to channel in zero time with zero distortion and with complete isolation between the off channels and the output. In actuality, of course, the signal passing through a real multiplexer (Fig. 9) is always somewhat distorted.

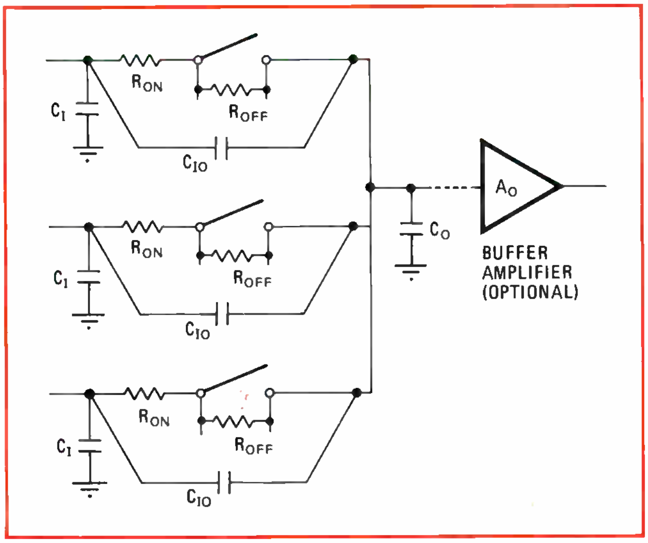
The transfer accuracy of a multiplexer is defined as the ratio of the amplitude lost to the input amplitude.

$$\textit{transfer accuracy} = 100\% \, (E_{in} - E_{out})/E_{in}$$

Input parameters such as frequency and source impedance affect the transfer accuracy, and the engineer must be aware of these differences when comparing units.

Each multiplexer channel exhibits some parasitic input capacitance to ground, which, along with other contributors, limits the bandwidth of the multiplexer. In the channel being sampled (ON mode), there is still a small residual resistance. This is usually as small as a few ohms but can be several thousand ohms if the multiplexer contains internal current-limiting resistors to protect the switch against overvoltage.

In the open position (OFF mode), the switch impedance becomes very large (on the order of 10^{12} ohms), but it still permits leakage current, which can cause an



9. Multiplexer model. The multiplexer is basically a switch array that exhibits: an input capacitance C_I; switch resistance in the closed position R_{on}; resistance R_{off} across the multiplexer when the switch is open; stray capacitance C_{IO} connecting the input to the output; and an output capacitance C_O.

error in the output and offset voltages at the input. For the FET switches used in most multiplexers, these leakage currents double for every 10°C rise in temperature.

Stray capacitance from the input causes feedthrough, i.e., the amount of signal coupled to the output by all OFF channels in the multiplexer for an input signal of specific amplitude and frequency. This specification is usually given per channel as a capacitance value or as an absolute voltage. Because the amount of signal being coupled from input to output is amplitude and frequency dependent, meaningful comparisons between different units can only be made for specifications derived from the same measurement techniques.

Source impedance into the multiplexer and the impedance of the closed multiplexer switch must be kept low. High impedances, when combined with the output capacitance of the multiplexer, are often the worst culprits in prolonging settling time (time for the switch output to reach and remain at a specified value).

Switches take a finite time to switch. The inverse of switching time, plus the settling time (caused by the output capacitance) is the throughput rate, and is specified by the multiplexer manufacturer. When a multiplexer is chosen with an output buffer, impedance matching, which will be discussed in Part II of this article, is one benefit. A buffered multiplexer can be used between a sample-and-hold with low input impedance and transducers that readily become load dependent. Also, when the buffered multiplexer is constructed by combining a good multiplexer and a fast amplifier within the same package, the component designer often can manipulate the physical layout to produce a faster and better performing unit than possible with separate components.

The a-d converter is needed to complete the data-acquisition system, and in Part 2 of this article, this device will be discussed in greater detail together with system design, sources of error and techniques for maximizing throughput. □

Circuit adds BCD numbers faster with less hardware

by Dharma P. Agrawal
Federal Polytechnic Institute of Lausanne, Switzerland

To add two binary-coded decimal numbers, at least four full adders are needed, not to mention the gates and inverters that correct the sums from each adder and generate the decimal carry-out. But this extra logic hardware can be simplified, as has already been shown ["Simplifying sum-correction logic for adding two BCD numbers," by Robert D. Guyton: *Electronics*, May 30, 1974, p. 108], and the new approach proposed here economizes on hardware and improves speed still further.

The circuit in the accompanying diagram uses a neat dodge to reduce the number of logic elements required to add the two BCD numbers $A_8A_4A_2A_1$ and $B_8B_4B_2B_1$. The dodge is to obtain the decimal carry-out, C_0, from the uncorrected sums S_2, S_4, and S_8, and the uncorrected carry C_{16} first, and only then to use C_0 to obtain the corrected sums S_1', S_2', S_4', and S_8'.

The boolean expression for the decimal carry-out can be written as

$$C_0 = C_{16} + S_8S_4 + S_8S_2$$

The circuit schematic shows how to obtain this value for C_0 by using just three NAND gates and one inverter.

The truth table for the corrected sums S_8', S_4', S_2', and S_1' as functions of C_0, S_8, S_4, S_2, and S_1 can be prepared, and their boolean expressions can be obtained as

$$S_8' = \bar{C}_0S_8$$

$$S_4' = S_4S_2 + \bar{C}_0S_4$$

or

$$= S_4S_2 + \bar{S}_8S_4$$

$$S_2' = C_0\bar{S}_2 + \bar{C}_0S_2$$

or

$$= C_0\bar{S}_2 + \bar{S}_8S_2$$

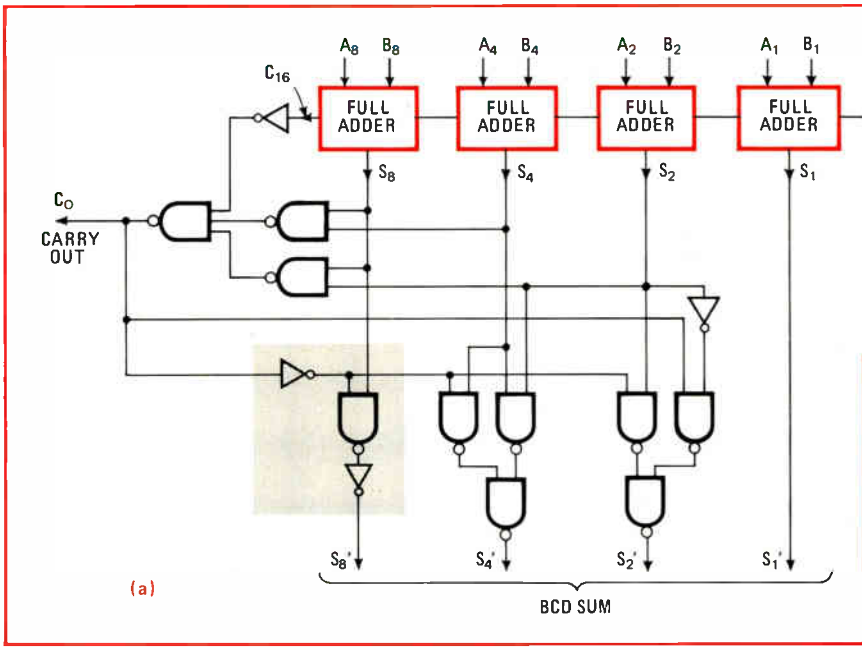
and $S_1' = S_1$

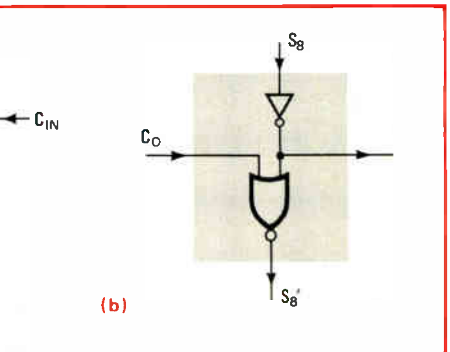
The circuit diagram clearly indicates the hardware accomplishment of each of these corrected sums. Note that the portion of (a) that is inside the shaded box can be replaced by the arrangement (b) to produce S_8' with one less gate and implement the alternative expressions for S_4' and S_2'.

The numbers in the accompanying table demonstrate how effectively this BCD adder reduces parts count and time delay, compared with some earlier circuits.□

COMPARISON OF BCD ADDERS

	Excess-3 adder	Guyton's adder	Proposed adder (a) shown here	Proposed adder (a), partially replaced by (b)
Number of full adders	5	4	4	4
Number of half adders	2	–	–	–
Number of 3-input NAND gates	20 (3-input and 2-input NAND gates together)	4	1	1
Number of 2-input NAND gates		10	9	8
Number of 2-input NOR gates	–	–	–	1
Number of inverters	9	6	4	3
Time delay in terms of number of:				
Full adders	5	4	4	4
Half adders	2	–	–	–
Gates	?	6	5	4





Hardware economy. Circuit adds two binary-coded decimal numbers with comparatively few logic elements by first obtaining decimal carry-out from uncorrected sums and uncorrected carry, then using this carry-out to obtain the corrected BCD sum. Basic circuit (a) shows fundamental implementation of this method; refinement of logic for corrected sum S_8' (b) saves a gate. With fewer devices, computation is faster.

IC timers control dc-dc converters

by P. R. K. Chetty
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An integrated-circuit timer such as the MC1455 can be used as the control element in a simple dc-to-dc converter regulator. Shown below are a current step-up converter regulator and a polarity-reversing voltage step-up converter regulator. Both are regulated to within 0.5% for load currents of 300 milliamperes, and have a ripple of less than 5 mA.

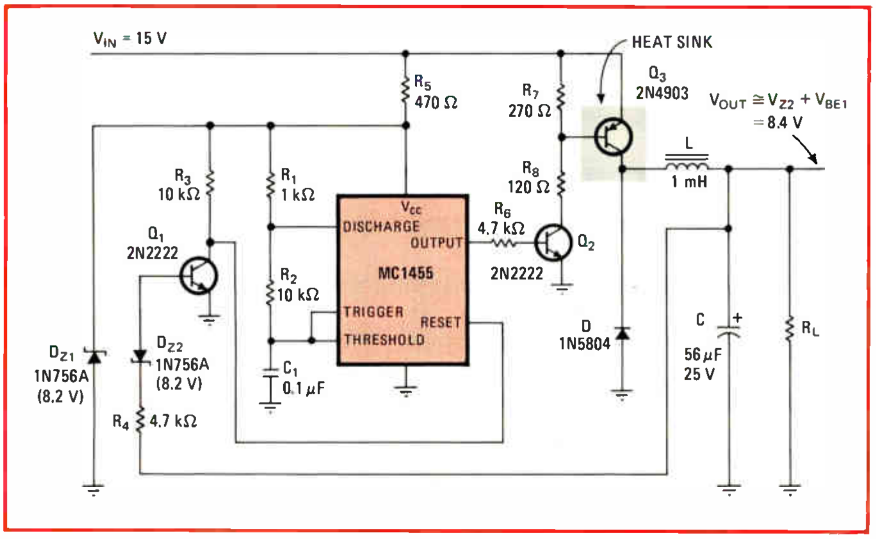
In these circuits the MC1455 operates as an astable multivibrator, turning the pass transistor on and off to keep the output-filter capacitor charged to the desired output voltage. Overvoltage is prevented by a feedback arrangement that turns off the multivibrator when the capacitor voltage reaches a predetermined level.

The astable-mode connection of the timer causes the voltage across capacitor C_1 to oscillate between $V_{CC}/3$ and $2\ V_{CC}/3$ at a frequency of approximately $1.44/(R_1+R_2)C_1$—about 1.3 kilohertz. The maximum operating voltage of the timer is 16 volts, but here its V_{CC} is clamped at 8.2 V by zener diode D_{Z1}. The input voltage therefore can have any value within the ratings of the pass transistor and the filter capacitor.

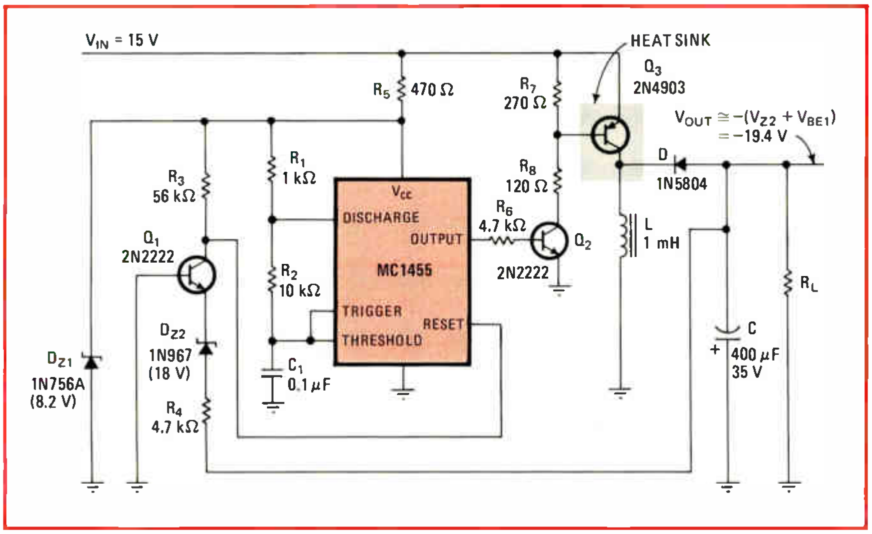
Figure 1 shows the current step-up converter regulator. When the output of the control timer is high, transistor Q_2 is turned on and therefore pass transistor Q_3 is turned on. Collector current from Q_3 flows through inductor L into the load and the filter capacitor. When the output of the timer goes low, the transistors turn off. Diode D commutates the current flow flowing through the inductor when Q_3 switches off. If there were no feedback circuit, the output voltage would depend upon the input voltage and the duty cycle.

The feedback circuit consists of R_4, zener diode D_{Z2}, transistor Q_1, and R_3, Whenever the output voltage exceeds $(V_{Z2}+V_{BE1})$, Q_1 turns on and drives the reset terminal of the 1455 low. The transistors Q_2 and Q_3 therefore stay off, allowing the output voltage to decrease. Thus the output voltage V_{out} is maintained approximately equal to $(V_{Z1}+V_{BE1})$.

The performance of the circuit in Fig. 1 is as follows:



1. Converted and regulated. Dc-to-dc converter includes IC timer for regulation. The MC1455, connected as free-running multivibrator, switches Q_3 on and off. If output gets too high, feedback circuit drives timer reset low to hold switch off. Regulation is less than 0.5% at 300 mA, and ripple is less than 5 mA. Output voltage is lower than input voltage, so current can be stepped up.



2. Polarity reversed. Positions of inductor, commutating diode, and feedback elements are changed here for negative output voltage. This circuit arrangement can step up magnitude of either voltage or current; components chosen here provide voltage step-up. Regulation is same as before.

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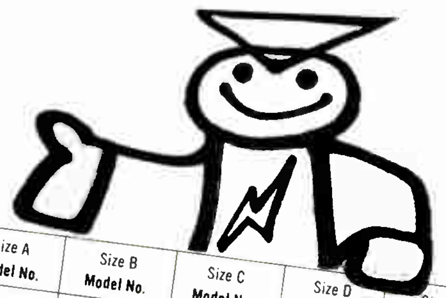
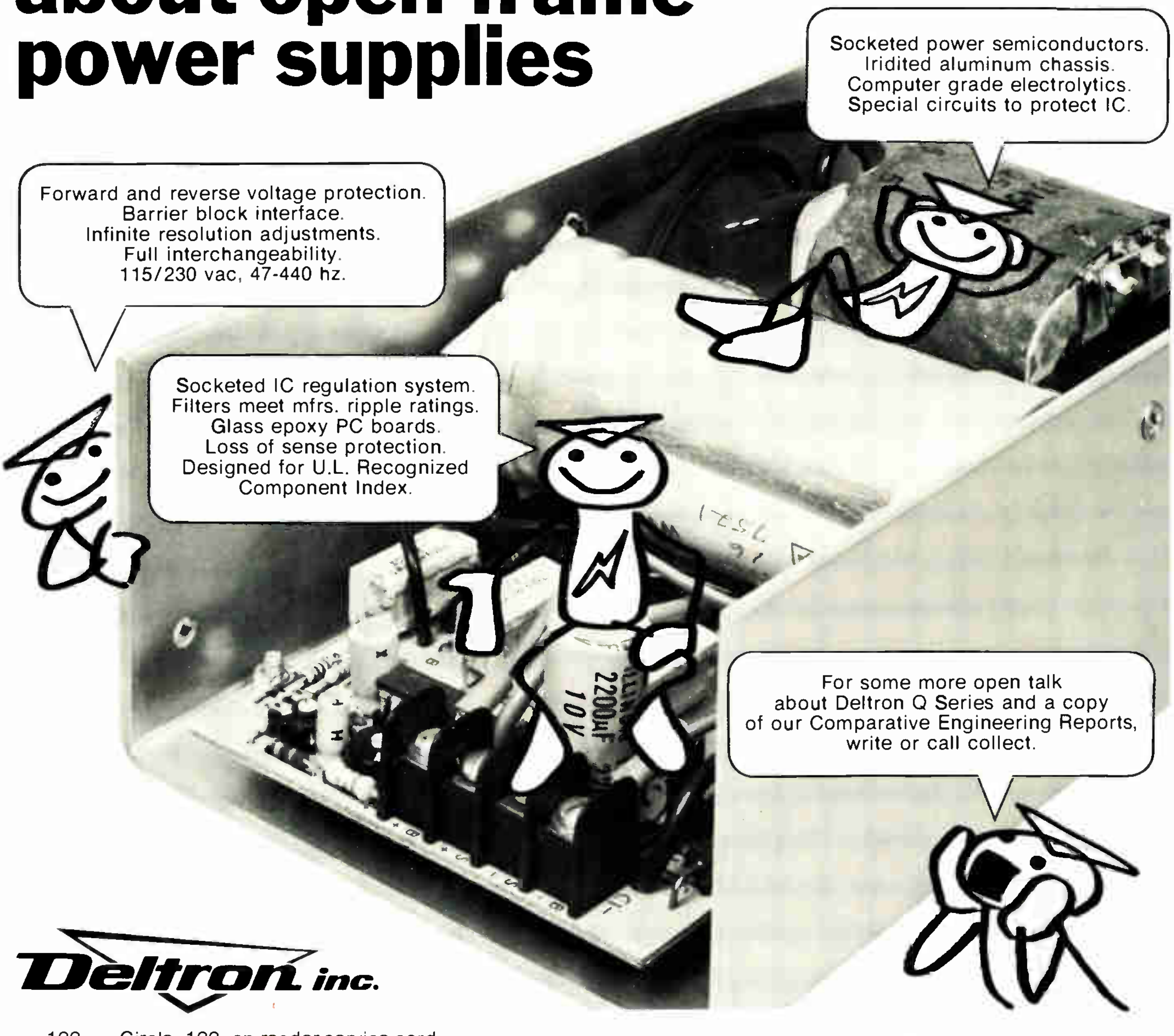


Size A Model No.	Size B Model No.	Size C Model No.	Size D Model No.	Size F Model No.
volts — amps	volts — amps	volts — amps	volts — amps	volts — amps
Q 5— 3.0	Q 5— 6.0	Q 5— 9.0	Q 5—12.0	Q 5—18.0
Q 6— 3.0	Q 6— 6.0	Q 6— 9.0	Q 6—12.0	Q 6—18.0
Q 12— 1.7	Q 12— 3.4	Q 12— 5.7	Q 12— 7.0	Q 12—10.8
Q 15— 1.5	Q 15— 3.0	Q 15— 4.8	Q 15— 6.3	Q 15— 9.5
Q 18— 1.3	Q 18— 2.6	Q 18— 4.0	Q 18— 5.2	Q 18— 7.8
Q 20— 1.3	Q 20— 2.6	Q 20— 4.0	Q 20— 5.2	Q 20— 7.8
Q 24— 1.2	Q 24— 2.4	Q 24— 3.3	Q 24— 4.8	Q 24— 7.2
Q 28— 1.0	Q 28— 2.0	Q 28— 3.1	Q 28— 4.2	Q 28— 6.0
Dimensions: 4⅞x4x1⅝	Dimensions: 5⅝x4⅞x2½	Dimensions: 7x4⅞x2¾	Dimensions: 9x4⅞x2¾	Dimensions: 14x4⅞x2¾
Price: 1—$32.00 100—$26.00 250—$24.00	Price: 1—$54.00 100—$44.00 250—$41.00	Price: 1—$67.00 100—$54.00 250—$51.00	Price: 1—$87.00 100—$70.00 250—$66.00	Price: 1—$113.00 100—$ 91.00 250—$ 85.00

Some open talk about open frame power supplies



Deltron inc.

Input voltage, V_{in} = 15 V
Output voltage, V_{out} = 8.4 V
Load current, I_{out} = 300 mA
Ripple, I_r (for I_{out} = 300 mA) = 5 mA
Load regulation (for V_{in} = 15 V and I_{out} = 0–300 mA) equals or is less than 0.5%
Line regulation (for V_{in} = 15–25 V and I_{out} = 300 mA) equals or is less than 2.5%

The polarity-reversing circuit of Fig. 2 differs from Fig. 1 in the arrangement of L, C, D, and the feedback elements. When Q_3 switches off, the commutating current in L charges C to produce an output voltage that is negative with respect to ground. This voltage is applied to the anode of D_{Z2} through limiting resistor R_4. Whenever the output is more negative than $-(V_{Z2} + V_{BE1})$, the timer reset goes low, allowing the voltage across the capacitor to become less negative. The output voltage of this circuit is therefore maintained at approximately $-(V_{Z2} + V_{BE1})$. This circuit can provide an output voltage equal to, less than, or greater than the input voltage.

The performance of the circuit in Fig. 2 is as follows:

Input voltage, V_{in} = +15 V
Output voltage, V_{out} = −19.4 V
Load current, I_{out} = 300 mA

Ripple and regulation are the same as in the earlier example. □

Discriminator displays first of four responses

by John S. French
Western Electric Co., Inc., Sunnyvale, Calif.

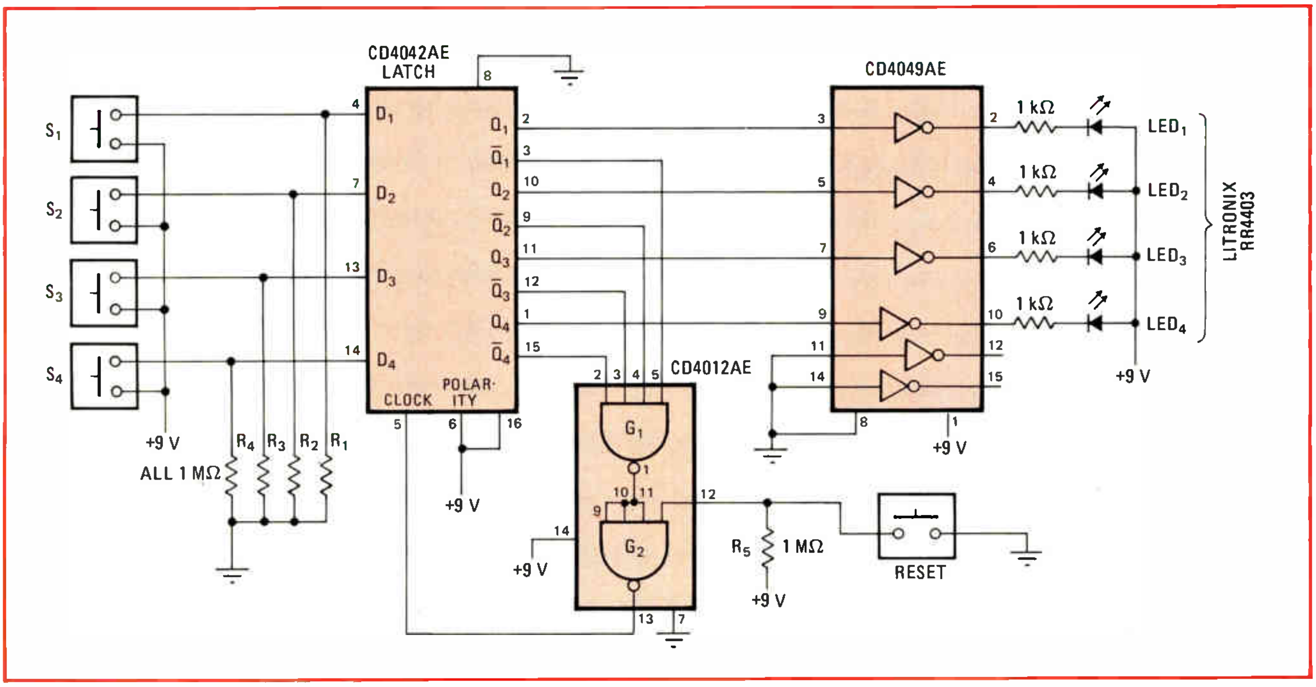
A first-response discriminator, which turns on a light indicating the first switch to close and simultaneously locks out the other switches, can be useful in sports, games, behaviorial learning studies, and experiments in physical science. The circuit shown here indicates which of four switches closes first. It uses three low-drain C-MOS integrated circuits and a 9-volt radio battery.

When the push-to-close switches S_1 through S_4 are open, inputs D_1 through D_4 to the 4042 quad latch are low. Therefore outputs Q_1 through Q_4 are low, and $\bar{Q}_1$ through $\bar{Q}_4$ are high. These four high inputs to NAND gate G_1 make G_1 low and G_2 high. The high output from G_2 is applied to the clock input of the latch; with the clock thus enabled, the outputs of the latch can follow the inputs.

If switch S_1 is closed, D_1 goes high and therefore Q_1 goes high, allowing light-emitting diode LED_1 to light. Simultaneously, $\bar{Q}_1$ goes low, sending G_1 high but G_2 and the clock input of the latch low. The clock low locks the latch so that D_2, D_3, and D_4 no longer control Q_2, Q_3, and Q_4. As a result, even if S_2, S_3, or S_4 is closed, the corresponding LED does not light.

The circuit is reset by momentary closing of the reset switch to set G_2 and clock high. If S_1 through S_4 are open, Q_1 through Q_4 go low for the next trial.

Expansion of this circuit to handle N inputs is straightforward. Only two NAND gates are required, but one of them must have N inputs. □



Who's on first? The first switch to close lights up its associated LED, and blocks all other LEDs from lighting if their switches are closed. Circuit can distinguish first-closed switch for time differences as small as 0.05 microsecond. Cost of parts for entire circuit is under $10.

Time base is key factor in oscilloscope measurements

Accuracy in checking rise times, computer timing, and propagation delays depends more on scope precision than on bandwidth

by Rex Berg, *Hewlett-Packard Co., Colorado Springs, Colo.*

☐ When looking for an oscilloscope to measure time intervals like rise times, pulse-repetition rates, and pulse widths, most engineers opt for the widest-band instrument available. Since bandwidth is synonymous with fidelity, they reason, a wideband scope should provide the most accurate timing measurements possible. Unfortunately, this assumption ignores the major factor contributing to error in such measurements—time-base inaccuracy.

Especially when measuring time intervals between 1.0 nanosecond and 1.0 microsecond, which are typical of digital-circuit rise times, propagation delays, and computer-timing requirements, oscilloscope time-base accuracy has a more profound effect than bandwidth. And two other factors—vertical amplifier fidelity with respect to true Gaussian response and resolution of the display—must also be considered.

Time-interval measurements and how oscilloscope specifications affect them can be divided into two categories, based on how often they are encountered:

- The usual case. When the rise time of the measured waveform is at least three times longer than the rise time of the vertical amplifier, the accuracy of the time-interval measurement is not affected by the response of the vertical amplifier, but depends only upon the specified accuracy of the time base.
- The special case. When the rise time of the waveform to be measured is less than three times the rise time of the vertical amplifier of the oscilloscope, the time-interval measurement is affected by the oscilloscope's bandwidth, but other factors also affect this accuracy.

Making most measurements

In the usual situation, or when the time between two transitions with equal rise times is to be determined, the response of the vertical amplifier does not contribute significant error.

For either differential-delay-sweep measurements, in which time intervals are determined by measuring a change in trace position, or direct, on-screen, measurements, the error can be tied directly to the specified error of the time base. Typically, the error in an on-screen measurement is specified as a percentage of full scale deflection, but for measuring a differential delayed-sweep time interval, it is specified as

$$\text{Error} = \pm 100\frac{AT_i + BS}{T_i} \qquad (1)$$

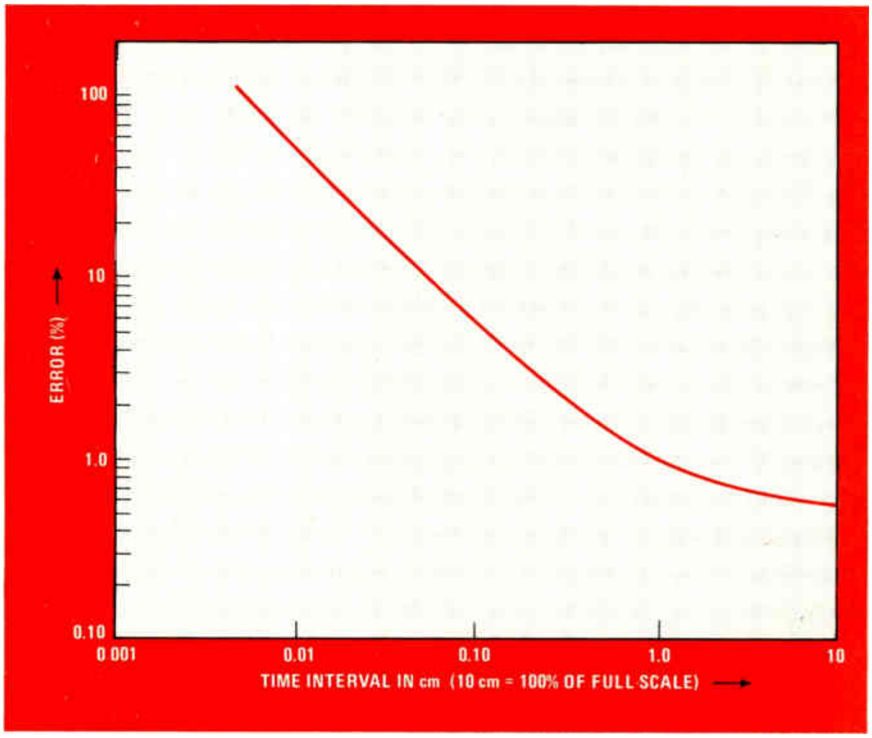
where A is a percentage of the measurement, B is a percentage of the scope's full-scale deflection, T_i is the time-interval measured (in divisions), S is the full-scale deflection of the scope (typically 10 divisions), and error is expressed as a percentage.

Because a good deal of the error in any time-interval measurement can be attributed to nonlinearities in the cathode-ray tube and horizontal amplifiers, the differential-delayed-sweep technique, in which the CRT and horizontal amplifiers are used as nulling devices, is generally preferable for timing measurements. In addition, delayed-sweep aids in expansion and location about the measurement point.

Since the error in this measurement is a function of

Closing the loop

The author will be available on Wednesday, Dec. 17, to answer any questions readers may have about this article. Call Mr. Berg between 11 a.m. and 6 p.m. Eastern Standard Time at (303) 598-1900, ext. 2071.



1. Off the mark. The error in time-interval measurements due to the inaccuracies in an oscilloscope's time base increases sharply as the time interval becomes shorter. When the time-base error is ±(0.5% of measurement + 0.05% of full scale), a measurement of one small graticule division of 0.10 cm has an uncertainty of more than 5%.

the measurement's relationship to full scale, the greater the time interval in divisions of full scale, the greater is the accuracy of the time-interval measurement. For example, if the time interval measured is 10% of full scale, or 1 division, and the time-base error is specified as ±(0.5% of measurement + 0.05% of full scale), then, from Eq. 1, the error is equal to 100(0.005 × 1 + 0.005 × 10)/1, or 1%.

A plot of error as a function of the time interval measured (Fig. 1) shows that the error increases steeply as the measured time interval becomes a smaller percentage of full-screen deflection.

Catching faster transitions

When the rise time of the waveform is less than three times the rise time of the vertical amplifier, or when the waveforms that define a time interval have unequal rise times, the response of the vertical amplifier contributes to the error in time-interval measurements. However, when these faster signals are measured, the sweep speed and ramp linearity typically are such that the time base still contributes most of the error (Fig. 2).

Recent improvements in horizontal-amplifier linearity, resolution, and repeatability, together with such technique advancements as dual-delayed sweep, have brought time-base accuracy to first place in importance for most timing applications. Bandwidth, of course, is an important parameter for an oscilloscope because higher bandwidth usually means increased writing speed or brightness, better continuous-wave amplitude fidelity, higher-frequency triggering, and better pulse response. But increasing the bandwidth of real-time oscilloscopes offers a diminishing return for time-interval measurements.

Curve (a) in Fig. 2 represents the total deviation or error in a rise-time measurement on an oscilloscope, determined from the specified time-base error when using the differential-delayed-sweep technique, and assuming that the vertical amplifier has true Gaussian response and bandwidth of 500 MHz. The specified time-base error is ±(1.5% of measurement + 0.5% of full scale).

If t_o is the rise time displayed on the screen and the main sweep is 10 nanoseconds per division, then, in the region of concern, the error contributed by the time base is, in nanoseconds, ±(0.015 t_o+0.5 ns). Further, if the vertical amplifier is Gaussian, which guarantees that all components of a step input, regardless of frequency, will be applied to the CRT at the same time, the observed rise time is related to the source rise time by

$$t_o = (t_s^2 + t_r^2)^{1/2} \qquad (2)$$

where t_o is the observed rise time of the source pulse, t_s is the actual rise time of the source pulse, and t_r is the oscilloscope rise time measured with an infinitely fast step-input pulse.

The error in the measurement of the source rise time contributed by the bandwidth of the vertical amplifier is equal to $100(t_o - t_s)/t_s$. Therefore, since the error of the time base is independent of the error in bandwidth, the total error is given by

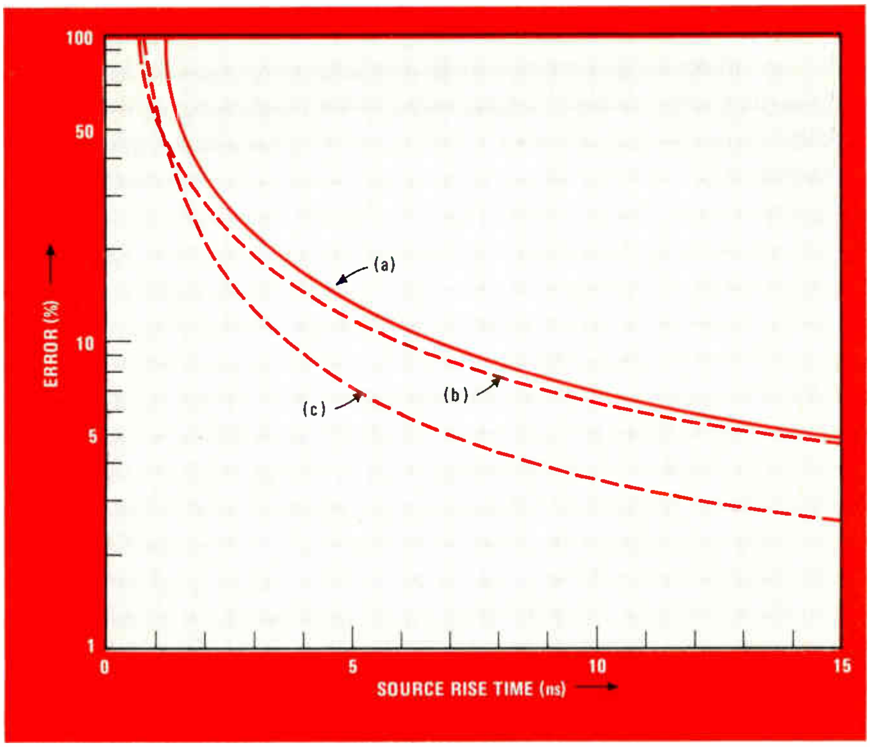
$$\text{Error} = 100\left[\pm\left(0.015 + \frac{0.5\text{ ns}}{t_o}\right) + \left(\frac{t_o - t_s}{t_s}\right)\right]$$

The rise time of the vertical amplifier is specified as 0.8 ns; so, finally, the error associated with rise-time measurements is given by

$$\text{Error} = \pm 100\left[\left(0.015 + \frac{0.5\text{ ns}}{t_o}\right) + \left(\frac{t_o - [t_o^2 - (0.8\text{ ns})^2]^{1/2}}{[t_o^2 - (0.8\text{ ns})^2]^{1/2}}\right)\right]$$

which is plotted as curve (a) in Fig. 2.

The error curve for a vertical amplifier with the same accuracy, but with a bandwidth of 1 GHz, is plotted as



2. Return on investment. Compared with an oscilloscope that has a bandwidth of 500 MHz and a time-base accuracy within ±(1.5% of reading + 0.5% of full scale) (a), doubling the bandwidth to 1 GHz (b) has less effect on rise-time measurements than doubling the accuracy to within ±(0.75% of reading + 0.25% of full scale) (c).

curve (b) in Fig. 2. When the bandwidth is doubled, the accuracy of the measurement is increased somewhat. If the maximum acceptable error is 10%, the minimum source rise time can be improved from 6.42 ns to 6.03 ns, or about 1.06 times, by doubling the bandwidth.

But the measurement capability can be nearly doubled by leaving the vertical amplifier bandwidth at 500 MHz and doubling the accuracy of the time base. The result is the error curve at (c) in Fig. 2. Again considering a 10% error, a pulse with a rise time of 3.59 ns can be measured.

Responding to many frequencies

Another factor that affects the accuracy of rise-time measurements is the fidelity of the vertical amplifier to true Gaussian response. It is imperative that all frequency components of the signal be applied to the CRT at the same time so that the display matches the input signal as closely as possible, since the most important oscilloscope applications are concerned with non-sinusoidal waveforms. For pure sinusoids, both amplitude and period can be much more accurately determined with a voltmeter and a counter. To achieve high fidelity, the phase response of the vertical amplifier must be linearly dependent upon the frequency.

By definition, these characteristics describe a Gaussian amplifier whose amplitude versus frequency response is functionally similar to $A = \exp(-X^2)$. Unfortunately, a true Gaussian amplifier is a physical and theoretical impossibility. Both impulse and step responses of such an amplifier would have a finite output prior to the arrival of the input signal, and the circuit characteristics of the amplifier would require an infinite number of identical poles and all zeroes at infinity.

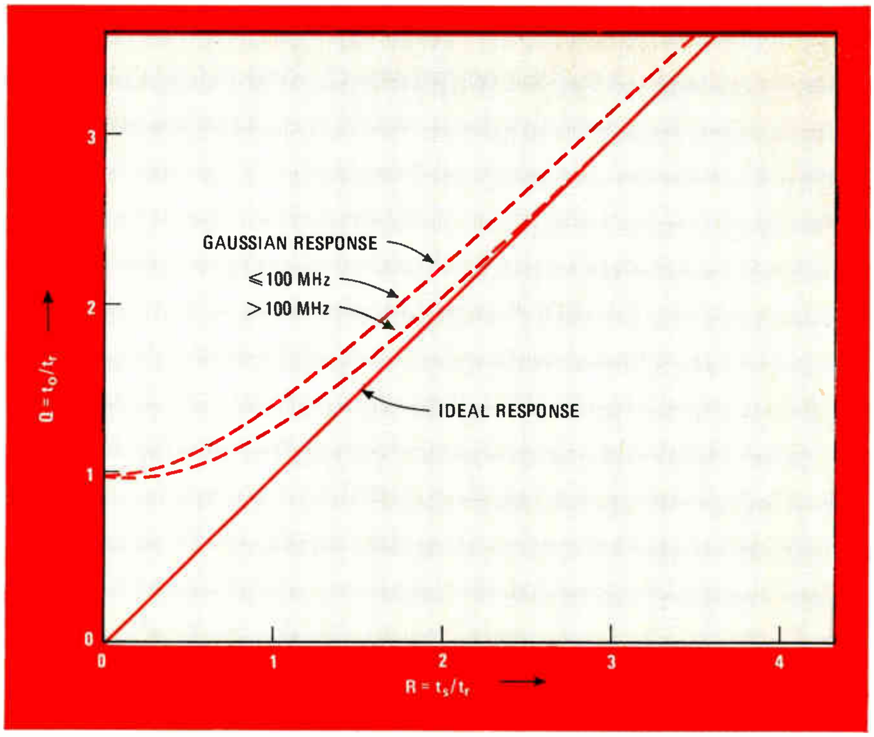
However, the vertical amplifiers in most oscilloscopes approximate Gaussian response very well. The pole and zero location is not the dominant characteristic of an amplifier with negligible peaking or pulse overshoot and, in fact, it can be shown that when the number of nearly identical poles becomes greater than five, the deviation from Gaussian response is less than 3%.

It can also be shown that the bandwidth-rise time product of a true Gaussian amplifier is 0.3396. The actual bandwidth-rise product of oscilloscope vertical amplifiers usually falls between 0.35 and 0.45. Those vertical amplifiers that have a rise-time-bandwidth product closest to 0.35 display the input signal best within their bandwidth limits. Those closer to 0.45 generally have unacceptable self-induced pulse overshoot.

Oscilloscopes can be classified into two groups—those with a bandwidth of 100 MHz or less and those with a bandwidth greater than 100 MHz—when considering the fidelity of their vertical amplifier responses with respect to true Gaussian response in measuring the rise time of fast pulses (Fig. 3). The response curves for a number of Hewlett-Packard real-time oscilloscopes with bandwidths from 75 to 275 MHz were normalized by using the ratios R and Q, where $R = t_s/t_r$ and $Q = t_o/t_r$. This allows the response curves to be plotted on the same graph and compares the fidelity of the vertical amplifiers to true Gaussian response without introducing time-base error.

The rise time, t_r, of each oscilloscope, which was typically much faster than specified, was measured with an HP 1108A tunnel diode displaying a rise time under 90 picoseconds. Then the source rise times, t_s, generated by an HP 8082A variable-transition-time pulse generator, were measured with an 18-GHz sampling-oscilloscope system. The scope has a maximum of 70 ps absolute error over the range of investigation (0.88 to 20 ns).

The responses were divided into two distinct groups. Typically, those oscilloscopes with 100-MHz bandwidth



3. Gaussian deviation. Oscilloscopes that have a vertical-amplifier bandwidth greater than 100 MHz have rise-time responses closer to the one-to-one response of an ideal amplifier than do amplifiers with a bandwidth of 100 MHz or less, even though the latter have responses nearly identical to that of the Gaussian prediction.

or less were, within experimental limits, Gaussian. Those with greater than 100-MHz bandwidth were faster than the Gaussian prediction, though within the industry's definition of Gaussian response.

Using these results, the root-sum-squares rise-time relationship can empirically be corrected to

$$t_s = 0.2\,t_r + (t_o^2 - t_r^2)^{1/2}$$

for the oscilloscopes with greater than 100 MHz response tested, and when t_o is equal to or less than 2.5 t_r.

The obvious benefit of wideband amplifiers is that for observed rise times greater than 2½ times the rise time of the oscilloscope, less than 0.1% correction is needed. The result displayed on-screen is essentially the source rise time. This relationship is valid within the practical resolution limits of the displayed waveforms.

While a wideband amplifier may be good enough, its Gaussian fidelity must be investigated to determine what corrections are necessary to improve the accuracy of the measurement. As a rule of thumb, the further the specified rise-time-bandwidth product is from 0.35, the more uncertain the measurement is near the specified rise time of the oscilloscope and the less valid is the standard root-sum-square correction.

The actual display resolution is another factor that must be considered when assessing the capability of an oscilloscope to measure rise times near its own minimum rise time. Strictly speaking, the rise time of the pulse produced by the source generator and the limits to which the display can distinguish between different source rise times is to be determined. Also to be determined is the accuracy that can be expected for a given measurement, as governed by the resolution of the display alone.

The resolution limits of the display are dictated by the sweep of the time base, the rise time of the vertical amplifier, and the user's ability to distinguish between and read the displays presented on the CRT. A good approximation of the resolution limits can be derived from the Gaussian root-sum-squares relationship, $t_s = (t_o^2 - t_r^2)^{1/2}$. The total derivative of t_s is

$$dt_s = \frac{t_o dt_o + t_r dt_r}{t_o^2 - t_r^2}$$

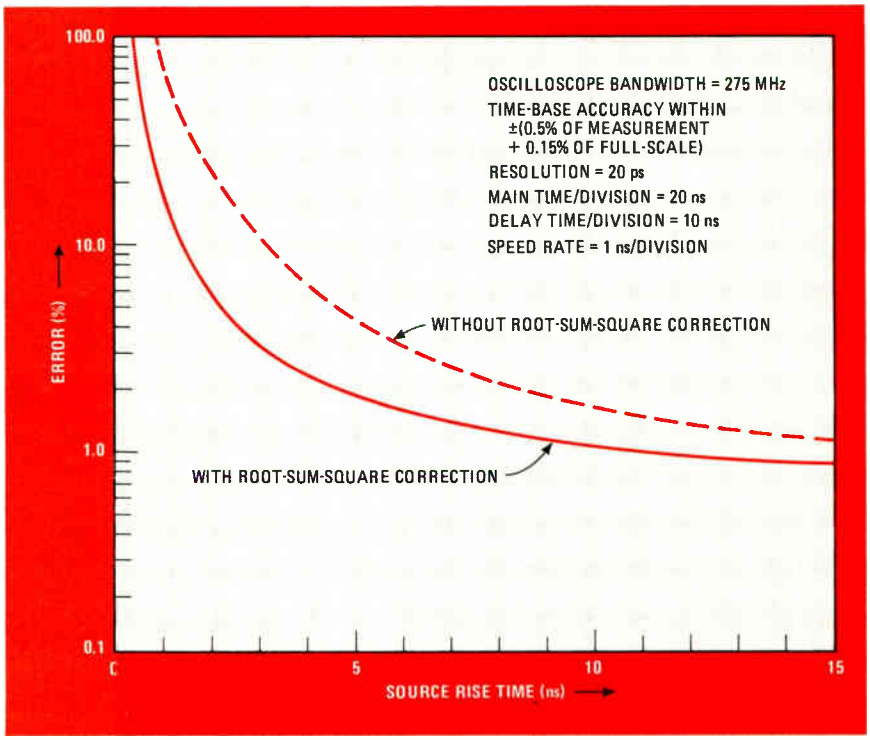
The quantities t_o and t_r can be defined by $t_o = t_1 s_1$ and $t_r = t_2 s_2$, where t_1 is the time interval in divisions of display of the observed rise time, t_2 is the time interval in divisions of display of the oscilloscope rise time, s_1 is the sweep speed in time per division of the observed rise time, and s_2 is the sweep speed in time per division of the oscilloscope rise time. If t_o is approximately equal to t_r, or at least $s_1 = s_2$, and the error introduced by the time base is ignored, then $dt_o = dt_r = dt$, which is the reading resolution of the measurement.

By substitution and simplification, the error in the corrected determination of the source rise time is

$$E_R = 100\frac{dt_s}{t_s} = 100\frac{dt}{t_1 - t_2}$$

Therefore, assuming the root-sum-square correction is used to measure the rise time of the source, the unavoidable error contributed by the uncertainty in resolution depends on the time-interval difference between the observed rise time of the source and the scope rise time. Hence, an oscilloscope will contribute to resolution accuracy if it has a time base fast enough to spread the observed rise time over a large portion of the CRT ($t_1 - t_2$), has good trace crispness, and has enhanced readability (dt) as provided by high-resolution digital tracking of the time interval measured.

With this estimate of the error caused by resolution in hand, the error contributed by the time base when using



4. Correcting for deviations. When time-base inaccuracies, resolution limits, and deviation from true Gaussian response are taken into account by applying the root-sum-square correction, the error in rise-time measurements can be reduced.

the root-sum-square correction is yet to be determined. Returning to the original total derivative and casting it into the form of time-base error,

$$E_{TB} = 100\frac{dt_s}{t_s} = 100\frac{t_o dt_o + t_r dt_r}{t_o^2 - t_r^2}$$

This error, which is independent of the resolution error, therefore, must be added to that error to determine the total error inherent in the measurement and in the subsequent correction. The total error, E_T, is given by

$$E_T = \pm 100\left(\frac{t_o dt_o + t_r dt_r}{t_o^2 - t_r^2} + \frac{dt}{t_1 - t_2}\right) \qquad (3)$$

Assuming Gaussian correction, this equation, which describes the error in t_s, can be compared with the equation plotted in Fig. 2, which describes the error in t_s with no correction for Gaussian response (Fig. 4).

Measuring between transitions

Although rise time is an important parameter, it forms only a subset in the spectrum of time-interval measurements. Propagation delay and pulse width are two other important parameters, and making these measurements with an oscilloscope must also be examined.

When the rise times of the leading edges or leading and trailing edges that define a time interval are different and one or both approach the rise time of the vertical amplifier, the response of the vertical amplifier again contributes to error. However, the corrections needed to compensate again are small when compared with those for time-base error.

If it is assumed that the observed rise times of the leading and trailing edges of the waveforms are connected to the source rise time by either the standard or corrected root-sum-squares relationship, it can be shown that

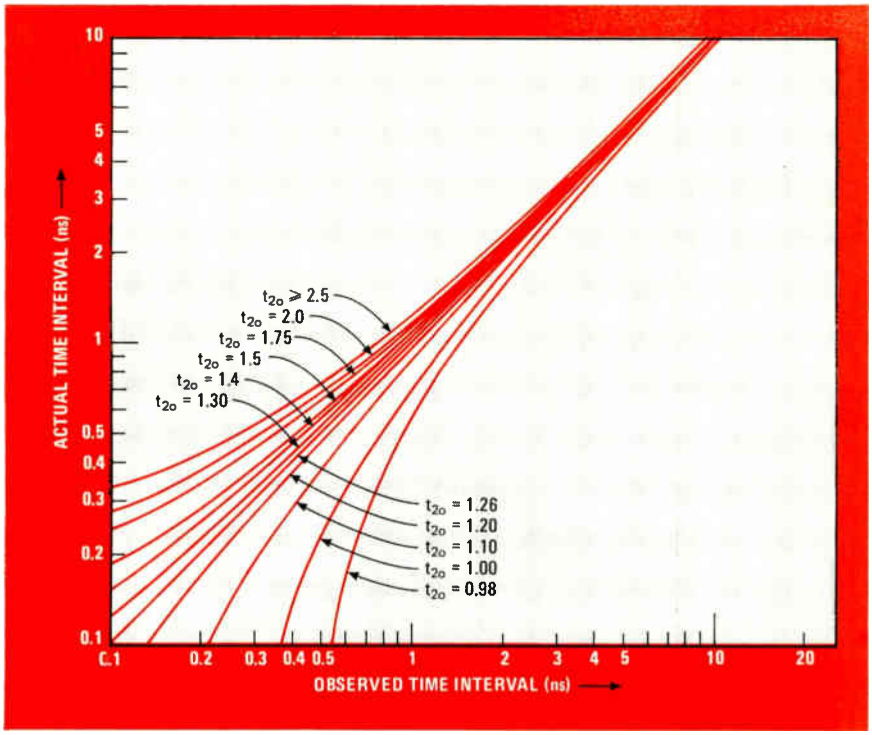
$$t_{is} = t_{io} + t_r[B([S^2 - 1]^{1/2} - S) - A([R^2 - 1]^{1/2} - R)]$$

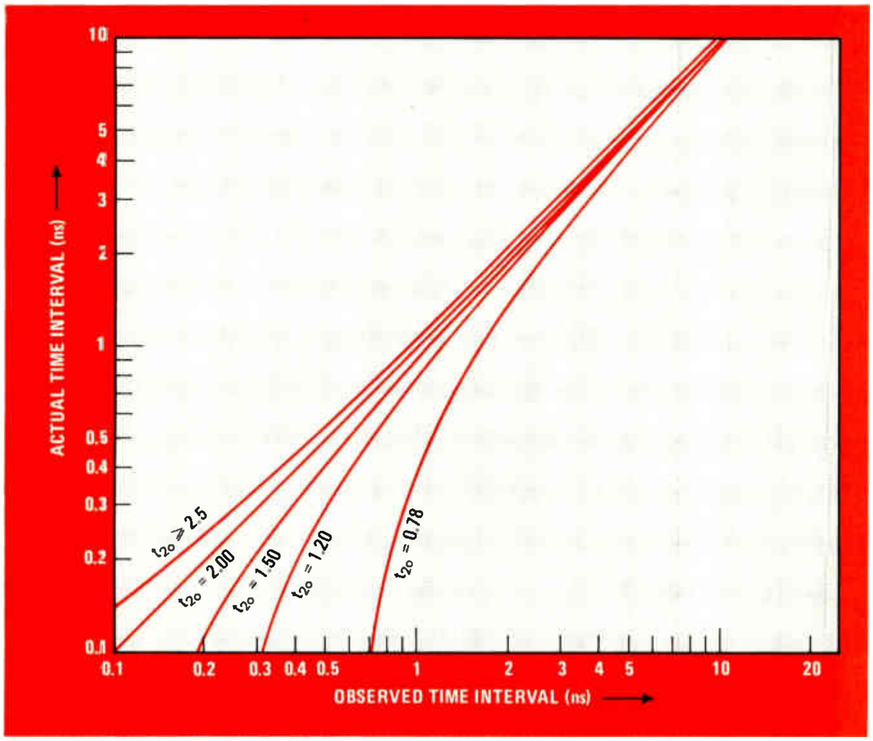
where t_{is} is the time interval of the source, t_{io} is the observed time interval, t_r is the scope rise time, S is the ratio of the observed rise time of the trailing edge to the scope rise time (t_{2o}/t_r), R is the ratio of the observed rise time of the leading edge to the scope rise time (t_{1o}/t_r), A is analagous to the vertical point on the leading edge of the waveform to which the measurement is made, and B is analagous to the vertical point on the trailing edge of the waveform to which the measurement is made.

This relationship shows that if the rise times of the leading edge and trailing edge are equal and A = B, then $t_{is} = t_{io}$, proving the earlier assumption that, with equal rise times on leading and trailing edges of waveforms, only the accuracy of the time base is important for the measurement. On the other hand, if one edge is very fast, that is, if either S or R = 1 and the other is slow, then for small time intervals, the response of the vertical amplifier does introduce error in the determination of the actual time interval.

A practical application of this relationship is in measuring the propagation delay of a logic gate by measuring the time interval between the input and output pulses at the 50% points of their amplitudes (Fig. 5). The rise time of the first pulse is defined as t_{1o} and the rise time of the second pulse is defined as t_{2o}. The object is to determine the actual time interval between the events using the observed time interval.

In Fig. 5(a), the family of curves represents emitter-coupled logic, ECL III, with t_{1o} of approximately 1 ns measured between the 20% and 80% points on the pulse. In Fig. 5(b), the family of curves represents ECL 10K logic, where t_{1o} is approximately 2 ns, measured between the 20% and 80% points. Other assumptions





5. Between transitions. The same kinds of corrections can be applied in time-interval measurements if the rise times of the oscilloscope and the transitions that define the time interval are known. Curve (a) is for ECL III measurements, where the rise time of the first transition is 1.26 ns, and curve (b) is for ECL 10K, with a rise time of 2.06 ns. In both cases, the oscilloscope rise time is 0.98 ns.

are that the oscilloscope's rise time is 1.0 ns, that the oscilloscope's response is faster than Gaussian so that $t_s = 0.2\ t_r + (t_o^2 - t_r^2)^{1/2}$, that t_{2o} varies from 1.0 ns to 2.5 ns, and that t_{1o} varies from nearly coincident to 10 ns.

Two preliminary observations can be made. As the observed time interval is increased, its deviation from the actual time interval becomes less important, and as the rise times of the pulses becomes slower, the error introduced by the vertical amplifier response diminishes.

The true time interval can be determined by measuring the rise times of the first and second pulses and the time interval between them. If t_{1o} is 1.26 ns, t_{2o} is 2.0 ns, and t_{io} is 1 ns, then, from the curve in Fig. 5(a), t_{is} is 1.17 ns. The true time interval is 17% longer than the value measured on the oscilloscope.

In this measurement range, the error caused by time-base inaccuracies is at least 20%. Of course, if any larger time-base error is present, as it is in all but a few oscilloscopes, corrections for vertical-amplifier errors are quantitatively meaningless—regardless of bandwidth. □

Product development profile

Lasting computer designs exploit standard parts

Distributed parallel logic, memory interleaving, achieve high marks for Eclipse units

by J. T. West, *Data General Corp., Southboro, Mass.*

☐ Trial-and-error techniques in the design of computer products have a much smaller chance of economic success today than they did not long ago. On the one hand there is the shrunken supply of investment capital, which makes each dollar less expendable for uncertain avenues of approach. On the other hand there is the fast pace of technology that makes overdesign easier, even though it remains economically undesirable. There is, in other words, less latitude for the computer-design engineer in finding an acceptable path between overdesign and underperformance.

At any rate, such were the circumstances facing Data General Corp., Southboro, Mass., when it set out to design what became the Eclipse family of computers. Data General designers had to evoke reliable state-of-the-art performance from readily available components, and one measure of their success has been shown through the running of benchmark Fortran programs, which the Eclipse has done faster than many larger machines. Yet its performance comes not from new technology but from clever architectural design, using relatively common components.

Design goals for the Eclipse system—processing speed, reliability, and high-level language orientation—were met by using cache memories together with intelligent high-speed core and semiconductor memories that could correct their own errors, plus a floating-point processor that runs in parallel with the Eclipse CPU, and a microcoded instruction set to help users get the best possible performance out of high-level languages and operating systems.

The results of combining innovative design with conservative technology are manifested, first of all, in a decentralized architecture based on Schottky TTL medium-scale integration (MSI). Although there has been a steady emergence of many new large-scale integrated logic components, a less noticeable but nonetheless dramatic development has also occurred: MSI logic has been dropping in cost to the point where high chip counts can still be cost effective.

Getting closer

The low cost of MSI logic (defined here as a standard-product, general-purpose chip of 25- to 125-gate complexity) allows engineers to use it "redundantly" by moving certain logic physically closer to its appropriate function, rather than in the central processing unit. Memory-control logic, for example, was distributed to each memory board so the memories themselves—not the CPU—could control and coordinate data traffic in and out. This idea of "distributed parallel logic" enables memory logic to run in parallel with CPU logic and thus save CPU processing time.

The processing speed, or throughput, of the entire system was more important to the designers than was CPU clock cycle time or memory speed. Neither one tells much about a system's throughput because they do not take into account the many additional factors that affect a system's performance in actual operation.

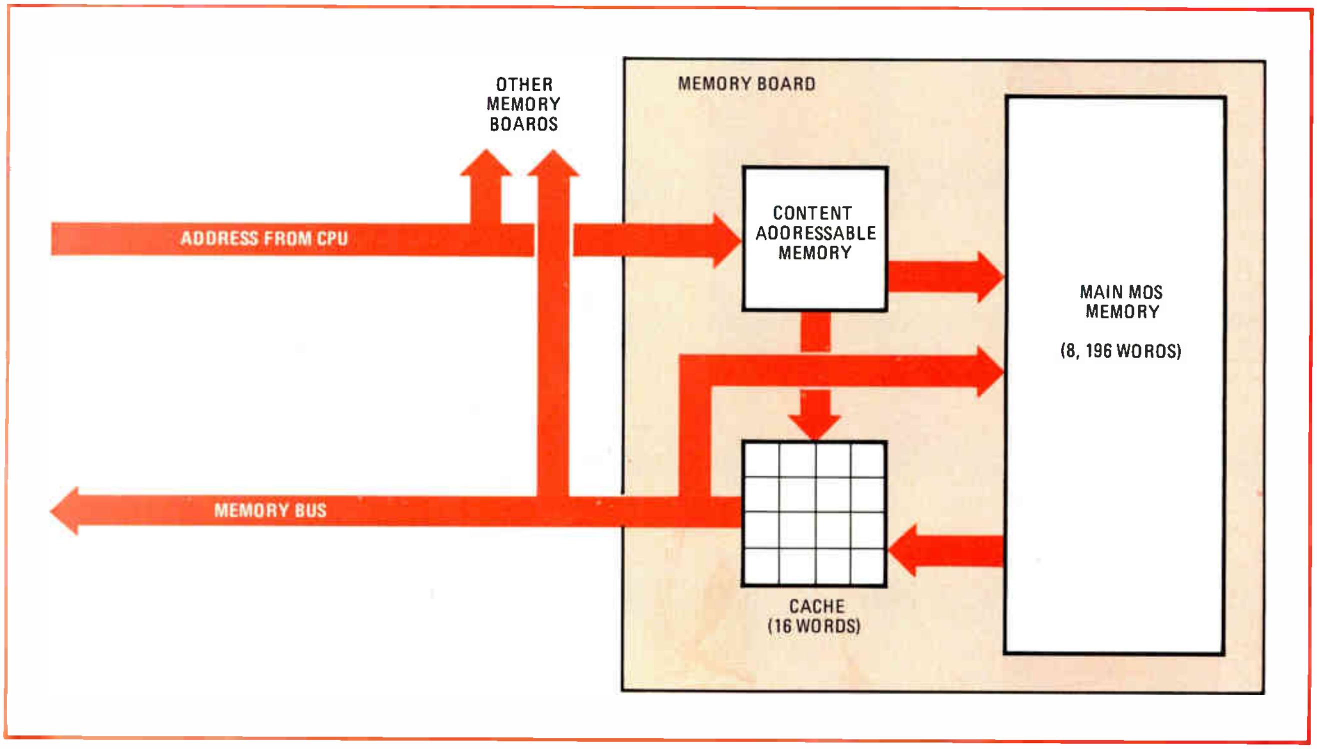
A better system-performance measurement can be obtained from the system bandwidth—the memory's word length multiplied by the number of words that can be accessed in a second. The resulting figure, when broken down into 8-bit bytes, shows how many millions of bytes per second the computer can access. For example, for a 16-bit word length and 3.2 million words accessed per second, the system bandwidth is about 6.4 megabytes per second.

Because the bandwidth computation takes into account the CPU clock-cycle time, memory speed, and memory bus capacity, it gives a more realistic indication of the computer's workday performance than do any of other features listed separately. A CPU with an impressive clock cycle of 200 nanoseconds, for example, may be required to access a memory that cycles at only 800 ns. Thus the CPU may spend much of its time idle, waiting for additional data to arrive from memory before processing can continue.

The Eclipse CPU has a clock cycle time of 200 ns, memory speeds of 800 ns for core and 700 ns for semiconductor, and a memory bus bandwidth of 20 megabytes per second. Though the memory speed might seem to be a weak link in achieving high computer throughput, it is not. A distributed semiconductor cache buffer (a small bipolar memory built into each MOS memory module) enables the Eclipse CPU to access two bytes of data every 200 ns, (100 ns per byte) or as fast as its own clock can cycle. The overall system bandwidth thus is about 10 megabytes per second, and the CPU is kept busy full-time.

A 16-word high-speed bipolar memory serves as a

1. Fast cache delivery. A high-speed bipolar cache memory holds 10 words. When a word is requested, the content-addressable memory gives the location of the data. If it is not already in cache, it and the contents of the three adjacent cells are loaded into cache.



The entrepreneur engineers

"About the most interesting thing about how this company works as opposed to other companies is that a project team is really seen as sort of a small company-within-a-company," says author West in recapping the history of the Eclipse design project. "It's not necessarily a profit center in the strictest sense, but the team of designers is regarded as a group of entrepreneur-engineers trying to produce a cost-effective product that serves a need in the marketplace."

Data General, he points out, was founded by an engineer-turned-entrepreneur (Edson deCastro, now DG president) who rebelled at the idea of designing a product to meet multiple specifications sent down from other groups. Instead, West says, Data General's philosophy is to allow design engineers to independently pursue ideas that they feel will lead to marketable products. Thus, much of the company's product planning moves up from the ranks rather than down from an ivory tower.

In the process, the marketing organization and software groups are consulted because, as West puts it, "anybody who designs minicomputer hardware that doesn't relate closely to software and to the market will not win the chance to design another product."

In telling the history of the Eclipse design, West recalls the early skepticism among the engineering staff as to whether the computer could be built cost-effectively in the first place and whether there was a market for such a high-end minicomputer. "There were times," he says, "when there were large doubts, and the only thing that kept the project going was the faith of management that unless you allow an engineer the freedom to stumble along the way, you will not get good products." He adds: "When you're designing products in the minicomputer business, which is moving so fast, you've got to be a little clairvoyant to design a completely new processor. And arguing for the right to do it is difficult initially because all you've got are qualitative arguments to help you convince management."

As to how the design process itself is changing, West asserts that the days of "hunt and peck" designing, where an engineer works for months on breadboarded logic circuits, are gone forever. What you must do today is "sit down with paper, pencil, and logic-symbol template, and design the computer right the first time. You write a definition of the project to make sure you really understand what it is that you're trying to accomplish, and then you design the critical parts of the system and see how those fit together. Then you design the rest of it." Finally, says West, "you heavily review it with a group of other people who know computers and then you can build the circuits directly on etched printed circuit boards."

cache buffer and acts as a "front end" for the regular 8-kiloword MOS main memory. When the CPU requests a word from memory, it checks a content addressable memory (CAM) for the location of the data (Fig. 1). If the word is already in cache, it is sent to the CPU in 200 ns. If not, it is retrieved from main MOS memory and sent through the cache to the CPU in 700 ns. Simultaneously, the cache is loaded with the addressed word plus the words from the three adjacent memory locations. Because programs tend to be sequential in nature, the next location requested is likely now to be in cache. If requested, that word will then be transmitted to the CPU in 200 ns.

Each memory board contains its own local cache and so the ratio of bipolar cache to MOS memory remains constant no matter how many memory boards are used. This allows easy memory expansion.

At the time the Eclipse was being designed, the only MOS-bipolar cache system in general use was the "global" cache, consisting of a large amount (typically greater than 2,000 bytes) of bipolar memory inserted as a buffer between the CPU and main MOS memory. Eclipse engineers began designing a global cache early in the project, but they grew disenchanted when the quantity and complexity of the logic needed to handle cache activity rose to unmanageable proportions, especially as the cache system was being designed to allow for future Eclipse product-line developments. Furthermore, the global cache concept would present a major shortcoming in a small-computer system: main-memory size varies more widely among small computers than large, and global cache capacity could not be enlarged or reduced to correspond to the main-memory size in a given system, so its cost effectiveness would be unbalanced in many systems.

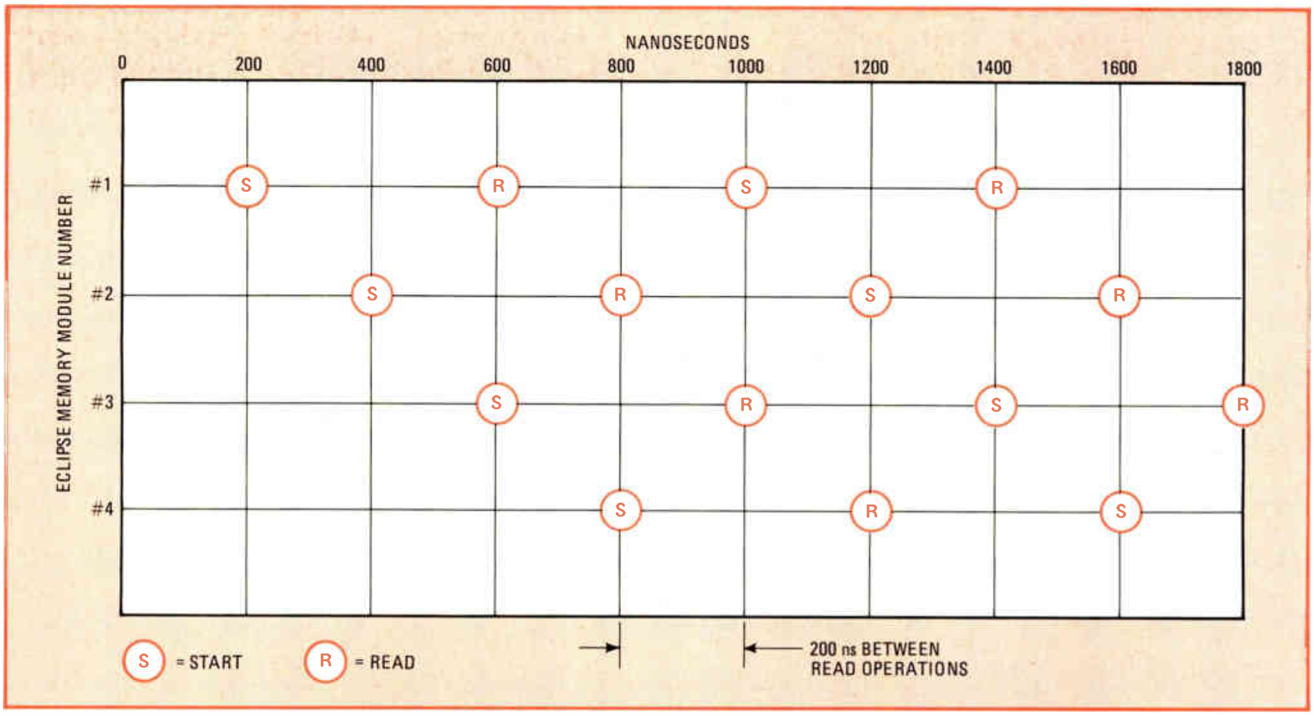
Power considerations

This distributed-cache concept grew out of several important decisions. The designers could have attained high-speed memory access by using bipolar logic throughout each memory board, but that would not have been practical because of power considerations. Current-driven bipolar logic requires considerably greater power and generates far more heat than voltage-driven MOS, and for 128-kilowords of main memory, the computer would have required a power supply about 20 times more powerful than eventually used.

Another question was whether to use 2,048-bit or 4,096-bit MOS random-access memory for the main semiconductor memory. The "conservative-technology" philosophy favored the older 2-k RAMs over the faster but just emerging 4-k technology because the performance and reliability information available for 2 k was much greater. And a number of dependable suppliers were manufacturing pin-compatible 2-k RAMs as standard products, so vendor dependence would be minimized. The 2 k's lower-speed was more than offset by the 16-word local cache buffer.

In operation, once the Eclipse cache buffer is full and the CPU requests a word not in cache, special logic implementing a least-recently-used (LRU) algorithm removes the least-recently-used four-word block from cache so the CAM can replace it with the newly addressed word plus the next three consecutive words in the main memory.

Actually, the LRU logic constantly monitors and coordinates cache activity. It continually assigns ratings—i.e., most recently used, next to most, next to least, and least-recently used—to each four-word block in



2. Interleaving. Up to eight memory boards can be interleaved. This example shows four-way interleaving. With a clock cycle of 200 nanoseconds, a new memory module is started every clock cycle and read 400 ns later. Thus, memory read operations occur every 200 ns.

cache, and it flags "invalid" data, making that data the next candidate for replacement. The LRU logic considers any word invalid if it is written back into main MOS memory in its cache form because that word may have been changed during processing.

As the Eclipse designers became more disillusioned with the global cache, one team member developed a "local cache" MOS system on a single 15-inch-square memory board that could be controlled by LRU logic contained in just five MSI chips. By choosing the distributed-cache method over the global cache, Eclipse engineers could keep the cache size manageable and in correct proportion to total MOS memory, no matter how many memory boards are eventually installed in a particular system.

A problem arose when initial prototypes showed each MOS/bipolar-equipped memory board drawing in excess of 5 amperes at 5 volts. In a large memory system, many memory boards running simultaneously would exceed the Eclipse power supply rating of 65 A at 5 V. One alternative—to restrict the number of semiconductor memory boards to be used with each Eclipse—was rejected out of hand.

A second alternative—to redesign a more powerful power supply—was under consideration when one Eclipse engineer substituted some new low-power Schottky chips for standard TTL chips used on the board. The low-power Schottky saved a total of 2 A per board with no decrease in speed and brought the power down to 3 A at 5 V per board—about the same power as is used for a core-memory module.

Memory interleaving, another means of achieving fast processing speed, was adopted for both core and semiconductor memories (see Fig. 2). Interleaving, like cache, takes advantage of the fact that most computer programs tend to reference sequential addresses. In interleaving, sequential addresses are placed on sequential memory boards (the Eclipse can interleave two, four, or eight memory modules at a time) so that the CPU can fetch a word, manipulate it, then fetch the next word without having to wait for completion of one board's memory cycle.

In operation, the Eclipse CPU may start a second memory fetch before reading a word from the first, then start the third before reading from the second, and so on. Memory timing generators and control circuits are mounted on a memory controller on each core and semiconductor memory board so the memories can determine where addresses should be written, which words should be sent to the CPU, and in what order they should be sent.

Proven their worth

Large computers were already using two-way interleaving, but there was some doubt among other engineers that four or eight-way interleaving would be more cost-effective than two way. However, four- and eight-way interleaving have since proven their worth: four-way core memory interleaving reduces effective memory cycle time for typical programs from 800 to below 600 ns, while eight-way can reduce core cycle time to 550 ns.

Large-memory configurations typically have a poorer mean time between failure than smaller memory systems. Single-bit errors also are more likely to occur in semiconductor than in core memories. As technology matures, semiconductor reliability will improve, but with available memory devices the Eclipse engineers needed are error-correction method to go hand in hand with the larger semiconductor memory designs. And although few engineers or programers could recall seeing a random core failure, the designers wanted to provide a memory for ultra-critical applications, like nuclear-reactor control or oil-pipeline monitoring. Error correction therefore had to work with core as well as semiconductor memories.

The most common error-detection method—simple byte parity—can detect single-bit errors, but cannot locate or correct single-bit errors. When such an error is indicated the operator can either shut down the system and call a repairman and wait, or proceed with processing and hope that the malfunctioning bit will not affect a critical operation. A third option, restarting the whole data-processing job, can be wasteful if the job is very large.

For simple byte parity, two check bits are added to every data word written into memory. But a far more effective method—error checking and correction (ERCC)—can be created by adding five check bits to each 16-bit word. The standard Data General core mat had to be redesigned to accept the error-correcting 21-bit word, but the designers recognized that this was less costly and less troublesome than might have been the case. Such design changes were easy, however, because Data General makes its own cores and core mats and uses just one type core for every core memory.

Data General's error checking and correction feature, optional for core and standard with semiconductor memories, automatically detects and corrects all single-bit errors and detects most—an average of 97%—of the multiple-bit errors. This allows the operator to schedule computer maintenance at his convenience and to maximize total system "up time." Using ERCC, an Eclipse computer with 256 kilobytes of semiconductor memory can actually run with as many as 64 chips missing (four from each 16-kilobyte board).

When an error occurs with ERCC, the memory-logic circuit flags and locates the error, corrects the inaccurate word, and writes it back into memory while sending the corrected version to the CPU. The process begins in the special encoding logic mounted on the memory board, which adds a 5-bit coded check field to every 16-bit word written into memory. Each check bit is responsible for the parity of eight different data bits in the word. (Check bit 1, for example, operates on data bits 4 through 10 and bit 15. Check bits 0, 2, and 4 operate with even parity—they set their bits if the total number of 1s is even. Check bits 1 and 3 operate with odd parity—they enter a 1 if the total number of 1s is odd. For example, for the data word shown in Fig. 3, the check field is 0, 1, 1, 1, 0.)

When the 21-bit word is read from memory, the encoder logic recalculates parity, this time adding the check field to this calculation. This way, all "error" bits should read zero if there is no error, and the word is sent to the CPU with no loss in cycle time. If an error has occurred, and the error bits show one or more "ones" (Fig. 3 shows error bits 1, 0, 1, 0,0, indicating an error), special fault-code logic consults a fault-code table (Fig. 3) to find which bit is at fault. When an error occurs, it is corrected and flagged in 200 ns for core memory, 800 ns for semiconductor.

Here again the encoder logic is distributed in parallel to each ERCC-equipped memory module. The dozen MSI ERCC chips could have been placed in the CPU, but that would have caused a loss in CPU speed.

Broadening the base

High-level programing languages, such as Fortran, and sophisticated operating system software have been responsible for broadening the small-computer customer base and have shown many first-time computer users that running a computer is not much harder than writing a letter. And as small-computer applications become more comprehensive, the job of the operating system—to schedule and coordinate interrupt activity, to partition and switch programing contexts, and to process system and user commands—is more important than ever before.

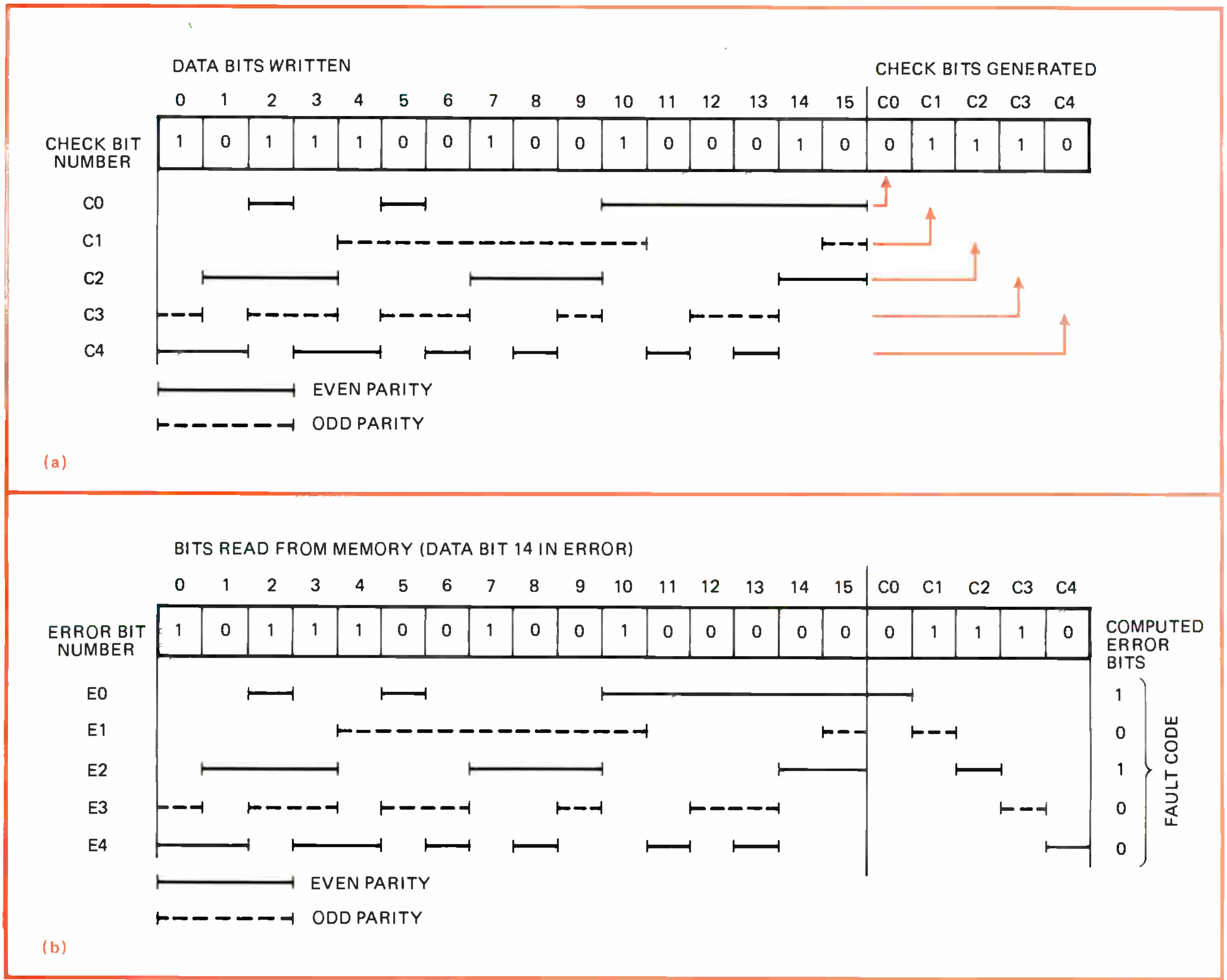
Two Eclipse features, the floating-point processor and a microcoded instruction set, were designed to accelerate high-level language and operating-system processing. These features not only aid system performance but also make generation and debugging of new languages easier for Data General programers as they develop new Eclipse software.

A number of architectural possibilities for floating-point processing confronted the designers. For one, floating-point instructions could be microcoded into the CPU microprogramed control store that holds the regular instruction set (including fixed-point operations). This was rejected because it would prohibit floating-point processing in parallel with the fixed-point operations, a feature considered necessary for fast processing of mathematical high-level languages like Fortran and Algol. Another possibility was to microcode a general-purpose CPU—perhaps another Eclipse—to handle floating-point arithmetic and run it in parallel with the main CPU. But this still would not have been fast enough.

The route taken by Eclipse engineers was to include a fixed-point CPU but also build a completely new floating-point CPU that would be optimized to perform only floating-point instructions. The two-board floating-point processor, which performs comparably to that of IBM's 370/158, has proven to be one of the fastest in the computer industry.

The floating-point processor contains four 64-bit program-accessible accumulators, a 32-bit status register, and 56 single- and double-word instructions. It can execute arithmetic instructions between floating-point accumulators and also between memory and any of the floating-point accumulators. When floating-point computation must be interrupted, a single instruction saves the contents of all accumulators and status registers in a hardware stack. Another instruction reverses the process. Distributed parallel logic mounted on the floating-point and the fixed-point boards allows a program to execute floating-point arithmetic while the CPU does other processing.

Perhaps the most signficant feature for general-purpose high-level language and operating-system optimization is the instruction set. The decision to microcode extended instructions into TTL bipolar ROMs rather than



FAULT CODE	MEANING
00000	No error
00001	Error in check bit 4
00010	Error in check bit 3
00011	Error in data bit 0
00100	Error in check bit 2
00101	Error in data bit 1
00110	Multiple-bit error
00111	Error in data bit 3
01000	Error in check bit 1
01001	Error in data bit 4
01010	All data bits and check bits in location are 1
01011	Error in data bit 6
01100	Error in data bit 7
01101	Error in data bit 8
01110	Error in data bit 9
01111	Multiple-bit error
10000	Error in check bit 0
10001	Error in data bit 11
10010	Error in data bit 12
10011	Error in data bit 13
10100	Error in data bit 14
10101	All data bits and check bits in location are 0
10110	Error in data bit 2
10111	Multiple-bit error
11000	Error in data bit 10
11001	Multiple-bit error
11010	Error in data bit 5
11011	Multiple-bit error
11100	Error in data bit 15
11101	Multiple-bit error
11110	Multiple-bit error
11111	Multiple-bit error

(c)

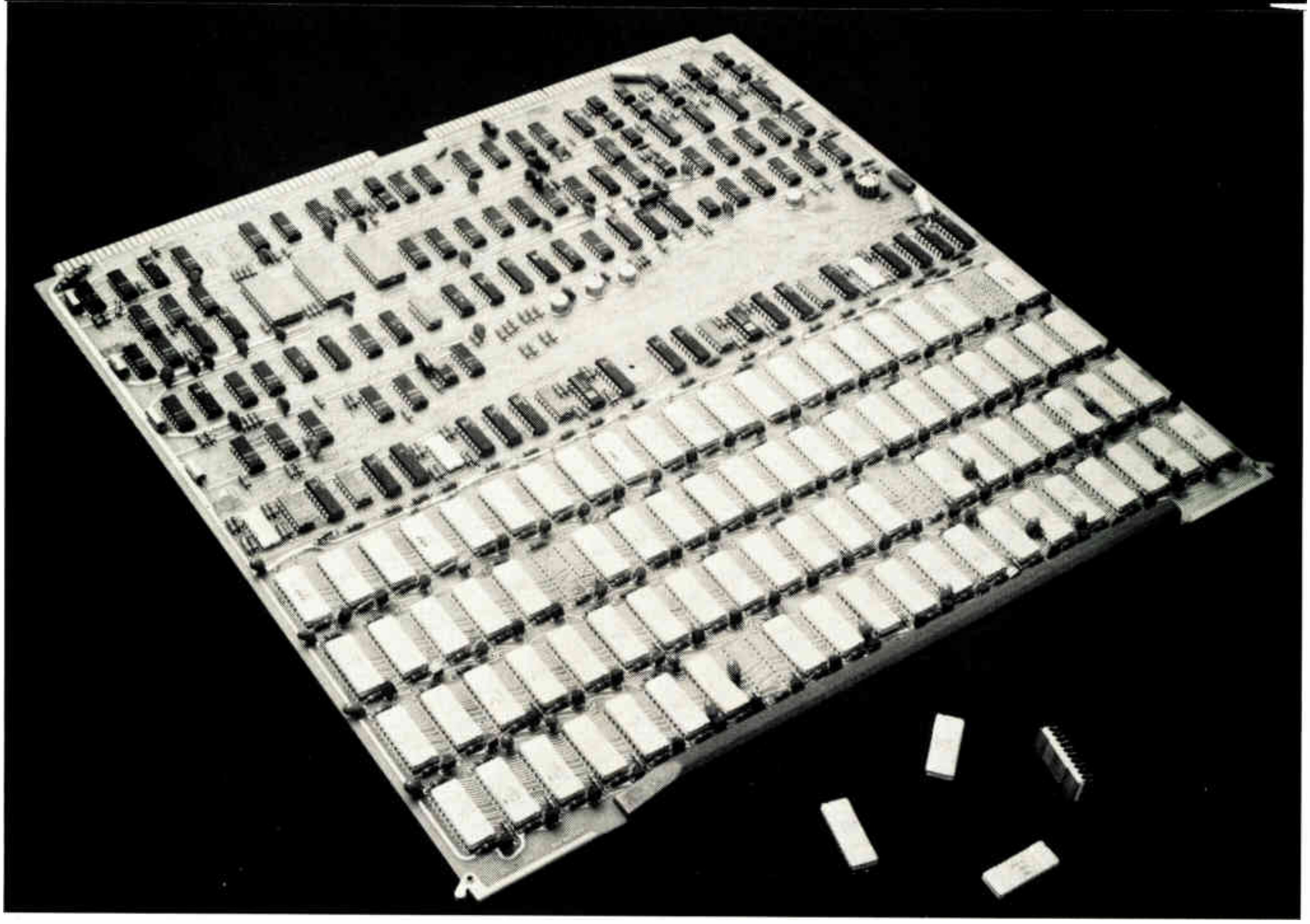
3. Error correction. Five check bits are added to each 16-bit word stored in memory. Each check bit uses a different combination of data bits to determine its own state. Check bits based on even parity enter a 1 if there are an even number of 1s in its data-bit group. A check bit for odd parity enters a 1 if number of 1s in its data-bit group is odd. Upon read-out, the error pattern reveals a bit in error.

to use conventional software subroutines also is related to distributed parallel-logic theory. The tradeoff was one of increased chip cost (in ROMs) versus time-consuming software routines, and the answer was to optimize software performance by putting commonly used subroutines into microcoded 1-k ROMs.

The Eclipse instruction set contains the standard Nova instructions plus more than 40 extended instructions, including bit, byte, and word addressing and operations, signed and unsigned multiply and divide, decimal add and subtract, block move and block add and move, vectored interrupts, and accelerators for compiling high-level languages.

Each microinstruction word is 56 bits long, allowing a large number of operations to be performed simultaneously in one CPU cycle. Additional logic can disconnect the microcode to perform certain high-speed instructions in hardware.

Implementing a 56-bit-wide microinstruction set



4. Memory board. The Eclipse semiconductor memory uses 2-kilobit chips and, with the error correction techniques, the memories have been operated with as many as four chips unplugged, simulating complete failures. Each memory module holds 8,192 words.

meant using two to four times as many read-only-memory (ROM) chips as with the narrower words of other computers. However, a narrow microinstruction word-length would have meant slower performance–it would have taken several instruction cycles to do the work of one wide instruction word. As Eclipse engineers evaluated these tradeoffs, the unit price of 1-k programable read-only memories (PROMs) dropped from about $50 to below $10, enabling the Eclipse designers to use a wide-word instruction set.

As an example of how one powerful firmware instruction can facilitate the performance of the operating system, the Vector instruction takes an interrupt, stores the machine state, branches to the appropriate device handle, switches stacks and allocates a stack frame in just 18 microseconds. This process would take a number of sequential subroutines if it were done by the operating system.

User microcoding

In addition to the regular instruction set, a special segment of RAM, containing 256 56-bit words, is set aside in models for user-programed microcode. Called a writeable control store, it lets the sophisticated user microcode his own specialized instruction set. This is suited particularly for applications such as communications and signal processing that require efficient execution of a few rather well-defined algorithms. User microprograming often allows these algorithms to be implemented at speeds approaching those of dedicated hardware designs with the additional benefits of greater flexibility and reduced implementation cost. Like the regular microcode, each 200-nanosecond CPU cycle executes a 56-bit microinstruction in which up to three data paths may be controlled simultaneously.

The engineers also put the writeable control store to use in writing the extended commercial instructions for the Eclipse C/300 commercial computer. The microprogramers ran each commercial instruction in the store to make sure it was bug-free before fixing it in read-only memory. Without the availability of the writeable control store, the Data General programers would have had to burn and discard a number of PROMs in the instruction-writing process before arriving at a bug-free instruction set and implementing it in read-only memory. (Because of the extended commercial instructions, the C/300 does not offer a user-programable writeable control store.)

Computer designers must be aware that today's blueprint won't become a computer reality for a few years, and that once it does become a real product it has to remain competitive and free of obsolenscence for many years after that. In some ways, the Eclipse design project was a lesson in clever engineering for members of the design team. Having to design within the "conservative technology/innovative design" philosophy, the Eclipse designers learned not to overlook obvious advantages of *non*-state-of-the-art technologies. While LSI caught the attention of the computer industry, MSI prices were dropping dramatically; application of the distributed-parallel-logic concept to the design enabled the Eclipse team to get the required high performance out of relatively common components, and at no loss in reliability. □

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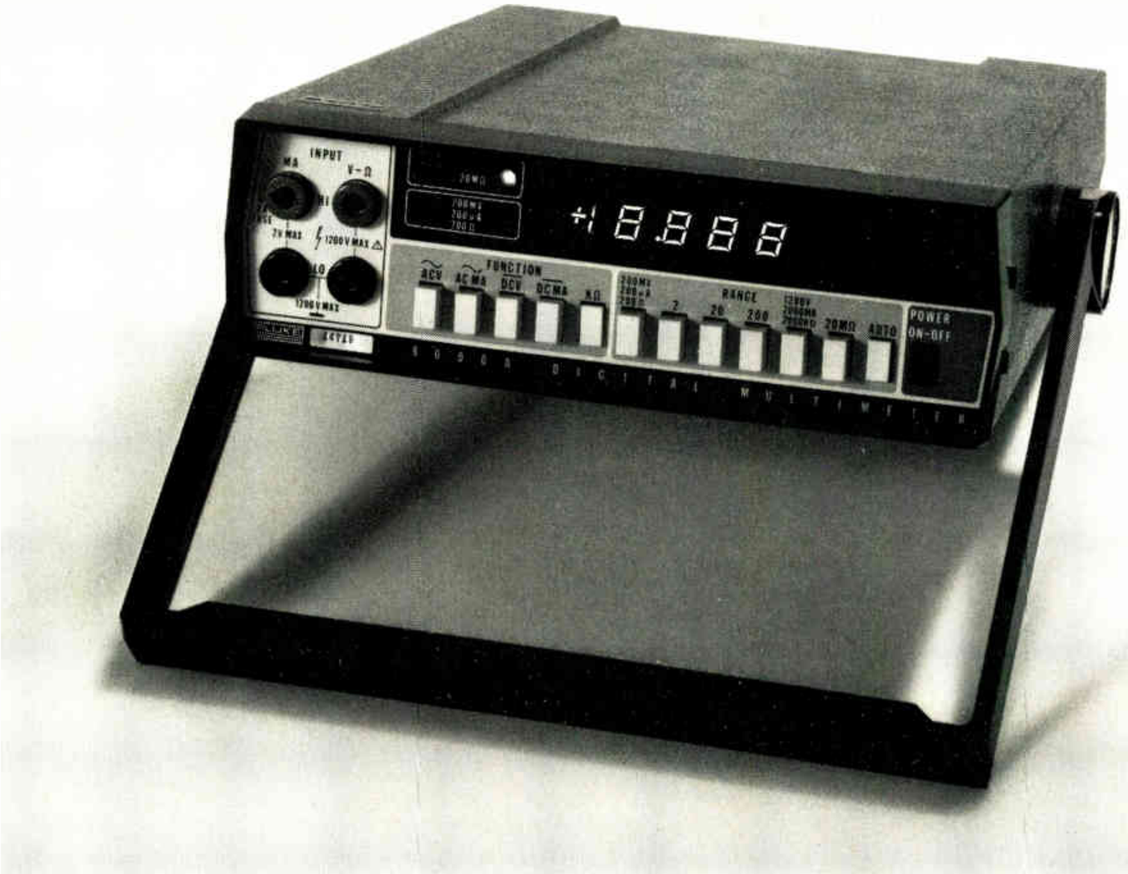

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CCD array forms random-access memory

by Roger T. Baker
Tabor, N.J.

Charge-coupled devices have previously been used in shift-register serial-readout memories, but not in random-access memories. The arrangement described here, however, uses CCDs in a RAM. This memory provides nondestructive readout, with access and cycle times as low as those of present MOS memories. This RAM is extremely simple in concept, construction, and operation. It utilizes the basic functions of a CCD—storing minority carriers in a potential well, and transferring these minority carriers from the well beneath one electrode to the well beneath a neighboring electrode.

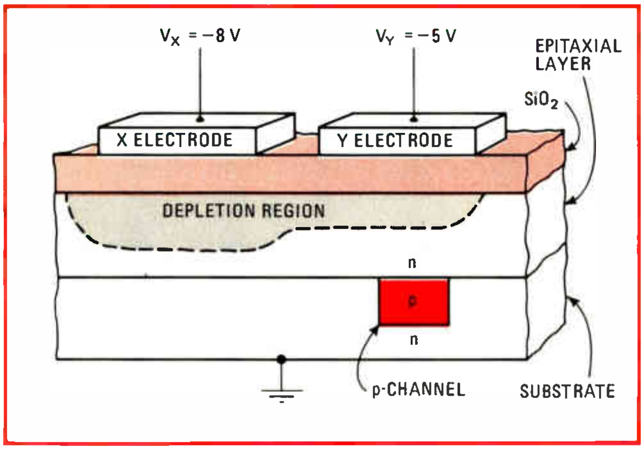
The CCD unit cell is better than other one-transistor cells because it is smaller (each cell has only two surface electrodes); response time is faster (no high-resistance channels are in series with the sense circuit); construction is simple; and readout is nondestructive.

This random-access memory consists of a monolithic array of CCD units like the one shown in Fig. 1. An array of N × N of these basic CCD cells, connected as shown in Fig. 2, can store N^2 bits that are completely accessible. Each CCD cell has two electrodes—X and Y. All of the X electrodes of the CCDs appearing in the same rows are connected in parallel to form the row-select lines, and similarly all the Y electrodes of the CCDs appearing in the same columns are connected in parallel to form the column-select lines.

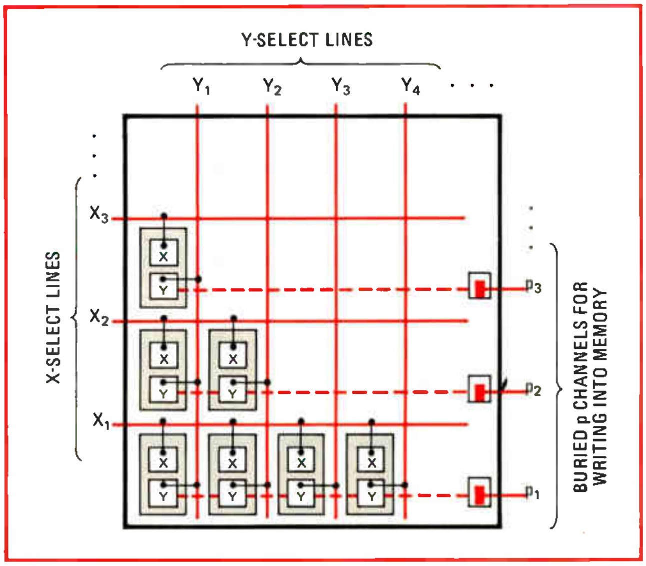
Binary data is represented by the presence or absence of minority carriers in the depletion-region potential well beneath the X and Y electrodes. A logic 1 is represented by a high density of minority carriers in the well, and a logic 0 by a low density of minority carriers in the well. The potential wells are produced by applying a voltage of –8 V to all the row (X) lines, and a voltage of –5 V to all of the column (Y) lines. These voltages are selected so that when a 1 is being stored, most of the minority carriers in the well are beneath the X electrode. Both voltages are needed to avoid loss of data during other operations.

To read the data that is stored in the CCD located at the intersection of the i^{th} row and the j^{th} column, a voltage pulse of –10 V is applied to the j^{th} column-select (Y) line, causing minority carriers to transfer from the X well to the Y well and back again. The voltage pulse induced in the X electrode by this transfer drives the i^{th} row-select (X) line more negative; if a 1 is stored in the device being interrogated, a large pulse is induced in the row line, but a stored 0 results in a small pulse. If all of the row lines are monitored, a complete column of data can be read simultaneously. The readout is nondestructive.

Because the CCD must drive a capacative load, it cannot be as small as CCDs used in shift registers. However, the degradation caused by capacitive loading is less than that of other one-device cells because there is no pn junction capacitance on the row line. The capacitive



1. CCD cell. Basic unit of RAM array is this simple two-electrode CCD cell. Negative potentials produce a depletion-region potential well in the n-type layer beneath the electrodes. To write a logic 1 in the cell, the p-type channel is pulsed positive, thus injecting holes into the well. To write a logic 0, both X and Y electrodes are grounded, letting any holes recombine. The cell is interrogated by applying an extra negative pulse to the Y electrode, thus inducing a pulse that drives the X electrode more negative; the induced pulse is large if the stored bit is a 1, and small if the stored bit is a 0.



2. RAM. Array of CCD cells, with X and Y buses and buried p channels, constitutes monolithic random-access memory. Writing uses Y and p lines. Reading uses X and Y lines; to read content of cell X_iY_j, pulse the Y_j line and sense the pulse that appears on the X_i line (large pulse = 1, small pulse = 0).

loading is caused by the MOS capacitance of the row line, and the differential capacitance of the N device electrodes connected to it. Furthermore, because the bias voltage on the electrodes maintains a depletion region beneath all the electrodes, the load is reduced from C_{oxide} to $C_{oxide} \times C_{depletion}/(C_{oxide} + C_{depletion})$. Also, only about 90% of the minority carriers have to transfer, instead of the 99+% required for CCD shift registers. Therefore the device area can be extended, increasing the ratio of storage capacitance to load capacitance while maintaining high frequency response.

To enter a logic 1 in a CCD cell, use is made of a pn junction located beneath the depletion region of the Y electrode. This junction is formed by diffusing a p-type channel into the substrate before the epitaxial layer is grown. For an N × N array, N channels or strips are required. In operation, all of the column lines except the selected one are grounded. The pn junction is then momentarily forward-biased to inject minority carriers (holes) into the depletion region.

To enter a logic 0 in a CCD cell, both the row-select and column-select lines are brought to ground, allowing any minority carriers previously stored in the device to recombine.

Neither recalling nor entering data in a particular device destroys the data being maintained by that device or any other devices. A periodic refresh is required.

Improvements in performance and a reduction in the number of voltages required, may be achieved by making use of CCD modifications that have been developed for shift registers—for example, use of overlapping electrodes with different gate-oxide thicknesses. □

ROM-stored sine functions yield square roots

by Lorenza S. Childress
IBM Corp., Kingston, N. Y.

The iterative method for computers to extract square roots uses an excessive amount of computer time, but it usually must be relied upon because of the general need for square roots. However, in applications where roots of extremely high numbers are not required, an efficient method that uses table lookup of the sine function and a simple circuit can be used. The method is based on the definition of the sine function and the Pythagorean theorem.

To illustrate the approach, consider a semicircle whose diameter ACB is the sum of two lines—the value of the number whose square root is to be taken (a) and a unit value (1). As shown in Fig. 1, the length AC is unity, and length CB is equal to quantity a. Quantity y is the perpendicular DC from the semicircle to the base. The radius, r, is (a + 1)/2 and the base of the triangle, x, is (a + 1)/2 - 1. By the Pythagorean theorem, $r^2 = x^2 + y^2$. Substituting for x and r and solving for y yields $y = a^{1/2}$. Also,

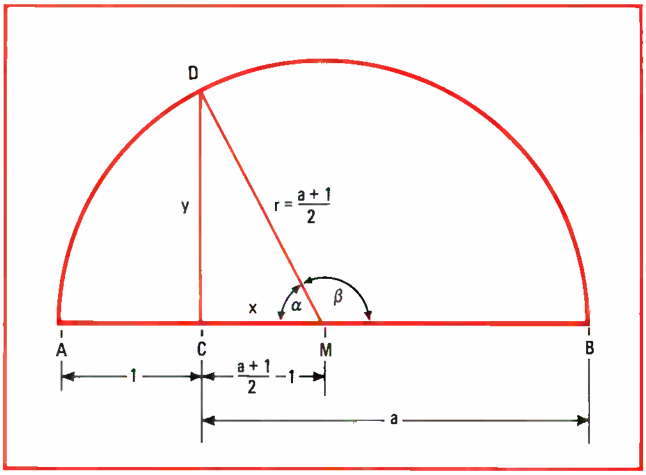
$$\sin\alpha = \frac{y}{r} = \frac{y}{(a+1)/2}$$

so

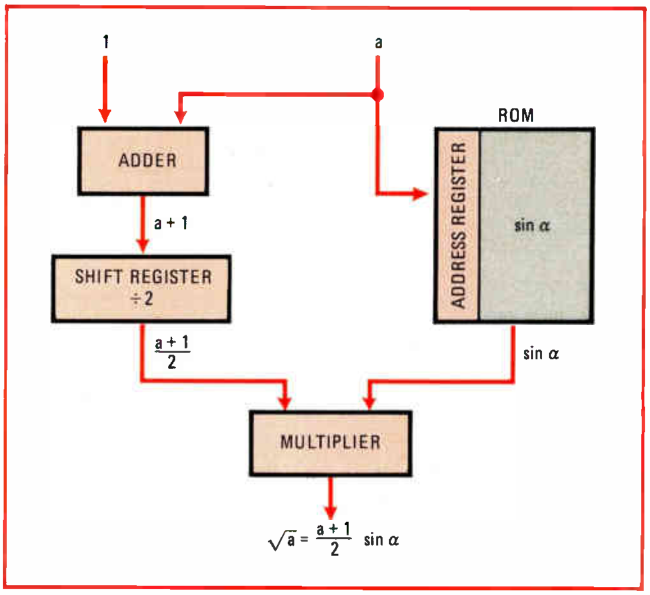
$$a^{1/2} = \frac{a+1}{2}\sin\alpha$$

The values of the sine can be stored as a table in a read-only memory.

Figure 2 shows the circuit implementation of the method. In addition to the read-only memory, the circuit requires only an adder, a shift register, and a multiplier. The table in the ROM can be addressed by the value of a. Because the sine function is cyclic, only certain values are required—those for angles between π/2 radians (90°) and 0.2 radians (11.5°), which handle val-



1. Getting to the root. Pythagorean theorem and sinα are used to calculate the square root of a number a with value between 1 and 100: $a^{1/2} = [(a + 1)/2] \sin\alpha$. Text tells how to handle values of a less than 1 or greater than 100.



2. Arithmetic block. Schematic diagram of circuit for calculating $a^{1/2} = [(a + 1)/2] \sin\alpha$ using a table-lookup method. Note that table in read-only memory is addressed by the value of a.

ues of a between 1.0 and 100. For values of a requiring angles greater and less than these, modifications can be used.

Square roots of numbers smaller than one can be calculated by using the cosine function or the sine of the supplement, that is, $a^{1/2} = (\sin\beta)(a + 1)/2$, where β is less than 90°. From the circuit standpoint, however, it appears to be easier to multiply the values of a by 100 or $10^{2(N-1)}$ where N is the number of decimal digits. After the table lookup, of course, a division is required. This can be handled as a negative multiply. A similar technique is used for numbers greater than 100.

For values of a less than one, the equation becomes

$$a^{1/2} = \frac{1}{[10^{2(N-1)}]^{1/2}}\left[\frac{a10^{2(N-1)} - 1}{2}\right]\sin\alpha$$

and for values of a greater than 100,

$$a^{1/2} = [10^{2(N-1)}]^{1/2}\left[\frac{(a/10^{2(N-1)}) - 1}{2}\right]\sin\alpha$$

The accuracy of the method depends on the accuracy of the sine calculation and the register length, or truncation. The multiply-divide process keeps register length reasonable with only a slight sacrifice in accuracy. □

Adjustable active load maintains constant dc power dissipation

by Norm Bernstein
Analog Devices Inc., Norwood, Massachusetts

An active load that dissipates constant power despite variations in supply voltages is useful for calibrating a dc power meter and for several thermal-control applications. Such a load may consist of one or more transistors, like the Darlington pair shown in the circuit diagram. The value of reference voltage V_{ref} and the accompanying control components determine how much power the load can dissipate. For the circuit arrangement shown, the transistors dissipate 1 watt when V_{ref} is 1 volt and proportionally less for lower reference voltages at any value of input voltage from 1 V to 10 V. The dissipation is constant to within 1% over this whole range of V_{in}.

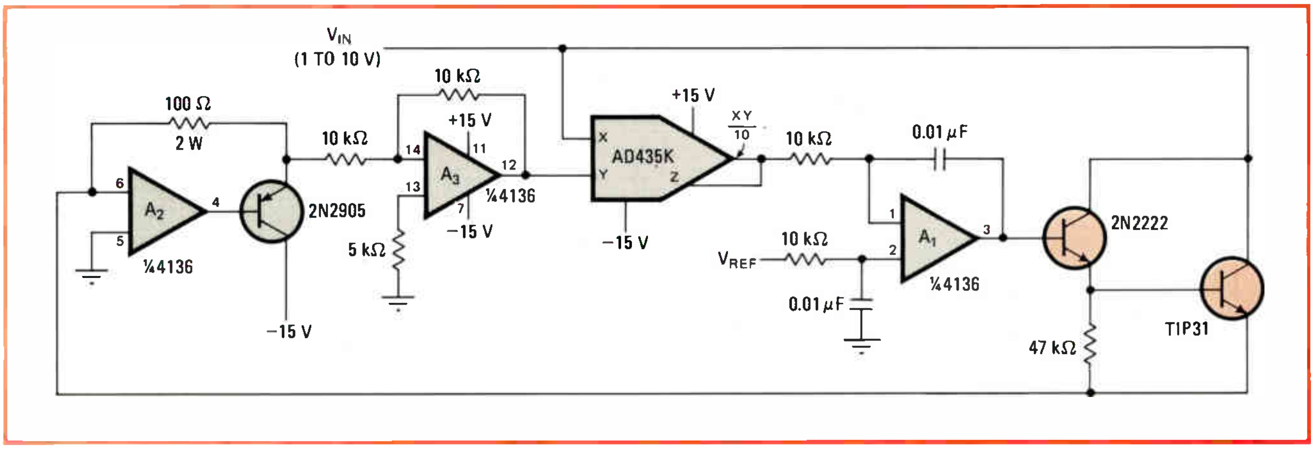
The operation of the circuit is simple. Amplifier A_2 references the dissipating element to ground and produces a signal proportional to the load current. This signal is inverted by amplifier A_3 and then is multiplied by V_{in} in the AD435 multiplier. The output from the multiplier is therefore a voltage that is proportional to power dissipation. This voltage is compared to V_{ref} and integrated to produce a bias voltage for the Darlington pair.

If the load voltage changes, the integrator adjusts the Darlington bias until the multiplier output equals V_{ref}, thereby maintaining constant power. The power dissipation can be adjusted by simply changing V_{ref}.

This circuit arrangement can be used for almost any power range by applying appropriate biasing current to the transistors and scaling the multiplier inputs. To minimize errors from multiplier offset and drift, and thus optimize accuracy over dynamic range, the multiplier should be operated with an output of at least 100 millivolts. Therefore, the input voltage range for each multiplier input should be between 1 and 10 V. The color-tinted components in the diagram represent all of the power-dissipation elements and may be easily isolated from the rest of the circuit.

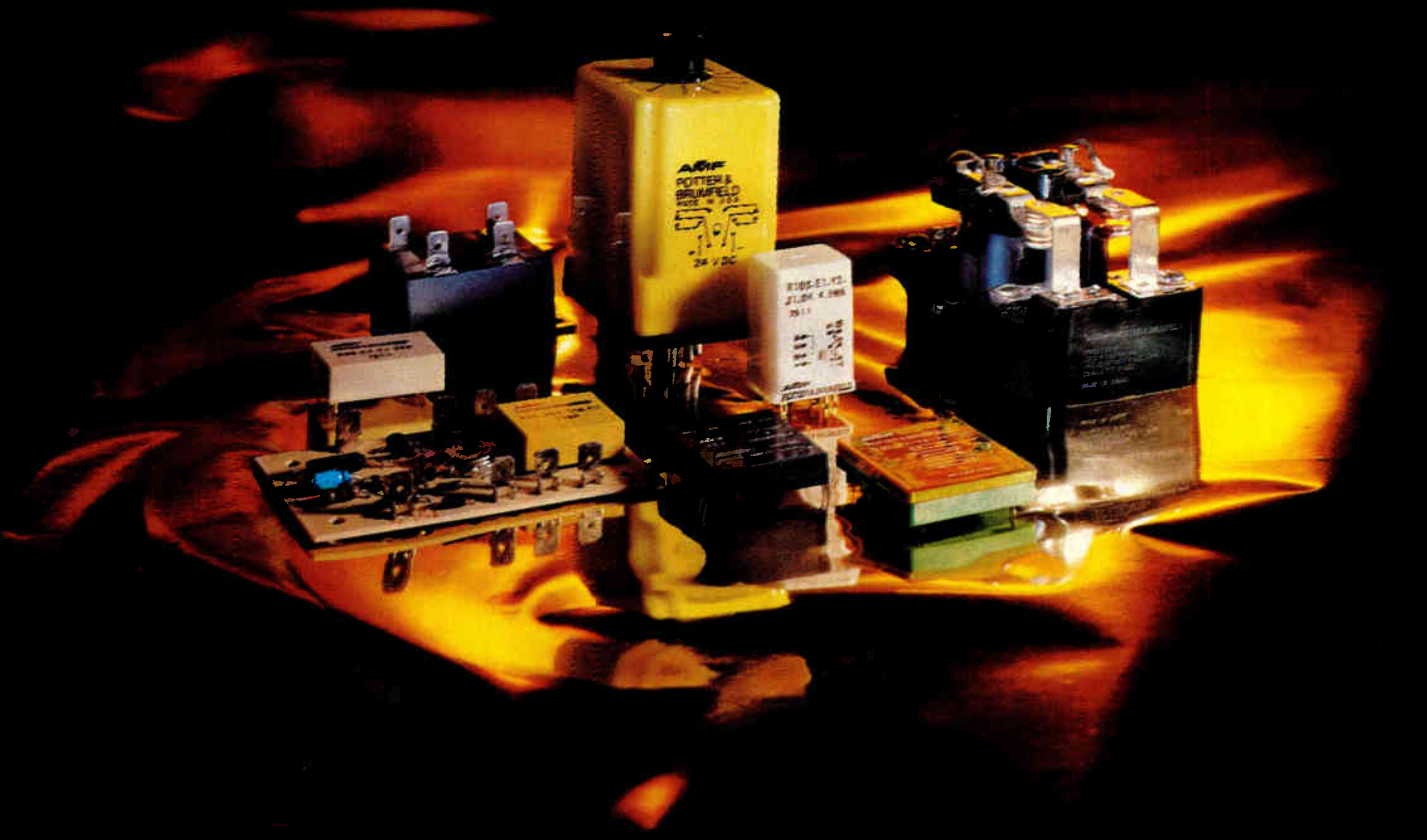
The constant-power property of this circuit has several interesting applications. For example, placing the power-dissipating elements within an environment of constant thermal transfer results in constant temperature. Measurement of temperature rise will give the thermal resistance of that environment. Or, if the power-dissipating elements are used as a heater for an environmental chamber, constant temperature can be achieved without the limit-cycling usually associated with thermostat-type controllers. □

Engineer's Notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.



Constant dissipation. Darlington pair dissipates constant power for fixed V_{ref}, even though V_{in} varies. Maximum dissipation in load for circuit shown is 1 watt when V_{ref} is 1 V. Different load transistors and different biasing arrangements permit higher power dissipation.

New from Potter & Brumfield



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7. EOT series relays. Opto-coupled, all solid state. Solve high cyclic switching problems. Synchronous zero crossover switching virtually eliminates EMI and RFI. Output: 2, 4, 5 or 7 amps @ 120 VAC standard.

8. PRD series power relays. New improved design. Interchangeable with famous PR series. Save 50¢ at list price! UL and CSA listed. Rugged terminals designed for power screwdrivers.

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Belfast BT1 4JX

From the Desk of: Harry S. Oliver
Director of Industrial Development for Northern Ireland.

Dear Sir,

Present difficult economic circumstances, not only in Europe, but around the world, may seem at first sight to indicate that this is a time for retrenchment rather than investment. However, investment is essentially a long-term business and the manufacturer who looks now to the future will reap the greatest benefit when the economic upsurge forecast for 1976/77 occurs. This, therefore, is a time for forward planning and for imaginative thinking.

In an investment context, Northern Ireland is worth looking at. Not at the sensational political image created by the headline writers, but at the astounding economic progress which has been achieved in recent years. At continued high output and productivity. At low rates of absenteeism. At a good industrial relations record. At a labour force with the will to work. At the most comprehensive Government training system in Europe. At levels of hard cash assistance from Government which are outstandingly generous. At a country where, in short, your production costs can be lower than they are either in Europe or the United States today and where your profitability can be that much higher.

I would be grateful for the 10 minutes of your time it will take you to read and ponder on the following two pages. Thereafter, if you wish to talk to me personally about investment in Northern Ireland, my telephone number is given above. Alternatively, one of our American representatives at the addresses listed, will be glad to supply you with further detailed information.

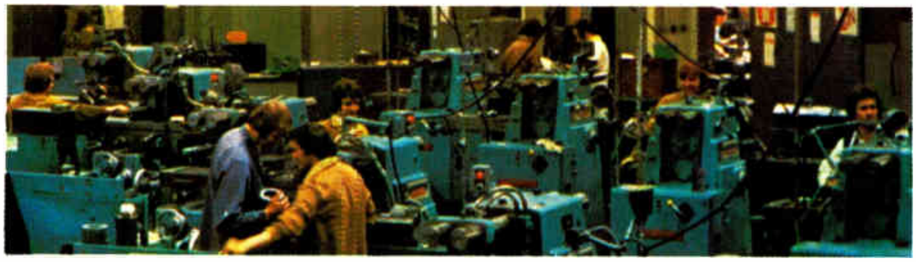
Kind regards.

Yours sincerely,

Harry S. Oliver

Lower production costs at all levels.

One of the major factors in deciding where to build a new plant must inevitably be the cost of the available work force. Is it preferable to seek a low wage work force drawn from a non-industrial society. Or a higher wage work force drawn from a highly industrialized society such as in the United States?

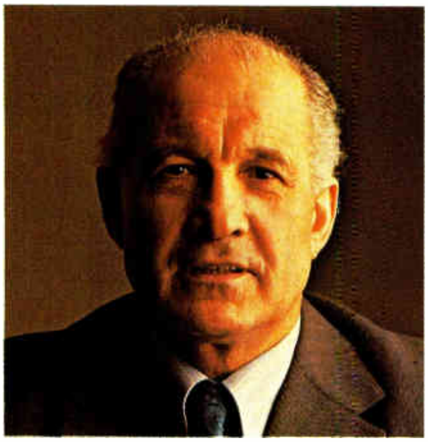


In Northern Ireland there is a ready-made solution. We are an established and fast developing industrial country, yet by your standards, production costs are low. And this is true not only for semi-skilled and unskilled labor, but also for skilled workers and management personnel.

Furthermore, although social security benefits in Northern Ireland are comparable with any in Europe, costs are lower. In Northern Ireland they amount, at most, to 12% net of gross wages.

The will to work.

In Northern Ireland you'll find that people believe in an honest day's work for a fair day's pay. Let one of their spokesmen speak to you on their behalf:



> "We realise that industry must be allowed to operate under favourable conditions in Northern Ireland in order to encourage new companies to locate here. We also fully appreciate that new companies must be profitable if they are to expand and create new jobs... anybody who brings jobs to Northern Ireland by locating a manufacturing company here may be assured of our co-operation and support."

So said Billy Blease in 1974, not a Government official but the most important Trade Union leader in Northern Ireland.

But is the work force available?

We have 54,000 people (10.5% of the working population) who would welcome the opportunity to work in industry. Many are already skilled. And for those who are not, we've some of the finest training facilities in Europe to enable them to qualify for the skills you will need. Don't underestimate the value of a sophisticated Government training program based on your previous experiences. Ours is something different. What's more, the attitudes and capabilities of our trainees guarantee that they develop quickly into a highly skilled and reliable work force.

So that manufacturers like you can take full advantage of our labor force, we've set up 14 well-equipped training centers where young people, after their normal schooling, are given free training in a variety of trades.

Bear in mind that Northern Ireland has been the home of the Irish Linen industry for 300 years. Centuries of working with textiles have endowed our people with an outstanding degree of manual dexterity which makes them very suitable for employment in modern fields of technology, particularly electronics.

Unique in-plant training schemes.

The wages of workers who receive free training can then be subsidized while they are employed by you – until a satisfactory level of productivity is reached.

Not surprisingly, the rate of output in Northern Ireland over the past ten years compares well with that of the more developed countries of Europe. Our training schemes and good industrial relations have undoubtedly made a unique contribution to our productivity.

Management recruited locally too.

In Northern Ireland you really can count on a well-trained, and willing work force. The same is true for all levels of management, too, because you can recruit highly qualified executive staff who have graduated from universities and colleges of advanced technology. As with the labor force, we will subsidize management training costs, including recruitment expenses and wages during training, to enable you to build up an efficient and cost-effective management.

Northern Ireland is an industrial country.

One look at the number of manufacturing companies operating in Northern Ireland – over 2,200 to date – will satisfy you that we are an industrial society.

Mini-airliners are designed and built in Belfast. We are also involved in two separate stages of production for the RB 211 engine which powers Lockheed's L/1011.

For a company coming to Northern Ireland such evidence of our industrial development is welcome assurance that both raw materials and purchased components are readily available here.

Ready-made infrastructure.

In Northern Ireland you'll find that the network of highways and other transportation facilities have more than kept pace with our industrial development. Other important transportation projects are now in final stages of completion and further projects are being constructed.

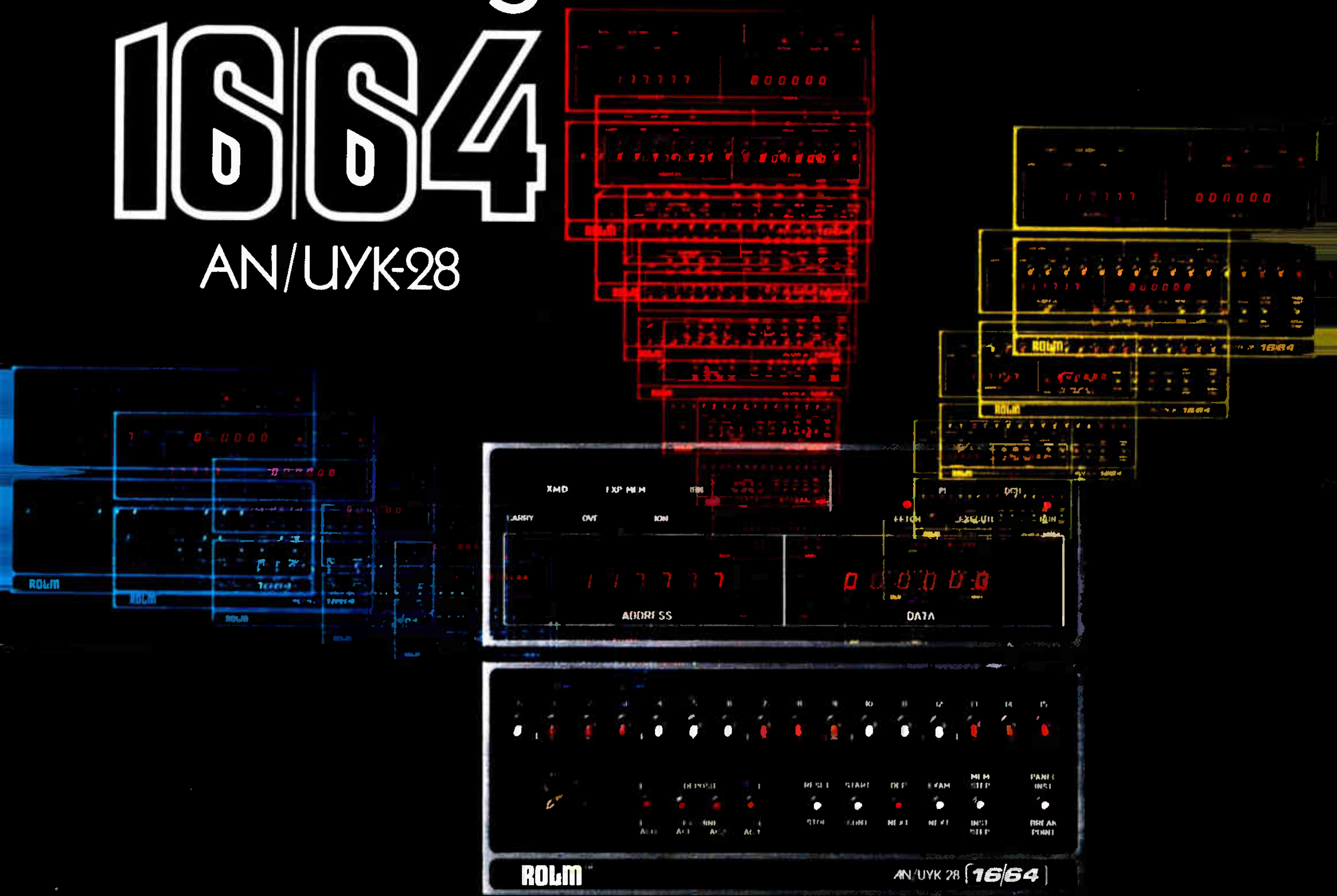
Northern Ireland is well served by seaports. Sixteen scheduled services operate between them and Great Britain, and there are direct services to over twenty foreign countries.

Regular air freight services exist between Belfast and airports in Great Britain, with automatic transfer to inter-continental and international flights.

introducing the

1664

AN/UYK-28



Not a mini... it's actually three processors in one

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So for 16 bits, 64 bits . . . or whatever you need, the 1664 has it. Call (408) 257-6440, TWX 910-338-0247 or write ROLM Corp., 18922 Forge Drive, Cupertino, CA 95014. In Europe: 06181 15011, TWX 841-418-4170, 645 Hanau, Muehlstrasse 19, Germany.

ROLM CORPORATION

The Rugged Computer Company

Radiophone tester is fast and simple

System for checking industrial, navigational, avionic, consumer receivers includes frequency generator, synthesizer, other modules

by John Gosch, Frankfurt bureau manager

"**Accuracy is not enough.** What's also needed [in testing radiotelephone systems] is speed and simple operation."

Tonio Frühauf, manager of the design laboratory for automatic instruments at West Germany's Rohde & Schwarz, adds that these needs result from the increasing use of radiotelephones and other radio-based systems in industrial, navigation, and avionic, as well as consumer applications. Also, with channel spaces dwindling, the available frequency bands are becoming more crowded, so that interference is becoming more of a problem, the company says.

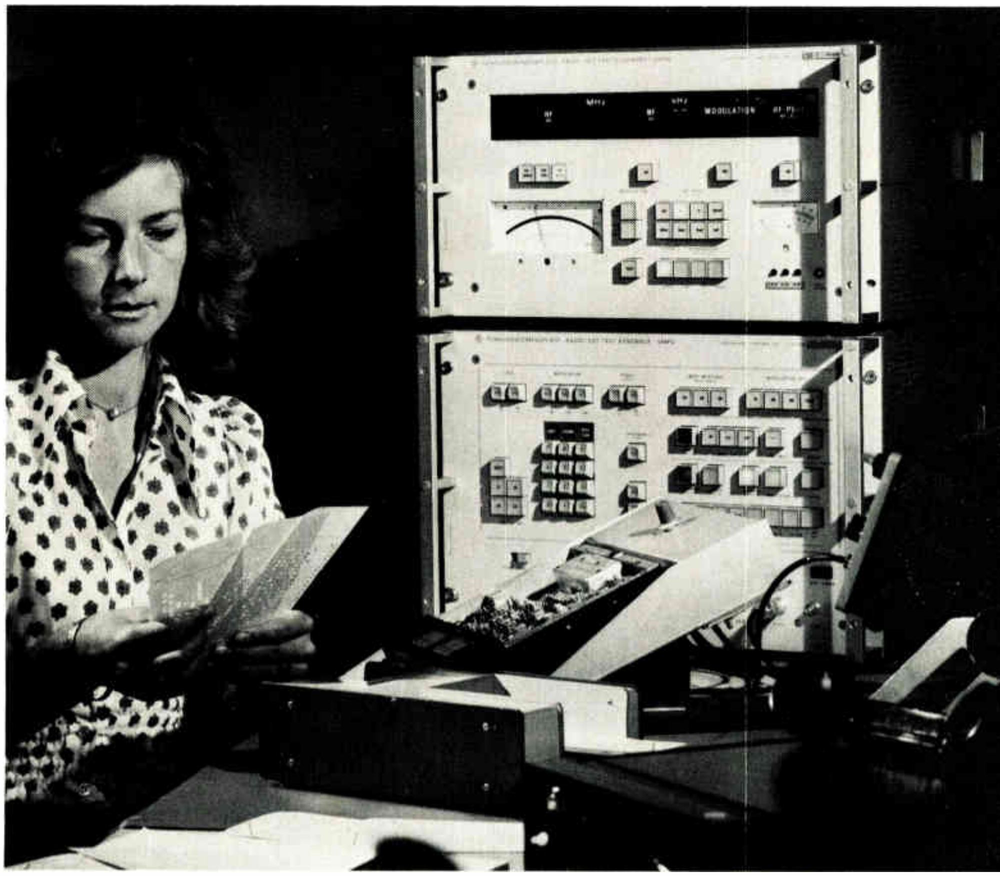
Check and log. Simplicity and speed are therefore what R&S offers in its model SMPU test system, which takes only a few minutes to check out a radiotelephone and log its parameters. This goes not only for direct quantities such as voltage, frequency, deviation, and power but also for indirect, or formula-derived, quantities like bandwidth, sensitivity, signal-to-noise ratio, and squelch.

To make such measurements, the SMPU has many modules: a 10-hertz-to-100-kilohertz audio-frequency generator, a radio-frequency synthesizer for up to 500 megahertz, an amplitude, frequency, and phase modulator, and an attenuator extending to 141 dBV. Then there are an automatic-frequency and phase-deviation meter, an automatic frequency-level meter for 3 millivolts to 10 volts, an rf counter from 40 kHz to 500 MHz, and an rf power meter with 0.5-, 5- and 50-watt ranges. Completing the lineup are an automatic frequency counter for up to 40 kHz, a psophometric weighting filter, a distortion meter, and an rf-switch panel.

The primary sales targets of the SMPU are builders and users of radiotelephones, such as taxi fleets, fire and police departments, and companies employing radios at building sites, in navigation, and in aviation. Although billed as a radiotelephone test assembly, the SMPU can be used for checking out other radio-based equipment, such as automobile receivers, navigational aids like ILS and VOR receivers, and high- and low-frequency radio modules and subsystems of various kinds.

The SMPU's instruments are integrated into the tester and controlled by a combination of internal microprocessor and external desktop calculator.

The microprocessor, an Intel 4004 circuit, controls the instrument modules and monitors their operation. Designed with a 2-kilobyte program memory, the 4004 handles, for example, automatic tuning of the deviation meter and allows digital-dis-



tortion-factor measurements to be made. It also keeps tabs on bandwidth and sensitivity measurements and transforms, say, signal-to-noise ratios into dB values.

Making the SMPU a fully automatic system, complete with data-logging capabilities, is the external desk calculator. Besides producing a record of the test results, the calculator handles all functions for which the microprocessor is not programed. It makes many kinds of logic decisions that are usually handled by a minicomputer in automatic test systems.

With computer or calculator control, it's easy to change or correct programs. All commands can be separately selected, substituted, or erased. It's also possible to insert instructions without rewriting programs.

The decisive factor in favor of calculator instead of computer control was price. For its SMPU, R&S selected the model TEK 31 desk calculator from Tektronix Inc.

With its arithmetic unit, keyboard, display, magnetic-tape cartridge and hard-copy printer, the TEK 31 incorporates all functional units needed for controlling and programing the SMPU and for displaying and logging the parameters it measures.

Couplers are eliminated. "If test equipment is made programable, then why not make it bus-programable?" Frühauf decided. So, an IEC-standard data bus adapts the calculator's interface to the tester, eliminating the need for complex couplers. Using the data bus also means that, in addition to the SMPU, the calculator can simultaneously control other IEC-standard instruments.

Further, the data bus makes it possible to use calculators other than the TEK 31 if they are IEC-compatible. It also allows SMPU control via a punched-card reader, which would replace the calculator in a semiautomatic system.

For the TEK-31 calculator, R&S supplies a magnetic-tape cartridge, containing the SMPU software, including all standard test routines. But customers can also prepare their own routines to suit special needs and applications.

The cassette containing the test program is put into the calculator. Then, a push of the start button puts the program through its paces. For quantity testing, the program can be recalled by the same button.

It is possible to enter data not in the program. For example, the calculator may request data on channel frequency or channel number. The user enters such data on the calculator's keyboard and pushes the continue button, to tell the calculator to resume its interrupted test routine. Unskilled personnel can easily run the system.

The SMPU not only has the standard manual and programable modes but a third one, called the combined mode, that allows simultaneous programed and manual operation. It enables programed values to be varied, erased, or corrected by hand, and vice versa. For example, a radio set's channel frequency may be read in from the calculator and varied manually for the actual measurement.

Instructions to the user. In data-logging, the calculator's thermal printer produces not only the test results and the requests for additional data, but also instructions for the user as well as comments like "beyond limits", "out-of-tolerance", "check power supply", and similar kinds of instructions.

Frühauf says that the SMPU offers a saving in test time of as much as 90% less than manual methods. More specifically, to check out a typical six-channel duplex radiophone manually may take as long as 45 minutes, according to Frühauf. With the SMPU used in a semi-automatic configuration (without the calculator), he says it takes 10 minutes and, with the fully automatic version (with the calculator), only 3 minutes.

U.S. price for a system that does not include a calculator or its interface is $43,000.

Rohde & Schwarz, 8 Munich 80, Muhldorfstr. 15, West Germany [339]

Rohde & Schwarz, 14 Gloria Lane, Fairfield, N.J. 07006 [340]

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Our Micro-K Capacitor is the newest member of the family. Tiny enough for quartz watches. And it has a precision lapped titanate stator and finely machined brass rotor.

Our 10mm model is low cost and mounts interchangeably with similar ceramic disc trimmers.

The 5mm type is even less expensive and can be used in the same applications as monolithic types where maximum stability isn't required.

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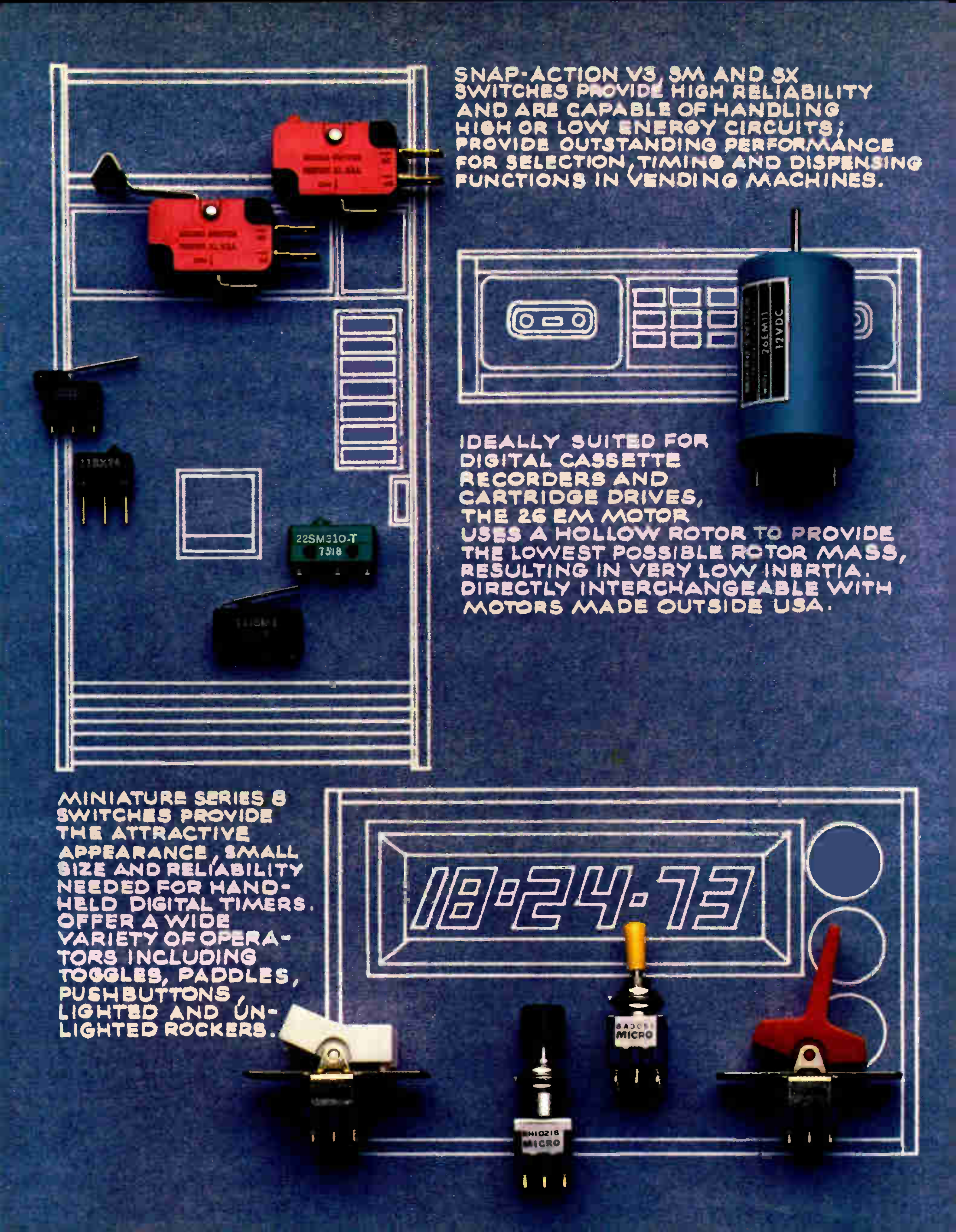
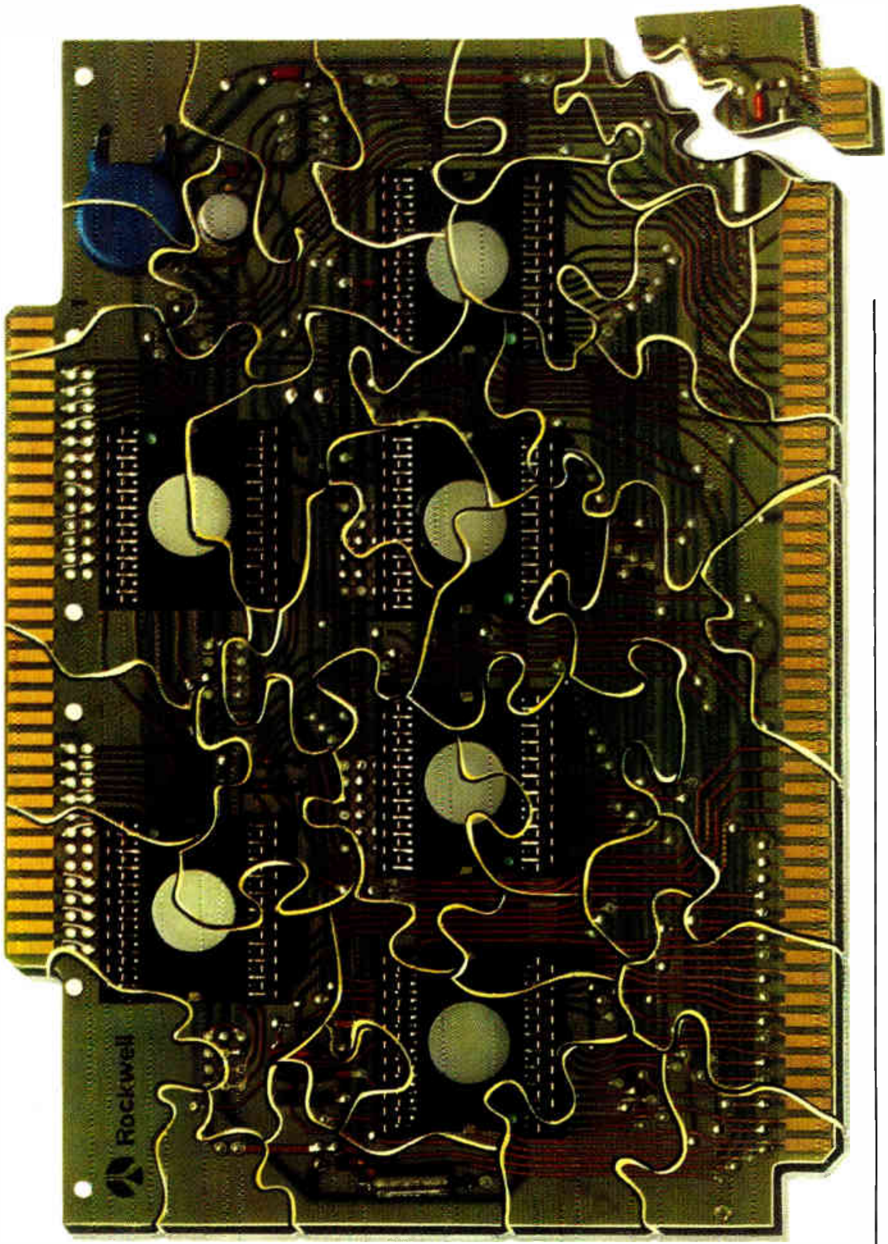
Circle 151 on reader service card

Some of these components will probably





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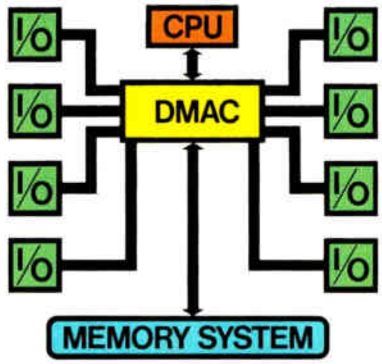
Our 8 channel Direct Memory Access Control (DMAC) gives priority to data flow between the I/O's and the system's memory. Once again, the CPU is freed from a routine, time-consuming chore.



Intelligent I/O's do the CPU's busywork.

We've identified many common tasks performed by microprocessing systems and designed intelligent LSI I/O's to control them — independent of the CPU. The CPU is thus able to delegate mundane chores such as running the peripherals, while concentrating on the serious thinking it does best.

The spreading of intelligence among the I/O's also reduces the amount and cost of program memory in your system. And because the CPU is no longer responsible for monitoring a multiplicity of functions all over the lot, programming becomes simpler, faster, and more flexible. You simply plug in or remove a chip with minor, not total, software changes to add or subtract functions.

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PARALLEL PROCESSING: HIGH SPEED RESULTS FROM LOW COST TECHNOLOGY

With so much independent intelligence spread through our system, many tasks can be executed at virtually the same time. With our parallel processing system (PPS) you can now perform tasks with MOS microprocessing that would otherwise require higher cost technologies.

A THRILLING CASE HISTORY

A fellow designed a new cash register whose I/O's sprawled over three PC boards and cost about $250. He felt there was a better way and went to a large microprocessing house, but one which sold chips, rather than systems. They reduced him to one large and two small PC boards, with a cost of about $160. Finally, he came to Rockwell, where we applied our LSI system approach to his problem. He walked out with his entire system in LSI on one PC board at a cost of about $85.

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We've spent millions of dollars to develop more than 40 LSI microprocessor circuits to offer you LSI options for most of your electronic needs. As well as a worldwide sales and field service organization. Add to that a production capacity of tens of millions of circuits per year and you get the picture: giant Rockwell is very serious about tiny microprocessors. Don't let anyone tell you otherwise.

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Just call us at any hour and tap into a wealth of Rockwell customer support: detailed literature, software libraries, assembler - simulators and other design aids. Programming and board development assistance. And training programs at our facilities or yours. Some of this help is free; some costs. Take as much or as little as you need. What's important is that it's there. Right now.

Stop trying to solve microprocessor problems by bits and pieces. Instead, see how Rockwell's LSI system approach can help you. Call Bill Roland at (714) 632-3729 or write to:

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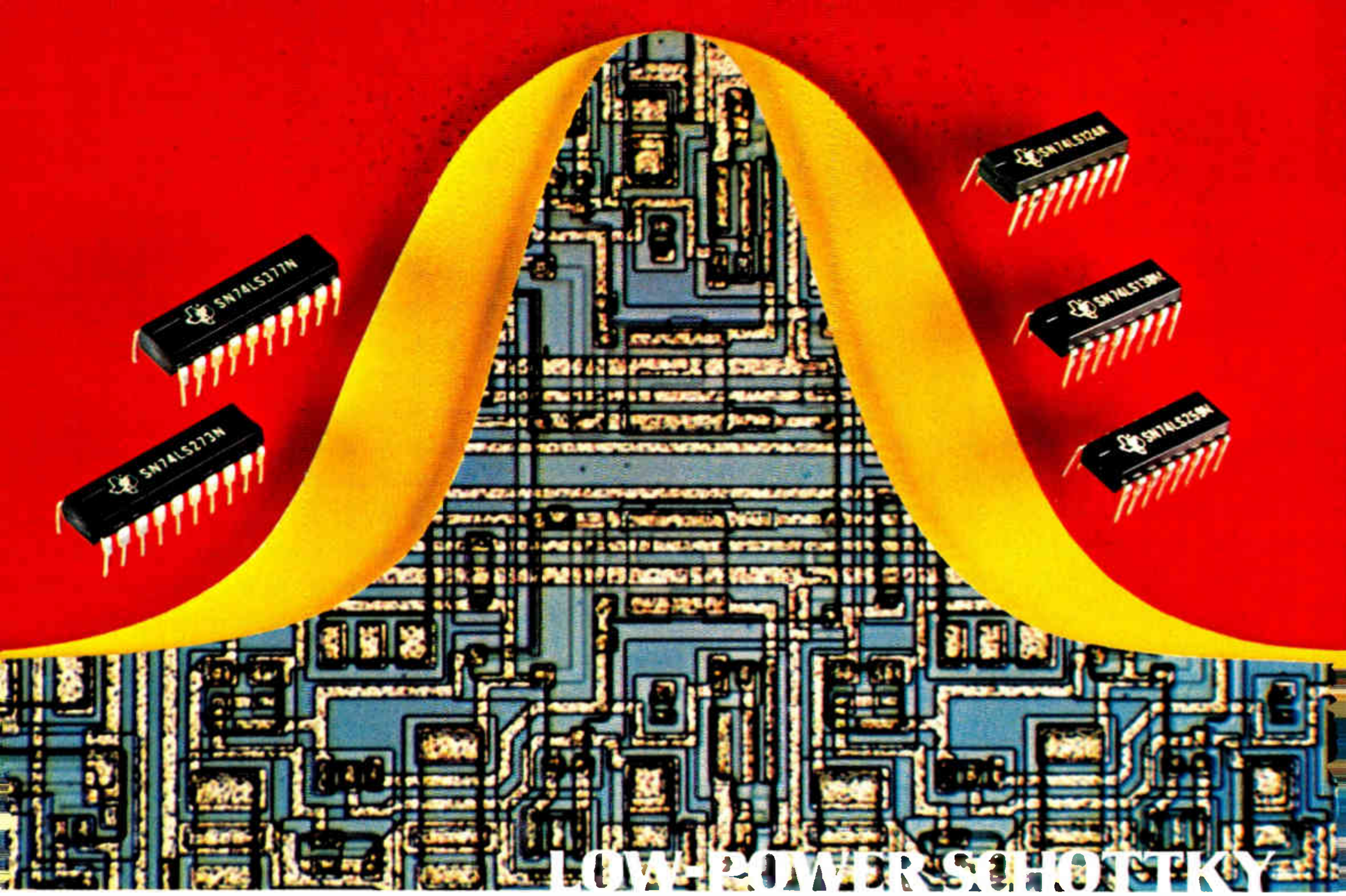

Ion implant

Tightens low-power Schottky performance parameters.

Choose TI's low-power Schottky integrated circuits, and you get performance and dependability.

The reason is ion implantation. It assures precise control, consistent quality, and performance so uniform it approaches the optimum. The bell curve above dramatically demonstrates how tightly TI maintains electrical parameter distribution in its low-power Schottky devices.

Reliability is in a class with that of TI's 38510, 883 and MACH IV Hi-Rel devices. TI's low-power Schottky circuits have undergone over 65-million equivalent hours of life testing with the outstanding results detailed in the box.

Low-Power Schottky Life Test Results

Test	Number of Devices Tested	Number Failed	Equivalent Hours @ 55°C
Operating Life @ 125°C	484	4	22,127,200
Operating Life @ 150°C	127	3	4,064,000
Storage Life @ 150°C	613	2	39,136,000
TOTALS	1224	9	65,327,200

NOTE: The failure rate estimate for above combined storage life and operating life data is: 0.00024%/100 hours. This is a best estimate failure rate extrapolated to 55°C, based on 1 ev activation energy.

And there is also an improvement in the speed of these TI "Power Savers." While power requirements remain at less than 2 mW per gate, speed is typically 8 ns.

Yet for all the improved performance and dependability it produces, ion implantation costs you no more. You have a broad choice of 126 readily-available low-power Schottky functions, with 15 more due before year end, and 50 to come in 1976—all at a very cost-effective price.

For more information, contact your nearest Texas Instruments sales office or your authorized TI distributor. Or write: Texas Instruments Incorporated, P.O. Box 5012 M/S 308, Dallas, Texas 75222. Or call us; (214) 238-3186

TEXAS INSTRUMENTS

INCORPORATED

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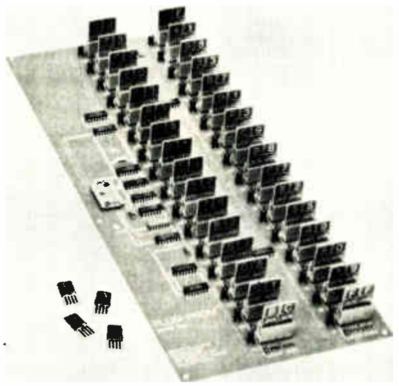
Semiconductors

PROMs program microprocessors

Plug-in units also debug prototype microcomputers, avoid software routines

For engineers who prefer the hands-on hardware approach, rather than working with software, a consulting engineer in the computer industry has developed an easy-to-use microprocessor-programing and debug-



ging aid. Called the Plug-PROM, the unit developed by Brent Olsen is a read-only-memory diode-matrix array that is programed by inserting small printed-circuit-board "plugs" into standard pc edge-connectors. Each plug is labeled with a hexadecimal value (0–9, A–F) that it programs into the diode matrix in any position into which it is inserted.

Each plug programs four bits, so that in the standard 8-bit-by-256-word unit, each word is easily and quickly programed by inserting two of the small 0.5-by-1-inch plugs. The plug-PROM connects easily to any system using a short cable with a 24-pin plug on the end and is electrically equivalent to the widely used Intel 1702A PROM. Olsen explains that interfacing consists only of plugging the unit into a socket that would normally contain a 1702A PROM. The unit can be substituted for more than two dozen commonly used ROMs and PROMs.

"Once plugged into the microcomputer system," says Olsen, "programing consists of selecting two properly coded plugs, each representing a 4-bit hexadecimal value and inserting them into the pc edge connector of the 8-bit word being programed. To change the program during debugging only requires removing and replacing plugs with different ones. What this means is that programing a microcomputer no longer requires the user to learn how to program a time-sharing computer or how to operate a specialized development system and learn abbreviated system commands."

In addition, he says, the user doesn't have to buy teletypewriters, CRT terminals, high-speed paper-tape punches, or high-speed paper-tape readers. All he has to do is build the prototype system just as originally intended, substitute the plug-PROM for the PROMs and ROMs, write the programs, and insert the plugs. The user can substitute and move them around until the program is executed properly. The plug-PROM can then be moved to a PROM duplicator and, once connected, PROM copies can be made.

An option provides the plug-PROM with light-emitting diodes that light in every word position when a particular word is selected. If the execution time is slowed or single-cycled, the LED indicators will visually show every fetch, jump, jump-to-subroutine, and return-to-subroutine in the program. The plug-PROM obtains its power from the socket in the system. The only other connection, says Olsen, is the ground lead attached to logic ground in the system. The unit requires only a few hundred extra milliamperes from a +5-volt supply.

The plug-PROM is available in eight models—four with the LED indicators. Dimensions range from 15 by 8 inches to 15 by 30 in., and organization ranges from 8-by-32 to 8-by-256 bits. Prices range from $250 to $1,995. Delivery of standard units is available from stock or in 60 days, depending on models and options.

Brent Olsen, 1950 Colony St., Mountain View, Calif. 94043 [411]

I/O unit is compatible with Rockwell microprocessor

An LSI input/output device for Rockwell's 4- and 8-bit microprocessor systems requires no external refresh or decoding logic. The 42-pin circuit interfaces with any standard 4,096-bit n-channel random-access memory.

With built-in logic controlled by software, the RAM interface permits buffered access to as many as 16,192 4- or 8-bit words of either data or program memory, which can be time-shared with such external systems as a computer or a controller. Designed to be used in pairs, the devices offer options enabling implementation of a variety of systems.

As with other LSI interfaces and input/output controllers in Rockwell's microprocessor systems, the new RAM circuit can be designed into existing microcomputers merely by changing a little software.

Prices are $25 each for one to 24, $17.50 for 25 to 99, and $13 for 100 to 999. Delivery is from stock.

Microelectronic Device Division, Rockwell International, 3310 Miraloma Ave., Anaheim, Calif. 92803 [412]

Schottky mixer diodes have low forward drops

A line of Schottky-barrier mixer diodes with forward voltage drops in the range of 200 to 300 millivolts, compared to 400 to 500 mv for conventional microwave Schottkys, provides better matching in 50-ohm circuits than do the conventional units. The noise figures of the low-V_f diodes is typically less than 6 decibels at 9 gigahertz for power levels from -5 dBm to +5 dBm. The diode line consists of 23 devices in a variety of packages from microstrip quads to beam-leaded chips. Prices range from $5.95 to $62.40, depending upon the package. Delivery is from stock.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [413]

Gate-turn-off SCRs can handle 8.5 amperes

A line of 18 gate-turn-off SCRs from RCA can handle 8.5 amperes at maximum voltages ranging from 100 to 600 V. Unlike conventional SCRs, the GTO devices can be turned off by the application of a negative voltage to the gate terminals. Their main advantage over comparable switching transistors is that they can maintain a low voltage drop over a wider current range than the transistors can. Housed in hermetic steel TO-3 packages, the devices can all be operated at temperatures up to 125°C. In lots of 1,000 pieces, their prices range from $2.50 to $6.95 each, depending upon voltage rating and speed. Turn-on times range from 1 to 2 μs, but turn-off times from 1 to 5 μs are available. Delivery is from stock.

RCA Solid State Division, Box 3200, Somerville, N. J. 08876 [414]

Four-bit register has common-enable function

A low-power Schottky TTL 4-bit register from Advanced Micro Devices is a parallel-input positive-edge-triggered D-type device with buffered common clock and register-enable functions. Designated the Am25LS08, the unit has both inverted and noninverted outputs, and can run at a maximum frequency of at least 40 megahertz (65 MHz, typical). The Am25LS08 is similar to the Am25LS175 and Am74LS175 quad registers, except that it has a common register-enable function instead of a common register-clear function. The device is used in digital systems in which information is associated with a logic-

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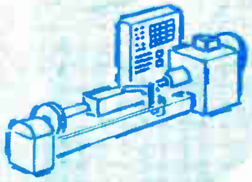

VARIABLE SPEED DRIVES
MACHINE TOOLS

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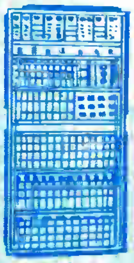
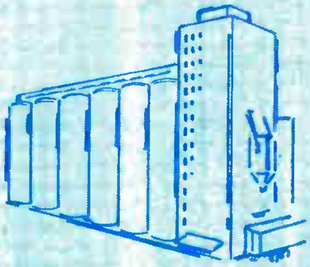


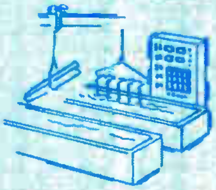
INVERTERS

POWER SUPPLIES

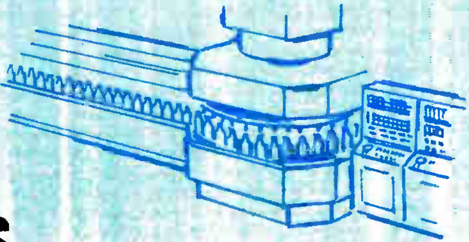
POWER CONTROLS



VARIABLE SPEED DRIVES
MOTOR CONTROL CIRCUITS



PLATING POWER SUPPLIES



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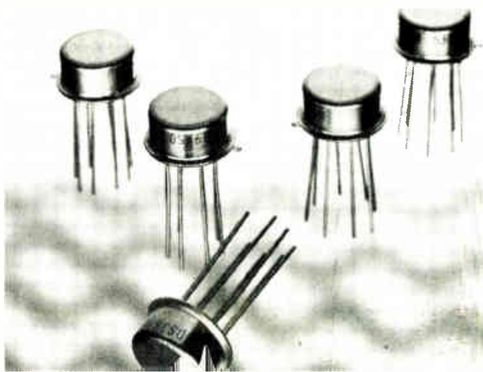
gating signal. When the enable is high, the register will not change state, regardless of the clock or data-input transitions. The price of the quad register, in 100-piece lots, varies from $1.60 to $10.88, depending upon temperature range (0°C to 70°C or -55°C to 125°C) and packaging (molded DIP, hermetic DIP, ceramic flatpack, or uncased dice).
Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086. Phone (408) 732-2400 [415]

Master slice for custom LSI contains 500 C-MOS pairs

A large-scale master-slice complementary-MOS chip containing more than 500 C-MOS transistor pairs along with 44 buffers and interface pins is designed to speed the production of custom integrated circuits. Called MasterMOS L, the new chip is completely compatible with existing smaller MasterMOS chips.
International Microcircuits Inc., 3000 Lawrence Expressway, Santa Clara, Calif. 95051. Phone (408) 735-9370 [416]

ICs drive 48-V telephone relays without protection

Two integrated interface circuits designed specifically to drive 48-volt telephone relays need no external clamping diodes for protection against inductive transients. Both circuits contain an internal reference that prevents the type of output-breakdown-latching that sometimes occurs with ordinary relay drivers. One of the ICs, the DS3686, is a positive-voltage driver, and the other, the DS3687, is for negative-



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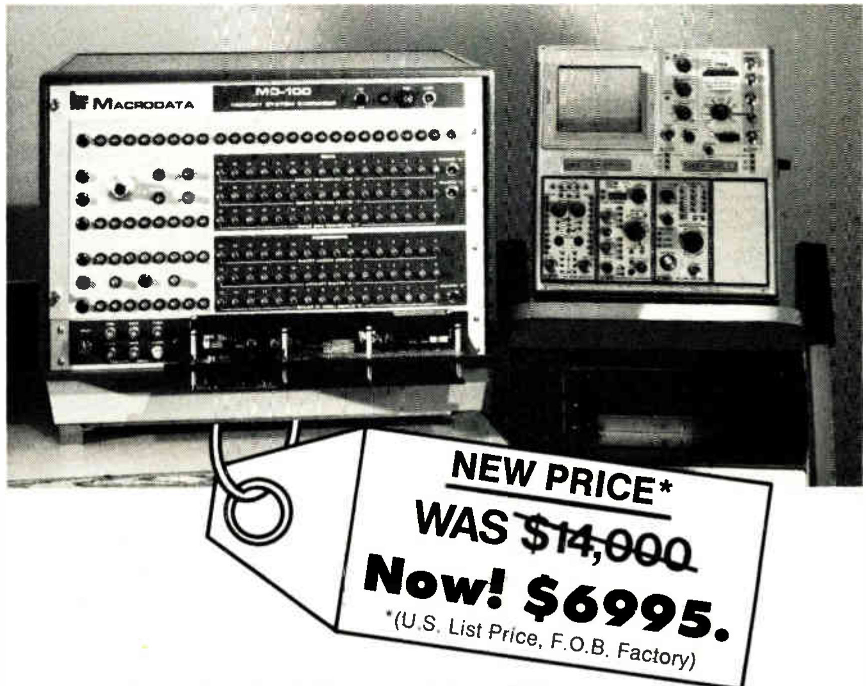
***(Multiport Digital Signal Generator)**



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(7) It's a Multiport Time Delay Instrument

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Communications

Automatic unit tests data links

Data transmission test set does two-way checks on half-duplex networks

A portable data transmission test set from W & G Instruments measures bit and block error rates on simplex, half-duplex, and full-duplex transmission links. Unlike most other testers, the model No. 1-8 measures

the two error rates at the same time, not only speeding the measurement process but also allowing the system operator to evaluate the correlation, if any, between the rates. The two measurements are stored in separate counters, and either can be displayed at the flick of a switch.

A novel feature of the model 1-8 is its ability to perform a full (two-way) test on a half-duplex system automatically. For this type of test two test sets are required, one at each end of the link. The test sets simulate the behavior of a pair of computers to check modem handshaking procedures, measure the bit and block error rates in one direction, automatically reverse direction, and make the same measurements for the return channel. In this way the effects of modem turnaround time are included in the test.

Besides testing the complete system, the 1-8 can make explicit measurements of bias distortion, peak distortion, and modem delay time. Since the test set has two independent clocks, one each for the generator and the analyzer, tests can be made on systems where the transmit and receive speeds differ. Also, the supervisory channel of a network can be tested simply by throwing a switch on the instrument.

Designed to work with networks whose interfaces are compatible with EIA RS-232-C (CCITT V28), the test set can operate synchronously at any speed up to 100,000 bits per second, or asynchronously at any of the 10 following speeds: 50, 75, 110, 200, 300, 600, 1,200, 2,400, 4,800, or 9,600 b/s.

Housed in a suitcase of tough ABS plastic, the model 1-8 weighs only 22 pounds, measures 17.5 by 15.75 by 7.25 inches, and is therefore light and compact enough for field use. The instrument is also so easy to use that people relatively unskilled in communications technology can use it with confidence.

Special features on the test set include a memory circuit that detects and indicates momentary carrier failures, automatic detection and correction of out-of-phase states, and a push button for injecting random bit errors. Various lamps that indicate the status of the modem and the test set are also included.

The model 1-8 consumes only 25 watts at 115/240 V ac, 60 Hz. It will meet all of its specifications over the temperature range from 2°C to 40°C. Its price is $2,490.

W & G Instruments Inc., 119 Naylon Ave., Livingston, N. J. 07039. Phone (201) 994-0854) [401]

Infrared system transmits video more than 2,000 feet

Designed to transmit studio-quality color or black-and-white television signals for distances in excess of 2,000 feet without coaxial cables or FCC licensing, the model 747 is an infrared system with a peak output power of 4 milliwatts at a wavelength of 9,300 angstroms. The system is both cheaper and easier to install than conventional links for such applications as sending signals across roads, rivers, railroads, and between buildings. It can also be

THE $BILLION COMPANY WITH SOMETHING NEW IN MEMORIES.

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The company is NEC – Japan's giant $1.6 billion Nippon Electric Co., Ltd. Who, through its American subsidiary – NEC Microcomputers, Inc. – is offering you the broad product base, state-of-the-art technology, and good delivery you expect from a major memory supplier, plus something you don't expect. Honest-to-goodness reliability.

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Our μPD411 series of 4K RAMs. In the industry standard 22-pin package, with access times to 150ns.

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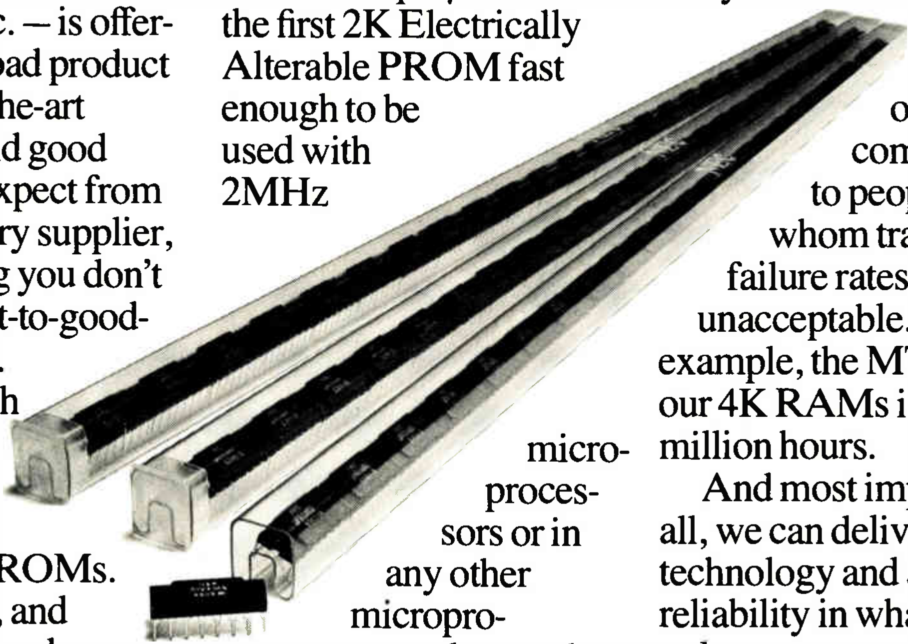
Our unique μPD454 – the first 2K Electrically Alterable PROM fast enough to be used with 2MHz microprocessors or in any other microprogrammed control application. And its Mask Programmable companion, the μPD464.



Our 600ns μPD466 16K Mask Programmable ROM.

And our 85ns μPD405 1K Static MOS RAM.

But what makes our memories truly different is that they're made to the highest standards of reliability in the business.

Simply because our parent company sells to people for whom traditional failure rates are wholly unacceptable. For example, the MTBF for our 4K RAMs is over 5 million hours.

And most important of all, we can deliver all this technology and all this reliability in whatever volume you want.

Which should give you every reason you need to call on us for all your memory requirements.

NEC Microcomputers, Inc., Five Militia Drive, Lexington, Mass. 02173. 617-862-6410.

NEC microcomputers, inc.

used profitably within a large building where it can replace extensive (and expensive) festooned-cable installations [Electronics, Oct. 16, p. 26]. Mirrors can be used with the system to facilitate transmission around obstacles, and extraneous visible lighting can be ignored.

The receiver uses a silicon avalanche photodetector to give it a high fade margin and over 100 dB of agc range. The signal-to-noise ratio at 2,000 feet is in excess of 48 dB.

The receiver and transmitter each come complete with a six-power alignment scope, and each weighs 10 pounds. Each also includes all

necessary horizontal and vertical alignment mechanisms. As a result, only about 15 minutes are required to get a system set up and running.

All electrical signal inputs and outputs are compatible with EIA standard impedance and voltage levels. Power consumption is about 20 watts at 110 or 220 V ac. A complete system sells for $4,000 and has a delivery time of 30 days.

American Laser Systems Inc., 106 James Fowler Rd., Santa Barbara Airport, Goleta, Calif. 93017. Phone (805) 967-0423 [402]

FDM test set is microprocessor controlled

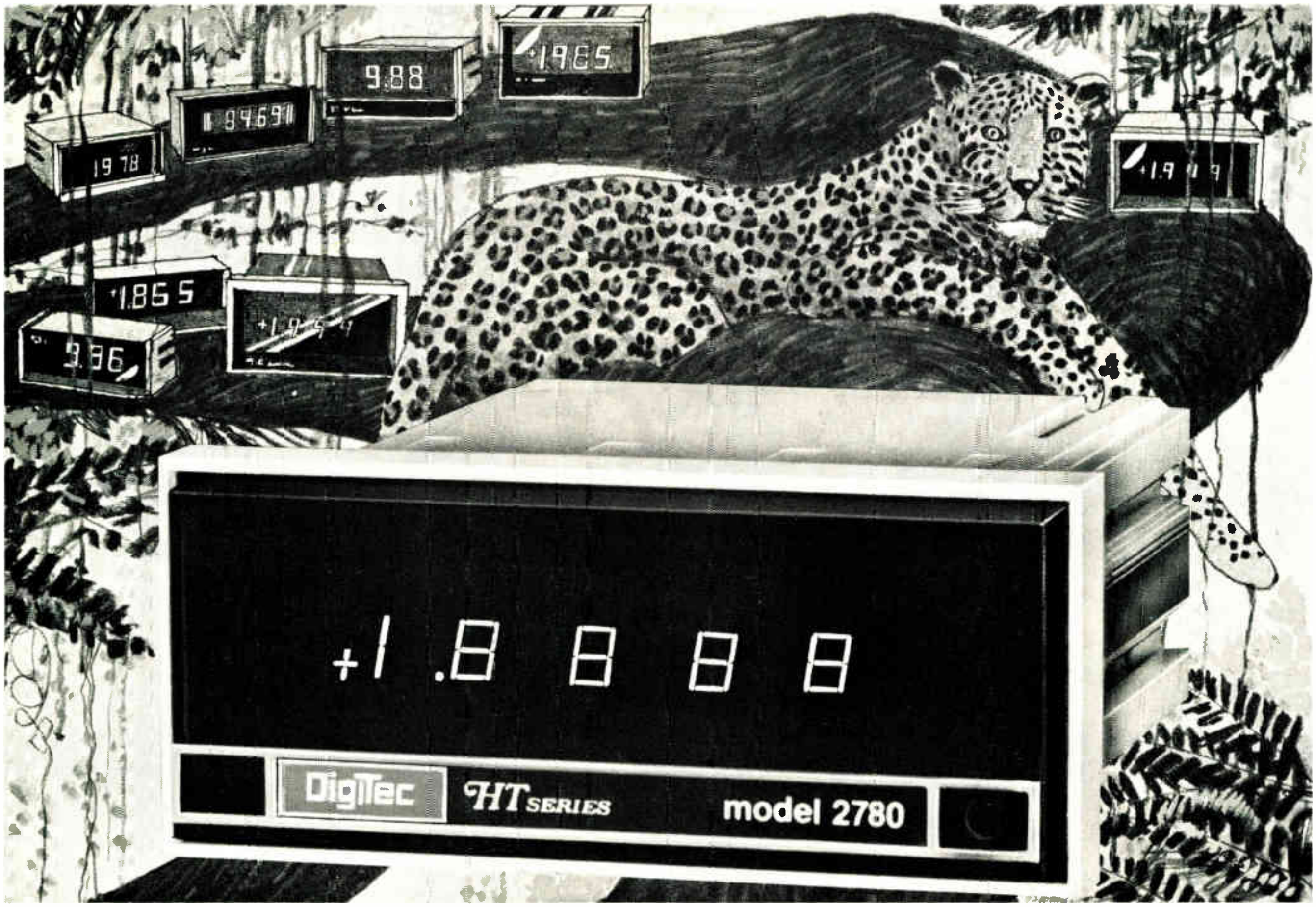
Designed for fast, precise measurements of pilot-tone levels, channel power, channel noise, and other pa-

rameters of frequency-division-multiplexed telecommunications systems, the model 3745 selective level measuring set is a microprocessor-controlled, synthesizer-based instrument. The unit can measure power levels from −125 dBm to +15 dBm over the frequency range from 1 kilohertz to 25 megahertz. Its ability to store FDM plans coupled with its sweep capability allows the instrument to make routine surveillance measurements automatically. As an example of its capability, for a 12-MHz, 2,700-channel system, the test set can measure all group pilots in two minutes, every channel power in 15 minutes. and all group powers in one minute. The unit can be operated from its own keyboard or via the Hewlett-Packard Interface Bus. Fault information can be printed out on an optional thermal printer. Two versions are offered: one contains all CCITT recommended plan information, the other contains Bell System recommendations. The 3745 sells for $23,625. Deliveries are scheduled to begin in January 1976.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [403]

Coupling transformers meet telephone company specs

Two hybrid telephone coupling transformers that meet telephone-company specifications for data and voice access arrangements are designed for the interconnection of external devices with the switched telecommunications network. The transformers' frequency responses



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There's a teeming jungle of panel meters available today. You need to slash thru the tangle of prices and specifications to the very roots. You must find a panel meter that can take anything while it gives continuous reliability and accuracy.

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Every DigiTec panel meter is bred to survive and deliver under any conditions. Proprietary CMOS LSI circuitry gives a lean component count with 5 times the reliability of competitive TTL models. All components are selected for savage stamina, with critical components 100% inspected and socket mounted to avoid assembly heat damage. Every LED display is pre-tested and rated at 1 million hours. Circuit boards are immune to humidity or floods because they're conformally coated on both sides. Shock, vibration and corrosion damage have been eliminated by extra mechanical reinforcement and gold plated connectors.

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All DigiTec panel meters are subjected to a minimum 168 consecutive hours of failure free burn-in at temperatures that vary from +25°C to +55°C. Before and after burn-in, each meter is visually inspected and electrically tested. When a DigiTec panel meter goes into that jungle . . . it's ready for anything and tough enough to last 9 lifetimes!

Model 2780 — 4½ digits, 0.01% accuracy (shown)
***Model 276** — 3½ digits, unipolar, 0.1% accuracy
Model 277 — 3½ digits, bipolar, 0.05% accuracy
Optional buffered, BCD output available - field installable.

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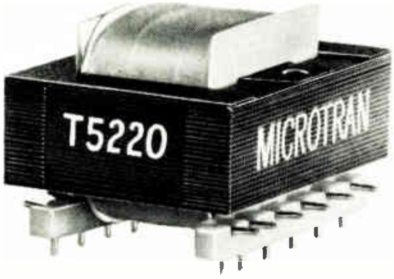
"Information only" circle 244 on reader service card. "Demonstration only" circle 168 on reader service card.

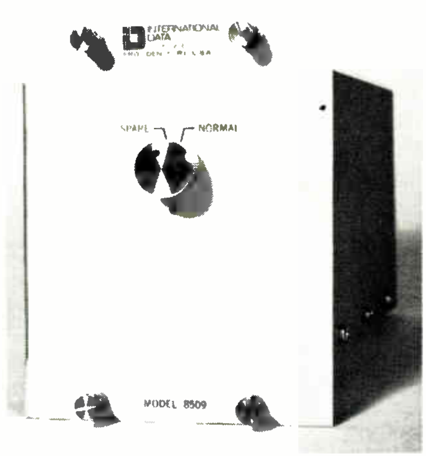


are flat within 0.5 dB from 300 to 3,500 Hz for power levels from –45 to +20 dBm. Model P/N T4220 handles 60 milliamperes dc on the two-wire side and has a typical trans-hybrid loss of 45 dB. The model P/N T5220 handles 100 mA dc and has a typical loss of 60 dB. In lots of 100 pieces, the T4220 sells for $7.60 each, and the T5220 is priced at $13.30.

Microtran Co. Inc., P.O. Box 236, Valley Stream, N.Y. 11582. Albert J. Eisenberg (516) LO1-6050 [404]

Switch allows spare modem to replace one of several

The model 8509 spare-modem backup switch is a module that permits a single spare modem to serve as a back-up to any one of a group of on-line modems. All signals, except chassis ground, are switched internally by the 8509. The switch sells for $220, and a separate switch is needed for every on-line modem in a group. Delivery of the 8509 switch is from



We thumbs prefer Cherry thumbwheel switches

"We like them because they're easy and accurate to use.

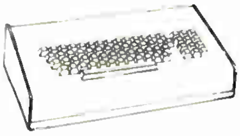
You'll like them because of selection, features and price."

You'll also like Cherry quality. The kind of quality you always hope for . . . but that is only realized when a company (like Cherry) has total in-house manufacturing capabilities. To make sure the thumbwheel or leverwheel switch you order is the finest available. Anywhere. Combine this dedication to quality with the broadest line and lowest prices, and you'll understand why our customers say "thumbs up" to Cherry thumbwheels.

NEW! The smallest thumb-wheel switch of them all.

The new T-50 sub-subminiature thumbwheel that takes only 8mm x 18mm front panel space . . . just 32mm depth back of panel.

For complete data and specs: TWX 910-235-1572 . . . or PHONE 312-689-7700 . . . or circle reader service number.



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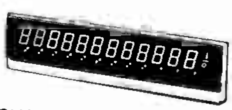

PLASMA-LUX GAS DISCHARGE DIGITAL DISPLAYS

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New products

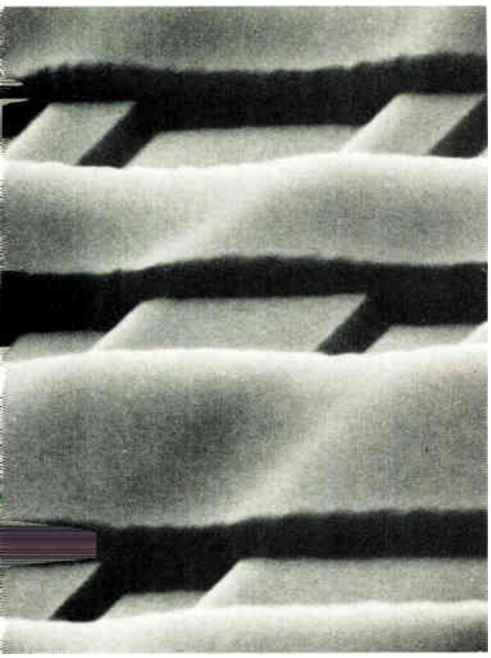
Packaging & production

Photoresist has fast exposure

Positive type also offers high level of stability and good geometry control

Liquid photoresists are photosensitive materials used for etching patterns through masks on semiconductor surfaces and thin films. Both negative and positive resists are available. In a negative-resist application, ultraviolet light is shone through a photomask onto a resist-covered surface. The resist film beneath the clear areas of the photomask undergoes a physical and chemical change that renders it insoluble in the developing solution. In a positive-resist system, the identical action produces areas that are soluble in a developing solution. At the present time, more than 85% of resist applications use the negative type.

In the last few years the use of positive photoresists for IC manufacturing has been picking up because of certain advantages over negative



materials. The advantages include lower processing costs due to reduced labor and higher yields, fine resolution in thick coatings, use of an aqueous rather than solvent-type developer, and easy removal of resist. However, positive photoresists do have one production bottleneck—an exposure time of about 30 seconds, compared with 10 for a negative photoresist.

A new positive photoresist, the AZ-2400 series from Shipley Company, Newton, Mass., has exposure speeds two to three times faster than older positive types, exceptional adhesion to silicon dioxide, a high level of stability, and good geometry control and edge acuity. AZ-2400 is suitable for the smaller geometries of new LSI devices which are beyond the resolution capability of negative resists. For instance, the ratio of thickness to resolution for AZ-2400 is 1 to 1 while the same ratio for a negative resist is 1 to 3. Because of this, negative resists are generally limited to 0.3-micrometer thicknesses with 1-micrometer geometry, while AZ resists are capable of producing sub-micrometer lines in 1-μm thicknesses.

Since the new positive resist, and positive resists in general, can give fine resolution with thick coatings, these materials are less likely to have pinholes—the largest cause of rejects in IC photolithographic processes. Pinholes are less prevalent above 0.6-micrometer film thickness, a thickness that would be suitable for a 0.6-μm line on a positive photoresist. The same line would require a 0.2-μm resist thickness with a negative resist, placing it in a region extremely susceptible to pinholing.

Another feature of the newest LSI patterns affecting the choice of a resist is the possibility of deep steps (see photo) resulting in resist thicknesses varying from 0.5 to 1.5 μm on the same layer. AZ resists can coat over these steps without line-width variations. Negative resists, on the other hand, have trouble maintaining resolution over this variation in coating thickness.

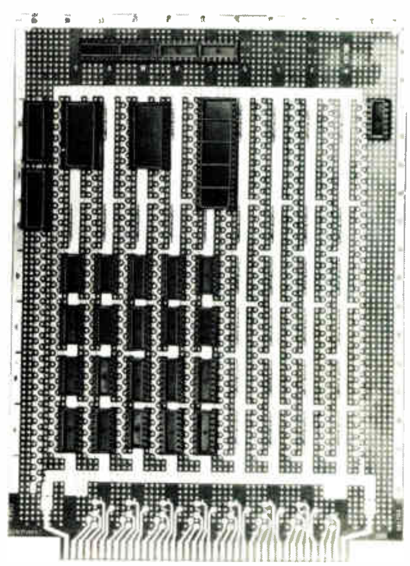
The new positive resist is already

down the cost of hybrid circuits. Semiconductor Equipment Corp. has developed the model 4400 Hot Shot—a machine that uses a tightly focused hot-nitrogen jet to remove bad semiconductor dice without affecting nearby good dice. The temperature of the gas jet can be adjusted up to 800°C. A heated substrate holder is provided to eliminate the thermal shock caused by the jet and thus prevent cracking of the substrate. The Hot Shot weighs only eight pounds, measures only 8 by 8 by 12 inches, and sells for $1,400. Delivery time is two to four weeks.

Semiconductor Equipment Corp., 1520 Lawrence Dr., Newbury Park, Calif. 91320. Jim Victor (805) 498-6727 [393]

IC panel made for analog and digital circuits

Called the model 4350 Plugbord, Vector's latest wiring panel is designed to accommodate a wide variety of microprocessors, interface circuitry, and discrete components. It has buses to distribute two power-supply voltages, plus ground. The buses, which pass under the DIP positions, are unperforated and opposite one another, thus providing a built-in bypass capacitance for the suppression of transients. Interwoven zig-zag lines, strapped to the

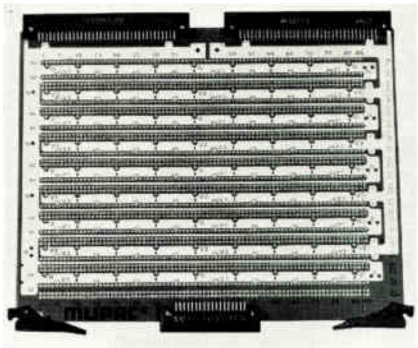


main buses, facilitate power distribution and allow the easy mixing of MOS and TTL devices. The 7-by-9.6-inch board can hold up to 63 14- or 16-pin DIPs, or nine 24-pin DIPs plus 45 of the smaller ones. Made of flame-retardant epoxy-glass, the board's surfaces are all tinned except for the contacts which are nickel-gold. The board is priced at $14.95 in small quantities; delivery is from stock.

Vector Electronic Co., 12460 Gladstone Ave., Sylmar, Calif. 91342. Phone (213) 365-9661 [396]

Universal panel holds ROMs, RAMs, and microprocessors

Able to accommodate the random-access memories, read-only memories, and microprocessors of all nationally known vendors, a universal wrapped-wire panel known as The

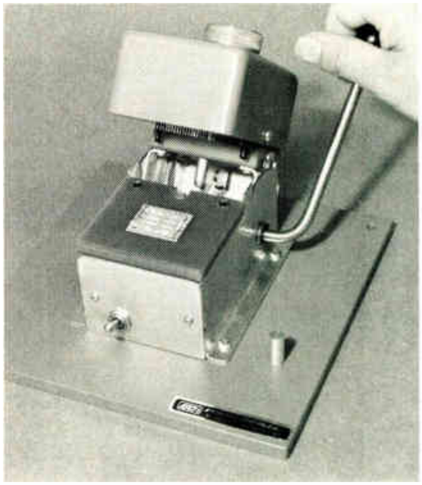


Sponge will permit the mounting of any dual in-line package with pin spacing that is a multiple of 0.1 inch. The panel contains four voltage planes for power distribution and up to 270 input/output pins. The Sponge sells for a price of $245 in lots of 10.

Mupac Corp., 646 Summer St., Brockton, Mass. 02402. Phone (617) 588-6110 [394]

Manual test fixture probes hybrid circuits

A manual access fixture from Everett/Charles uses an array of spring probes to provide full access to one



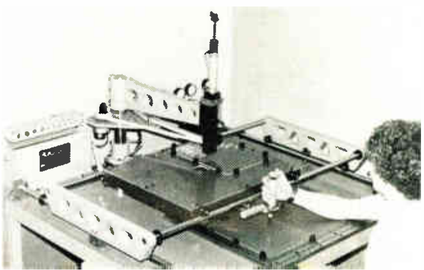
side, and limited access to the other side, of ceramic substrates up to 2.25 by 2.75 inches in area. The low-cost device has a tilting test head, to ease loading, examination of the spring probes, and microscopic inspection of the unit under test.

Everett/Charles Inc., 2806 Metropolitan Place, Pomona, Calif. 91767. Phone (714) 593-2541 [395]

Pin-insertion system can place 4,500 pins an hour

The Auto-Sert pin-insertion system is a manually operated machine with which a skilled operator, working from a template, can place up to 4,500 pins per hour. Wrapost pins for the machine are prepositioned on special tape and coiled onto a standard 10,000-piece, 5-inch Wrapost reel. The pins are fed to a fixed insertion head beneath which the board moves on an X-Y table. A pneumatic-electronic system prevents the insertion of pins if the pin is not located above a hole in the board, if the hole is already filled, or if it has been badly drilled. The Auto-Sert can handle board sizes up to 15.75 by 19.5 inches.

Auto-Swage Products Inc., 726 River Rd., Shelton, Conn. 06484. Phone (203) 929-1401 [397]



Subassemblies

Dual supplies run cool

Line-operated modules put out ±12 or ±15 V dc at efficiencies up to 80%

Satisfying modern demands for small size and cool operation, a new family of dual-output switching power supplies from Semiconductor Circuits offers operating efficiencies of up to 80%, and case temperature rises no more than 15°C at full-rated conditions. The six models in the family provide an output of either ±12 or ±15 volts dc at a current of 500 milliamperes. The ES/EA models are housed in pin-out modules measuring 2.5 by 3.5 by 1.56 inches, and the EC models are terminal-strip versions measuring 2.5 by 3.5 by 2 in.

All the units operate from an input of 105 to 125 v ac at 50 to 440 hertz. Line and load regulation is 0.15%, while output ripple and noise are held to 7 millivolts root-mean-square. Each output of any model can withstand a short circuit for an indefinite period. Additionally, no derating is required over the full operating range of 0°C to 71°C.

The new supplies employ a ripple-regulation technique that keeps their efficiency high and output constant over a wide range of input voltage, says Paul J. LaBrie, vice president. The input-line voltage is converted into positive and negative dc voltages by a transformer-coupled dual-output diode bridge. These raw dc voltages are then applied to a tracking dual-ripple regulator.

In a ripple regulator, a high-gain open-loop analog comparator drives the base terminal of a series-pass transistor. One input of the comparator is connected to a zener reference voltage, while the other monitors the output ripple. The comparator treats the output ripple as a loop-error voltage that it corrects by switching the transistor to either a full-on or full-off state.

The circuit's efficiency remains high because a transistor in deep saturation or cutoff dissipates far less power than one operating in its linear region, as a conventional series-pass transistor does, notes LaBrie.

Tracking between the two regulators is achieved by using the negative regulated output as the reference for the regulator controlling the positive output. This technique keeps the voltage difference between the positive and negative outputs essentially constant.

To prevent destruction under short circuits or overloads, the supplies are built with power-foldback current-limiting. At the same time that current is limited under a fault condition, the operating points of the affected regulator are folded back so that the power it must dissipate is reduced. This not only enables the supplies to withstand faults for very long periods, but also prevents excessive internal heating from eventually causing a long-term failure, claims LaBrie.

In quantities of one to nine, the ES/EA models are priced at \$124.95 each, the EC models at \$129.95. Delivery is two to four weeks.

Semiconductor Circuits Inc., 306 River St., Haverhill, Mass. 01830 [381]

5-V power supply delivers 60 A at efficiency of 68%

A switching-regulated power supply from Hewlett-Packard, the model 62605L, can deliver 60 amperes at 5 volts with an efficiency of 68%. The

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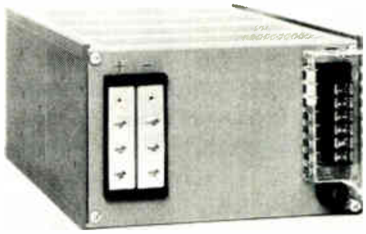
Circle 183 on reader service card

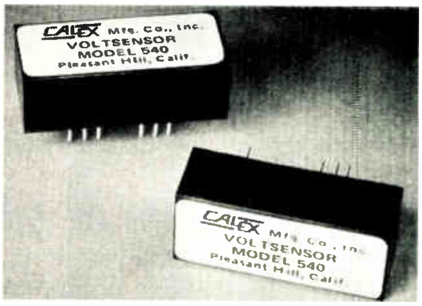


single-output unit contains its own forced-air cooling system, and so is both compact and reasonably insensitive to its orientation within the equipment it powers. Regulated to within 0.1%, the supply has ripple and noise ratings of 15 millivolts rms and 50 mv peak-to-peak from 20 hertz to 20 megahertz. The supply can put out its full rated current from 0°C up to 40°C, it then must be linearly derated to 30 A at 70°C. The 62605L sells for $450 in OEM quantities of 25. Delivery time is six weeks.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [383]

Rugged voltage comparator has 1-mV sensitivity

Intended for use in the hostile environment of industrial electronics, the Calex model 540 Voltsensor is an inexpensive device with a sensitivity and repeatability of 1 millivolt. Input protected against voltages as high as ±100 V, the comparator has an output current rating of 100 milliamperes. It can operate from dual power supplies from ±5 V to ±16 V or from a single supply from ±5 V to +32 V dc. Measuring 1.4 by 0.6 by 0.5 inches, the



unit plugs into any standard 16-pin DIP socket. Priced at $19 in unit quantities and $12 in hundreds, the 540 Voltsensor has a two-week delivery time.

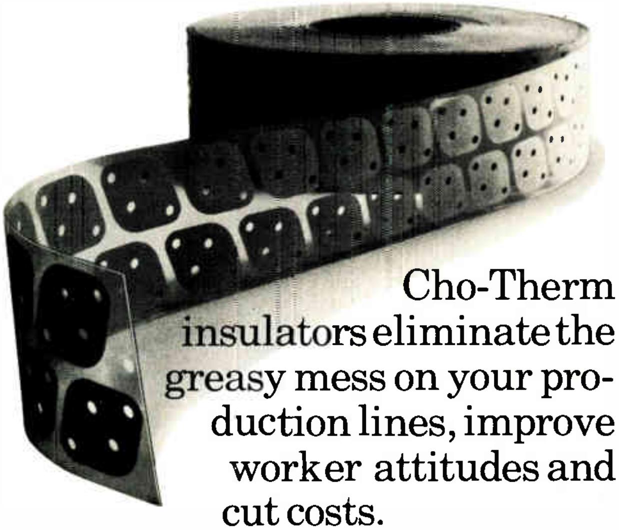
Calex Mfg. Co. Inc., 3305 Vincent Rd., Pleasant Hill, Calif. 94523. Rick Belford (415) 932-3911 [384]

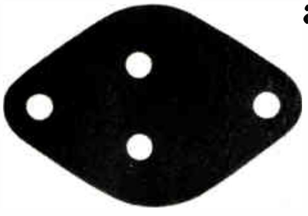
V-f converters are high in accuracy, low in price

Six 10-kilohertz voltage-to-frequency converters from Analog Devices mark that company's entry into a market that it feels is expanding at an annual rate of 20% from its present $2 million level. Determined to dominate the market within the next two years, Analog has introduced half a dozen converters that set new price/performance standards. The model 450K is the top-of-the-line unit with a maximum nonlinearity of 0.005%, a maximum

full-scale temperature drift of 25 ppm/°C, and a maximum input offset voltage drift of 20 microvolts/°C. The 450K sells for $59 each in small quantities. The companion 450J has corresponding specifications of 0.01%, 50 ppm/°C, and 50 μV/°C, and sells for $49.

The bottom of the line is the model 456J, a unit that sells for $25 each in hundreds, $34 in singles, and still has a maximum nonlinearity of 0.03% over its full 1-millivolt-to-15-volt input range. Its maximum full-scale drift is 120 ppm/°C, and its maximum input offset drift is 100 ±V/°C. Other models in the line offer the versatility of both voltage and current input capability, a feature that allows the modules to be





easily configured to handle bipolar inputs. Housed in packages that measure 1.5 by 1.5 by 0.4 inches, all of the 10-kHz v-f converters are available from stock.

While no firm date has been set, the company has indicated that a line of frequency-to-voltage converters will be following shortly.

Analog Devices Inc., P.O. Box 280, Norwood, Mass. 02062. Fred Pouliot (617) 329-4700 [385]

Switches handle 400 V at 15 A to 200 A

Designed for application to motor controls, switching regulators, and inverters, a series of solid-state power switches is rated for operation at 15 amperes to 200 A, with voltage ratings up to 400 volts. The line offers single switches with matched internal commutation diode and dual switches for push-pull operation. All switches are overload-protected with automatic reset. The opto-isolated input can be driven by standard TTL integrated circuits. Switching times of less than 1 microsecond permit operation from continuous dc to 20 kilohertz. Prices range from $90 to $400 each for one to nine. Delivery is from stock.

Power Functions Engineering Inc., P.O. Box 2312, Garland, Texas 75041. Phone (213) 278-0996 [388]

Nonswitching supplies have 60% efficiency

A line of linear power supplies for logic circuitry and other applications that need a 5-volt source offers efficiencies approaching those of switching regulators while avoiding the noise, spikes, and reliability problems that sometimes crop up with the latter. The RD5-15/OVP, RE5-23/OVP, and the RG5-40/OVP all provide 5 V at respective currents of 15, 23, and 40 amperes. Typical full-load efficiency is 60%, and 66% has been achieved at

reduced current. Regulation is within 0.02%, response time is 30 microseconds for a 50% change in load, and maximum ripple is 1.5 millivolts peak-to-peak. The three supplies, in order of increasing current rating, sell for $99.95, $130, and $220. Delivery time is two weeks.

Power-One Inc., 531 Dawson Dr., Camarillo, Calif. 93010. Phone (805) 484-2806 [386]

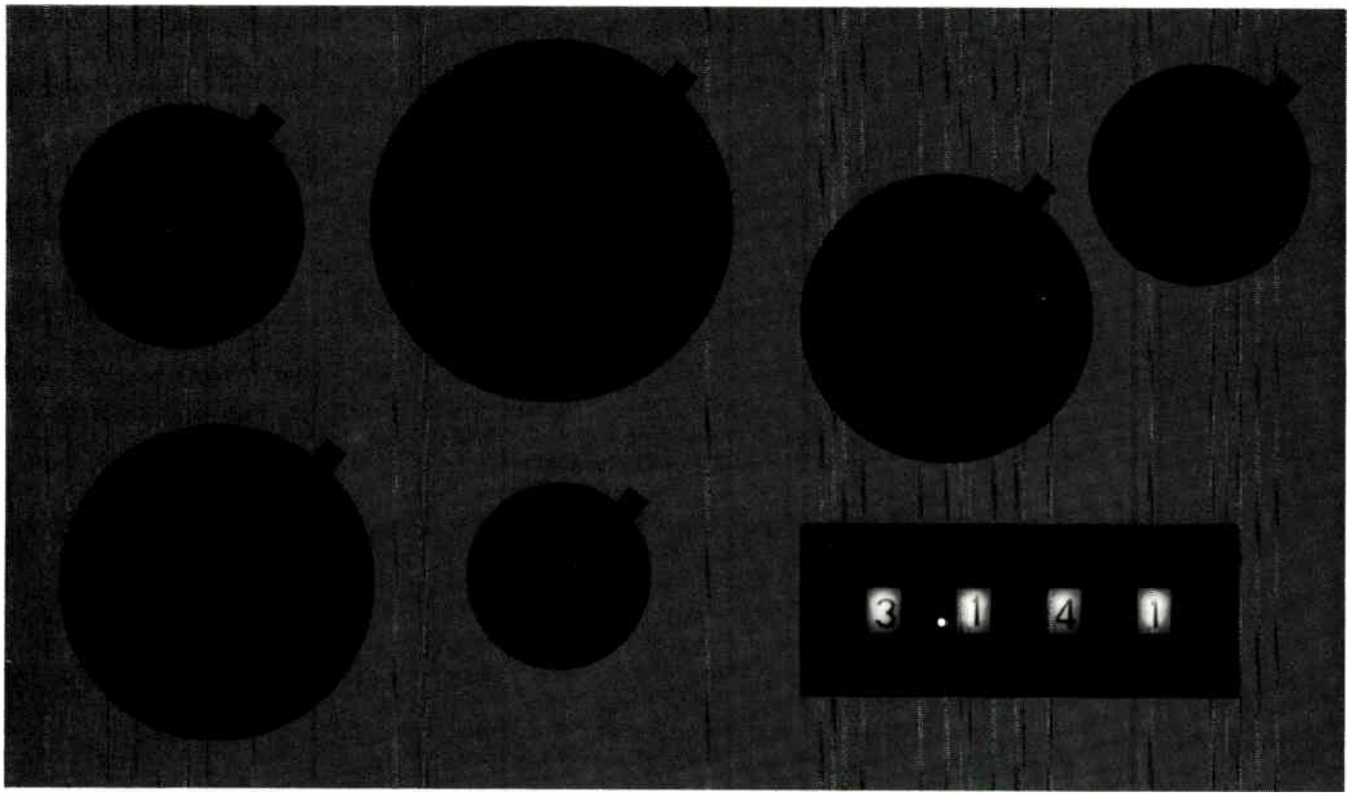
Programable interface drivers deliver up to 100 mA/15 V

For use in building high-speed test equipment, three programable high-speed and high-voltage interface drivers are said to provide pulse-generator-type drive capabilities at component costs. The PI-1000, PI-2000 and PI-3000 are capable of delivering 100 milliamperes at 15 volts, 50 mA/40 V, and 25 mA/80 V, respectively. The output currents can be programed by means of reference voltages, currents or resistances. Their high-impedance outputs are both open- and short-circuit-protected, and they can be ORed with outputs of other drivers for increasing ouput currents or for generating complex waveforms without loading the drive system or the device under test. When used with matched 50-ohm systems, their respective output characteristics are: Rise and fall times: 3 nanoseconds, 5 ns, 15 ns; maximum repetition rate: 50 megahertz, 35 MHz, 10 MHz; propagation delay: 10 ns, 15 ns, 50 ns; and maximum output offset: ±10 V, +35 V/−30 V, +75 V/−65 V.

Unit price of the three programable interface drivers is $80 each.

Pulse Instruments Co., P.O. Box 1655, San Pedro, Calif. 90733. Phone (213) 541-3204 [389]

All 10-turn pots look alike



in the dark.

In the dark they're all unreadable. And if you're more than three feet away, you can't even read them in the light.

Ergo our new Thumbpot. It can be illuminated to read in the dark (above), and the numbers are large enough to read 10 feet away.

In addition you can set in those numbers rapidly with finger or thumb. And you can reset any number right on the button, exactly.

The reason for these superior features is that Thumbpot is not a pot. It is an incremental voltage divider. A switch. A switch specifically designed to replace panel-mounted 10-turn pots.

Because Thumbpot is really a switch, it affords some other advantages. It is available in two sizes, with 1, 2, 3 or 4-digit readout, with or without a fixed or floating decimal point, in more than 400 standard versions. And its design is inherently more reliable and longer-lived than that of 10-turn pots.

There's much more to Thumbpot than we can cover here, however, so we urge you to request our brochure, by mail or telephone.

Thumbpot. No look-alike.

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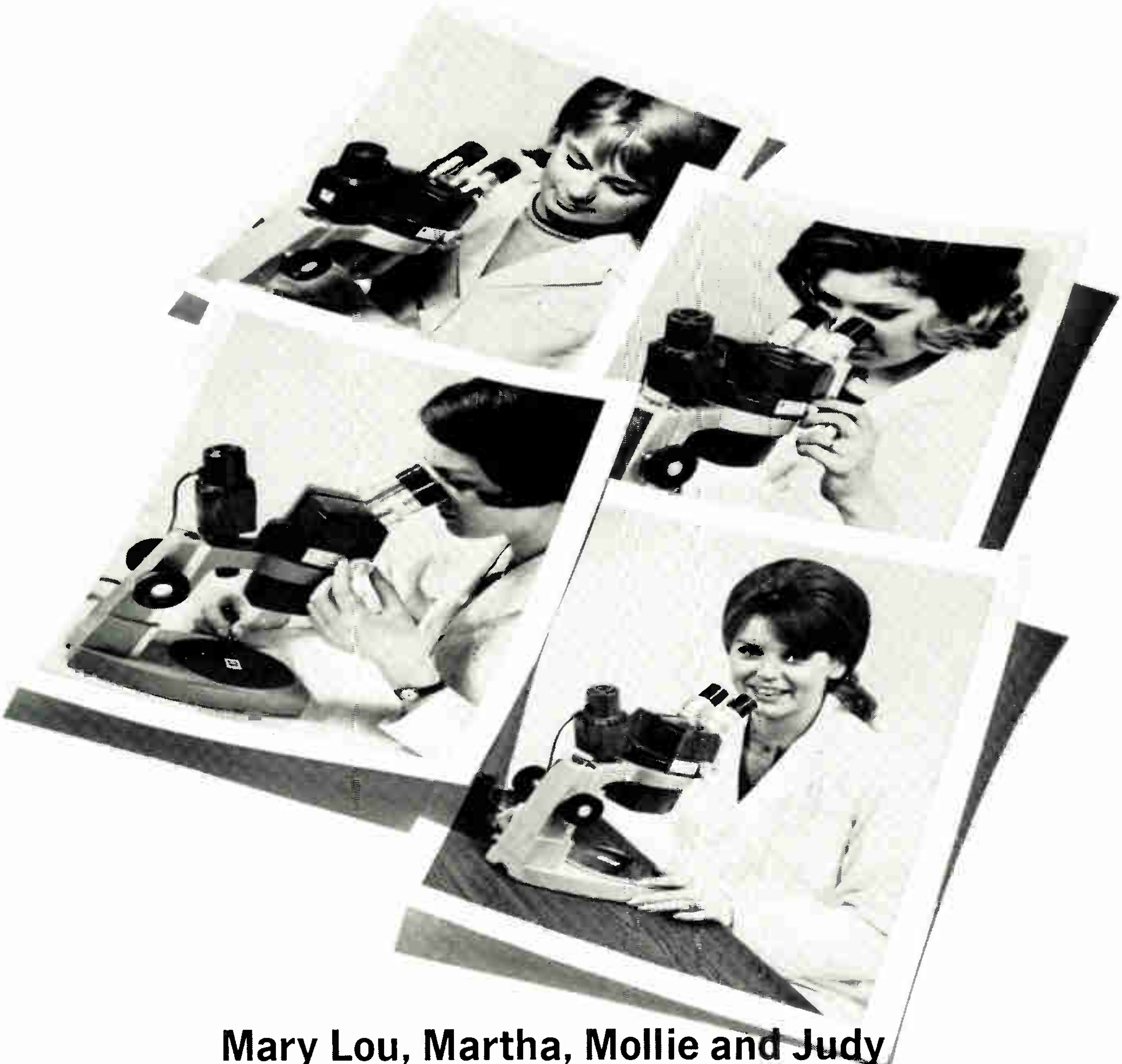
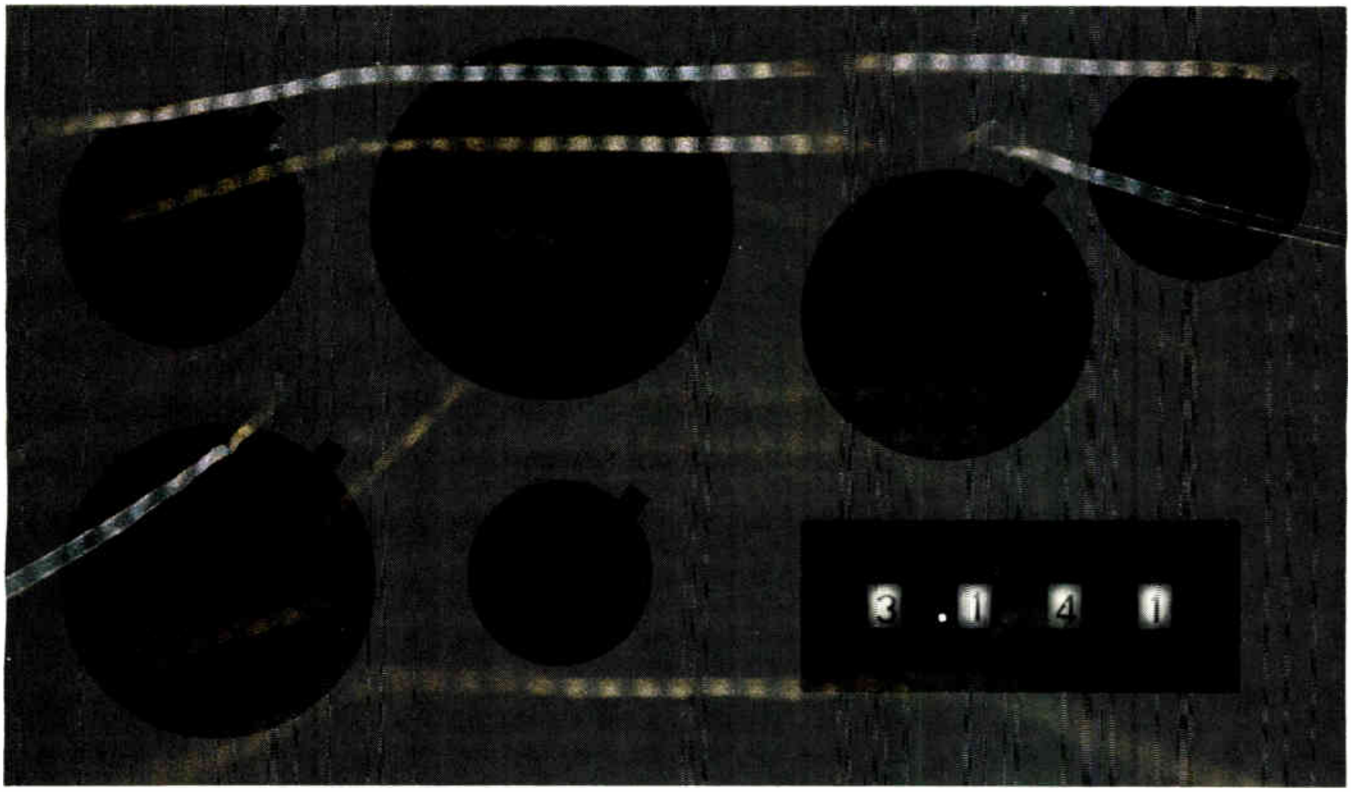
1441 East Chestnut Avenue, Santa Ana, California 92701
Phone 714/835-6000

Also available from Hall-Mark G. S. Marshall Schweber

Circle 189 on reader service card



All 10-turn pots look alike



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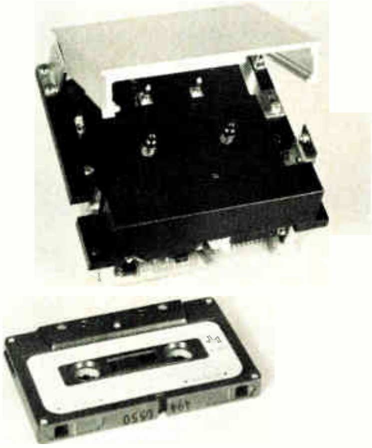
Data handling

More data on less tape

Use of two dc motors boosts information level through rapid start-stop

A digital cassette tape transport based on two dc motors eliminates the usual capstan drives and, with a new method of speed control, increases the tape-storage capacity. The $165 (in quantity) model CD-200 transport from Braemar Computer Products requires only one loosely regulated (14 to 30 volts) dc supply and can also work with 115 volts ac as an option.



The use of the two motors eliminates many of the mechnical parts responsible for unreliable operation in other transports, according to the Braemar director of product development, John C. Rooks. "Being an electronics guy, I have a feeling that most failures are related to mechanical things, and in our business reliability is quite important. By getting the number of moving parts down to a small number—two—you should really increase the reliability."

The unit has one motor for each reel and, attached to each motor, a perforated strobe disk that allows the transport to maintain a constant speed. An electronic servo system uses LEDs and photosensors to pick up the speed signals and thus control the speed. Rooks notes, though, that the digital recording speed tolerances need not be as close as those for audio specs—"the whole idea of digital recording is that you don't have to have very good speed tolerances," he says, but his method does constitute an improvement over similar techniques. Both tape channels are available for data, since the company does not use one of the data tracks for speed control, as in other devices.

Rapid start and stop allows the user to get more data on the tape, since the inter-record gaps can be cut to less than 0.5 inch at a speed of 10 inches per second. Operating speed can also range up to 40 inches per second, and the unit can have bidirectional read, write, and search operation. Tape-to-head alignment is maintained through machined, rather than stamped, parts.

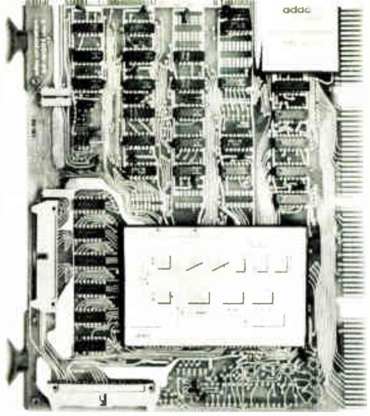
The unit can be remotely controlled and has TTL- and complementary MOS-compatible inputs and outputs. Other features include a fingertip release mechanism—a simple tap of the cover flips it open—which can eliminate the need for the operator to find the release button. The control electronics are mounted on a printed-circuit board beneath the case, and the two motors project through the pc board. The unit measures only slightly larger than the cassette itself—4.65 by 4.9 by 3.5 inches deep (the depth would change as more electronics are added). The company will soon offer read, write, and decoding electronics, according to Rooks.

Braemar Computer Devices, Inc., 11950 Twelfth Ave. South, Burnsville, Minn. 55337 [361]

Data-acquisition system works with DEC's LSI-11

The first data-acquisition system made to work with Digital Equipment Corp's. LSI-11 one-board minicomputer has both software and hardware compatibility with the computer. Contained on a single 8.5- by 10-inch printed-circuit board, the ADAC model 600-LSI includes a 12-bit analog-to-digital converter, a sample-and-hold amplifier, 16 channels of multiplexed inputs, and all the logic interface circuitry needed for compatibility with the LSI-11. The 600-LSI contains a dc-to-dc converter which runs off the computer's 5-volt supply.

Able to handle single-ended, differential, and pseudo-differential inputs, the data-acquisition system is expandable from 16 to as many as 64 channels. Standard input voltage



ranges are 0 to +5 v, 0 to +10 v, ±5 v, and ±10 v. Optional features include a programable-gain amplifier with four gain settings and an automatic zeroing circuit that prevents offset drifts at even the highest gain settings.

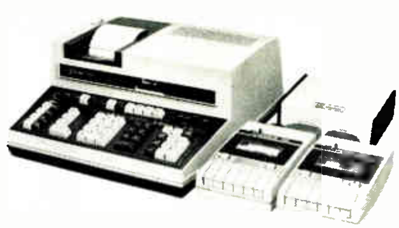
The heart of the 600-LSI is a 12-bit data-acquisition module called the ADAM 12. Although lacking the dc-dc converter and interfacing circuitry of the larger unit, the ADAM 12 contains the 16-channel multiplexer, sample-and-hold unit, and a-d converter of the full system. It is housed in a 3- by 4.6- by 0.375-inch metal case that provides electrostatic and electromagnetic shielding on all six sides.

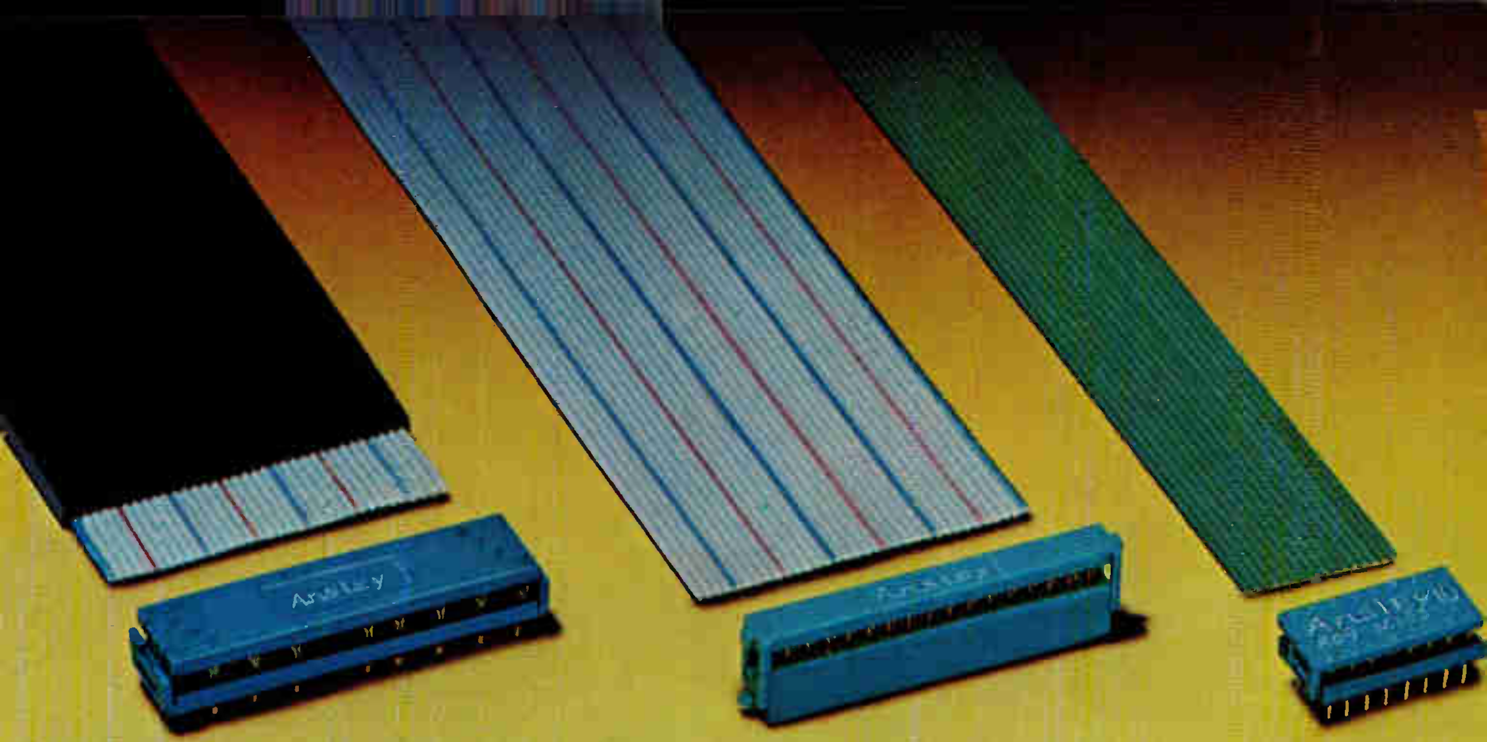
The 600-LSI system sells for $895 in small quantities, while the ADAM 12 module has a corresponding price of $285. Delivery time for both units is 45 to 60 days.

ADAC Corp., 118 Cummings Park, Woburn, Mass. 01801. A. L. Grant (617) 935-6668 [362]

Cassette unit expands storage of calculators

A read/write tape cassette system increases the storage capability of Monroe's 1800 series of programable calculators. The model 392 uses standard Philips-type cassettes. Each C30 cassette can hold 150 blocks of data per side; and each





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In short, our one-source BLUE MACS termination technique offers built-in design compatibility to provide you with the most reliable and complete mass-assembled-connector-system in the industry. After all, who else would know more about mass termination techniques than T&B/Ansley . . . the company that's been doing it since 1958.

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In Canada: Ansley Electronics Ltd., P.Q.

The BLUE MACS system is stocked and sold through authorized T&B/Ansley distributors worldwide.

Circle 193 on reader service card

block contains either 256 bytes or 32 registers. Read and write times are 5 seconds per block. The cassette systems are available in either single-or dual-drive versions. The single-drive unit sells for $695.

Monroe Division, Litton Industries, Box 9000R, Morristown, N. J. 07960. Mrs. Norma Backster (201) 540-7645 [365]

Simple CRT terminal sells for $1,095

A simple keyboard/CRT terminal intended for applications that do not require the sophistication of so-called "intelligent" terminals is priced at only $1,095. The ADM-

3LC has a standard display of 960 characters organized as 12 lines of 80 characters. Well suited for inquiry-response applications, the unit has a standard 59-key keyboard and interfaces for connection to any standard computer.

Lear Siegler Inc., Electronic Instrumentation Division, 714 N. Brookhurst St., Anaheim, Calif. 92803. Phone (714) 774-1010 [366]

16-bit microcomputer has 350-ns cycle time

The Miproc 16 microcomputer is a complete microprocessor with 82 instructions and a cycle time of only 350 nanoseconds. Configured for parallel fetch and execution, the unit is able to carry out most instructions in a single cycle. Conditional branches take 700 ns, and multiply and divide times are 5.6 and 11.2 microseconds, respectively.

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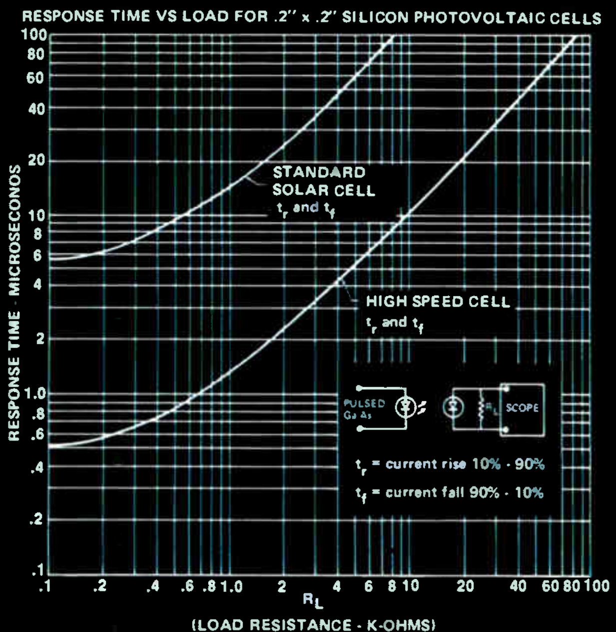

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New products

Offered in standard and ruggedized versions, the Miproc 16 is supported by a Fortran IV cross-assembler and a simulator for use on the Tymshare and GE Mark III networks.

Plessey Microsystems Inc., 1674 McGaw Ave., Santa Ana, Calif. 92705. Phone (714) 540-9945 [367]

Modular data-entry system is flexible and expandable

The CMC 1800 shared-processor data-entry system is modular in both hardware and software so that it can be easily expanded in small increments to fit a user's changing

needs. The system can handle up to 64 keystations. A basic system includes a supervisory desk-style console, a command console, magnetic-tape and disk storage units, and a processor having 64 kilobytes of core memory. In a typical 10-keystation configuration, such a system sells for $86,000 and leases for $1,650 per month, including maintenance, on a three-year lease. Peripherals include line printers, card

Why you can afford the very finest in function generators.

Because Interstate's new F77 truly is a universal signal source. With F77's 0.00002 Hz to 20 MHz range, you can test with frequencies from infrasonics through video, and beyond. There are 6 output waveforms, 7 operating modes, and precision interface controls (waveform inversion and a 5/95% waveform variable symmetry vernier, for example) that can be actuated with remarkable variations. And output amplitude is specified at 15 volts p-p into 50 ohms — that's 50% more voltage swing than most 20 MHz function generators provide.

Because the F77 also incorporates a very capable. independent sweep generator offering linear and logarithmic performance, with a selection of auxiliary outputs. Sweep up or down, sweep reset control. and continuous, triggered, burst, sweep-and-hold modes. too. Interstate's special frequency dial has a direct-reading sweep limit cursor, plus two calibration scales (X1 and X2) to improve resolution and permit continuous tuning across the 20 Hz-to-20 KHz audio band.

Because this function generator is the first of its kind to deliver real pulse generator capability. The F77 produces a 15 ns rise time pulse to 20 MHz with constant width setability from 30 ns to 10 milliseconds, and full offset and mode flexibility. The generator's fully-calibrated attenuator gives you 15-volt unipolar pulses into high impedance loads, particularly useful for testing MOS, or millivolt pulses down to 1.5 mv.

Because there's also a constant duty cycle pulse (in addition to F77's standard pulse) for a variety of digital signal response applications. Circuit sensitivity to duty cycle on/off times can be tested using varying pulse rates without adjusting the width control.

Because the F77 can be used as an analog power amplifier to amplify externally applied signals as much as 600%. Even TTL pulses can be amplified to drive 50-ohm loads, and the resulting output has controlled dc offset and attenuation.

Because the F77 gives you many other high performance and human engineering features, like VCF capability for sweeping frequency-sensitive devices, and "oscilloscope-style" triggering with a variable start-stop phase control to generate haversines and havertriangles. There's even a "brown-out" switch to allow the instrument to operate at low line voltages.

Because the F77 only costs $1,095.*

*U.S. price; other 20 MHz Series 70 models available from $695.

IEC

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Circle 197 on reader service card

readers, a CRT command console, and magnetic-tape units.
Computer Machinery Corp., 2500 Walnut Ave., Marina del Rey, P.O. Box 92300, Los Angeles, Calif. 90009. (213) 390-8411 [368]

Data-entry system can support four stations

A distributed data-entry system for both small companies and small departments within large organizations can support from one to four data-entry keystations. The model 1300 key-to-disk system is intended for situations in which data must be converted, edited, and prepared for computer processing at a location away from the main computer center. It offers both Inforex synchronous (Infosync) and conventional binary synchronous (Bisync) modes of data communications at rates up to 9,600 bits per second. A typical four-station system, consisting of a control unit, a 5,000-record disk drive, an 800-bit/inch tape drive, and four video display/keyboard stations, leases for $683 per month, including maintenance, on a three-year lease.

Inforex Inc., 21 North Avenue, Burlington, Mass. 01803. Phone (617) 272-6470 [363]

One-pass assembler developed for Intel 8080

A one-pass assembler that runs in resident mode on an Intel model 8080 microprocessor occupies less than 2 kilobytes of memory. The


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ITALY SP Elettronica spa Via Carlo Pisacane 7, 20016 Pero (Milan) Italy • 35 30 241 • TELEX 36091
Circle 199 on reader service card

program assembles a compatible subset of the Intel language and generates machine code directly into memory for immediate execution, if desired. The one-pass assembler has a considerable speed advantage over conventional three-pass programs; for example, a user with a teletypewriter who has a source program that requires 30 minutes to read and 5 minutes to punch will need three hours and 5 minutes with a three-pass assembler but only one hour and 15 minutes with a one-pass program.

Micro Systems Software, 355 West Olive, Sunnyvale, Calif. 94086. Phone (408) 735-1656 [364]

Latest PDP-8 minicomputer goes parallel for speed

A parallel-processor version of the PDP-8/A minicomputer performs calculations much faster than previous PDP-8 models. Sample instruction times include 10.5 microseconds for fixed-point add, 30 μs for floating-point add, and 37.5 μs for floating-point multiply. The computer uses an auxiliary processor to perform fixed- and floating-point operations in hardware. Priced from $5,995 including 8-k words of core memory, it is scheduled for delivery in April 1976.

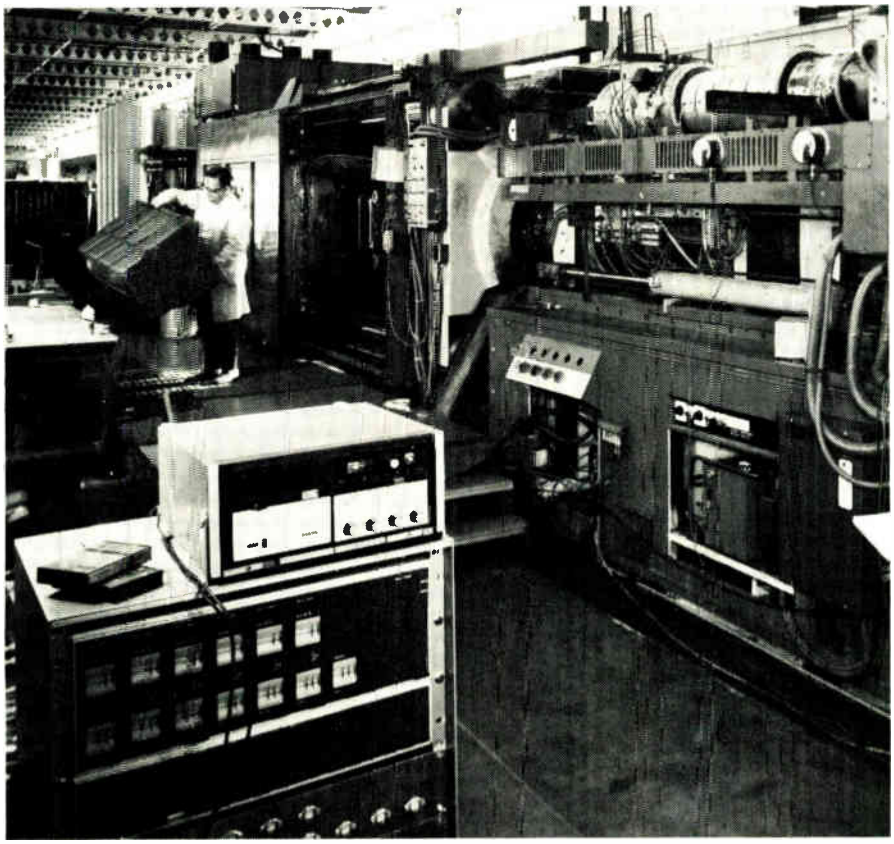
Digital Equipment Corp., Maynard, Mass. 01754. Phone (617) 897-5111 [369]

Disk systems offer high reliability at low price

Aimed at the user who needs the high data integrity of hard disks but does not require their capacity, the Dynastor system provides 2.2 million bits of storage for a complete-system price of $3,000. Plug-compatible with Data General Nova series and DCC computers, the Dynastor system includes all interface logic, interconnecting cables, power supplies, and packaging.

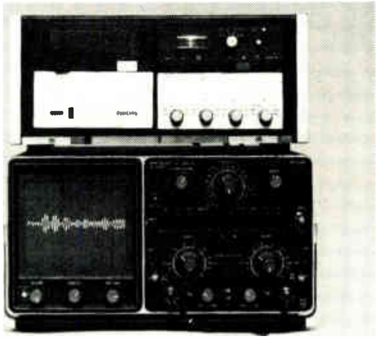
Dynastor Inc., 5867 N. Broadway, Denver, Colo. 80216. Phone (303) 572-1170 [370]

We've taken the expense out of data recording



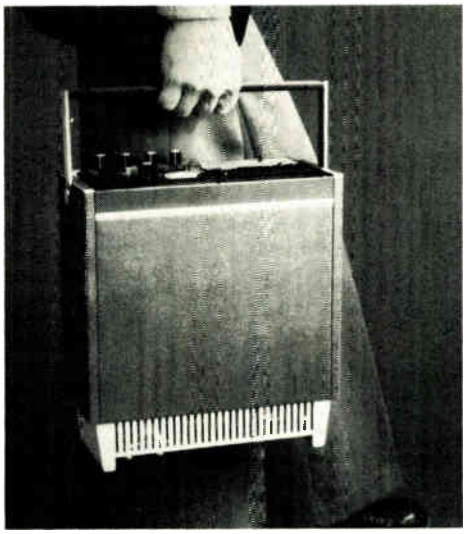
For trouble-shooting or process control two speeds allow rapid survey or slow motion analyses.

Low operating costs and simple operation combined with high-performance and reliability makes the new Mini-Log 4 analogue cassette-recorder a really practical proposition for industry. Mini-Log 4 uses standard compact-cassettes. Equally important, its purchase price is considerably lower than any competitive system.



Outputs from the four FM-channels on the Mini-Log 4 can be used to drive an oscilloscope or chart recorder.

Simply 'post' a compact-cassette into a slot in the front panel and Mini-Log 4 is ready to use.



Mini-Log 4 is extremely compact and lightweight and operates from mains or battery supplies.

I am interested in *full information/demonstration of the new Mini-Log 4.

Name: ______________________

Company: ______________________

Address: ______________________

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*Delete which does not apply 3-2

Write for demonstration or full information to:
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   DC and AC current, 0-1, 10, 100, 1000mA;
   Ohms, 0-100, 1K, 10K, 1 meg, 10 megs.
   10 meg industry standard input impedance
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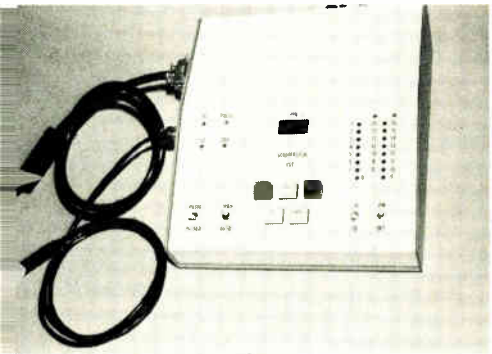
Instruments

Logic probe speeds tests

Checkout system includes DIP clip; pin under test is identified on LED display

In troubleshooting a dual in-line module, many an engineer or technician has had to struggle to keep one, possibly two probes touching the right pin-outs while also watching a counter or scope. Information



Scan Technology's Scanmaster probe is designed to do away with that struggle.

In addition to the standard probe, which also acts as a pulser, the Scanmaster comes supplied with a specially designed DIP clip that fits over either 14- or 16-pin dual in-line digital logic ICs. According to Gary Rhodes, IST's marketing manager, troubleshooting with the Scanmaster simply involves switching the probe from pin to pin by pushing buttons and reading an LED display to determine which pin is being tested. Not only does the Scanmaster have its own logic-level and pulse indicators, he says, but it also serves as a convenient pin-switching interface for a scope or counter.

The Scanmaster has four basic modes of operation. Autoscan rapidly scans all of the module pins and stores the static-state level of each. It automatically stops its scanning when it sees a bad level and displays the associated pin number. Manual scan allows the user to test each pin on the module by simply pushing a button and reading the pin number on the display. A fast-scan button allows him to find a pin rapidly. As long as this button is depressed, the Scanmaster will rapidly step through the pins. When the display nears the correct pin number, releasing the button stops the scan. If the user should miss by a pin or two, pressing an up or down button brings the correct pin.

The pulser mode, says Rhodes, allows the user to inject a pulse into the module and watch the output without having to hold two probes in place. All that is necessary is to touch the desired pin at the top of the DIP clip and watch the pulse LED or the scope as the pulse is triggered by a switch on the probe. To shift to the probe mode, all that is necessary is to switch a pulser-probe switch to prove and test points where the DIP clip cannot be used.

Logic-high threshold is adjustable from 1.2 volts to 20 V. Logic-low threshold is adjustable from 0.3 to 4.5 V. Any voltage between the threshold high and low settings is detected as a bad level. The Scanmaster, says Rhodes, can be used for TTL, C-MOS, HTL, RTL, DTL, and other logic families. Pulser output is 4.5 V with logic-high set less than 8 V, and 10 V for logic-high greater than 8 V. Pulse duration is 0.4 microsecond, and input impedance is greater than 200 kilohms. Overvoltage protection is ±25 V. Pulse-detection range is 2 to 5 megahertz, and pulse excursion must meet high- and low-logic threshold settings.

The Scanmaster probe measures 8 by 2 by 10 inches and weighs 10 pounds. Price is $895.

Information Scan Technology, 3650 Charles St., Santa Clara, Calif. 95050 [351]

Low-cost frequency counter runs on four AA batteries

To meet servicing needs of data-processing, data-communications, and other systems, Logic Tech-

nology Inc. of Mountain View, Calif., is marketing a compact low-cost frequency counter. Called the Pocket Counter II, the hand-held, battery-operated instrument, which measures 8 by 4 by 2 inches, sells for $189.

The instrument has an eight-digit light-emitting-diode readout and an overrange indicator. Measurement range is 1 hertz to 10 megahertz, and sensitivity is 250 millivolts rms from 0 to 40°C. Maximum error is ±(0.01% of reading + 1 count). Input impedance is 100 kilohms shunted by less than 51 picofarads, and maximum input is 200 volts rms at 10 kilohertz, derated to 10 V rms at 10 MHz.

The counter is powered by four AA rechargeable nickel-cadmium batteries (which are supplied), and they will operate for more than eight hours at 30% duty cycle when fully charged.

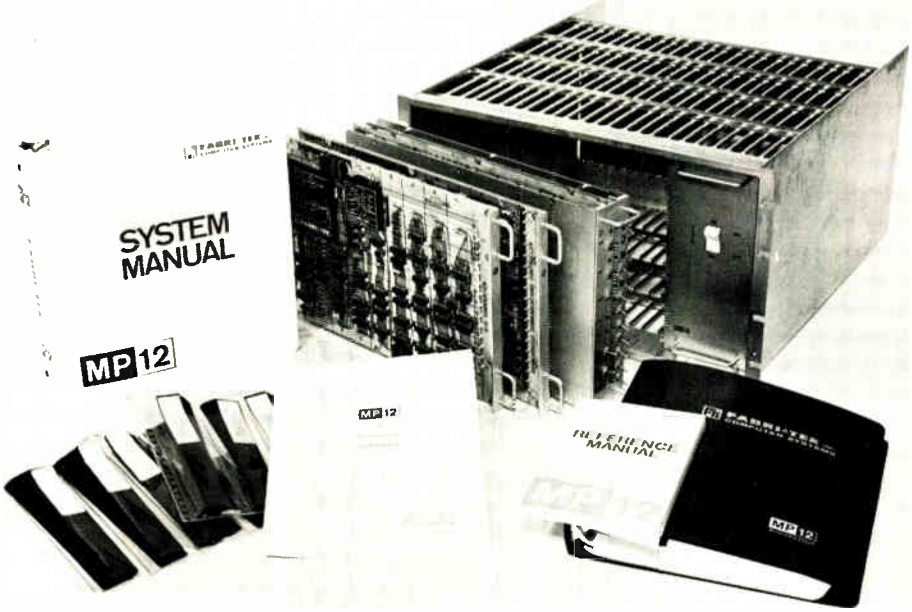
Delivery time is 30 days. Quantity and OEM prices for the counter are negotiable, the company says.

Logic Technology Inc., 1950 Colony St., Mountain View, Calif. 94043 [352]

Digital phasemeter is accurate to within 0.03°

Able to measure phase angles to within an accuracy of better than 0.03°, the model 305 digital

The MP 12 Do-It-Yourself Kit:



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D/A Converter, dual channel, 12 bit: **$549**
Magnetic Tape Controller, 9 track, IBM compatible: **$640**
Tape Cassette Controller: **$372**
4K Data Memory: **$665**

*Quantity 100 U.S. Prices, F.O.B. Minneapolis.
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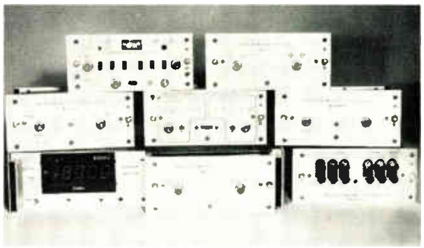
Circle 205 on reader service card

New products



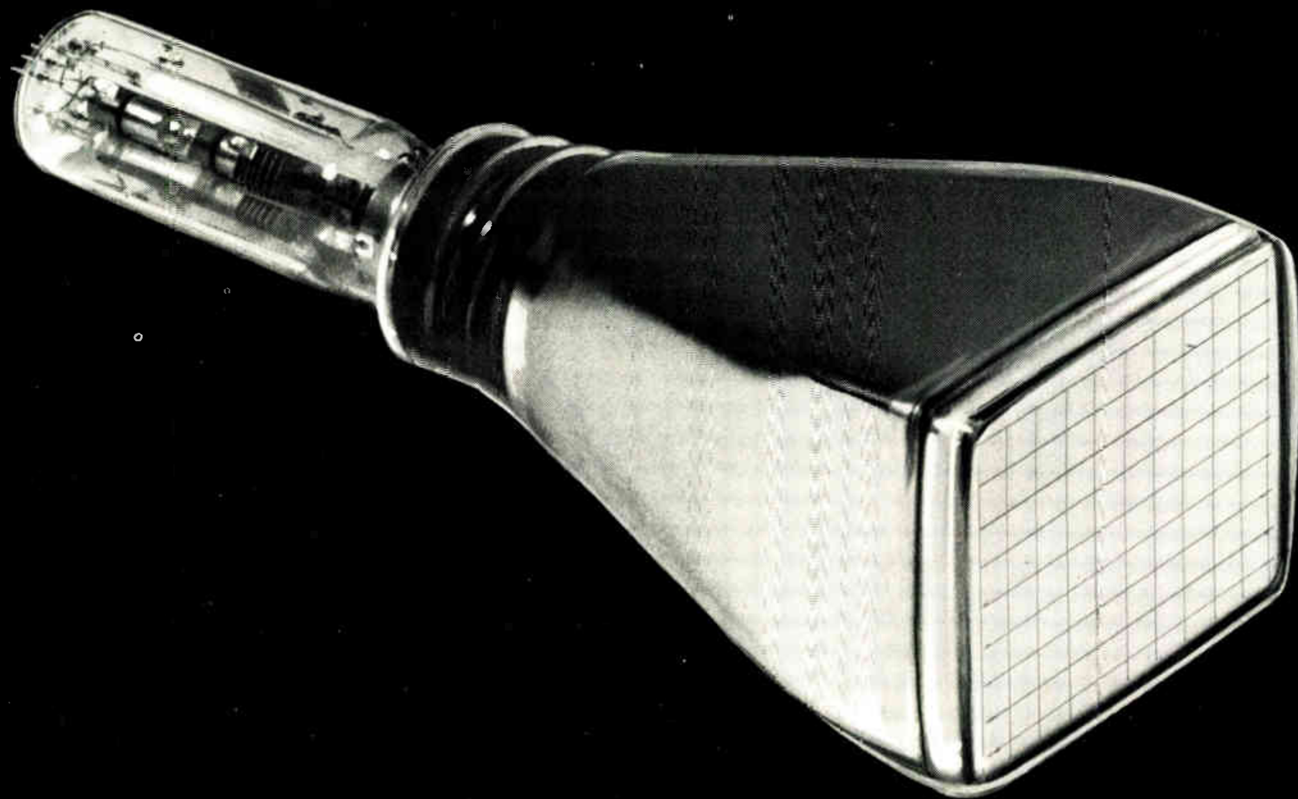
phasemeter is a five-digit instrument that can handle frequencies from 1 hertz to 11 megahertz. The automatic meter requires no adjustments by the operator because internal control circuitry sets the ac gains, selects the output time constants (for the best combination of measurement speed and ripple), senses whether the angle is leading or lagging, and chooses the appropriate measurement range. Input voltages from 1 millivolt to 300 V rms can be accepted by the phasemeter which has a resolution of 0.01° and a maximum nonlinearity of 0.02°. Price varies from $1,930 to $4,500, depending upon plug-ins and other options.

Dranetz Engineering Laboratories Inc., 2385 S. Clinton Ave., S. Plainfield, N. J. 07080. Arnold Ackerman, (201) 755-7080 [353]

Counter/timer sets range and resolution automatically

A resolution control on the model 5500B universal counter/timer selects the number of digits to be displayed, and a microprocessor-like internal controller then selects the time base or gate period required, positions the decimal point, sets the dimension annunciator, and controls the display of the measurand to the desired number of digits. Available in a six-digit model (with selectable resolutions of four, five, and six digits), and an eight-digit

Market requires large screen oscilloscopes



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Type	Screen cm	Sensitivity V/cm	Length mm	Operating frequency MHz
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TH 8205	8 x 10	2.2	340	100
TH 8203	8 x 10	1.2	370	350

Information about ruggedized versions of these tubes and custom electrostatic screens of larger size available upon request.

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Circle 207 on reader service card

version (five through eight digits), the 5500B is especially well suited for automatic test systems because its internal logic circuitry greatly simplifies and reduces the commands and control lines needed to link it with the system controller. The autoranging instrument has 10 modes of operation, including frequency-counting up to 118 megahertz and time-interval measurement to a resolution of 100 nanoseconds. Its two input channels are both dc-coupled. The aging rate of the oven-stabilized crystal-controlled time base is less than 3 parts in 10^7 per month. The six-digit version of the 5500B sells for $695, while the eight-digit unit is priced at $765. Remote programing adds $100 to the price of either model. Delivery time is four to six weeks.

Ballantine Laboratories Inc., P.O. Box 97, Boonton, N. J. 07005. Phone (201) 335-0900 [355]

Contactless meter reads up to 1,000 A ac or dc

A key problem in the design of noncontacting current meters is residual magnetism in the magnetic core that is used as a flux concentrator. The model 1776 digital current meter from F. W. Bell overcomes this problem with a dynamic feedback scheme which greatly reduces errors from this source, and hence allows the use of silicon-steel cores with their very high levels of saturation magnetization. The result is a 3½-digit meter that can read 1,000 amperes full scale and yet retain a maximum dc error of 0.5% of full scale all the way to the bottom of its range. Th Hall-effect instrument uses three probes which give it full-

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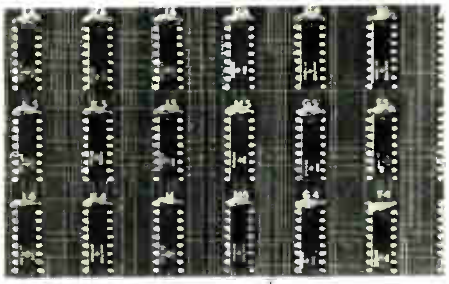

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Circle 209 on reader service card

Mini maximizer systems

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DIVA, Inc. 607 Industrial Way West / Eatontown, N. J. 07724 / Phone: 201-544-9000 / TWX 710-722-6645 scale ranges of 10, 100, and 1,000 A for frequencies from dc to 10 kilohertz. The price of the meter, with one probe, is $850.

F. W. Bell Inc., 4949 Freeway Drive, East, Columbus, Ohio 43229. Phone (614) 888-7501 [356]

3½-digit multimeter kit sells for $89.95

A 3½-digit (2,000-count) digital multimeter, built around the Siliconix DVM chip set, can measure ac and dc voltages to 2,000 volts, dc current to 2 amperes, and resistance to 2 gigohms. The autopolarity instrument has a maximum error on dc volts of ±(0.05% of reading + 1 count) and a maximum ac voltage error of ±(0.5% of reading + 1

count). In its standard kit form, the model 75B comes with Monsanto 0.3-inch light-emitting-diode displays and sells for $89.95. The factory-wired version is priced at $149.95. The unit is also available, in both kit and wired form, with Litronix 0.5-in. LEDs. Designated then as the 75A, the meter is priced $10 higher in both cases.

Roto-Kit Division, Alpha Centauri Electronics Inc., 415 Kay Ave., Addison, Ill. 60101. John Castro (312) 543-2699 [357]

Microwattmeter spans 200 kHz to 18 GHz

The 42C series of microwattmeters is a line of three instruments that can measure power levels from about 10 nanowatts up to 100 milliwatts. Three power-detector heads are available, and all have a lower

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frequency limit of 200 kilohertz, while their upper frequency limits are 4 gigahertz, 12.4 GHz, and 18 GHz. The respective maximum voltage standing wave ratios are less than 1.12, 1.18, and 1.28. The three meters in the series are the 42C analog meter which is priced at $1,210, the 42CB battery-operated analog meter which sells for $1,370, and the 42CD digital meter which carries a price tag of $1,600.

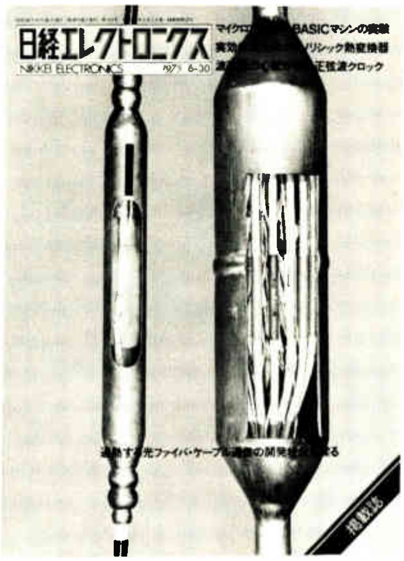
Boonton Electronics Corp., Parsippany, N. J. Wallace F. White (201) 887-5110 [358]

20-MHz function generator has full pulse capability

The model F72 pulse/function generator from Interstate Electronics puts out sine, square, triangle, and pulse waveforms at frequencies from 20 microhertz to 20 megahertz. Unlike most other function generators with pulse-output capability, however, the F72 provides for the adjustment of pulse rise and fall times and also for a very wide range of pulse-width adjustment: 30 nanoseconds to 1 second. A special variable-symmetry mode of operation allows the function generator to have the duty cycle of its square-wave output (as well as its sine and triangle waveforms) vary from 5% to 95%. In this mode of operation, the maximum frequency of the instrument is 1 MHz. The F72 sells for $895; delivery time for the generator is 30 days.

Interstate Electronics Corp., Dept. 7000, 707 East Vermont Ave., Anaheim, Calif. 92803. Robert Visser (714) 549-8282 [359]

Outsiders on the inside in a big way in the Japanese electronics market advertise in Nikkei Electronics



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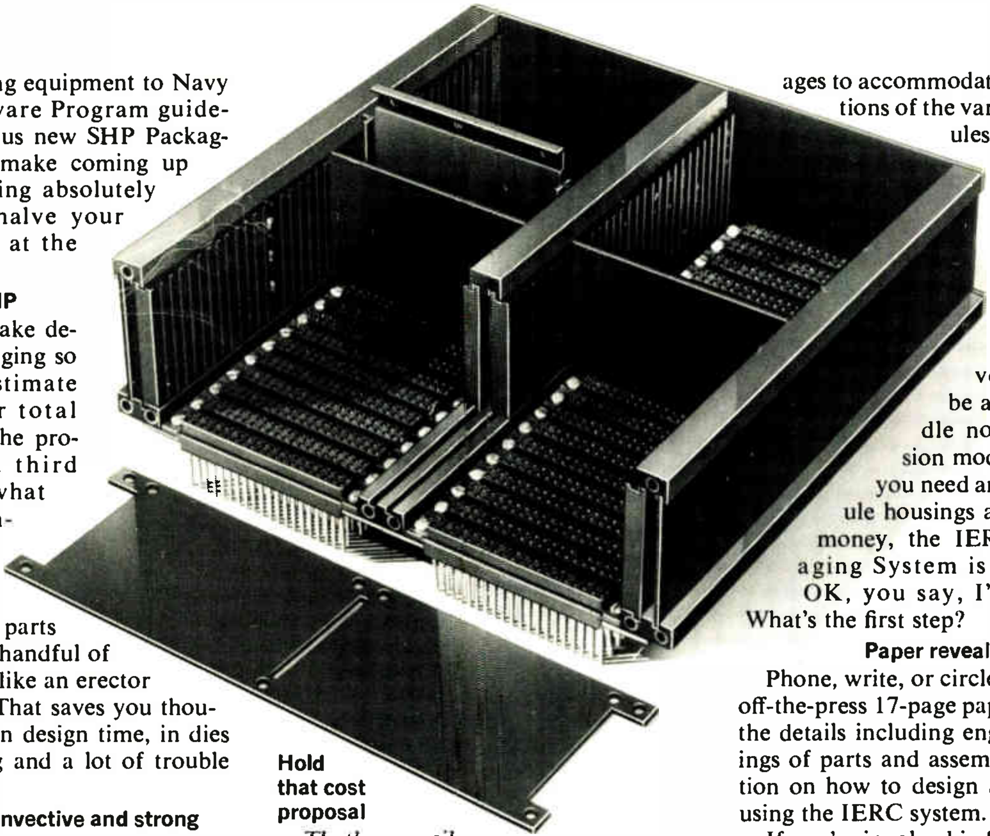
Conformal coating R-4-3117 is a transparent silicone resin that displays good dielectric properties from low frequencies up through the microwave region. It is intended as both a protective coating for circuit boards and an impregnating material for porous substrates, and its main function is to improve moisture resistance. It can be applied by dipping, spraying, brushing, or flow-coating.
Dow Corning Corp., Midland, Mich. Phone (517) 496-4984 [477]

Conductive adhesive Eccobond 60C is a one-part material which is less expensive, and less conductive, than silver-bearing products. Its bulk resistivity is approximately 50 ohm-centimeters. Applications include the sealing of joints against rf leakage, the formation of absorptive coatings, and the fabrication of coatings with good thermal conductivity. Once cured, Eccobond 60C can be used over the temperature range from -65°F (-54°C) to 350°F (177°C). It sells for $7 per pound in 10-pound lots.
Emerson & Cuming Inc., Canton, Mass. 02021. Phone (617) 828-3300 [479]

Selling for half as much as silver, a conductive alloy is a fine powder with a maximum resistivity of 0.06 ohm-centimeters. The material, Cobaloy 807-S, was developed as a lower-cost alternative to silver powder in the manufacture of thermally and electrically conductive coatings and adhesives. The material has a particle size of 35 micrometers, and, unlike silver, it does not tend to settle into a hard cake.
The Cobaloy Co., 626 Great Southwest Parkway, Arlington, Texas 76011 [480]

Navy Standard Hardware Program* packaging made easy and profitable

***Now called Standard Electronic Module Program (SEM)**



If you're supplying equipment to Navy Standard Hardware Program guidelines, our ingenious new SHP Packaging System will make coming up with the packaging absolutely simplistic and halve your packaging costs at the same time.

No sweat SHP

First off, we make designing the packaging so effortless we estimate you'll cut your total design load for the procurement by a third because that's what our first customers are experiencing.

Production consists of putting parts together — just a handful of different kinds — like an erector set. Only easier. That saves you thousands of dollars in design time, in dies and other tooling and a lot of trouble to boot.

Conductive, convective and strong

And when you get finished you'll have packaging for your circuitry with the high order of thermal efficiency you'd expect from industry's leading manufacturer of circuit heat dissipating devices. Plus mechanical integrity that's ready for the most demanding environments.

Packaging that cannot be individually produced for twice the price.

Hold that cost proposal

That's a pencil-sharpening fact you can ill afford to ignore if you're in the middle of preparing a proposal in response to an RFP that calls out SHP — or if you ever expect to bid an SHP program.

Here's how our new SHP Packaging System works:

We've designed six basic parts — plus a few specials for unusual configurations — with which you can build circuit module housings conforming to Navy Avionics Facility, Indianapolis, guidelines and dimensions for any of the common SHP-defined circuit modules using nothing but a screwdriver.

Ad infinitum

You can build these packages to accommodate any combinations of the various SHP modules, and the potential dimensions of the packaging in span and depth are for practical purposes limitless.

In fact, our system is so versatile it can be adjusted to handle non-SHP-dimension modules as well. If you need any kind of module housings and like to save money, the IERC SHP Packaging System is for you, too.

OK, you say, I'm interested. What's the first step?

Paper reveals all

Phone, write, or circle to get our hot-off-the-press 17-page paper that gives all the details including engineering drawings of parts and assemblies and a section on how to design SHP packaging using the IERC system.

If you're involved in SHP or ever expect to be, get involved with the IERC SHP Packaging System today.

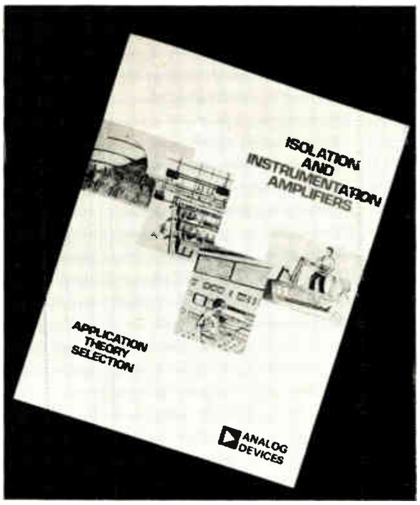
Ask about our SHP module plates including our revolutionary Metal Core Circuit Board plates for extremely high power densities, too. International Electronic Research Corporation, a subsidiary of Dynamics Corporation of America, 135 West Magnolia Blvd., Burbank, Calif. 91502. (213) 849-2481.

IERC DCA

Heat Sinks/Dissipators

New literature

Amplifiers. The operation, application, and selection of single and multichannel isolation amplifiers and instrumentation amplifiers are discussed in a 16-page brochure offered by Analog Devices Inc., P.O.



Box 280, Norwood, Mass. 02062. Definitions of pertinent terms are included, and the differences between ordinary operational amplifiers, instrumentation amplifiers, and isolation amplifiers are made clear. Circle reader service number 421.

Data acquisition. Technical bulletin No. 203 describes a family of data-acquisition systems made up of modules manufactured by Tustin Electronics Co., 1656 S. Minnie St., Santa Ana, Calif. 92707. The bulletin emphasizes price/performance trade-offs for systems with various speeds and resolutions. [422]

Crossed-field amplifiers. "Introduction to Pulsed Crossed-Field Amplifiers" is a 36-page publication that explains the inner workings of CFAs in a general qualitative way suitable for a radar-systems designer. It is not a text for people who actually make microwave tubes. The booklet includes many line drawings, spectrum-analyzer photos, schematics, and other diagrams. Copies can be obtained from Varian, Beverly Division, Salem Rd., Beverly, Mass. 01915 [423]

Statistics software. A brochure entitled "Statistical Solutions and Data Analysis with the HP 9820/9821" lists and gives details on two software packages that perform statistical calculations on the two named Hewlett-Packard programmable calculators. The brochure (Pub. No. 5952-8952) also contains a section on the 9820/21 user's club—an organization with a library of more than 600 programs. Copies are available from Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [425]

Low-noise TWAs. A 12-page short-form catalog from Watkins-Johnson lists more than 100 models of low-noise traveling-wave amplifiers. Included are outline drawings detailed specifications, and color photographs of representative configurations. The catalog can be obtained from Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif. 94304 [426]

Rotary pc switches. Rotary printed-circuit switches including standard and custom pc assemblies, pc terminations on standard rotaries, and flexible conductor-cable switches are covered in brochure SP714, which is offered by Oak Switch Division, Crystal Lake, Ill. 60014 [427]

Measuring sound. A short-form catalog of instrumentation for the measurement and analysis of sound and vibration—from hearing-aid calibrators to airport-sound monitors—has been put out by B & K Instruments Inc., 5111 West 164 St., Cleveland, Ohio 44142. The colorful 40-page catalog includes accelerometers, microphones, vibration exciters, and all necessary electronic instruments for the measurement of such signals as room noise, underwater sounds, passing-vehicle noise, and the vibration of industrial machinery. [428]

Beryllium oxide. A 14-page design guide for beryllium oxide provides data on the physical, mechanical, thermal, and electrical properties of

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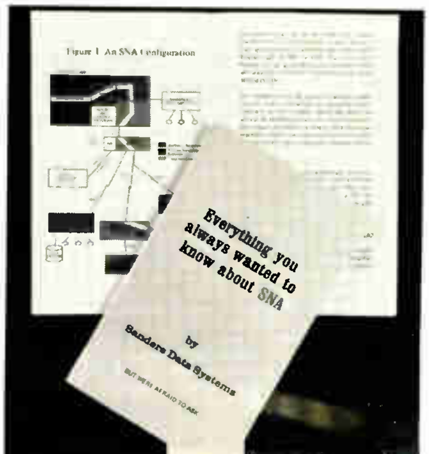
the material. The guide can be obtained from National Beryllia Corp., Greenwood Ave., Haskell, N. J. 07420 [429]

Phaselock applications. A booklet published by Plessey Semiconductors introduces the reader to concepts of the phase-locked loop, describes a monolithic PLL device, and explains typical applications such as frequency and amplitude modulation; frequency-shift, phase-shift, and tone-burst keying; waveform generation; pulse-amplitude and pulse-width modulation; and suppressed-carrier amplitude modulation. Copies may be obtained by writing to Mr. Dennis Chant, Marketing Manager, Plessey Semiconductors, 1674 McGaw Ave., Santa Ana, Calif. 92705 [430]

Optical components. A line of antireflection coatings, beam-splitters, laser-line interference filters, cold mirrors, hot mirrors, and similar optical componentry is described in a catalog that is available from Pomfret Research Optics Inc., 817 Long Ridge Rd., Stamford, Conn. 06902. The catalog includes a short glossary of optical terms. [431]

Data communications. A colorful handbook entitled "Everything You Always Wanted to Know About SNA (but were afraid to ask)" tells what SNA (systems network architecture) is composed of, some of its advantages and disadvantages, and how it works. A glossary of SNA and SDLC (synchronous data link control) terms and acronyms is also included. Priced at $1, the handbook can be ordered from Sanders Data Systems, NHQ 1-401, Nashua, N. H. 03060



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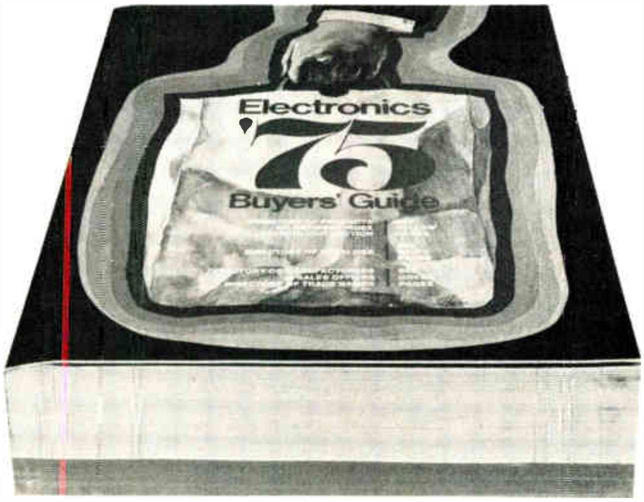

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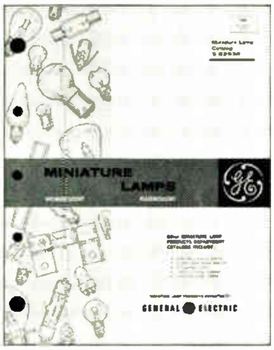

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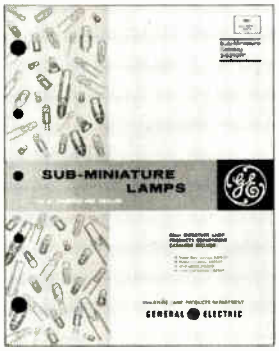

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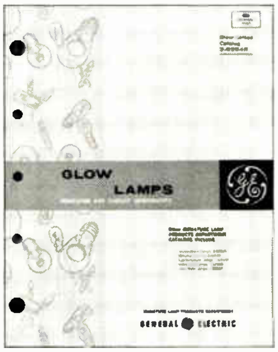

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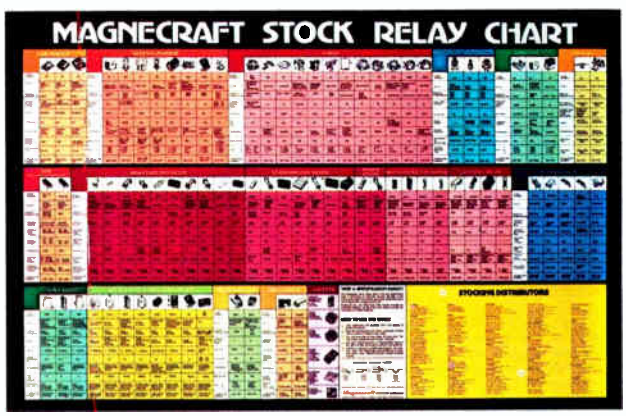

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