

OCTOBER 28, 1976

ANNUAL TECHNOLOGY UPDATE ISSUE

The microprocessor revolution continues unabated,
feeding the growing demand for electronics systems/74

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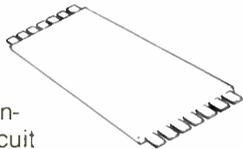
ROBERT C. DOBKIN

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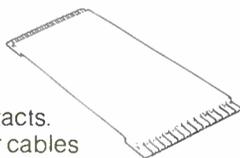
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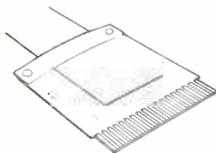
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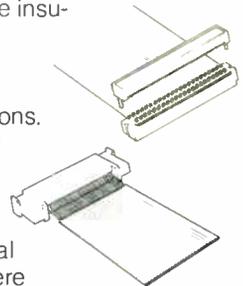
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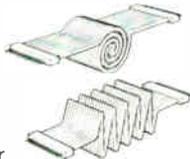
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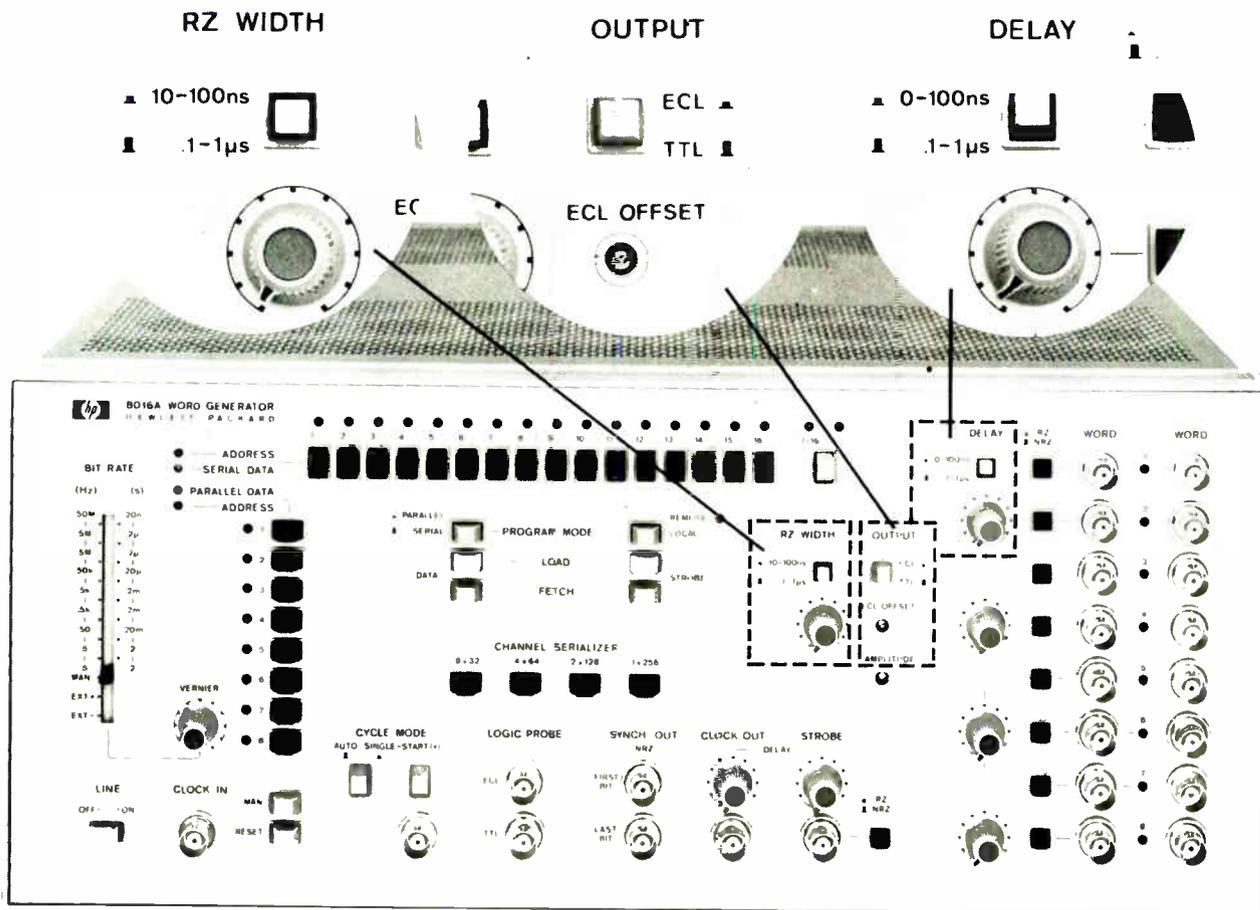
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HP announces pulse-parameter control in a word generator



That means an end to building arrays of pulse and word generators to do complex digital testing in the lab or production. HP's new 8016A gives you the digital stimuli you need for IC development or testing, for digital circuit evaluation, for microprocessor system troubleshooting, and for interface evaluation—at data rates to 50 MHz.

Now you can vary pulse width, height, and delay for worst-case or parametric testing such as set-up and hold-time measurements, as well as functional testing. Add HP's new 1600A Logic State Analyzer to your system and you have the ideal combination for observing your logic circuits in action.

Parallel and serial data selection. In the parallel mode, output is 32 bytes, each 8-bits wide. In the serial mode you get up to eight 32-bit words. Or you can serialize outputs for word length up to 256 bits. You have complementary outputs and a selection of RZ/NRZ formats on each channel.

Programming options. Manual data loading is simple with the pushbutton matrix and LED indicators. And a remote programming option allows fast

loading with an HP Interface Bus compatible card reader, calculator, or minicomputer—a valuable option for on-line testing where speed and accuracy are important.

There's still more. The 8016A includes manual clocking for single step testing; a strobe channel to use as a ninth data channel or serial qualifier; clock and sync outputs; ECL and TTL logic-probe power outputs; and other features to provide flexibility and ease of use.

Your local HP field engineer can give you all the details on this powerful new word generator, which is priced at \$6,400*. Or, write for our 10-page data sheet. It gives all the specs, output timing diagrams, and includes application information.

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A Logic Pulser That Does More Than Just Give Single Pulses. The new 546A Programmable Logic Pulser (above)

gives one pulse, a 1.10 or 100 Hz pulse stream, or a burst of exactly 10 or 100 pulses. Now you can rapidly set your circuit to any state you wish. It's a voltage and current source that provides the controllable stimulus you need for troubleshooting. It'll drive TTL or CMOS high nodes low or low nodes high.



New Multi-Family Logic Probe. The HP 545A tests most positive families including TTL and CMOS. An unambiguous single lamp at probe's tip quickly indicates logic high, low, bad level, pulses, pulse trains. Its built-in pulse memory catches elusive transitions that occur when you're not looking.

New Multi-Family Logic Clip. The Model 548A's 16 LEDs show logic states of 16 IC pins at once, revealing the cir-

cuit's truth table. It automatically adapts to TTL, RTL, CMOS and HTL and



automatically seeks Vcc and ground. It draws <math><15 \mu\text{A}</math> per pin, yet is overload protected to 30 Vdc.

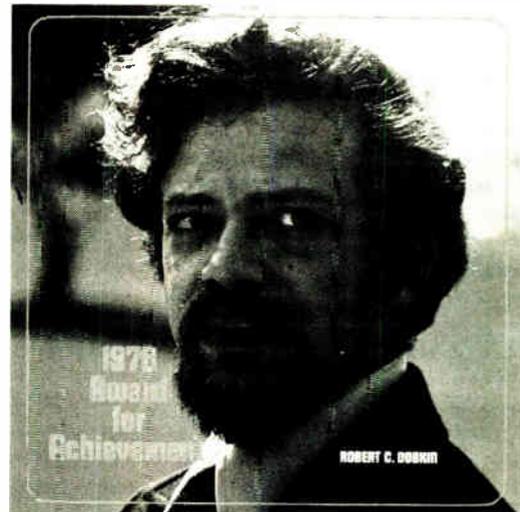
Prices: HP 545A \$125, HP 546A \$150, HP 547A \$350, HP 548A \$105, Domestic U.S.A.

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Cover: Award goes to linear wizard, 66

For significant advances in linear technology, including many devices that have become industry standards, *Electronics* salutes Robert C. Dobkin, the director of advanced-linear-product design at National Semiconductor Corp. in Santa Clara, Calif.

Cover photo is by Fred Kaplan.

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Dramatic improvements in cost and performance achieved with large-scale integration are expanding capabilities in almost every area of electronics. The next 12 months promise to continue the strong technical advances.

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Our annual Technology Update issue, in which we review the major advances that have been made over the past year in electronics technology, is also the vehicle for announcing the winner of the *Electronics* Award for Achievement. The third annual award has been bestowed on Robert C. Dobkin, director of advanced linear-product design at National Semiconductor Corp., for his wide-ranging contributions to semiconductor technology. The award is given to those who, in the judgement of the editors of *Electronics*, best exemplify either leadership in electronics technology or, in the case of those in government, business, or the academic world, leadership in promoting the welfare of the electronics industry. Turn to page 66 for our profile of this year's winner.

One big factor contributing to the difficulty of deciding who will be our award winner is the fact that technology cuts across so many different fields and can take so many different paths. So, in addition to our

Dobkin profile, we have sprinkled profiles of noteworthy innovators throughout the Technology Update pages. The progress of electronics technology, in particular, requires people with imagination, drive, and vision, as well as basic technical skills. That, after all, is one of the things that makes electronics the dynamic field it is.

Even with the benefit of hindsight, putting together the Technology Update kind of story is no easy matter. Months of preparation by our entire New York staff, backed up by on-the-spot reporting by our extensive field staff, both in the United States and abroad, went into this issue, which we believe is one of the year's most rewarding efforts in terms of service to readers. You'll find Technology Update beginning on page 74.



We are looking for an editor

We have an exciting and rewarding career opportunity available for an engineer with writing skills who is interesting in applying those skills and his professional expertise to technical publishing. We have an opening on the New York staff of *Electronics* for circuit design editor. An applicant for the job must be adept at modern analog and digital circuit design and analysis and be able to evaluate circuits for accuracy and innovativeness. He will also write and edit technical articles in that field.

Candidates should have at least a BSEE and substantial engineering experience. If you are interested, send resumé and salary requirements to: Executive Editor, *Electronics*, 1221 Avenue of the Americas, New York, N. Y. 10020.

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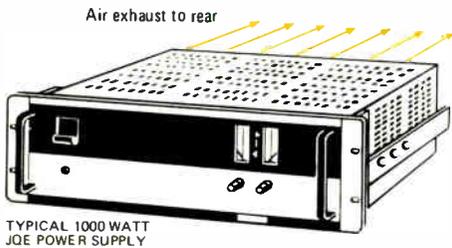
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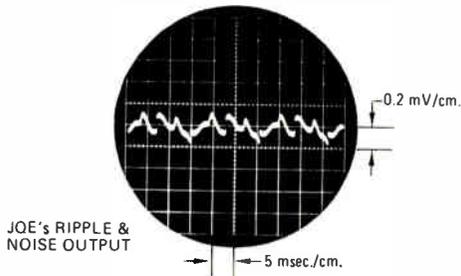
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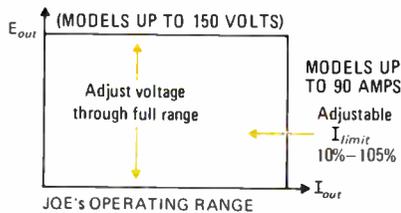
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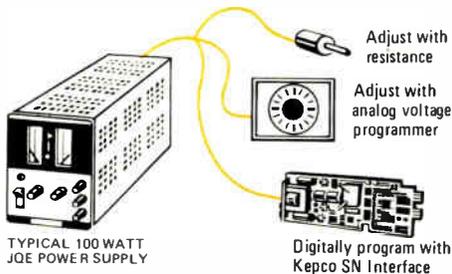
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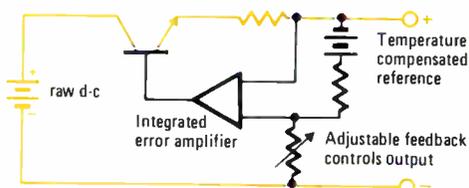
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Readers' comments

A resistor gives practicality

To the Editor: In "Fiber-optic data transmission: a practical, low-cost technology" [Sept. 2, p. 94], the receiver in Fig. 5 needs some modification before it will be practical.

It is suggested that the zener diode be turned around and a resistor be inserted between the -12-volt power supply and the zener anode and 2N2905 base junction. Otherwise, the receiver is neither practical, nor is it low-cost.

Bela Marton
Texas Instruments Inc.
Dallas, Texas

■ **The author replies:** The changes detailed are necessary to correct an oversight on my part.

It's not official

To the Editor: The Washington newsletter item "FCC refuses bid to speed action on satellite review" [Sept. 2, p. 51] asserts that the Federal Communications Commission "will not drop a request for an evidentiary hearing" in connection with Satellite Business Systems' proposed domestic satellite system.

Since the commission has not acted on our applications, your headline is plainly erroneous. The text is pure speculation and should have been labeled as such. SBS believes the FCC has the information necessary for its decision. We hope for early commission approval to proceed with implementation of our system.

P. N. Whittaker
Satellite Business Systems
Washington, D.C.

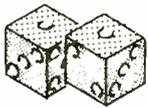
■ *While the FCC has not taken official action, it is expected to hold the hearing, as the item indicated.*

Correction

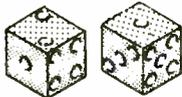
While the story on Texas Instruments Inc.'s plans to begin selling samples of 92,304-bit bubble memories [Sept. 30, p. 29] correctly gave the production prices for the packages as ranging from 40 to 50 millicents per bit, we erred in translating 50 millicents per bit into cents per bit for the deck of the headline. It should read "... volume-production goal is under 0.05 cent a bit."

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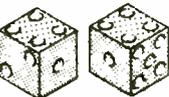
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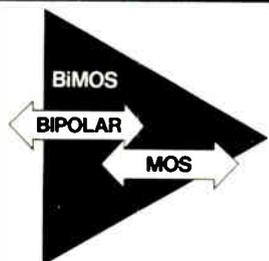
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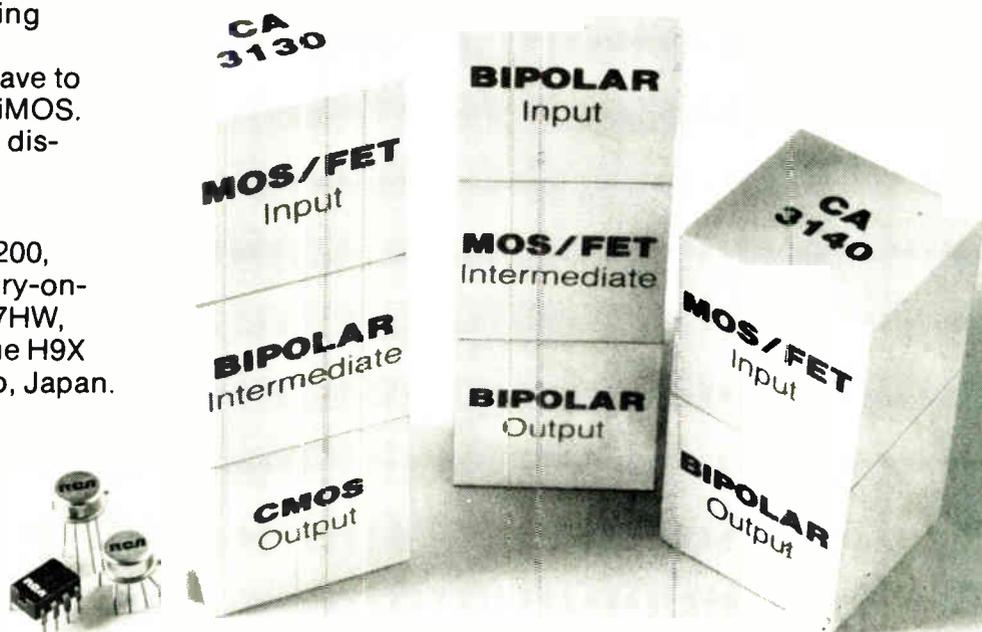
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Op amp category	What BiMOS contributes	RCA device
General Purpose	Wide applicability. Low cost.	CA3140 CA3130
FET Input	Lower device cost. Reduced circuit cost. Large input voltage range: capability of swinging to 0.5 V below rail.	CA3140 CA3130
Wideband 4.5 to 70 MHz	High slew rate with low ringing.	CA3140 CA3130 CA3100
Micropower (down to 1.5 mW)	Strobability.	CA3130
High Current up to 22mA	Eliminates driver stage. Low device cost. Rail-to-rail output swing	CA3130

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News update

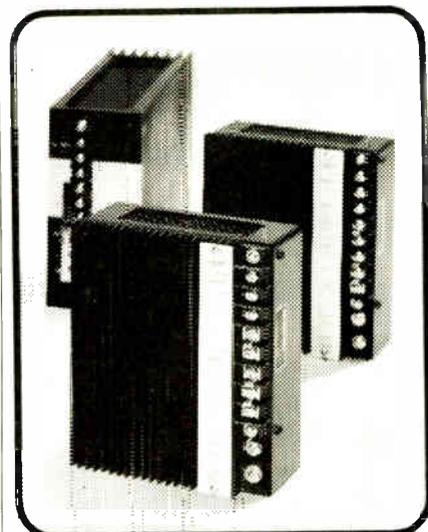
■ The U.S. Army's Picatinny Arsenal in Dover, N.J., has scheduled another series of tests for miniature television cameras under development for battlefield surveillance systems. The TV systems, being developed by Fairchild Camera & Instrument Corp.'s Imaging Systems division in Syosset, N.Y., use a sturdy array of charge-coupled devices to replace the fragile vidicon tube [*Electronics*, Oct. 16, 1975, p. 31]. Tests of the full systems will be conducted next January or February with participation by the Army's Artillery School at Fort Sill, Okla.

The Army made its first deployment of the CCD-array TV systems on July 31 at the Yuma Proving Grounds in Arizona. Three systems were fired at high-G level environments, two at the maximum charge from a 155-millimeter howitzer, notes Ernest Ohloff, a project engineer with Picatinny's Precision Munitions Group. "All three systems functioned perfectly. We considered it a highly successful test," says Ohloff of the TV system that is carried inside a projectile over a target area and released at the right altitude by a timing fuze. Suspended by a parachute, the camera floats and sends pictures of the terrain and ground action to a command post. In the Yuma tests, the systems were deployed at 2,000 feet and picked up and relayed high-resolution pictures of all target symbols on the barren desert's terrain. It would be possible to install a self-destruct mechanism in the system to keep it out of enemy hands.

The Picatinny system is designed to be used with an illumination artillery projectile—the M485 for the 155-mm gun—that is already in the Army's catalog. In fact, the total system uses many of the components of the shell. The camera and associated electronics simply would replace the illuminating canister.

This is not the military's first attempt to put together such a camera system. The Navy experimented with a similar arrangement, using a Fairchild-developed 100-by-100-element CCD array, but dropped the work when it ran out of funds. □

World Radio History



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YP-1520A		20
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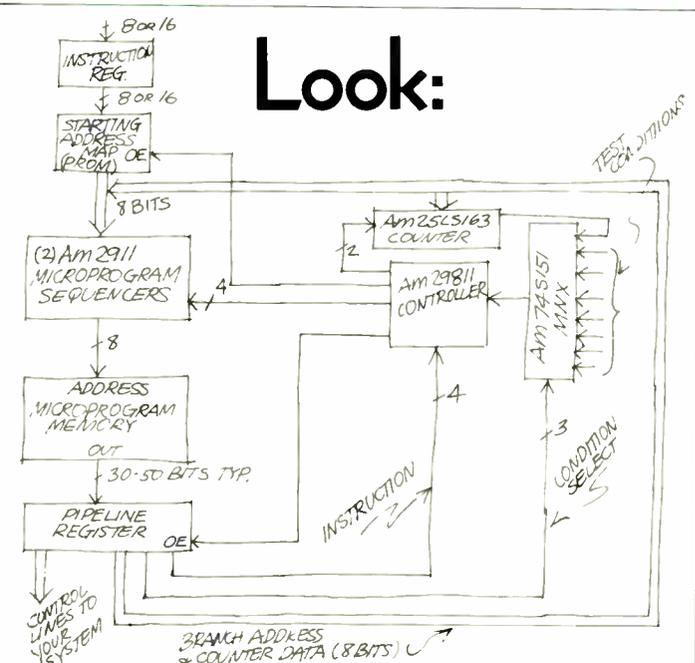
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Two Am2911's can control up to 256 words of microprogram, enough for many state machines. (With three Am2911's, up to 4K words of microcode can be controlled.)

Look again:

Sequence Control Instructions

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- Load Counter
- *Repeat Jump if Counter \neq 0
- *Push PC or Push PC and Load Counter
- Jump to Map Address
- *Loop
- *Repeat Loop if Counter \neq 0
- *Jump to Subroutine
- *Return
- *Jump to One-of-Two Subroutines
- *Jump and Pop Stack
- Jump to External Address
- Jump to Branch Address
- *Jump to One-of-Two Branch Addresses
- Continue

*Conditional Instructions

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Boy. Some guys really have it made.

Advanced Microprocessors



Is dumping really dumping? . . . and other questions

The questions raised about whether Japanese TV manufacturers are dumping their wares on the U.S. market lead not to answers, but to more questions. A goodly number of them are raised by a report, recently prepared by the U.S. embassy in Tokyo and now circulating in Washington, which contains some interesting arguments in favor of unrestricted trade. Take its points on private-labeling, for example.

On the one hand, electronics technology in general and the growth of the electronics industries in the U.S. have always gone along with free trade. In addition, there are many U.S. enterprises, particularly in the consumer sector of calculators, watches, now even games, that depend on off-shore assembly and thus have a stake in fairly open borders. On the other side, however, there are industries like TV-set manufacturing that have been hit hardest by the exports, especially because the Japanese influx has centered around the all-important 19-inch size, the most popular in America.

That, in turn, leads to the question of where the sets are going—whether one should look closer to home for the source of the problems. Of the major mail-order houses, Sears Roebuck now has 80% of its TV sets made in Japan, and Montgomery Ward and J. C. Penney buy from Japanese makers, too.

For these big retailers, the Japanese connection makes sense. Sears, which is listed as having the third largest share of the U.S. color-TV market, wants to have a TV set for a low price, goes to Japan, and gets the right price. The Japanese supplier needs only sign the deal and ship as far as the port in Yokohama. Who could resist a deal like this, especially when hard times

hit Japan's market? The conclusion is that the Japanese are not pushing their sets on the U.S., it's the Americans who are pulling them in via Sears and the merchandisers.

Price is the key in private-labeling, the report continues. It's not exactly dumping, because the U.S. firm is responsible. If the U.S. were to stop Japanese imports next week, it would not end the problem. Sears, Ward, and Penney would have to go to Taiwan, Korea, or elsewhere in Southeast Asia. Even if the various governors from the United States who go over to Japan to lure industry into their states were successful in getting all the Japanese companies to make their receivers in America, there still would be more than a million sets imported, simply because of the price that the big retailers want to offer.

There is a certain validity to these arguments, but let's pose some other questions. For one: In a period of consumerism, isn't it part of the Government's responsibility not to interfere with the consumers' right to get products for the lowest possible price? In other words, consumerism in trade decisions may have arrived. Does the American citizen have a right to buy the cheapest TV set he can get? If so, it's up to those manufacturers to meet the competition through greater productivity. After all, the Japanese took steps two to three years ago to automate, reduce parts count, cut power requirements, and improve productivity in order to survive the 1974 oil crisis. It's now paying off, while American makers are still stuck with high costs.

If the U.S. companies are not truly competitive, no amount of Government support will help in the long run. If they are, no Government support is really needed.

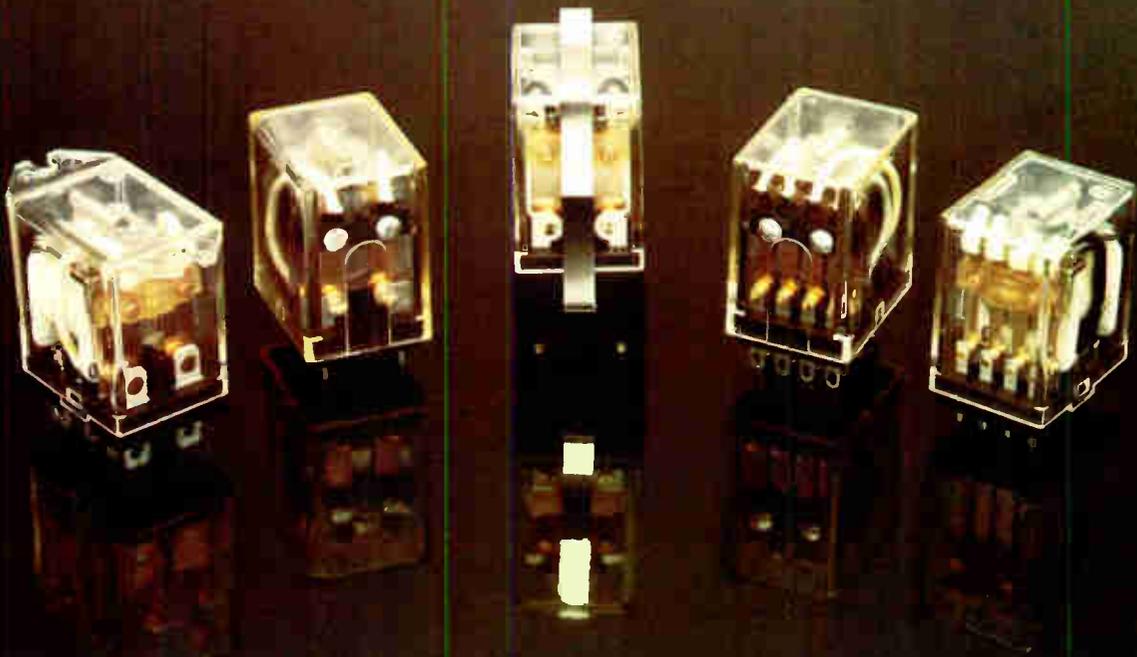
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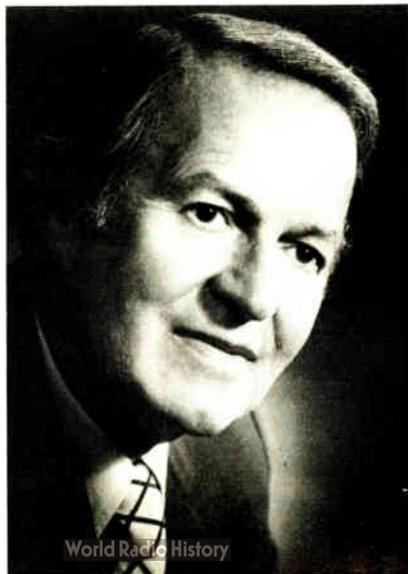
Van Deerlin: helping the
law catch up with technology

Lionel Van Deerlin's justification for revising the Communications Act of 1934 is simple: technology has outpaced the law. Says the new chairman of the House Interstate and Foreign Commerce subcommittee on communications, "Yesterday's technology and yesterday's law covering that technology are as out of date as the Dead Sea scrolls."

Yet the 62-year-old California Democrat, a print and broadcast journalist in his home town of San Diego before his first election to Congress 14 years ago, gives the impression that his views of the changes that should be made may be different from those of AT&T and its allies sponsoring the Consumer Communications Reform Act of 1976 [*Electronics*, March 4, p. 33]. In opening three days of preliminary hearings at the end of September on "the Bell Bill," Van Deerlin warned the telephone industry "that those arguing for restraints on competition" must "accept the burden of proof."

In any event, the subcommittee will chart its own course in rewriting the law, beginning with a study next year that will look carefully at the Federal Communications Commission's spectrum allocations, as well as at communications alternatives that do not employ spectrum space.

Law man. Lionel Van Deerlin (D., Calif.) heads subcommittee studying the Bell Bill.



Beyond laws affecting domestic common carriers, the subcommittee is also responsible for legislation covering commercial and public broadcasting, cable television, communications satellites, and radio-frequency allocations including citizens' bands.

First view. The jam-packed hearing room on Capitol Hill provided the first view of Van Deerlin in his new role as subcommittee chairman since he succeeded the late Rep. Torbert MacDonald in April. A self-styled "early exponent of consumerism," Van Deerlin had chaired the commerce unit's subcommittee on consumer protection and finance.

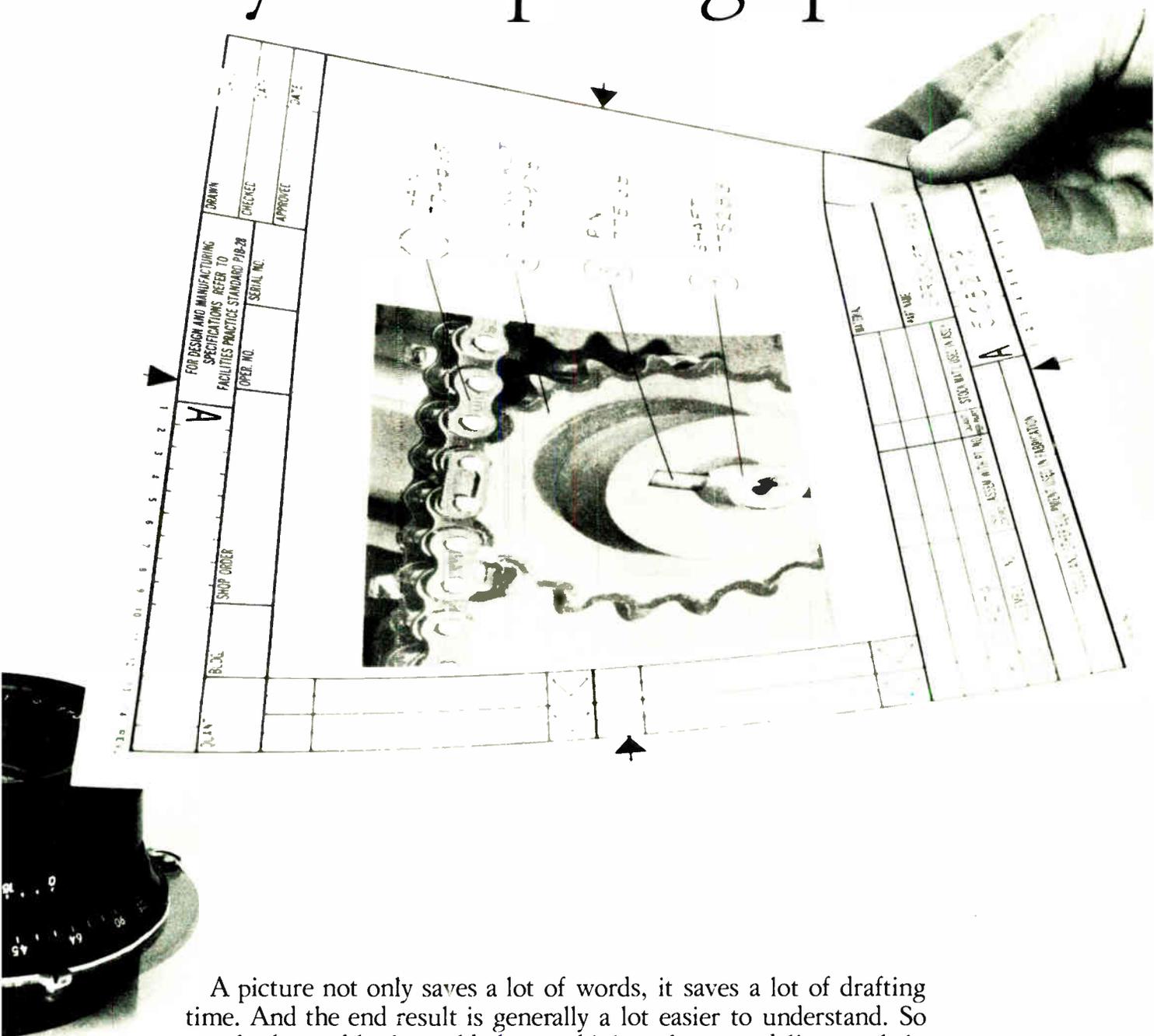
At the hearings, he challenged AT&T and other telephone company leaders to disprove the FCC's "exhaustive inquiry" which found "that any impact of competition on residential [telephone] rates will be limited, [and may even] have the effect of reducing rather than raising residential rates, and is, in any case, manageable by making certain policy adjustments." Yet the commission, Van Deerlin added quickly, is not infallible, and he called for a full airing of both sides of the issue.

Van Deerlin's visibility in his new assignment is sure to increase when the Bell Bill is reintroduced next year in the 95th Congress. The Californian, convinced of the importance of the legislation to the future of American telecommunications, is already making plans to keep his fellow legislators informed. Every new member of the House will receive a transcript of the initial hearings with a personal note from the chairman when the new Congress convenes in January.

GTE's Sacra has hopes for
smaller earth-station terminals

The recent reorganization of General Telephone & Electronics Corp. elevated Glenn H. Sacra to the presidency of GTE International Systems Corp. in Waltham, Mass., which designs and builds communication-satellite earth stations and micro-

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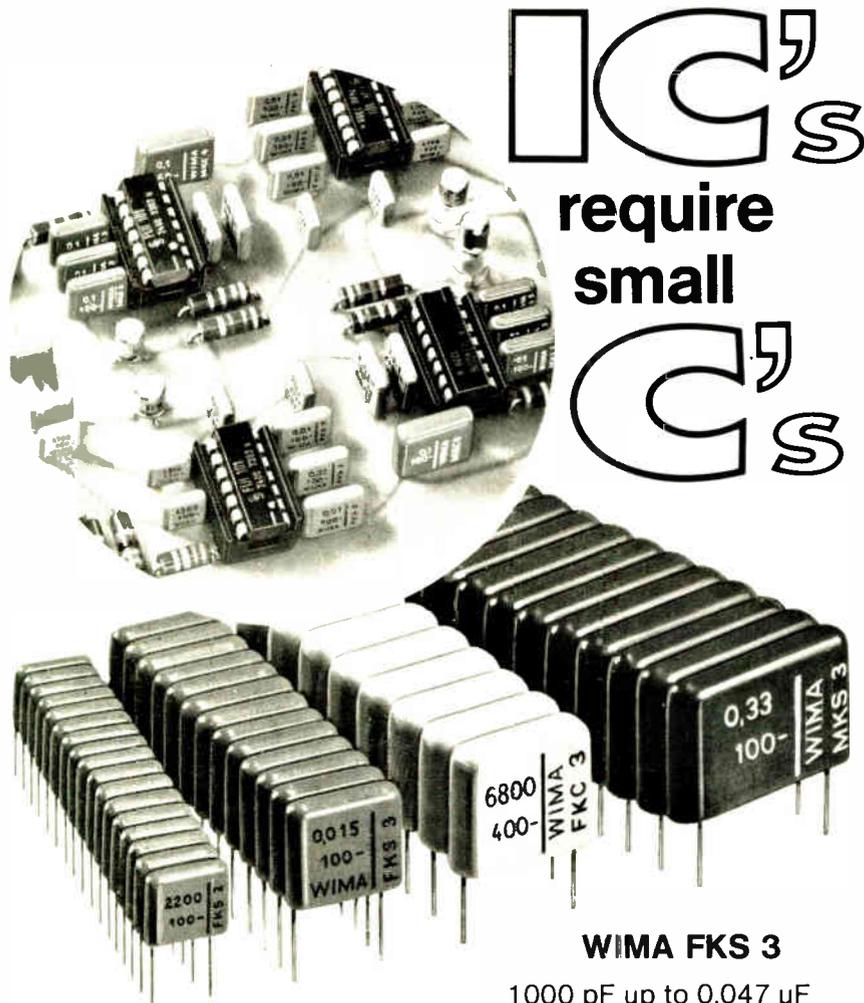
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wave communications systems that have been installed worldwide. Most of the earth stations have antennas ranging in diameter from 30 to 32 meters, with an installation selling for \$4.5 million to \$5.5 million.

But the 45-year-old Sacra has his sights on a new market in smaller stations. These include the Intelsat consortium's "standard B" terminals with 10–13-m antennas for international telephone and television links that sell for \$1 million to \$2.2 million, and domestic stations for intra-country communications that range from \$500,000 to \$1 million and in antenna diameter from 4 to 8 meters.

Leadership. The firm recently won contracts for standard B stations in Upper Volta and Mali, and the low-keyed, affable new president has identified 20 to 30 other sales targets. "My goal for ISC is to establish the company in a solid world leadership position in satellite communications, which implies obtaining a significant portion of those standard B stations," Sacra declares.

He would also like to win "one or two more" intracountry programs like the Algerian domestic earth-station system, "where we would have the total national responsibility for a growing system."

Satellite terminals are about 70% of ISC's business, but Sacra also wants to expand in microwaves. "We want to expand beyond pure microwave communications to telephone switching systems and closed-circuit TV so that we're providing total systems service."

To help ISC grow, Sacra is counting on its own good reputation after completing "90% plus" of its projects on time and the leverage of being part of GTE.

But a weakness he hopes to overcome by mid-1977 is that GTE "hasn't been on the leading edge of technology" in developing the equipment needed for the standard B and domestic earth stations. "But we've been pressing very hard for these developments," Sacra points out, "because over the long run [we can't be] dependent on outside suppliers."

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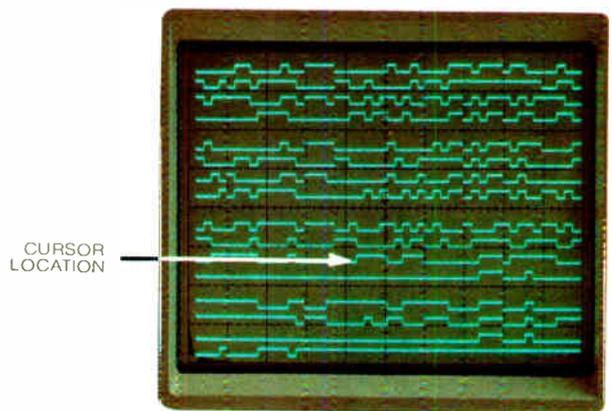
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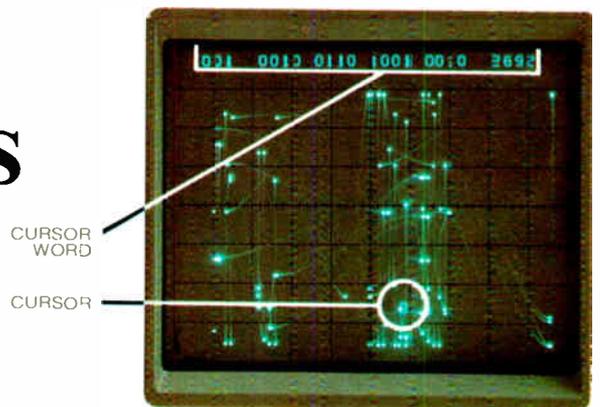
Accessories can now give you a logic state (1's and 0's) display of any 16 stored words; hex or octal translation; and a vector map of memory contents. The 8 and 16-channel logic analyzers feature:

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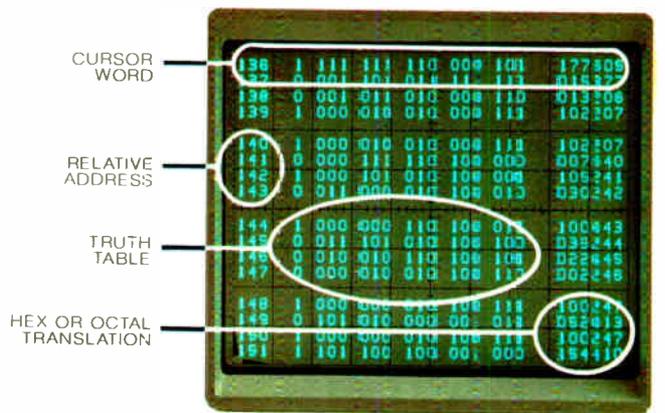
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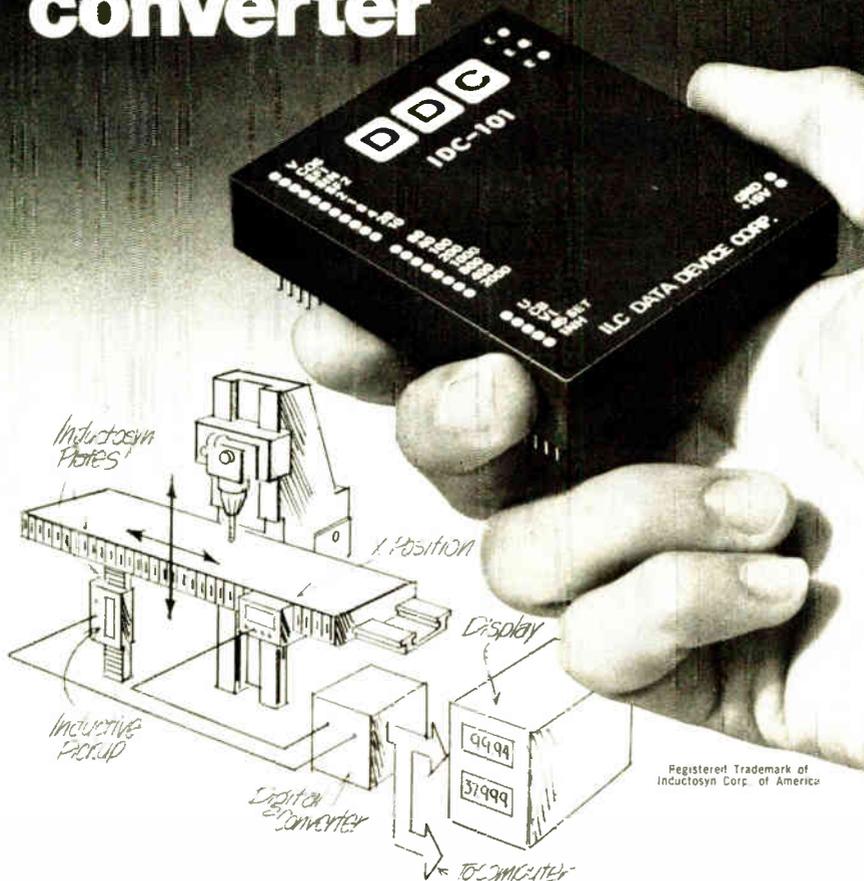


Logic state—provides memory address location, binary output of the 16 channels and selectable octal or hexadecimal translation. 16 words are displayed at one time with the cursor address location at the top of the screen. Movement of the cursor control allows accessing any 16 words of the entire 512 words stored in the 1650-D. The display control memory can store 16 words while a different set of 16 is selected from the 1650's main memory (or a new recording is made). These two sets of 16 words can then be overlaid on the CRT. Any differences will blink and be easily identified.

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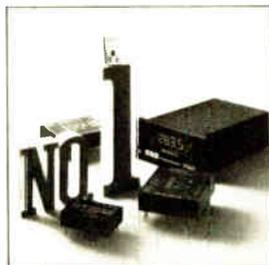
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1976 Gomac—Government Microcircuit Applications Conference, Dept. of Defense et al., Dutch Inn, Lake Buena Vista, Orlando, Fla., Nov. 9-11.

Fourth Computer-Aided—Design and Computer-Aided—Manufacturing Conference and Exposition, Society of Manufacturing Engineers (Dearborn, Mich.), Dallas Hilton Hotel, Dallas, Nov. 15-18.

Computer Networks: Trends and Applications, IEEE, National Bureau of Standards, Gaithersburg, Md., Nov. 17.

Electronica 76—7th International Trade Fair for Components and Production Facilities, Munich Fair Authority, Munich, West Germany, Nov. 25-Dec. 1.

National Telecommunications Conference, IEEE, Fairmont Hotel, Dallas, Nov. 29-Dec. 1.

Forum on Computer Technology, American Society of Mechanical Engineers, Statler Hilton Hotel, New York, Dec. 5-10.

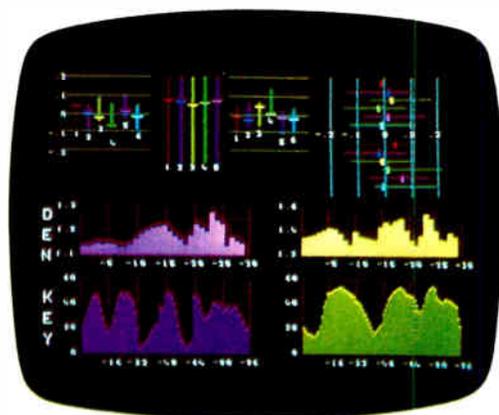
Chicago Fall Conference on Consumer Electronics, IEEE, Ramada Inn-O'Hare, Des Plaines, Ill., Dec. 6-7.

Distributed Data Processing Conference, American Institute of Industrial Engineers (Santa Monica, Calif.), Ramada Inn-O'Hare, Des Plaines, Ill., Dec. 7-10.

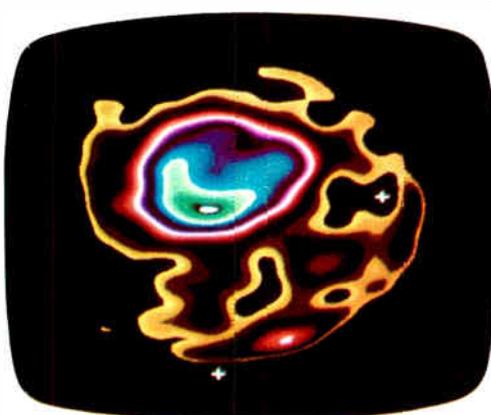
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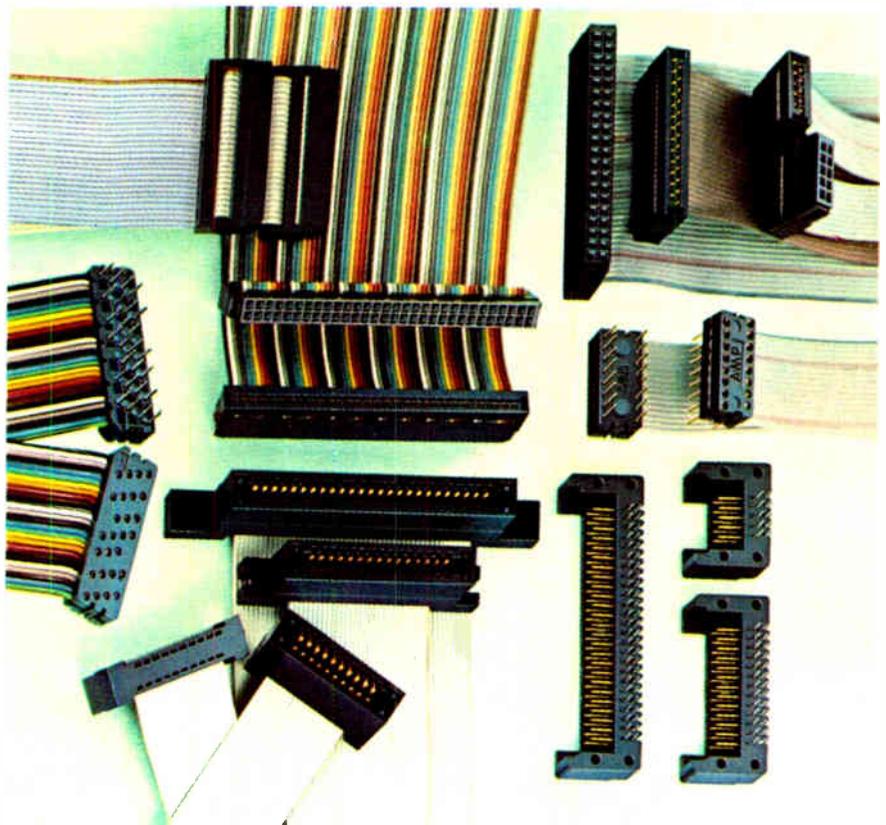
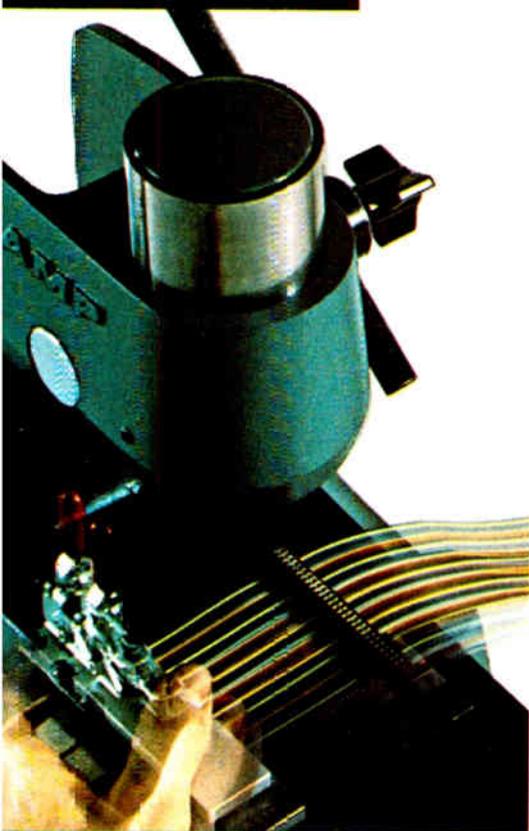
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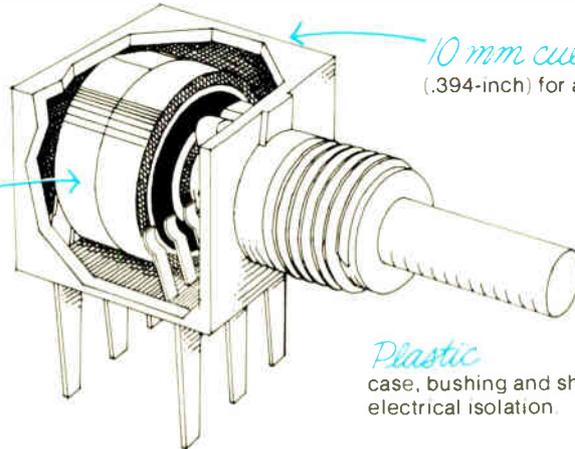
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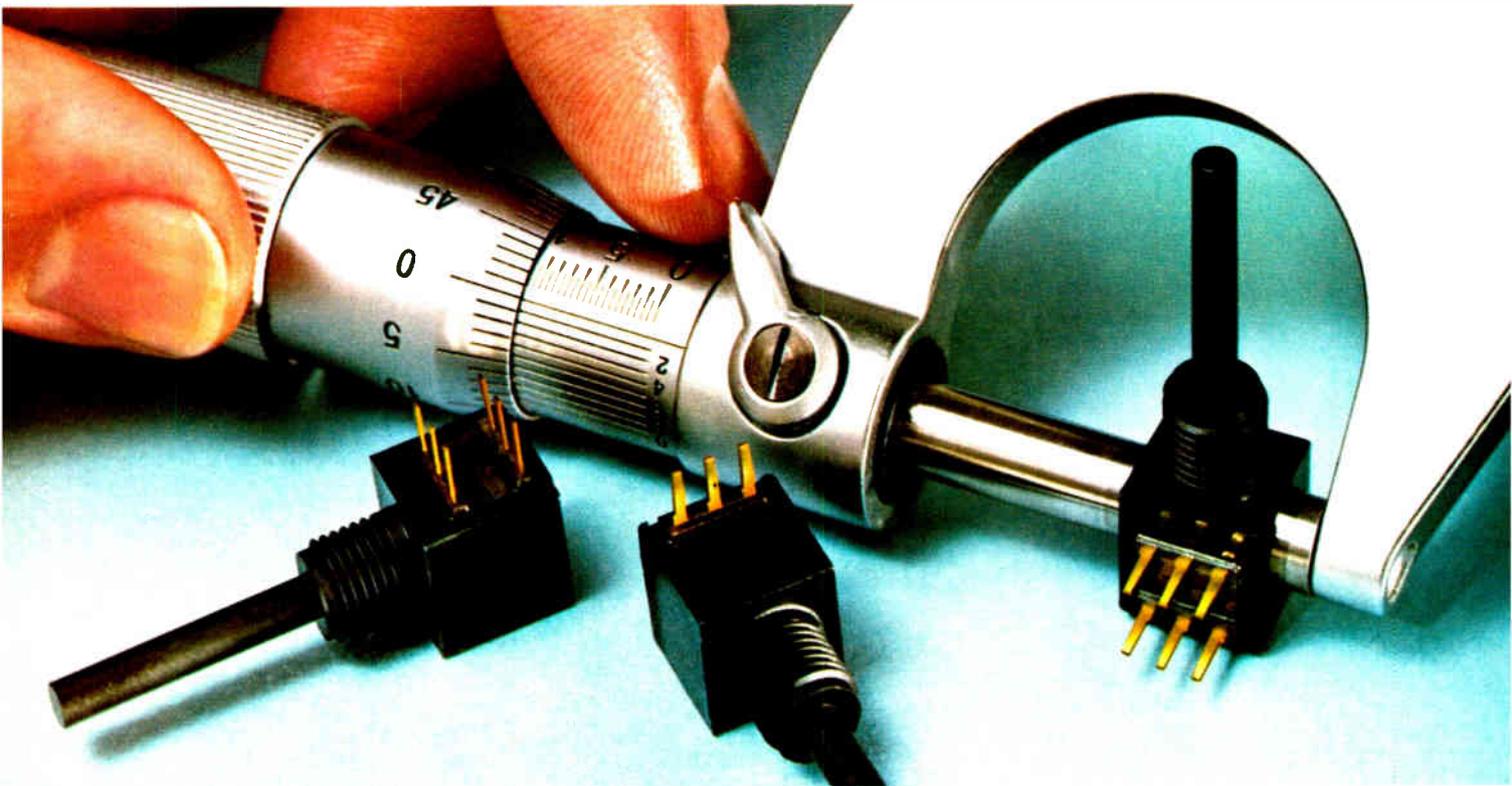


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Intel to challenge IBM computers next year in Europe

San Francisco-based Intel Corp. plans to deliver its first Advanced System computers to Europe in the fourth quarter of 1977. The company expects to sell 25 to 30 of these large computers in Europe during the next 18 months. Intel says the Advanced System machines, which are being built by a subsidiary of National Semiconductor Corp., are compatible with IBM 370 models. **The Intel AS/5, which has the same operating speed as the 370/158 and uses similar software, is priced about 25% lower than the IBM system.** The smaller AS/4 will sell for about the same as the IBM 370/148 but has 1.4 times its performance. Intel says the lower power consumption and heat generation, as well as higher operating speed of its machines, should promote sales.

AMI making LSI chips for \$550 sewing machine

A \$550 home sewing machine, to be introduced in the U.S. next month by the Singer Co., will contain custom p-MOS metal-gate, ion-implanted LSI chips supplied by American Microsystems Inc. of Santa Clara, Calif.

The Singer-designed chip has a read-only memory for programmed pattern storage and input/output recognition circuitry that outputs to a servo amplifier to drive the needle for "feed and bite" functions. For cost reasons, the chip for the new machine, called the Diana, has fewer stored programs than the LSI devices also being supplied by AMI for Singer's first electronic sewing machine, the \$800 Athena 2000, introduced last year. **Singer is seeking multiple sources for the new chip.**

AMI also is supplying custom microprocessors for Singer's new industrial self-programmable sewing machine, the Centurion, whose "brain" is capable of remembering more than 100 different sewing tasks and reusing any one at any time. Intel Corp., also of Santa Clara, is supplying ROMs for the Centurion, which will be available in December and will cost up to \$3,000.

RCA developing microprocessor-based auto data system

RCA Laboratories in Princeton, N.J., is developing a microprocessor-controlled information system that will monitor the operating conditions of an automobile and even brake the car in an emergency. The work is being done under contract to Minicars Inc. of Goleta, Calif., for the research safety vehicle program sponsored by the National Highway Safety Administration. The system will present dashboard information and other data such as rate of fuel consumption and engine rpms in luminescent orange alphanumeric.

The system uses a standard, commercially available RCA Cosmac microprocessor to process information from sensors mounted throughout the vehicle. In determining the probability of a collision, the microprocessor **considers return signals from an RCA-developed microwave radar**, which shows the vehicle's direction and speed, as well as obstacles and the location, speed, and direction of other cars. If the lights or windshield wipers are on, indicating poor driving conditions, the microprocessor includes this information in continually calculating in thousandths of a second the probability of collision. The system can also be used with an automatic cruise-control system.

Air Force seeks long-range optical recon system

To augment its airborne radar and infrared day-and-night reconnaissance capability, the Air Force will probably award a development contract in December for a long-range electro-optical reconnaissance system that would **be able to discriminate between small targets at ranges of 20 to 30 miles**. The camera images would be relayed to the ground in real time via a data link, where processing and interpretation would be done.

The development contract from the avionics laboratory at Wright-Patterson Air Force Base, Dayton, Ohio, isn't expected to top \$3 million, but the production potential would be substantially greater. The system is supposed to be operational in the 1980s. Bidders for the development award include Actron Industries division of McDonnell Douglas Corp., Chicago Aerial Industries division of Bourns Inc., Fairchild Camera and Instrument Corp., Itek Corp., and Perkin-Elmer Corp.

Motorola first in U.S. with 3-leaded devices in SOT-23 packages

Motorola Semiconductor Products division is about to become the first U.S. producer of three-leaded devices in the popular SOT-23 package [*Electronics*, July 22, p. 99]. Prototype production is scheduled to start during the first quarter of 1977, **with full production due during the second quarter**. The package, now being used heavily in commercial hybrid circuits, will be dubbed MiniBloc by Motorola.

Vector shrinks airborne telemetry discriminators

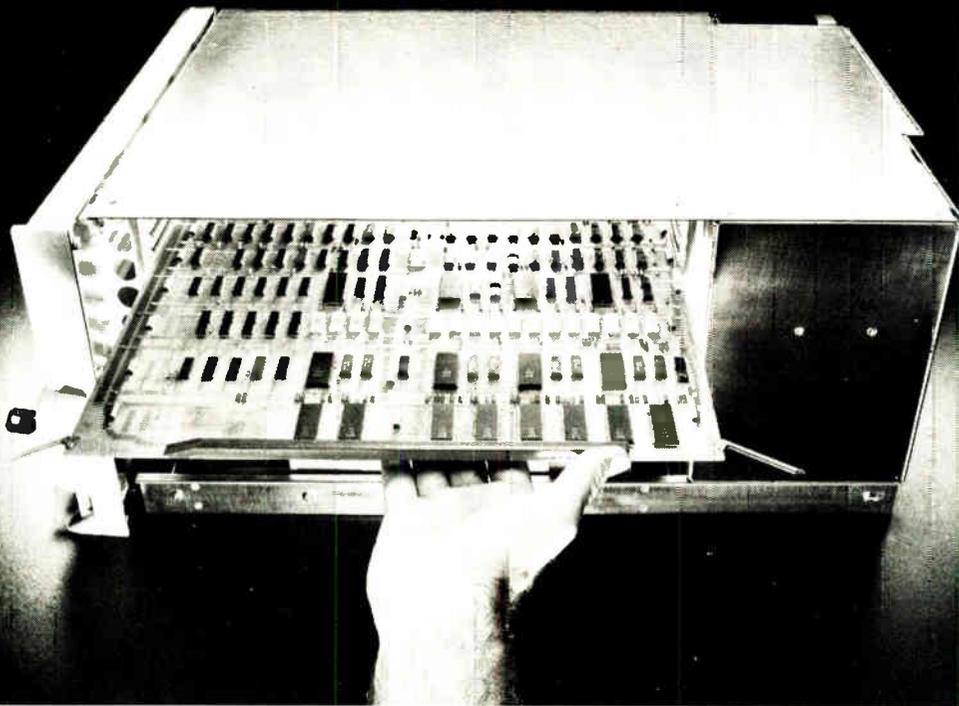
The Vector division of Aydin Corp. in Newtown, Pa., is marketing airborne telemetry receiving systems, beginning with a line of micro-miniature discriminators. Using the hybrid technology and packaging techniques developed for its voltage-controlled oscillators and other telemetry transmission equipment, Vector has come up with a discriminator that **consumes less than 1.5 watts per channel**. In its 1.42-by-1.38-by-2.18-inch package, the device is about one third the size of presently available units but, at \$600/channel, is also more costly. Each of three modules in the discriminators has two 1-in. hybrid substrates. The three-ounce discriminators, the ABD-111 series, are for airborne fm receiving systems such as those used in missiles, remotely piloted vehicles, and space vehicles with tight space, weight, and power-consumption constraints.

Sweda to market Data General's POS system

The Sweda International division of Litton Industries has purchased the **worldwide distribution rights to the supermarket point-of-sale system** announced by Data General Corp. In August 1974, legislation frustrating development of that market had the Southboro, Mass., discouraged the minicomputer maker from pursuing it. Under terms of the agreement, Sweda will buy some \$40 million in Data General products through 1980.

Addenda

Wema estimates worldwide semiconductor shipments by U.S. makers this year will total \$2.536 billion, **although the volume through August indicates the total could top that figure**. With shipments for that month hitting \$277 million, the first eight months of 1976 saw shipments soar to \$2.186 billion.



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MAJOR PARAMETER LIMITS

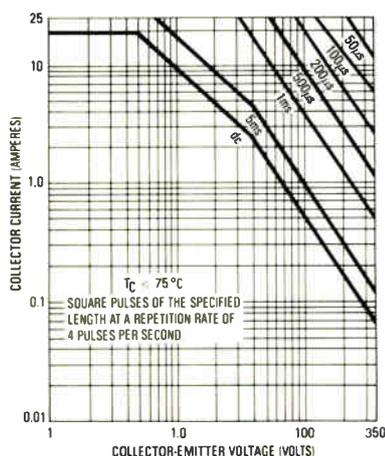
Type	hFE @ 25A	hFE @ 10A	VCEO (sus)	VCE (sat) @ 20A	ICEO @ 600V
DTS-4066	5	75	350V	3.5V	0.25mA
DTS-4067	10	150	350V	2.0V	0.25mA
DTS-4074	5	75	350V	3.5V	0.25mA
DTS-4075	10	150	350V	2.0V	0.25mA

TYPICAL SWITCHING

	DTS-4066 DTS-4067	DTS-4074 DTS-4075
t_r	0.5 μ s	0.5 μ s
t_s	5.0 μ s	3.2 μ s
t_f	4.5 μ s	1.0 μ s

NPN triple diffused silicon Darlingtons are packaged in solid copper cases conforming to JEDEC TO-3 outline dimensions.

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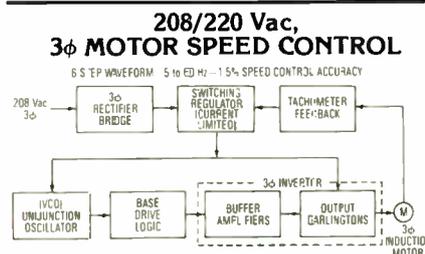
with parallel Darlingtons. A speed-up diode is built into the DTS-4074 and DTS-4075 permitting data sheet t_f typicals of 1.0 μ s. Drive circuit techniques involving $I_{B2} \geq 2 A$ and a Baker clamp produce t_f typicals in the 0.4-0.6 μ s range for the DTS-4066, DTS-4067, DTS-4074, and DTS-4075.

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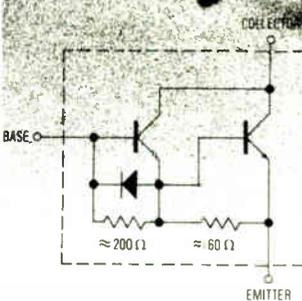
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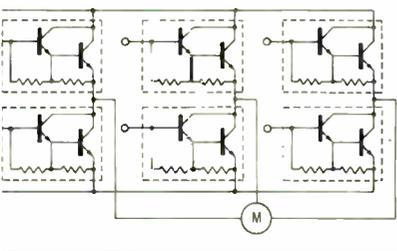
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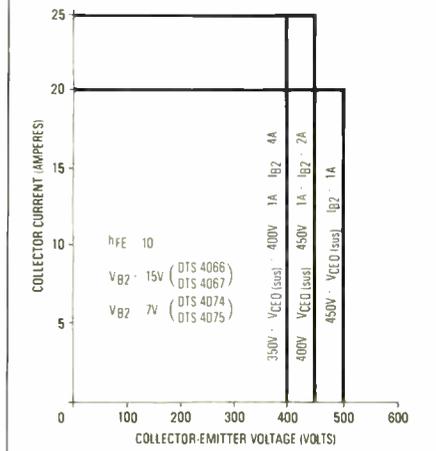


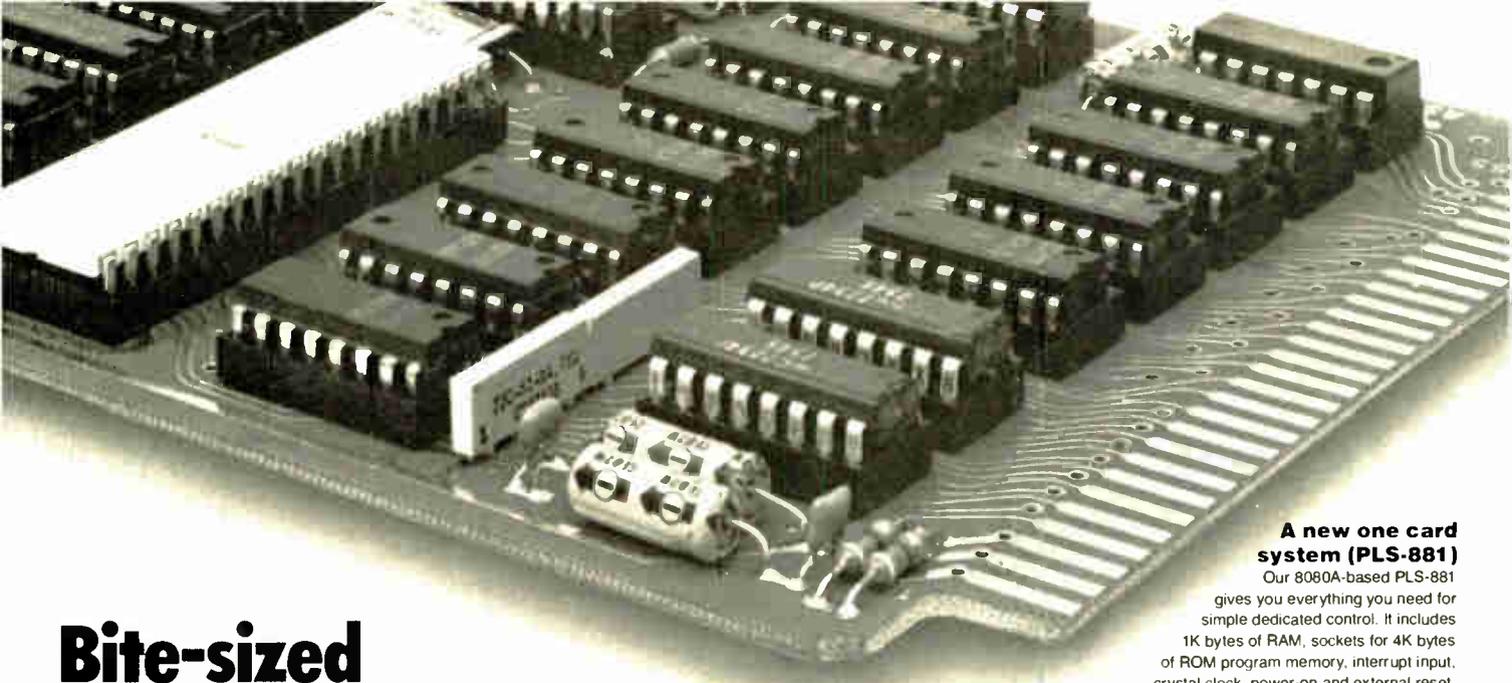
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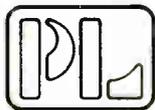
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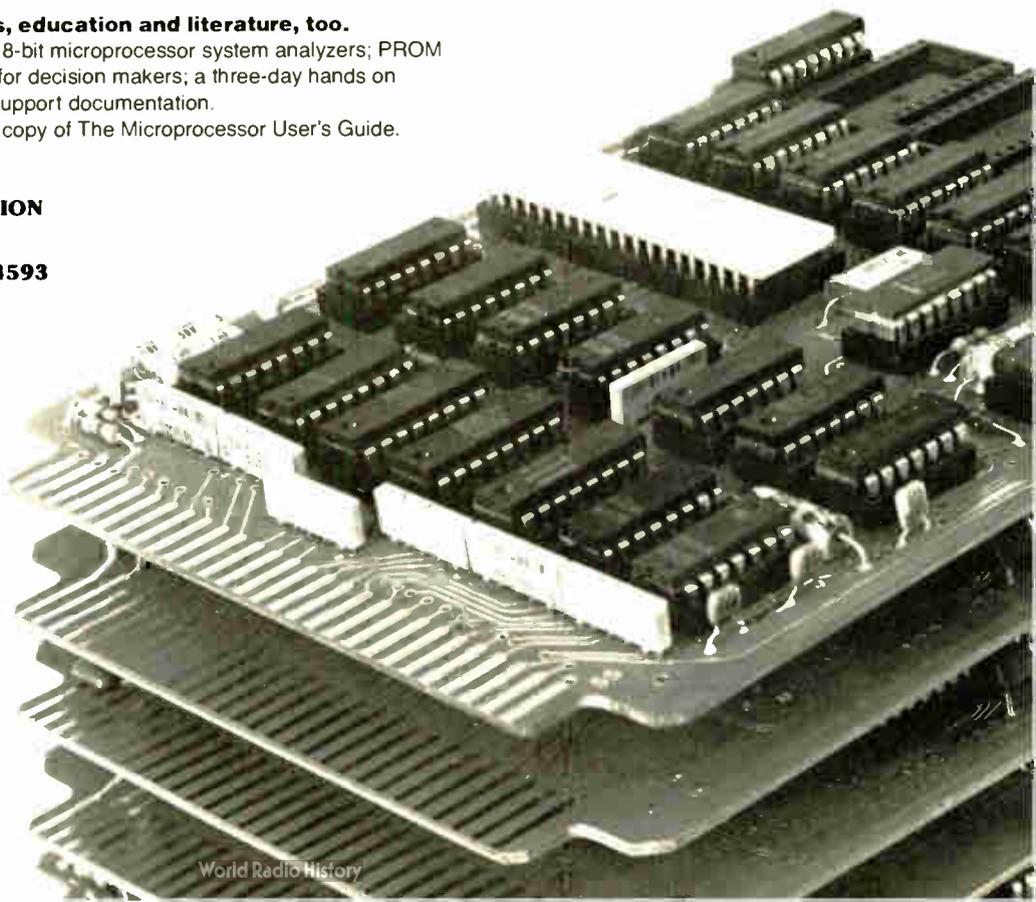
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Circle 30 on reader service card

Four-level logic coming next year from Signetics

I^2L process is applied to current-mode thresholding; circuit area reduced by 75% and pin counts cut in half

Practical nonbinary integrated circuits are about to elbow their way onto the digital logic scene. The Signetics Corp. breakthrough promises to increase the information-processing capability of bipolar large-scale-integrated devices 4 to 10 times—and in theory the increase could be 1,000 times.

The firm's first multivalued circuits use integrated injection logic and current-mode thresholding for a four-level logic (0, 1, 2, 3), according to David Kleitman, vice president of research and development at the Sunnyvale, Calif., subsidiary of Netherlands-based Philips (see p. 56). They are the precursors of a binary-compatible Quad Logic family of devices, which the company expects to sample in the second half of next year.

"In such circuits, metal conductors carry either 0, 1, 2, or 3 quantized units [levels] of current—double the number of information bits in a binary system—with the result that pin counts can be roughly halved," Kleitman says. "And circuits have been built that occupy one quarter the area needed in standard I^2L with the same design rules and no extra processing steps."

With increased production experience, he says, there is no practical impediment to the development of ICs using octal (8-level) and decimal (10-level) logic systems.

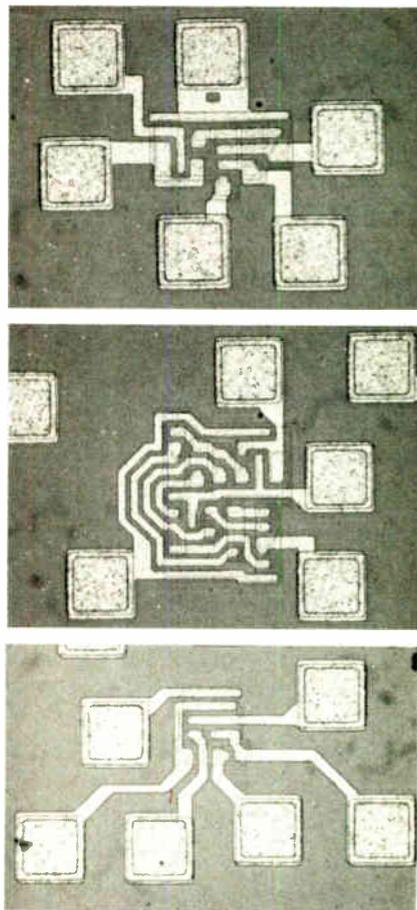
Multivalued, or multilevel, logic circuits until recently were considered interesting, but only a theoretical possibility. But it has been only with the development of high-density current-mode threshold techniques like emitter-coupled logic, and more recently I^2L , that designers have begun to think about multilevel-logic ICs.

Signetics, however, has a significant jump on any competitors—two years of work on what it calls multi-threshold I^2L , almost two dozen patents pending, prototype production runs on some of the basic circuits, and commercial production experience with a binary version it calls threshold-function I^2L .

Building blocks. The Signetics developers found that by adapting other circuit techniques—such as emitter-coupled threshold detection, analog current mirrors, and input/output weighting, the basic I^2L gate would perform threshold logic.

The ability to discriminate among several input thresholds is derived from binary-based ECL. It differs, however, because I^2L , basically a current-mode rather than voltage-mode logic, requires a conversion from current to voltage at its output. This conversion is adapted from operational-amplifier circuits that use current-mirroring techniques to produce a current that varies linearly with the applied input voltage.

Input weighting is achieved by adjusting the size of the output collectors of the npn transistor in the I^2L gate. Collectors of different sizes and different biases are connected together to form weighted sums. In addition, a current differential amplifier—another analog technique—is used to perform most of the



Quad world. Metalization is most striking feature in photos of multivalued logic. At top is a three-input max function (similar to a binary OR), next is a quantizer (a 4-bit a-d converter) and last a triple-complement circuit (like a binary triple inverter).

threshold detector functions.

To test the concept, Signetics built several commercial ICs that have threshold-function gates with binary inputs and outputs externally but multilevel weighted summing and detection schemes internally. Used in the input control logic of a de-

skew first-in, first-out memory, called the 8X04 [*Electronics*, Jan. 8, p. 129], such gates were used to determine if the memory was one-fourth, one-half, three-fourths, or completely full. If ordinary transistor-transistor-logic circuitry or even standard 1^2 had been used, at least 4,000 transistor devices would have been required. In this approach, there are only four.

Quad Logic. "Because of the wide array of weights and threshold combinations," says circuit research

manager Keith Russell, "it's a relatively simple matter to extend the technique to multi-valued circuits."

Using weighted outputs and inputs and a multilevel threshold detector, Signetics has built Quad Logic structures that perform functions roughly equivalent to binary functions such as "AND, OR, INVERT, as well as more complex ones such as multiplexing. In multilevel logic terminology these are, respectively, the "min", "max", "complement" and "T-gate" functions. □

Military

Norden uses microprocessor from Marconi in artillery computer for the U.S. Army

Generally, MPs aren't known for fighting the Army's front-line battles. But, when MP stands for microprocessor, the U.S. Army expects the computer-on-a-chip to make quite a name for itself as a battlefield hero. Out to see that happen is United Technologies Corp.'s Norden division in Norwalk, Conn.

Winner of a \$6.2 million contract to develop the battery computer system for the U.S. Army Electronics Command at Fort Monmouth, N.J. [*Electronics*, Oct. 14, p. 77], Norden is banking on microprocessor technology for its multirole central-computing system designed to perform general artillery computing tasks. The BCS, which will not enter production until late 1978 or early 1979, according to Norden president Peter Scott, is targeted for fire-control jobs by all active field artillery units of the Army as well as National Guard and Reserve units.

Surprise. Norden's winning proposal surprised some in industry who were expecting it to bid a system based on a military version of the PDP-11 computer from Digital Equipment Corp. in Maynard, Mass. Last year DEC licensed Norden to militarize its small, highly successful commercial computer, but Norden's initial PDP-11 entry won't be ready until later this year. For the battery computer, the firm teamed with Marconi Space

and Defence Systems Ltd. of England, a GEC-Marconi Electronics division that has been using microprocessors in advanced fire-control and gunnery-data systems it designs and builds for European armies.

It will use a new Marconi-designed microcomputer built around a standard, commercially-available 4-bit microprocessor slice, says Peter Lewis, assistant managing director of the Marconi division. And the memory of the rugged, portable system can be expanded with plug-in modules.

The microcomputer is one of a family employing similar architecture that Marconi used in earlier fire-control systems. "It emulates the earlier members of the family so that it can use a lot of the previously-developed software," he notes. "However, the BCS will be much more sophisticated than our earlier systems."

In its role as the primary subcontractor for the BCS' development, Marconi is responsible for the operational software and the gun display unit, a hand-held display with its own microprocessor to control "all of the information that a section chief requires to engage a target," says Lewis. Installed at each gun site, the display unit looks like a large calculator with push buttons for calling up specific data, such as azimuth

and elevation of targets, fuze lengths, and number of rounds left, to be shown on its light-emitting diode display.

Army Electronics Command project engineer Mike Simpson says the microprocessor-based battery computer system will be used "primarily as a replacement for Fadac [the current field-artillery digital automatic computer], which is fading out of the Army's inventory, as well as for the battery display unit [BDU] of the Tacfire [tactical fire direction] system," currently supplied by Litton Industries Inc.

"The capabilities of the BCS are well above those of the BDU," Simpson asserts. Pointing to its ability to simultaneously control up to 12 guns via direct data links to the gun sites, as opposed to the present network of voice links, he adds, "It provides for increased mobility and reduced manual error and response times."

In winning the prime contract, Norden bested Litton's Data Systems division in Van Nuys, Calif., and Teledyne Brown Engineering, Huntsville, Ala., the other finalists. Simpson notes Norden is to deliver five systems by October, 1977, for extensive Army testing. "We hope to award a production contract no later than February 1979," he says. "We have no commitments as to how large the production order will be, but right now we're thinking in terms of 1,000 units, including 150 for the Marine Corps." □

Computers

Burroughs plans 'super' machine

Burroughs Corp., whose last foray into large-scale scientific computing ended five years ago with Illiac IV, says it's developing "a new super computer designed to handle the largest problem-solving requirements of science, industry, and government." The computer, which won't be ready until the fourth quarter of 1978, will use "an array-

Microprocessors appear to make progress in process control at Houston show

processor architecture, which will enable it to complete vector-oriented problems at speeds in excess of any system currently installed or believed to be under development," claims Burroughs chairman Ray W. Macdonald.

Presumably included in that statement are the Control Data Star 100, Texas Instruments' ASC, and today's biggest, fastest system, the Cray-1, from Cray Research Inc., Chippewa Falls, Wis., which also performs vector operations. The Cray-1 uses emitter-coupled logic and has a memory of 0.5 to 1 million 64-bit words, based on 1-kilobit bipolar random-access memories. In bursts, the computer can produce 250 million results per second.

Limits. The market for such large \$5 million-and-up machines, however, is limited. Cray, in its preliminary stock prospectus dated last Jan. 28, notes "the market for such large machines consists of approximately 100 governmental agencies, corporations, and educational institutions in the United States and abroad which are engaged primarily in scientific research." Burroughs delivered just one Illiac IV to the University of Illinois [*Electronics*, Oct. 11, 1971, p. 32].

The new Burroughs machine will use the company's own large-scale-integrated logic, called Burroughs current-mode logic. These circuits, which are similar to emitter-coupled logic, were previously used in the 800 family [*Electronics*, Dec. 25, 1975, p. 76]. The machine will be programmed exclusively in Fortran with a new "vectorizing" compiler that converts frequently used serial Fortran instructions into vector operations.

Manager. Being developed at the company's Great Valley, Pa., laboratories, the Burroughs machine will use the large-scale B7700 processor as its system manager, performing under the company's operating system called the master control program. The MCP has been used for some time in other Burroughs systems to provide automatic job scheduling and the management of system resources. □

Though digital computers have been able to handle process control for 20 years, most users still prefer control systems that rely on electrical analog or pneumatic controllers. They're preferred for their inherent reliability—a failure shuts down only a single control loop rather than a complete plant.

But now microprocessor-based controllers are attempting to bridge the gap between single-loop controls that make local decisions and master minicomputers that run the entire process or plant from a central console. And record crowds at Houston's Astrohall this month for the Instrument Society of America's biennial international show witnessed an onrush of microprocessor products trying to gain part of a \$175 million market.

Many of the applications are still in the buzz-word stage, however. Design times for new process-control systems often range from three to five years, and many "microprocessors" were presented in card-board systems mockups and non-functioning printed-circuit boards. Few firms put the device in the control loop, instead assigning it to such peripheral tasks as acquiring data for display, or multiplexing communications systems.

Bold move. One of the boldest steps toward microprocessors was taken by Honeywell's Process Control division, Fort Washington, Pa., earlier this year. Its TDC [total distributed control] system uses a 16-bit processor developed jointly with General Instrument Corp. The CP1600 is used, not only for data

Fastest 16-k RAM available from Mostek

Mostek Corp. has published the final data sheets for the first two versions of its 16,384-by-1-bit random-access memory, the MK4116. The parts have maximum access times of 150 and 200 nanoseconds and 375-ns cycle times, by far the fastest of any vendor that has shown parts. The Carrollton, Texas, memory firm, shipping through distributors, is charging \$100 each for the fast RAM and \$50 for the slower one, in quantities of 100.

Mostek's data sheet is explicit. "Our strategy is to draw a tight target for our competitors to meet," explains H. Berry Cash, vice president. "It's the most fully disclosed part we've ever made." Specifications are worst-case only; "typical" specs are relegated to the back of the document and displayed in graph form. In addition, Mostek includes parameters for device characterization and guarantees performance outside of specified operating conditions. Although the firm will ship fewer than 50,000 16-kilobit devices this year, Cash says it will sell about a million in 1977.

Competitors Texas Instruments Inc. and Intel Corp. are reportedly still redesigning their parts. TI has started shipping samples of a version of its IMS4070 that has the same pinout and timing as Mostek's, plus the Mostek early-write and noncritical clock features. And samples of TI's high-performance, double-level polysilicon design are expected early next year.

Others working on the Mostek configuration include National Semiconductor Corp., Motorola Inc.'s Semiconductor group, Fairchild Camera and Instrument, American Microsystems Inc., Fujitsu Ltd., and Nippon Electric Co. National is already shipping samples, and Intel is shipping as many parts as Mostek, but they're not socket-compatible. Intel will probably be joined by American Microsystems and Nippon Electric in producing its latched-output RAM.

handling and communications with the control room, but also for local process control: changing setpoints in up to eight loops under its control based on information coming from other loops. However, there is manual backup should the controller fail.

But an even bolder distributed control system was shown in Houston by Electronic Modules Corp., Timonium, Md. Its DSC-9700 system puts the decision power for up to 50 loops in a microprocessor with a host PDP-11 minicomputer downloading instructions. By including automatic process shutdown and manual override, the company believes it can eliminate the risk while spreading the microprocessor cost around many loops.

No risk. Others are more cautious. "We want to use the microprocessor where it doesn't ask the user to take a system risk," says William J. Kirk, program manager for electronic control systems at Bailey Meter Co., Wickliffe, Ohio. "Our controls today are single-loop analog or single-loop pneumatic. When the microprocessor is cheap enough that we can use one per loop, we'll do it." Nevertheless, the Babcock and Wilcox Co. subsidiary has designed about 30

digital modules aimed at data handling, computer interfaces, and communications applications that it will start shipping next year. "About a third of them use microprocessors," Kirk says.

Similarly, Taylor Instrument Process Control also plans microprocessor-based controls. "Our goal is to use microprocessors, but to maintain single-loop integrity," says Larry Fetterly, product engineer for the Rochester, N.Y., division of Sybron Corp. "Sure they're powerful and flexible, but they're very expensive for single-loop control." Taylor will first apply them, in mid-1977, to replace the transistor-transistor-logic console electronics on its new Mod III analog control, he says.

Beckman Instruments Inc., Fullerton, Calif., is using a single microprocessor per loop, but only in a new hierarchical system that's built around a central minicomputer. Jack J. Murray, senior applications engineer, explains, "Individual analog circuitry is used to compute the PID [proportional-integral-derivative] algorithm. Microprocessors can be plugged into only those controllers that require computer monitoring and control." □

have two responsibilities: to review the responses from the sections and to prepare detailed reports on the individual goals.

Written statements are due at the end of this month and will be aired by the full 16-member U.S. Activities Board at its November 12 meeting. Also at this meeting, a 1977 budget proposal will be drafted. Then, a second round of open meetings for members will take place to go over the modifications implemented from the first group of reports.

Shortcomings. However, there may be some shortcomings to this initial effort to solicit grass-roots opinion, the first of its kind. The opinions being sought must be gathered in a relatively short time—only about three weeks. And, only a dozen sections out of the IEEE's more than 250 U.S. sections are involved. But they represent the largest sections, with the most active professional-activities programs. And the leaders that have been chosen have been among the most critical of the IEEE's past professional activities efforts.

"I'm guardedly optimistic," says task-force leader Bruce. "USAB has made motions to involve the professional-activities committees and that's a step forward. But it's a vast program, and it will take time to discuss and formulate a response."

James H. Mulligan, Jr., IEEE's vice president for professional activities and chairman of the U.S. Activities Board, says: "My objective is to tighten the feedback loops. I have serious doubts that we've been getting good data on which to base our decisions and I want to find out exactly what's going on, what members really want." □

Communications

U.S. policy overhaul urged in Congress

A thorough rewrite of the Communications Act of 1934—and Federal policy with it—will top the agenda

IEEE

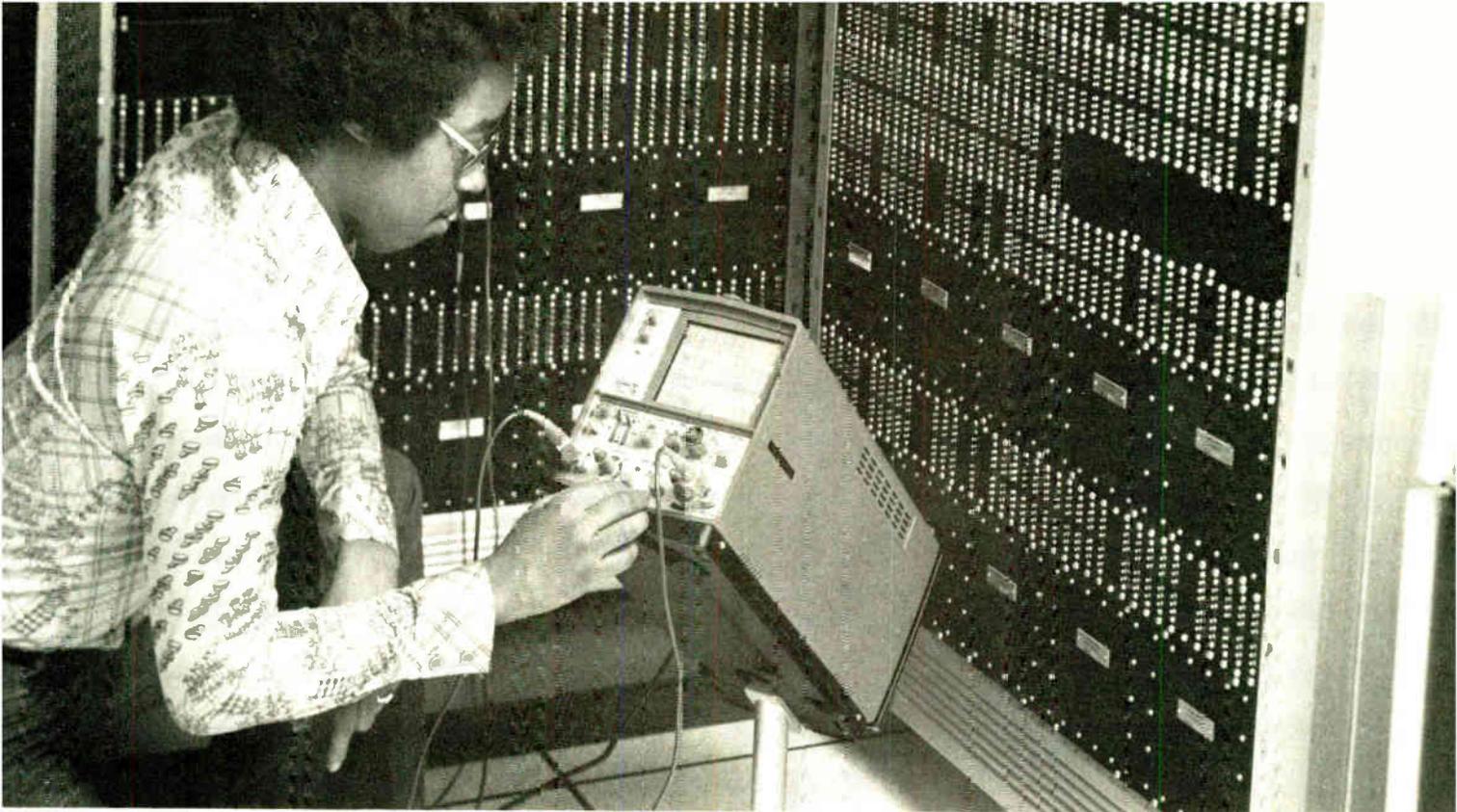
Opinions from grass roots solicited for next year's professional-program plans

The U.S. Activities Board of the Institute of Electrical and Electronic Engineers has taken another important step toward opening the plans for next year's professional program to suggestions from its members. The new approach was put in motion at a weekend meeting earlier this month of board members and chairmen of professional-activities committees from local IEEE sections.

A dozen leaders were chosen to organize meetings of members in their sections that would review the board's draft of over 40 proposals for the 1977 program [*Electronics*, August 5, p. 32]. Budget for the program could exceed \$1 million.

The idea is to establish priorities for the proposals, to identify crucial gaps in the proposals, and to find out from members how they feel about the directions the institute's professional activities should take.

Reviews. Grass-roots task forces have been set up that cover the three main goals of the activities board's plan: improvement in financial and economic benefits, headed by Alvin Reiner of Washington, D.C.; improvement in career conditions and opportunities, headed by Robert Bruce of Long Island, N.Y., and improvement in professional status, headed by Gerry M. Goldenstern of Los Angeles. These three men will



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of the House Interstate and Foreign Commerce Committee's communications subcommittee when the 95th Congress convenes in January, according to chairman Lionel Van Deerlin. The California Democrat (see p. 14) was joined in this commitment by Rep. Lou Frey (R., Fla.), the subcommittee's ranking minority member, as the dust settled following three hectic days of controversy during preliminary hearings in late September on telephone-industry proposals to limit telecommunications competition in terminal equipment and special services.

Complex issues. Congressional recognition of the complexity of the issues was evident in both House and Senate at adjournment. Pro-competition interests were encouraged that leaders in both branches want to develop their own legislation from scratch next year, rather than rely on the various "Consumer Communications Reform Acts" being pushed by the American Telephone & Telegraph Co., its Bell System affiliates, and independent phone companies.

To guarantee "American consumers the best and most efficient access to modern communications technology," say the two subcommittee leaders, "we need to go back and take a look at the whole basis of regulation." Competition, they point out, is but one segment of the problem that will require revising present rules "from the basement to the attic."

At the same time, leaders of the communications subcommittee of the Senate's Commerce Committee, Vance Hartke (D., Ind.) and Howard Baker (R., Tenn.), reiterated earlier requests for a separate study.

IBM's threat. Rep. John M. Murphy (D., N.Y.) believes AT&T's anti-competition moves are directed at potential forays into the communications field by International Business Machines Corp., rather than at small specialized carriers. He wants a joint House-Senate study effort next session. Murphy's proposal calls for a five-man study group to be appointed by leaders of both houses.

News briefs

Data General picks North Carolina for software facility

Data General Corp., Southboro, Mass., says that because of the difficulty of attracting software professionals to its New England location, it is setting up an advanced research and development facility in the Raleigh-Durham Research Triangle in North Carolina. The company has been searching for the past six months for the best spot to locate the facility and settled on the Research Triangle area because of its "cordial business environment" and its proximity to Duke, North Carolina State, and University of North Carolina, all of which offer advanced computer science programs. The move was prompted by the threat of a graduated income tax in Massachusetts, plus a "business environment that is extremely depressing, to say the least." According to the company, its software R&D budget has doubled as a percentage of total R&D expenditures over the past two years; it is now running at 35% to 40% and is still climbing.

Datran assets going to Southern Pacific Communications

Southern Pacific Communications Co. has bought at auction the communications network and related equipment of defunct specialized common carrier Data Transmission Co. (Datran). Bidding began at \$2.5 million, and SPC's winning offer of \$4.9 million topped that of the only other bidder, Western Union Telegraph Co. Details of the sale should be completed by year's end. Proceeds are earmarked for yet-to-be-determined creditors of Datran, a subsidiary of University Computing Co. in Dallas [*Electronics*, Sept. 2, p. 32].

Raytheon gets rest of Pave Paws

The other shoe has been dropped in the Air Force's program to build its Pave Paws radars to detect sea-launched ballistic missiles approaching the U.S. coastlines [*Electronics*, Aug. 7, 1975, p. 43]. Raytheon Co.'s Equipment division, Sudbury, Mass., will build the West Coast installation at Beale Air Force Base, Calif., under terms of a \$28 million contract option exercised by the Air Force Electronic Systems division, Hanscom Air Force Base, Bedford, Mass. Raytheon had won an earlier \$46.5 million award for the East Coast radar, to be constructed at Otis Air Force Base, Mass. [*Electronics*, April 29, p. 36].

This group would include at least one communications engineer, an economist, a consumer advocate, as well as a businessman.

"What (the Bell System) is really worried about," Murphy contends, "is that somewhere down the road a company like IBM, with billions of dollars at its disposal, will take advantage of the blurred interface between data processing and data communications to provide services that the Bell System thinks belong to it." Yet, he points out, there is little or no mention of these questions so far in congressional consideration of legislative proposals. Murphy initially wanted the in-depth study to be performed by the Federal Communications Commission, but changed his mind because of FCC's "vested interest in its past decisions"

and a performance record "marked by a lack of interest, excessive delay, and a poverty of thought." □

Military

Loral adding to P-3C surveillance

The new electromagnetic threats presented by the Soviet Union's fleet pose problems for U.S. Navy patrol aircraft. However, the Navy hopes to attack these problems with a micro-computer-based electronic-surveillance system being developed at Loral Corp.'s Electronic Systems division in Yonkers, N.Y.

Under contract to the Naval Air Development Center, Johnsville, Pa.,

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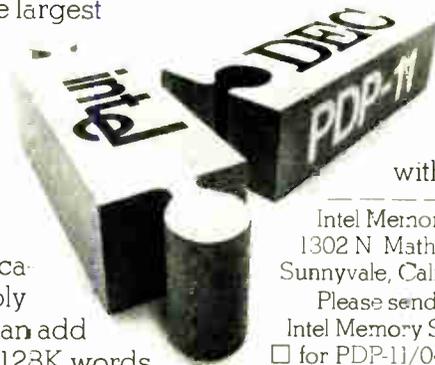
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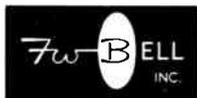
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Electronics review

the system is part of a general update of the land-based P-3C Orion's electronics as the plane's mission is expanded. Loral hopes to begin delivering its ESM system in late 1978 for production-line aircraft and then retrofit about 200 P-3Cs with it.

In addition to its use as a patrol aircraft for antisubmarine warfare, the Lockheed-California Co. plane will also be used as a platform for launching the Harpoon missile against surface vessels. "But even if the P-3C wasn't getting the Harpoon, we would still have a requirement for the advanced ESM capability," says Comdr. Joe Kiel, deputy project manager for P-3C update programs at the Naval Air Systems Command in Washington, D.C.

Final R&D. Loral is performing final qualification and system integration tests on the first two ESM units, scheduled for flight tests early next year. Like the new radio-frequency surveillance/electronic-countermeasures system being built for the Air Force B-1 bomber by Cutler-Hammer Inc.'s AII division in Deer Park, N.Y. [*Electronics*, Aug. 5, p. 36], the Loral system can use software to change parameters even during flight as new threats emerge.

The system can pick up and identify such threats as surface-to-air missiles, radar-controlled anti-aircraft missiles, and anti-missile-defense systems, points out Loral's division president Frank Lanza. "We're going from analog to digital processing to increase the system's capacity and response time by several orders of magnitude," he adds.

The antennas and receivers in the present ESM system (part of the AN/ALQ-78 countermeasures set) will be expanded to cover the E through I (2-10-gigahertz) frequency bands. And the system's data-converter-control unit, which had used basically analog hardware to determine the direction and identity of enemy emitters, will now use a Loral-built 16-bit microcomputer to do the emitter-sorting and identification.

"With the analog hardware, we

could only measure one emitter at a time," says Lanza. "Typically, even with low enemy densities (10,000 to 15,000 pulses per second), it took seconds to sort and identify the pulses. Even after that, you still had high false-alarm rates."

More pulses. But with the computational and mathematical capability of the digital processor, Lanza continues, "you can sort and identify about 300,000 pulses per second in microseconds with very high reliability." Use of the microcomputer, Kiel adds, automates some of the things the operator has had to do and relieves the load on the computer.

To sort and identify emitters, the system notes their characteristics, such as direction, pulse amplitude, frequency, and time of arrival. After being digitized, this information goes to the central on-board computer, which will be either the current Sperry Univac CP901/ASQ-114 or a new standard Navy minicomputer, the AN/AYK-14. The emitter is identified by the threat library in the computer memory.

"Before, we had a limited library in analog circuitry that could be changed only with a change in circuitry. This was very costly and slow and considerably increased the size of the system," Lanza notes. "Now, the same computer can do all the computations and, if necessary, you just add memory." □

Consumer

Mosquito repellents sting only buyers

Buzz off. That's what the Environmental Protection Agency has told New York's Buzz-Off Products Co. and a dozen other makers of what EPA calls "electronic contraptions" sold as mosquito repellents. After extensive product testing in the mosquito-infested Chesapeake Bay area, the agency has declared the repellents "worthless" and is moving to prevent their sale as well as their importation.

So far the agency has stopped the

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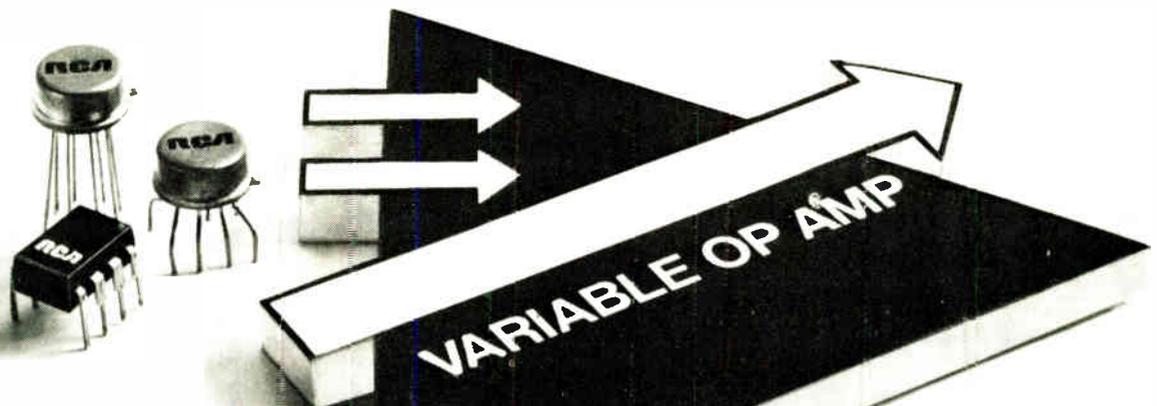
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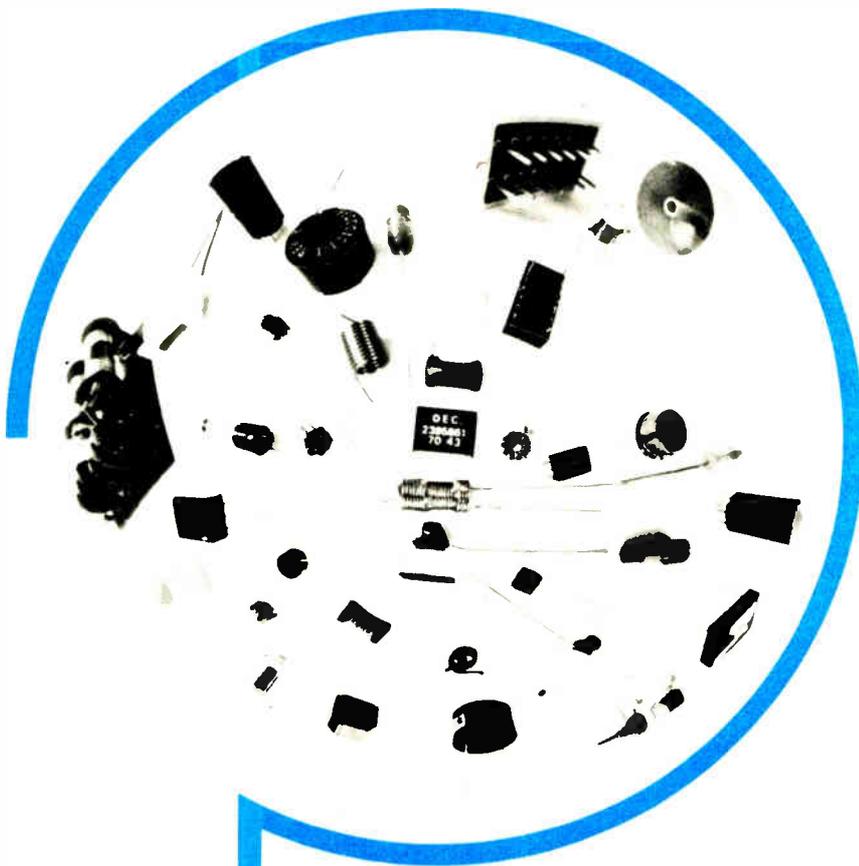
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sale of a variety of repellents in Washington, D.C., New York, and Denver and ordered major distributors in Salt Lake City and New York to make no further sales or shipments, according to EPA's Stanley W. Legro, assistant administrator for enforcement. But the agency's most effective move to prevent consumers from being bitten is likely to come from its agreement with the Bureau of Customs, since nine of the 13 repellents it has tested are imports, mostly from Hong Kong.

Customs, which inspects incoming merchandise, has agreed to prohibit entry of ineffective devices and impound others at the dock or warehouse until they can be properly tested. EPA's authority stems from the 1972 Federal pesticides law, which prohibits false and misleading claims in device labeling. The repellents are pocket-sized, battery-powered boxes that emit sound waves supposedly repugnant to mosquitoes [*Electronics*, Oct. 2, 1975, p. 48]. They typically retail for about \$20, the agency says.

Batty. EPA cited one repellent's claim that "it repels the female mosquito (the one that does all the biting) by mimicking the sound of the bat, the mosquito's greatest enemy." Legro admits, "It's true that the female does the biting and that bats do eat mosquitoes, and there is even some scientific evidence that certain sounds could be offensive to some insects." But Legro stops there. Translating those principles into technology has flopped thus far, he says. "None of them works."

In addition to Buzz-Off Products, the agency's list of corporate gadgeteers hustling repellents includes Progressive Electronics Corp., Dallas, Norris and Co., Salt Lake City, and Trans International Corp., Chicago, which imports its repellent from Taiwan. Overseas makers include six from Hong Kong—Information Systems, Ltd., HBS International Ltd., Beuty Industrial Co., Mascotte Manufacturers Corp., Sonway Manufacturers Ltd., and Kelly & Co., plus Domac Industries Pty. Ltd., Melbourne, Australia. □

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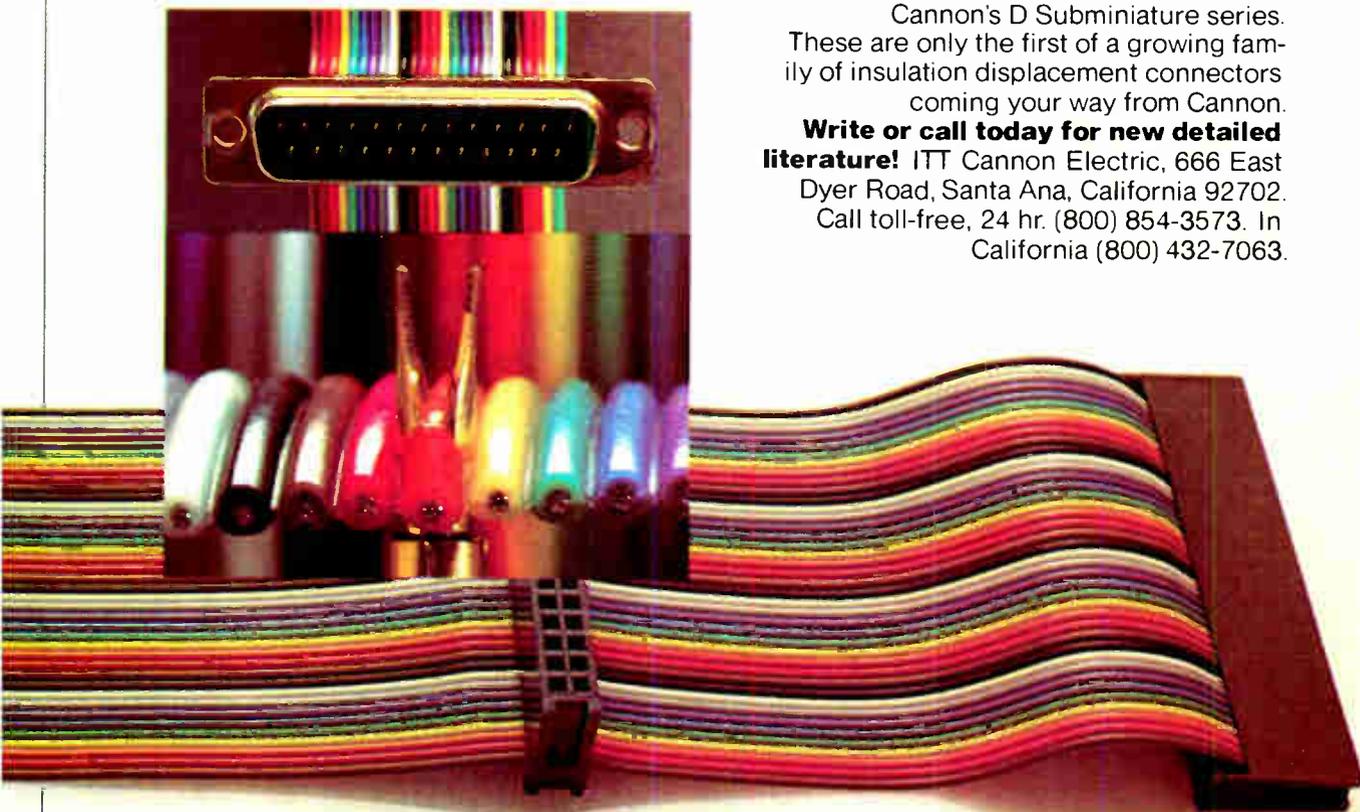
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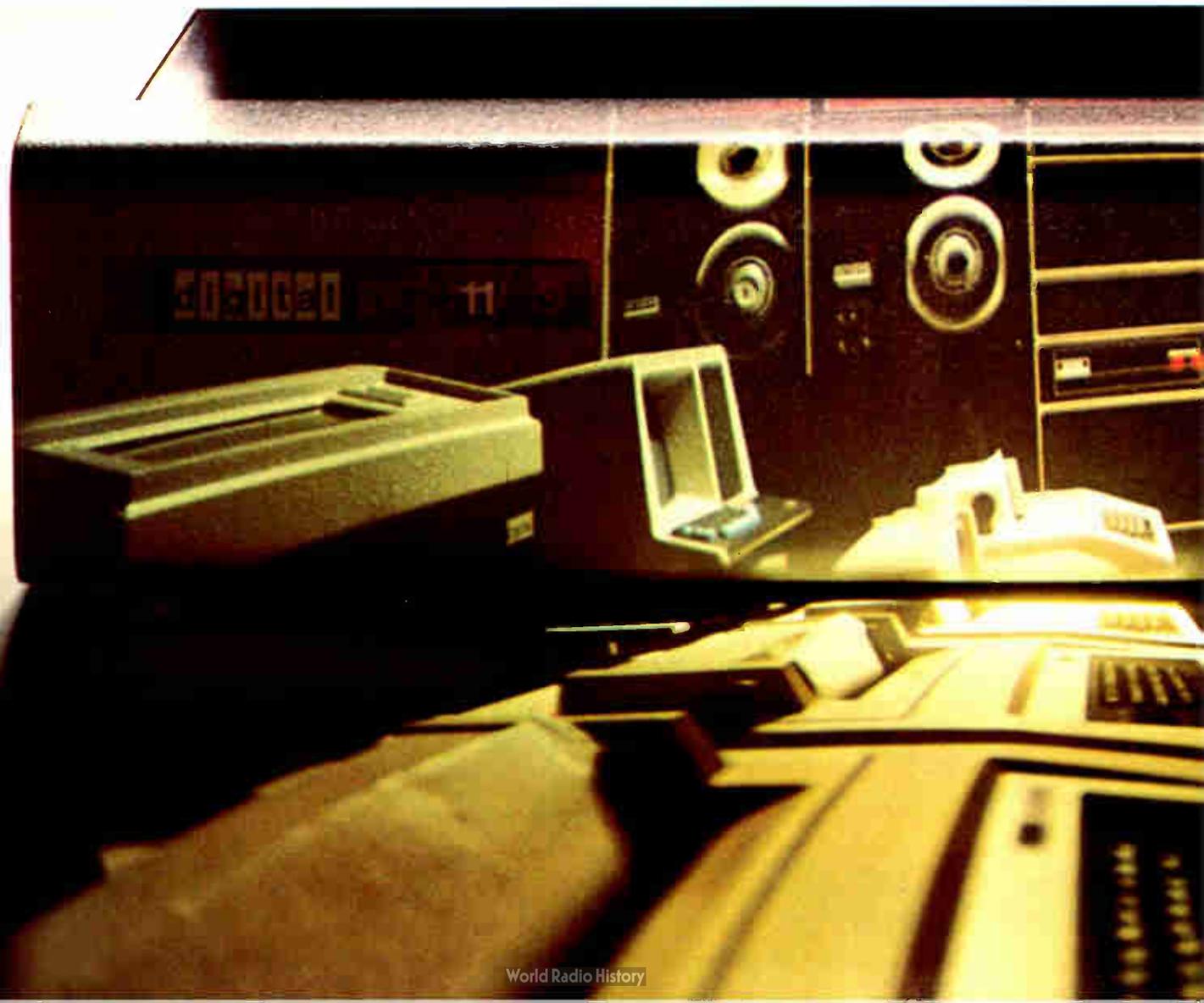
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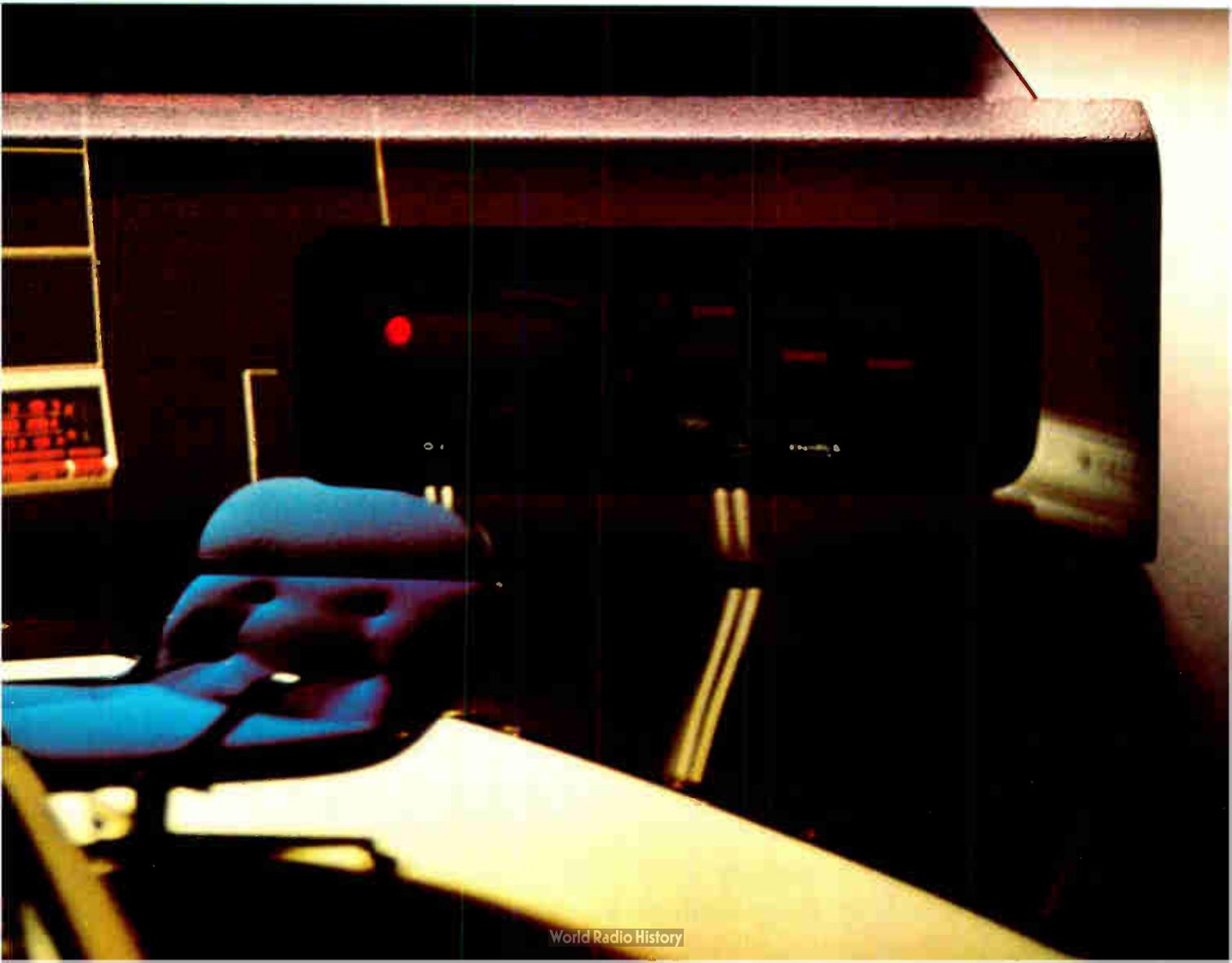
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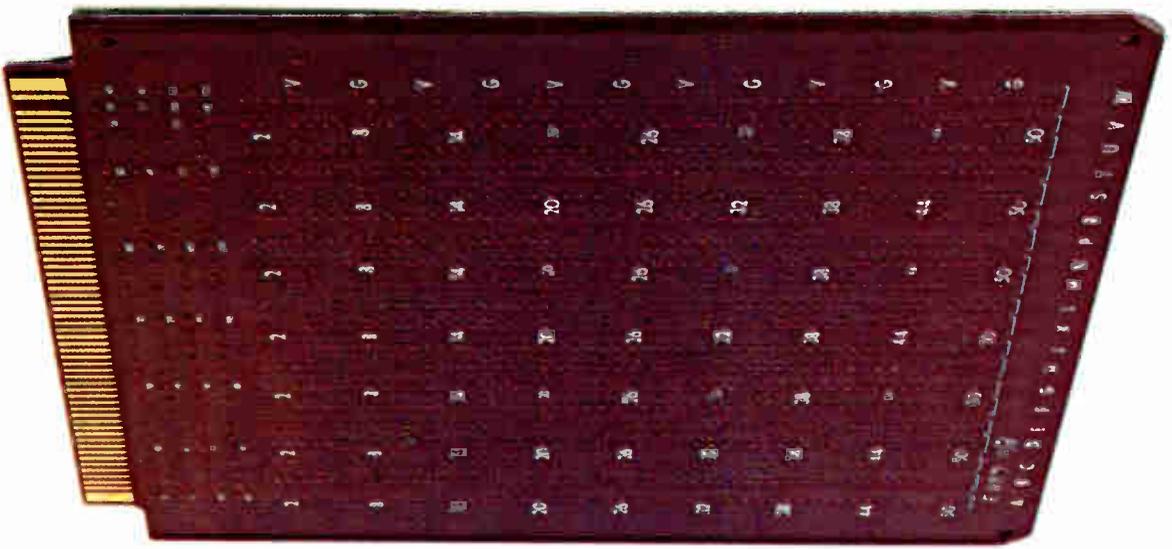
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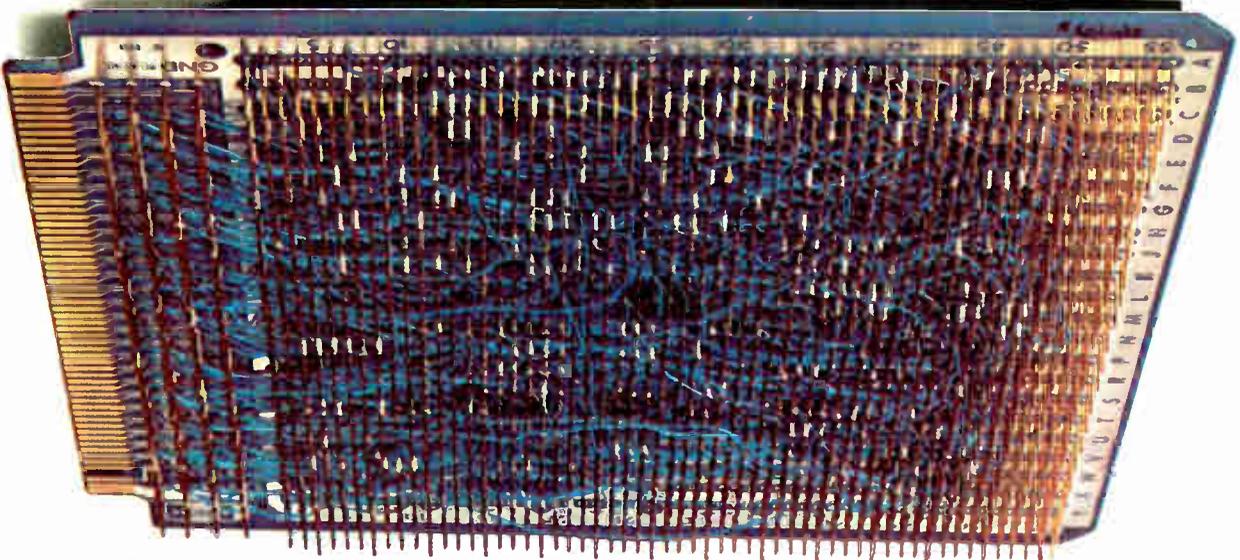
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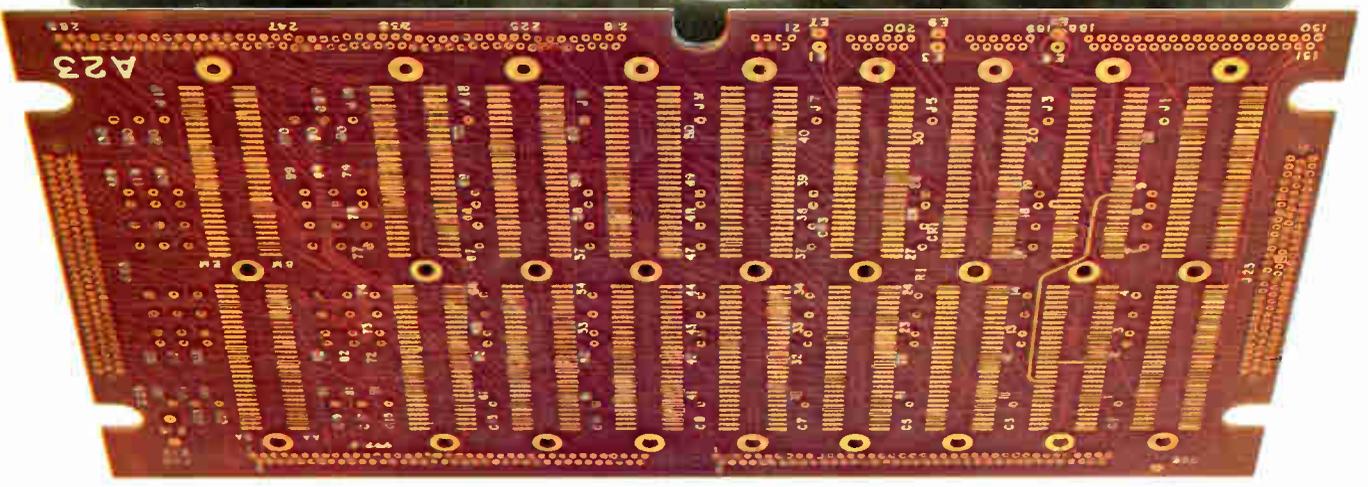
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Two major systems — wirewrapping and multilayering — have been used for complex electronic interconnection in the last 15 years. Despite improvements and refinements, each still has inherent disadvantages. That's why Multiwire was created by Photocircuits. It overcomes the disadvantages of wirewrapping and multilayering.

A Multiwire board is basically a customized pattern of insulated wires laid down on an adhesive-coated substrate by a machine operating under numerical control.

Multiwire vs. wirewrapping.

Today, interconnection costs are more important than ever. So take a long, hard look at a key advantage of Multiwire panels. They cost much less than wirewrapping in small or production quantities.

Here's an example of how much less: a Multiwire replacement of a 60 DIP wrapped-wire panel. Total tooling costs were just \$750. In order quantities of 1000 pieces, the Multiwire boards at \$45 each were more than \$30 less than the wrapped-wire panel. (A 40% cost savings.) Multiwire prices also include a 100% continuity check.

But cost is not the only reason for the superiority of Multiwire over wirewrapping. There are also design advantages. For example, Multiwire offers two-dimensional packaging density equal to wirewrapping. But with Multiwire panels, you reduce board-to-board spacing. And Multiwire weighs much less too. So it can contribute substantially toward improving the envelope or three-dimensional package of your product.

Electrically, Multiwire is also superior. The extreme repeatability of the manufacturing process provides much higher electrical reliability as received — this is an important cost-saving factor. In addition, you get the controlled impedance characteristics required without variations.

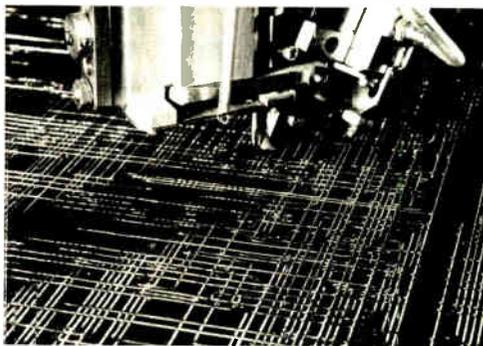
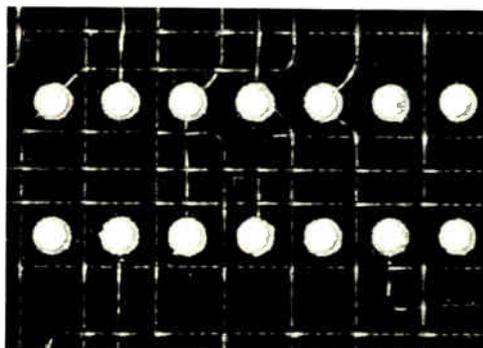
Multiwire vs. multilayering

With Multiwire, reliability goes up and inspection cost goes down. Multiwire doesn't need extensive inspection — like multilayering does — for nicks, pinholes, hairline cracks, spacing violations and bridging. Yet Multiwire regularly yields better than 99% reliability at incoming inspection.

Compared to multilayering, designing a new Multiwire board is a far simpler operation. Component locations and a wiring list are all we need. Our computer-aided system does the rest.

Since the computer also takes care of deletions and/or additions, engineering changes are simplified. What's more, Multiwire makes it easier to find paths for interconnections, because the insulated wires can cross one another. For these reasons we can deliver finished Multiwire boards to your door in weeks rather than months.

The advantages of Multiwire over wirewrapping and multilayering vary from case to case. We'd like to help you evaluate possible time, cost, design and reliability benefits. For information and price estimates, call the Multiwire Marketing Department at 516-448-1111.



	Wrapped panels	Multi-layers	Multi-wire
Design & tooling cost	Low	Very High	Low
Design & tooling time	Short	Very long	Short
1st piece delivery	Short to Very Short	Long	Short
Board cost in small quantities	High	High	Medium
Board cost in production quantities	High	Medium	Medium
2 dimensional packaging density	High	High	High
3 dimensional packaging density	Medium	High	High
Weight	High	Low	Low
Ease of changes	Excellent	Poor	Good
High speed electrical characteristics	Fair to Poor	Excellent	Excellent
Interchangeability with other techniques	Fair	Excellent	Excellent
Repairability	Excellent	Poor	Good
Controlled impedance	Poor	Good	Good
Electrical reliability as received	Fair	Good	Excellent

Multiwire from Photocircuits

Division of Kollmorgen Corporation, Glen Cove, New York 11542

“Itchy Palms” to buy all his mini



Palmer used peripherals on price

Ebenezer "Itchy Palms" Palmer.

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Shortened his first name to "Eb" to save writing time.

Once used a borrowed tea bag for 126 consecutive days.

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But "Itchy Palms" Palmer's penchant for parsimonious peripheral purchasing was beginning to cost him a lot in returned devices, repairs, headaches and lost customers.

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"Pay only once," smiled Palmer. "Won't come back to haunt me. Comprehensive product support."

They were talking *his* language.

So from that day on, Eb Palmer bought all his mini peripherals from Plessey Microsystems.

He ended up spending much less in the long run.

And he rewarded himself with a cup of well-aged tea.

If you'd like to find out how Plessey add-on core memories, single and dual disc drives and punched tape readers can expand your mini without depleting your resources, just call us today.

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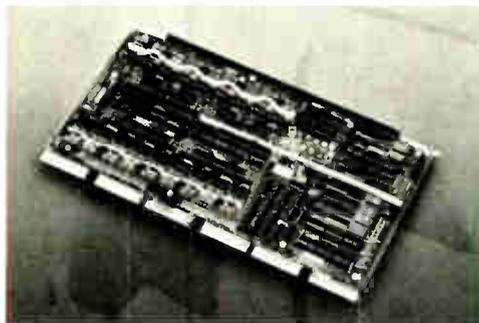
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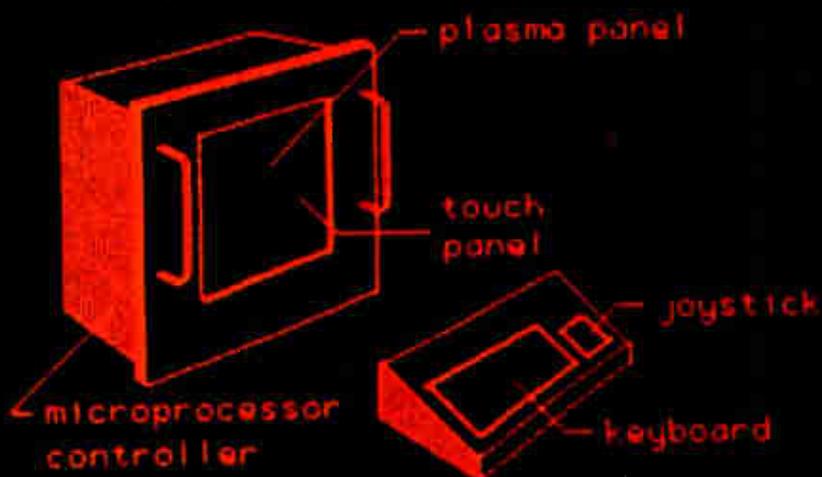
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Mixed-process devices gain ground

Bi-FET and bi-MOS linear chips invade area that was exclusively bipolar with input bias currents that are 1,000 times lower

by Lucinda Mattera, Components Editor

Mixed-process chips are moving in on what has been the traditionally bipolar domain of linear integrated circuits.

Popularly dubbed either bi-FET or bi-MOS, most mixed-process chips have bipolar outputs and matched field-effect transistors at their inputs. And because of their FET front ends, mixed-process devices can operate with input bias currents that are 1,000 times lower than those of bipolar chips. Additionally, they respond more than 10 times faster, offer broader bandwidths, and exhibit lower noise and better stability.

In bi-FET devices, ion implantation is used to fabricate the input p-channel junction FETs. With high-energy ion beams, the low-concentration dopant profile needed for building good JFETs can be obtained easily. On the other hand, as a rule, the bi-MOS process involves only diffusion, but requires an extra masking step to define the gates for the input p-channel MOSFETs.

Bi-FET and bi-MOS device performance is fairly evenly matched, with perhaps a slight edge going to bi-FET products for somewhat lower noise and less offset-voltage drift. On the other hand, input MOSFETs can accommodate signals over the full range of the supply voltage. Finally, MOSFET inputs generally require protection diodes to guard against damage from electrostatic charge.

Most of today's mixed-process linears are operational amplifiers, but other types of devices are beginning to appear. By the end of the year, more than half a dozen major semiconductor firms will have their

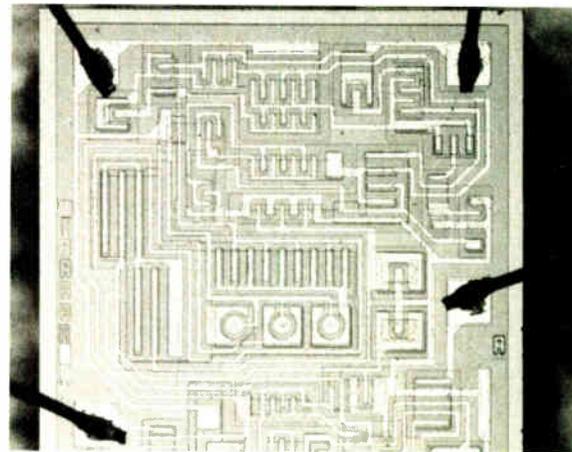
own bi-FET processes. And bi-MOS is by no means standing still, with leaders in the field planning exciting introductions in the near future.

At this time, National Semiconductor Corp., Santa Clara, Calif., has already announced the greatest variety of bi-FET products, including op amps, instrumentation amplifiers, comparators, analog switches, and sample-and-hold circuits. Moreover, the firm, which will shortly introduce a bi-FET quad op amp, is also investigating bi-FET data converters and products for telecommunications applications.

According to James Soloman, manager of linear design at National, bi-FET processing, besides being more complex than straight bipolar technology, requires 5 to 10 times more die area than the equivalent bipolar function. As a result, he says, bi-FET devices will always cost about 15% more. However, he believes that bi-FET technology will have a significant impact on hybrids, replacing most of them with monolithics within a few years.

Drawback. High input offset voltage is probably the biggest drawback of present bi-FET technology. "The dimensional control of channel width has to be about 10 times better than for bipolar to obtain the equivalent offset voltages," notes Soloman. But even with the improved dimensional control permitted by ion implantation, a JFET pair can be matched to within only about 3 millivolts, whereas bipolar transistors can be matched as closely as 0.8 mV, he points out.

Because of the obvious performance advantages of bi-FET devices, a number of other semiconductor



Dual technologies. This op amp from National is a bi-FET device. It has JFETs on the same chip as bipolar transistors.

houses are perfecting their own bi-FET processes. Both Intersil Inc. of Cupertino, Calif., and Fairchild Camera and Instrument Corp. of Mountain View, Calif., will soon announce their versions of National's op amps, followed by a series of analog switches and multiplexers. And Signetics Corp., Sunnyvale, Calif., a pioneer in the development of ion implantation as a production process, is also planning a family of bi-FET products, scheduled for introduction during the first quarter of 1977.

Texas Instruments in Dallas already has a family of bi-FET op amps, encompassing quad, dual, and single versions, and is now second-sourcing National's op amps. The company is also offering a line of bi-FET analog switches and plans to follow with related products, like comparators. What's more, within a few weeks, TI will make available selected versions of its bi-FET quads—input offset voltage of the devices will be approx-

Probing the news

imately half as large, down around 6 to 7 mV.

And early next year, Precision Monolithics Inc., Santa Clara, Calif., will announce an improved version of National's bi-FET op amp. "For one thing, we've developed a different circuit technique to optimize the JFET matching, as well as get rid of some unwanted effects," says Dan Dooley, the company's vice president of engineering. Instead of input bias current doubling every 10°C, as is the case in the National device, it will increase 1% to 2% every 10°C.

In December, Motorola Semiconductor Products, Phoenix, Ariz., intends to introduce its first bi-FET

device—a quad op amp. Each amplifier in the package will have a 10-megahertz bandwidth. While specific price is not yet determined, it is expected to be in the \$5 range for 100-and-up quantities. After the bi-FET quad, the company will second-source National Semiconductor's line of op-amps.

TI occupies a unique market position, since it has both bi-FET and bi-MOS processes. Mixed technologies open tremendous possibilities, says John Spencer, applications engineer for linears. "We've busted a dam, and it's really difficult to pick out what specific direction we're going in," he adds. Future mixed-process op amps will not be just simple amplifier circuits, but systems components like programable gain blocks or op amps with multiplexed

front ends that can handle a number of different input signals, he foresees.

Besides applying its bi-MOS process to amplifiers and analog switches, Siliconix Inc., Santa Clara, Calif., has a bi-MOS IC that is half of a chip set for a 3½-digit analog-to-digital converter. But probably the most intriguing mixtures are coming from RCA's Solid State division in Somerville, N.J.

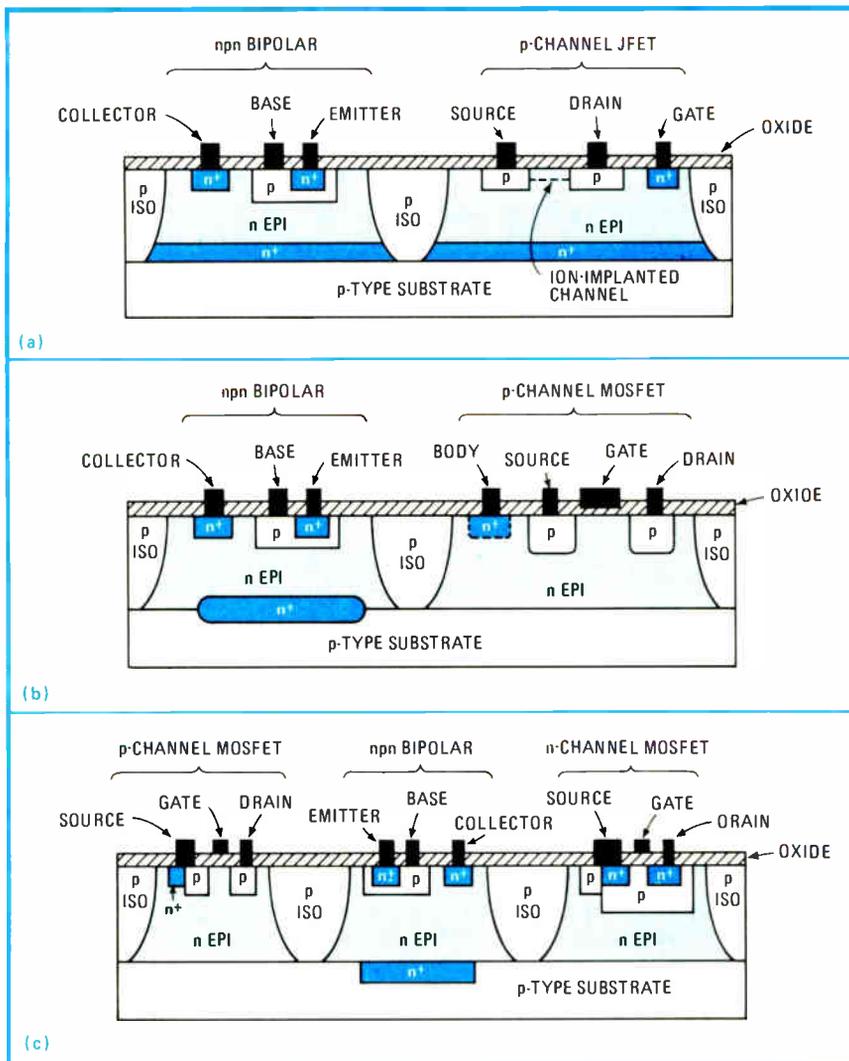
The firm already has three unusual mixed-process devices on the market, among them an op amp combining bipolar and complementary-MOS technologies, and is planning to complete some custom circuits for consumer applications sometime next year. Mixed processing is ideal for putting both digital functions such as frequency division and control logic on the same chip as linear functions, notes the Solid State division's Merle Hoover, a member of the bipolar integrated-circuit group.

Performer. The newest mixed-process chip from RCA is a bi-MOS op amp having a p-MOS front end and a bipolar output. It's an all-around better performer than the industry-standard 741 bipolar op amp, says Hoover, and even input offset voltage is comparable. What's more, he points out, the device can be operated from a single-polarity supply without the loss of common-mode-voltage integrity. And the price is good, too—the device sells for only 69¢ each in hundreds.

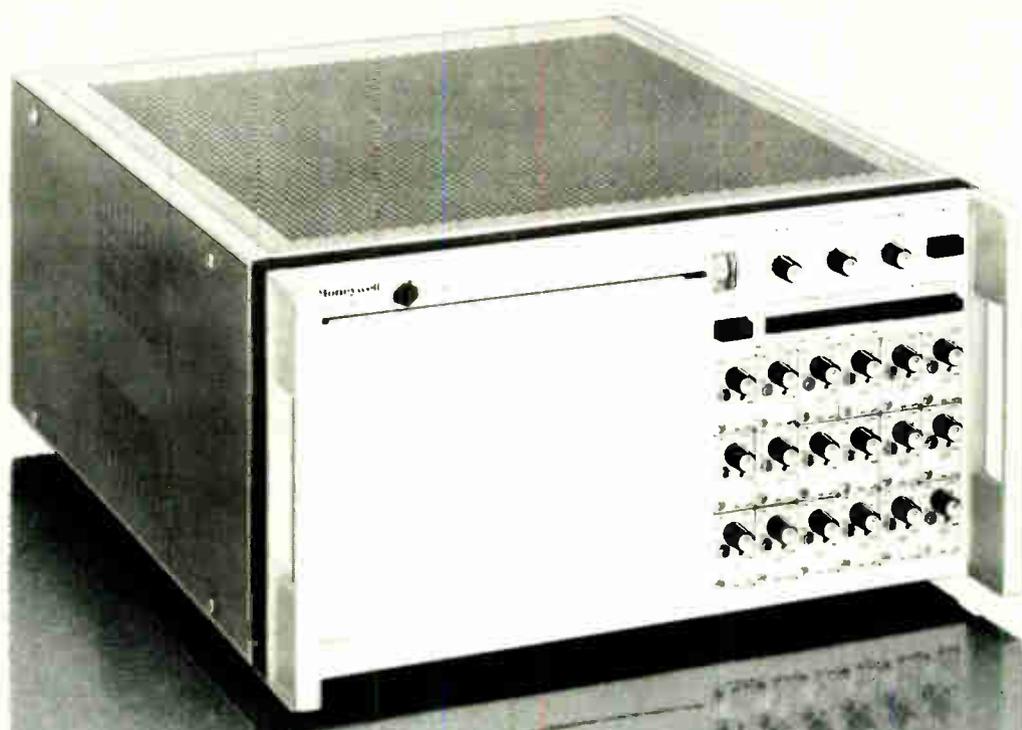
Dielectric isolation can also be used to fabricate mixed-process devices. Harris Semiconductor, Melbourne, Fla., the chief proponent of dielectric isolation, has successfully combined bipolar and n-MOS transistors on the same chip for a wide-band inverting op amp, a current amplifier, and a chopper-stabilized op amp.

As might be expected, now that mixed processing has started to roll, new variations are beginning to crop up. For example, at National, designers are investigating n-channel bi-FET devices that outperform their p-channel counterparts. Among other things, they offer five to six times higher gain at one-fourth the noise, as well as faster slew rates and lower on-resistance. □

Integrated neighbors. Mixed-process chips may consist of bipolar and JFET devices (a), bipolar and p-MOS transistors (b), or a combination of bipolar and C-MOS structures (c).



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Consumer electronics

Japanese press microcassettes

On the market since 1969, ultrasmall tape recorders finally are ready to gain niche in market as sales and competition pick up

by Gerald M. Walker, Consumer Editor, and Charles L. Cohen, Tokyo bureau manager

The microcassette tape recorder, a machine that has been struggling to gain consumer acceptance since it hit the market in 1969, is a product whose time has finally come in Japan. And, based on the history of other Japanese consumer electronics products, America can't be far behind.

One of the drawbacks of the transistor-radio-sized recorder, aside from its initial selling price of \$150 to \$280 depending on options, was that it was developed by a camera company, Olympus. That firm has had great success with tiny cameras, but was not known for its skill in tape recorders. But the picture has changed in the last 18 months, as two well-known consumer-electronics companies have joined the competition. Now other firms are getting set to enter. The net effect is that the microcassette recorder has become a viable product.

According to Olympus, total sales in Japan by all manufacturers last year amounted to 150,000 to 170,000 units, a drop in the bucket in a 4-million-plus portable-tape-recorder market. This year sales will probably total 240,000 to 250,000 units and in 1977 could climb to almost 310,000 units domestically. There is very little export so far, because the Japanese companies have been concentrating on the larger minicassette machines for overseas which use standard Philips-type tape cassettes (see table).

The microcassette reels and housing, about a quarter the size of the standard type, was also developed by Olympus using tape supplied by TDK Electronics Co. Tape speed is 15/16 inch per second, exactly one-half

HAND-HELD TAPE PLAYERS			
	Microcassettes		Minicassette
	Olympus, Sony, Matsushita RQ 160	Matsushita RQ 170	
Dimensions (mm)	64.5 x 132.6 x 28.2	67 x 31.5 x 138	141 x 92 x 40 to 166 x 45 x 100
Weight (grams)	340	345	640 to 830
Price	\$156 to \$171	\$122	\$97 to \$139

that of the standard Philips cassette. Tape width is 3.81 millimeters, frequency response is 200 to 4,000 hertz, and running time is 30 minutes per side for one-hour total playing time. The cassette itself measures only 33.5 by 50.2 by 8.1 mm.

The first to join Olympus in the market was Matsushita Electric Industrial Co. which started selling the R 160 last year for about \$163. It is made for Matsushita by Olympus, but has different options. Then, in March of this year, Sony Corp. got into the act with two models priced at around \$160 and \$156. They are available in the U.S. through office-equipment outlets. In July, Olympus brought out a new Pearlrecorder-SD for \$156 with a-m and fm radio options at \$17 and \$22, respectively.

New models. Last month, Matsushita started selling a new model, RQ 170, priced around \$120. Early next year, Toshiba Electric Co. Ltd. expects to introduce one of its own at the same price, but also is aiming for a unit under \$75, which is the Japanese commodity-tax breakpoint. Sanyo Electric Co. Ltd. will probably join the field as well.

The new Matsushita recorder measures 138 by 67 by 31.5 mm and with batteries weighs 345 grams, slightly bigger and heavier than the first model. Production economies and use of standard components made by Matsushita account for the lower price, explains M. Shingai, manager of the Audio Tape Recorder department. In addition, the new model has a plastic case rather than metal.

Akiyoshi Tshitani, manager of radio and tape-recorder sales-planning department for Sanyo, says, "The microcassette offers a good opportunity because there are fewer competitors compared to the minicassettes. But the problem is the high price, which means fewer potential customers at first."

Studying. In the United States, the hand-held tape players have been sold primarily to businessmen, but the prime target in Japan is the student. Therefore, it's important for all the competitors to get prices down. However, working in the manufacturers' favor is the fact that conscientious Japanese parents can be counted on to buy the microcassettes to help their children get ahead in school. □

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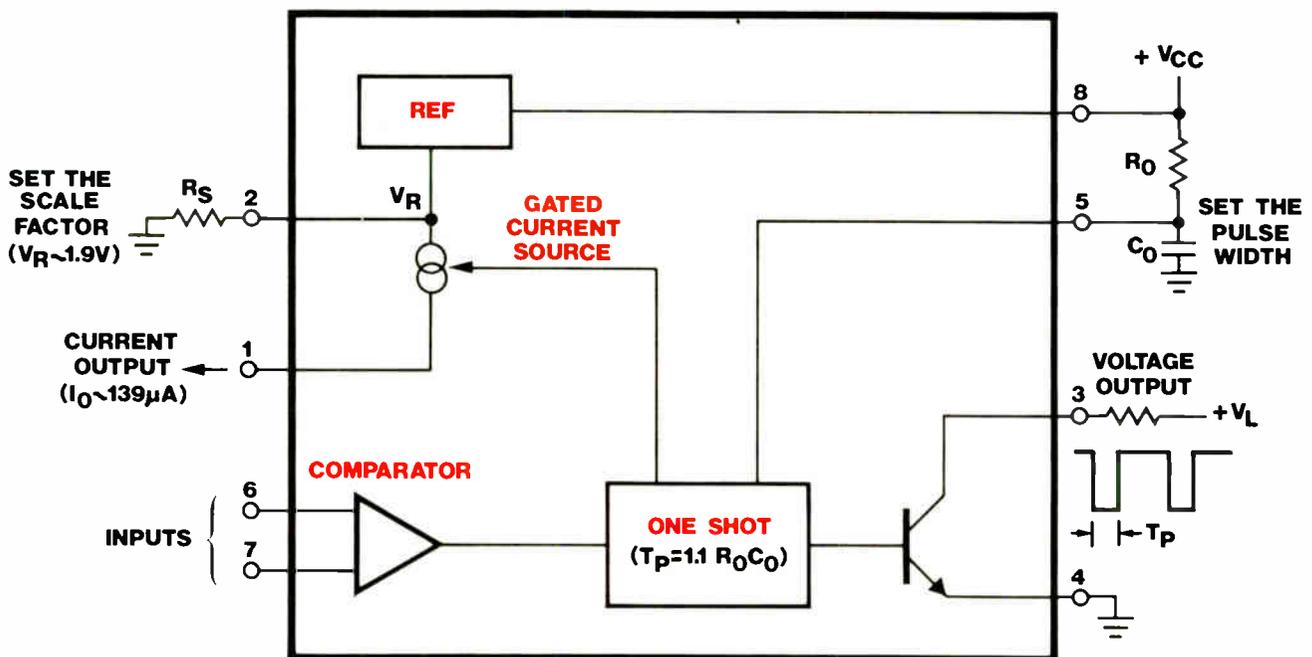
Make what you need. It's all in the way you connect it up. You can make a voltage-to-frequency converter, a frequency-to-voltage converter or a voltage-controlled pulse generator. It's up to you.

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easy to interface with any logic family. You can design high-performance data conversion and signal generating circuits at the lowest possible cost.

Combine the 4151 with a little external logic, an op amp or two, possibly a 555 timer, and you can make integrating analog-to-digital converters, long-term analog integrators, signal isolators, FSK demodulators, frequency scalars and many, many more special functions.

For complete details on this unique multifunction VFC, contact your local distributor or Raytheon Company, Semiconductor Division, Dept. 4151, 350 Ellis Street, Mountain View, CA 94042, (415) 968-9211.



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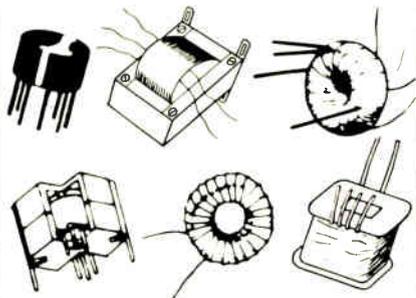


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Companies

Signetics warms in Philips' glow

Acquisition by Dutch giant fuels optimism as IC maker prepares 80% proprietary, 20% standard product mix

by Judith Curtis, San Francisco bureau

How would you like to run a \$120 million company with a \$200 million R&D budget? That, in effect, is what has happened to Signetics Corp. since it was acquired last year by Philips Gloeilampenfabrieken N.V., the Dutch giant whose R&D and financial resources could go a long way toward thrusting Signetics out of the doldrums.

And since the Sunnyvale, Calif., semiconductor maker slid into them in 1970, those doldrums have at times been deep. In that year, the company suffered a net income loss from the previous year of more than \$8 million; the following year it was \$6 million, and in 1974 the loss approached \$4 million. Employee count dropped in the last six months of 1974 to 5,500 from 12,000.

But the picture is changing. Signetics president Charles Harwood predicts that 1976 will see a gross of \$120 million, up from 1975's \$80 million and equal to 1974's total. Part of the reason is the Philips connection, which cost Signetics 5.5 million shares of its stock at \$8 a share but, says Harwood, "certainly has helped us in the last year" technologically. He believes the effects of the association with Philips will really be showing by 1977 "and from then on." In return, Philips gains Signetics' bipolar and MOS expertise plus an American base from which to expand worldwide markets.

But still, Signetics' main strength—and the basis for its strong sales outlook for 1976—lies in its line of standard transistor-transistor-logic products. James Reilly, who was Signetics' president until 1970,



Overseas help. Signetics president Harwood calls Philips deal a big help.

predicts, "In the short term, [the company] will stay in the mainstream of business" with TTL, which he says constitutes half its business. The market for TTL will be \$800 million in 1980. Jon Gruber, investment analyst at the San Francisco brokerage house of Robertson, Coleman, Siebel, and Weisel, notes that "Signetics is doing better because commodity products, especially TTL, are harder to get."

Cycling. Harwood admits that the company has relied on standard products for its strength and has not been the technological innovator it could be. But he plans to change that image. Now, he says, a third cycle is starting: "We've gone from a proprietary position to industry standard back to proprietary." By

"proprietary," Harwood means new technologies developed in house—and he predicts Signetics will be 80% proprietary within the next few years, compared to 20% now. For instance, the company is building I^2L circuits using multi-level logic (see p. 31).

The transition from follower to leader will be lengthy and will require a product mix far different from Signetics' present one: TTL first, and analog and bipolar memory products following. The other markets Harwood is aiming at include MOS, microprocessors, bipolar system logic, and integrated injection logic, and to reach these, "different things have to be done," admits Jack Halter, director of marketing. First, he says, the company must "increase its applications support, particularly in the microprocessor area."

Bipolar push. The thrust will be in bipolar LSI products, using I^2L , a technology that Signetics helped pioneer. In fact, one industry insider believes the company will produce more new proprietary products in the next year than in its entire history, most of them I^2L . The company also plans to become a major supplier of I^2L watch modules and circuits.

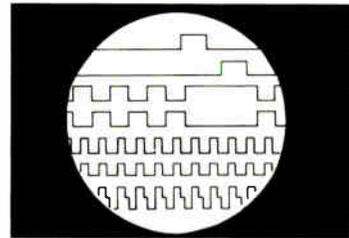
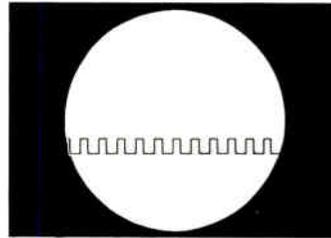
One of Signetics' first steps into more proprietary products on the MOS side was the introduction of its 2650 microprocessor, designed to compete with Intel's 8080. Although Harwood acknowledges that "our microprocessor effort last year was small," he predicts that over the next five years, "a larger proportion of our business will be in MOS and microprocessors." With the addition of n- and p-channel silicon-gate MOS, Schottky emitter-coupled phase-locked loops, and timing circuits, Harwood expects the company to place fifth or sixth in IC sales.

Signetics is in a strong position to build, unlike the down year of 1974 when distributors cashed in on escape clauses and sent back \$40 million worth of inventory. The company has "substantially reduced" that stock, says Harwood. As further evidence that it is coming on strong, he points to a 40% increase in shipments during the first half of 1976. □

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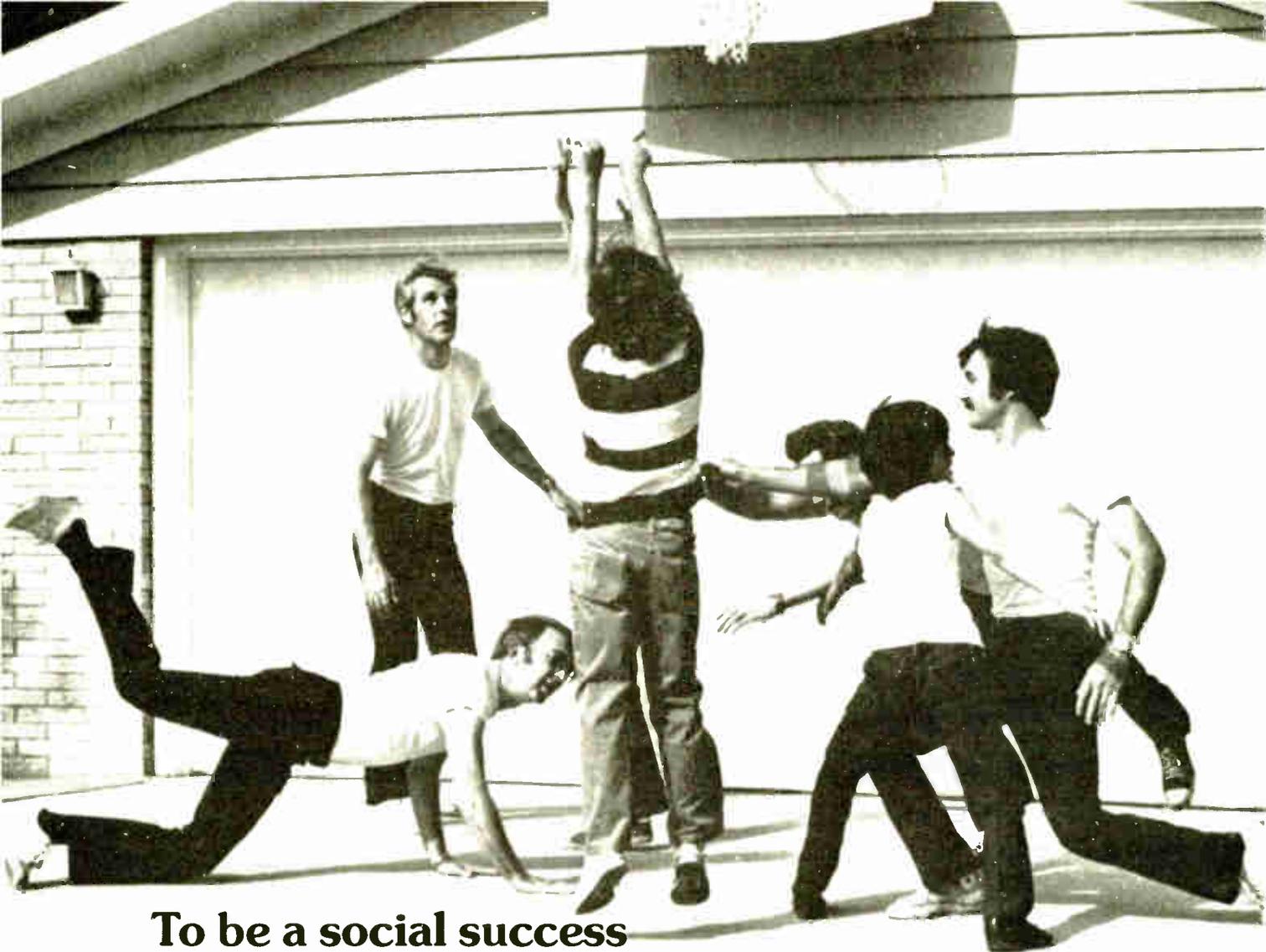
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World Radio History

Enterprise to keep assemblies with counterfeit devices . . .

The six electric-load controllers in Rockwell International's space shuttle, the Enterprise, **won't have to be replaced.** That's NASA's decision, even though Rockwell has discovered that the units may contain as many as 673 transistors misrepresented as JANTX 2N2222A from Transitron Electronic Corp.

The \$150,000 assemblies "check out fine" in tests, says NASA's Office of Space Flight, despite the fact that some of the transistors were 2222A devices from International Telephone and Telegraph Corp. and Tele-dyne Inc. inside the Transitron can. None of the device makers is suspect in what NASA's James J. Cummings, chief of inspections and security, says may be "fraud against the Government." An investigation is continuing.

Rockwell's Autonetics operation, which supplied the six power-controller assemblies for the Enterprise, says it has pulled the suspect batch of transistors from its inventory. Tests on the lot show, Rockwell says, "**a failure rate of less than 0.2%**"—within specifications—and no field failures. Moreover, Rockwell points out that the assemblies have triple redundancy built in, are intended for use only in Enterprise approach and landing tests, and were never planned for use in orbital flights.

. . . that Rockwell, NASA say came from N.Y. distributor

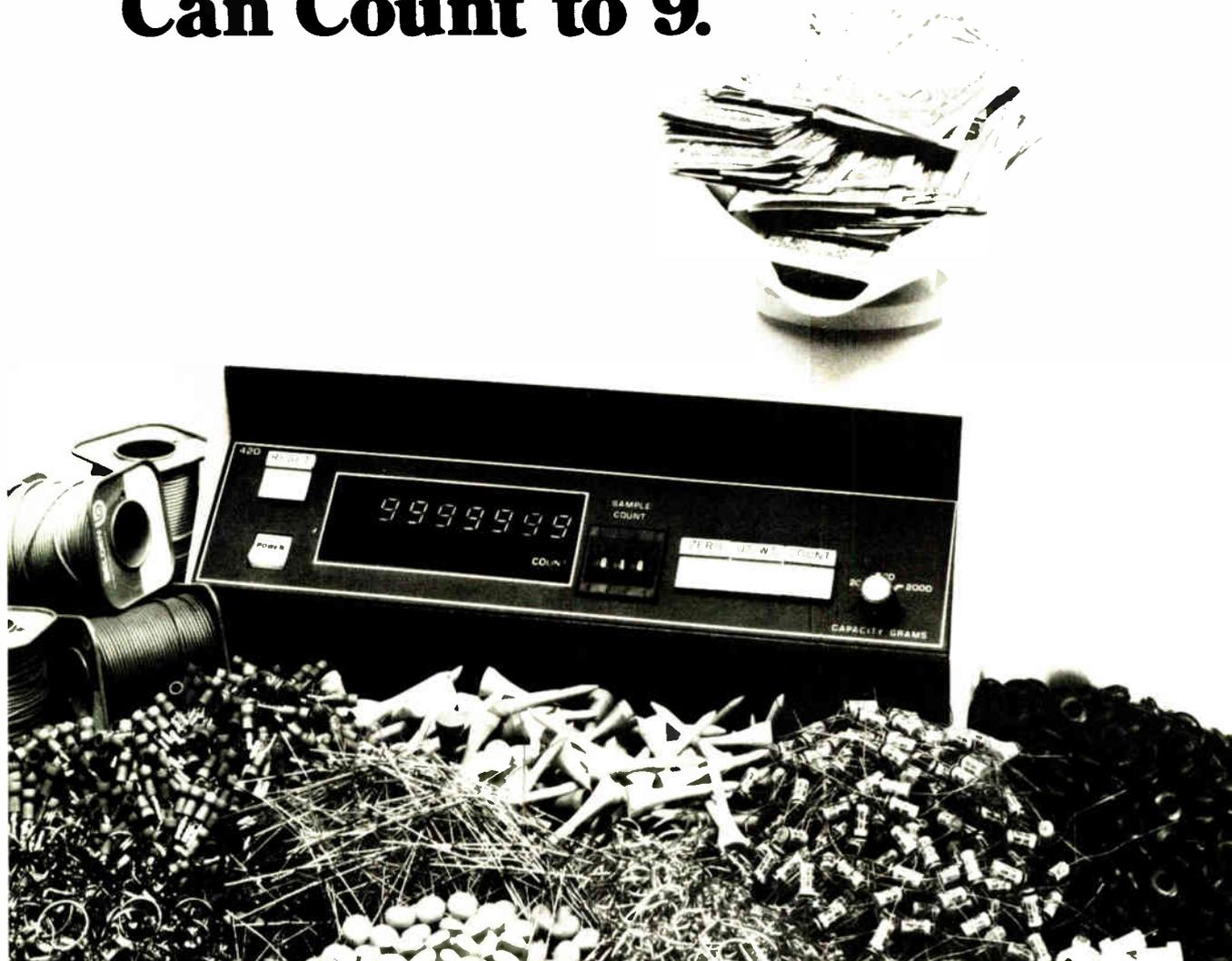
The counterfeit transistors turned up in a lot of 14,000 acquired in 1974 by Rockwell's Autonetics operation, supplier of the Enterprise load controllers, **from Time Electronics, a Hauppauge, N.Y., distributor** owned by Avnet Inc., explain NASA and Rockwell spokesmen. They say Time, which is not a franchised Transitron distributor, told Rockwell that it acquired the Transitron transistors from another source. Time has named those sources but won't identify them publicly.

EIA uncovers seven cases in 53-firm survey

The Electronic Industries Association has turned up seven cases of semiconductor counterfeiting—all involving discrete devices—in a survey of 20 producers and 33 device users. In five cases another maker's name had been put on the device, while three cases showed a commercial product from the same maker had been upgraded by marking with a JAN or JANTX mil-spec part number. In four cases, the part was procured through a single distributor.

EIA's new Semiconductor Counterfeiting Task Group, coordinated by staff vice president and engineering director Allen M. Wilson, held its first meeting at the end of September. Eleven companies representing both producers and users attended, as did five distributors, the National Electronic Distributors Association, and the Defense Electronic Supply Center's Col. Floyd E. Heinzig. The group doubted that industry could mount any coordinated effort against the problem. However, individual users and military buyers like Rockwell International lean toward **buying semiconductors only from manufacturers or franchised distributors.** **The EIA group is trying to develop consensus recommendations for government to cope with the problem.**

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Matsushita's ceramic filter handles video i-f in color-television sets

With the development of a multi-mode bulk ceramic filter for video intermediate-frequency amplifiers, video i-f filter design should catch up with such color-television advances as integrated circuits and in-line picture tubes. Although the inductance-capacitance filter now used requires a large handful of parts, the single IC will provide adequate gain. And it comes along just in time, too, because, with the advent of in-line picture tubes, the video i-f filter has the greatest concentration of adjustments in the TV set.

The Matsushita Electric Industrial Co. Materials Research Laboratory developed a ceramic with the desired characteristics, and its Wireless Research Laboratory developed the filter. The ceramic, made of lead zirconate, lead titanate, and lead magnesium niobate, has a high Poisson ratio, which aids in eliminating spurious response, and a high coupling coefficient that makes possible the required bandwidth of about 5% with negligible ripple in the passband. The new material is also suitable for fabrication into the 40-micrometer-thick sheets for operation at about 60 megahertz in Japanese color-TV sets.

Similar technology is also being used to make filters with a bandwidth of about 1 MHz at the 27-MHz citizens' band frequency. Using this filter between two low-level stages of the transmitter greatly attenuates out-of-band spurious signals generated by the frequency synthesizer.

IC processing. Many filters are formed on a single sheet of ceramic by deposition of chrome-gold electrodes through a metal mask. The wafer is then scribed and broken into individual chips. Each filter's active portion is 1 millimeter square by 40 micrometers thick. Two parallel electrodes on one side of the chip overlay a perpendicular electrode on other side. The thickness vibration,

or symmetrical mode, of the ceramic sets the upper frequency pole of the filter, while the symmetrical-mode vibration sets the lower pole. Bandwidth is primarily determined by ceramic characteristics.

In operation, a small inductance between the common electrode and ground decreases the frequency of the low-frequency pole, thereby increasing filter bandwidth, and also permitting adjustment of the low-frequency pole. Required inductance is inconveniently small, though, and

a capacitor is connected in series with the inductor to permit a practical value of inductance to be used.

Both one- and two-section ceramic filters have been used. A single-section filter does not sufficiently attenuate adjacent-channel audio and video signals, and piezomotor traps—narrow-bandwidth ceramic filters—are used for additional attenuation at these frequencies. A third piezomotor in series with a resistor produces the shelf for the same-channel sound carrier. □

Around the world

Process puts MOS or bipolar circuits on CCD chip

A single process may be used to integrate either metal-oxide-semiconductor or bipolar driving circuits on the same chips with charge-coupled devices. At the recent Third International Conference on the Technology and Applications of Charge-Coupled Devices at the University of Edinburgh, Scotland, the Plessey Co.'s narrow-gap shadow-etch process was advocated for both types of circuits.

The performance of the popular 741 operational amplifier was matched by a CCD chip containing an n-channel MOS amplifier built by researchers at the university's Department of Electrical Engineering. However, the chip's gain is limited to 100, and it must be used at frequencies below 10 megahertz because of MOS-technology limitations. But for frequencies between 5 and 25 MHz, bipolar circuits were advocated by designers at Plessey's Allen Clark Research Centre. For the MOS circuits, the shadow-etch process effectively adds one layer of aluminum in two depositions. However, to get the bipolar circuits, photoengraving and ion-implantation stages are added.

For high-gain and large-bandwidth amplifiers, bipolar drivers are better than MOS, the researchers say.

Digital thermometer gives probe choice

A digital electronic fever thermometer introduced by the West German firm ETW GmbH is one of the smallest and fastest being marketed. Powered by a 5-volt rechargeable battery, the Digimed H01 thermometer set will be sold in Germany, the U. S., and elsewhere for about \$250, including a battery charger and a number of probes. The Digimed H01 weighs only 300 grams.

It comes with three types of probes—a "throwaway" version intended for use primarily in hospitals and infirmaries, a standard type, and one for taking the temperature of the skin surface. The probes are attached to the thermometer by a plug-in cable so that many temperatures can be taken quickly in a hospital ward. The throwaway type is priced at about \$2.50, but the price is expected to drop to less than \$1.

A temperature reading, accurate within 0.1°C, is registered in only 2 to 3 seconds, thanks to the tiny negative-temperature-coefficient sensor made by Siemens AG. This disk-shaped sensor is mounted at the tip of the thin probe.

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A new name in keyboards. CORTRON actually has a history dating back to 1968, when Illinois Tool Works Inc. made news with the introduction of its first solid state keyboard through its Licon Division. ITW has emerged as a major producer of solid state keyboard products and has supplied thousands upon thousands of custom-designed keyboards to meet specific customer requirements.

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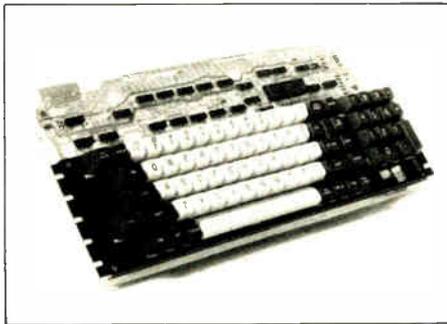
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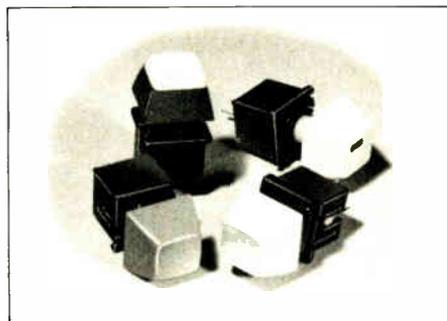
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CORTRON is writing the solid state keyboard success story.

TO BE CONTINUED . . .



CORTRON

THE KEYBOARD
PROFESSIONALS

Bankruptcy sought by Japan's leading calculator exporter

Systek Corp., which had led all Japanese manufacturers in calculator exports and was second only to Casio Computer Co. in production, has applied for bankruptcy under the Stock Company Reorganization and Rehabilitation Act. Systek's debts are estimated at about \$40 million, a new record for failing calculator companies. **The failure is blamed on increased competition in low-price calculators from Taiwan and Hong Kong and the surplus of calculators in principal markets**, which led to a decrease in new orders, cancellation of orders, and a pile-up of components in Systek's plants. The company also had large stock of components for television games.

Systek, which was started in November 1968, last year had sales in excess of \$100 million, and at its peak monthly production was more than 1.1 million units, mostly for export. The rapid downturn came in August. In September, both components manufacturer Kyoto Ceramic Co. and Tokai Bank Ltd. agreed to help Systek. However, they pulled out on Oct. 12 after examining the company's books.

British firm bags \$57 million pact for F-16 displays

Marconi-Elliott Avionic Systems Ltd. of the UK will supply the heads-up display/weapons-aiming system for the U.S. Air Force's F-16 fighter under a \$57 million contract with prime contractor General Dynamics Corp. The pact covers 650 F-16s for the U.S. and 348 for four NATO countries—Belgium, Denmark, Norway, and the Netherlands—in the so-called arms deal of the century.

Each system includes a pilot's display unit, a digital-electronics unit, and a rate-sensor unit. The latter two products for 430 heads-up displays will be made by Norway's Kongsberg-Vapenfabrik in a \$17.5 million deal with Marconi, which also will negotiate with a second European firm for the pilot's display unit. Marconi's U.S. subsidiary, E-A Industrial Corp., Atlanta, Ga., will make several full systems.

CCD circuit wipes out video 'ghosts'

"Ghosts" on television screens caused by multipath echoes will be eliminated if Philips' research laboratories in Eindhoven, the Netherlands, has its way. The remedy is a recursive filter that is based on a p-channel charge-coupled device. But Philips says a commercial product will be delayed about a year.

The circuit, which provides automatic gain and polarity control, **adds a synthetically generated ghost signal to the incoming real one to wipe out the interference caused by signal delay of 0.6 to 8.5 microseconds** over the full 5-megahertz PAL video bandwidth. Besides the four-phase, buried-channel, 128-bit CCD, the circuit will have off-chip video drivers and one chip for the timing, comparator, up-down counter and digital-to-analog circuits.

Gold use halved by plating process from German firm

West Germany's Glaswerk Schott has developed a pure gold-plating process that uses 50% less gold than conventional gold-plating methods. Applicable to electronic components, even those of complex shapes, the technique makes gold layers only 0.5 to 0.8 micrometer thick, about half that of gold layers made by other plating processes. **The proprietary technique provides smooth, poreless, pure gold layers that are well suited for further processing steps** such as resistance welding, alloying, and bonding, the company says.

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翻訳

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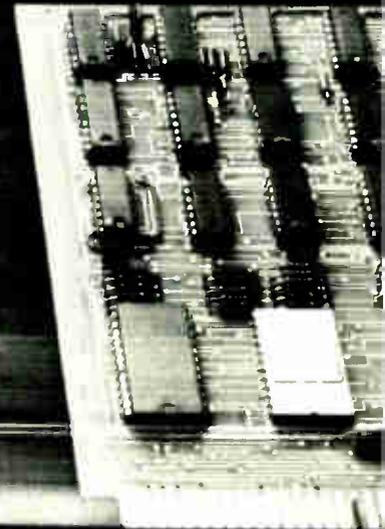
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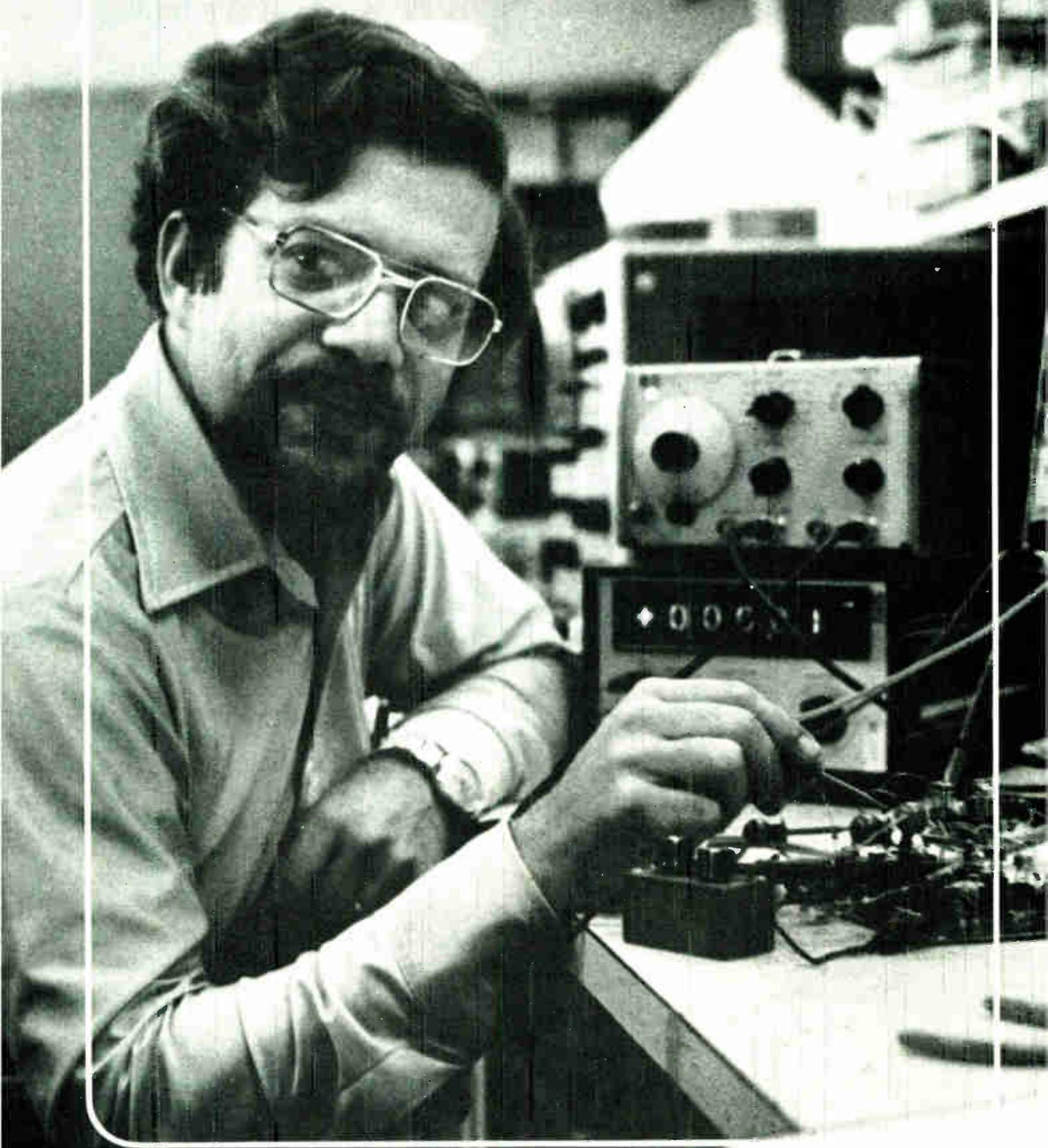
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1970 Demand for Achievement



National's Dobkin cited for his linear wizardry

In a world increasingly dominated by microprocessors and other digital large-scale-integrated circuits, it takes an exceptionally creative designer to make waves in the less glamorous linear domain. Yet, over the past ten years, just such waves have come from Robert C. Dobkin, a self-taught 33-year-old engineer and circuit designer who dropped out of the Massachusetts Institute of Technology because he was bored.

He is now director of advanced-linear-product design at National Semiconductor Corp. in Santa Clara, Calif. His 20 patents and patent applications cover circuits and processes fundamental to monolithic linear-circuit design, as well as such diverse areas as transistor-transistor-logic circuits, digital-watch testing, pressure- and temperature-transducer design, and vertical-channel field-effect-transistor fabrication. In concert with his predecessor at National, Robert Widlar, he is responsible for the design of some of the industry's first operational amplifiers and linear circuits incorporating band-gap-referencing techniques.

Dobkin, who has the look of a slight-

ly mellow revolutionary, is of the generation of design engineers who grew up with semiconductor technology. Its intricacies and idiosyncracies have become almost second nature to him. "Bob is more than just a clever linear-circuit designer," says Widlar, now a consultant to National. "He's a damn smart one with an asset a lot of designers lack—a detailed knowledge of the terrain he's working: the silicon."

This knowledge comes quite naturally, for "I've been playing around with electronics since I was six or eight years old," Dobkin says. But after he got his hands on one of his first semiconductor devices in his early teens ("a germanium pnp transistor: the CK722, I think"), he would have nothing more to do with vacuum tubes.

It was not simply a hobbyist's interest in what could be built with these components. It was a fascination with the devices themselves—how they did what they did and how far they could be pushed beyond the capabilities listed on data sheets. "There seemed something almost magical about those chunks of material," he says. "It just amazed the hell out of me that they could do what they did. Of course there was no magic at all after I pushed and poked at them enough."

But his approach to a problem is more than just a push and a poke, according to National's converter-products manager, Brent Welling. "Bob has an almost uncanny capacity to absorb information quickly, digest it, and come up with the essentials needed to solve a particular problem. If he can't get the information he needs from tests on the work table, he'll read everything he can get his hands on. If that's not enough, he'll corner anyone he thinks has information he needs. Then he'll go back to pushing and poking at the problem until he has an answer—the answer."

While this ag-

The 1976 Achievement Award

For significant contributions to linear-circuit development, the editors of *Electronics* have voted Robert C. Dobkin, head of advanced linear design at National Semiconductor Corp., the recipient of the magazine's 1976 Achievement Award. At National, he has guided a small group of designers to an impressive string of successful linear-product designs that encompass both circuit and process innovations. Their achievements include the LM120, the industry's first three-terminal voltage regulator; the LM123, the industry's first high-current-output three-terminal regulator; the LM117, the industry's first adjustable three-terminal regulator, and the LM195, the industry's first integrated-circuit power-transistor amplifier. Previous winners of the award were Gordon E. Moore, Intel Corp., in 1974, and for 1975, Arie Slob and Cornelius Hart of Philips Gloeilampenfabrieken, along with Horst Berger and Siegfried Wiedmann of IBM.

gressively obstinate approach to solving problems is a key element in Dobkin's present success, it was not conducive to an academic career. In fact, his attitude probably contributed to his departure from MIT in 1963 at the end of his sophomore year. "I left because I was bored," he says. "I was climbing the walls. They just expected me to sit there, take notes, and take tests. I need a productive situation to do my best. So I got out."

After a series of technician jobs he landed a job in 1966 at General Electric Co. in Philadelphia, where he was responsible for evaluating and building test equipment for semiconductor components in space applications. It wasn't exactly either a technician's or a designer's job. "It was sort of in between," he recalls, "amorphous enough to be anything I wanted it to be."

About this time there began to appear some of the first linear IC work by, among others, Widlar at Fairchild Semiconductor and later at National. "The feeling I got about the technology—and that I still have—is that it is wide open," Dobkin says. "There are no hard and fast rules, except the laws of physics. And, if you know those well enough, you can find the loophole in any given situation to allow you to do almost anything you want to. It's completely eclectic. Nothing is ruled out as long as it works."

He was especially interested in operational amplifiers. After tearing up several made by a pioneer in the field, Teledyne Philbrick, Dedham, Mass., he called engineers there and began asking a lot of penetrating questions. After several weeks they stopped answering. "I think they thought he was from a competitor," says Robert Pease, who was a Philbrick engineer then and is now a member of Dobkin's design group. But to his last question in late 1967—"can I have a job?"—the firm said yes, and he went to work as a linear-circuit designer.

"But after a year it was clear that the real action in linear design was elsewhere," he says. About the same time as this realization came a job offer from Widlar at National. It was the culmination of two years of irritating phone calls, Widlar says.

"Every now and then I would get these calls from a wild-sounding freak. He was always asking questions. Finally I hired him and told him to go answer his own damned questions."

Starting in 1969, Widlar and Dobkin worked together on a number of linear circuits including the LM111 comparator. They were joint authors of a patent describing the first use of band-gap-referencing techniques in op amps and other linear devices.

Since taking over the advanced-linear-product-development group in 1970, he has kept it "lean and mean," at first working with just one other designer, Carl Nelson. Later he added Peter Lefferts and Pease.



And what has resulted from this small group of designers in the past five years is at least 15 new linear IC families, more than half of which were industry firsts. Many others have become industry standards. At the same time, the small group has kept up a continuous stream of redesigns on older products with ten- to one-hundred-fold improvements in performance. It also has produced process and fabrication improvements that have allowed National to remain the pricing pacesetter in high-volume linear ICs.

"Dobkin is not only one of the most brilliant designers I've worked with, he also has an amazing feel for exactly what the marketplace needs and wants," says his boss, Robert

Swanson, director of linear-circuit operations. "On a number of products he's suggested, my marketing people have told me the volume just didn't justify it. Usually I just take a deep breath and tell him to go ahead. So far, his batting average has been pretty good, and I haven't regretted it."

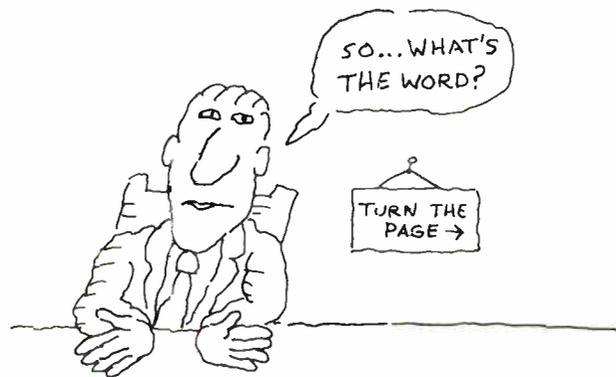
According to Brian Hollins, director of processing for the advanced-linear-products group, Dobkin "has a gut-level understanding for processing and for the limits and capabilities of the silicon," unusually so for a circuit designer. "He'd make a pretty good process guy, if he weren't a circuit designer," he says.

His participation in the various projects ranges from complete engineering responsibility, such as on the LX5600, to working as a coinvestigator as on the zener IC project with Nelson. Just as often his contribution is the right insight at just the right time. "Just when my brain is turning to mush trying to work through a particular problem," Pease says, "Dobkin says something that makes everything crystal-clear."

This ability extends beyond his own group, according to Siegel who says a number of linear hybrid products came from "a few conversations over coffee." Similar conversations with digital-logic designers led to a patent on a Schottky-TTL-clamped circuit using a linear biasing technique—pnp current sources—instead of resistors. On the digital-watch production line, a calibration technique he invented, based on an optical pickup from the light-emitting-diode display, is used to test modules. And an interest in improvements to the power-handling capabilities of field-effect transistors led to a patent on a vertical-channel FET technique.

With his wife Carrie and two dogs, Dobkin makes his home in Hillsborough, Calif., in a slightly run-down, two-story, 9,000-square-foot frame house built in 1884, which the two of them are restoring. From there they embark on their other favorite pastime, collecting antiques. It's more profitable than house restoration, he says. "It's pretty easy once you know more than the experts." □

A word to the wise for those considering microprocessors.



ea



There is one, and only one, easy-to-use microprocessor.

The early μ Ps were bears.

Cute, but cantankerous. And difficult to work with. All kinds of special interfaces, difficult to debug, their own language, expensive to program, ponderous and not terribly efficient. Strange animals indeed. But they held great promise, so a lot of companies spent a lot of money working around their limitations.

Pity the pioneers.

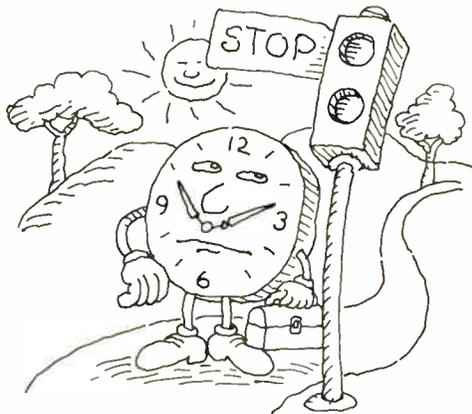
Sad, but true. Many of those early applications just have to work for those who invested in them. Too much development cost. Too much invested in programming. In training. In hardware. In design. In prototypes. Incredible.

The early birds in microprocessor applications got more than their share of worms. There ought to be an easier way. And there is.



Easy does it.

The 8 bit NMOS 2650 microprocessor uses standard memory, standard TTL logic, is easy to use, easy to operate, easy to learn, easy to program, and easy to de-bug. By design. With fewer chips doing the whole job, its costs are significantly lower. It requires less real estate. And it was designed to require far less memory in its own operations. It's the smart way to get ahead of the competition who beat you into microprocessors. And save a bundle doing it.



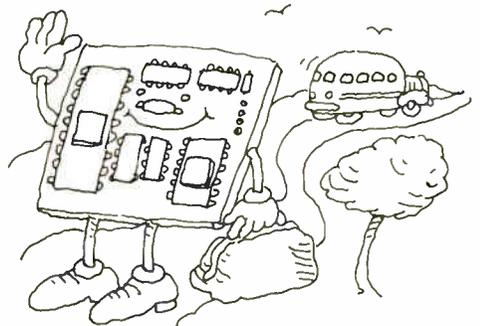
Stop the clock.

Because the 2650 is totally static, you can single step the clock or even turn it off at will. It makes for the easiest debugging in microprocessorland, and it's a single phase TTL clock at that. No two-phase clock required.

The easiest interface.

Where the other microprocessors require custom interface devices (extra circuits, more chips, more board room) for every peripheral and for memory, the 2650 requires interface only to its single 5V

power supply (simple again) and naturally for data bus buffering. In interface requirements, none is best and the 2650 is as close as you can get. All I/O levels are TTL compatible and all outputs are three state.

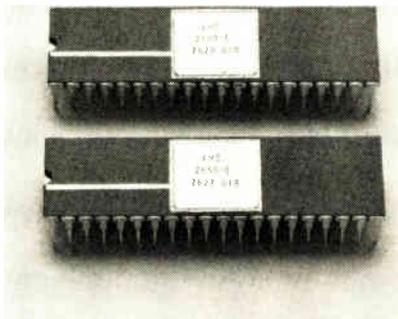


Off the bus.

The 2650 features serial I/O operations separated from the data bus. This means UART type simple functions with no separate chips required. Hook up a teletype direct, for instance.

Easy to program.

With 75 instructions, the 2650 looks very much like the mini-computers you're used to working with. Both the instruction set and architecture are what you've found in working with minis. Seven general purpose registers on chip. Vectored rather than polled interrupt. Much more flexible. Information goes straight in. With variable length instructions, 8 16 and 24 bit instructions do not



Sy.

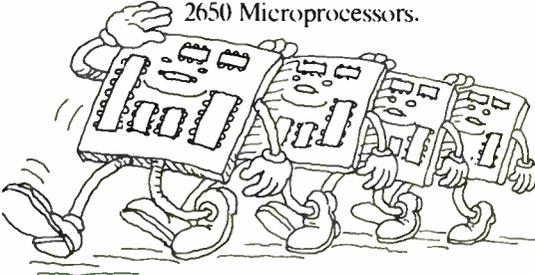
waste program memory. Fewer chips and less RAM requirement; save memory space and save costs. And the 2650 has a wide variety of addressing modes, many of which can be combined for optimum usage.

Easy I/O.

One instruction will switch the general purpose registers which saves register contents without a special store/retrieve routine. Again, you save time, you save memory, you save money. Nothing easier.

More to come.

Between now and January 1977 we'll be introducing in rapid-fire succession a series of LSI I/O devices designed to make use of the 2650 even easier still: the 2651 PCI Programmable Communications Interface; 2652 SDLC Synchronous Data Link Control for IBM line protocol; 2655 PPI Programmable Peripheral Interface; 2656 SMI System Memory Interface; and 2657 DMA Direct Memory Access. Fewer chips, less memory requirement, better use of memory, lower hardware costs, lower programming costs, all easy with 2650 Microprocessors.



Easy to learn.

TED, our dynamite microprocessor trainer, makes it easy. Equipped with hex keyboard, lights and switches, it lets you enter instructions and simulate performance with actual I/O operation. Used with our programmed learning manual, it lets you teach yourself.

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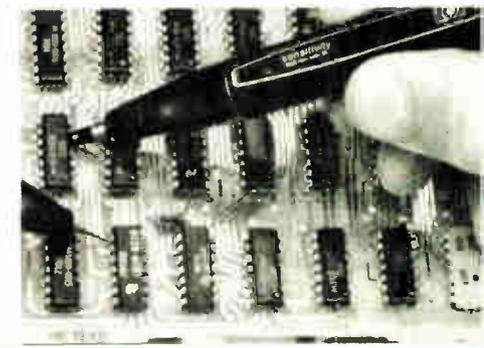
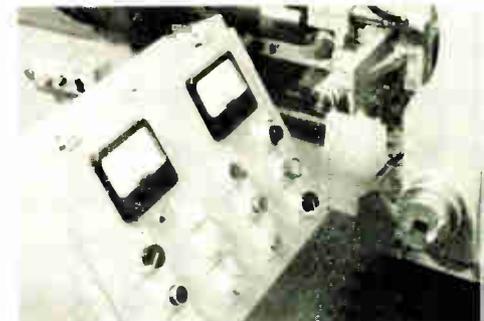
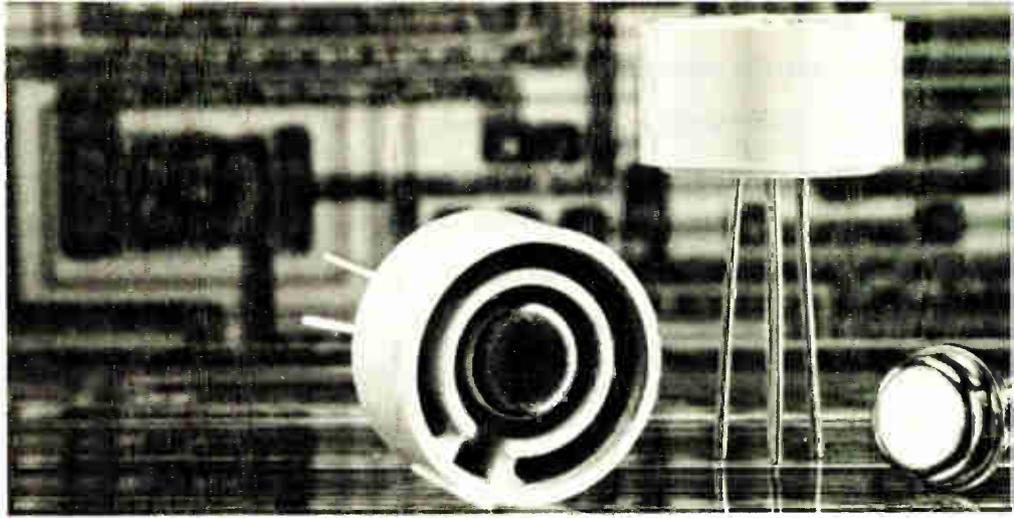
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almost every segment of electronics is benefiting from the dramatic improvements in cost and performance being attained with large-scale integration. Microprocessors are spearheading this dynamic expansion of electronic capabilities, as they find their way into instruments, communications systems, consumer products, computers, and industrial controls.

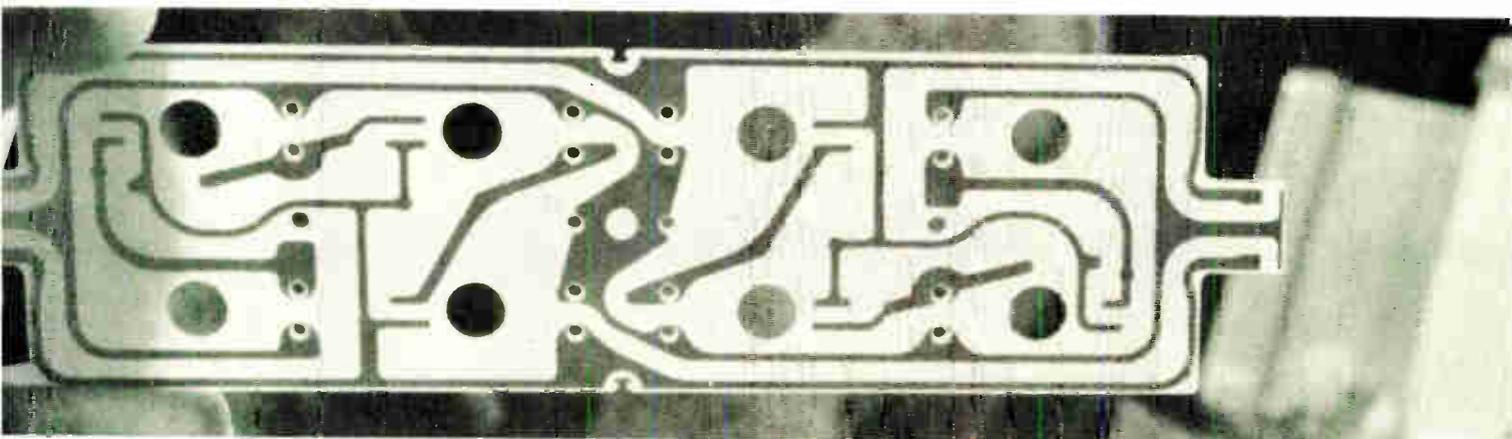
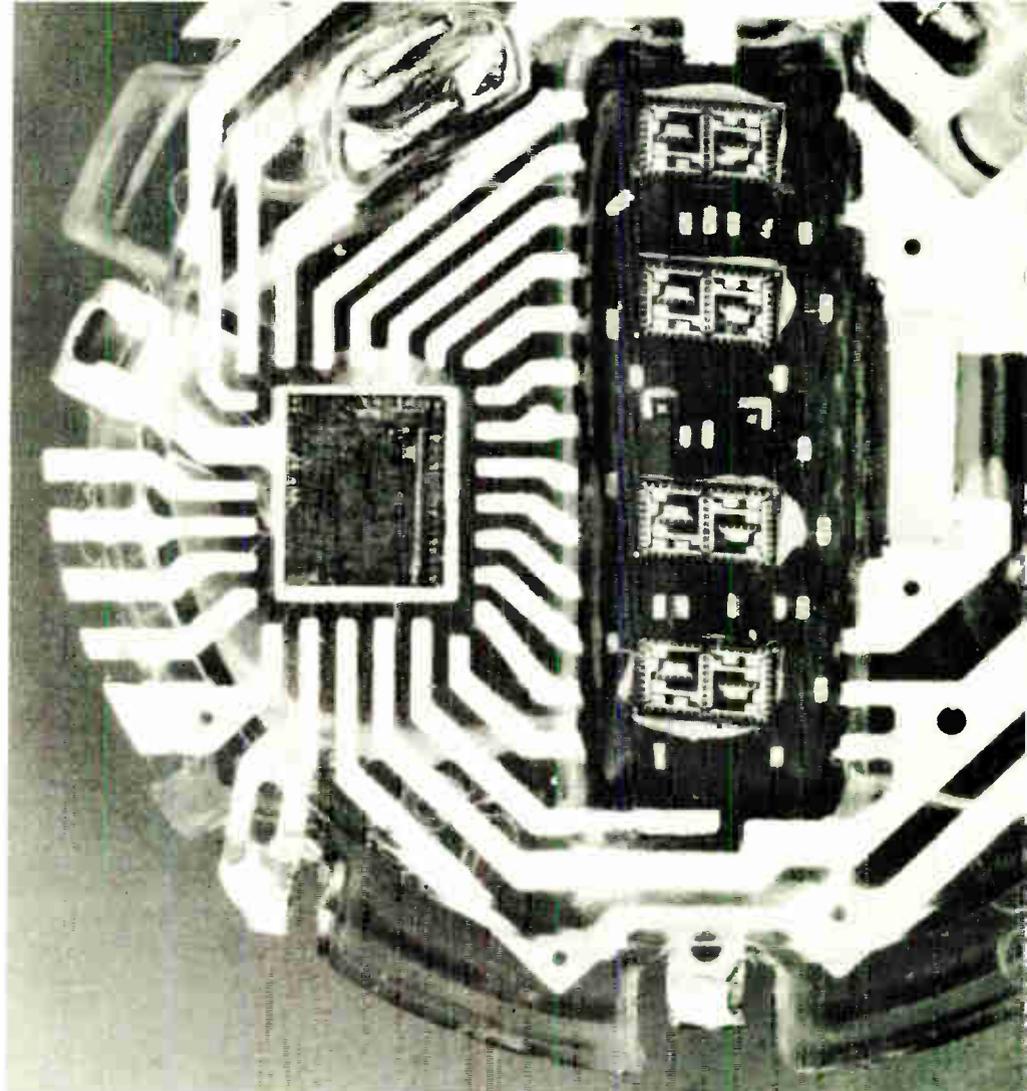
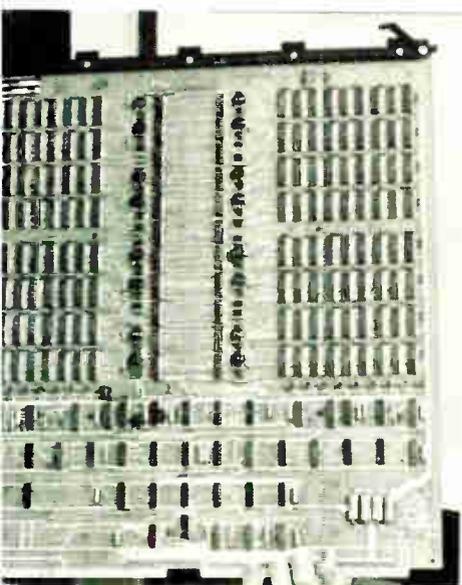
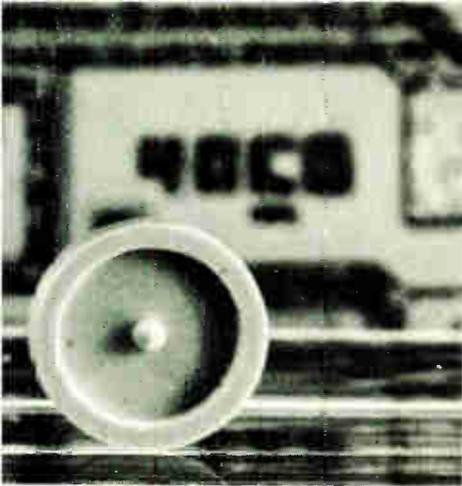
But important as they are, microprocessors aren't the whole story in 1976 technology developments. Memories are experiencing dramatic changes in form, density, and speed as newer processes, materials, and chip organizations are applied. In communications, optical fibers performed nobly in field trials.

Linear technology, too, has kept pace. It has adapted monolithic techniques in devices that rival their older hybrid forms in performance. Improved thick- and thin-film techniques are providing dramatic reductions in the size of high-performance systems.

All in all, it was a normal year for electronics technology in 1976; that is, a decade's worth of progress.

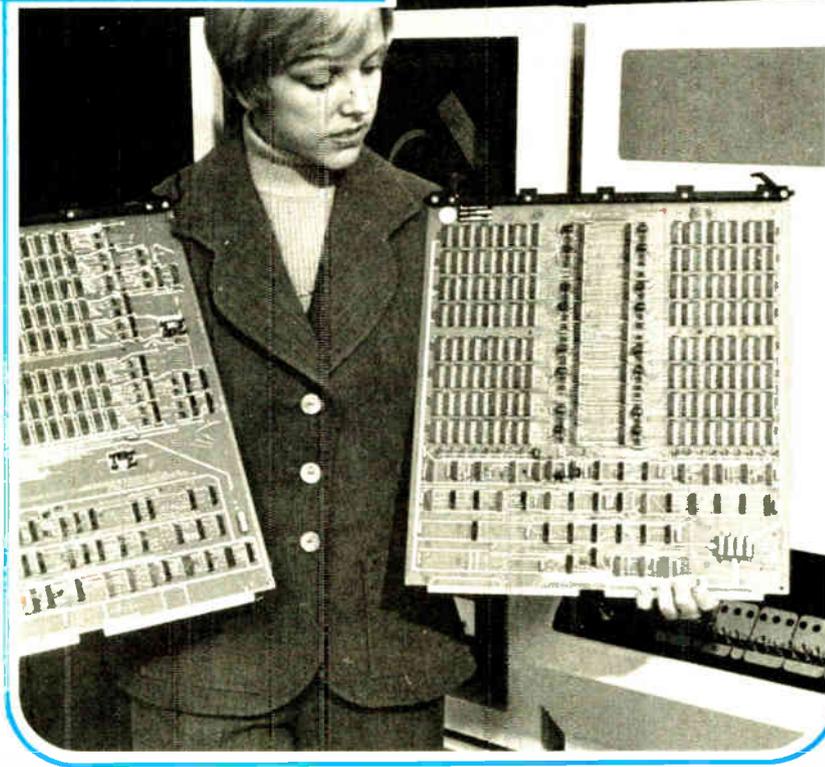


Technology



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Density grows. 16-kilobit RAMs are invading equipment throughout the computer industry. This 256-kilobyte memory board from Prime Computer Inc., which measures only 16 inches by 18 inches, contains 128 packages of RAM, or four times fewer than would be needed if it were fabricated with 4-kilobit chips.

Memory types multiply, microprocessor families grow

by Laurence Altman, *Solid-State Editor*

□ While the last 18 months saw the big push in microprocessor technology, the emphasis is now shifting back to memory and linear-circuit development (see p. 86). Most microprocessor suppliers are now concentrating on filling out their product lines, while memory suppliers are just starting to exploit new technology, such as integrated injection logic, charge-pumped metal-oxide-semiconductor, double-level MOS, charge-coupled-device, silicon-on-sapphire, and nonvolatile storage techniques. For instance:

- I^2L and SOS random-access memories are challenging conventional MOS in two areas—dynamic types in some high-speed mainframe applications, and static types in some peripheral memory jobs.
- Conversely, a new static n-channel MOS technique has been built into a 70-nanosecond 1,024-bit RAM that is now intruding on some buffer and cache memory designs formerly dominated by bipolar technology.
- In the more traditional 4-k and 16-k mainframe, peripheral and microprocessor area, a double-level poly-

silicon cell has produced a much higher level of MOS chip integration that is forcing down the cost of memory usage to less than a 0.1 cent per bit for dynamic memory and to less than 1 cent per bit for static memory.

- Nonvolatile read-only memories that are also electrically alterable have begun moving ahead rapidly with two competing technologies: a nitride-storage MNOS technique and a modified avalanche MOS technique, both of which have led to impressive 8,192-bit devices.
- Finally, charge-coupled devices are now reaching the economically feasible 65,536-bit level, and magnetic-bubble memories are making it finally into production with impressive 92,304-bit chips. Both technologies are ready to attack the bulk storage memory—the last major stronghold of nonsemiconductor memories.

Meanwhile, on the microprocessor front, suppliers are moving in two directions:

- They are adding peripheral chips to their established families to include almost every circuit block needed in most computer designs.

■ They are extending their product lines downward with single-chip controllers and upwards with powerful mini-computer-like-chip sets.

The MOS-bipolar battleground

The changing state of memory technology is illustrated in Table 1, where competing MOS and bipolar devices are shown fighting for the same sockets. Notice that 4-k and 16-k MOS RAMs still dominate in large mainframe systems, where low cost is the prime consideration. They are also still preferred by most system designers in microprocessor dynamic memory applications, where their compatibility with the MOS processor logic is an asset.

But bipolars are gaining in the smaller mainframe applications that need fast access times of under 100 nanoseconds, as in military computers; in auxiliary memory that can provide fast access to subroutines in large mainframe computers, and in minicomputer-controlled high-speed data-processing systems that are being built with bipolar bit-slice techniques. Here, the sudden influx of I²L devices into the mainstream of MOS applications is causing a major rethinking of the traditional wisdom, which favored MOS for low cost and bipolar for high speed.

Leading the way into this new cost-performance middle ground is a RAM with an access time of less than 100 nanoseconds. Built by Fairchild Semiconductor of Mountain View, Calif., the 93481 is the first bipolar dynamic memory. It uses an Isoplanar version of the I²L process, which Fairchild dubs I³L. Not only is it twice as fast as n-MOS 4,096-bit dynamic designs, but it requires a chip less than 14,000 mils square, so that it fits into the

same 0.3-inch-wide dual in-line package that's used in most high-density-board MOS designs.

Texas Instruments Inc.'s 4,096-bit static RAM also uses I²L and also outperforms 4-k MOS static devices. The TI part, of which samples are now available, has a maximum access time of less than 100 ns, half to a third that of any other proposed n-channel 4-k static memory. Moreover, besides being fully static, dissipating only 500 milliwatts, and fitting in a 18-pin package, the S400 is a 5-volt device. This fact makes it a useful high-speed replacement for the widely used 2102 static RAM, as well as a good alternate to the new 4-k MOS static devices.

As for cost, the Dallas company's use of I²L results in an extremely compact chip. Its area of around 20,000 mil² is much than that of MOS 4-k static chips. In the IC business, of course, the smaller the chip, the higher the yields, and the lower the costs, so TI planners see this higher-performing memory as potentially no more expensive than MOS 4-k static devices.

MOS fights back

MOS memory designers, while conceding ground in mainframe and peripheral applications, are themselves making inroads in bipolar-dominated buffer and cache applications. Here, new MOS static designs now offer bipolar performance: access times of under 100 ns (without refresh clocking), and full TTL input/output compatibility. At last designers of buffer systems have a choice: they can use bipolar RAMs in the parts of a system calling for all-out speed, like 25- to 50-ns scratch-pads, and either bipolar or the new compatible MOS statics for the 50- to 100-ns systems.

Heading up the new fast statics is the 2115-2 from

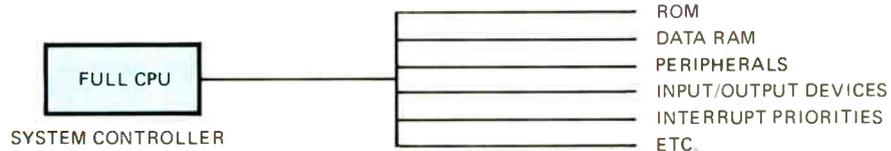
TABLE 1: COMPARISON OF READ/WRITE MEMORY DEVICES

Application	Device types	Access time (ns)	Active power dissipation per chip	1977 cost per bit (cents)
Large mainframe	4 k n-MOS dynamic	150 - 350	450	0.15
	16 k n-MOS dynamic	200 - 350	500 - 700	0.08
Small mainframe microprocessor-based	4-k to 16 k n-MOS dynamic	150 - 350	450 - 700	0.15
	4-k I ² L dynamic	90	500	0.25
	4-k I ² L static	70 - 100	500	0.25
	4-k n-MOS static	150 - 550	350 - 500	0.20
	1-k SOS/C MOS static (5 V)	150	4	1.5
	1-k TTL static	40 - 100	600 - 800	1.5
Buffer, cache, etc.	1-k n MOS fast static	70	600 - 800	1.0
	4 k I ² L static	75 - 100	400	0.25
	1-k n-MOS static	150 - 500	300	0.3
Peripheral	4-k n MOS static	150 - 550	350 - 500	0.2
	4-k I ² L static	90	500	0.25
	4-k n-MOS dynamic	150 - 350	450	0.15
	16-k n-MOS dynamic	200 - 350	500 - 750	0.08
	CCD memory	100 μs		0.03
Small storage (1 - 5 Mb)	disk	100 ms		0.01
	bubbles	10,000		0.02
Large storage (5 Mb)	disk	10,000		0.01

TABLE 2: AVAILABLE MICROPROCESSOR TYPES

(a) - GENERAL PURPOSE TYPES

- 8080
- 6800
- PPS-8
- Z-80
- 9900
- 2650
- 6502
- 1802
- PACE
- PPS-4
- 4040
- etc.



(b) - DEDICATED TYPES

- F-8
- 9002
- Scamp
- PPS-8/2
- PPS-4/2
- etc.



(c) - CONTROLLER TYPES

- 8048 - Intel
- 3860 - Fairchild
- 5799 - National
- PPS-4 - Rockwell
- etc.



(d) - CALCULATOR TYPES

- TMS 1000 - TI
- Rockwell
- National

SETS OF 1, 2, or 3 CHIPS

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Intel Corp. of Santa Clara, Calif., which has a maximum access time of 70 ns. The chip is a single 5-volt 18-pin part that is fully decoded, and it comes in either an open-collector or a three-state-output version. It can also drive TTL packages directly, without buffers, at TTL voltage levels. These virtues for the first time allow MOS RAMs to plug directly into bipolar RAM sockets. That's important, since enhanced static MOS RAMs will probably drop steadily in price like other MOS memories.

Manufacturers are also going for increased density in static 5-v parts, as new 4-k designs enter production. These big statics, which operate in the 150-500-ns range, are intended as high-density replacements for the popular 1,024-bit 2102 RAM as well or serve as an alternate to dynamic 4-k RAMs in microprocessor designs. System designers would use the static memories in small-capacity systems, say under 4 kilowords, where their slightly higher cost per bit over dynamic RAMs would be offset by the elimination of clocking circuits needed in dynamic systems.

The first fully static 4-k arrivals come from Advanced Micro Devices with two devices in production. (Intel, Semi, Phoenix, Ariz., and National Semiconductor are at the sampling stage with their devices.) AMD's memories are 4,096-by-1-bit and 1,024-by-4-bit configurations and operate in the 150-to-250-ns speed range. Both parts, the AM9130 and 9140, come in 22-pin packages

and dissipate about 350 milliwatts. Since their specifications almost duplicate those of many 4-k dynamics, the Sunnyvale, Calif., company can promise nearly complete interchangeability.

Further enriching the options in static memories are the silicon-on-sapphire RAMs that are now available from RCA's Solid State division, Somerville, N.J. RCA presently offers four 1,024-bit configurations and is working on a 4-k design as well. Operating in the 90-ns range at 10 volts and 150 ns at 56 v, these static parts can be used in buffer memories as bipolar replacements, in high-speed peripheral systems that require very low power dissipation (the 5-v part dissipates only 4 mw), or in microprocessor-based systems where a small, high-speed static memory can serve as a scratchpad buffer or interrupt store.

Apart from RCA, which continues to make headway in SOS product development, no other commercial supplier is working with the process. Solid-State Scientific Inc. has all but dropped out of commercial SOS, and while Hewlett-Packard Co.'s announced SOS program is for its own computer products. The biggest objection to SOS is the expense of its starting material: sapphire costs almost seven times more than bulk silicon. According to RCA developers, however, silicon-on-sapphire processing is actually easier, more forgiving, and produces higher yields than bulk silicon processing and thus compensates

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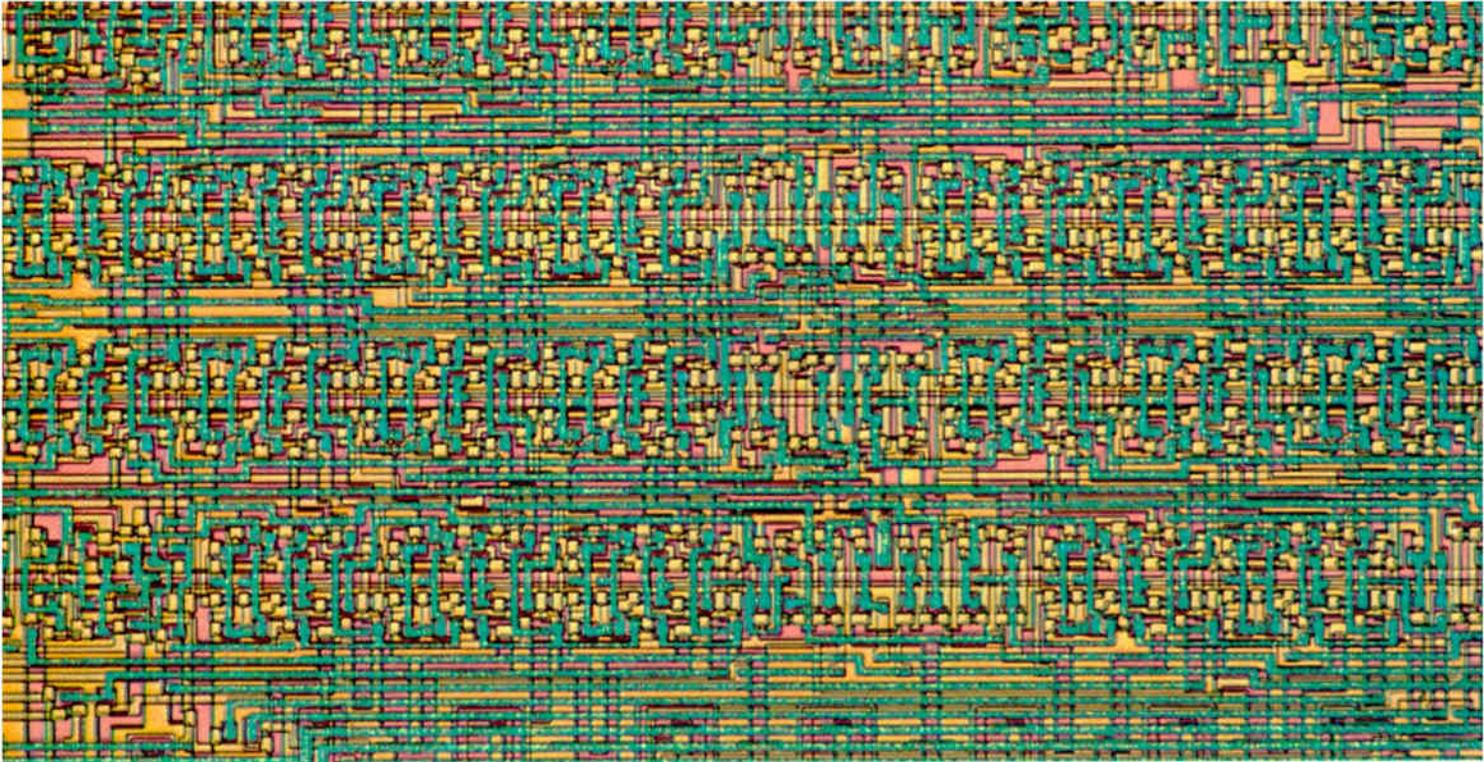
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for the higher initial starting costs experienced.

A surge of activity is occurring in electrically alterable memories. Because they are also nonvolatile and retain their data when the power is off, they are in great demand for many television, calculator, and microprocessor-based applications. Examples are point-of-sale systems and telecommunications terminals.

Only three memory suppliers in the world offer electrically alterable ROMs: General Instruments Corp., Hicksville, N.Y., McDonnell Douglas Corp.'s Nitron division, Cupertino, Calif., and Japan's Nippon Electric Co., which also plans to market its devices in this country. Recently GI and NEC developed 8,192-bit electrically alterable ROMs, a level of complexity that is extremely useful from many applications. GI uses a standard nitride or MNOS technique, and NEC uses a modified avalanche MOS process.

Freedom to change

Electrically alterable memories, of course, allow a system's capabilities to be continuously updated simply by applying voltages to the package pins. The only other field-alterable ROMs are Intel-developed ultraviolet-erasable ROMs. But while extremely popular, they are used primarily in prototyping since to erase them the user must remove them from the circuit.

GI's alterable ROMs, including its new ER 2800 8,192-bit part, have performance typical of today's MNOS technology: fairly slow read times of 2 microseconds at about 15 v (standard p-channel MOS levels) and quite slow write and erase times, in the tens of milliseconds, at 28 v. Because of their slowness, the new devices will not be made extensively for large ROM programs in fast microprocessor or computer systems. Nor will they impinge heavily on the major RAM markets, where 200–300 ns and very low cost are needed. But faster versions are on the way—GI will soon begin distributing samples of a 4-k device that has a read time of 650 ns.

In microprocessors, chip suppliers are filling out their established product lines with new and more powerful peripheral chips, such as data links, memory controllers, and keyboard and CRT chips. They are also broadening their application range with very basic single-chip central processors for low-end control applications and with chip sets containing greater processing power for high-end minicomputer applications.

Pushing the limits in microprocessors

The oldest general-purpose 8-bit families, such as the 8080, 6800, PPS-8, are rapidly being extended with chip versions of large subsystems that formerly required hundreds of TTL packages. At least a dozen such peripheral chips are on their way from Intel. Already available are interface and communication controllers, interval timers, direct-memory-access chips and interrupt controllers. Soon to come are even higher-level subsystems—Intel's 70 series, which includes a synchronous data-link controller as well as controller chips for a floppy disk, cathode-ray tube, and keyboard.

Also busy in the peripheral area is Rockwell International Corp.'s Microelectronics group. It has already equipped its PPS-8 microprocessor family with programmable peripheral and communication controllers on chips, and floppy-disk and synchronous data-link chips are soon to come.

These high-level peripheral chips are impressive achievements, being complete subsystems in themselves that require two to three times the complexity of processor chips. Moreover, they all plug into the main system bus and so are controlled by signals from the central processing unit. And since the CPU treats them as input/output, in effect they are controlled directly by program data residing in RAM. This means that a designer wishing to expand his system with these peripherals need only increase his or her RAM capacity and add the appropriate instructions. No hardware interfacing or

TABLE 3: MICROPROCESSOR CAPABILITY

	TTL equivalent	Most comfortable address capability (kilowords)	Program size	Interrupt capability	Maximum execution time (μs)	Number of packages
General purpose (low volume)	100 and up	4 – 64	30 – 150	5 – 10	4 – 8	10 – 50
Dedicated types	100 and down	2 – 4	50	up to 5	5 – 10	5 – 10
Controller types	50 and down	1 – 2	50 and down	2 or so	5 – 10	below 5
Calculator types custom (high volume)	25	none (with a few exceptions)	25 and down	1 or 2	100 or so	1 or 2
Bit slices	100 – 200 and up	64		5 – 10	5	50 – 100

special program implementations are required.

As for new major CPU entries, Texas Instruments came in with its 9900 chip—a 16-bit n-channel microprocessor that is powerful enough to replace the mini-computer in many real-time control and data processing systems. It joins General Instrument's 1600 and National Semiconductor's PACE families in the 16-bit camp, and some observers expect them to gain at the expense of 8-bit systems over the next few years.

Of course, 8-bit suppliers are fighting back with high-performance units. First to reach production are the Z-80 from Zilog Inc., Los Altos, Calif., which takes the 8080 instruction repertory and expands it to about 158, and RCA's 1802 single-chip version of its COSMAC C-MOS system. Intel itself is planning to augment its 8-bit family with a higher-performance 8085 chip that promises five times greater throughput—and to follow that up with a full 16-bit chip. Motorola Semiconductor, too, is rumored to be developing an 8-bit CPU with ten times the performance of the 6800.

Equally important is the activity on the low end, where chip suppliers are readying single- and two-chip microprocessor families for high-volume low-cost applications. Intel's soon-to-be-announced single-chip 8040 and 8748 each contain CPU, ROM, RAM and I/O, while its 8041/8741 is a stripped-down version intended to serve as a peripheral controller in 8080-based systems. They

will be supplied in a version containing an 8,192-bit ultraviolet-erasable ROM on the chip, a feature that significantly adds to the flexibility of the device. Similarly, Motorola is readying the 6802-single-chip controller for its 6800 family (Motorola is reported to be working with Nitron Corp. on an electrically alterable ROM version), Rockwell has samples out of a two-chip PPS 8/2, and Fairchild is readying a single-chip F-8.

What all this device activity means to the user is shown in Table 2, which distinguishes between four types of microprocessors: general-purpose, dedicated, single-chip controller, and calculator types.

From this, it is clear that, to make the most out of their powerful CPUs, the general-purpose microprocessors are intended for full system expansion, including a large instruction ROM, 32 to 64 bytes of data RAM, and a large number of I/Os and peripherals. On the other hand, the dedicated and single-chip controllers serve the requirements of much smaller systems that can be handled with one, two or three chips.

Table 3 shows the rough capability of each processor type and roughly the number of TTI packages they replace. It can come as a surprise, though, to the new microcomputer designer to realize that a system built around general-purpose microprocessor also requires a good many other TTI packages—maybe 50 excluding memory for, say, a real-time control application. □

Profile

Few other designers can have done as much as Mostek Corp.'s Bob Proebsting to advance the state of circuit design. He conceived of the 16-pin multiplexed 4,096-bit memory circuit that not only put a fledgling Mostek on the map in 1972 but is now copied throughout the industry. He was the first to use dynamic sense amplifiers in RAM designs, a power-saving innovation that's now also being widely copied by his colleagues. He also invented the programmable logic array and pushed the use of depletion-load circuitry in MOS designs—achievements that by their own would cap the career of many engineers.

People who have worked with Proebsting have often been fooled by his mild manner, only to be brought up short by his aggressive, audacious approach to circuit design. Take his radically different 4-k RAM design. "You must remember," says Proebsting, "that when I proposed my approach we were small fish indeed, and going against the tide required a lot of confidence from the people around here. The rest of the industry, the big guys like TI and Intel, were all developing a straightforward 22-pin chip, and here I was talking about a completely different multiplexed circuit, with a totally different pinout. But in this business you've got to have guts and a feeling about your design; so I was able to convince my management to back the project."

Proebsting has acquired 10 major patents in the course of a career that has been as speculative as his designs. After leaving Wisconsin with a Ph.D. in 1967, he went to Texas Instruments, working for L. J. Sevin, now president of Mostek, who was then TI's director of MOS design.

When Sevin left to raise money for a startup company, TI managers appointed Proebsting head of the department, even though he was 32 years old and almost fresh out of school. That might have been enough for other designers. But when Sevin got the money together in June 1969 and founded Mostek, Proebsting didn't hesitate to jump over and start designing circuits for him again.

Why? "I'm a designer," says Proebsting, "and that's what they let me do around here."



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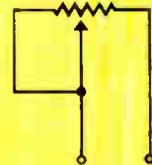
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AVAILABLE CIRCUIT OPTIONS

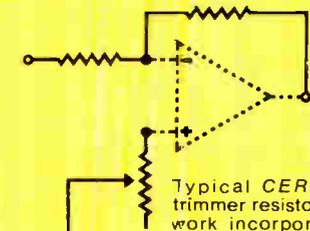
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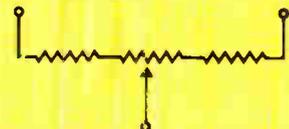
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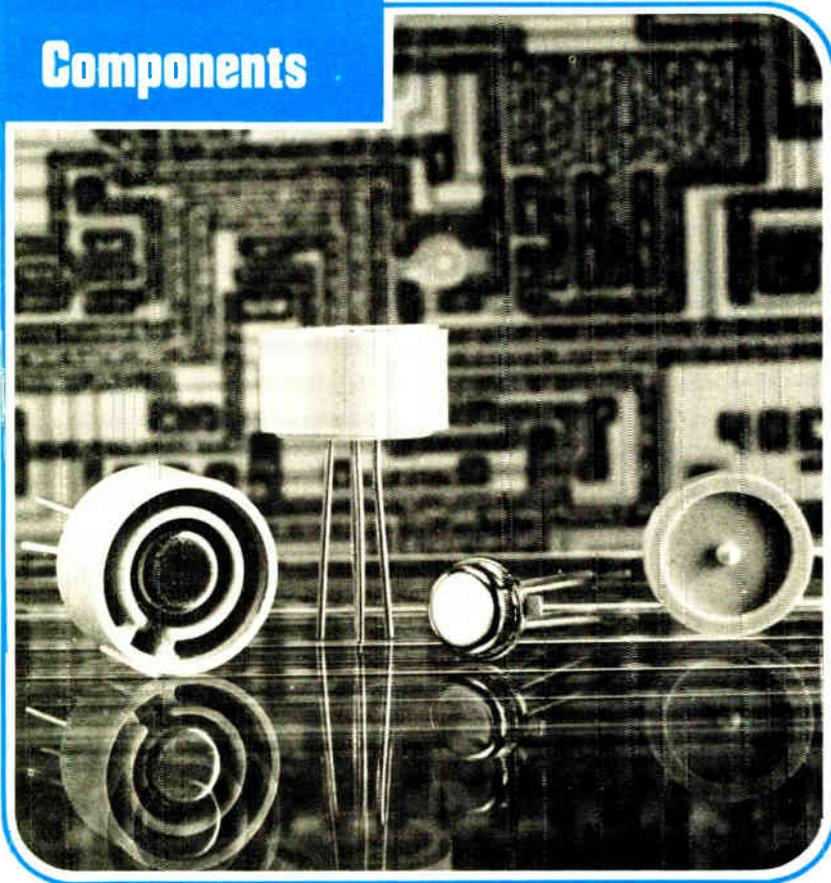
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Linears lead the field. In components, advances in linear-IC technology are outstripping all other areas. The performance of monolithic data converters and mixed-process amplifiers is coming closer to that of hybrids. Special-purpose linears, like temperature transducers and motor controls, are proliferating, as are bipolar linears for power supplies and voltage references. Depicted here is a temperature-stabilized IC zener from National Semiconductor.

Hybrid, monolithic units displacing more discretetes

by Lucinda Mattera, *Components Editor*

□ The latest active and passive components are sparking new markets and stimulating ever more sophisticated equipment design, besides fueling the continuing drive to ever simpler, smaller, and cheaper electronic products. Examples abound.

■ Monolithic data converters and mixed-process amplifiers are performing nearly as well as comparable hybrid units, but at lower costs.

■ A new class of bipolar large-scale-integrated circuits has dramatically simplified power-supply design.

■ Special-purpose linears for sensing and control are replacing a host of discrete components.

■ Vertically integrated field-effect transistors are threatening the pre-eminence of bipolar power transistors.

■ With thick-film hybrid technology, isolation amplifiers are being reduced to miniature components in dual in-line packages.

■ Simplified designs for rotary switches are displacing conventional labor-intensive assemblies.

■ Finally, in passive-component technology, revamped

element designs and computer-controlled laser trimming are creating a new class of potentiometers for semiprecision applications, as packaged resistor networks continue to encroach on the domain of discrete devices.

Accuracy improving for IC converters

The growth of microprocessor-based data systems depends on the availability of low-cost but fast and accurate data converters. Although hybrid devices perform well enough, low enough prices can be achieved only with monolithic analog-to-digital and digital-to-analog converters.

In successive-approximation a-d converters, TRW Systems Group, Redondo Beach, Calif., has developed a 10-bit high-speed high-accuracy bipolar LSI chip. It processes signals at the rate of 5 million samples per second, quantizing them into 10 bits within $\pm 1/4$ least significant bit. Accuracy is also getting better for monolithic integrating a-d converters, which generally end up in instruments. From Analog Devices Inc. of Norwood,

Mass., comes a 13-bit complementary-MOS chip that is self-calibrating—it employs a novel circuit technique called quad slope in which internal gain and offset errors are compensated for automatically.

Improved processing techniques are helping to tighten the accuracy of monolithic d-a converters, too. Motorola Semiconductor Products in Phoenix, Ariz., is using automatic laser trimming at the wafer-prove stage to produce a 10-bit d-a chip that is accurate to within 0.05%. An unusual monolithic d-a converter comes from Precision Monolithics Inc., Santa Clara, Calif.—it's a companding device, principally aimed at telecommunications.

The FET-input fashion in linears

Mixed processing—be it bi-fet or biMOS—is becoming the name of the game in monolithic amplifiers. Mixed-process amplifiers have FET inputs and bipolar outputs—the former for low input bias current with high input impedance and the latter for good linearity. A bi-fet device provides p-channel junction-FETs up front, whereas a biMOS device instead incorporates p-channel MOSFETs up front.

National Semiconductor Corp., Santa Clara, Calif., now offers a bi-fet instrumentation amplifier that holds gain nonlinearity to within 0.02% to 0.05%. The company is also making a bi-fet version of the industry-standard 741-type op amp—its input bias current ranges from only 50 to 200 picoamperes. In addition, National is applying its bi-fet process to other product lines, including analog switches, comparators, and sample-and-hold circuits.

Among the bi-fet products from Texas Instruments, Dallas, are a quad op amp and a line of analog switches. Each amplifier of the quad device has an input bias current of 4 nanoamperes and a unity-gain bandwidth of 3 megahertz. What's more, with its biMOS technology, TI is fabricating a low-cost chopper-stabilized op amp that's priced at only \$14.50 in hundreds.

Another important mixed-process development comes from RCA's Solid State division in Somerville, N.J., which is offering a biMOS op amp that may prove to be as useful as the workhorse 741. It's internally compensated and has input bipolar diodes to guard against damaging electrostatic charges.

In hybrid amplifiers, Burr-Brown Research Corp., Tucson, Ariz., has introduced the first isolation amplifiers to be made as thick-film hybrid circuits. They are a fraction of the size and cost of their modular counterparts. Also, instead of the more usual transformer coupling, a set of linearized optoelectronic semiconductors isolate input and output stages in the new devices. The table shows the varying performance available from monolithic, hybrid, and modular amplifiers.

Switching regulators go monolithic

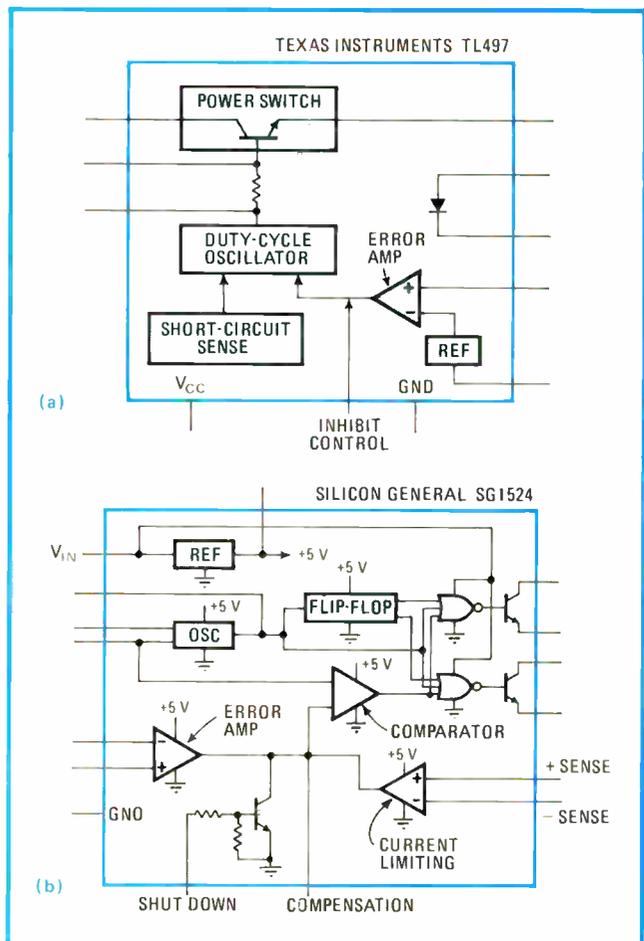
Within only a few years, power linear ICs have become standard components in power supplies, and now there's a new generation of these devices—monolithic switching regulators that replace 20 or more discrete components.

These bipolar LSI chips (see Fig. 1) include a voltage reference, an error amplifier, an oscillator, pulse-width-modulating circuitry, short-circuit protection, and switching transistors.

To obtain the small geometries needed for such a circuit, TI is using ion implantation to fabricate its IC switching regulator, which contains a single output power switch. For push-pull or double-ended operation, both Silicon General of Westminster, Calif., and Plessey Semiconductors of Santa Ana, Calif., have chips that fill the bill.

Conveniently, too, IC voltage regulators are now available in adjustable versions. A National family of 1.5-ampere three-terminal devices has an adjustment range of 1.2 to 37 volts. A Precision Monolithics line of 10-v references has an output that can be varied by $\pm 3\%$ from nominal, while the firm's 5-v models have $\pm 6\%$ adjustability. Both positive- and negative-output adjustable regulators rated at up to 1.5 A can be obtained from Lambda Electronics Corp., Melville, N.Y.

Other types of monolithic regulators are also coming on the market. For example, TI has an adjustable three-



1. For power suppliers. These monolithic switching regulators include all the circuitry needed to control switching-mode power supplies. Texas Instruments has a chip (a) for single-ended operation, while Silicon General offers a device (b) for push-pull control.

PERFORMANCE SURVEY OF COMPONENT AMPLIFIERS

Technology	Type of amplifier		Input offset voltage	Offset voltage drift ($\mu\text{V}/^\circ\text{C}$)	Input bias current	Open-loop gain (V/V) or nonlinearity (%)	Unity-gain bandwidth (Hz)	Output slew rate (V/ μs)	Approximate price (commercial grade)
	Family	Classification							
Monolithic	operational	general-purpose	2 mV typ	15 typ	20 – 50 nA	50 k – 100 k	500 k – 3 M	0.5 – 2	40¢ – 60¢*
		wideband	2 mV typ	15 typ	20 – 200 nA	25 k – 100 k	8 M – 25 M	10 – 150	\$1 – \$7*
		low bias, FET input	2 – 6 mV	5 – 50	10 – 100 pA	50 k – 100 k	1 M – 10 M	3 – 15	\$1 – \$4*
		precision, low offset, low drift	50 μV – 0.5 mV	0.5 – 5	1 – 10 nA	100 k – 1 M	400 k – 1 M	0.1 typ	\$1 – \$4*
		precision, low bias	0.5 – 6 mV	5 – 50	50 pA – 2 nA	100 k typ	500 k – 1 M	0.1 typ	\$1 – \$4*
		chopper-stabilized	50 – 80 μV	0.4 – 0.6	150 pA typ	500 M typ	3 M typ	2.5 typ	\$25* typ
	instrumentation	bipolar input	1 – 5 mV	2 – 20	20 nA typ	0.02% – 0.1%	100 k – 1 M	1 – 5	\$4 – \$15*
		FET input	15 mV typ	10 – 15	20 pA typ	0.02% – 0.1%	100 k – 1 M	1 – 5	\$4 – \$15*
Hybrid	operational	wideband	from 0.5 mV	from 15	from 12 pA	up to 1 M	up to 60 M	up to 1,000	from \$70*
		low bias, FET input	from 0.4 mV	from 25	from 75 fA	up to 50 k	up to 1 M	up to 1	from \$18*
		low offset, low drift	from 8 μV	from 0.1	from 10 pA	up to 10 M	up to 1.5 M	up to 0.6	from \$7*
		high voltage, high current***	from 2 mV	from 25	from 20 pA	up to 100 k	up to 5 M	up to 30	from \$42*
	instrumentation	bipolar input	from 0.2 mV	from 2	from 40 nA	0.03% – 0.1%	up to 2 M	up to 10	from \$12*
		FET input	from 5 mV	from 25	from 10 nA	0.05% – 0.1%	up to 600 k	up to 2	from \$20*
	isolation	all classes****	from 1 mV	from 20	50 pA – 40 nA	0.1% – 0.2%	15 k typ	1 typ	\$40 – \$62**
	Modular	operational	general-purpose, FET input	1 – 5 mV	5 – 25	25 – 100 pA	50 k – 1 M	500 k – 5 M	0.25 – 1,000
general-purpose, chopper			25 – 50 μV	0.1 – 1	300 pA typ	5 M typ	100 typ	0.0001 typ	\$50** typ
general-purpose, electrometer			1 – 5 mV	15 – 50	75 – 350 fA	100 k – 500 k	500 k – 1 M	0.1 – 0.3	\$30** typ
wideband			1 – 3 mV	15 – 50	100 pA – 5 nA	25 k – 100 k	60 M – 120 M	300 – 1,000	\$75 – \$100**
precision, FET input			200 μV – 1 mV	1 – 5	0.1 – 25 pA	50 k – 100 k	500 k – 5 M	0.25 – 1,000	\$40 – \$100**
precision, chopper			10 – 25 μV	0.1 – 1	50 – 150 pA	10 M – 100 M	100 typ	0.2 – 100	\$50 – \$115**
precision, electrometer			1 – 10 mV	10 – 30	10 fA typ	100 k typ	2 k typ	0.0004 typ	\$60** typ
instrumentation		general-purpose	1 – 5 mV	0.5 – 3	10 pA – 5 nA	0.02% – 0.2%	500 k – 1 M	0.1 – 1	\$40 – \$60**
		precision	200 μV – 1 mV	0.2 – 2	10 pA – 5 nA	0.002% – 0.01%	500 k – 1 M	0.5 – 3	\$60 – \$150**
isolation		all classes****	0.5 – 150 mV	from 1	10 pA – 50 nA	0.002% – 1%	1 k – 2.5 k	0.1 typ	\$60 – \$180**

*in quantities of 100 **in quantities of 1 – 9 ***output current up to 7 A pk ac ****CMRR = 110 dB typ *****CMRR = from 60 – 140 dB

terminal shunt regulator that can be used like a temperature-compensated zener diode. Output voltage can be set from 2.75 to 30 v, with output current ranging from 600 microamperes to 100 milliamperes.

Special-purpose linear ICs are beginning to open up many new applications in consumer and industrial electronics. Particularly active in these linears is National, which this year announced a monolithic temperature transducer selling for less than \$1, monolithic tachometer/switches for automotive and industrial applications, and a monolithic ultrasonic sonar system that includes a transmitter, a receiver, and a display driver.

Even motor control has gone monolithic. Micro Components Corp., Cranston, R.I., is offering a dual control that can regulate motor speed to within $\pm 0.1\%$ for consumer products like cassette recorders and movie cameras.

The big news in power semiconductors is vertical FETs. They can provide very high current gains and extremely fast switching speeds and are not susceptible to secondary breakdown, which can lead to thermal runaway in bipolar transistors. Vertical-channel power MOSFETs from Siliconix, Santa Clara, Calif., are capable of switching 1 ampere in only 4 nanoseconds.

New designs and automated production techniques are also upgrading such traditional components as switches, relays, resistors, and capacitors.

Rotary switches have been multiple-deck clip-laden units, assembled by hand from a myriad of tiny parts. But designs are getting simpler. For example, in one approach, Oak Industries' Switch division, Crystal Lake, Ill., is stamping all conducting paths and terminals for a switch from a single piece of metal. Similarly, the new rotaries for citizens' band radio provide 40 or more BCD-encoded positions with only a single deck. Inside the switches, a disk-shaped printed-circuit card containing the conducting paths rotates past stationary wipers that are mounted in the switch housing.

As for passive components, packaged resistor networks are continuing to replace discrete units in applications requiring localized clusters of resistors. More networks are going into single in-line packages these days, but DIPs are still the predominant package form. As in other areas, the use of simplified designs, lower-cost materials, and higher degrees of automation is cutting costs of variable resistors that still deliver on performance.

In potentiometers, for example, the Trimpot Products division of Bourns Inc., Riverside, Calif., now makes a line of single-turn semiprecision units that sell for only \$2 to \$2.50 in quantity. Zero-based linearity is 2% for cermet versions, 3% for conductive-plastic models. To obtain this kind of performance at low cost, Bourns divides the resistive elements into 10 equal segments for fast, accurate, automatic laser trimming. □

Profile

Ivar Wold is one of the new breed of chip designers who are putting not just circuits but entire systems on tiny pieces of silicon. Now with Analog Devices Inc., Norwood, Mass., he's the man behind the firm's monolithic quad-slope analog-to-digital converter. Presently, as director of systems development, he manages a group that is developing microprocessor-related hardware, software, and subsystems.

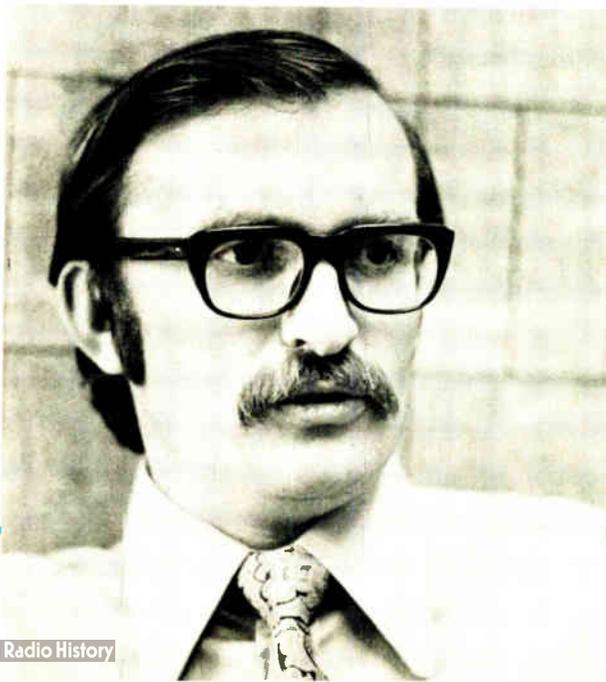
Wold, who joined the Massachusetts company about four and one-half years ago, came to it as an experienced equipment designer. While working in his native Norway, he designed minicomputer-based point-of-sale terminals—the sort used at airports for exchanging currency. Previously in England, he designed dynamic-analysis instrumentation, of the kind that is needed for vector measurement.

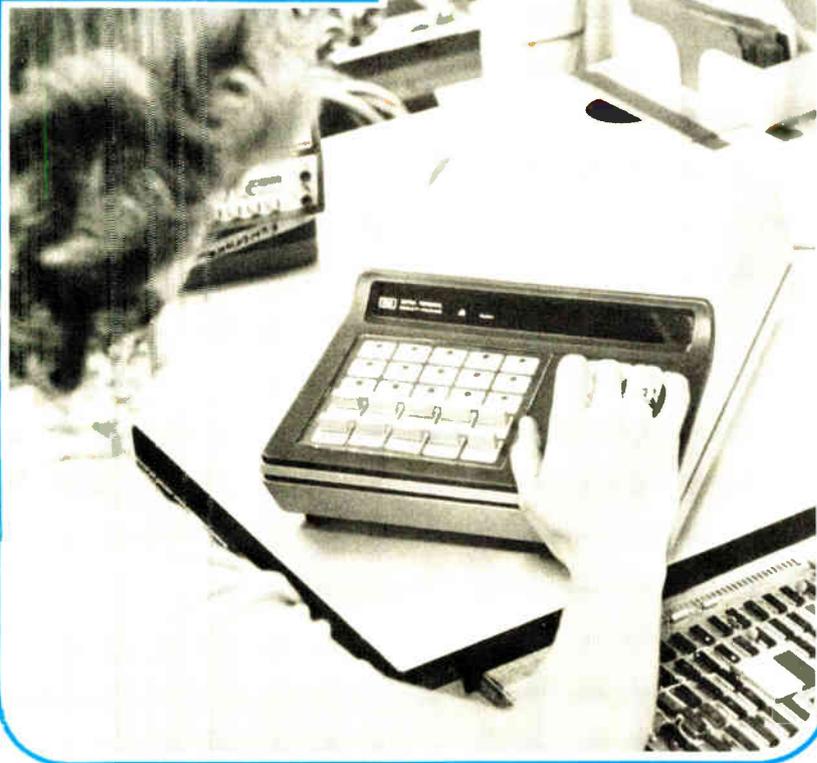
At Analog, Wold has been involved with widely varying projects—ranging from digital panel meters to data converters to modules for serial data transmission. The DPMs are small 3½-digit units that can operate from a 5-volt power supply, while the data converters are 10-bit microprocessor-compatible complementary-MOS chips. Called Serdex, the modules enable parallel-output devices, like data converters and DPMs, to communicate with serial-input equipment, like teletypewriters and minicomputers.

The quad-slope a-d converter designed by Wold is an integrating 13-bit C-MOS chip. But, instead of the usual two-phase integration period, it has four phases, in addition to a reset phase. The extra two phases are put to

good use, making up a digitally corrected auto-zero cycle. With this self-calibration scheme, gain and offset temperature drifts are held to less than 1 part per million per degree celsius.

More recently, Wold has been working on programmable microprocessor-related subsystems for acquiring, manipulating, and processing data. "They are not just hardware, but involve a significant amount of software," he explains. According to Wold, Analog is now test-marketing the new family of products.





At the input. Hewlett-Packard's HP 3070A numerical data-entry terminal, designed for use with the company's HP 2100, 21MX, and 1000 computers, is intended for inexperienced operators, as in the production testing shown here. The terminal also interfaces to instruments via the Hewlett-Packard interface bus, allowing a computer to control instruments up to 1.24 miles away.

Small systems move into the design spotlight

by Stephen E. Scrupski, *Computers Editor*

□ Right on the cutting edge of advances in computer technology is large-scale integration—but semiconductor devices aren't the full story of 1976. New LSI devices are indeed reducing the size and cost of low-end central processing units, but developments in software, magnetic storage devices, and distributed-processor architecture will have an almost equal impact on the design of computer systems.

The year's developments that highlight the major trends in computer technology are:

- One-board 8- and 16-bit computers offer substantial power in small systems.
- Bit-slice bipolar microprocessors are appearing in commercial minicomputers.
- 16-kilobit RAMs offer lower memory costs and increased throughputs, both achieved by cutting down the swaps between memory and external mass storage.
- Magnetic cores, however, are still alive. Improved versions offer lower cost-per-bit and higher packing density.

■ Mass storage for small systems is being increased in capacity with such developments as higher bit densities on tape cartridges and double-density floppy disks.

■ Multiple processors are being used in large mainframe computers to give higher throughputs.

■ Software tools greatly ease the writing of programs for microprocessor-based systems.

One-board computers arrive

Semiconductor LSI technology has advanced to the point that a full computer—a central processing unit, memory, and input/output controls—can be built on one board. Minicomputer and microprocessor makers and other manufacturers announced a host of such computers in 1976. Generally 8- or 16-bit units, they offer an intermediate choice—and intermediate performance—between a microprocessor-based system built from scratch and a full-blown minicomputer.

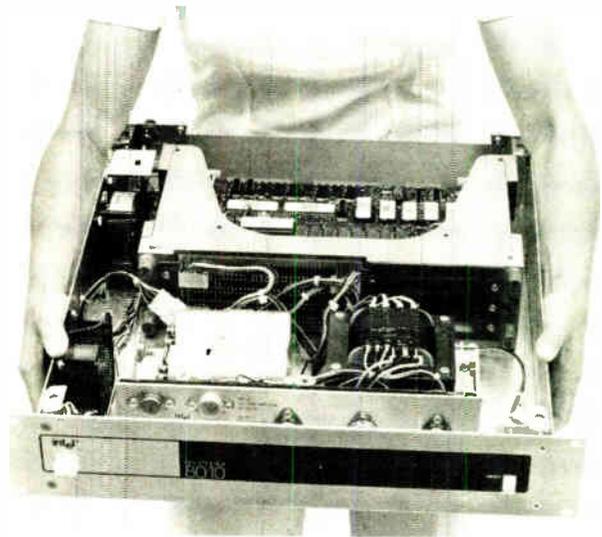
Two major advantages of one-board computers is that the supplier performs much of the testing, and the

software is likely to be more extensive when the unit is part of an established minicomputer family. For example, the LSI-11 from Digital Equipment Corp., Maynard, Mass., can handle most PDP-11 software and undergoes extensive testing in the company's Puerto Rico plant. Boards are automatically tested for logic faults, temperature-cycled, then tested again. With the manufacturer responsible for such testing, the user can spend more time in solving the application problem. He also can save the capital investment required for test equipment.

Minicomputer and semiconductor manufacturers that have introduced one-board computers include:

- DEC: The LSI-11, a 16-bit unit with 8 kilobytes of memory on an 8.5-by-10-inch board.
 - Data General Corp., Southboro, Mass.: the micro-Nova, a 16-bit unit based on the company's own metal-oxide-semiconductor microprocessor chip. The 7½-by-9½-in. board holds up to 8 kilobytes of RAM and handles the Nova-family development software.
 - Texas Instruments Inc., Dallas, Texas: the 990/4, a 16-bit unit based on TI's 9900 MOS microprocessor chip. The 14.25-by-10.8-in. board holds up to 8 kilobytes of RAM and 2 kilobytes of read-only memory.
 - Intel Corp., Santa Clara, Calif.: the SBC 80/20, an 8-bit unit based on the 8080A MOS microprocessor chip. The 6¾-by-12-in. board holds 2 kilobytes of RAM and 4 kilobytes of ROM and has programable input/output lines. The company also moved up to the packaged minicomputer level by adding a power supply and front panel to the SBC 80/10 one-board computer (Fig. 1).
 - Motorola Semiconductor Products group, Phoenix, Ariz.: The M68MM01, an 8-bit unit based on the 6800 MOS microprocessor chip. The 9.75-by-6-in. board holds 1 kilobyte of RAM and 4 kilobytes of ROM.
- Bipolar bit-slice microprocessors offer the cost advantages of LSI with the speed of bipolar technology, and computer manufacturers are starting to cash in on it:
- Honeywell Inc., Minneapolis, Minn.: the series 60 level 6 minicomputers, announced in January, use the 5700 family of 4-bit devices from Monolithic Memories Inc., Sunnyvale, Calif.
 - Interdata Inc., Oceanport, N.J.: its 6/16 and 5/16 computers use the 2900 family from Advanced Micro Devices Inc., Sunnyvale, Calif.
 - Harris Corp. Computer Systems division, Fort Lauderdale, Fla.: its Slash/6 system uses the AMD parts.
 - Hughes Aircraft Co. Microelectronics Products division, Newport Beach, Calif.: the military computer UYK-30 uses Intel's 3000 series of 2-bit slices.
 - Itek Corp.'s Applied Technology division, Sunnyvale, Calif.: the recently introduced ATAC 16M avionics processor uses the AMD 2900 devices.

Although 16,384-bit RAMs are beginning to filter into the development laboratories for evaluation, by no means will they replace 4,096-bit RAMs soon. In fact, the 1,024-bit devices haven't given way completely to 4-k units in production versions of many main memories.



1. Packaged micro. Intel Corp. expanded its microcomputer line upward by packaging the SBC 80/10 single-board computer in an enclosure and adding power supply, cooling, and front-panel. Up to three memory or input/output boards can be added.

Honeywell, for example, recently announced that 4-k devices would henceforth be the standard in large-system main memories. Earlier this year, Burroughs Corp., Detroit, Mich., announced its B80 series of small systems with 1-k RAMs.

One system manufacturer preceded the semiconductor makers with a 16-k RAM. Four-Phase Systems, Cupertino, Calif. announced its NP-80 network processor last December with the company's own 16-k RAMs, which were designed and are being produced in house. With the devices, 256 kilobytes can be placed on one printed-circuit board. Early models of the processor were shipped with 4-k RAM memories, but the company says the larger systems are being readied for shipment. Prime Computer Inc., Framingham, Mass., also says it will be shipping 16-k RAM boards totaling 256 kilobytes late this year.

Despite the advances in semiconductor memories, manufacturers of core memories still are advancing their technology. Ampex Corp.'s Memory Products division, Marina del Rey, Calif., for example, says it will produce all cores with a new tape process, which raises yields to about 99%. The process, called Unibit, produces cores stamped out of a tape material and then fired. The 13-mil-size cores have better uniformity than those produced with the older powder-press techniques. Ampex, in fact, says it will be increasing its total bit production by 50% next year.

Solid-state mass storage systems—based on charge-coupled devices, magnetic bubbles, or both—will almost certainly be announced in 1977, but they won't be used in any quantity until 1978. System prices are likely to be in the 0.1-to-0.2-cent-per-bit range. Intel's memory systems division has been shipping a 1-megabit board based on 16-k CCD devices, but, with the appearance of the 16-k RAM, CCDs will have to hit 65,536 bits per chip

REPRESENTATIVE GENERAL-PURPOSE ONE-BOARD COMPUTERS				
Manufacturer	Model	Bits	CPU technology	Memory on board
Intel	SBC 80/20	8	MOS (8080A)	2-k RAM, 4-k ROM
Motorola	M68MM01A	8	MOS (M6800)	1-k RAM, 4-k ROM
National	Super-Pace	16	bipolar MSI	4-k ROM
Computer Automation	LSI 3/05 (Naked Mili)	16	bipolar MSI	(CPU only)
Data General	microNova	16	MOS custom chip	4-k RAM
Digital Equipment Corp.	LSI 11	16	MOS custom chip	4-k RAM
General Automation	GA-16/110	16	MOS custom chip	512-word RAM, 2-k ROM
Interrlata	5/16	16	bipolar LSI (AMD 2900)	16-k RAM
Microdata	Micro-One	16	bipolar MSI	(CPU only)
Texas Instruments	990/4	16	MOS (TMS 9900)	4-k RAM, 1-k ROM

before they begin to appear as an attractive alternative to disk and tape mass storage. Fairchild Semiconductor, Mountain View, Calif., is offering samples of such devices, while Texas Instruments and Intel are close behind.

Texas Instruments has started production on a 92-kilobit bubble device. When full systems using such devices are announced, it's likely that total capacities will be in the range now offered by large disk drives—32 to 64 megabytes, with increments of 4 or 8 megabytes.

Tapes, disks carry more

Higher bit densities are coming for magnetic tapes. Microdata Corp., Irvine, Calif., increased the bit density on 3M-type cartridges from the customary 1,600 bits per inch to 6,400 bits, thus raising the total capacity from about 2.7 megabytes to more than 10 megabytes. And, in the large reel-to-reel tape drives, Control Data Corp., Minneapolis, Minn., joined IBM and Storage Technology Corp., Louisville, Col., as suppliers of 6,250-bit-per-in. tape systems. Today's maximum density on large drives is 6,250 b/in. because of the skew problems involved

with recording and recovering nine tracks across the tape. The cartridge records a serial bit stream in one track and so can achieve much greater densities.

Magnetic floppy disks also are being improved with higher-capacity recording. This is being attained, first of all, by writing on both sides of the disk, as in IBM's 3602 programable communications controllers and in the Burroughs B80 system. IBM's unit stores a total of 560 kilobytes, while Burroughs, by increasing recording density and using both sides of the disk, hits a capacity of 1 megabyte.

So-called double-density floppy-disk drives were introduced by such manufacturers as Remex, Santa Ana, Calif., General Systems International Inc., Anaheim, Calif., and Shugart Associates, Sunnyvale, Calif. These drives simply double the bit-recording density on one side of the disk to reach a capacity of 800 kilobytes.

Miniature floppy-disk drives—handling disks 5¼ in. in diameter compared to the 8-in. standard diameter—were introduced for lower-cost, less demanding applications. Shugart's SA400 drive, for example, stores 89.6 kilobytes, but costs about half of a standard drive. Figure 2 compares the various kinds of magnetic storages.

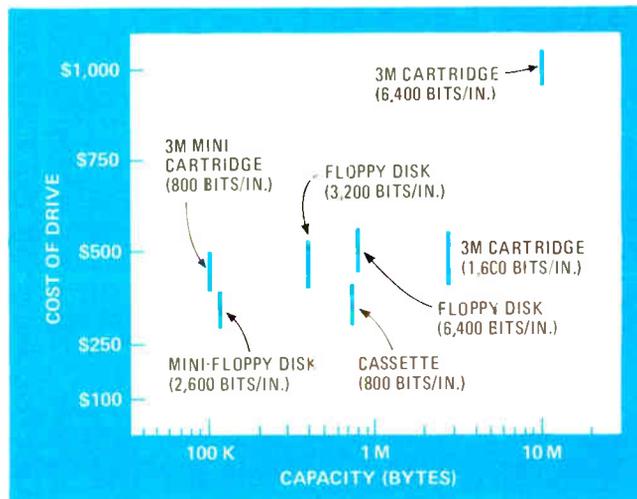
One device that may help recording densities on magnetic disks in the future are thin-film heads. Burroughs introduced a disk file using one such head for each track, while Applied Magnetics Corp., Goleta, Calif., also is developing them. With the AMC head, bit densities could soon reach 8,000 or 10,000 bits per inch, whereas today's disks generally record at 6,400 b/in. Track density, too, would be increased—from today's 600 or 700 tracks/in. to 1,000 tracks/in. The AMC heads are being evaluated by system manufacturers, and commercial systems using them could hit the market in late 1977 or early 1978.

Hitching up processors

Large mainframe machines are becoming an interconnection of small, modular processors that communicate with one another over a wideband bus. The best example of this architecture is Criterion, introduced by NCR Corp., Dayton, Ohio, this year. The system, which uses emitter-coupled logic, 4-k RAMs and a pipeline processor cycling as fast as 56 ns, comprises several processors. In addition to a central unit, others include a manager for control and diagnostics, another to interface with the disk memory, and still others to serve as low-cost communication interfaces.

Similarly, the new 90/80, the largest member of the series 90 family from Sperry-Univac, Blue Bell, Pa., uses two processors—one as the central instruction processor and the other to control peripherals. These, too, use emitter-coupled logic. The instruction processor has a 98-ns cycle time.

In giant mainframes, Control Data claimed a new world speed record for computers with a Star-100 (see Fig. 3), which produced nearly 100 million results per second, breaking the mark of 36 million operations per



2. Low-cost storage. Various means of low-cost storage are shown in terms of their capacity and approximate costs of the drive in quantities of about 100. The newest types are the mini floppy disk-drives and the high-density 6,400-bit/in. drive for the 3M cartridge.

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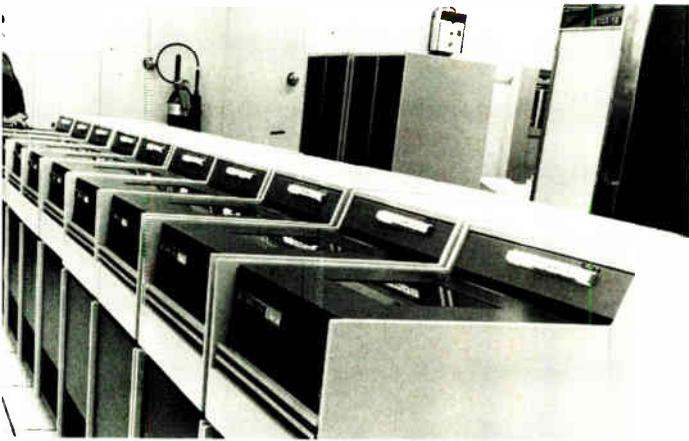
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3. Big disks. Control Data's new Star service center uses 10 type 819 disk drives to provide more than 2.5 billion bytes of on-line data storage. The Star computer itself recently performed more than 100 million operations per second, claimed as a new world's record.

4. Upgrades. IBM upgraded its system 370 models 135 and 145 to the 138, shown here, and 148. Performance was increased 28 to 43 percent, while purchase prices decreased by about 45%. The systems use MOS main memories based on 2-kilobit RAMs.



second held since 1969 by the CDC 7600. The computer will be the center of a new data service announced by the company.

Amdahl Corp., Sunnyvale, Calif., has been shipping its 470 V/6 systems at the rate of about one a week, and by the end of the year it will have around 30 systems installed. The system's performance topped IBM's top-of-the-line system 370 model 168, but IBM is getting ready to leapfrog Amdahl. Although no details of the enhanced 168 have been disclosed, chances are it will contain many of the improvements of the 138 and 148.

The first model of the largest scientific computing system ever built, the Cray-1, by Cray Research Inc., Chippewa Falls, Wisc., has been shipped to the Atomic Energy Commission's Laboratory in Los Alamos, N. Mex. The company says it plans to ship another this year and perhaps four more next year. The first Cray-1 had a memory of half a million words, of 64 bits each.

IBM upgraded its system 370 models 135 and 145 to the 138 and 148 (Fig. 4). Although the company did not disclose much about the hardware improvements, it did note that the new systems make greater use of firmware in the form of a reloadable control store of 131,072 characters. Software had been used to control operation sequences and emulation and diagnostic routines.

Processors also are being geographically distributed to bring computer power closer to where the information is gathered and results are needed. The basis for such system architectures is the increasing ability to build small, low-cost terminals. Intelligent terminals are steadily hiking their IQ by taking advantage of the advances in small processors and peripherals—memory, with 4-k and, soon, 16-k RAMs, higher-capacity mass storage with floppy disks or tape cartridges, and lower-cost, more

capable printers, which often use microprocessors to control the printing formats.

Since Intel's 1975 announcement of its Intellec micro-computer-development system, the byword in such equipment has been in-circuit emulation. Intellec's operation is typical of such systems. The designer can write, edit, and partially debug his program and, using in-circuit emulation, can run the program in his actual prototype hardware. The Intellec replaces the 8080A microprocessor in the prototype.

In-circuit emulators

In the past year, many development systems from other manufacturers have come out with in-circuit emulation. Motorola, for example, added the feature to its Exorciser, which is used to develop 6800-based systems, and called it USE, for user system evaluator. An independent, Millenium Information Systems Inc., Santa Clara, Calif., designed the development system for the 2650 microprocessor from Signetics Corp., Sunnyvale, Calif. Then it announced its own version, calling it the Universal One, with two processors, master and slave. It can be used for any processor type for which Millenium has developed the slave unit.

It was also a banner year for microprocessor-development software. Many high-level-language compilers were introduced for versions of PL/I, Basic, and Fortran. Such high-level languages can substantially ease programming, compared with the more detailed assembly-language statements. Intel's PL/M was the first language based on PL/I, and many others are now available. Motorola has its MPL for the 6800; Signetics has PL μ S for the 2650; National Semiconductor Corp., Santa Clara, Calif., has SMPL for the IMP-16, PACE, and other



5. Optical magic. The Key Tronic OCR wand (top) uses a wheel moving across the paper to generate pulses that cause the photodiode array to take readings every 1/200 in., while the Recognition Products wand need not be in contact with the paper.

devices; Zilog Inc., Los Altos, Calif., has PL/Z for the Z-80, and many independent software houses introduced compilers for the PL/I derivatives.

Most of the compilers, however, are cross-compilers, which means that they must be run on a large computer. The next push is to develop compilers that will be resident in the semiconductor firm's own microprocessor-development system. Intel recently announced PL/M as resident in the Inteltec, and Motorola has installed a resident version of Fortran in the Exorciser.

Among the more unusual developments in data-entry technology was a pair of wands that perform optical-character recognition (Fig. 5). They are found in such applications as point-of-sale systems, inventory control, and recording manufacturing data. A wand from Recognition Products Inc., Dallas, Texas, can read 26 OCR-A-coded characters while being moved left to right or vice versa. The associated electronics module is built around an F8 microprocessor. Another wand, from Key Tronic Corp., Spokane, Wash., has a displacement wheel that turns as the wand is moved across the paper. The wheel, in turn, generates a series of marker pulses that trigger the photosensor array to read a different slice of the character every 1/200 inch. This wand reads all OCR-A letters and numerals, some other fonts, and even hand-printed numbers and a few letters.

Profile

Diskette, flexible disk, floppy disk, call it what you will, this data-storage medium has had a tremendous impact on small computer systems since it was developed by IBM at its San Jose, Calif., plant in the late 1960s. And two of the leaders of the project are still in the business, further refining today's floppy-disk drives. Don Wartner, left, is chief engineer at Shugart Associates, Sunnyvale, Calif., while Warren Dalziel is a senior engineer at Shugart. Along the way, they worked at Memorex Corp., Santa Clara, Calif.

Each joined IBM in San Jose upon graduation from college—Wartner in 1958 from the University of Colorado and Dalziel in 1962 from Oregon State University. Each left in 1969 to join Memorex, along with Al Shugart, who became vice president for development at Memorex, and others. At that time, the IBM system was well on its way, having passed the final tests before manufacturing.

The first drive, however, was a read-only device intended to load a microprogram into a larger disk drive upon startup. The project, called Minnow, went through some difficult times at IBM as the engineers tried to come up with the right flexible medium. One ill-fated idea was to bond thin magnetic sheets of Mylar to the two sides of a plastic foam disk and allow the read head to press into the Mylar while the foam acted as a backing. Problems in maintaining production tolerances on the foam, however, forced them to discard this idea and eventually adopt the jacketed, flexible medium as it is known today.

"The requirements of the project were fairly easy by today's standards, but at the time they seemed hard," Wartner says. "The bit density was 1,594 bits per inch, whereas today we typically operate at 3,200 bits/in. Track density was 32 per inch, and today it's 48 per inch. And rotational speed was 90 rpm, while today we spin the disk at 360 rpm."

Did the two engineers foresee the eventual impact of their Minnow? "I have to admit that I didn't have the foresight to see there would be a big market for floppies," Dalziel says. Wartner notes that it wasn't until IBM announced in Europe the 3741 keypunch replacement system based on a read-write floppy disk that he realized that the company had continued to develop the device.



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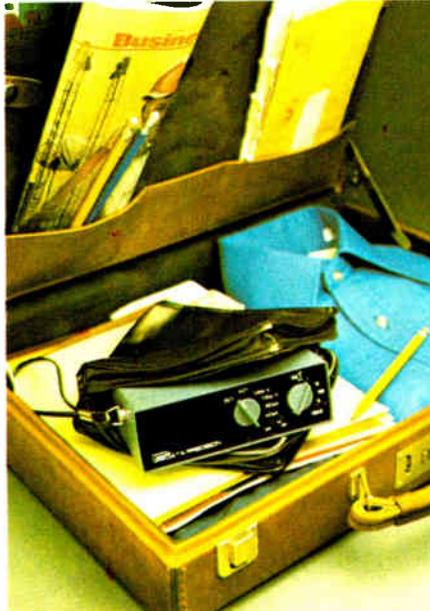
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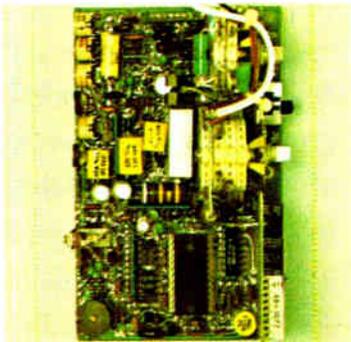


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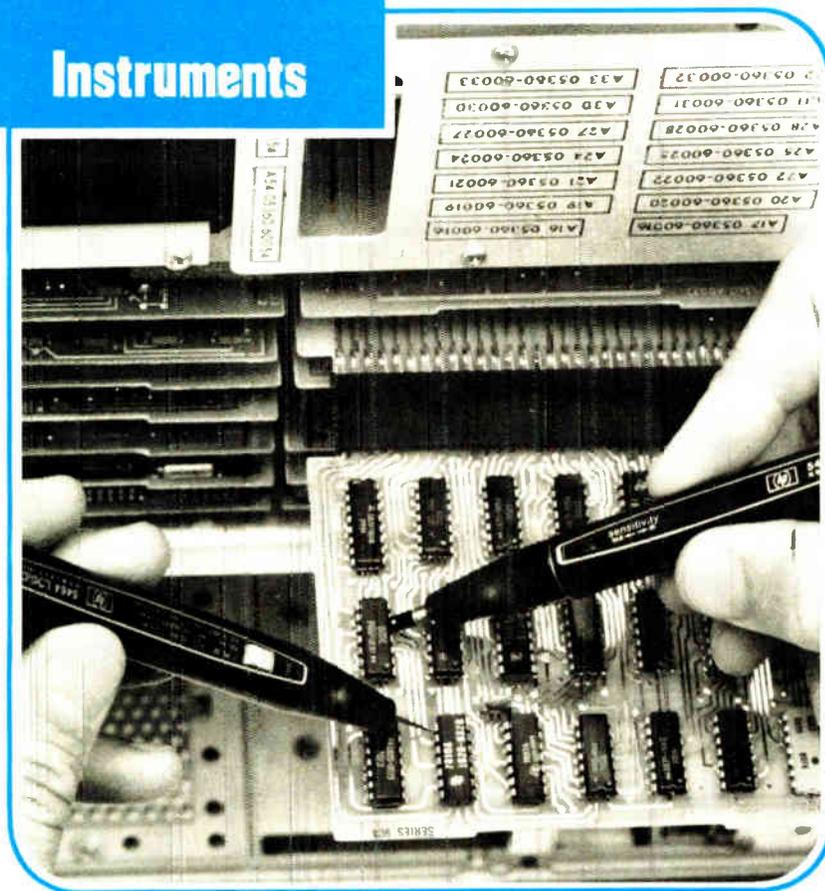
	Data Precision Model 175	HP 3435	HP 3176B	Fluke 8000 A
Digits	3½	3½	3½	3½
Size	34 cu. in.	395 cu. in.	123 cu. in.	212.5 cu. in.
Display Size	0.43" LED	0.30" LED	0.25" LED	0.25" LED
Basic Accuracy for 1 Year ±1 Digit	0.1%	0.1%	0.3%	0.1%
DCV Sensitivity	100µV	100µV	100µV	100µV
AC Frequency Response	30Hz-50kHz	30Hz-100kHz	45Hz-10kHz	45Hz-20kHz
Functions	6	5	5	5
Ranges	32	27	19	26
Hi/Lo Excitation	Yes	No	No	No
Calibration Accuracy Guaranteed	1 year	1 year	1 year	1 year
Overrange	100%	100%	10%	100%
Ranging	Manual	Manual & Auto (except current)	Auto	Manual
Rechargeable Batteries	Yes	Yes	Yes	Optional (\$50.00)
Recharges Batteries While Operating	Yes	Yes	No	Optional
Full Scale Voltage Drop Measuring Current	100 millivolts (EIA STANDARD)	220-400 millivolts	100 millivolts	100 millivolts
Price With Batteries	\$189.00	\$400.00	\$275.00	\$349.00

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Finding failures. The emphasis in digital testing hardware is on gear that can trace a fault directly to the errant integrated circuit, solder splash, or other cause, thus avoiding slow, costly, and inefficient hit-or-miss techniques like mass IC replacement. Troubleshooters like this Hewlett-Packard pulser and probe help make the right fix first time.

Digital systems spawn new tasks in measurement

by Andy Santoni, *Instrumentation Editor*

Improvements in circuit design and the increased use of large-scale-integrated circuits—especially microprocessors—are making instruments faster, less expensive, and more convenient to use. Equally important, new kinds of testers and variations of older types of equipment are simplifying the testing and troubleshooting of the latest in microprocessors and other digital circuits.

- In the past year, microprocessor analyzers have emerged as a major product line, aimed at the needs created by microprocessor-based circuits (Fig. 1).

- New versions of logic probes and other hand-held troubleshooting instruments have made tracking faults in digital circuits simpler.

- Testers for printed-circuit boards containing digital logic have been improved to permit faster and less expensive repairs.

- Oscilloscopes combined with digital multimeters and time-interval counters offer more capability in one instrument.

- Digital voltmeters and multimeters are heading in two

directions: higher reading rates and lower prices.

- Frequency counters are measuring pulsed signals in the gigahertz range to simplify tests of communications and radar systems.

- Calculator-based measurement systems are supplanting minicomputer-based systems at lower costs.

Testing microprocessors

Microprocessors have created new markets for test-instrument manufacturers. With 24 lines of addresses and data on an 8-bit microprocessor, logic analyzers with more than the maximum of 16 lines of older instruments are required. To meet the need, almost a dozen instrument makers are offering analyzers with as many as 32 input channels and with features aimed at microprocessor circuit designers, such as hexadecimal readouts and one-clip interfaces. Enough equipment of this kind has hit the market to establish a new category of instruments—microprocessor analyzers.

No two microprocessor analyzers are alike. They

range in price from under \$1,000 for units from Pro-Log Corp., Monterey, Calif., and Systron-Donner Corp., Concord, Calif., to \$5,000 and more for the complex analyzers built by Hewlett-Packard Co., Palo Alto, Calif., and Biomation Corp., Cupertino, Calif. Yet all types simplify trouble-shooting circuits that contain microprocessors.

Displaying data

By wiring the analyzer's test probes differently for different microprocessors, the manufacturer can guarantee that the signals coming from the microprocessor buses go to the right point on the display of the analyzer. That display can be a row of light-emitting diodes corresponding to one program or instruction step. Another display approach is to offer hexadecimal readouts on a built-in cathode-ray-tube screen or an external oscilloscope. Hexadecimal readout is preferred by software programmers, who use it to compare actual circuit operation to documented programs.

By far the most complex microprocessor analyzer displays are offered by HP's model 1611A and Biomation's model 168-D. The HP unit, in addition to hexadecimal readout, can display system activity on its CRT in the alphanumeric mnemonics of the microprocessor's instruction set, thus even further simplifying interpretation. The CRT on Biomation's analyzer can display a 16-by-16-position map of the instrument's 256-word memory so that similar instructions and the program loops they identify can be located.

With a microprocessor analyzer, an engineer can determine that a failure has occurred and can often trace the fault to a software error. The analyzer can some-

times even determine where a hardware problem exists. But it usually cannot track a fault far enough to determine which integrated circuit must be replaced or where a solder splash exists on the system's pc board.

Hand-held digital troubleshooting instruments such as logic probes, pulsers, and test clips come into play for tracking such faults. These low-cost instruments are gaining greater popularity now that prices are falling. The latest such gear can handle the demands of mixed logic types on a single board. But they cost less than their predecessors, which could only handle one logic family at a time.

One logic probe that indicates logic level and pulse activity at a node under test in either complementary-metal-oxide-semiconductor or transistor-transistor-logic



1. Microprocessor monitor. Analyzers like this Systron-Donner unit simplify microprocessor-program generation and debugging by displaying the activity on address and data buses.

LOGIC ANALYZER APPLICATIONS

Number of channels	Memory bits per channel	Applications
1 - 2 4 8 16 32		analyzing serial data transmissions comparing control signals comparing complex control signals and analyzing data lines in peripherals analyzing transactions on microprocessor and other buses, and tracing programs examining total processor operations, including addresses, data, and control signals
	1 16 256 ≥1024	storing status information recording sequences of logic states analyzing timing relationships and long sequences of logic states making high-resolution timing analyses and analyzing serial data transmissions

Analyzing analyzers. The memory capacity of a logic analyzer determines the range of applications it can cover, says Murlan Kaufman, project manager at Tektronix. Units with almost any combination of memory width and depth are available.

systems is available from Continental Specialties Corp. of New Haven, Conn. Its \$44.95 price is less than half that of many earlier logic probes that could handle only one family. For systems with an even greater mix of logic types, Hewlett-Packard's model 545A, which can test resistor-transistor, high-threshold, and MOS logic in addition to TTL and C-MOS, is priced at \$125.

Unfortunately, these instruments cannot readily determine which IC has failed. All they can tell is whether a line is stuck at a logic high or a logic low, not whether

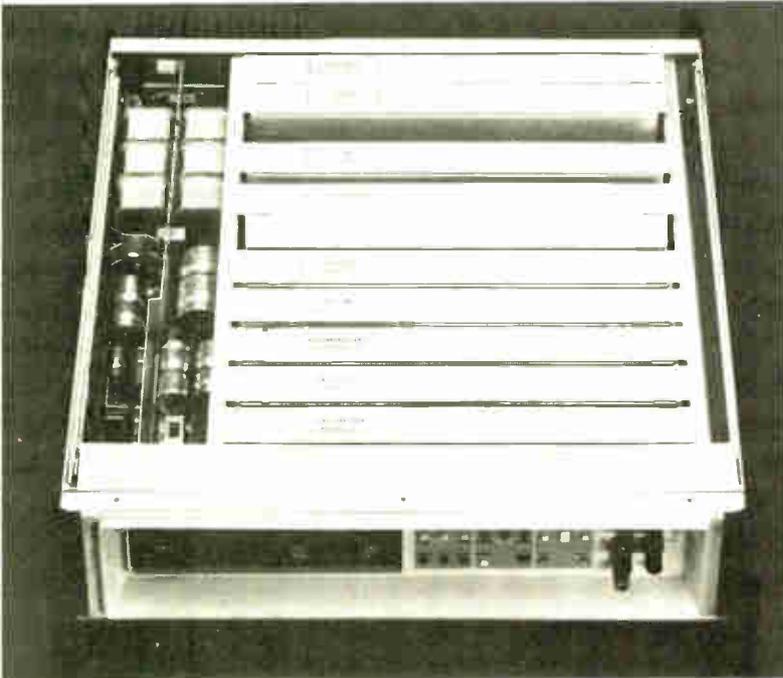
it's the driver or receiver that is at fault. Nor can they determine which driver has failed when the outputs of a number of gates are tied into a single wired-OR bus.

To solve these problems, instrument makers have introduced logic troubleshooters that trace signals through pc paths, instead of checking a line's voltage level with respect to system ground. For example, the current-path indicator from Storage Technology Corp., Broomfield, Colo., is a microvoltmeter with a zero-center scale that indicates the direction of current flow between two points on a pc path and can thus locate a solder splash or the IC pin that's shorted to the power-supply voltage or to ground. The Short-Trak from Digital Facilities Inc., Dallas, performs a similar function and includes a third probe that can act as a current-pulse source.

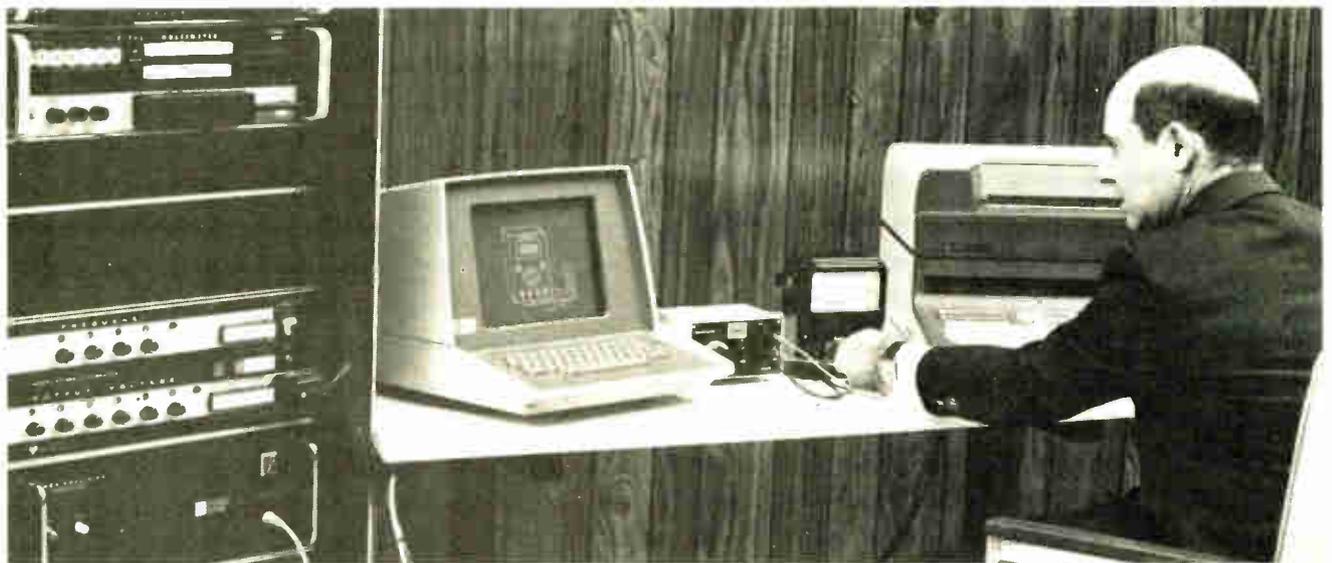
Another approach to current sensing is to look for the fields surrounding the paths through which current flows. This approach is taken by HP in its model 547A current tracer, a \$350 instrument that has a pickup coil at its tip and a wideband, variable-sensitivity amplifier that turns on a lamp when current is present. A similar technique is used by Testline Instruments Inc., Titusville, Fla., in its wired-OR probe, which also includes a pulse source.

Testing boards

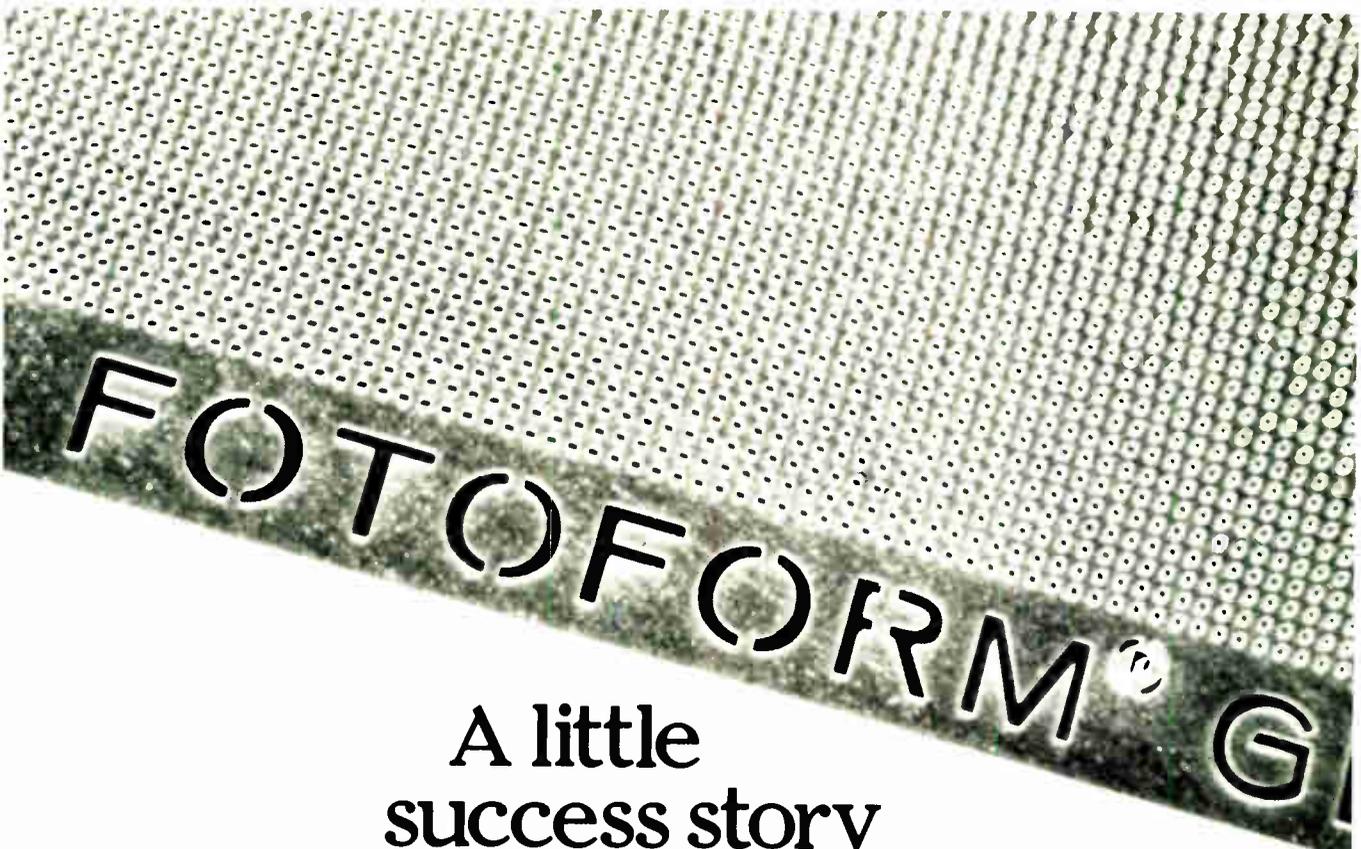
Testline has expanded its relatively simple wired-OR probe into a complete board-test system that fits into a suitcase and gives a clear go/no-go indication of the board's performance. Called the AFIT 1000, the tester drives an IC's pins with a signal from a 2-ohm source impedance. This low impedance is critical, says Roger Boatman, Testline's president, because the impedance at a failed device's pin is about 3 Ω , while the highest impedance exhibited by a common board problem such



2. Speed system. The converter in Fluke's 8500A digital multimeter can take 500 readings per second at 5 1/2 digits of resolution.



3. Calculator control. As the speed and flexibility of desktop programmable calculators increase, more of these devices are applied in automatic test systems such as this Julie Research calibration console. The tester can generate images of the unit under test on a graphics terminal, thereby simplifying the location of test points and controls.



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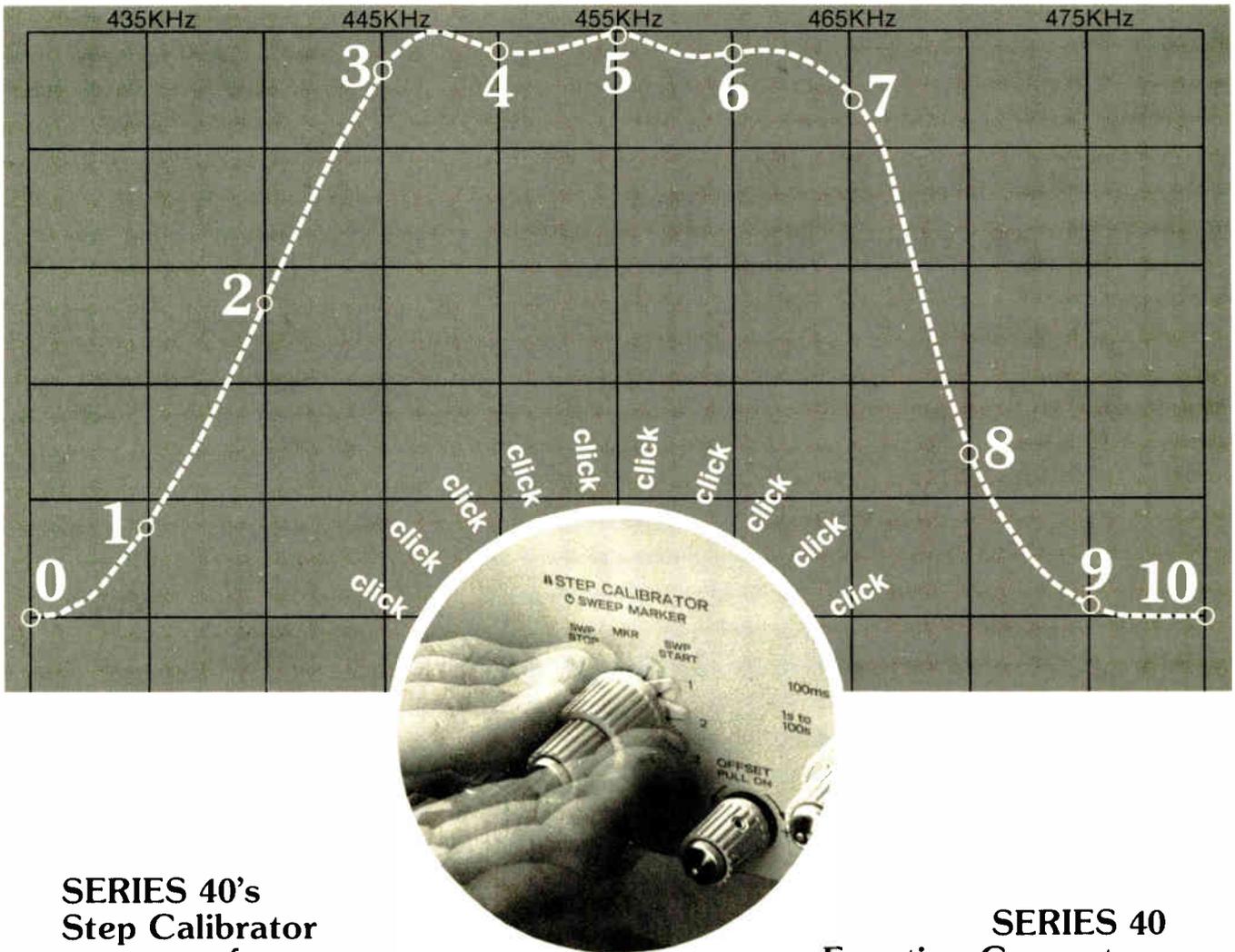
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as a solder splash is less than 0.1 Ω. If a 2-Ω source impedance can drive the IC, the failure is in the chip, since a board failure would short out the signal.

While much emphasis in instrumentation has been on solving problems in digital circuits, analog-oriented instruments such as oscilloscopes, voltmeters, and frequency counters have not been ignored. In fact, these three types of instruments are more often being provided within a single cabinet.

Vu-Data Corp. of San Diego, for example, is offering its model PS915/975, which contains a digital multimeter, a frequency counter, and an oscilloscope in a 10-pound package. Priced at \$1,250, the unit permits measuring the voltage and frequency of a signal while displaying the waveform on the scope screen.

Tektronix Inc., Beaverton, Ore., offers its model DM44, a digital multimeter and time-interval counter that rides piggyback on many of the firm's portable oscilloscopes. To measure a time interval on screen, the scope is set for sweep A intensified by sweep B, and two intensified spots are positioned at the beginning and end of the interval to be measured. The time is read out on a 3½-digit display that's part of the DM44. For greater precision, the DM44 can measure a time interval (and its inverse) with accuracies to within 1% by switching the scope into the sweep-B-intensified-by-sweep-A mode, in which detailed views of the interval's beginning and end are displayed. Using the delta-time control, the end of the interval is superimposed on the beginning to produce a readout.

Measuring volts faster

Improvements are also being made in stand-alone digital voltmeters and multimeters. In meters designed for applications in systems, the trend is toward higher conversion rates and, therefore, shorter overall test times. The model 8500A systems multimeter from John Fluke Manufacturing Co. of Mountlake Terrace, Wash., for example, can take up to 500 readings per second while achieving 5½ digits of resolution (Fig. 2). The instrument employs an analog-to-digital converter that can make less precise approximations to the unknown voltage at each stage of the conversion. It makes the approximations more quickly because it can correct the error, whether positive or negative, on the next conversion step.

Data Precision Corp., Wakefield, Mass., took a different approach. In its model 7500 voltmeter, the unknown input is integrated for 200 microseconds so that 1,000 conversions per second are possible. The instrument integrates a large reference input for as long as is required to get within 1% of full scale. Then a comparator sends a signal that changes the reference current and the clock rate each by a factor of 100, reducing the load on the comparator for the final, brief integration period.

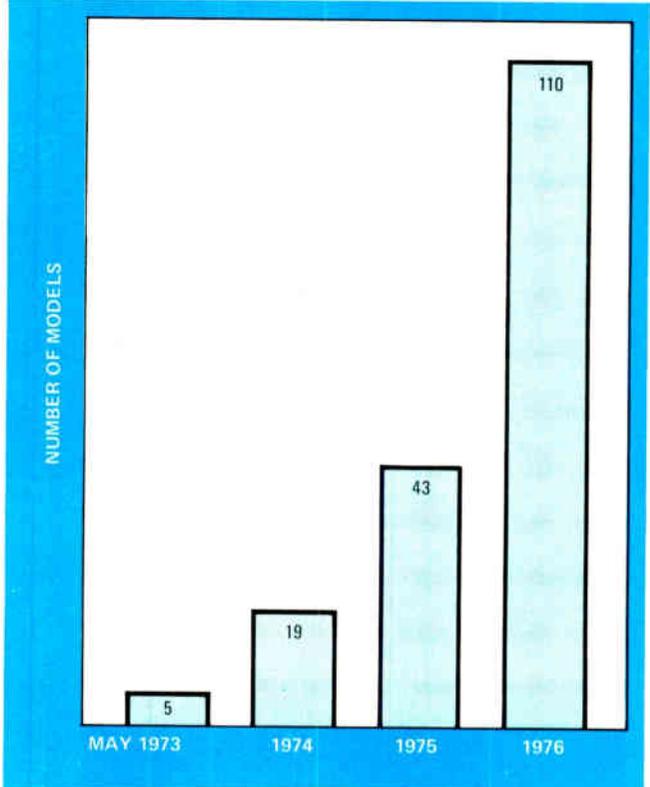
An even faster system voltmeter is Hewlett-Packard's model 3437A. It can measure dc voltages at better than 5,000 readings per second with a resolution of 3½ digits,

which is often enough in data-acquisition systems. By combining high measurement speed with an internal sample-and-hold circuit, the 3437A can analyze transient signals. Repetitive waveforms with frequency components up to 1 megahertz and low-frequency transients with components up to 1 kilohertz are quickly digitized and analyzed, so that parameters such as residual dc, harmonic content, peak values, and root-mean-square values can be determined.

The ability to measure rms values is becoming more important as engineers begin to realize the benefits of making these measurements in a wide variety of power-dissipating circuitry. At the same time, prices for rms-responding digital multimeters are falling, so that such instruments are now available for large-scale use in field service or on the production line.

Two digital multimeters from Fluke offer rms response in low-cost instruments whose small size and light weight are designed for field service as well as bench use. The \$235 3½-digit model 8030A and the \$425 4½-digit model 8040A both have 26 ranges and five major functions (ac and dc voltage, ac and dc current, and resistance). In addition to five ranges for each function, the 8040A has an additional resistance range, and the 8030A has a diode-test position.

In Data Precision's latest entry, the \$345 4½-digit model 248, the rms-to-dc conversion is performed by a



4. Bus bonanza. More than 35 manufacturers are supplying systems, instruments, or components that are compatible with the standard interface bus.

linear, bipolar integrated circuit made by Analog Devices Inc.'s Semiconductor division in Wilmington, Mass. The IC is capable of less than 1% error in measuring signals with crest factors up to seven and is responsible, at least in part, for the DMM's low price.

Counting in bursts

Just as voltmeters are improving in performance, so, too, are frequency counters. The latest instruments from Systron-Donner, EIP Inc. of Santa Clara, Calif., and Eldorado Instruments Co. of Pleasant Hill, Calif., can measure frequencies in the gigahertz range, even when the signal under test is pulsed, not continuous. For example, a radar system under test does not have to be put into a standby, continuous-wave mode, but can continue in normal operation.

Eldorado's model 9899 is a heterodyne counter with a range from 925 MHz to 18 GHz. It is similar to the firm's continuous-mode model 989 except for the addition of pulsed-radio-frequency measurement circuits. The model 451 from EIP uses the same heterodyne technique and features fully automatic pulsed-rf counting capability over a range from 300 MHz to 10 GHz. Systron-Donner's model 6063, planned as the first in a series of pulsed rf counters, covers the range from 20 Hz to 6.5 GHz, with 1-Hz resolution.

Along with single-function instruments like these

counters, instrumentation makers are looking toward more complete systems for testing communications gear. In telecommunications, as well as other testing applications, calculator-based systems have moved into the spotlight because they give engineers or production-line personnel a great deal of information quickly, yet are less expensive than computer-controlled systems (Fig. 3).

Control by calculator

Although most calculator-based testers are built by users, some are commercial products. For example, the SMPU radiophone tester from West Germany's Rohde and Schwarz uses a microprocessor to control instrument modules and monitor their operation, along with a TEK 31 desk-top calculator to make a fully automatic system complete with datalogging. This system also reflects the trend toward compatibility with the IEEE-488-standard instrument-interface bus (Fig. 4).

More such systems will be required because of the demands for more sophisticated instrumentation to lower labor costs, says Norman Christianson, director of engineering at w & G Instruments Inc., Livingston, N.J. "We have to give the user the information he wants in the parameters he desires, so we need smart instruments to do the jobs faster and provide whatever data reduction is necessary." □

Profile

When Chuck House's development team at Hewlett-Packard's Colorado Springs division ran into snags while trying to troubleshoot the serial-data bus in what was supposed to be a new generation of oscilloscopes, they turned their attention to the problems of testing digital circuits. As a result of the insights they gained, the new products turned out not to be oscilloscopes at all, but instead a whole new class of instruments—logic state analyzers.

House realized that digital transmissions are fundamentally different in character from analog signals. As a result, test equipment designed to measure the parameters that define an analog signal—voltage and frequency, for example—may be totally inappropriate for digital-circuit testing. What was needed, House determined, was an instrument that abstracted the data flowing in digital streams and presented only the essential information—logic states that existed at the time the circuit made use of them, on the system clock edge.

Like most ingenious ideas, the concept of the "data domain," as House calls it, seems rather simple. Yet, until a few months ago, HP was alone in implementing logic-state analysis in commercial products. All but a few engineers used oscilloscopes to troubleshoot digital systems, even though scopes—including multi-trace and multi-beam units—do not display enough signals to make the necessary comparisons among the many lines common in digital systems. Logic state analyzers and microprocessor analyzers trade off the ability to display precise voltage and timing relationships to increase the number of data lines displayed.

House's varied experiences all contributed to his present position as logic-analyzer department manager. He joined HP in 1962 upon graduation from the California Institute of Technology, where he studied solid-state physics. He was anxious to take a job in Colorado Springs because nearby Denver is his wife's home town. ("We've been happily married for almost half my life," the 36-year-old House says.)

"I was going to turn myself into a circuit designer," says House, who spent the next four years designing what he calls "moderately successful" oscilloscopes. He then became involved in a project to design a large-screen cathode-ray-tube monitor for the Federal Aviation Administration, which led to an assignment researching other possible applications for the device—"and I got hooked on product planning."

Meanwhile, he was appointed to the Air Pollution Control Commission by the governor of Colorado and there gained an appreciation for systems engineering, in which there is more emphasis on solving a problem and less on circuit design.

At HP, he realized that "another scope is nothing to write about. It didn't make any fundamental measurements you couldn't make before." Late in 1971, he made a proposal to John Young, now executive vice-president of the firm, and Barney Oliver, vice-president for research and development, to spend \$5 million over five years to develop the state analyzer. He didn't get that much money or that much time, but he and his team developed the product nonetheless.

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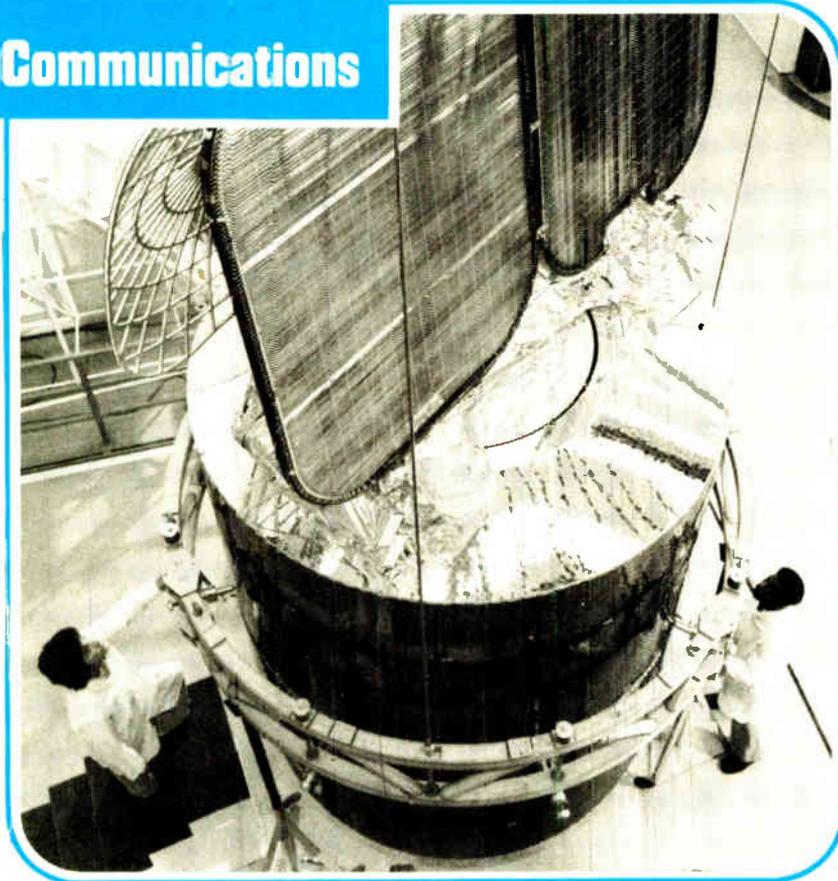
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Orbiting switching center. At 22,300 miles in space, Comstar, a geosynchronous-orbit communications satellite will be used jointly by AT&T and GTE to relay the myriad telephone calls across the 48 contiguous states as well as Hawaii, Alaska, and Puerto Rico.

All technologies aim at greater channel capacity

by Richard Gundlach, *Communications & Microwave Editor*

□ Communications technology was the father of the electronics revolution that is reshaping our lives, and the developments of the past year show there's plenty of life left in the old man. The demand for more and faster information transfer is spurring the adoption of new technology, notably in the development of optical-fiber communications. There also were solid advances in satellites and the adaption of large-scale integration.

- This year optical-fiber communications came out of the laboratory into operating environments.
- Higher-power satellites, some operating at higher frequencies with increased channel capacity, were launched, with others to follow soon.
- Microprocessor technology found increased use in radar, microwave receivers, and navigational equipment, and it was being tapped for telephony tasks as well.

Large-scale integration is playing a major role in reshaping communications products (Fig. 1). Acceptance had been slow in telecommunications, because most companies have large investments in existing plants. But

many semiconductor makers see LSI technology making inroads into all phases of communications as users demand improvements in performance, versatility, reliability, and economy. It is already found in a good range of products from several companies.

Fiber optics come on strong

The advance of fiber-optic technology was demonstrated dramatically by Bell Telephone Laboratories Inc. engineers in an experimental telephone link started last January. Not only did it show a fiber-optic system working successfully with existing telephone equipment, but it proved the mass producibility of fibers by demonstrating that cables of 144 single fibers could be produced and mass-spliced without individual handling of fibers. These cables, only half an inch in diameter, are capable of carrying almost 50,000 simultaneous telephone conversations.

Another fiber-optic system, designed to carry television signals over several fibers to a cable-TV headend

some 800 feet away, was established in New York City in July by TelePrompter Manhattan Cable Television. The Japanese will start testing a fiber-optic interactive network to provide two-way residential video information to households in Japan. An in-building prototype system will determine technical feasibility this November. Later, an expanded video information system will be tested by 300 subscribers in the Higashi Ikoma area, a model city near Osaka. And General Telephone and Electronics Corp. is readying a fiber-optic link to handle telephone messages between central offices.

Several advances in fiber-optic component technology have surfaced this year as well. Practical single-fiber connectors were developed by several companies, and a new generation of fiber cables was announced by Corning Glass Works, Corning, N.Y., which doubles source-to-fiber coupling efficiency over that of standard graded-index cables. The cables have 400-megahertz bandwidth capability with losses as low as 6 decibels per kilometer.

Still in the laboratory stage is an ultra-low-loss step-index fiber developed by the Fujikura Cable Works Ltd. of Japan. By eliminating almost all water ions from the glass, researchers there reduced fiber loss to only 0.47 dB/km at a wavelength of 1.2 micrometers. (For more on fiber-optic developments, see the special report in *Electronics* Aug. 5, pp. 81-104, and related articles in subsequent issues.)

Going up

Satellite communications for international and domestic applications have jumped almost exponentially since 1974. One cause of the growth is the shift from costly ground systems to lower-cost earth stations. And with this year's launch of Marisat, satellite communications are serving ships at sea.

Satellite networks can bring communications directly to a user without access to telephone or telegraph networks. They meet the growing demand for domestic and international telephone channels, as well as distribution of data, direct connection of computers, television broadcasting, and high-speed facsimile distribution. In addition, satellites teamed with radar technology are being used for automatic vehicle locators, mapping the terrain on distant planets, and planning flood control and management of crop, forest, and water resources.

In the past, satellite technology centered on low-power satellite transponders that required large earth-station terminals removed from metropolitan areas to avoid interference with terrestrial microwave networks operating on the same 4- and 6-gigahertz bands. Higher-power satellite transmitters operating at higher frequencies will avoid terrestrial congestion and make it possible to use much smaller antennas right on the customer's property, even on urban rooftops.

This year's blessing by the Federal Communications Commission of what's called a standard B earth station lets users participate in Intelsat, the biggest international satellite network, with a 10-meter antenna with band-



1. First of a kind. Bell Northern Research has developed an all-electronic telephone using LSI circuitry to replace the electromechanical parts of conventional telephones. One result is that future phones could take many shapes, as the model shown suggests.

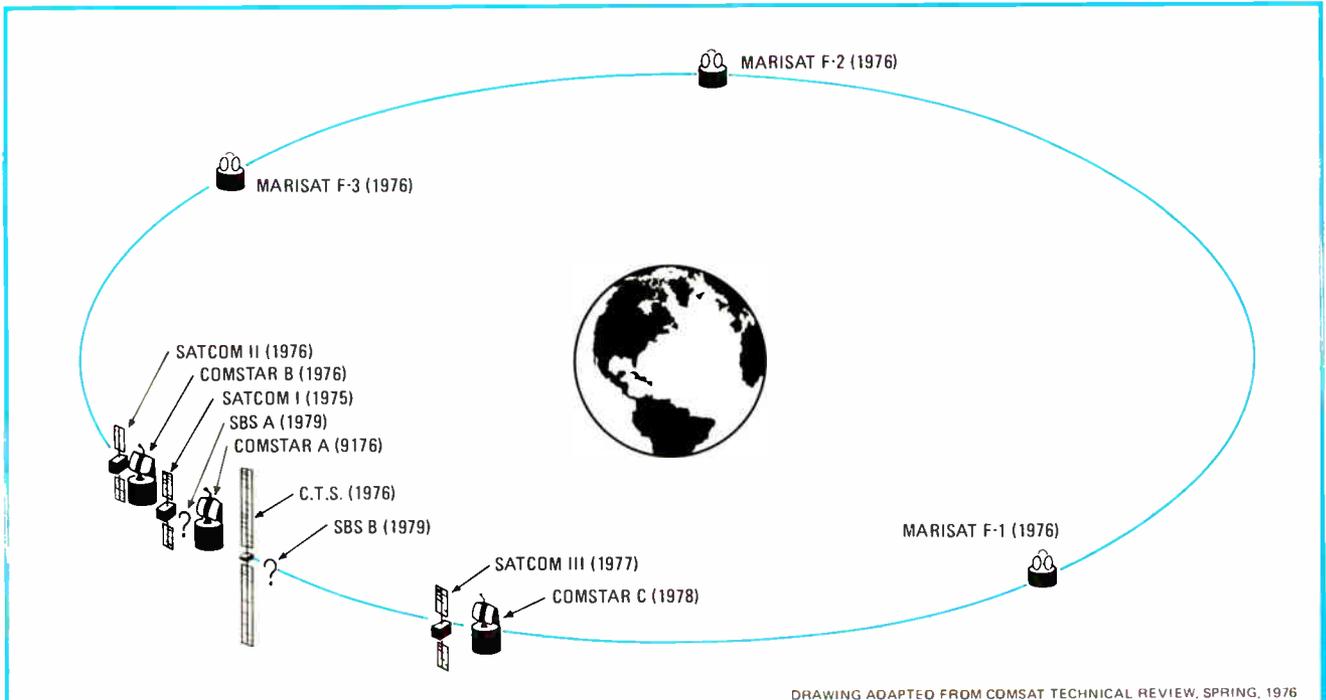
width-efficient single-channel-per-carrier techniques. No longer is a 30-meter antenna on a \$6 million earth station needed.

Modulation schemes for satellite networks, such as single-channel-per-carrier and time-division-multiple-access, can efficiently accommodate single-voice channels or receive-only terminals and handle the complex and varied demands of a network of users. Originally, Intelsat network stations used wideband frequency modulation with frequency-division multiplexing, but with this technique only one station could gain access to a satellite transponder at any given time.

Single-channel-per-carrier systems have been a boon for small earth-terminal users. Such systems offer low startup costs and allow for the later addition of extra channels. They are especially advantageous in low-demand situations if combined with demand-assignment multiple access, which allows each earth station use of a channel only as required, under control of a master ground station.

Satellite departures

This year saw the launch of several domestic satellites (Fig. 2), such as Satcom I and II from RCA Corp. With the FCC's permission, American Telephone & Telegraph Inc. and GTE have combined their planned domestic communications satellites into a single system. Two Comstars were launched this year with a third planned for launch in 1978. Initially they will operate in the 4- and 6-GHz bands, using 24 transponders to handle 28,800 simultaneous telephone conversations. The total system will provide enough video and data distribution



Satellite	Launch date	Application	Operator
Satcom I	Dec. 12, 1975	Commercial communications for Alaska, Hawaii and contiguous 48 states	RCA
C.T.S.	Jan. 17, 1976	Broadcast satellite experiments – shared by Canada and U.S.	Canadian government
Marisat F-1	Feb. 19, 1976	Ship to shore (Atlantic)	Cosat General
Satcom II	Mar. 26, 1976	Second RCA satellite	RCA
Comstar A	May 13, 1976	First AT&T and GTE satellite to serve Alaska, Hawaii, Puerto Rico and contiguous 48 states	Cosat General
Marisat F-3	June 9, 1976	Ship to shore (Pacific)	Cosat General
Comstar B	July 22, 1976	Second AT&T and GTE satellite	Cosat General
Marisat F-2	Oct. 14, 1976	Ship to shore (Indian Ocean)	Cosat General

2. Heavy traffic. Satellites placed in a geosynchronous orbit, a circular path around the earth some 22,300 miles high, appear stationary with respect to a point on earth. Shown are several such communications satellites launched recently to serve the Americas.

and telephone service for Alaska, Hawaii, and the other 48 states. Later, higher-frequency bands are certain to be used to provide additional capacity and to avoid the congestion on the lower bands.

Rivalling the size of the new Comstar system is a satellite system planned by Satellite Business Systems, a combined venture of International Business Machine Corp., Aetna Life and Casualty Co., and Cosat General Corp. Since it will operate in the 12- and 14-GHz bands, its terminals can be in metropolitan areas without interfering with terrestrial microwave systems.

The system will use two satellites and will include dedicated full-period and on-demand capacity, along with time-division-multiple-access techniques. It will feature all-digital techniques for the transmission of voice, facsimile, and data and will provide point-to-point and multipoint service directly to the user in a switched,

private-line network, thus bypassing common-carrier land lines completely.

The next decade will witness continuing growth of domestic satellite systems to handle the expected increases in telephony, data, and television transmission. And an aeronautical satellite service will join the maritime service just launched. Satellite systems in the development and planning stages worldwide will continue to use the congested 4- and 6-GHz bands, but eventually will come to use higher frequencies, even well above today's 12- and 14-GHz limit.

What may well be the harbinger of a new breed of high-power, high-frequency satellites was launched last January. A U.S.-Canadian effort, the communications technology satellite will test technology, applications, and the social impact of satellites offering expanded services through smaller, cheaper earth stations. Many observers look upon the project as the forerunner of the direct-broadcasting satellite.

With an output of 200 watts—10 to 20 times higher than any of today's communications satellites—CTS will provide data on propagation in space and prove out the feasibility of using TDMA synchronization schemes in transmitting high-speed data via satellites. Also, it will determine if frequency-division-multiple-access techniques can adequately provide telephone channel-sharing for remote locations.

Also to be evaluated is reception of high-powered 12-GHz TV signals from satellite to 2-m antennas in metropolitan areas and the practicality of TV reception with a

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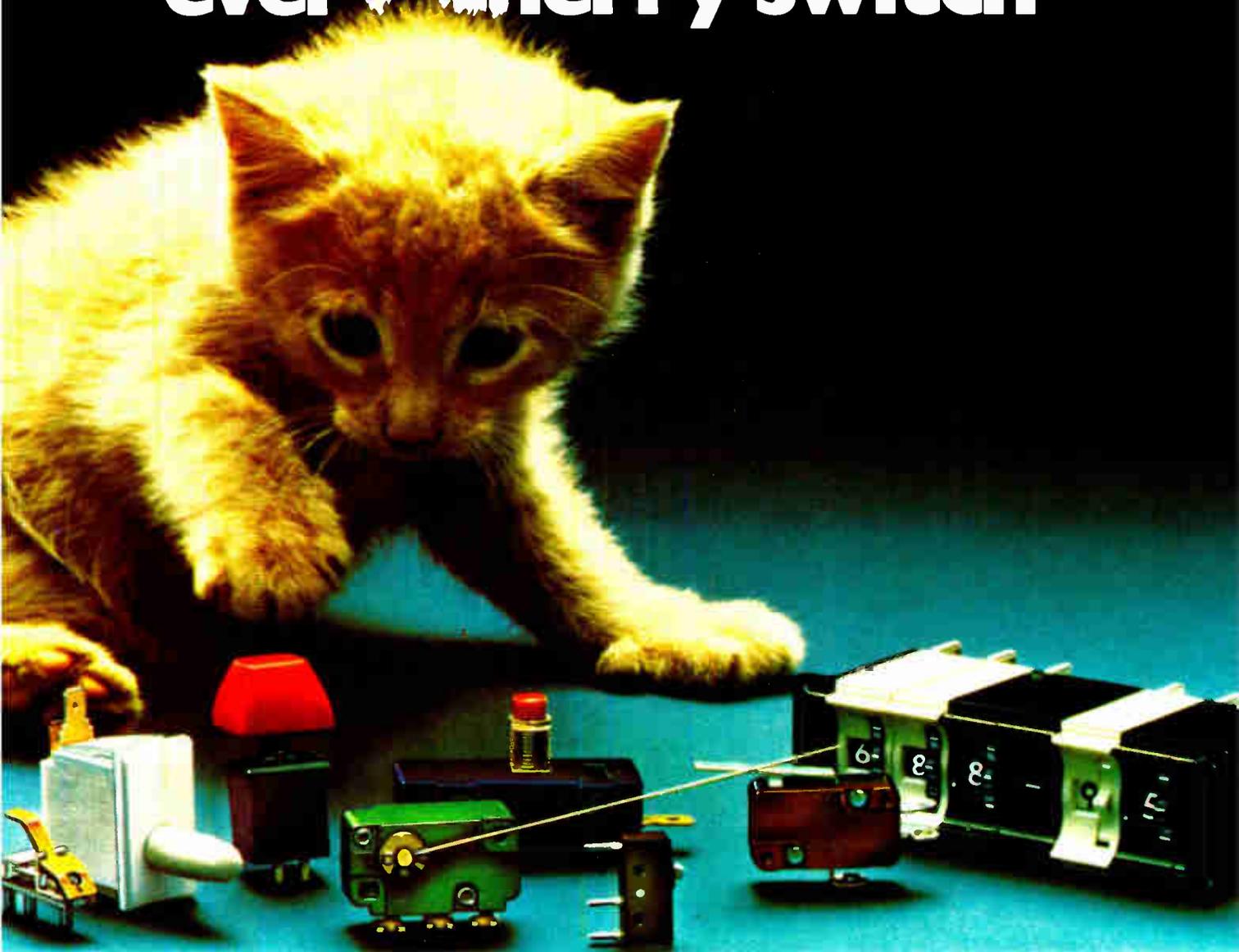
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dish antenna as small as 30 inches in diameter. The results could have a tremendous impact on planning of future TV-distribution systems and worldwide satellite communications systems.

CB adopts phase-locked loop

Makers of citizens' band equipment, busily trying to keep up with the exploding demand, are turning to phase-locked-loop technology, long a staple in more sophisticated frequency-control equipment. Its principal attraction is that it reduces the number of crystals needed to accurately generate the assigned frequencies. The January 1977 increase in channel allocation from 23 to 40 makes PPT frequency synthesizers even more attractive for CB radios.

But along with the FCC's granting of additional channels come more stringent restrictions on close-in spurious radiation from both transmitter and receiver sections of the CB sets.

New answers for phones

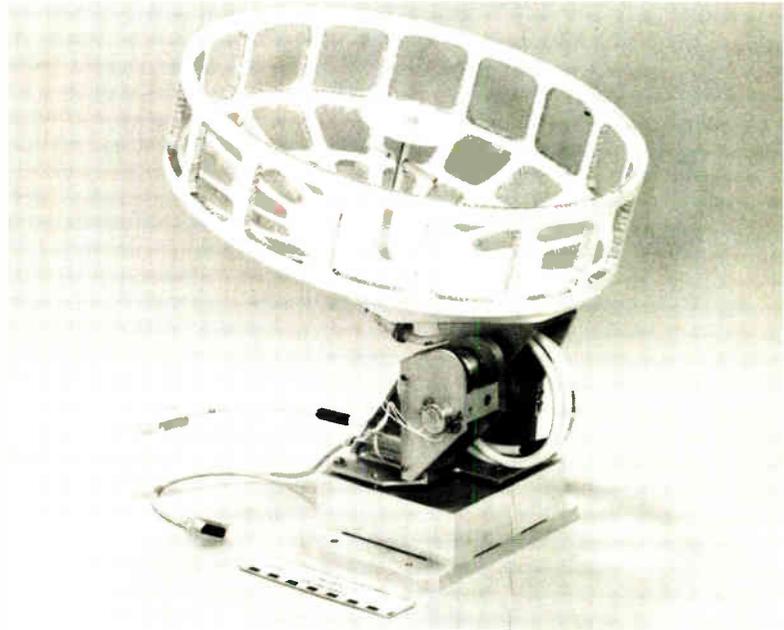
Advances in technology will help both operating telephone companies and outside firms to bring innovations in integrated circuits into the total network and into the telephone itself. The one part of the telephone system that really hasn't changed in over a hundred years, the telephone itself, is even getting a new look.

Bell Northern Research, the research arm of Bell Canada, has developed an exploratory all-electronic telephone (Fig. 1). Two hundred of them are undergoing user trials in the Canadian telephone system. The heart of the new equipment is an IC package that replaces the ringer, transformer-coupled speech network, and dial-pad assembly. It's built with bipolar integrated-injection logic technology that enables the stringent telephone-system specifications to be met with ICs for the first time.

These telephones are extremely cost-effective, according to BNR, since the highly labor-intensive electromechanical components are replaced with LSI circuitry that keeps dropping in price. The resulting reduction in component size also makes new receiver shapes possible. If field trials uncover no problem areas, these telephones will be used exclusively in the future.

Solid response

The FCC decisions to allow nontelephone equipment from outside companies to be connected to the telephone system have evoked a response from many semiconductor companies. Various products already or soon to be available use double-diffused-metal-oxide-semiconductor, complementary-MOS, I^2L , and standard bipolar technologies. Devices under development include cross-point switches, PCM coder/decoders, tone encoders with a variety of output codes and control functions, dial pulsers, repertory dialers, electronic ringers with added features, companders, and filters. Some companies are even considering developing \$20-to-\$30 all-electronic telephones with memory for repertory dialing and last-



3. Radar mapper. The antenna assembly being built for NASA Ames Research Center by Hughes Aircraft Co. will be part of the Venus-Pioneer radar mapper. Based on a high-efficiency configuration called the short-backfire reflector antenna, it uses a parabolic dish.

number-dialed options, as well as controlled tone ringing and display of number dialed.

Digital technology and the telephone

The digital telephone interests semiconductor manufacturers because of the potential high-volume market. But it is still too early to decide which is the best technology— I^2L or standard bipolar, n-channel MOS or C-MOS, one chip or two.

Companies are investing in various technologies to develop a coder/decoder that's cheap enough to install on each telephone line (about \$10). Precision Monolithics Inc., Santa Clara, Calif., and Exar Integrated Systems Inc., Sunnyvale, Calif., are two companies that have already announced the availability of a companded digital-to-analog converter, the most difficult component in the codec. National Semiconductor Corp. is working on a bipolar C-MOS codec for the telephone handset—the last component needed for a completely digital system. Signetics is using I^2L technology because it lends itself to combining analog and digital circuitry on one chip, and American Microsystems Inc. is working on an MOS codec, using a charge-redistribution approach. A single chip, all-digital codec from Intel Corp., Santa Clara, Calif., will use n-channel MOS technology.

For home telephones, there's much interest in using tone-key signaling to control functions remote from the telephone and to transmit and receive data after the call is completed. A tone encoder with controller equipment could control devices in the home, using a phone call to turn on the lights, for example.

General-purpose microprocessor architecture with all

the needed peripheral devices may be too expensive for many telecommunications applications, so an approach somewhere between the microprocessor and custom random logic may be what evolves. Some semiconductor companies foresee single-chip microprocessors with special instruction sets and hardware included on the chip to tailor it to such telephone applications.

Not all of the year's advances were in hardware. The major promise of computerized private-branch exchanges is vastly reduced equipment obsolescence, because additional user features and options are derived from software. And the promise is coming true.

The power of the stored-program computer-controlled switches introduced last year lies in the new features and system improvements brought about by software. Bell updated its Dimension PBX, as did manufacturers of other PBXs. For example, since its introduction in May 1975, the computerized branch exchange from Rolm Corp., Cupertino, Calif., it has been upgraded twice with additional software.

LSI shrinks radar antennas

Thanks to high-speed digital processing and low-cost memories, synthetic-aperture radar now appears very attractive for real-time, high-resolution applications. In fact, both range and azimuth resolution under 10 feet is possible. The SARs have very small antennas, but use digital processing to synthesize the performance of a very large one. The antenna and scan mechanism for the Pioneer-Venus radar mapper is shown in Fig. 3.

What was needed was upwards of 100 megabits of memory, high-speed arithmetic (up to 100 million multiplications per second), and high-speed analog-to-digital converters to handle at least as many samples per second. With low-cost mass memories, fast Fourier transform circuits, a-d converters, low-cost high-resolution radar is being considered for commercial aeronautical use, as well as in such areas as satellite mapping, crash location, and flood control.

As with telecommunications, microprocessor architecture isn't optimum for SAR. But the devices are finding their way into other communications equipment. For instance, they are taking over chores originally relegated to minicomputers in some navigational receivers. Substituting microprocessor technology along with several radio-frequency redesigns, Navigation Communication Systems, Inc. of Chatsworth, Calif. has sliced the cost of satellite navigational-receiver systems almost in half. An Intel SBC 80/10 microprocessor provides a fixed resident program to eliminate a big user problem: loading the program into core-type minicomputers.

And GTE Sylvania Inc. has developed a microwave receiving system controlled by a 8080A processor. Intended for reconnaissance, it operates in the 0.5-40-GHz region. The software provides flexibility for control, display, and switching functions. And, with microprocessor capability, the system can test itself and can select an optimum intermediate-frequency filter and scan rate when in automatic scan mode. □

Profile

Although the concept of communicating over light has been around for many years, what really made it practical was a low-loss glass fiber developed at Corning Glass Works in 1970. The scientists responsible for reducing fiber loss from more than 1,000 decibels per kilometer to 16 dB/km, agree that the key to that breakthrough was developing a pure enough glass composition that could be processed into hair-thin fibers.

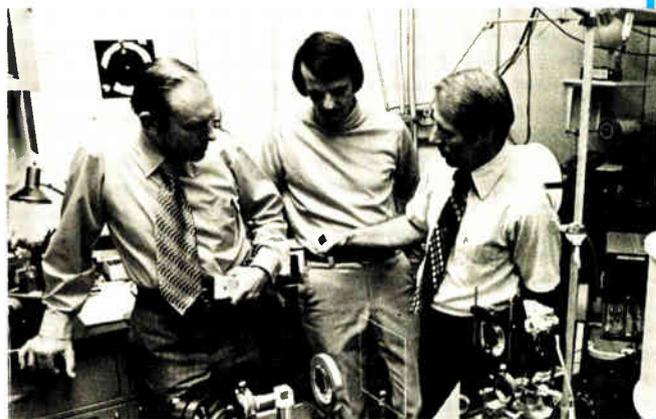
Providing the pure glass was only half of that battle, for it had to be fabricated so as to maintain the low-loss characteristics. Previously the thrust was to purify the more conventional glass ingredients before melting them. But the problem really boiled down to one of glass chemistry and unconventional processing techniques.

Peter C. Schultz (center), the chemist on the Corning team that developed the fiber, remembers being just a bit surprised that it had come so far in only a few years. "Until that time no one even knew if low-loss glass could be made," reflects the 33-year-old researcher. "It was a combination of chemical-vapor-deposition techniques and processing the high-purity glass compositions that made low-loss fibers a reality."

Donald Keck, a 35-year-old research physicist (right), viewed the breakthrough with guarded optimism. "When it happened, I carefully rechecked the measurements before I could believe that we really had produced a fiber with only 16-dB/km loss." Robert D. Maurer, the leader of the project, was elated at the breakthrough, but what he remembers best is the reaction to the paper that announced the existence of the fiber. "I was amazed at the quickness with which the audience grasped the potential of the fibers we had just developed," the 52-year-old Corning veteran recalls.

All three are still very much involved in the firm's continuing commitment to fiber-optics technology. Maurer is now manager of applied-physics research, Keck is a senior research scientist, and Schultz is manager of glass synthesis research.

The researchers predict a bright future for fiber-optic technology. "Optical fibers will find use in communications links that now use coaxial cable or copper wires," Maurer says, "areas such as computer and instrumentation links, CATV or 'wired-city' networks, and applications in power utilities and electric railways, as well as various government and military areas."



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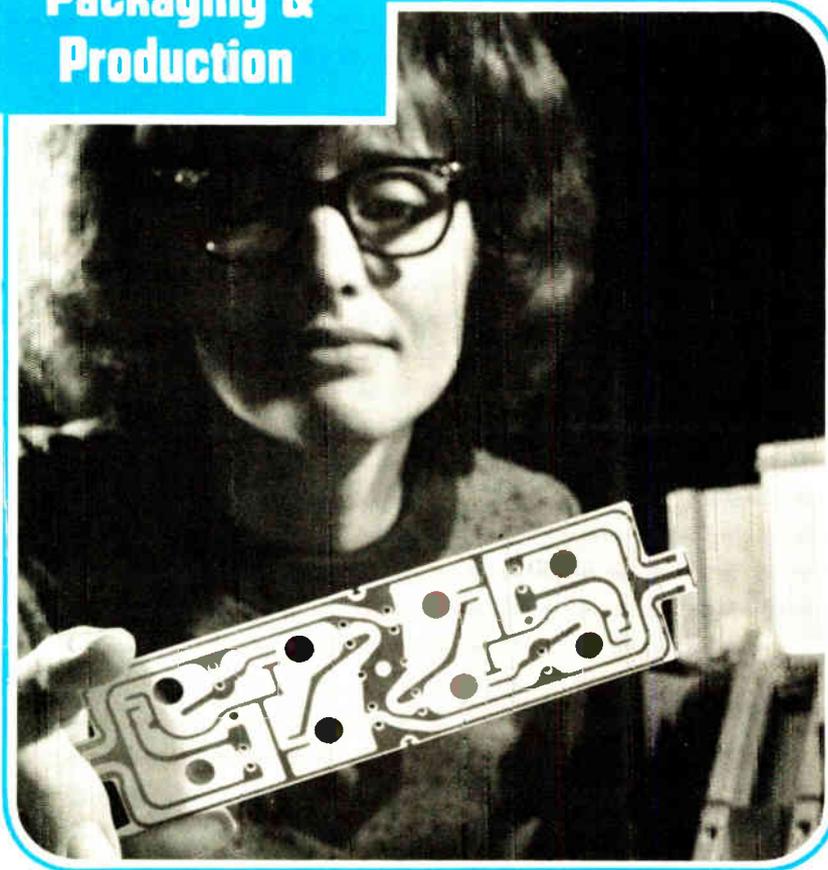
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Screened pc. A low-cost porcelainized steel circuit board developed at General Electric uses a screenable, low-temperature-fired, polymer-based silver ink for the conductive patterns of a flashbulb array.

Process adaptation shrinks interconnection costs

by Jerry Lyman, *Packaging & Production Editor*

□ In the never-ending battle for lower packaging and production costs, several skirmishes were won this year. Cheaper methods of building printed-circuit boards arrived, lower-cost (and better-performing) hybrid techniques were adopted, and new methods for packaging large-scale integration are appearing.

■ The year's most important development is the adaptation of thick-film inks intended for hybrid designs to printed-circuit boards.

■ A low-cost screenable copper-ink system emerged that is applicable to thick-film hybrids in every kind of circuit, from low-frequency to microwave.

■ A gradual adaptation of film-carrier technology to hybrids is appearing.

■ Also significant is the introduction of a tiny discrete-device package, several new LSI carriers, and two automatic-wiring methods.

Manufacturers of pc boards have long wished they could adapt the simple screen-and-fire process of thick-film hybrids, because labor, material, and machinery

costs are low compared to additive or subtractive plating. However, the 800–1,000°C firing of the screening process is well above the temperature limits of standard pc substrates such as epoxy glass and paper phenolic.

The silver screen

The wish has been fulfilled, thanks to last year's introduction of screenable inks that fire in the 65–150°C range. Methode Development Co., Chicago, is using them to produce on-board silver conductors, carbon resistors, and dielectrics. These inks, also available from Electro Science Laboratories, Pennsauken, N.J., and Electro-Materials Corp. of America, Mamaroneck, N.Y., can be screened onto a wide range of materials, from thermosetting plastics to conventional pc substrates. They are being used on pc boards for TVs, security systems, smoke detectors, and test equipment.

Most of the conductors are composed of polymer-based binders and silver. Resistor materials are based on carbon plus polymer binders and are available with

resistivity values between 10 ohms per square and 1 megohm per square.

While the resistors may be screened onto copper-plated pc boards, the real cost savings comes from screening both conductors and resistors onto bare substrates. "Resistor screening gives a pc manufacturer the equivalent of automatic resistor insertion without investing in expensive equipment," says Wayne Martin, Methode's chief engineer. "The resistors are simply designed into the pc pattern."

Aside from saving the cost of inserting discrete resistors or potentiometers, the cost of components is drastically cut. Martin cites the case of a customer who had 32 discrete potentiometers on a pc board. Each component cost 17 cents. Screened-on elements cost only 1-2 cents.

Another tack has been taken by General Electric Co. and GTE-Sylvania, who last year began producing screened-on pc boards for flash-bulb arrays. The boards, composed only of conductors, use a porcelainized steel substrate, which has an inherently high temperature limit, and a special resin-based silver conductor ink. Production time for GE's boards from screen printing through curing is only a few minutes, compared to up to 60 minutes for plated boards.

A related development is the introduction of polymer-based conductive inks by Electro-Materials Corp. and Engelhard Industries, East Newark, N.J. The inks can be fired onto porcelainized steel in the 550-650°C range. Since they are available commercially, they open up the possibility of using the coated steel for other electronics applications, such as less expensive hybrids.

Copper inks cut hybrid costs

This year's big story in hybrid thick-film technology is also an ink development. Cheap, screenable nitrogen-fired copper conductive inks have surfaced along with nitrogen-fired dielectrics and resistive inks. Practically all the air-fired conductive inks for thick films are precious metals—gold, palladium, silver, platinum, or compounds of them. They have two disadvantages: they are expensive, and they aren't easily soldered.

The new copper inks are relatively inexpensive compared to those based on precious metals. They are excellent conductors and can be soldered and wire-bonded. What's more, they have good adhesion, good solder-leach resistance, and excellent low-frequency and microwave properties.

Almost all the major hybrid-ink companies are supplying nitrogen-fired copper inks and dielectrics. While most of them have nitrogen-fired resistor materials in the laboratory, only Cermalloy, a division of Bala Electronics Corp., West Conshohocken, Pa., supplies a resistance ink compatible with the copper ink. The firm's NPS 7000 inks have a resistivity range from 100 to 100,000 ohms per square and a temperature coefficient of ± 500 parts per million.

Copper inks are already in use as conductors in multilayer hybrids, microstrip conductors, high-power

diode conductors on alumina and beryllia substrates, and as a termination material for certain types of capacitors. All major hybrid companies are evaluating them. For example, a comparative cost study by CII-Honeywell Bull in France of copper and gold multilayer substrates shows that the copper lowers substrate cost from \$1.80 to 16 cents (Table I). The comparison is between 2-by-1-inch substrates with two conductor layers separated by a double-printed dielectric.

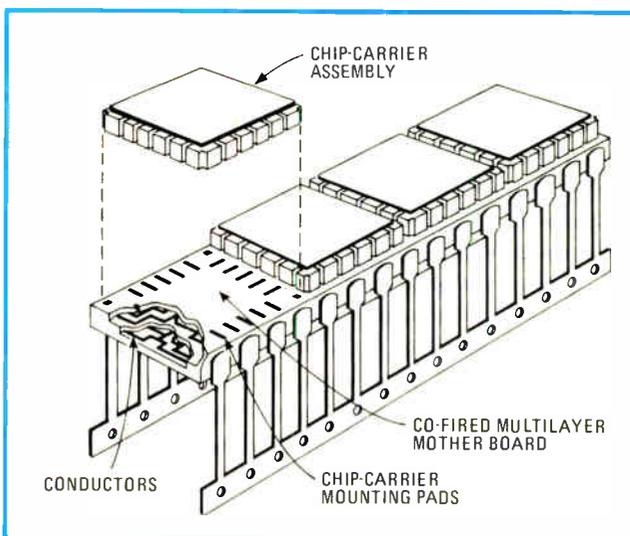
Another field where copper inks are finding immediate use is microstrip circuit applications at microwave frequencies. They require a full ground plane on one side and well-defined conductor patterns on the circuit side, so the ink must be capable of printing large areas and fine lines, as well as providing low direct-current resistance and low radio-frequency loss. Copper inks easily meet all these requirements, in contrast to the costly thick-film gold that requires expensive indium-bearing solders for chip bonding. These circuits can also be made by thin-film processes, but only with a large investment in sputtering or evaporation equipment.

Film carriers fit hybrid needs

Another hybrid development, as important as the new inks, is the adoption of film carriers for chip mounting. It is a solution to the yield problems for hybrid packages caused by the loss of chips during optical inspection, probe testing, and handling.

The film-carrier system uses a sprocketed, nonconductive film with a copper surface etched into the integrated-circuit interconnections. Specially bumped chips are automatically gang-bonded to the inner leads of the interconnections. (The bumps are raised, metalized interconnect pads.) The completed film can easily be moved for on-tape testing or outer-lead bonding.

Two factors have kept hybrid makers away from film-



1. Chip carrier/mother board. By combining four square, leadless ceramic chip carriers with a co-fired ceramic multilayered substrate, it is possible to put four LSI chips in the pc-board space that one chip in a standard dual in-line package would take.

carrier techniques. The major IC firms weren't willing to sell chips on tape; instead they were putting most of their output into dual in-line packages. And the hybrid manufacturer who decided to do their film-carrier work in house ran up against the lack of suppliers of either the bumped chips or of low-cost tape-bonding equipment.

Recently matters began to look up. Pactel Corp., Westlake Village, Calif., came out with a tape that has the copper interconnect pattern on one side connected through the tape to bumps on the other side. This should eliminate the need for specially bumped chips.

This year also brought some good news for those firms unwilling to go the in-house route. Motorola Semiconductor Products Group, Phoenix, Ariz., is prepared to supply standard chips (mostly digital logic) on all-copper-tape carriers.

Semiconductor packages shrink

"Think small" was the watchword for semiconductor packaging in 1976. Discrete components became available in a tiny reflow-solderable plastic package, and smaller alternatives to the DIP started appearing. In addition, some firms are beginning to use multilayer hybrid techniques to jam even more chips onto the LSI carriers usually occupied by standard DIPs.

This year saw the U.S. introduction of the 3-by-3-by-0.85-millimeter SOT-23 plastic packages for transistors,

diodes, optical couplers, and field-effect transistors and also of a companion unit, the 4.6-by-2.6-by-1.6-mm SOT-89 for 1-ampere switching transistors. These small semiconductors, made in Japan and Europe, can take rough handling and are suited to automatic insertion.

Consumer and industrial users of thick-film hybrids are the chief beneficiaries, because these packages are amenable to low-cost reflow soldering. For instance, SOT-23 transistors are being applied as display drivers for light-emitting diodes in digital wrist watches. Next, linear ICs will be put into this small package.

Saving precious pc-board space is the impetus behind the trend toward square LSI packages. One of the newest is the MiniPak from General Instruments Corp.'s Semiconductor Products division in Hicksville, N.Y. This glass-epoxy carrier is about 1/2 in. on a side, a third the size of a DIP. On this carrier, an LSI chip is wire-bonded to plated conductors linked to an array of solder bumps on the underside of the package.

After the chip is covered with a protective drop of epoxy, the solder bumps are reflowed to a pc board or substrate. At present the package is only being used for the firm's 28-pin ICs, but there are plans for adapting it to all of its custom and standard ICs.

Another new approach to maximum LSI packaging density is the chip-carrier/motherboard design from Minnesota Mining and Manufacturing Co. (Fig. 1). In this technique, a rectangular, multilayered, cofired ceramic substrate with a lead frame attached acts as the motherboard for four LSI chips sealed in small, square ceramic chip carriers. The carriers are reflow-soldered to mounting pads on the motherboard and are easily removed for repairs. The entire assembly occupies the space of a standard DIP carrying one of the LSI chips.

As well as easing removal, the carriers facilitate chip pretesting. The motherboard substrate offers extremely short lead lengths that allow full-rated IC switching speeds. Since most interconnection is on the motherboard, the system pc can be a simple double-sided type, rather than a multilayer type.

The Wire-Wrap process has dominated the automatic-wiring field because of its readily available machines and

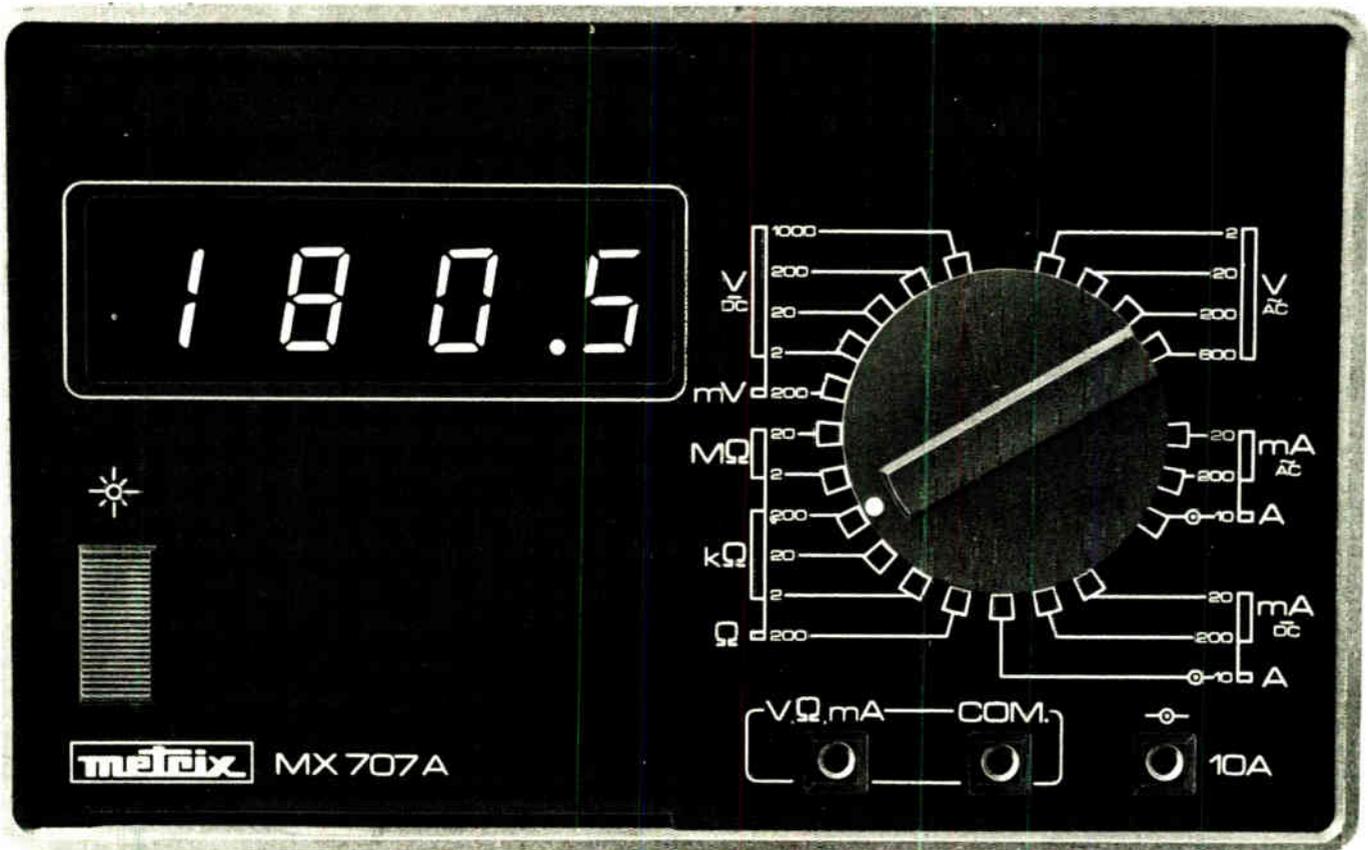
TABLE 1: PASTE COST OF GOLD AND COPPER HYBRID-SYSTEMS

	Gold system		Copper system	
	Conductor layer	Dielectric layers	Conductor layer	Dielectric layers
Quantity of paste (mg)	258	170	134	170
Paste price* (\$/g)	6.70	0.43	0.45	0.43
Cost of used paste (\$)	1.73	0.073	0.060	0.073
Nitrogen: cost of separate firings (\$)			0.018	0.01
Total cost of substrate (\$)	1.80		0.16	

*June 1975

TABLE 2: COMPARISON OF INTERCONNECT PROCESSES

Process	Requires artwork	Engineer design	Engineer changes	Density (surface/cubic)	Production cost	Field-changeable	Prototype process	Schottky logic
Two-sided boards	yes	long (6 - 10 wk)	artwork changes	low / high	low	poor	very poor	poor
Multi-layer boards	yes	long (10 - 12 wk)	artwork changes	high / high	high	very poor	very poor	good
Wire-wrap	no	short (2 - 4 wk)	no artwork	high / low	high	good	good	fair
Stitch-weld	no	short (2 - 4 wk)	no artwork	high / fair	medium to high	fair	good	fair
Single-sided solder-wrap	no	short (2 - 4 wk)	no artwork	high / high	low	good	good	fair
Two-sided solder-wrap	no	short (2 - 4 wk)	no artwork	high / high	low to medium	good	good	good



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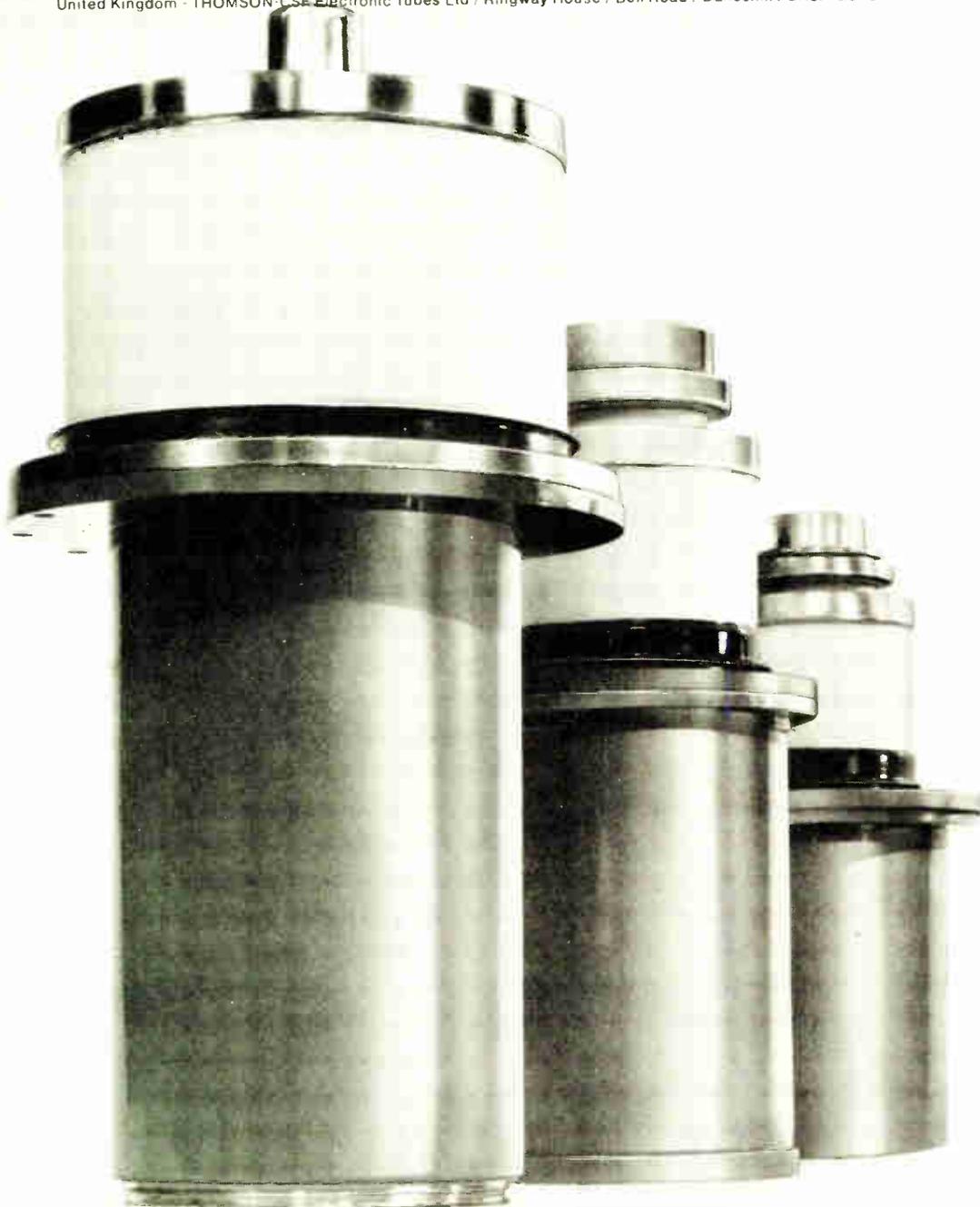
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special IC socket panels with pin matrices. Now two new contenders are entering the arena: Solder-Wrap, from United Wiring and Manufacturing Co., Garland, Texas, and Bell Laboratory Inc.'s Quick Connect.

Solder-Wrap is already in use by Texas Instruments Inc. and Control Data Corp. The Bell Labs system, on the other hand, is still confined to in-house use.

Alternatives in automated wiring

The United Wiring process forms interconnects at speeds two to three times as fast as Wire Wrap—as much as 2,400 connections per hour on automatic equipment. It routes a fine insulated wire to the protruding pins of components previously inserted in a specially patterned pc board. The individual wires and component leads are soldered to the pc pads by a soldering probe, which simultaneously melts away the wire insulation at the solder area.

Solder-Wrap has completely automatic equipment with a self-checking feature that makes sure of each connection. The process will not proceed if an error in wiring has occurred. Wiring costs are said to be 20–30% lower than for competitive methods. So far Solder-Wrap has been used extensively for transistor-

transistor logic, as well as for emitter-coupled logic where it is possible to put down twisted pairs to eliminate cross-coupling and reflections. Table 2 (furnished by United Wiring and Manufacturing) compares Solder-Wrap to its major competitors in this field.

Quick Connect, the second new automatic-wiring method, was developed at Bell Labs, Holmdel, N.J., by Charles Von Roesgen, supervisor of optical systems. It began as a breadboarding technique that had insulation-piercing terminals on one side and special pins to accept IC leads on the other. Arrays of these pins were mounted on special epoxy-glass boards with plated-on ground and power planes. The boards were wired by pressing insulated wires into the terminals, making a gas-tight connection. The system's low profile (about 420 mils including DIPs) permits use of high-speed logic.

With the addition of a semi-automatic, self-checking wiring machine that accepts Wire-Wrap software, Quick Connect has become a full-fledged automatic-wiring system. Von Roesgen says it is at least twice as fast as Wire-Wrap. Hundreds of boards have been wired at three branches of Bell Labs, most of them with TTL and TTL-Schottky logic. This system is not commercially available, but the firm will probably license it. □

Profile

In late 1971, market researchers at Owens-Illinois Inc., Toledo, Ohio, decided that the rising cost of precious metals made the time right for research on non-noble conductors for thick-film microelectronics. A young chemist, John D. Grier, who had been with the firm for five years, was assigned as program manager.

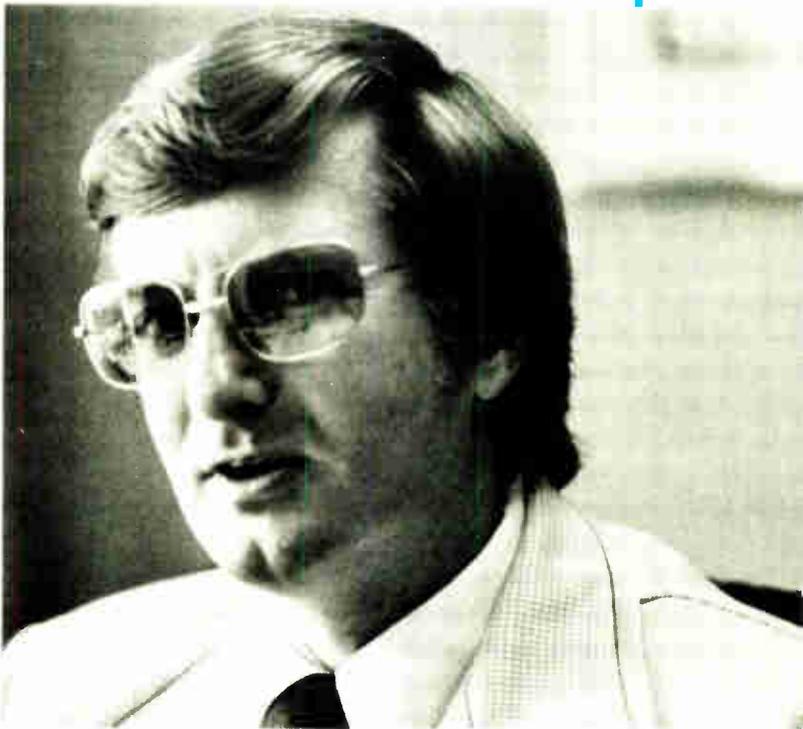
Grier decided to concentrate on creating a workable nitrogen-fired copper paste. There had been earlier research on copper pastes, but these compositions used 100-micrometer copper particles to produce conductors with poor peel strength and low conductivity.

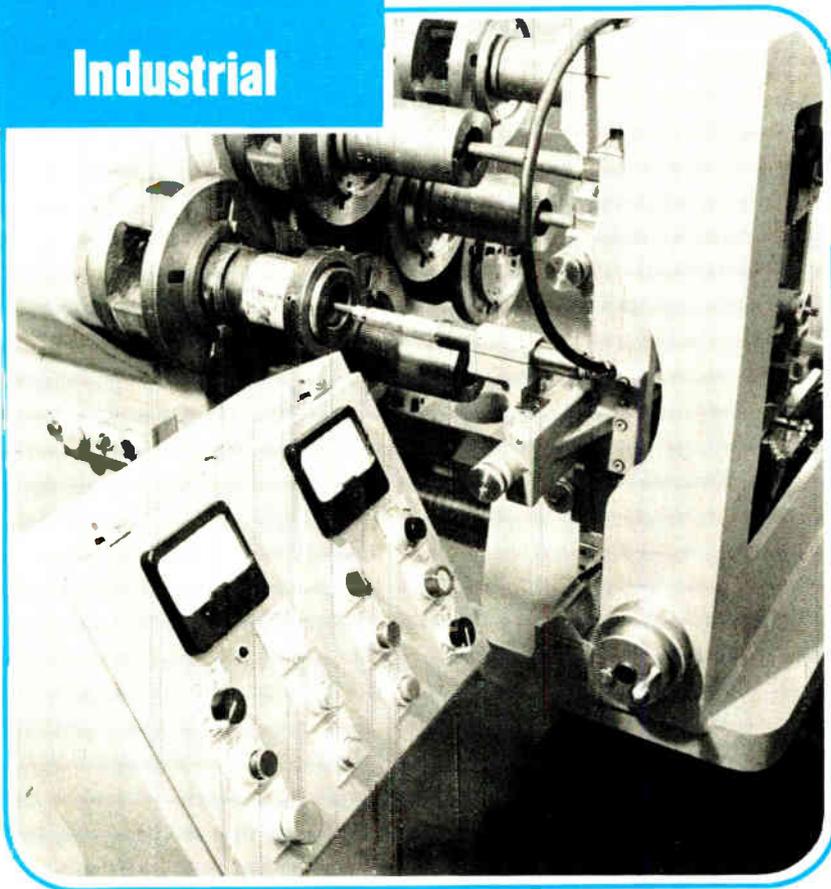
He went to 3-to-5- μm copper particles for the functional phase of the ink and found both a glass binder and vehicle that could survive firing at about 800°C. The late 1972 result was a patented, practical, screenable copper paste that had good peel strength and conductivity. At that point Grier correctly predicted that the new copper paste would be suitable for microstrip and thick-film hybrid applications.

After leaving Owens-Illinois in January 1973 and spending a short time at Dynasil Corp. of America, he came to the Cermalloy division of Bala Electronics Corp., West Conshohocken, Pa., as director of new-product development. It was there that he continued his original work on base-metal inks and developed a full copper system of conductor, resistor, and dielectric inks. In addition, he created a low-firing-temperature (580°C) nickel ink suitable for gas displays fabricated on black alumina substrates. He has also done extensive work on other base-metal inks such as zinc and aluminum, which is radiation-resistant.

"Base-metal technology, and copper in particular, will take advantage of all the experience hybrid manufacturers

have already gained in air-fired systems to cut the time lag for the full use of these new inks," Grier says. "Large numbers of microstrip circuits using copper inks will appear this year followed in about a year by multilayered thick-film hybrids with copper conductors."





Mold maker. Six-spindle bottle-mold machine with Honeywell controls can produce five molds in approximately 6½ hours.

More tools, processes yield to microprocessor control

by Michael J. Riezenman, *New Products Editor*

- Activity has been lively in three areas:
- Microcomputer-controlled machine tools.
- Microprocessor-based process-control systems.
- The development of semiconductors for the generation of electricity, and the control of its consumption.

Microprocessors are finally getting into the mainstream of industrial new-product development. Although only a year or two ago they were regarded merely as promising devices, they are now routinely used in a variety of applications—principally in the machine shop, in process control, and in energy-management systems.

Some progress has been made in the use of photovoltaic cells to generate electricity. But the day on which they become serious competition for oil is still in the unforeseeable future.

Controlling the machine shop

Electronic control, of course, has carved out its niche in the machine shop. But this year, some changes have been made in the size of that niche, as well as in what's

filling it. As the doors closed on last month's giant International Machine Tool Show, attendees, who are accustomed to the increasing price of iron, were amazed by the falling price of silicon. More new machine tools have numerical controls instead of manual ones, more numerical-control systems include computers, and more of those computers are microcomputers rather than more expensive minicomputers.

Although two years ago only one computer numerical control was being built around a microprocessor, a half-dozen controls manufacturers are now offering CNCs built around microprocessors instead of minicomputers [*Electronics*, Sept. 16, p. 44]. General Electric Co., Waynesboro, Va., by far the largest control maker, has filled out its line with several new controls, including a low-cost family with limited capabilities that is built around Toshiba 12-bit processors and programable read-only memories. Its pioneering 1974 entry, the Mark Century 1050, used a five-chip IMP-16 from National Semiconductor Corp. and more than a score of dedicated

arithmetic processors. McDonnell Douglas Corp. hopes to become an important controls manufacturer through its Actron division in Monrovia, Calif., while Germany's Siemens AG and Japan's Fujitsu Fanuc Ltd. are pursuing the U.S. market through a joint venture, General Numerics Corp., in Elk Grove Village, Ill. Actron is building its control around a microprocessor from Nitron, a division of McDonnell Douglas, while General Numerics is using an Intel unit.

Divide and rule

The microprocessor has presented manufacturers of process-control systems with the combined opportunity and problem of distributing intelligence around the plant, rather than concentrating it in one central computer or a small number of computers. The advantages include increased reliability—especially minimizing the effects of failure of any single computer, reducing communications requirements, and reducing system costs. The major problem now is to figure out the best way to distribute intelligence around a plant.

One approach, that of Beckman Instruments Inc., Fullerton, Calif., is to use one microprocessor for each control loop in a system. The Beckman series 8000 ASCII computer interface system, which was unveiled earlier this month at the Instrumentation Society of America show in Houston, doesn't so much distribute intelligence as reduce communications costs. It allows a single five-wire data bus to connect a maximum of 36 controllers to one computer port. Most other techniques require that each controller have its own set of wires going to and from the computer. At an estimated cost of \$5 to \$10 per connection in the field, plus the cost of wire and ductwork, it is clear that this so-called data-highway approach can produce large savings.

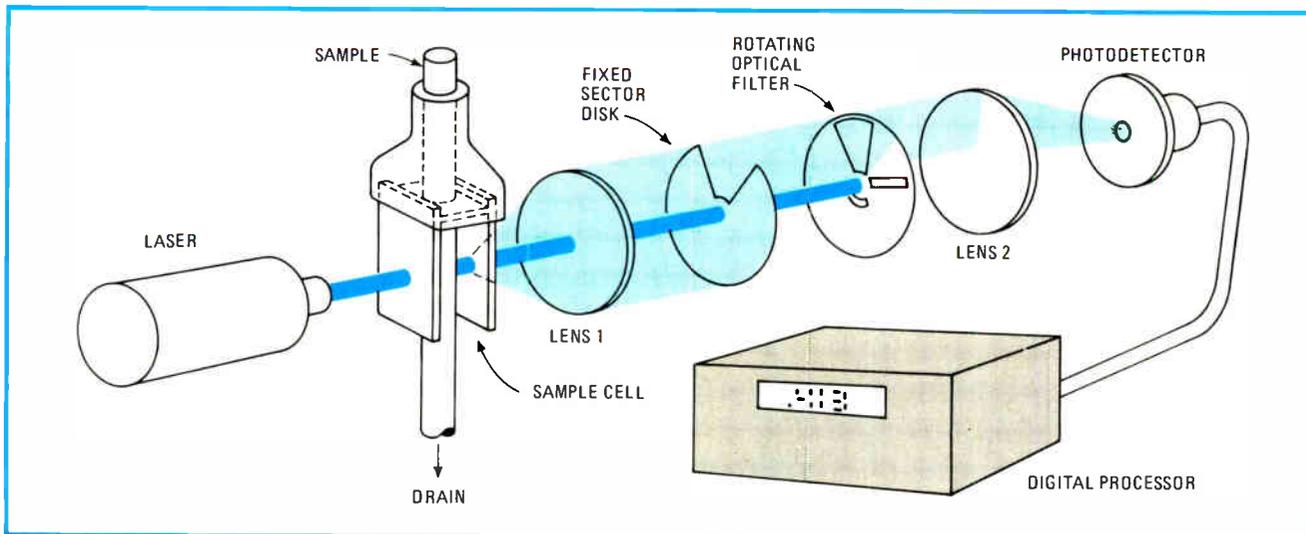
A somewhat different method is being applied by Honeywell's Process Control division, Fort Washington, Pa. Its TDC 2000 system also communicates over a data

highway, but a single microcomputer controls up to eight loops. The microcomputer acts not only as a communications controller but also as a local process controller. It can make changes in the setpoints of some of the loops under its control as they are affected by changes in other loops. This not only allows for more efficient operation of the system if the central computer fails, it also relieves the central machine of much of its simple, but time-consuming and repetitive work.

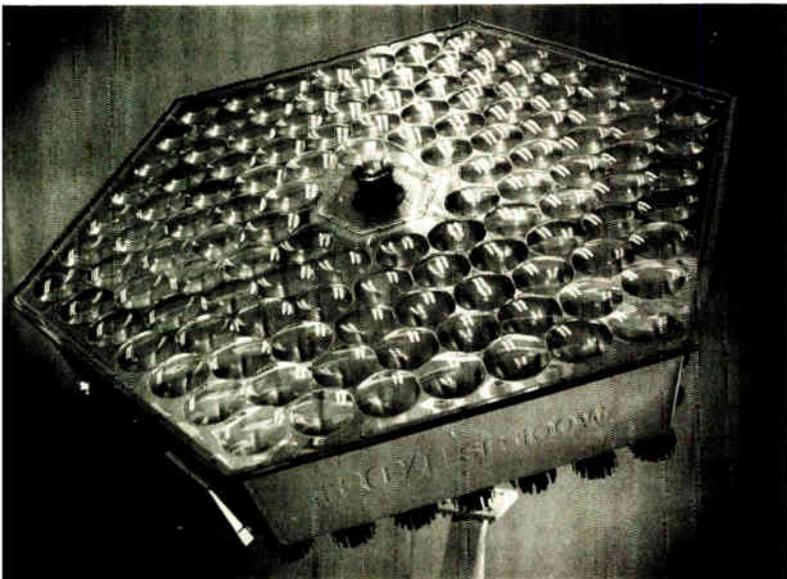
While microprocessors are cutting costs and increasing the reliability of minicomputer-based process-control systems, at the individual-instrument level microprocessors make possible devices that were economically impossible before. "Smart" recorders and plotters, for example, are being offered by several companies. One measuring device that combines two recent technologies—microprocessors and lasers—is the Microtrac particle-size analyzer recently developed by Leeds & Northrup Co., North Wales, Pa. Useful for measuring particle-size distributions in such varied applications as ore-grinding, pottery-manufacturing, flour-milling, and the preparation of pharmaceutical powders for compression into pills, the Microtrac device can handle particles measuring anywhere from about 1 to 200 micrometers.

The analyzer (Fig. 1) works by passing a laser beam through a sample of the material being studied and then measuring the characteristics of the light scattered by the particles. (The laser is used not for its monochromatic or coherent properties, but because it is an inexpensive, reliable source of well collimated light.) After the scattered light emerges from the sample cell, it is collected by lens 1 and projected through a fixed sector disk and a computer-generated rotating optical filter to the photodetector.

The photodetector output is sent to the digital processor where it is digitized by an analog-to-digital converter and processed by a microcomputer built around an Intel 8008 microprocessor. The microcom-



1. Particle sizer. Small particles scatter laser light further from its axis than do large particles. Exploiting this phenomenon, Leeds & Northrup's Microtrac analyzer uses a rotating optical filter to determine mean particle size and standard deviation.



2. Keeping cool. Although operated under concentrating lenses, this RCA silicon-cell array keeps its temperature rise to only 10°C by using small cells spaced relatively far apart on a heat sink. At 1,000 suns, the array has an efficiency of 10%.

puter correlates the photodetector output with the angular position of the rotating filter. Data displayed by the digital processor includes mean particle size and standard deviation of particle-size distribution.

Solar cells dawdle

The economical generation of electricity by photovoltaics still faces a chicken-and-egg dilemma: the price of solar generators is too high to make them competitive

with alternate sources of electricity for most applications, and demand is not yet sufficient to attract enough suppliers to drive the cost down. However, that situation is changing slowly. The Federal Government's Energy Research and Development Administration has recently announced that the cost of using solar cells to generate 1 watt of peak power has been halved from about \$30 to a little more than \$15 in only 18 months. Meanwhile, the conversion efficiency of silicon cells in volume production has crept up from about 10% two years ago to 12% today, and 15% is being promised two years hence.

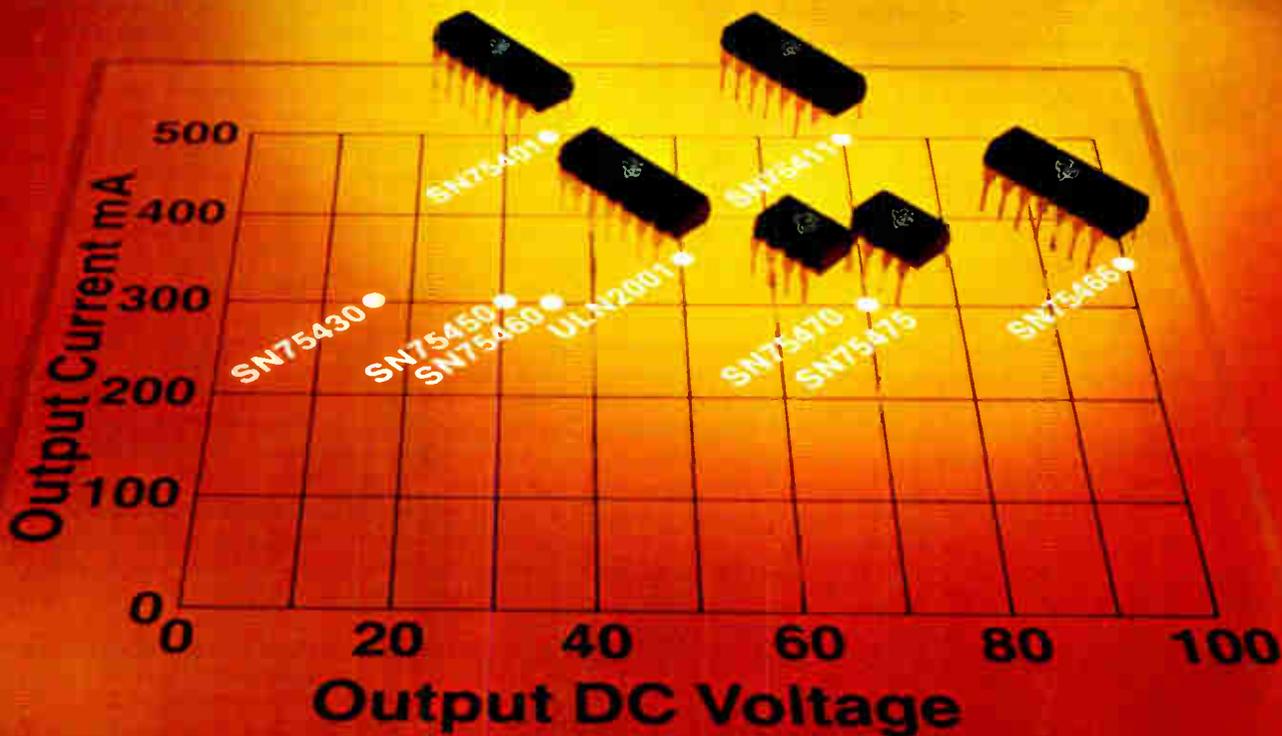
But when the ERDA price goal of 50 cents per peak watt by 1986 is considered, it's clear that U.S. producers still have a long way to go. ERDA officials say that's the price at which solar generators can readily compete with other energy sources across the board, not merely at remote sites where it's too costly to install land lines.

Further, there's some indication that silicon may have fundamental limitations that won't allow much more than 18% to 20% conversion efficiencies. That's one reason silicon-cell makers are looking more and more at sunlight concentrators—lenses that intensify the light focused on their arrays (Fig. 2).

Of more immediate value than its potential as a source of electricity is the capability of electronics to conserve energy through careful control of its usage. This idea is being implemented at present mainly in the control of the heating, ventilating, and air-conditioning (HVAC) systems of large commercial and industrial buildings. This may not solve the energy crisis, but it is a good first step, and it can be done now. □

EFFECT OF COMPUTER CONTROL IN VARIOUS PROCESSES				
Process	Major importance	Relatively important	Relatively unimportant	Minor importance
Drilling				
Milling				
Jig boring				
Grinding				
Gear cutting				
Turning				
Welding				
Die sinking				
Cold forming				
Hot forming				
Hot rolling				
Cold rolling				
Powder metallurgy				
Pressure die casting				
Precision casting				
Injection moulding				
Extrusion				
Wood-working				

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And no problem with driving inductive loads. TI's new SN75475 and

SN75466/67/68/69 have output clamp diodes built-in on the chip. No externals required.

TI PERIPHERAL DRIVER FAMILY						
	No. per Package	Latch-up Voltage	Typical Speed	Logic Type	Package	
SN75430-SN75434	2	15V	13ns	Ad	N/J/P/JG	
SN75450-SN75454	2	20V	20ns	All	N/J/P/JG	
SN75460-SN75464	2	30V	42ns	All	N/J/P/JG	
SN75470-SN75474	2	55V	42ns	All	N/J/P/JG	
SN75401-SN75404	2	30V	42ns	All	NE	
SN75411-SN75414	2	55V	42ns	All	NE	
SN75475	2	55V	42ns	NAND	P/JG	
ULN2001-ULN2004	7	50V	1µs	Inverter	N/J	
SN75466-SN75469	7	60V	1µs	Inverter	N/J	

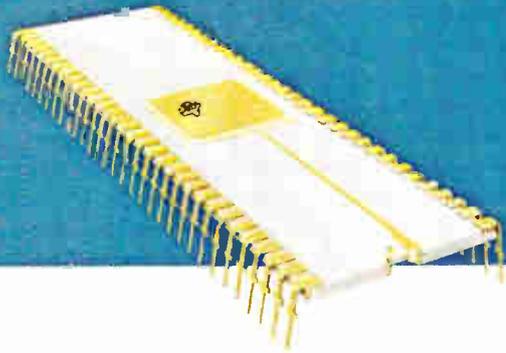
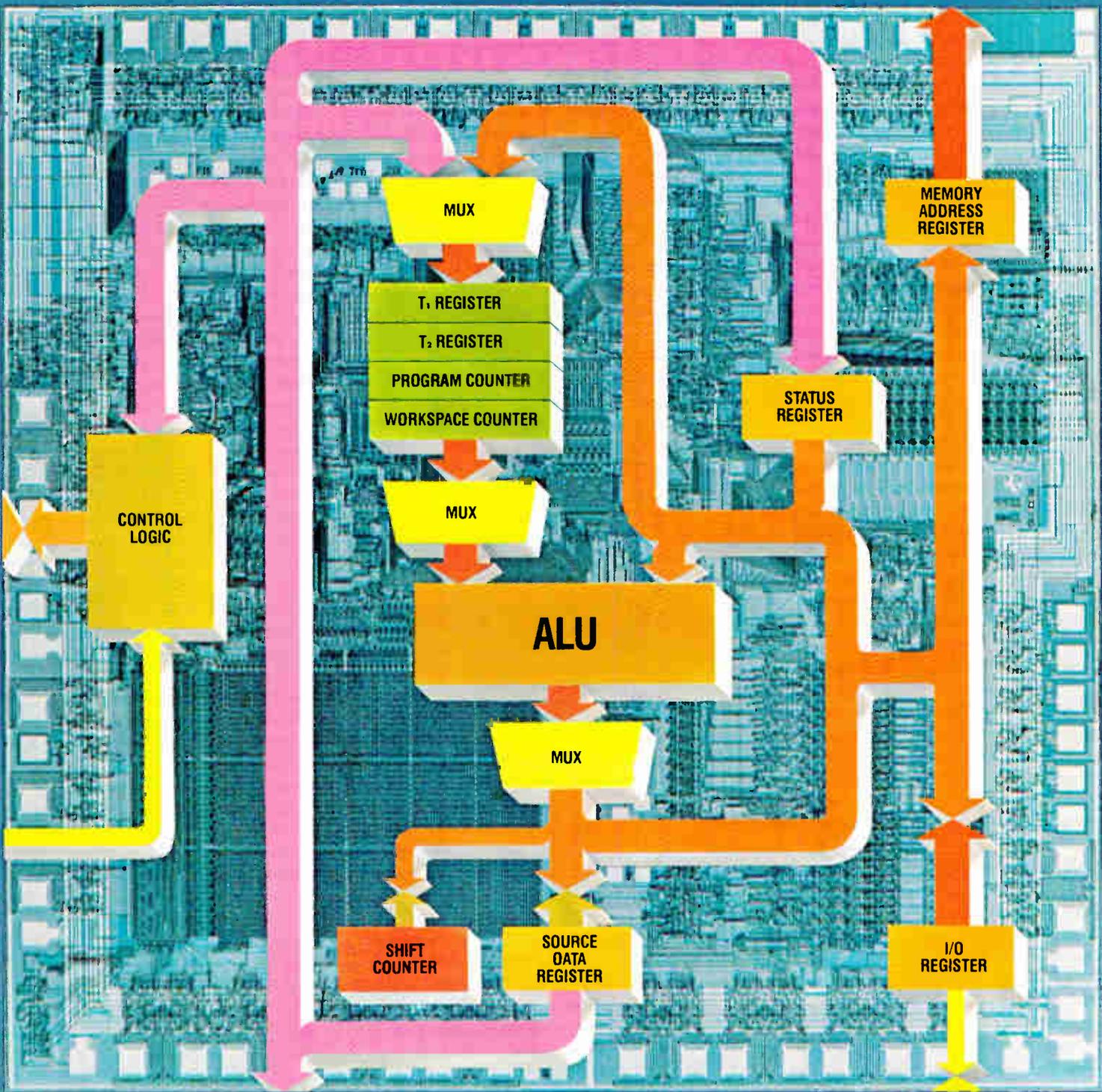
N=14-pin plastic DIP; J=14-pin ceramic DIP; P=8-pin plastic DIP; JG=8-pin ceramic DIP; NE=Heat sink 14-pin plastic DIP.

Another new wrinkle: the SN75401 and SN75411 Series come in a special low thermal impedance (NE) package with copper-clad silver-plated leads. You have a choice of logic functions—AND, NAND, NOR, OR—as well as packages. Excellent availability; competitive prices.

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- 30% faster execution time
- 50% saving in program coding
- 50% saving on system interface costs
- 50% more efficient interrupt handling
- 20% reduction in memory bit requirements

These benefits stem from the TMS9900's advanced features:

16-bit instruction word with full 16-bit data precision.

Operation at 3.3 MHz clock rate.

Full minicomputer instruction set including hardware multiply and divide.

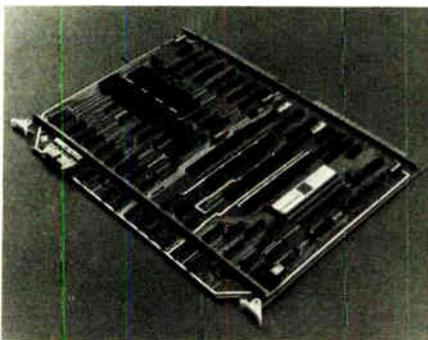
Advanced memory-to-memory architecture that locates general-purpose register files in memory.

Separate address, data, I/O and interrupt buses.

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990/4 Prototyping System

More 9900 Family Soon

The TMS9900 is just the beginning. Future family circuits, all software compatible: SBP9900, an I²L microprocessor designed to handle military temperature ranges. TMS9980, an N-channel μ P with an 8-bit data bus for smaller systems.

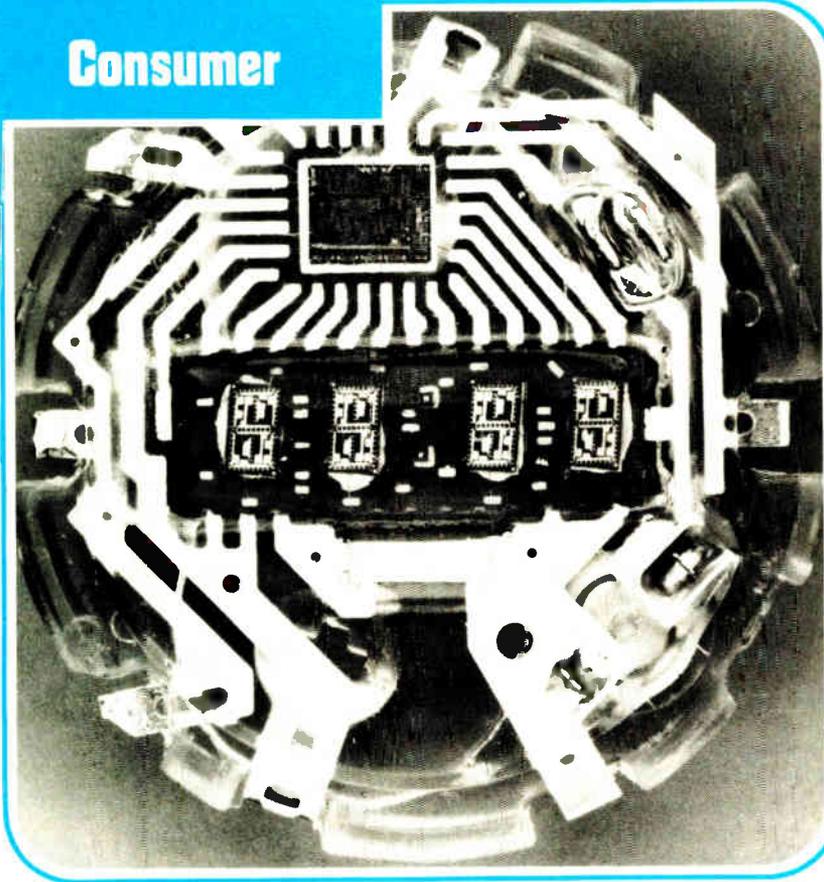
Also coming are 9900 peripheral support circuits: TMS9901 programmable systems interface. TMS9902 asynchronous communication controller. TMS9903 synchronous communications controller. And the TIM9904 low power Schottky TTL 4-phase clock generator.

Applications Workshops

TI distributors are sponsoring applications workshops in 36 locations across the nation beginning in November. For more information about the workshops, the 9900 First Family, or price and availability, contact your TI field sales office. Or write Texas Instruments Incorporated, P. O. Box 1443, M/S 669, Houston, Texas 77001.



TEXAS INSTRUMENTS
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Trend setter. A good example of the rapid application of LSI technology in low-cost consumer products is the Texas Instruments plastic case watch that retails for \$19.95. The module (left) is a chip and lead frame encapsulated in plastic (opaque in actuality) similar to other standard IC packages. It makes automated production possible for large-volume output at low total cost.

LSI chips taking over more household chores

by Gerald M. Walker, *Consumer Editor*

☐ Cooks, commuters, competitive types, and clock-watchers may not be aware of it, but microprocessors are about to enter their lives. Already established in such commercial products as point-of-sale devices and text editors for the office, the devices will soon be titillating the consumer's fancy in video games, microwave ovens, automobiles, and even some digital watches.

- Using other LSI circuits, TV makers are equipping their sets with remote electronic tuning and automatic color control as well as rigging them for video games.
- Further ahead, some imaginative entrepreneurs hope to team the TV set with a Touch-Tone telephone keyboard and a microprocessor for data processing.
- In digital watches, μ P and C-MOS chips are competing, and so are LED and LCD displays.
- Although the calculator must have nearly reached the maximum performance for the lowest possible price, nonvolatile memories are being installed for the first time in scientific models.
- An expensive video offshoot, projection television, has

begun to move into American homes. But development of video-disk players has slowed, though Japanese manufacturers of video-tape recorders are jockeying to establish their products as the VTR player/recorder standard for home systems [*Electronics*, Oct. 14, p. 68].

- Home appliances are rapidly getting solid-state controls to conserve electricity as well as for timing precision.
- After a couple of years of idling, automobile electronics is being shifted into high by the Environmental Protection Agency's tightening of emission standards, the public's demand for fuel economy, and the likelihood of renewed Government interest in mandatory air bags. The first digital microprocessor will be installed in a 1977 car, and more—many more—are sure to follow.

Games score with microprocessors

In the past year, the most successful video games have been adaptations of the popular paddle-type games originally developed for arcades. Home games are becoming

so popular that a couple of dozen companies are trying to get a piece of the action. More variations and increased difficulty have been added by the entry of the first microprocessor in a game.

The microprocessor has brought about programs for additional games stored in digital tape cassettes. Some of these games, such as blackjack, enable the player to compete against the microprocessor. Most of the first-generation games have been based on MOS chips that generate images of the paddle, the ball, and playing field, as well as store the logic necessary to control movements of the players and ball.

Although the simple paddle-type games have barely reached the market, the TV industry is excited over next-generation programable games based on microprocessors, such as Fairchild's Video Entertainment System (VES), built around an F-8 microprocessor set. The reason for the excitement is obvious: the games using hard-wired LSI chips are no match for microprocessor-controlled systems in variety of challenges and sheer playability. Some programable games aimed for high-volume production will probably contain dedicated custom processors rather than standard units like the four-chip F-8.

The Fairchild VES, which uses additional random-access memory and video modulator circuits, will probably be converted to a dedicated microprocessor later. The present model, priced at \$150, consists of a set-top console that contains two preprogramed games and a pair of joystick controls. The VES is programed by a library of digital tape cartridges, called Videocarts, which are inserted into the console. By the end of the year, Fairchild hopes to have five Videocarts offering 10 games and four types of arithmetic quizzes.

Although building game chips into the TV set is an efficient way to use them, the resulting sets may become obsolete so that fewer people will buy them than if the consoles are connected to the antenna terminals of

existing home receivers. German manufacturers are leaning toward the built-in approach, but in the U.S., only Magnavox has elected to do so. That company, which in 1972 offered Odyssey as the first video game, will have a \$499 19-inch model that contains a three-game chip supplied by General Instrument Corp.'s Microelectronics division in Hicksville, N.Y. Texas Instruments has been supplying PL chips for Magnavox's other Odyssey models.

The leading supplier of multigame chips this year has been General Instrument Corp. Later, National Semiconductor Corp. of Santa Clara, Calif., introduced a chip for three games in full color that will be used in a game to be marketed by National's Consumer Products division.

For the set owner who wishes to spend less money, Texas Instruments, Dallas, has introduced a two-game monochrome chip. In contrast to the \$60 to \$120 for most units, games using the TI entry could retail for \$30 to \$40. And ITT's West German subsidiary, Intermetall, is introducing a chip for the European market.

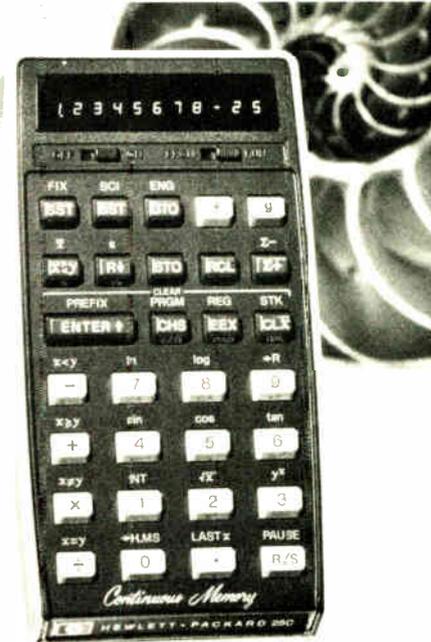
By the end of the year, General Instrument will be offering three more games. One design, built around a microprocessor, provides blackjack and slot-machine games of chance. Another will be the second-generation chip for a paddle-and-ball game, and the third will be a battle game on one or two chips.

GI's n-channel MOS chip enables an original-equipment manufacturer to build a game fairly easily. In addition to the chip, the only components required are an oscillator-modulator, a couple of potentiometers, a power supply, a switch to decouple the game console from the TV antenna, and a case to hold the circuit boards. For manufacturers of add-on games, however, a formidable technical hurdle—the Federal Communications Commission—must be cleared. Type approval must be obtained for these Class I TV devices, which must conform to specifications in part 15 of the FCC rules

1977 ELECTRONIC GAME PRODUCTS		
	Selection	Retail price
Arcade (high end)	dedicated arcade games reprogrammable pinball machines reprogrammable arcade games	\$1,000 to \$3,000
Recreation room	free-standing (cassette programable) pinball card games	\$200 to \$500
TV add-on	ball and paddle (second generation) battle race cards/gambling/doodle (programable) educational (interactive)	\$25 to \$100
Non-TV	boxes hand-held	\$10 to \$50



1. Selection. All-electronic tuning has been advancing rapidly in West Germany. For example, this Grundig channel-selection system designed jointly with TI, features scan and select frequency search. When user finds correct frequency, he enters it into memory.



2. Watch memories. Microma's LCD chronograph watch (left), which sells for under \$100, is based on a mask-programable MOS circuit from Intel. Hewlett Packard's HP-25C programable scientific calculator has a C-MOS continuous memory that retains input when turned off.

which cover interference regulations.

The television receiver itself has been undergoing considerable changes in the last few years. The 1977 line is chock-full of innovations that range from digital electronic-tuner address systems and automatic color controls to the picture tube itself.

TV sets get revamped

The rapid improvement of electronic tuners with LSI digital address systems has made it possible to design truly efficient remote controllers, some of which can change contrast, brightness, color intensity, channel, and volume, as well as switching the set on and off. In Europe, which is ahead of the U.S. and Japan in acceptance of remote tuning, both infrared and ultrasonic systems are being used.

U.S. set designers for the last few years have been working toward automatic control of contrast, brightness, color saturation, and tint. There are now two ways to go—either internal factory-preset controls and circuits that correct picture appearance to match these settings or external decoding of the vertical-interval reference (VIR) transmitted by some broadcasters on the 19th line for each frame. Thus far, only the General Electric Television Business department, Portsmouth, Va., has elected to go the VIR route.

GE's VIR system identifies the 19th line and decodes the reference data, which automatically adjusts the color control. If the VIR switch is not turned on or the station being received is not transmitting the VIR signal on the 19th line, the receiver must be operated by manual controls. Circuitry to detect and process the VIR consists of five off-the-shelf TTL integrated circuits and 30 transistors.

However, these components may be integrated into one or two LSI chips in future models.

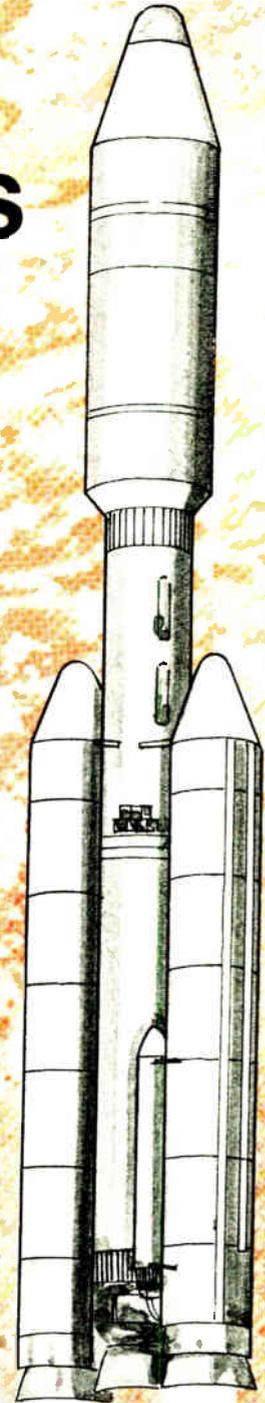
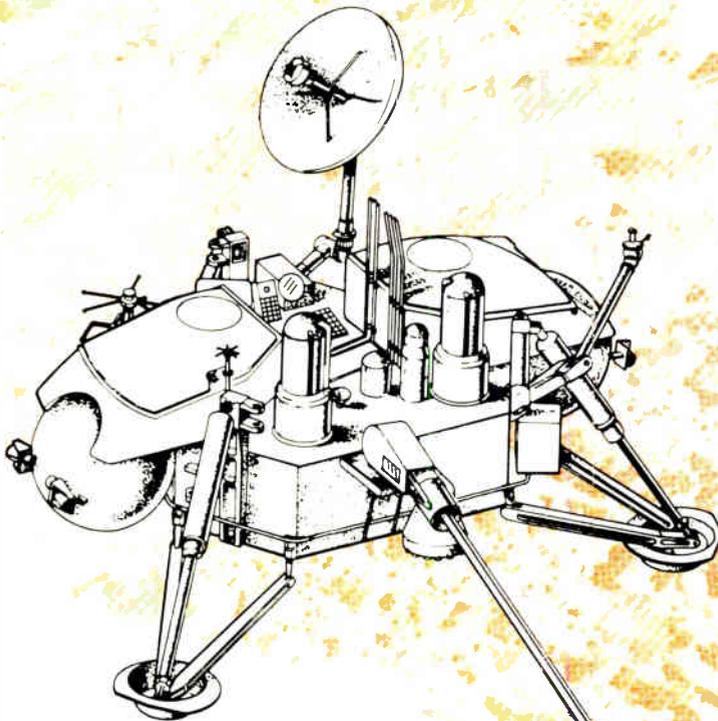
Infrared remote control, installed on most sets in the new line from Grundig of West Germany, is implemented with a photodiode on the set and a small hand-held IR transmitter. For each of five control functions, the transmitter produces a specially coded ultrasound signal, modulates that signal into the 950-nanometer IR beam, and sends it to the photodiode at the TV set. After demodulation, the signal performs control functions.

The RCA Consumer Electronics division, Indianapolis, Ind., also has an elaborate remote controller that operates by ultrasound. The RCA ColorTrak model with remote control displays the channel number and time on the screen. In addition, the hand-held remote unit has buttons for channel-selection, as well as to control volume, color, and tint. When the set is in the color-control mode, the channel display is recalled in red, and the buttons used for volume then control the color. When the set is in the tint-control mode, the channel display is in green. The up button then changes flesh tones in increments toward magenta, while the down button changes it in increments toward green.

Not only have digital-address systems made remote controllers more elaborate, they have made remotes easier to install. Magnavox Consumer Electronics Co., Fort Wayne, Ind., and Rockwell's Admiral group in Schaumburg, Ill., have both introduced remote-control kits for retrofit after the set is purchased.

The Magnavox kit, consisting of a microphone and amplifier that interfaces with the digital address package, must be installed in the cabinet by the dealer. The set owner can plug in the Admiral unit, which has a

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combination microphone/amplifier, through the front of the set. Each kit includes a battery-powered, hand-held controller for on/off, volume, and channel selection, plus mute. A major advantage in having field-installable remote tuners is that receiver inventories can be reduced for both the manufacturer and the dealer. A single receiver model can be equipped with a remote control if the customer desires it. In addition, more people may be inclined to buy the remote control some time after purchasing the set when the additional cost of \$99.95 does not seem as formidable.

Watch technologies compete

Even though the digital watch has become entrenched in the world market, two technologies are still in dispute: integrated-injection-logic versus complementary metal-oxide-semiconductor electronics and light-emitting-diode versus liquid-crystal displays. A single PL chip and a plastic case enabled TI to deliver in April the \$19.95 watch it had promised in January. Competitors have countered by mounting display logic and timing logic on the single C-MOS chip. National Semiconductor ran into highly publicized yield problems with its C-MOS chip, but these have apparently been overcome.

PL has the inherent advantage because the LED-display drivers can easily be mounted on the same chip as the control logic. Such a configuration is more difficult with C-MOS technology, but the necessary packing density has been made possible by silicon-gate processing.

At the high end of the market, the development of so-called programable MOS chips has been a key factor in the design of economical multifunctional watches. Intel's processor-type watch chip, which has been customized for use by the company's Microma watch subsidiary in Cupertino, Calif., has programed-logic arrays to control timesetting, and a ROM and a RAM are used for time counting and related functions. This chip is programed at the mask level for 4-, 6-, and 8-digit displays, as many as eight timing functions, including chronograph, and a choice of several styles of alphanumeric characters.

Watch-display technology has not been settled yet either. Even though LEDs dominate the low end of the market, LCDs have made a strong comeback in the medium-to-high-end watches, thanks to improvements in reliability, viewability, and the addition of command back-lights for visibility in the dark.

Memory extended for calculators

Manufacturers have started a new major trend, the use of nonvolatile memories in calculators. Due out this year is a range of scientific calculators, some with metal-nitride-oxide-semiconductor (MNOS) memories, a relatively untried semiconductor technology. A more conventional approach is use of clocked static C-MOS random-access memories that require only a few microamperes of current to maintain the stored input.

New clocked static 1,024-bit C-MOS RAMs from National, Intersil, and American Microsystems Inc. dissipate in the standby mode only 75 to 100 microwatts,

which is within the self-discharge rate of nickel-cadmium batteries—2% to 3% a week.

The MNOS memory is truly nonvolatile. It consumes no power to store data, the data can be changed electrically, and the readout is nondestructive. Unfortunately, the adoption of MNOS has been retarded by its high cost and uncertain reliability. The nitride storage medium has a tendency to take charge into the substrate so that the memory loses data.

Microprocessors travel to Detroit

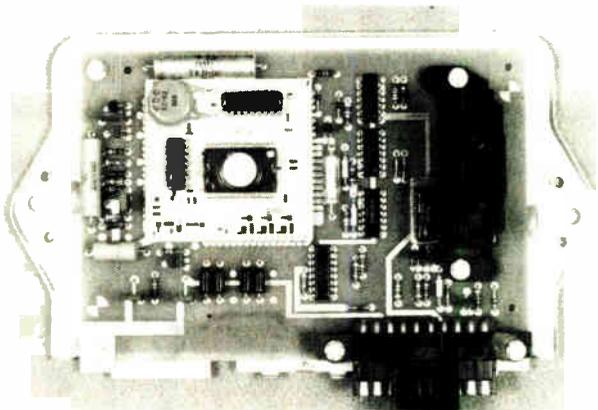
When General Motors Corp. announced that it will use a 10-bit digital microprocessor to control ignition in the 1977 Oldsmobile Toronados, some of the suspense over Detroit's intentions in processors was relieved. The custom two-chip microprocessor was designed by GM's Delco-Remy and Oldsmobile divisions, and it was developed by Rockwell International. GM will second-source the manufacturer chosen to produce it.

This processor, which times the ignition and regulates the spark, is expected to increase the Toronado's fuel economy by 1.2 miles per gallon. Called Misar, for microprocessor sensing and automatic regulation, the system processes inputs from three sensors—coolant temperature, manifold vacuum, and crankshaft position, which also provides engine speed.

Misar, which is programed to interpolate speed and vacuum information and look up in memory the optimum ignition timing, also controls the dwell and either advances or retards the firing according to the temperature of the coolant. The microprocessor's programability is expected to pay off handsomely as it is matched eventually to the various types of GM engines.

Meanwhile, Chrysler Corp. engineers are planning to use customized automotive microprocessors to succeed the discrete electronic spark computer used on the lean-burn engine. Taking another tack, Ford Motor Co. is seeking to develop a custom microprocessor to control several functions.

The long-range prospects for consumer electronics are



3. Custom job. GM's 10-bit microprocessor-controlled spark timing system, designed by Delco-Remy for the 1977 Olds Toronados, uses inputs from three sensors and computes spark advance based on engine speed, vacuum, and coolant temperature.

also tied to the microprocessor. The way it will invade the television receiver is suggested by the Admiral Videospond, a proposed system that uses the TV set to display several non-broadcast services. Designed around the PPS-8 microprocessor from Rockwell International Microelectronics group in Anaheim, Calif. Videospond is an interactive system, programed by digital-tape cassettes and has joysticks to control on-screen cursors. Though Videospond has been put on the back burner at Admiral, it's been demonstrated in four distinct modes: programed instruction, information storage with text editing, calculations such as determining the optimum diet and exercise to reach an individual's ideal weight, and highly sophisticated games and entertainment.

Other services will be performed around the house by

microprocessor-controlled appliances, as well. A robot that cleans the house is entirely possible, for example. Systems are also being considered to provide heating and cooling precisely to demand. Additional plans for consumer application of microprocessors depend on the further rapid decline in hardware prices. In the last 10 years processing intelligence has dropped by three orders of magnitude in cost to today's microprocessors, while IC complexity has increased by four orders of magnitude.

Over the long run, consumer-electronics hardware is headed toward virtually free processing, and software will eventually represent the only important cost. With this kind of economics at work, there is no end to the electronic products that probably will become available to consumers in the next decade. □

Profile

One of the most significant developments this year in the consumer market was Texas Instruments' introduction in April of the first digital watch to retail at less than \$20. Its arrival opened up a large new market much sooner than had been predicted.

The engineers responsible for meeting the April deadline with the \$19.95 five-function watch agree that at every step of the design and production cycle they were dealing from TI's strengths in semiconductor technology. From the chip to the module to the unique plastic case, there was a minimum of technical tightrope walking because the team was applying technologies mastered in previous products.

Nevertheless, particular challenges had to be overcome. "If this were some other company, we probably would have approached the problem from a different direction," comments Hector Cardenas, 39-year-old engineering manager for the Time Products division and technical director for the low-cost watch project. "But we took advantage of our leadership in ICs, calculator displays, and molding techniques to reach our own solution."

Cardenas, who in 15 years at TI has helped develop diode-transistor and emitter-coupled logic, points out that the original goal was to develop a watch to sell for more than \$100. But in doing so, he realized that all the elements were in hand for entering the under-\$25 mass market, where 70–80% of all watches are sold.

At the chip level, the fundamental decision was to use integrated injection logic rather than complementary-MOS technology. This decision eventually led to a small dense chip that was easy to integrate and was compatible with the light-emitting-diode display. "Using a bipolar process, one of TI's strongest suits, we were also able to place the driver on the same chip," Cardenas explains.

Clark Williams, a graduate of Arizona State College, was in charge of the chip design, including investigating the relative merits of I²L and C-MOS technologies. The 31-year-old Williams and his IC-development team added an isolation process to a conventional nonisolated I²L process so that the display drivers could be integrated on the chip. "It was not a major extension of technology, but it was different from TI's other I²L products," Williams says.

James Harper, a veteran design engineer, handled the

module effort. A key decision was to use the firm's advanced automated-assembly line to turn out the modules, packaged in plastic. "The TI watch module is, in effect, a plastic-packaged IC with a round, rather than rectangular, shape," remarks Harper.

The automated bonding process put the watch module under tight production control. In addition, TI had the advantage of being vertically integrated in key components.

The final step in making the \$20 watch practical was using polysulfone plastic in the case. "The molding technology already in place at TI allowed us to solve the problems inherent in new product startup, just as semiconductor-production expertise enabled the molded module, and bipolar leadership made the single chip with on-board driver possible," states Cardenas.

Like the company, the design team relied on its strengths—Cardenas (below, left) in integrated circuits, Williams (right) in bipolar ICs, and Harper in advanced assembly—to get the \$20 watch out on time.



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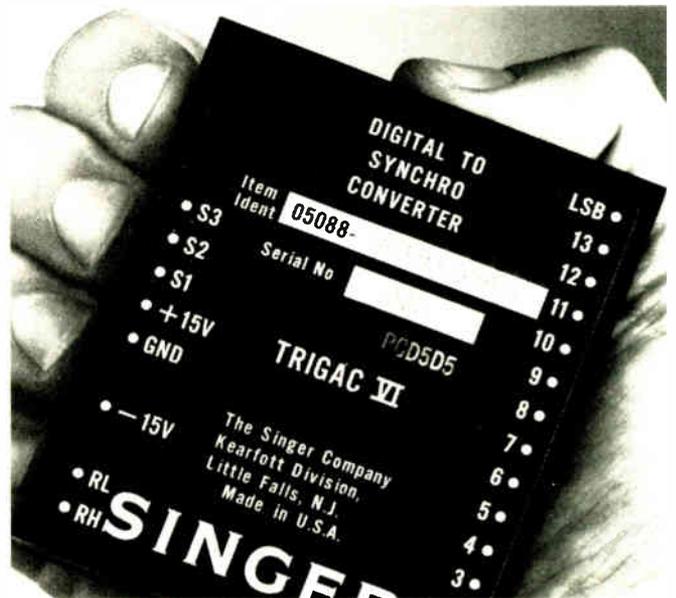
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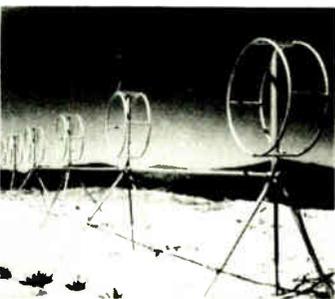
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Chronology

- OCTOBER 1975**
- First low-cost monolithic temperature transducer, which includes a sensor, a zener reference, and an op amp, is announced by National Semiconductor. *Oct. 16, p. 148*
 - Automatic continuity tester for thick-film hybrid substrates, developed by Westinghouse, slashes testing time from 2 hrs to 2 min. *Oct. 30, p. 30*
 - Stitch-wireable microprocessor boards, produced by the Apac division of Varian Data Machines, facilitate low-profile microprocessor packaging for military. *Oct. 30, p. 125*
 - Microprocessor-based programable controllers introduced by Eagle Signal offer many features of minicomputer-based systems. *Oct. 30, p. 137*
- NOVEMBER 1975**
- ERDA's photovoltaic-cell effort reaches contract-award stage with orders for \$1 million worth of solar cells. *Nov. 13, p. 40*
 - First use of 16-k RAM chips in a commercial computer system is announced by Four-Phase Systems Inc., Cupertino, Calif. *Nov. 27, p. 36*
 - Quick Connect wiring system developed at Bell Labs, Holmdel, N.J. is faster than wire wrapping and easier to modify or repair. *Nov. 27, p. 48*
- DECEMBER 1975**
- Laser-based photorepeater from D.W. Mann division of GCA Corp. has a resolution of 1 μ meter and exposable area of 36 in.² *Dec. 25, p. 96*
 - Fail-safe computer based on multiple redundant processors and standard operating-system software is announced by Tandem Computers Inc. *Dec. 25, p. 97*
- JANUARY 1976**
- Varactor VHF television tuner developed by Zenith provides reliable performance at low cost. *Jan. 8, p. 36*
 - Satellite Business Systems (IBM, Comsat General Corp. and Aetna Life and Casualty Co.) plan a new end-to-end domestic communications satellite system to become operational by August 1979. AT&T and GTE receive FCC approval to develop a satellite system for long-distance voice service; first Comstar launched in May. *Jan. 8, p. 38*
 - Texas Instruments Inc. announces a \$19.95 five-function, LED, plastic-case watch using a single 2 L chip. *Jan. 22, p. 44*
- FEBRUARY 1976**
- Utilizing a new quad-slope technique, a 13-bit integrating C-MOS a-d converter from Analog Devices compensates for drift errors. *Feb. 5, p. 25*
 - Magazine-style information services via TV tested in Britain using digital information transmitted on two lines of each blanking period and displayed through a home decoder. *Feb. 5, p. 68*
 - Commercially available glass fiber for optical communications is sold by Corning Glass Works for \$1 a meter. It is unjacketed, provides 20-MHz bandwidth, and has attenuation of 10 dB per kilometer. *Feb. 19, p. 36*
 - First samples of the long-awaited 16-k RAMs enter market; Intel and TI lead the way, followed closely by Mostek. *Feb. 19, p. 119*
- MARCH 1976**
- Low-temperature nitride process that permits hermetic sealing of silicon wafers is developed by LFE Corp. *March 4, p. 40*
 - First commercial ROM to hit 32-k level is marketed by Electronic Arrays Inc. *March 4, p. 40*
 - First maritime communications satellite (Marisat), providing ships with full-time quality communications, goes up. A second Marisat is launched in June. *March 4, p. 42*
 - RCA's new 8-bit 1802 microprocessor is built with a faster, smaller C-MOS process called closed C-MOS logic (C^2 L). *March 18, pp. 35 and 129*
 - Zenith unveils an in-line 19-in. color-TV picture tube featuring a tripotential gun, 100° deflection, and new glass envelope. *March 18, p. 39*
 - First commercially-available wand for optical-character recognition is announced by Key Tronic Corp. It can read the standard OCR font, several numeric fonts, hand-printed numerals, and five hand-printed letters. *March 18, 1976, p. 46*
 - First commercial power MOSFET, a vertical-channel MOS device that switches 1 ampere in 5 nanoseconds, is developed by Siliconix. *March 18, p. 124*

APRIL 1976

- Switching regulators for power supplies go monolithic with advent of a bipolar chip from Texas Instruments. *April 15, p. 25* (Silicon General later introduces a version with push-pull capability. *Aug. 5, p. 133*)
- New dedicated microprocessors appear aimed at the low-end controller market: Intel begins sampling the first one-chip microcontroller containing a field-erasable 8-k ROM; TI broadens its TMS 1000 line with an array of new devices; Rockwell starts production on a 4-bit chip, and National builds a line of calculator chips for control applications. *April 15, p. 74*
- Calculator firms aim at nonvolatile memory with MNOS and clocked static C-MOS designs. *April 29, p. 75*

MAY 1976

- First of the enhanced 8-bit general-purpose microprocessors appears as Exxon-backed Zilog Corp. readies its Z-80 device. TI breaks ground with its TMS 900 full-performance 16-bit n-channel MOS unit. *May 13, p. 25*
- Industry's first RAMs built with I²L burst on the scene. Fairchild is developing a 4-k dynamic RAM, TI slates a 4-k static device, and National readies 1-k 35-ns static units. *May 13, p. 25*
- All-electronic phones, developed by Bell Northern Research, begin user trials in the Bell Canada system. *May 27, p. 36*
- Hardware and software package interfaces Hewlett-Packard minicomputers to the IEEE-488-standard instrumentation-interface bus. *May 27, p. 145*

JUNE 1976

- Three different memory types—C-MOS, MNOS, and p-channel MOS—are used for nonvolatile performance in National's 7100 all-semiconductor-memory programmable scientific calculator. *June 10, p. 29* (The nonvolatile memory in Hewlett-Packard's HP-25C programmable calculator relies on C-MOS chips. *June 24, p. 26*)
- Japanese develop an ultra-low-loss fiber-optic cable with attenuation of only 0.47 dB/km at a wavelength of 1.2 μ meters. *June 10, p. 55*
- First monolithic instrumentation amp with a J-FET front end is made by National with its bi-fet process. *June 10, p. 143* (RCA offers bi-mos op amp. *p. 193*)
- Thick-film-hybrid isolation amplifier from Burr-Brown is the first to employ optoelectronic semiconductors for coupling input and output stages. *June 24, p. 144*

JULY 1976

- Fairchild starts production on the industry's first 65-k CCD memory, giving users a semiconductor alternative to disks in storage application; TI readies a similar prototype. *July 8, p. 32*
- FCC issues the first standard specification for plugs and jacks to allow interconnection to telephone networks. *July 22, p. 36*
- Bell System finishes six months of successful testing on an experimental fiber-optic phone link in Atlanta; Teleprompter uses an 800-ft fiber-optic link for CATV in New York. *July 22, p. 43*
- Using a bi-fet linear process, National Semiconductor introduces the first single-chip sample-and-hold circuit, breaking the \$5 barrier. *July 22, p. 44*

AUGUST 1976

- FCC expands class D citizens' band radio service from 23 to 40 channels, effective Jan. 1, 1977. *Aug. 5, p. 49*
- General Motors Corp. announces that 1977 Oldsmobile Toronados will use custom 10-bit microprocessors from Rockwell for ignition timing. Gas mileage is expected to improve 8%. *Aug. 19, p. 43*

SEPTEMBER 1976

- Resident PL/M compiler on Intel Corp.'s Intellec system gives microcomputer designers access to powerful software techniques. *Sept. 2, p. 34*
- General Instruments' new 8-k electrically-alterable read-only memory answers users' needs for erasable, nonvolatile semiconductor memories. *Sept. 16, p. 40*
- A 350-ns, 16-k ROM from Mostek, the industry's fastest MOS ROM, boosts throughput of microprocessor systems. *Sept. 16, p. 42*
- Texas Instruments starts the first commercial bubble-memory production with a 92-k device aimed at disk and drum storage memory systems. *Sept. 30, p. 29*

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IC simulates matched transistor pairs

100 units on die are randomly paired for statistical matching; technique said to yield improved amplifiers, loggers, multipliers

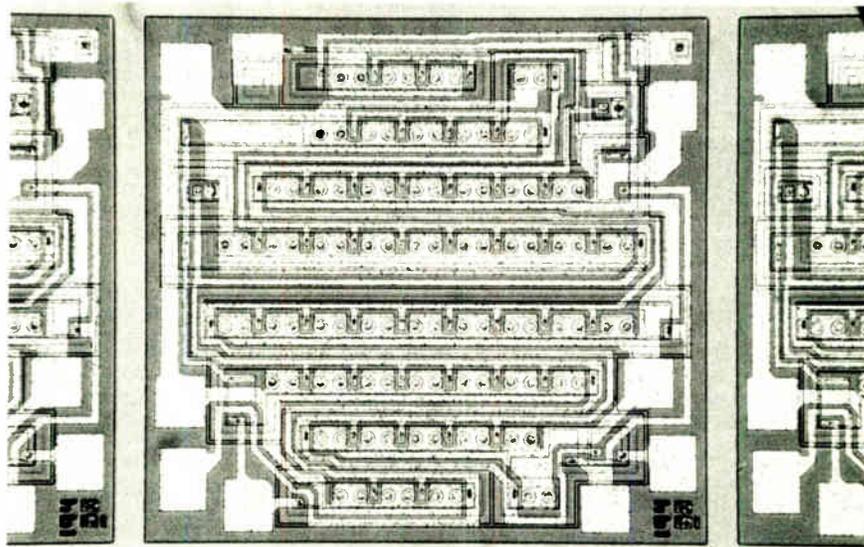
by Bernard Cole, San Francisco bureau manager

In a departure from traditional techniques, National Semiconductor Corp. has built what is essentially an integrated circuit that simulates the function of a matched transistor pair. The matching that results from the device—designated the LM194/394—is 10 to 60 times better than present transistor pairs, according to the company.

An unsung workhorse of the electronics industries, matched transistor pairs are used in many dc biasing jobs such as in instrumentation and power supplies, as well as in rf applications. They are usually made by fabricating two monolithic npn transistors on the same 600-to-800-square-mil die and trying to match their offsets. This approach has yielded transistor pairs matched within 0.5 to 3 millivolts.

What National has done with the LM194/394, says Carl Nelson, advanced-linear designer, is fabricate 100 npn monolithic transistors onto a die that is about 2,500 square mils in area and connect 25 pairs in parallel with the other 25. "But rather than attempting to match offsets," he says, "the attempt is made to randomly interconnect the 50 pairs of transistors to take advantage of statistical variations and random cancellation of offsets."

Even though any one pair may have offsets whose match varies between 0.5 and 3 millivolts, the net effect for all the 50 pairs is an offset matching to within 50 microvolts. "The matching gets closer to zero as the number of pairs in parallel goes up," he says. "More accurately, matching improves as a direct ratio of the square root of the number of transistors." A 100-transistor



matched-pair simulation, Nelson says, therefore offers a ten-fold improvement in performance over standard matched pairs on a die that is only two to four times larger.

Electrical characteristics of the LM194/394, such as drift versus initial offset voltage, noise, and the exponential relationship of the emitter-base voltage to the collector current, he says, "closely approach those of a theoretical transistor." On top of the 50- μV matching, offset voltage drift in dc amplifiers is held to 0.1 $\mu\text{V}/^\circ\text{C}$ (versus 2 μV for most transistor pairs). The IC circuit has a minimum current gain of 500, a current-gain match within 2%, and a common-mode rejection ratio of 120 to 130 decibels, compared with the 100 dB of conventional matched pairs.

Another product of the statistical matching of transistor pairs, he adds, "is a device with virtually only theoretical noise, enhancing its useful-

ness in ac amplifiers and nonlinear circuitry." Most of the parameters are guaranteed over a current range of 1 to 10 microamperes and a collector-base voltage from 0 to 40 v.

To guarantee long-term stability of matching parameters, internal clamp diodes have been added across the emitter-base junction of each transistor. These prevent degradation from reverse-biased emitter current, the most common cause of field failures in matched devices, Nelson says. "The parasitic isolation junction formed by the diodes also ensures isolation between devices," the designer adds.

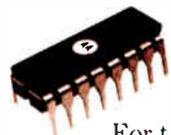
Available in an isolated-header, six-lead TO-5 package, the LM194/394 is priced at \$2.75 each for devices specified for operation from 0°C to 70°C.

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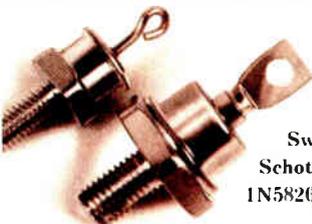
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by Lucinda Mattera, Components Editor

As they become smaller in size and lower in price, isolation amplifiers are being more widely used in medical and industrial applications. But to provide true isolation, these devices must be operated from an isolated power supply.

Now Analog Devices is offering a modular isolation amplifier that contains its own isolated supply—within a package that measures merely 1.5 by 1.5 by 0.62 inches. What's more, in quantities of 100, the model 284J is priced at just \$41 each. "OEMs can now cost-effectively buy a complete isolation amplifier, instead of investing engineering time in building their own," says Fred Pouliot, product marketing manager for Systems Components.

Besides powering the 284J's guarded floating front end, the internal dual-output supply can provide power for external circuitry, like transducers and signal-conditioning devices, he notes. It delivers an isolated output of ± 8.5 volts dc at ± 5 milliamperes. Furthermore, the 284J itself requires just a single-polarity supply of +8 to +15.5 v, enabling it to operate directly from a

single battery. The unit, therefore, is suitable for portable-equipment applications, and power consumption is only 85 milliwatts at 12 v, Pouliot says.

The 284J can withstand common-mode voltages of 2,500 v continuous or 5,000 v pulsed. Additionally, its common-mode rejection is guaranteed at 110 decibels minimum, even under a worst-case source imbalance of 5 kilohms. With a single resistor, gain can be adjusted from 1 to 10 v/v. This means that the unit can operate over a wide dynamic range, handling low-level signals as small as 8 microvolts peak to peak as well as large signals of up to 10 v pk-pk.

A transformer-isolated unit, the new module meets the patient-safety requirements of Underwriters Laboratories' Standard 544. In fact, leakage current is only 1.2 microamperes root-mean-square at 115 v ac and 60 hertz, Pouliot points out.

Over the entire gain range, linearity error is held to within $\pm 0.3\%$, while gain drift is just $\pm 0.025\%/^{\circ}\text{C}$ over a temperature range of 0°C to 70°C . From 0.05 to 100 Hz, input noise voltage is a low 8 μV pk-pk,

increasing slightly to 10 μV rms at frequencies of 10 Hz to 1 kilohertz. The 3-dB small-signal bandwidth is 1.1 kHz for gains from 1 to 10 v/v.

Applications are numerous, Pouliot observes, including biomedical instrumentation, patient-monitoring equipment, industrial process-control systems, interfacing with remote transducers, eliminating ground loops, and measuring off-ground signals.

In medical applications, such as multilead electrocardiography recorders and diagnostic equipment, the 284J provides protection from ground-fault currents and from 5-kilovolt defibrillator pulse inputs. In industrial applications, the 284J is suitable for computer interface systems, process-signal isolators, and sensitive instrumentation. It offers complete galvanic isolation and protection from high-voltage transients or fault surges.

The new amplifier, which is priced at \$59 in single quantities, is available from stock.

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The universality of the system is based on Universal One's innovative multiple CPU architecture. One CPU, the Master CPU, is the controlling element of the system and executes all application independent functions; file management, text editing, system utilities, system I/O and software debugging.

The second CPU, the slave, which is controlled by the master, executes those functions that are application dependent; the microprocessor Assembler, in-circuit testing, user application programs, and user I/O. Additional microprocessor slaves are readily added by interfacing the new slave to the system bus and integrating it into the system software.

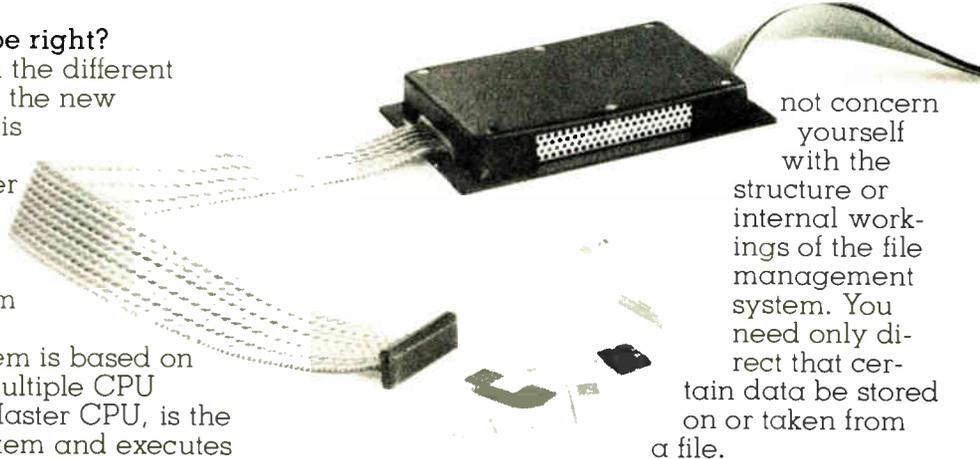
By meeting all the staff's needs, Universal One cuts costs. It's not necessary to have special test fixtures for design engineers and software development systems for programmers. Universal One saves on personnel training expenses since only one system interface need be learned.

Can the programmer be right?

Universal One's software capabilities rival those found on many powerful minicomputer systems. Universal Disk Operating System (UDOS) was developed specifically for and tailored to the multiple CPU architecture. The

operating system is executed by the Master CPU in its own totally protected Master memory to prevent disruptions by application programs.

UDOS is floppy disk file oriented. The system was designed specifically for the characteristics and peculiarities of a floppy disk and as such makes maximum use of it's benefits. Many file management functions, normally required to be performed by the user, are performed automatically by UDOS. You need



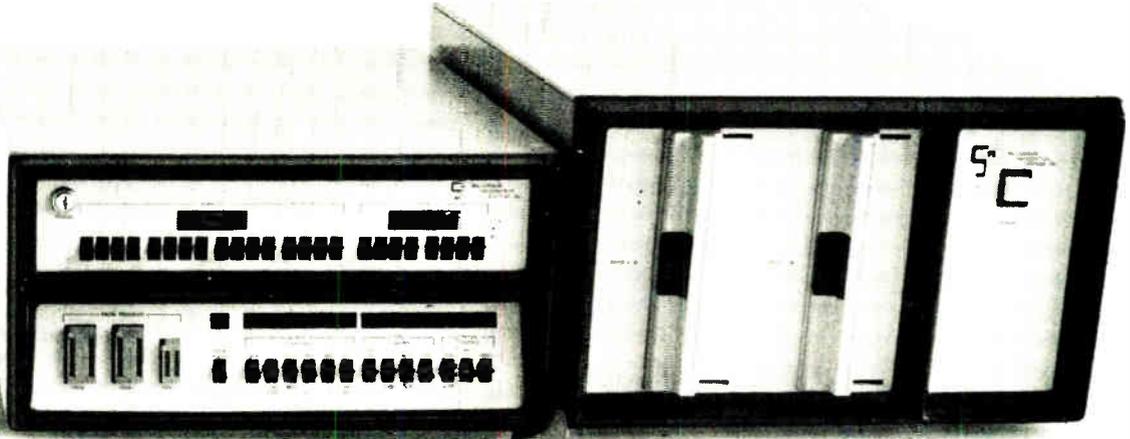
not concern yourself with the structure or internal workings of the file management system. You need only direct that certain data be stored on or taken from a file.

μ BASIC™, Millennium's proprietary high level compiler, is a flexible version of BASIC tailored for microprocessor development applications. Unlike interpretive systems the final output of μ BASIC is the object code for the microprocessor. μ BASIC can also be intermixed with Assembly for memory space reduction and faster program execution.

With Universal One's dynamic trace capability, the activity of a program is traced, instruction by instruction. For break-point analysis two hardware registers provide a break and display of the breakpoint address and contents on memory fetch only, memory write only or on memory read/write access.

Universal One contains a powerful text editor which is file oriented and has macro and iteration capabilities for combining commands.

Millennium provides comprehensive diagnostics which not only test the system's processors, memory & I/O but also check peripheral devices and interrupt logic.



Can the design engineer be right?

Universal One provides two modes of development system emulation for saving time during initial hardware debug and during hardware/software integration. In the first mode, Universal One emulates the prototype's microprocessor and its memory, while I/O functions are controlled by the user hardware. In the second mode, the prototype uses its own memory and I/O. Universal One's two-stage emulation eases the transition from initial test to full prototype implementation.

The front panel PROM sockets accommodate the most commonly used PROMs, the *2708, the 1702A MOS erasable and 82S115 family of bipolar PROMs. Others will be added in the future.

Can they all be right?

Obviously yes! Universal One has the capabilities to get development projects completed on time and within budget. And, Universal One will be just as valuable in the future as it is today. The universal architecture assures the product will never be obsolete.

Universal One's powerful operating system is easy to use so personnel get the most out of it whether they are inexperienced or advanced programmers. μ BASIC saves vast amounts of software development and maintenance time.

Last but not least, development system emulation simplifies hardware and software integration. Put it all together, it's the Universal One for 8080s, 2650s, *6800s, application programmers and design engineers.

* Available January, 1977

A better hardware solution

If you already have good techniques for assembling and debugging your programs but need hardware and PROM programming capabilities, Millennium has a solution. It's Universal Emulator, an advanced product that provides all the hardware emulation and PROM programming capabilities of Universal One at a lower price. And, it can be upgraded to the Universal One in the field at any time.

You can be right, too!

Universal One and Universal Emulator are available for immediate delivery. A complete Universal One System with a single slave and dual flexible disc is \$8,900. Additional slaves are \$1,250. A single slave Universal Emulator is \$4,500. For a prompt direct reply, return the coupon.

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420 Mathew Street
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New products

Semiconductors

ICs drive gas displays

Interface circuits

deliver high voltages to gas-discharge units

Gas-discharge displays are enjoying healthy growth in such markets as point-of-sale equipment, calculators, instruments, electronic games, computer terminals, and industrial-process monitoring. But these displays require fairly high operating voltages, compared to the relatively low voltages available from the logic circuitry that controls them.

However, Dionics Inc. of Westbury, N.Y., now has three new families of monolithic drivers for gas-discharge displays that deliver high-voltage outputs from low-voltage logic inputs. The new lines include the series DI-300 segment drivers, the series DI-500 digit drivers, and the series DI-5100/5200 drivers for ac plasma displays. All the chips are dielectrically isolated integrated circuits.

The DI-300 and the DI-302 segment drivers are designed to operate from signals developed in

MOS or TTL circuitry. Both are intended for eight-channel operation and are housed in 18-pin plastic dual in-line packages. Their constant-current outputs are programmable over a range of 0.1 to 2.5 milliamperes. Supply voltage is -200 v for the DI-300, and -125 v for the DI-302. In quantities of 1,000, the DI-300 sells for \$2.45 each, while the DI-302 is priced at \$2.06 each in the same quantities.

Available in 4-, 6-, and 8-line versions, the DI-500 series of digit drivers is also compatible with either MOS or TTL circuitry. Each section of these devices is made up of a switched constant-current level shifter and a complementary-transistor driver pair. The DI-500, -505, and -510 devices offer 200-v level-shift capability, while the DI-502, -507, and -512 provide 125-v level shifting.

They are packaged in 14-, 16-, or 18-pin plastic DIPs. Prices range from \$1.50 to \$3.97 each in 1,000-unit lots.

The drivers for ac plasma displays are designed to deliver switched, high-voltage, square-wave signals to either multisegment or dot-matrix panels. Each driver provides five outputs that have integral diodes for pullup of off segments. Output current is as high as 5 mA per line, yet required input voltage is typically only 3 v. Output voltage is 140

v for the DI-5140, 180 v for the DI-5180, 240 v for the DI-5240, and 280 v for the DI-5280. The units come in 14-pin plastic DIPs, and operating temperatures can range from -15°C to $+70^{\circ}\text{C}$. They are priced at from \$1.41 to \$3.09 each in quantities of 1,000. All are available from stock.

Dionics Inc., 65 Rushmore St., Westbury, N.Y. 11590. Phone (516) 997-7474 (411)

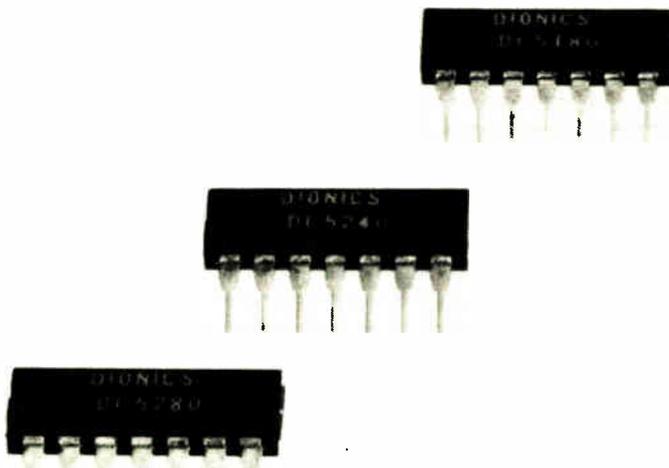
Uhf power transistors are broadband, rugged

Operating in the range from 450 to 512 megahertz, a line of ultra-high-frequency power transistors is designed for broadband performance and unusual ruggedness. Made by Communications Transistor Corp., the devices are upgraded versions of CTC units widely used in land-mobile communications equipment. Offering maximum reliability because of their single-chip construction, they can withstand infinite voltage standing-wave ratio at all phase angles at 15.5 volts dc and rated output power. The transistors, all 12.5-v units in low-inductance stripline flange packages, consist of the 10-watt CM10-12A, priced at \$12.45 each in 100-piece quantities; the 20-w CM20-12A, \$16; the 30-w CM30-12A, \$20; the 45-w CM45-12A, \$24.50, and the 60-w CM60-12A, \$34.20. All are available from stock.

Communications Transistor Corporation, subsidiary of Varian Associates, 301 Industrial Way, San Carlos, Calif. 94070. Phone (415) 592-9390. [416]

Timer IC functions as stable controller

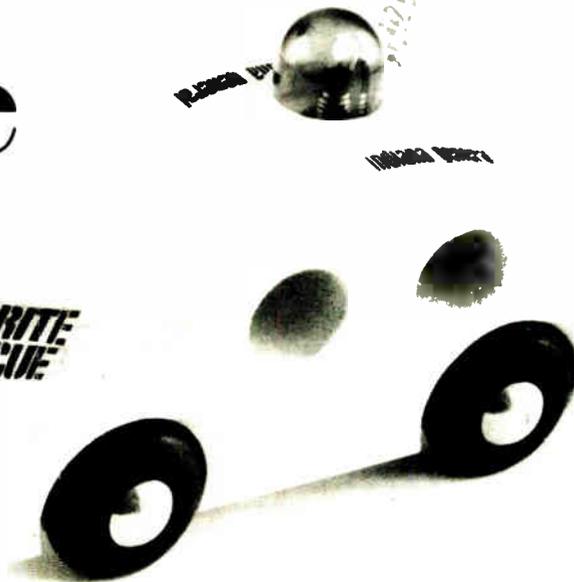
Selling for less than 50 cents each in OEM volumes, a timer integrated circuit from Micro Components Corporation functions as a highly stable controller. The MCC-555 timer circuit, housed in a standard eight-lead dual in-line package, can be used for accurate time delays (monostable mode) and as an oscil-



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help

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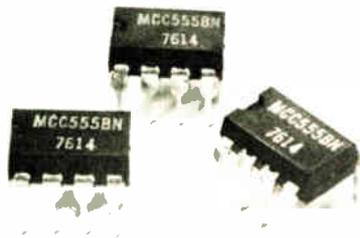
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Circle 149 on reader service card

World Radio History

New products



lators (astable mode). All input-output terminals are compatible with direct transistor-transistor-logic/diode-transistor-logic interfaces. Resettable time delays ranging from microseconds to hours can be obtained over the single power supply range from 5 to 15 volts. Output of the MC-555 can either sink or source up to 200 milliamperes.

Micro Components Corporation, 99 Bald Hill Rd., Cranston, R.I. 02920. Phone (401) 463-6000. [415]

Transistors offer ratings to 1,000 volts, 500 watts

Aimed at applications in high-voltage dc regulators, high-voltage switching power supplies, and switching regulators, a series of npn power transistors made by International Rectifier, have ratings up to 1,000 volts and 50 watts. Designated the series IR721, the transistors are rated for a continuous collector current of 3 amperes. Maximum dc gain for the devices is 60 at 150 milliamperes and 5 v. All are glass-passivated to provide stability at high junction temperatures and are made with triple-diffused processing to allow operation at exceptionally high voltages with a wide safe-operating region. The IR721 high-voltage transistors are among a group of 15 power transistors and Darlington transistors being introduced by IR. Price of the IR721 devices is \$6.10 each in quantities from 100 to 999. Delivery is from stock.

Semiconductor Division, International Rectifier, 233 Kansas St., El Segundo, Calif. 90245. Phone (213) 322-3331. [417]

One-chip stopwatch circuits are multifunctional

Through use of digital stopwatch circuits that operate as dual timing systems, a single electronic stopwatch can replace two timepieces in sports, engineering and scientific applications. Also the metal-oxide-semiconductor large-scale-integrated devices from Siliconix provide single-chip replacements for 20 or more conventional logic circuits in precision timing systems. This is expected to lead to widespread use of digital-stopwatch technology in a variety of industrial applications.

The new integrated circuits are the DF213 minutes-seconds sports stopwatch and an interchangeable version, the DF214 decimal-minutes industrial stopwatch. The DF214 provides a readout format that simplifies tabulation and calculation of timing in process control, test timing, time and motion studies, laboratory instrumentation, and aircraft navigation. Each device con-



tains two independent timers that can operate in two readout modes. One timer accumulates total elapsed time, and the other accumulates lap time. The technique allows the ICs to perform timing functions that usually require the skilled manipulation of two separate stopwatches or use of a complex timing-logic system. Outputs are delivered in a binary-coded-



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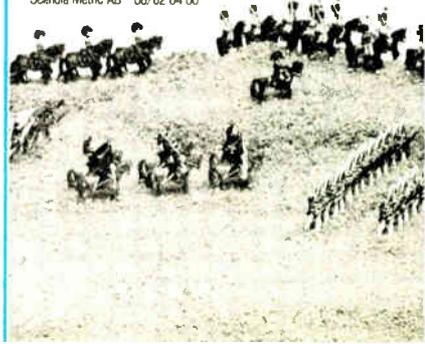
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The Battle of the 80's continues:

The Z-80 is a third generation LSI component set including CPU and I/O Controllers with full software support and second sourcing available now.

A single chip, N-channel processor arms you with a super-set of 158 instructions that include all of the 8080A's 78 instructions with total software compatibility. The new instructions include 1, 4, 8 and 16-bit operations. That means less programming time, less program storage and less end costs. And you get memory-to-memory or memory-to-I/O

block transfers, nine types of rotates and shifts, bit manipulation, a legion of addressing modes and a standard instruction speed of 1.6µsec. The Z-80 CPU and peripheral circuits require only a single 5V power supply and a single phase clock. With these circuits you can interface directly to a wide range of both parallel and serial interface peripherals and even dynamic memories without other external logic. With all these features you'll require approximately 50% less memory space for program storage and you'll get up to 500% more throughput than the 8080A.

The Zilog Battalion includes a development system with: Z-80 CPU Card with 4K Bytes of ROM/RAM Monitor software • 16K Bytes of RAM memory, expandable to 60K Bytes • Real Time Debug Module and In-Circuit Emulation

With the introduction of Zilog's Z-80 microcomputer products the tide is turning in the battle for supremacy.

Features	8080A	Z80-CPU	Features	8080A	Z80-CPU
Power Supplies	+5, -5, +12	+5	Addressing Modes	7	11
Clock	2φ +12 Volt	1φ 5 Volt	Working Registers	8	17
Standard Clock Speed	500 ns	DC to 400 ns	Static Operation	No	Yes
Interface	Requires 8222, 8228 & 8224	Requires no other logic and includes dynamic RAM Refresh	Non-maskable Interrupt	No	Yes
Interrupt	1 mode	3 modes, up to 6X faster	Full TTL Compatibility	No	Yes
Instructions	78	158*	Throughput	Up to 5 times greater than the 8080A	
OP Codes	244	696	Program Memory	Generally 50% less than the 8080A	
			*Including all of the 8080A's instructions.		

Module • Dual Floppy Disc System • Software Package including Z-80 Assembler, Editor, Disc Operating System, File Maintenance and Debug.

We'll support this with resident microcomputer software, time sharing programs, software libraries and high-level languages such as PL/Z.

A reserve of reinforcements is ready. The Zilog Z-80 brings to the battlefield new levels of performance and ease of programming not available in second generation systems.

And while all the others busy themselves with overtaking the Z-80, we're busy on the next generation—continuing to demonstrate our pledge to stay a generation ahead.

The Z-80's troops are the specialists who were directly responsible for the development of the most successful first and second generation microprocessors. Nowhere in the field is there a corps of seasoned veterans with such a distinguished record of victory.

Think of your next microcomputer as a weapon against horrendous inefficiencies, outrageous costs and antiquated speeds.



Zilog MICROCOMPUTERS

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(415) 941-5055/TWX 910-370-7955

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Circle 151 on reader service card

Now there's a universal computer-based in-circuit/functional test system with extensive digital test capability.



FAULTFINDER[®] FF303

The new FF303 provides two separate in-circuit test approaches. Analog testing procedures use guarding techniques for straightforward component fault isolation. Pulse techniques are used for digital testing of all combinatorial and sequential logic independent of the surrounding circuitry. The FF303 can be configured with up to 928 analog test points and 1216 digital test points.

In-circuit test programming is done with a Faultfinder extension of BASIC which permits on-line editing and simplified, high-level language programming with user nomenclature.

The FF303 is a complete, flexible in-circuit test system for your production floor with low-cost software generation and unique capabilities for testing hybrid boards. We'd like to show you what it can do for you. Write or call for complete information.

Circle 152 on reader service card

FF FAULTFINDERS Inc.
15 AVIS DRIVE, LATHAM, NY 12110 (518) 783-7786

Irvine, CA Cicero, IN
Sunnyvale, Waltham, MA
Park Ridge, IL
Faultfinders GmbH, Eschborn, Germany

New products

decimal, digit-multiplexed format that is compatible with light-emitting-diode and gas-discharge display drivers. Housed in plastic dual in-line packages, both chips are priced at \$9.80 each in quantities of 100 to 999.

Siliconix, 2201 Laurelwood Rd., Santa Clara, Calif. 95054 [414]

Dual line-driver meets EIA data interface standard

Satisfying the interface requirements between data terminals and communications equipment as defined by EIA Standard RS-232-C, a dual line-driver from Fairchild permits 20,000 bits per second to be transmitted with a full 2,500-pico-farad load. The logic input is compatible with most transistor-transistor-logic and diode-transistor logic families. Operation is from power supplies of $\pm 12V$.

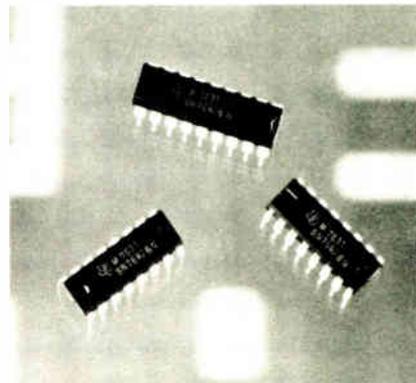
The 75150 is a pin-for-pin replacement for the SN75150. It is available from stock in a ceramic dual in-line package, priced at \$2.07 in quantities of 100; a plastic DIP at \$1.72; a ceramic mini-DIP at \$2, and a plastic mini-DIP at \$1.67.

Linear Integrated Circuits Division, Fairchild Camera and Instrument Corporation, 464 Ellis St., Mountain View, Calif. 94042 [418]

Video-game circuits offer wide flexibility

First group in a line of universal game circuits planned for applications in video games, six circuits developed by Texas Instruments Inc. offer a wide range of games with easily changeable features and game rules. Combinations of the six circuits allow games with multiple balls, multiple walls, multiple players, and obstacles. They can be used in simple tennis and hockey games or in more complex games such as races, battles, soccer, pool, and pinball. All are compatible with joystick operation.

The first six circuits are the



SN76423, game logic with automatic random English priced at \$1.25 in 100-unit quantities; SN76425, a horizontal and vertical synchronization generator priced at \$1.89; SN76426, a character generator, \$1.53; SN76427, a wall and ball generator, \$1.53; SN76428, game logic with manual English, \$1.25, and SN76460, O to W (Win) digital-scoring circuit, \$4.54.

Texas Instruments Incorporated, Inquiry Answering Service, P.O. Box 5012, M/S 308 (Attn: Video Game ICs), Dallas, Texas 75222. Phone John Stich at (806) 747-3737. Ext. 246 [413]

TOPICS

Semiconductors

Motorola Semiconductor Products Inc., Phoenix, Ariz.,

has slashed the price of its MRF901 microwave transistor nearly 50%—from \$7.80 to \$3.75 (in hundreds). The small-signal device is commonly used in land-mobile and paging applications.

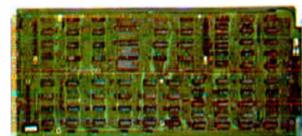
Fairchild Camera and Instrument Corp., Mountain View, Calif.,

has added six new device types to its Isoplanar 4000 series complementary-MOS family. Included are an 18-stage shift register, a quad buffer, two three-state latches, and two up/down counters.

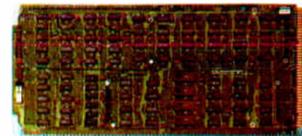
Texas Instruments Inc., Dallas, has announced price reductions on its 1,024-by-1, 64-by-8, and 256-by-4 MOS static random-access memories. Prices for the 450-nanosecond versions of each of the memories, in hundreds, are \$2.10, \$3.80, and \$3.80, respectively.

Circle 154 on reader service card →

The computerization solution.



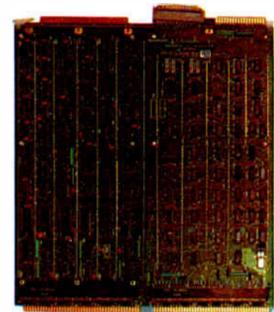
NAKED MILLI LSI-3/05 CPU, Type 0. Model 10300-00. Small low-cost processor offers exceptional power and features. 95 instructions, Power Fail Restart, vectored priority interrupts and 16-bit DMA port.



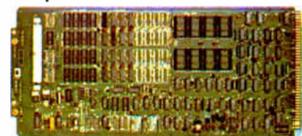
NAKED MILLI LSI-3/05 CPU, Type 1. Model 10300-01. Same as Type 0 at left, but also includes Real-Time Clock and AutoLoad capability.



NAKED MINI LSI-2/10 CPU. Model 10600-00. 16-bit minicomputer processor offers twice the speed of LSI-3/05 processors. Includes Power Fail Restart option. See ALPHA LSI-2/10 description.



NAKED MINI LSI-2/20 CPU. Model 10400-00. Designed for high-performance applications. Twice the performance of the LSI-2/10 for only a nominal increase in cost. Also includes Power Fail Restart.



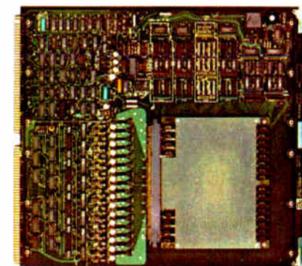
RAM/ROM/PROM Memories. Model 11650-XX. Includes semiconductor RAM in choice of 256, 1K or 2K words; sockets for 8K words of ROM and sockets for 2K words of PROM. Available with On-card Battery Backup.



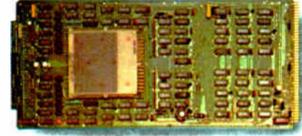
RAM-only Memories. Model 11642-XX. Choice of 4K or 8K words. Available with Battery Pack.



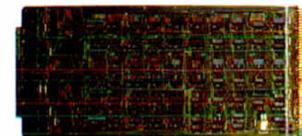
RAM/EPROM Memories. Model 11530-XX. Includes semiconductor RAM in choice of 1K or 2K words and sockets for 4K words of ultra-violet Erasable Programmable ROM. Available with On-card Battery Backup; also, optional EPROM Programmer.



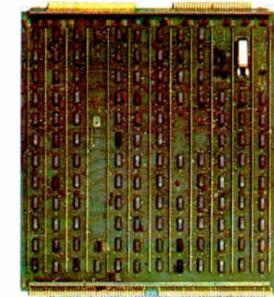
Full-card Core Memories. Model 115X0-XX. Choice of 8K words of Core 980 Memory or 16K words of Core 1200 Memory. For Standard or Jumbo Chassis only.



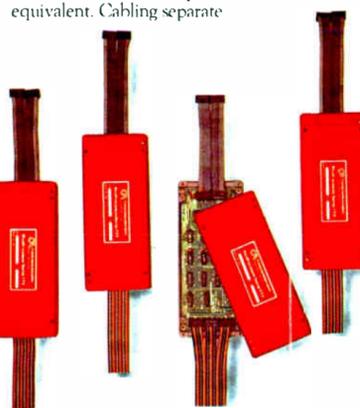
Half-card Core Memory. Model 11671-XX. 4K words. For either NAKED MILLI/ALPHA LSI-3/05 or NAKED MINI/ALPHA LSI-2 Series Computers.



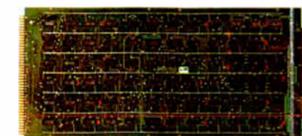
I/O Distributor. Model 14629-XX. In conjunction with Intelligent Cables (see text), the I/O Distributor provides up to eight interfaces—serial or parallel in any mix. Small version accommodates four interfaces. A DMA version allows data transfer rates up to 250K bytes per second.



Magnetic Tape Controller. Model 14224-00. Provides interfaces for one to four 9-track standard tape units, or equivalent. Cabling separate.



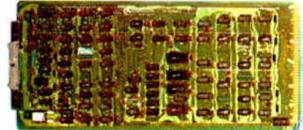
Intelligent Cables. Model 14631-XX. A broad assortment of models offers low-cost, off-the-shelf interface for most standard and special user devices: Line Printer, Card Reader, Paper Tape Reader, Paper Tape Punch, Current Loop, CRT, Modem, etc. Also, General Purpose and Custom Programmable versions.



16-channel Priority Interrupt Module. Model 13220-00. 16 interrupts with acknowledgement lines.



Paper Peripheral Controller. Model 14223-00. Single device controller for paper tape reader, paper tape punch, line printer or card reader. Cabling separate.



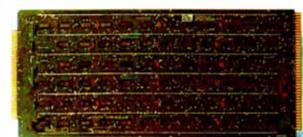
Floppy Disk Controller. Model 14566-01. Provides interfaces for one to four IBM-compatible standard floppy disks, or equivalent. Cabling separate.



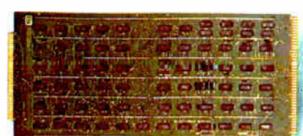
Piggyback Teletype Interface. Model 12635-01. For LSI-3/05 processor. On-board mounting provides bit-serial interface. (For byte-serial interface, use Distributed I/O System with Current-Loop Serial Intelligent Cable.)



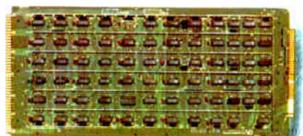
I/O Terminator Module. Model 14511-00. Convenient means for terminating user-designed I/O cables. Plugs onto rear of I/O cards (uses 100 pin connector) with rigid termination. Pads for mounting termination components provided.



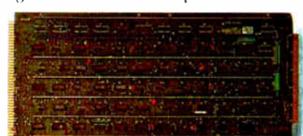
Utility I/O Interface Module. Model 14223-00. General purpose interface with 8 or 12-bit output transfers with 4 control bits in parallel.



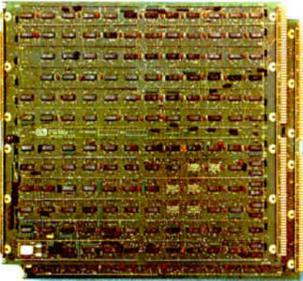
64-bit Input Module. Model 13219-00. Provides 64, 32, 16 or 8-bit inputs with individual strobes.



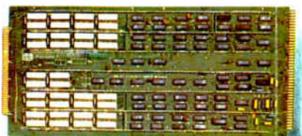
16-bit Digital Input/Output Module. Model 13213-00. Provides input and output registers which may be used as one 16-bit or two 8-bit registers. DTL/TTL compatible.



I/O Driver Module. Model 13222-00. Units drive the computer I/O bus up to 25 feet, buffer internal I/O bus from external noise. Does not include memory signals.



Moving Head Disk Controller. Model 14530-XX. Provides interfaces for one to four standard moving head disk drives, or equivalent. 1500 or 2400 RPM. Cabling separate.



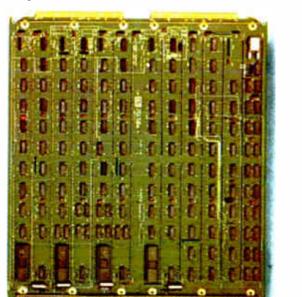
32-bit Relay Input Module. Model 13215-00. Operates as one 32-bit, two 16-bit, or four 8-bit inputs.



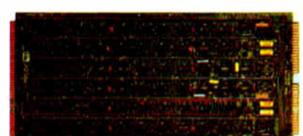
32-bit Relay Output Module. Model 13214-20. Operates as one 32-bit, two 16-bit, or four 8-bit outputs.



Asynchronous Modem Controller. Model 14535-0X. For one asynchronous line (point-to-point, multipoint, or direct dial). Fully programmable for mode, character size, parity, echoplex, diagnostic loop-back, special character detect, variable stop bits. Send/receive speed individually selectable with jumpers—75 to 9600 baud. Available as EIA Interface with full Data Set Controls or as Current Loop Interface.



Asynchronous Modem Multiplexer. Model 14512-XX. As above, but for two or four independent asynchronous lines. Multiple vectored interrupts for each line.



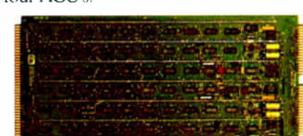
Dual TTY Interface. Model 14236-21. For two modified ASR-33 Teletypes. 20 mA Current loop, 110 baud, two half-duplex channels. Has circuit for programmed motor on/off.



EIA RS232 Interface. Model 14236-5X. For one CRT at baud rates from 110 to 9600. Half-duplex operations only.



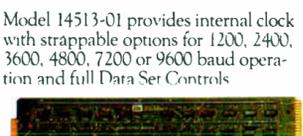
Automatic Calling Unit (ACU) Multiplexer. Model 13523-0X. Provides interfaces for one to four Model 801 ACU's, or equivalent. Simultaneous operations, full digit buffering and sense date-line busy. Four vectored interrupts per ACU. Available for either two or four ACU's.



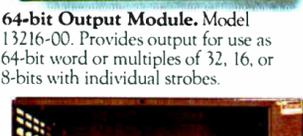
Dual CRT Interface. Model 14236-1X. For two CRT's or leased line modems. EIA RS232 interface with two half-duplex channels, each with one output control line and one input status line. Baud rates from 110 to 9600.



Synchronous Modem Controller. Model 14513-00. Double buffered, half or full-duplex interface for synchronous communications line (point-to-point, multipoint, or direct dial). EIA RS232C/CCITT compatible, programmable synchronous character, and one special character detect. Odd, even or no parity and 5-8 bit frame size program selectable. Transfer to 9600 baud.



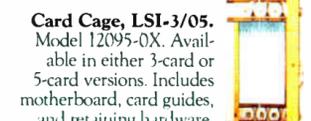
64-bit Output Module. Model 13216-00. Provides output for use as 64-bit word or multiples of 32, 16, or 8-bits with individual strobes.



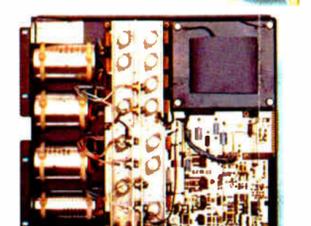
Processor Chassis. Model 12034-00/20500-01. Full-card chassis. Available in 5-slot and 9-slot versions. Includes motherboard and fans.



Card Expansion Modules. Model 12098-00/12099-00. Five and nine-slot versions include chassis, blank panel with expansion buffer controller, interconnecting cables and power supply.



Card Cage, LSI-3/05. Model 12095-0X. Available in either 3-card or 5-card versions. Includes motherboard, card guides, and retaining hardware.



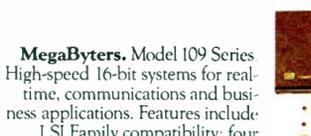
Standard Power Supply. Model 12044-00. Supplies +5V @ 25 Amps, +12V @ 4 Amps and -12V @ 9 Amps.



Power supplies for LSI-3/05. Model 12046-0X. Open frame power supplies mount in any plane. Supply +5V @ 10 Amps, +12V @ 0.8 Amps, -12V @ 0.8 Amps; +12V @ 1 Amp, -12V @ 1.5 Amps. With fan.



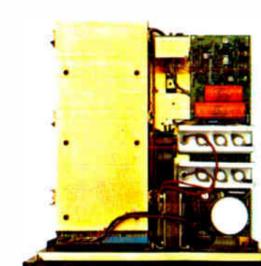
Jumbo Power Supply. Model 20441-00. Supplies +5V @ 36 Amps, +12V @ 5.6 Amps, -12V @ 10.7 Amps.



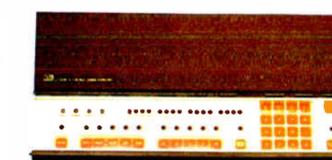
MegaByters. Model 109 Series. High-speed 16-bit systems for real-time, communications and business applications. Features include LSI Family compatibility; four standard input-output modes, including Direct Memory Access; vectored priority interrupts; and a comprehensive set of 224 instructions. Includes Jumbo Chassis, Jumbo Power Supply, Programmer's Console, Power Fail Restart, Basic Variables, Teletype or EIA CRT interface, Real-Time Clock, AutoLoad and AutoLoad ROM Set. Full Memory options.



ALPHA LSI-3/05, NAKED MILLI Series. Model 10373-XX. Includes LSI-3/05 CPU (Type 1), with LSI Family compatibility, three half-card chassis, 10-Amp power supply and Operator's Console. This small, low-cost computer offers exceptional power and features, including 95 instructions, Power Fail Restart, vectored priority interrupts, Real-Time Clock, AutoLoad capability and 16-bit DMA port. Full memory options.



ALPHA LSI-3/05 B, NAKED MILLI Series. Model 10375-XX. Includes LSI-3/05 CPU (Type 1) described at left, plus 5 half-card chassis with fan, 15-Amp power supply and Operator's Console. Full memory options.



ALPHA LSI-3/05 C, NAKED MILLI Series. Model 10376-XX. Same as LSI-3/05 B configuration with addition of Programmer's Console.



ALPHA LSI-3/05 D, NAKED MILLI Series. Model 10356-XX. Includes LSI-3/05 CPU (Type 1) as above, standard five full-slot processor chassis, 25-Amp power supply and Operator's Console. Core memory in either 4K, 8K or 16K word sizes.



ALPHA LSI-3/05 E, NAKED MILLI Series. Model 10366-XX. Same as LSI-3/05 D configuration with addition of Programmer's Console. Either RAM-only or Core Memory in 4K, 8K, or 16K sizes.



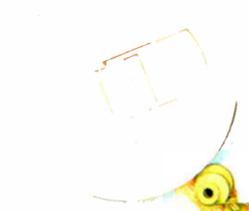
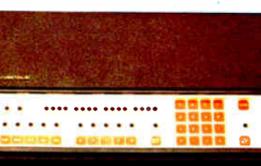
ALPHA LSI-2/20 T, NAKED MINI Series. Model 1055X-XX. Same as LSI-2/10 configuration except with high performance LSI-2/20 CPU offering twice the speed of the LSI-2/10.



ALPHA LSI-2/20 G, NAKED MINI Series. Model 1055X-XX. Same as LSI-2/10 G configuration except with high performance LSI-2/20 CPU, as above.



ALPHA LSI-2/10 T, NAKED MINI Series. Model 1074X-XX. A 16-bit mini-computer offering twice the speed of our LSI-3/05 computers. CPU provides 188 major instructions, including multiple stack handling, hardware multiply/divide, memory scan, and extensive byte capability. Five vectored priority interrupts are expandable to 256; two direct memory channels may be increased to 64. Direct Memory Access is standard. Includes Power Fail Restart. Also includes chassis with power supply and Operator's Console. Available in either 5-card or 9-card (Jumbo) versions. 4K or 8K Core 980 Memory or 16K Core 1200 Memory. Memory modules may be added up to 256K words using Memory Bank Control.



Software and Documentation Packages. Advanced software and documentation packages, including BASIC, FORTRAN IV, Real-Time Executive and Operating System are available. Plus a complete inventory of diagnostics, editors, assemblers.

The computerization problem.

The cost of an OEM computer can be a lot different than the price on the P.O.

In fact, everything considered, the purchase price could be as little as ten percent of the costs incurred over the life of the computer.

To be brutally blunt, it all depends on whose hardware you buy. That's because the cost of computerizing goes way up with most machines.

The cost of hardware integration, for example.

The cost of developing interface electronics. The cost of developing software.

The cost to maintain the machine once it's out in the field.

Any one of which could seriously impact the profitability of your product. Given that possibility, here's what you need to know to protect those profits.

Engineering Costs.

Prototyping and systems integration is a high-cost area where, traditionally, the OEM has been left to his own devices, so to speak.

ComputerAutomation doesn't work that way. We've accumulated enormous experience in systems integration because we get involved in our customer's projects.

What's more, we've put together a program for sharing that experience with our customers... free, of course. Part of it includes extraordinarily comprehensive documentation provided on an on-going basis. But more importantly, it's a people-to-people program that even provides on-board support personnel when they're needed.

Programming Costs.

No other endeavor consumes time and money quite like programming. For the OEM who's usually racing to release a new product ASAP, even a minor programming effort can be a major setback.

The solution is to concentrate on the applications end of it and not re-invent software that's already on somebody's shelf—ours. ComputerAutomation has an enormous library of powerful software that will cost you next-to-nothing. Everything from humble assemblers to high-powered compilers in BASIC and FORTRAN IV.

The powerful instruction set that comes with our computers will spare you countless hours of programming effort, too, because it's designed with that objective in mind.

Remember, too, that all our computers are buss compatible. Which means you won't have to start programming all over again when you switch to another computer in our LSI Family.

Interface Costs.

Many times an OEM is forced to invent his own interface... usually a very expensive proposition... because the supplier he's

picked doesn't offer all the interface he needs.

Or, in some cases, the supplier's interface solution is so expensive it forces the OEM to go his own way.

So, at a time when he needs to concentrate all his energies on his own product development, the OEM finds himself committing substantial resources to a peripheral project. One that can be deceptively time-consuming and costly.

Suddenly the designers are coming in, more test equipment is being designed/built/ordered, ditto for new jigs and test fixturing, the documentation hassle is getting under way, and the dollar and time costs start really piling up.

ComputerAutomation is the only computer company that has solved that problem. You can see it here in the picture. Our exclusive Distributed I/O System. Probably the closest thing to a universal interface you'll ever come across.

The Distributed I/O System only works with our computers, but it works with *all* our computers.

The way it works is this: one half-card I/O Distributor handles the commonalities for up to eight interfaces. (There's a four interface version, too.) The actual interface is accomplished by an Intelligent Cable—so-called because of the microcoded PicoProcessor molded into the cable.

This system offers amazing versatility: any and all kinds of interface can be mixed in any combination—serial, parallel or whatever. And not just standard peripherals, either. The Distributed I/O System accommodates special purpose black box kinds of things, too. There's even a version you can custom microcode yourself.

The cost? Typically under \$200 per interface in OEM quantities of 100.

Maintenance Costs.

The cost of keeping a computer in service over the long haul can be enormous. The proof of which is the huge service revenues reported by some computer companies. (Up to \$2,000 per year per computer!)

ComputerAutomation's service revenues, by comparison, are minuscule. The reason is that our equipment is so reliable that breakdowns are few and far between. And when there is a malfunction, the fix is almost always a matter of plugging in a spare board and sending the bad board back to us. No tricky fine-tuning to worry about and no high-priced junior technician in there messing around with your customer's equipment.

The Computerization Solution.

The computerization problem obviously goes far beyond computers. So it makes sense that the solution is not only a computer solution, but a systems solution as well.

To find that solution you have to look at the big picture... which we invite you to do by turning the page.



When you're buying low-cost computers, it pays to look beneath the surface.

ComputerAutomation cuts the cost of computerizing.

Knowing what the OEM needs... understanding the OEM predicament. That's what sets ComputerAutomation apart. It's the reason we ship over 100 computers per week—the second highest shipping rate in the industry.

Guaranteed savings.

OEM's buy our computers because they're the most reliable machines made. Every IC, subassembly, memory subsystem and completed computer is temperature, shock and vibration tested.

That's why ComputerAutomation can offer the only one-year warranty in the industry—when we send a computer out, we know it's not coming back for a long time.

We deliver.

In an industry where one delinquent diode can (and sooner or later will) shut down an entire assembly line, that's saying a lot.

It especially says a lot to OEM's who know they're at the mercy of their sole source computer supplier. One thing you can't do is stick somebody else's machine in that slot.

So here's a thought you might want to stick in the back of your mind for future use:

ComputerAutomation delivers on time. The reason is that we deliver from inventory—usually a comfortable 30-day cushion of computers sitting around getting more reliable by the minute because they're kept under power and constant test scrutiny.

A lot more trouble for us, but a lot less worry for you. And it does tend to prove our point. We understand the problem.

From the people who brought you the NAKED MINI.

The people who brought you the first solution to high-cost computers. And the most recent solution as well. And all the solutions in between. Including low-cost memory. And the Distributed I/O System.

Plus on-time delivery. And the only full-year warranty in the business.

The total solution to computerization. So if you can't spare the time and money to re-invent the wheel, there's a simple solution... from the people who came up with all the other solutions.



Temperature chambers stress computers to isolate marginal components. Computers are continuously tested during 72-hour burn-in at 50°C. Any error starts the test over from the beginning. To further stress the computer, power is cycled on and off approximately 2000 times during test.



Computers awaiting shipment idle away the hours under test. Reliability benefits from the additional component aging.

 **ComputerAutomation**
Naked Mini Division

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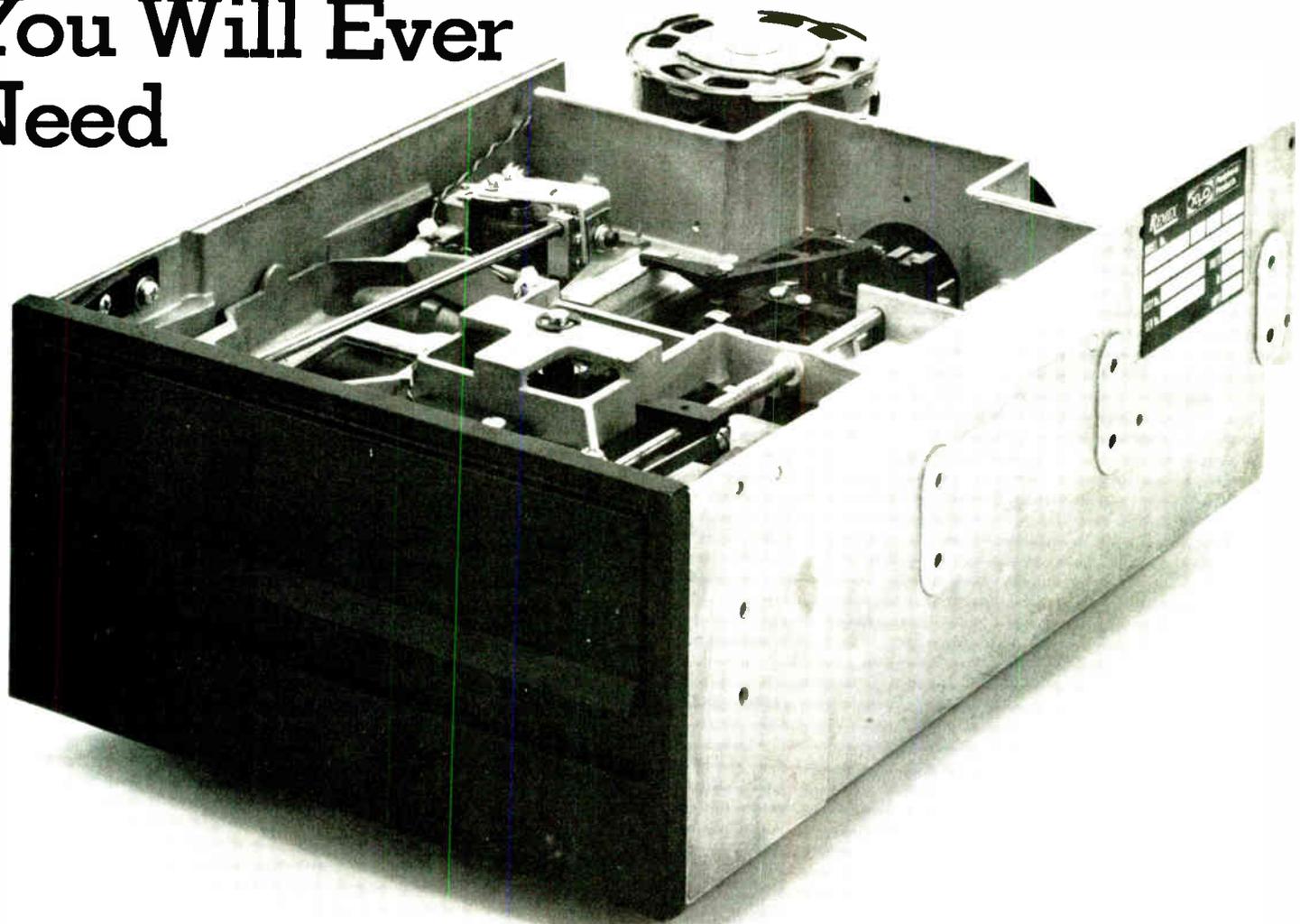
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The REMEX RFD 1000 — Because It's Versatile. Double or single density with capacity up to 6.4 Mbits... IBM standard or 32 hole hard sectored media without drive modification... IBM compatible or expanded hard and soft sectored formats for application flexibility... Unit select daisy chain capability for maximum controller efficiency... Selectable DC negative voltage for system compatibility... Individual drive housing or two drives horizontally side by side in a 19 inch rack configuration.

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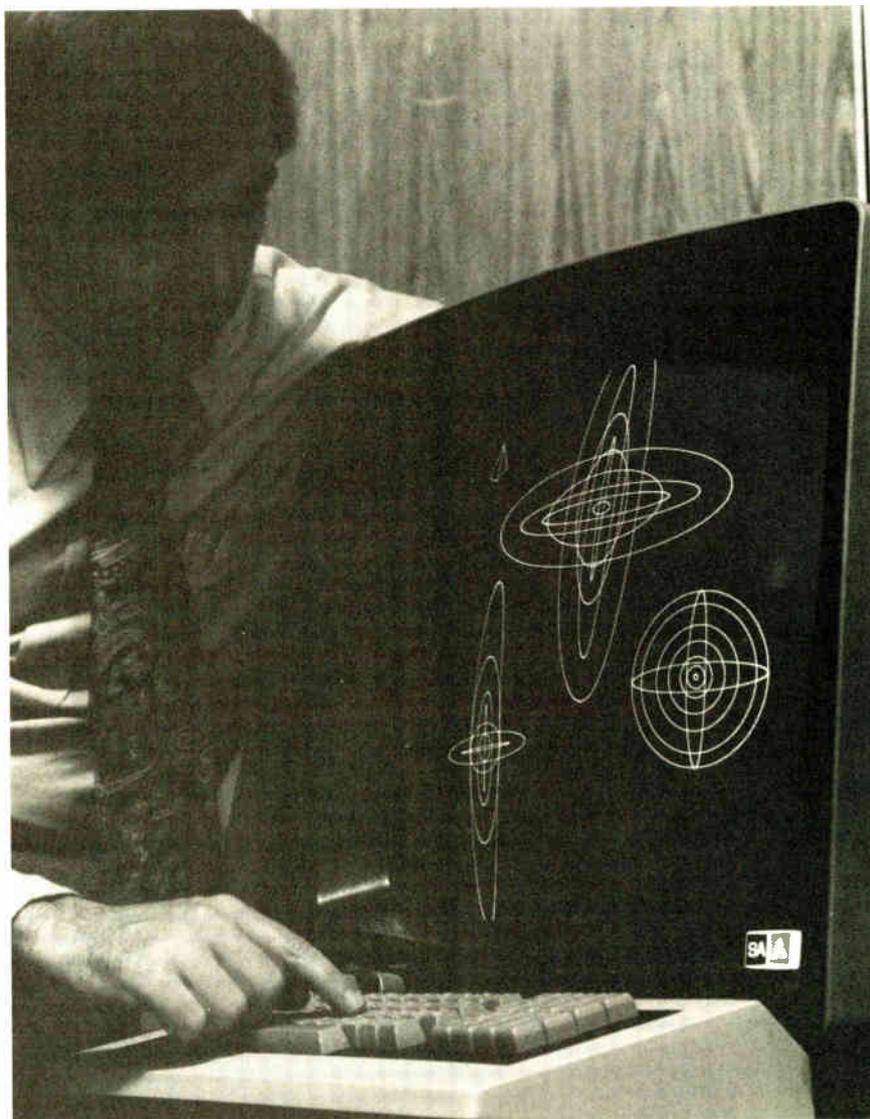
Microcomputers shrink terminal

Bipolar microprocessors
used in graphics unit
aid speed and flexibility

The incorporation of two microcomputers in the Graphic 7 interactive graphics terminal has allowed engineers in the Computer Graphics division of Sanders Associates to substantially reduce the size and price of the cathode-ray-tube terminal

[*Electronics*, Oct. 14, p. 26]. The microcomputers are based on bipolar bit-slice microprocessors.

Sanders engineers chose the 4-bit MMI 6701 microprocessor from Monolithic Memories Inc. to get bipolar speed and because it allowed them to write their own instruction set. One of the two microcomputer boards in the Graphic 7 has been programmed as the display processor, replacing a minicomputer used in the earlier Sanders SA 500 system. Elimination of that separate box is the big contributor to size reduction, allowing the Graphic 7 to fit most desk tops. The other microcomputer is the graphics controller, which controls and refreshes the images presented on the screen. This micro-



ChipStrates™ cost up to 40% less than other power SCRs and Triacs.

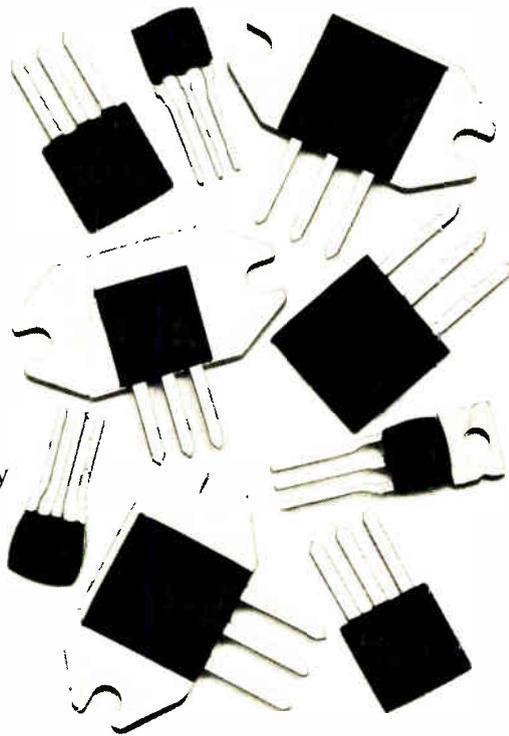
And that's only the beginning.

ChipStrates are glassivated power SCR or Triac chips mounted on solderable ceramic substrates. Since they eliminate the need for expensive metal packages, they cost up to 40% less than other power SCRs or Triacs.

For example, our 55A, 400V, ChipStrate goes for just \$3.80 in quantities of 5,000. The electrically equivalent press fit Triac will run you \$5.00 in the same quantity.

But that's not all.

ChipStrates are available in ratings from 3 to 55A and up to 800V



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Their exceptionally good form factor will simplify the packaging of your system.

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Write or phone Bob Ross for details, 11 Hamlin St. Boston, MA 02127 (617) 268-9696



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164 Circle 228 on reader service card

New products

computer contains 40 Sanders-developed instructions that are compatible with the earlier SA 500.

The display processor is a general-purpose unit that operates with 16-bit words or 8-bit bytes. The graphic controller is a 16-bit parallel micro-computer with the 40 display instructions, 13 display registers, and four general registers. It provides refresh rates of 30, 40, and 60 hertz.

The Graphic 7 can be connected to any standard local or remote computer. Roy Williams of the division's New Product Development department says a typical system, consisting of the terminal controller, 21-inch CRT display and keyboard, and 8,192 words of semiconductor memory, will sell for \$32,800. But the controller can drive several displays, and additional memory is available in 8-k increments.

Williams looks for the terminal to expand Sanders' penetration of the computer-aided design market for a variety of products from auto tire treads to aircraft parts. A.A. Hastbacka, manager of systems marketing in the Military Data Systems division, looks for the terminal to find widespread use in the military simulation and training market in which Sanders is already established. A version of the unit is being bid for a variety of Air Force aircraft simulation programs.

Interface options for the Graphic 7 include 16-bit parallel or RS-232C serial interfaces. Deliveries will begin in March.

Computer Graphics Division, Sanders Associates Inc., Daniel Webster Highway (South), Nashua, N. H. 03061. Phone (603) 885-5280. [361]

CRT display terminal
costs less, does more

Selling for \$2,600—13% less than its predecessor, the 2640A—the model 2640B interactive CRT terminal sports an improved keyboard and cursor sensing and positioning. The B version terminal gives the user a choice of either main-channel proto-

Electronics/October 28, 1976

17 days from now this trace will look the same as it does today. Now that's storage!

The Gould OS-4000 Digital Storage Oscilloscope . . .

will store any signal up to 450 kHz for as long as you need, while providing the performance of a conventional 10 MHz scope as well. The OS-4000 opens the door for entirely new viewing possibilities involving low frequency measurements. It is ideal for displaying and recording transient waveforms for medical, electrical, vibration, dynamic testing and pulse testing applications.

The digital storage capability provides a non-flickering, full trace at low frequencies and a unique "Dot Joining" technique.

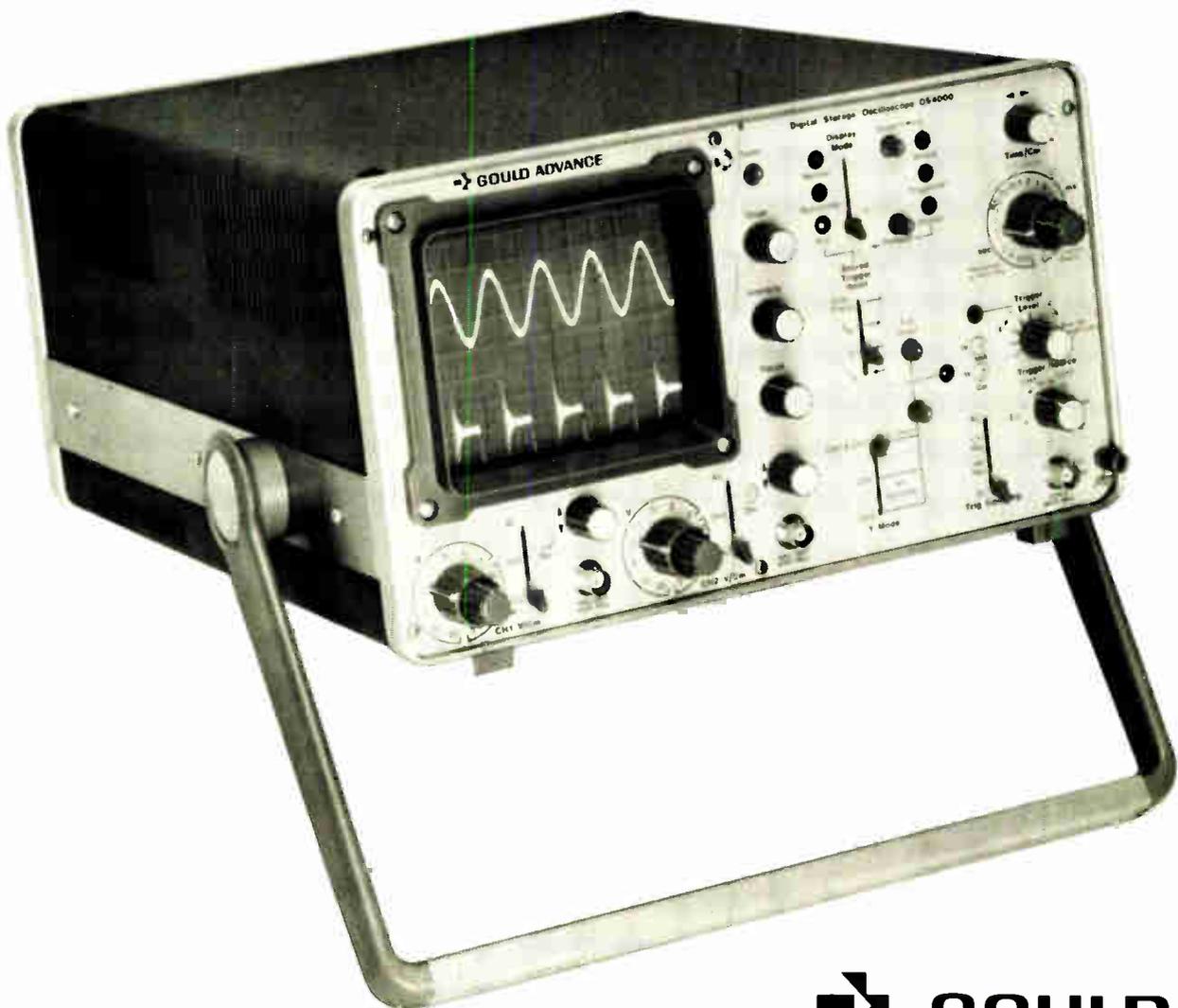
The OS-4000 will allow you to simultaneously view stored and real time signals. These may even be superimposed to reveal small changes.

The OS-4000 also allows you to examine a single event trace prior to, as well as after, a trigger point; and it's stored indefinitely as long as power is supplied to the unit.

If you'd like a hard copy of a stored trace, you can record it in either analog or digital form on your recorder by using the Gould 4001 Output Unit.

Find out how the unique Gould OS-4000 Digital Storage Oscilloscope and the companion 4001 Output Unit can make your work more efficient and easier. Call your nearest Gould Sales Engineer for details. Or write Gould Inc., Instrument Systems Division, 3631 Perkins Avenue, Cleveland, Ohio 44114.

PHONE TOLL FREE FOR BROCHURE (800) 325-6400.
(In Missouri (800) 342-6600)

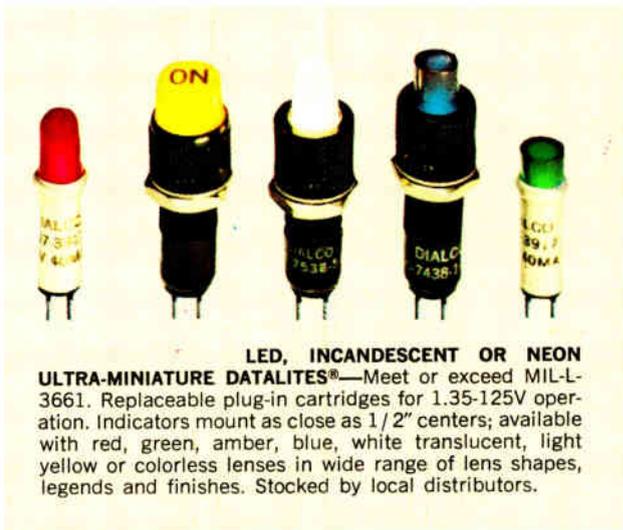


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INCANDESCENT OR NEON SUB-MINIATURE INDICATORS—Meet or exceed MIL-L-3661. Mounts in 15/32", 1/2" or 17/32" clearance holes. Incandescent for 1.35-28V; neon has patented built-in current limiting resistor. Choice of cylindrical, faceted, convex, flat, square and round lens shapes, finishes, legends. Stocked by local distributors.



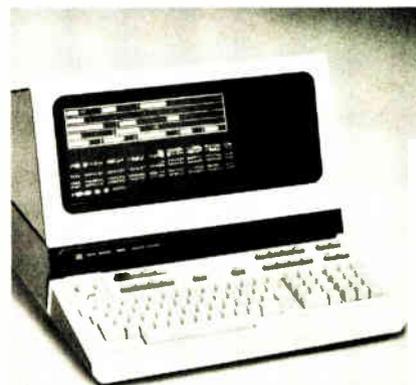
Dialight, the company with the widest choice in switches, LEDs, indicator lights and readouts, looks for needs . . . your needs . . . and then they develop solutions for your every application. No other company offers you one-stop shopping in all these product areas. And no other company has more experience in the visual display field. Dialight helps you do more with these products than any other company in the business, because we are specialists that have done more with them. Talk to the specialists at Dialight first. You won't have to talk to anyone else. Send for your free new copy of Dialight's current catalog.

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See Dialight.

New products



col or standard reverse-channel protocol for half-duplex modem operation. And its additional firmware allows connection of most serial printers via an EIA RS-232-C interface. Like its predecessor, the new terminal is designed for both page-mode and character-mode operation. It has a semiconductor memory that can store more than 400 lines of data, which the user can view 24 lines at a time. Other standard features are off-line data preparation and editing, built-in self-testing, and modular construction for easy maintenance and expansion.

Two units based on the 2640B—the 2640N and the 2640S—offer keyboard layouts and character sets conforming to Danish/Norwegian and Swedish/Finnish language requirements, respectively. The N and S versions are priced at \$2,750.

Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. 94304 [363]

Exerciser tests

2315-type disk drives

A series of switch-selectable tests ranging from simple restore operations through complex data exercises can be performed on 2315-type disk drives by the DX-1000 disk exerciser. Able to test drives made by such manufacturers as Wangco, Pertec, and Diablo, the model DX-1000 tests such functions as seek, seek incrementing, decrement seek, increment or decrement up or down disk, and random incrementing. A digital readout of seek time, rota-

FLUKE PROVES AN INEXPENSIVE, HANDHELD DMM CAN BE BUILT WITHOUT LEAVING EVERYTHING OUT.

Let's face it.

Before now, if you bought an inexpensive, handheld digital multimeter you didn't get much—they just left most everything out.

We knew that was no answer.

So we built the 8030A 3½-digit DMM. It's a small, portable, inexpensive, handheld DMM, but it performs like our benchtop units.

With one basic difference. The 8030A was designed, built and tested to a size and shape proven best for field service and laboratory technicians. There's a built-in hood that can be slipped forward to shade the readout in sunshine. It has rms capability. The best overload protection. Diode test. It weighs 2.2 pounds, and will take a beating without failing. Finally, we guarantee accuracy specifications for one year.

And it only costs \$235*.

True rms.	Fluke
1-year accuracy specs.	Fluke
High voltage protection.	Fluke
Diode test.	Fluke

A full line of accessories offering rf voltage, high current ac, high voltage dc, and temperature measurement probes. Fluke

There's only one place to go for all the performance you need in a handheld DMM.

There are measurement functions in five selectable ranges for dc volts, ac volts (true rms), dc current, ac current (true rms), and resistance. DC voltage measurement is from 100 μ V to 1100V with basic accuracy of $\pm 0.1\%$, ac measurement is from 100 μ V to 750V rms with basic accuracy of $\pm 0.5\%$. DC and ac current is from 100 nanoamps to 1.999 amps with basic dc accuracy of $\pm 0.35\%$ and basic ac accuracy of $\pm 1\%$. Resistance measurement is from 100 milliohms to 2 megohms with a basic accuracy of $\pm 0.4\%$.

We added true rms response for ac measurements. Specified accuracy is still attainable when the measured waveform is distorted.



"Fluke does the impossible again."

There is extensive overload protection. It has been tested with transients up to 6000V peak across the input terminals.

Options include two battery operations: a rechargeable NiCad for 8 hours operation and throw-away alkaline cells. Accessories include probes for measure-

ment of rf voltages, high current ac, high voltage dc and temperature.

80T-150 Temperature Probe	
Sensitivity:	1 mV/°C or 1 mV/°F
Accuracy:	
+15°C to +35°C ambient:	$\pm 2^\circ\text{C}$ (3.6°F) — 25°C to +125°C $\pm 3^\circ\text{C}$ (5.8°F)
-50°C to -25°C and +125°C to +150°C	
0°C to 15°C, 35°C to 50°C ambient:	Add 1°C (1.8°F) to above

You can also get temperature measuring capabilities with the 8030A.

And because the 8030A gives you so much in performance, let us remind you once more of the price.

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For the first handheld DMM that's small in size, small in price, but huge in performance.

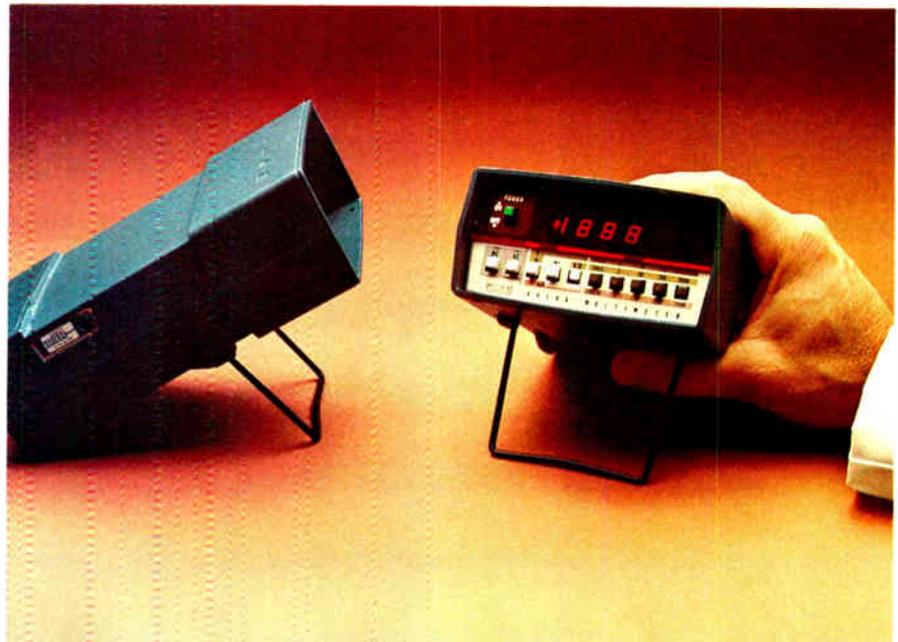
For data out today, dial our toll-free hotline, 800-426-0361.

John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043

Fluke (Nederland) B.V., P.O. Box 5053, Tilburg, The Netherlands.

Phone: (013) 673-973 Telex: 52237

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A NEW ADVANCE. 8030A DMM. 

AIRPAX™



UPG Delay 66 Circuit Protector

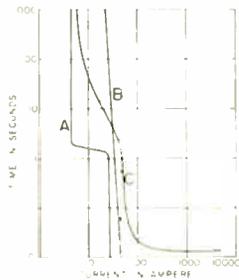


Problem Solver!

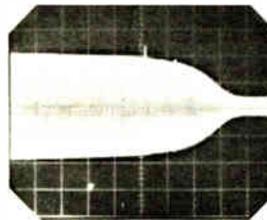
Problem:

Customer had a 1/3 hp, 115 volt single phase capacitor-run 3450 rpm motor. Running current was 4.6 amperes and starting current was 28 amperes with a start-up time of 1.6 seconds.

He needed overload protection that was faster than that supplied by the internal sensors and a fairly quick dropout in case of a jammed load or stalled rotor.



Time vs Current
A — Motor Characteristics
B — 15A Fuse
C — UPG Delay 66, 5A

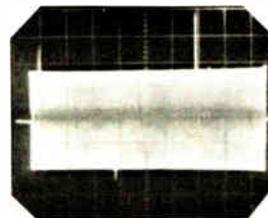


Start-up Current Envelope
Vertical 7.5 amps rms/div.
Horizontal .2 sec./div.

In order to start the motor without blowing a fuse, he was forced to use a 15 ampere rating. This gave him stalled rotor protection at about 10 seconds, but no overload protection. The standard long delay magnetic protector required a 7½ amp rating to be able to turn his motor on reliably. This gave him his stalled rotor protection at about 5 seconds, and overload protection at 200%. Still not good enough.

Solution:

The Airpax UPG Delay 66, at 5 amp rating eliminated this problem with turn on . . . locked rotor protection at about 4½ seconds . . . and overload protection at about 150% on nameplate in approximately 400 seconds. This allowed short periods of overload without nuisance tripping. His problem was solved. (Delay 66 is also available in larger Airpax Type 219 and 229 Molded Case units up through 100 amperes.)

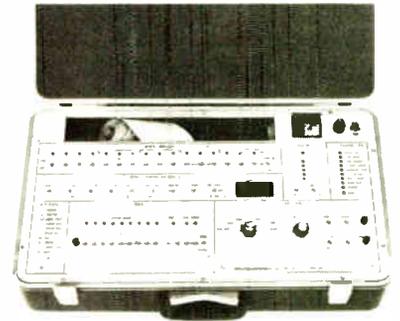


Stalled Rotor Trip Out
Vertical 7.5 amps rms/div.
Horizontal .5 sec./div.

If you have an application with a special protection problem, call Airpax Electronics at Cambridge, Maryland (301-228-4600) or write for literature on Airpax Circuit Protectors and Circuit Breakers.

New products

tional speed, and sector count allows the user to determine if the drive is within factory specifications.



The exerciser offers three basic data patterns: 16 bits of fixed track address data, 16 bits of incrementing data, and 16 bits of random data. Switches allow the user to choose various standard bit packing densities, track packing densities, disk speeds, and read/write formats. The DX-1000 is equipped with 16 bits of error counting with overflow, and has a stop-on-error feature for overnight testing for bit dropouts.

The portable, 20-pound unit sells for \$1,995.

Wilson Laboratories Inc., 2536-D East Fen-
der Ave., Fullerton, Calif. 92631 (364)

Impact printers run at
up to 240 lines/minute

Two rotating-belt impact printers
have maximum printing speeds for
upper- and lower-case text of 240



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TV Products

LOGIC BOARD TESTING DOES NOT DEMAND SOFTWARE PROGRAMMERS, AND LOTS OF MONEY.

There is a foolish notion in logic board test circles that says, "Plan on spending all the budget you have, plus a lot more, to get logic board testing results."

What nonsense.

Why, that's as bad as the arguments for testing in the end product. Is there no middle ground? You know, a good testing system for a fair price.

Of course there is. And we built it.

It's our 3000 Series Logic Testers.

The 3020A is a console for high-volume production applications. It comes complete with 128 pins for under \$30,000*.

The 3010A is a compact version for field service and low-volume production at less than half the price.

O.K. So why no high cost?

Most testers share one major short-coming: the cost and complexity of programming. As logic boards become larger and more complex, test engineers anxiously reach for more computer power and more software.

It just isn't necessary.

The fact is that tediously developed, bit-by-bit sequences are now past history. Instead, we provide powerful groups of general-purpose sequences with various duty cycles and frequencies. Boards respond to them. Their mathematical qualities honor the constraints of your circuits and the laws of logic.

Specifically, the 3000 Series Testers have seven classes of signals. Over 350 unique bit streams and their complements are available to exercise the most complex boards.

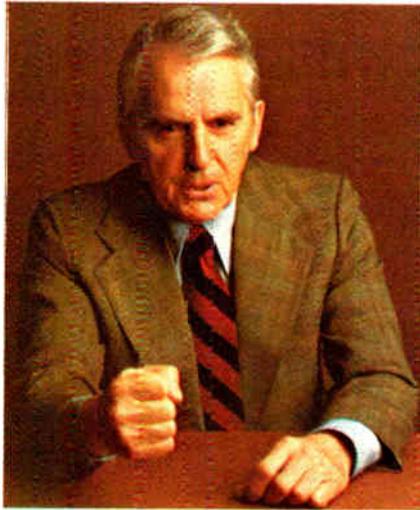
And, where a specific sequence is needed, it is easily added.

The test engineer doesn't program in the conventional sense. He simply develops a test plan which consists of selecting the appropriate stimulus algorithm for each input.

We've pre-programmed the CPU, simplified the peripherals, and eliminated 80% of the programming. That's what keeps the cost down.

The beautiful part is that test confidence ends up higher.

And fault isolation is just as practical as the price. It's hard to imagine



"Prove it."

any other tester making more common sense.

Test program assignments and editing are made on-line by pushbutton. Program debugging is simple. Whenever a pin number is entered, the sequence assignment is displayed. Sequences can be changed simply by depressing the appropriate pushbutton.

Again, there are no assemblers or compilers to fuss with. Highly compre-

hensive programs are completed in hours, not days or weeks.

And once the test program is entered into memory, you can record it easily on a handy little magnetic credit card that looks exactly like those credit cards in your wallet. The programmed card will function interchangeably with the production Model 3020A, or the field service 3010A.

Maybe we've made our point.

You can get a tester that offers four million tests per second, test sequences to 40 million words, and programmable logic levels without subsidizing a computer center and staff of programmers.

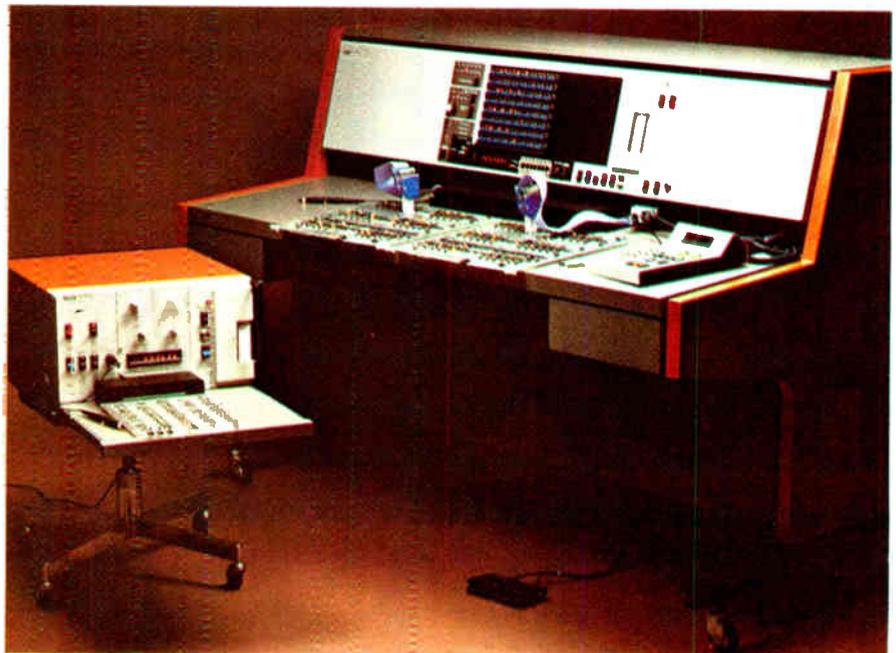
We'll prove it to you in dollars and cents.

Write and ask for "The Economics of Logic Board Testing." Everything you need is there to get you into logic board testing. Economically, for a change.

For data out today, dial (415) 965-0350. Fluke Trendar, a subsidiary of John Fluke Mfg. Co., Inc., 500 Clyde Avenue, Mountain View, CA 94043

Fluke (Nederland) B.V., P.O. Box 5053, Tilburg, The Netherlands. Phone: (013) 673-973 Telex: 52237

*U.S. price only



COMMON SENSE 3010A/3020A TESTERS. 

HP's Small Wonders

The 33311B OEM Microwave Switch

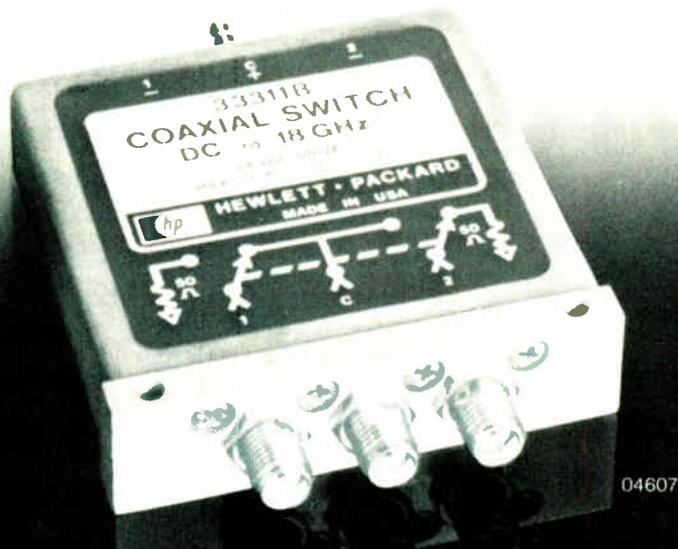
- DC to 18 GHz with 1.4 SWR, 0.8 dB loss and useable to 24 GHz.
- 90 dB isolation, $\pm .03$ dB repeatability at 10^6 switchings, ungated port terminated in 50 ohms.
- 30 ms switching time, zero-power magnetic latch, 5V or 24V coils.
- Small, rugged with a compact design that fits easily into microwave equipment. SMA connectors. Price is \$395* with quantity discounts available.

These and more than 300 other microwave measurement items are described in our 80 page coaxial and waveguide catalog. You can get a copy from your nearby HP field office, or write... *Domestic US prices only.

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Circle 170 on reader service card

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Project HOPE exists because there are people with hope—people who have given 3.5 million men, women, and children on four continents the chance for happier, more productive lives through improved health care.

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HOPE**

Department A
Washington, D. C. 20007

New products

lines per minute. Depending upon the number of characters per line, the model 9212 prints from 120 to 240 lines/min, while the model 9214 puts out 230 to 240 lines/min. Both 132-column printers may be ordered with an option that restricts them to upper-case characters; in that case, maximum speed is raised to 340 lines/min.

Packed with sound-absorbing material to make them suitable for use in business offices, the 9212 and 9214 have prices of \$8,640 and \$11,880, respectively. Their respective monthly leasing charges are \$312 and \$395.

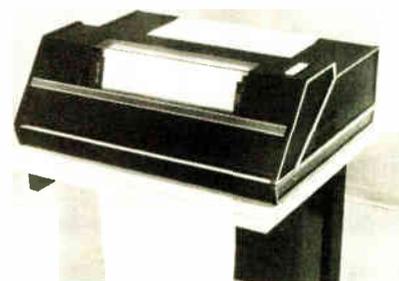
Marketing Dept., Datapoint Corp., 9725 Datapoint Dr., San Antonio, Texas 78284 [365]

Low-cost printer bangs out 300 to 500 lines/minute

Offered in both 80- and 132-column widths, the Data Test 300 line printer operates at 300 and 500 lines per minute. Vertical spacing is 6 lines per inch at 50 lines per second (8.3 inches per second).

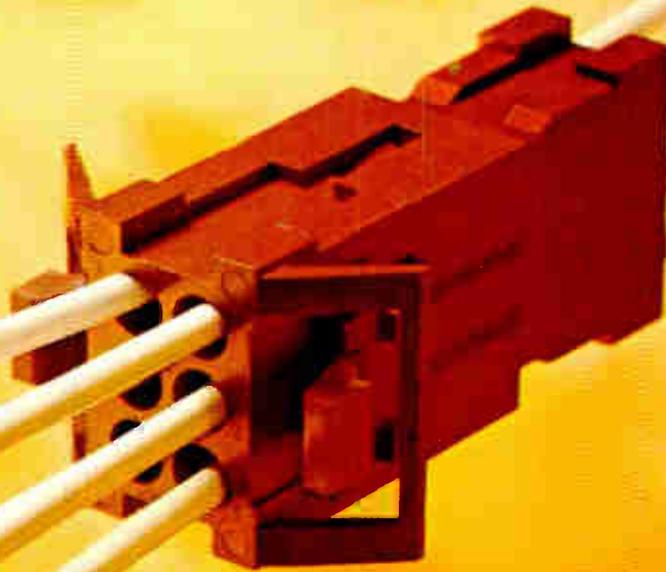
The printer uses a fully formed character font on a horizontal type carrier, which is removable and replaceable for changing type styles. It employs one hammer per position and can produce an original and up to five copies. The printer is available with 48-, 64-, and 96-character ASCII sets. A wide variety of interfaces is offered: Centronics, Data Products, Intellec 8, Incoterm, and RS-232-C up to 9,600 baud in an asynchronous mode.

In quantities of 100 printers, the 80-column unit sells for \$4,295 each, and the 132-column version of the



Electronics/October 28, 1976

*Our FIRE-PLUG™
connectors already
meet UL 94V-0
flammability tests.*



And you can't beat our price.

These new Amphenol® connectors are classified 94V-0 for flame resistance by Underwriters Laboratories. That's the most stringent test of plastic material flammability conducted by UL. And these connectors are also listed by CSA.

What's more, FIRE-PLUG connectors exceed UL's upgraded standards for thermoplastic materials scheduled to go into effect July 1, 1977. So you can upgrade your products now.

They cost no more than what you're buying now. FIRE-PLUG connectors are priced no higher than commercial connectors sold under the less stringent UL 94V-2 rating.

Interchangeable, too. FIRE-PLUG connectors are interchangeable, intermatable, and intermountable with the most popular types of commercial connectors.

Save time and labor with faster panel mounting. The FIRE-PLUG has mounting latches that flex easily. Only fingertip pressure is needed to push and lock the housing into a panel. Cable-to-cable styles are also available.

You can get them now—in quantity. Just call your Amphenol Industrial Distributor for fast delivery. Or write or call: Ray Hayer, Amphenol Connector Systems, Bunker Ramo Corporation, 900 Commerce Drive, Oak Brook, Illinois 60521. (312) 986-3749



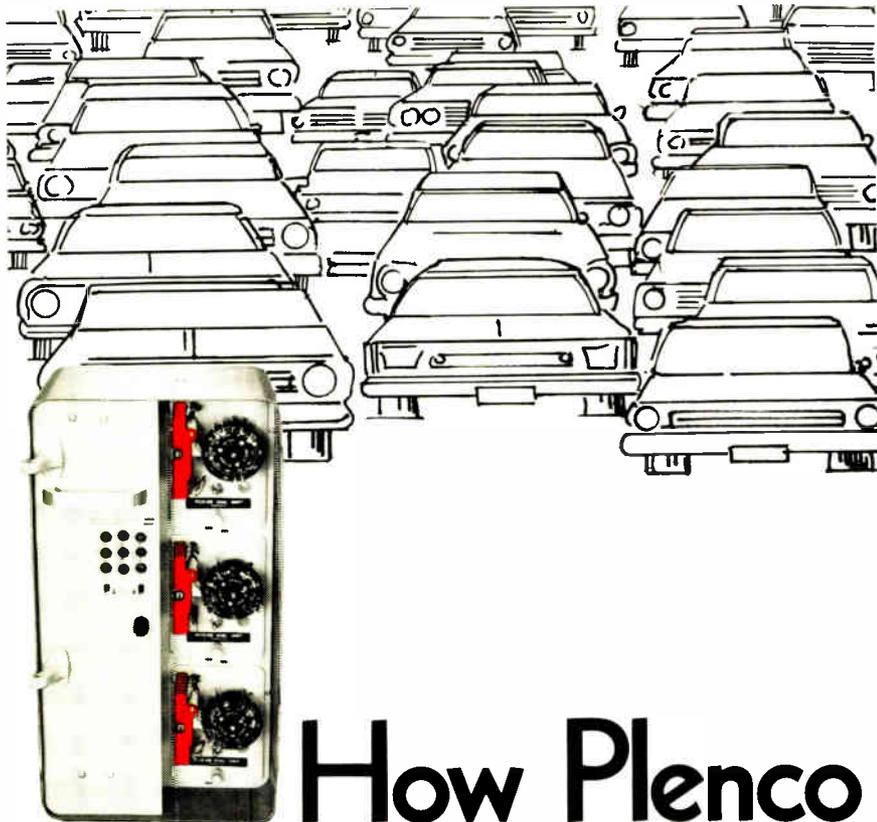
*Semi-automatic crimping machine.
Hand tools also available.*

*The right idea
at the right time.*

AMPHENOL Connector Systems



Circle 171 on reader service card



How Plenco helps Crouse-Hinds keep the police off the streets:

Plenco 317 Red. This dial contact block is molded of it.



Manufactured by Crouse-Hinds Company, Traffic Control Products Division, Syracuse, N.Y., thermoset-molded contact blocks like this are used in motor-driven dial timing devices.

These dial units in turn are used in Crouse-Hinds pre-timed traffic controllers, coordinating units and synchronizers. Measuring only 1'9" in height, the controller shown is part of a close-working traffic team that's been called a policeman's best friend.

Clearly the components used in Crouse-Hinds traffic control equipment must have a long service life and a high degree of

reliability. We're pleased that our Plenco 317 Red General-Purpose Phenolic Molding Compound was chosen to help.

Next time you have to specify compound, signal your needs.

Chances are you'll give Plenco the go-ahead.

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PLASTICS ENGINEERING COMPANY
Sheboygan, WI 53081

Through Plenco research... a wide range of ready-made or custom-formulated phenolic, melamine-phenolic and alkyd thermoset molding compounds, and industrial resins.

New products

new machine is priced at \$3,490. Data Test Corp., 2450 Whitman Rd., Concord, Calif. 94518 [367]

Core memory designed for PDP-11/70 computers

A plug-compatible magnetic-core memory for PDP-11/70 computers is offered by Ampex Corp. at what the company says is a savings of up to 40% over the price of the MJ11 memories used in those machines. The Ampex ARM-1170 is available in 128-kilobyte increments (32 kilowords of 36 bits each) and is capable of expanding PDP-11/70 computers to their maximum of 4 megabytes. All the equipment needed for expansion to the full 4-megabyte capacity can be contained within the two PDP-11 cabinets, according to Max Bennett, Ampex vice president.

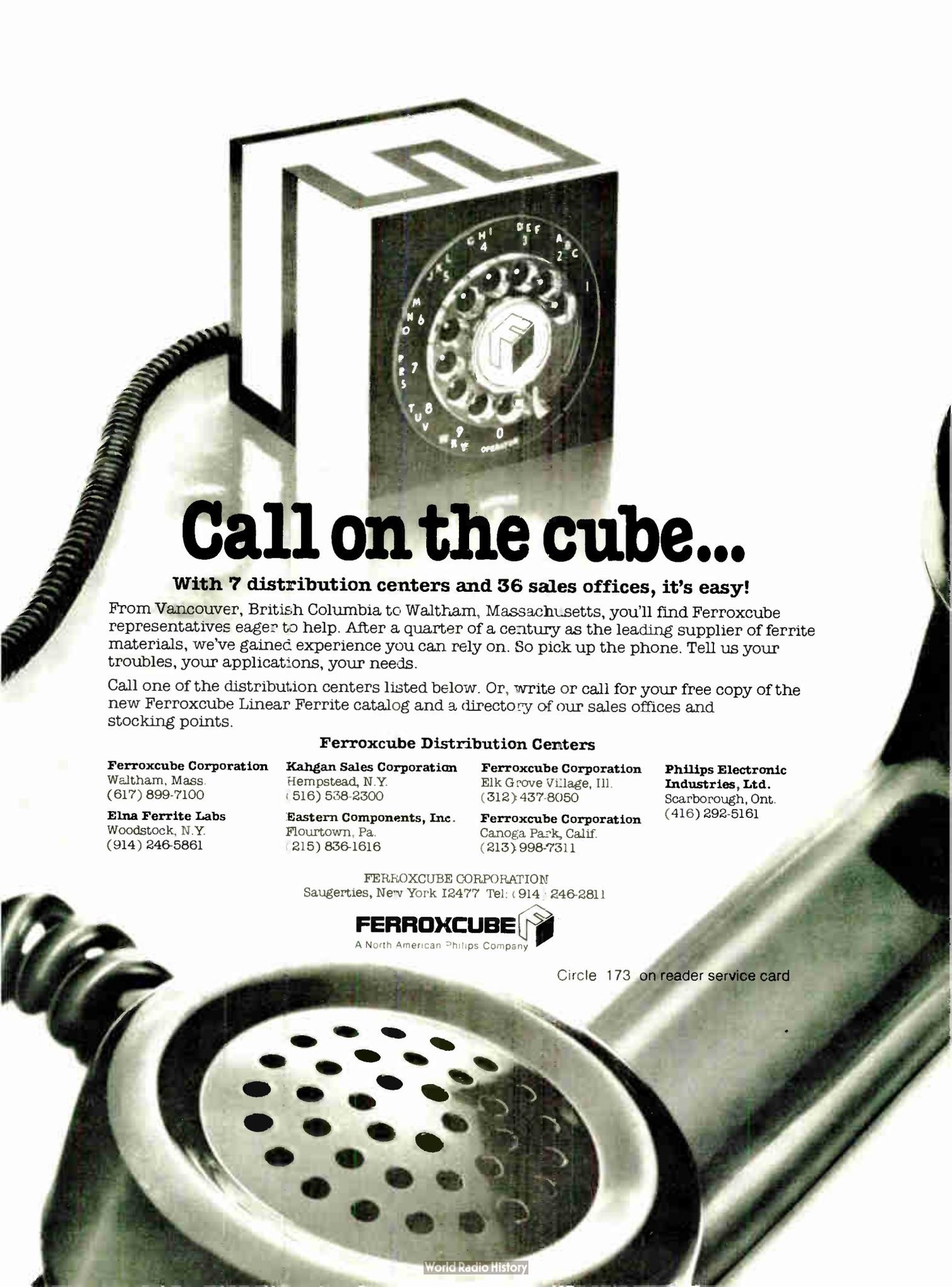
One megabyte of ARM-1170 memory sells for \$48,500 in small quantities and has a delivery time of 45 days.

Ampex Corp., 200 N. Nash St., El Segundo, Calif. 90245 [368]

Low-priced terminals built for distributed processing

Two low-priced intelligent batch-terminals from General Terminal Systems are designed to serve the field of distributed data processing. Built around General Electric Company's TermiNet 9600 communications controller and including a TermiNet 320 line printer and a 300-card-per-minute reader, the first terminal—called the GTS 5030—is suited for line speeds of 2,000 and 2,400 bits per second. The terminal, which includes an IBM 2780 emulator, is priced at \$12,900. The other new unit, the GTS 5040, is capable of a line speed of 4,800 bits per second. A TermiNet 340 line printer is included in the terminal, which is priced at \$14,900.

General Terminal Systems Inc., Suite 416, 13777 North Central Expressway, Dallas, Texas 75243. Phone (214) 234-3346 [369]



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Eastern Components, Inc.
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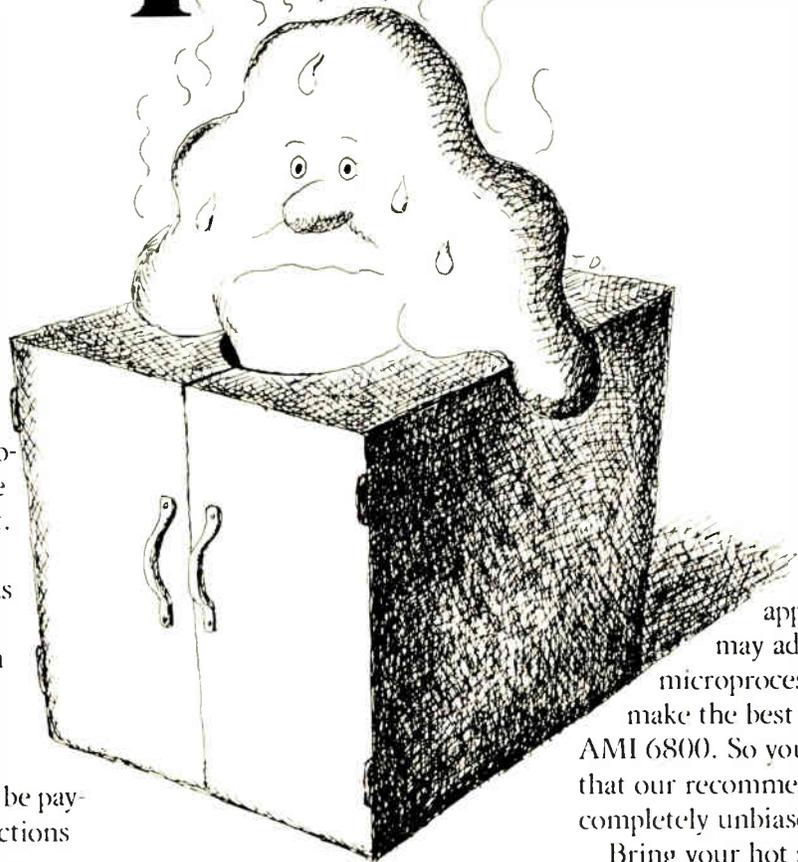
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Circle 173 on reader service card

A reducing plan for microprocessors.

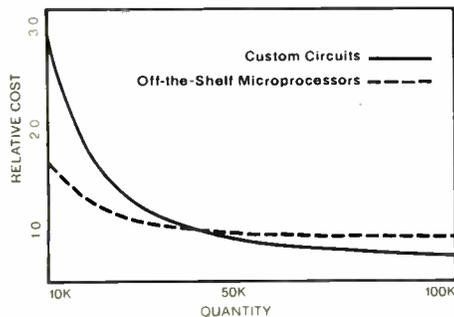


Here's a way to get a micro-computer that's *exactly* the right size for your product.

It's a custom microprocessor. We've made millions of them since 1966. And we're selling more of them today than ever.

The reason is simple. When you buy a standard microprocessor, you could be paying for a lot of built-in functions that you don't need. And, even though the standard part is cheaper going in, you can tell by the chart that custom comes out ahead in high volume runs.

If you're not sure which way to



go, come to us. Nobody can match our experience in custom MOS, with our full-time staff of engineers, technicians and marketing specialists. We've recently developed a totally new method of design that cuts about 25 percent off the development cycle time. And our production lines in Santa Clara and Pocatello are geared to produce all the CMOS, N-Channel or P-Channel circuits you want.

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AMERICAN MICROSYSTEMS, INC.

New products

Packaging & production

Tester counts toroidal turns

Easy-to-use instrument displays winding's turns on 3½-digit LED readout

Engineers using wound toroidal inductors and transformers customarily use three parameters to specify them: turns per winding, wire size, and core material. Turns per winding is perhaps the most critical—and the hardest to check. A new instrument from Semiconductor Circuits Inc., the model 2000, allows non-technical test personnel to quickly measure the number of turns in toroids having single, multiple, and tapped windings. Turns are read out directly on a 3½-digit light-emitting-diode display.

Many companies inspecting toroids have been measuring their

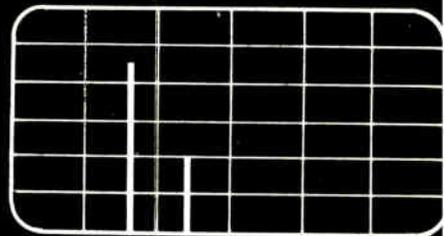
inductance and calculating the number of turns or, alternately, attempting to measure turns ratios by nulling the winding under test against a precision ac ratio box. Both of these methods required skilled operators and long setup and test times. In addition, each method had some inherent inaccuracies.

The model 2000, on the other hand, is said to be extremely accurate. A front panel turns-test-range switch allows an operator to scale the digital readout for best resolution. For instance, an operator can use the 0–200 turns range with an accuracy of one turn out of 200 or the 0–2,000 turns range with an accuracy of 20 turns out of 2000. Scaling of the readout permits measurements of up to 19,999 turns. Interpolation and estimation normally used on analog panel meters is eliminated. Four front-panel switches permit independent measurements of up to four windings that share the same core.

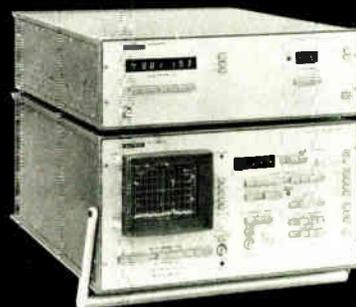
Don Delanger, president of the firm, says the new tester was originally developed to meet an in-house



Q. How do you resolve two signals spaced 1 Hz apart at 2 MHz?



A. With EMR's new Model 1520 Digital Spectrum Translator and Model 1510-03 Digital Real-Time Spectrum Analyzer.



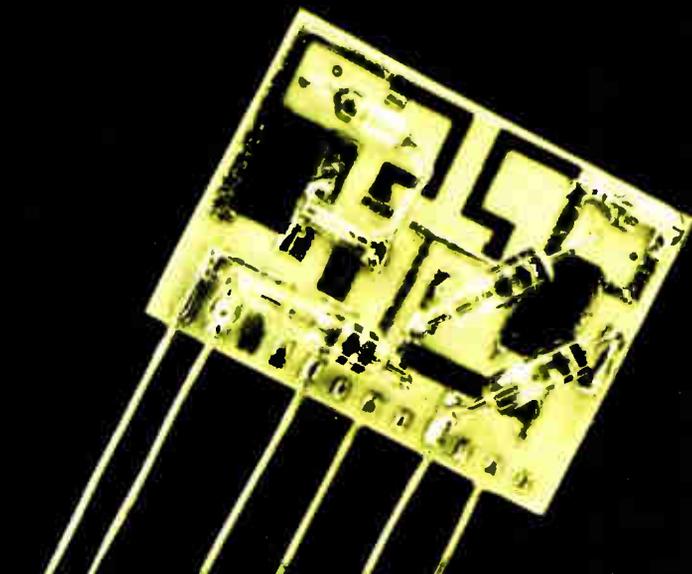
Why go partway in analyzing data? Get the resolution/performance edge of our Model 1510-03 Digital Real-Time Spectrum Analyzer, then go it one better. Enhance frequency resolution still more by adding the Model 1520 Digital Spectrum Translator to concentrate the full resolution of the Analyzer about a selectable point of interest in the spectrum. For that matter, why stop there? Step up from 25.6 kHz to a full 2 MHz upper frequency limit by adding the optional Model 1521 Range Extension Module, too!

Other features of the unequalled 1520 Translator: nine translatable frequency ranges from 25.6 Hz to 10.24 kHz; center frequency selectable in 1-Hz steps and automatic gain ranging — each with an easy-to-read LED display; plus, an automatic frequency sweep. Full-scale out-of-band signal to minimum-detectable in-band signal exceeds 100 dB.

EMR EMR
Schlumberger

EMR Telemetry
Weston Instruments, Inc.
Box 3041, Sarasota, Florida 33578
(813) 371-0811

Circle 194 on reader service card



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They are not intended for use as general purpose protective coatings or for other purposes. This accounts for their high quality performance in circuit board applications. Reliable performance attested to by years of successful on-the-job service and backed with a full staff of customer service specialists.

Broad Selection of Coatings

Conap's economical, easy-to-process printed circuit coatings include both single component and two part systems conforming to MIL-I-46058C, Type UR requirements. There are formulations for dipping, spraying, or brushing. Coatings that cure at room temperature or elevated temperatures. Available in quart, gallon, 5-gallon and 55-gallon containers as well as convenient, easy-to-use, aerosols.

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Films are available to provide excellent resistance to reversion, abrasion, impact, chemicals and solvents, fungus, thermal shock. Good electrical properties are a common denominator.

These coatings will protect assemblies from water, high humidity, contamination, and other severe environmental conditions. At the same time, they can ruggedize units against shock and vibration.

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Free Bulletin, Low Cost Evaluation Kits.

Send for Conformal Coatings Brochure C-110 containing complete specifications and information on inexpensive evaluation kits.

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CONAP

Conap, Inc. / Olean, N.Y. 14760 / 716-372-9650
Conap (Canada) Ltd. / Mississauga, Ont. 416/625-2520

need to speed up toroid inspection. Circuitry of the model 2000 is surprisingly simple. The heart of the tester is a single-turn reference probe that is placed within the inner diameter of the device under test. With an internally generated 20-kilohertz signal exciting the toroid, voltages across the reference and any of the toroidal windings are compared. The factor by which the toroid winding voltage exceeds the single-turn reference winding voltage is a direct measure of the turns ratio of the toroidal turns to the single turn.

The in-house version of the tester has cut production time on products using toroids, Delanger says. In addition, the firm's engineers have found that the added accuracy of the new tester has eliminated many low-line input voltage rejects on the inverter line. The turns ratios that were slightly on the low side had slipped through previous in-house inspections.

The tester operates from 105 to 125 volts ac at 10 watts and weighs 8 pounds. Its dimensions are 4 by 10 by 11 inches. Single-quantity price is \$1,495, and delivery time is two to four weeks.

Semiconductor Circuits Inc., 306 River St., Haverhill, Mass. 01830. Phone (617) 373-9104 [391]

Vacuum gage identifies three types of leaks

Most vacuum-leak detectors simply indicate the presence of a leak. A gage developed by Varian Associates—and called smart—does more. Besides detecting vacuum system leaks and giving a readout of pressure, it can tell what type of leak is present: air, water vapor, or internal outgassing from contaminants.

Range of the instrument is 10^{-8} to 10^{-4} torr. Accuracy is comparable to that of a nude ion gage of the same range; however, the new gage eliminates the ambiguity that exists when carbon monoxide and nitrogen are present in the system.

For detecting leaks, the gage

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We have it.

GET 1130 LPM FOR LESS THAN \$10,000 IN 48-CHARACTER SET APPLICATIONS, OEM QUANTITIES.

Here now: CDC horizontal font Band Printers with truly operator-interchangeable bands — plus exclusive choice of 10 and 15 cpi bands! Just look at their advantages:

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Paper-saving condensed pitch! Prints 132-character lines either on 14⁷/₈" or 11" paper! Unique 15 cpi bands cut user paper costs and storage needs by reducing paper volume 40%!

Three look-alike models. Only six differences between units: identical spare parts kits. Offer a choice of speeds — without tying up capital in spare parts inventories!

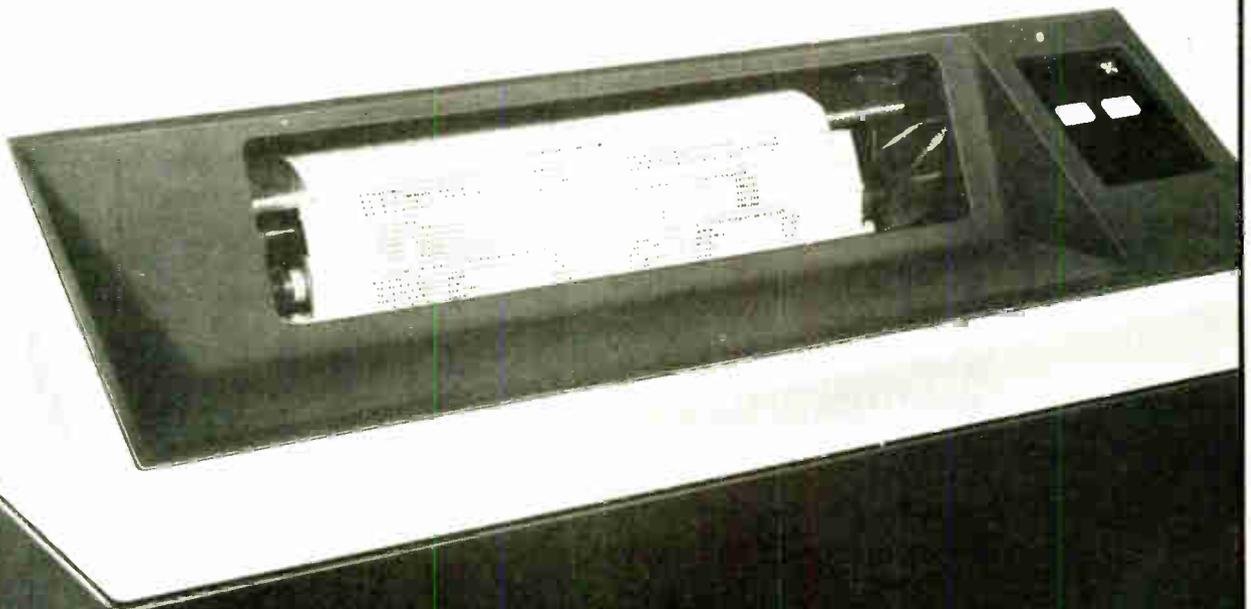
Minimum operator attention. Exclusive patented control permits use of double-length 48-yard ribbon. cuts ribbon changes 50%! Electric eye automatically reacts to any paper feed jam-up. permits use of lighter-weight paper

Superior readability. These CDC Band Printers deliver full, solid strokes — top to bottom — even on super- and sub-scripts

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Write for complete information plus sample printout. Compare our sample with copy from any printer. See how CDC Band Printers offer print quality and printer features never before available in a medium-to-high-speed printer under \$10,000!

New compact 34" width. Takes a minimum of precious floor space: produces up to 900 lpm (using 64-character sets).



Phone (313) 651-8810 or write: Harrison Craig, Peripheral Products Sales Manager, Control Data Corporation, 1480 N. Rochester Road, Rochester, Michigan 48063. Ask a CDC Sales Representative to bring me a Band Printer evaluation unit. Send more information and sample print-out.

Ask the CDC OEM people

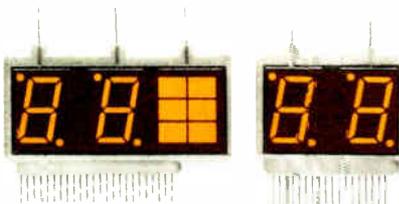
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GD CONTROL DATA CORPORATION



NEC Matrix Plasma Display Panel — compact, complete with driver circuits. TTL compatible.

Type PXD0503A displays 256 characters (32 x 8 lines) in 5 x 7 dot matrix form. The 0.26-inch high characters are high contrast neon orange. No glare, distortion, flicker or fuzziness. NEC's unique transparent electrodes enhance inherent high readability. TTL level interface. Measures 5.5 x 12.6 x 2.1 inches including connectors. Ideal for terminal display applications.



Type PO2504T-02 Type PH2524T-02

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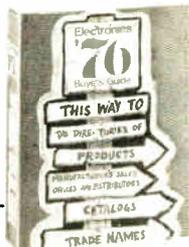
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makes use of the established ratio of nitrogen to total gas present in a normal leak-free vacuum system at any given pressure. An optical filter, tuned to the spectral line of nitrogen, enables measurement of the partial pressure of nitrogen in the system. The gage compares that partial pressure with the total system pressure to determine the nitrogen percentage that is present.

An abnormally high nitrogen percentage indicates an air leak in the system. An abnormally low percentage indicates the presence of an unwanted gas, such as water vapor. If the gage indicates an abnormally high system pressure with the correct percentage of nitrogen, internal contaminants are outgassing.

A three-position switch controls the meter to cover system pressure, nitrogen percentage, and leak checks. For recording and automated process-control purposes, total pressure and percent nitrogen outputs are provided at the rear panel.

Varian Vacuum Division, 611 Hansen Way, Palo Alto, Calif. 94303. Telephone: (415) 493-4000. [392]

High-speed chip prober operates automatically

Described by its maker as the first automatic chip prober to be available to the semiconductor industry, the Electroglas/Xynetics model 146X is an electronically controlled electromechanical system for automatically test-probing and classifying semiconductor devices at high speed. The system requires less than eight minutes to test 100 devices. This, according to the manufacturer, makes 100% testing economically



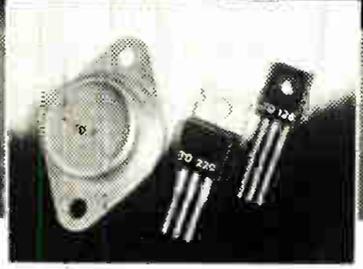
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2N 6038	2N 6035
2N 6039	2N 6036
SJE 800	SJE 700
SJE 801	SJE 701
SJE 802	SJE 702
SJE 803	SJE 703

8 Amperes - TO 220 package

BDX 53/A/B/C	BDX 54/A/B/C
--------------	--------------

8 Amperes - TO 3 package

NPN	PNP
SJ 1000	SJ 900
SJ 1001	SJ 901
2N 6055	2N 6053
2N 6056	2N 6054

10 Amperes - TO 3 package

SJ 3000	SJ 2500
SJ 3001	SJ 2501

12 Amperes - TO 3 package

2N 6057	2N 6050
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2N 6059	2N 6052

SGS-ATES Semiconductor Corporation - Newtonville, MA, 02161 - 435 Newtonville Avenue - Tel: (617) 9691610 - Telex: 922482
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55% efficiency in a 25 watt DC to DC Converter

Why pay for useless heat when you want power? That's the philosophy behind the new high efficiency 1200 Series 25 volt regulated converter from Tecnetics.

With efficiency as high as 55% at full load under normal conditions, an integral heat sink, improved circuitry and a black anodized aluminum case, this converter operates within a range of -20 C ambient to -100 C case temperature.

Available with a single output, this series features full input-output isolation to 500VDC allowing the user to change polarity and prevent ground loops. Compact size and sturdy barrier strip terminals make this the perfect converter for a wide

variety of military, industrial, aerospace and telecommunication applications.

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SPECIFICATIONS: 1200 Series 25 watt DC to DC converter

Inputs: 12 +2VDC to 48 +6VDC

Outputs: 12, 24, 28 and 48VDC

Dimensions: 5" x 4.1" x 1.25" (typ)

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Price: Single Output - \$198.00

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New products

practical for the manufacturers of hybrid circuits.

In conjunction with an external IC tester, the model 146X automatically indexes to each chip cavity on the carrier, optically aligns the chip, makes probe-to-chip contact and subsequent separation on command from the tester, and returns to the load position at the end of the cycle. Provision is made for no-chip and position-error signals to prevent time loss in false alignment searches. The system can also classify devices by inking bad and improperly positioned chips, and it can accommodate up to three different categories of the same device type.

Electrogas Inc., 2901 Coronado Dr., Santa Clara, Calif. 95051. Phone Al Harmon at (408) 246-6500 [393]

Computerized board-design system sells for \$90,000

With such standard features as automatic component placement, auto-routing, design-rules checking, and multilayer capability, the Redac Mini PCB Designer combines interactive capabilities and a system price tag of only \$90,000. At this price, companies that previously could not afford a computer-aided design system can obtain the benefits of such a system for less than the price of a traditional manual-digitizer-type system. The Redac Mini is built around a Digital Equipment Corp. PDP-11/34 computer system with a 17-inch refresh graphics terminal for interaction with the designer. Options include a Gerber photoplotter



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Time delay relays with up to $\pm .05\%$ repeatability.
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R12, R13, R14, R15 Series. Sophisticated circuitry usually found in more expensive relays. Repeatabilities to $\pm 3\%$; time delays to 600 sec.

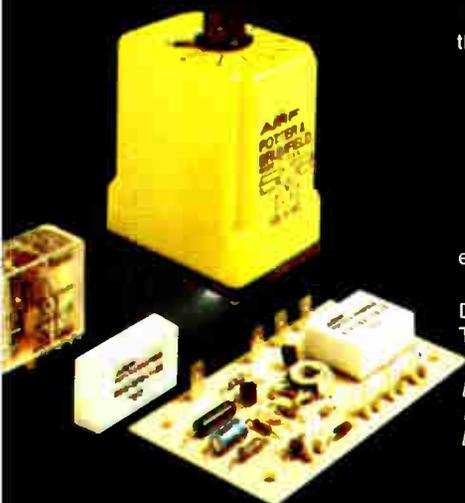
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New products

table for the generation of master-board and silk-screen artwork, provisions for generating numerical-control drilling tapes, and interfaces to other artwork tables.

Redac Interactive Graphics Inc., 225 Great Rd., Littleton, Mass. 01460. Phone H.G. Marsh at (617) 486-8751 [394]

Modular system tests memories at up to 20 MHz

The model 203 semiconductor-memory tester is a modular system that operates with up to 16 multichannel clock-pulse generators to achieve a resolution of 1 nanosecond at a maximum clock frequency of 20 megahertz. Used mainly for memory-oriented and problem-oriented tests, the system allows judgments to be made of the function and behavior of such memory devices as random-access memories, read-only memories, and shift registers.

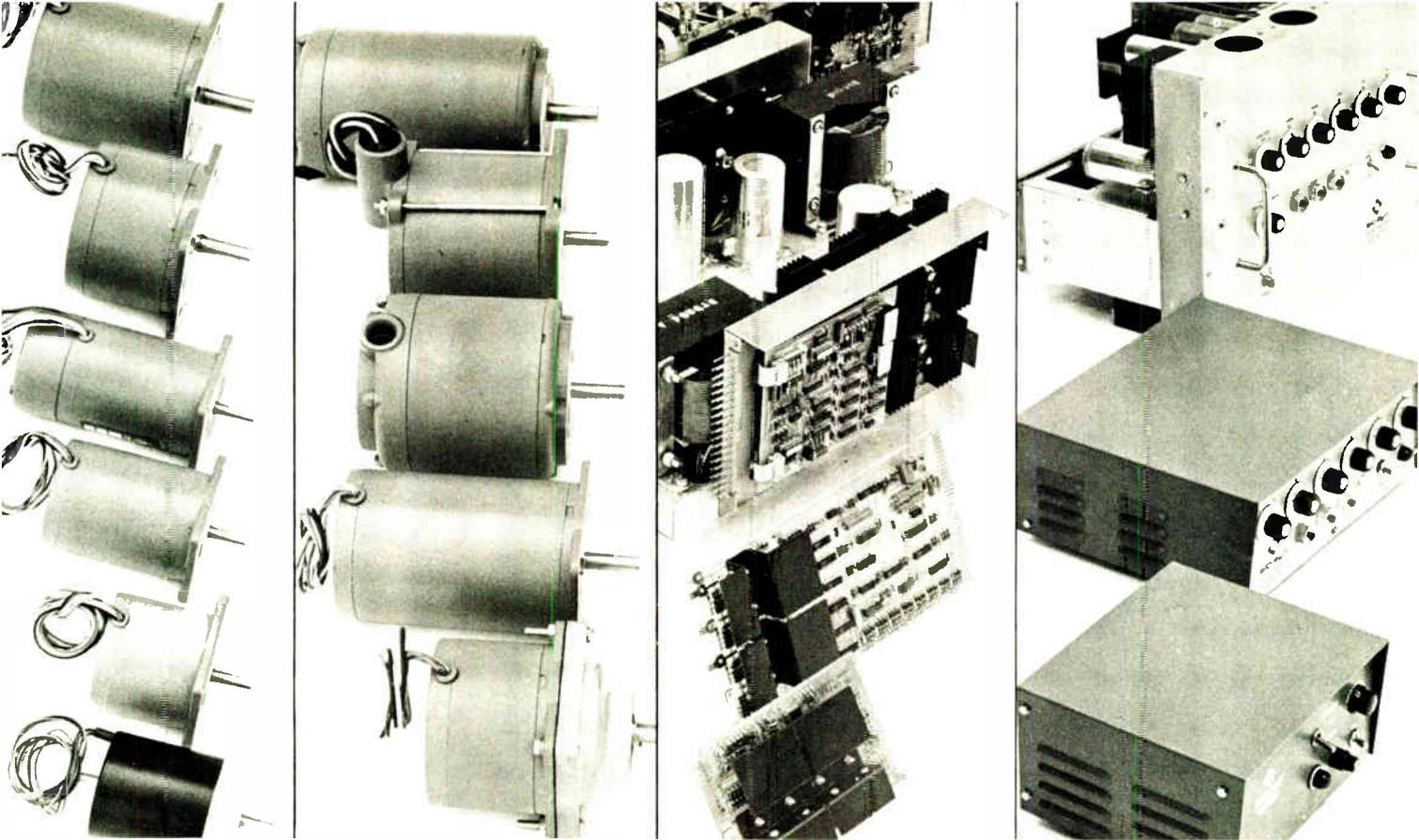
Because the system is modular, various programmable stimulus and measurement instruments can be added to it for determining such parameters as short-circuit, interruption, discharge, and loading currents. The computer-controlled system can handle up to four manual or automatic-feed test stations.

Siemens Corp., 186 Wood Ave. South, Iselin, N.J. 08830. Phone (201) 494-1000.

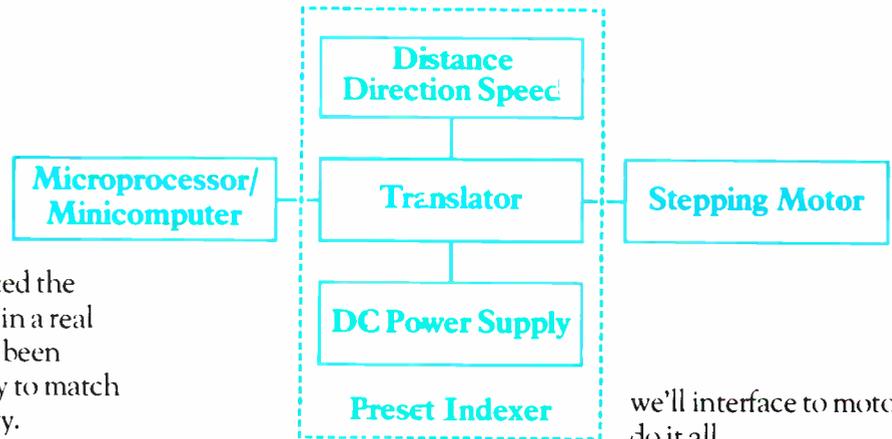
Siemens AG, Zentralstelle für Information, Postfach 3240, D-8520 Erlangen 2, Federal Republic of Germany. Phone Joachim Ullmann at (09131) 7-3394 [396]

Low-cost system programs Signetics logic array

A field programmer for the Signetics 82S100/101 field-programable logic array allows data entry, either manually or automatically, from a master FPLA. Called the PR-100, the FPLA programmer contains an internal random-access memory, which can be loaded automatically in about 1 second or manually in about 30 minutes. (The Signetics 82S100/101 FPLA accommodates 16 input varia-



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Fifteen years ago, we introduced the first stepper. SLO-SYN.[®] But in a real sense, the stepping motor has been waiting for today's technology to match circuitry with motor capability. Converting electronic input into mechanical output.

For starters. From 0 to 2,000 steps per second in 4 msec with our M060 series (up to 150 oz-in of static torque).

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High Performance. At 10,000 steps/sec (3,000 rpm), output torque of 525 oz-in, shaft power 1,165 watts (1.65 hp).

The stepper's logical companion is the Slo-Syn translator or preset indexer. The power for moving loads, controlling distance, speed, direction. Velocity control means motion/time efficiency for a wide range of inertial loads.

Drives interface with microprocessors and minicomputers. Design modularity prevents over-design. You control the options: 1) Modular or packaged drives. 2) If you want to provide the logic,

we'll interface to motor. 3) Or we can do it all.

Whatever the manufacturing move, see the company that's in the best position to help. Write The Superior Electric Company, Bristol, CT 06010. Or call us direct (203) 582-9561.

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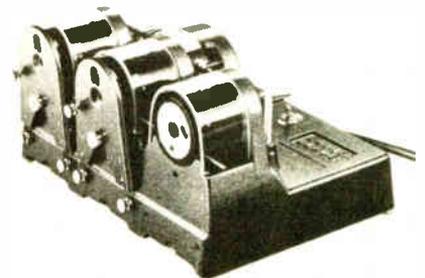
bles, allows a minimum of 48 product terms, and provides 8 outputs.)

Housed in a 16-by-10-by-4.5-inch metal cabinet that weighs 10 pounds, the PR-100 is powered by 115 v ac. It sells for \$1,299.

Curtis Electro Devices Inc., Box 4090, Mountain View, Calif. 94040. Phone (415) 964-3136 [395]

Swing-blade unit
strips coax cable

The model 74A swing-blade coaxial-cable stripper is a three-in-one machine that can strip wires of three different gages to individually predetermined lengths. Miniature coaxial cables and hook-up wires to a maximum outer diameter of 0.265 inch (6.7 millimeters) are stripped quickly, leaving the insulation square-shouldered and free of residue. The stripper can handle most extruded, built-up, or wrapped insulations including Teflon, Kapton, and Neoprene. The model 74A is



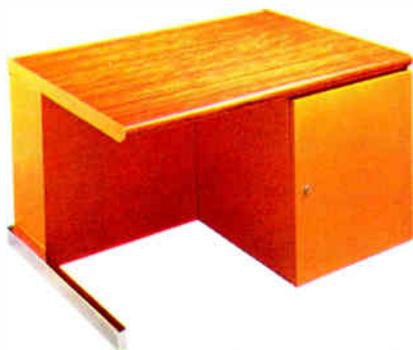
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supplied with two twin-blade and one single-blade face-place assemblies. It measures 6-by-10.75-by-9 inches and weighs 11.25 pounds.

Carpenter Mfg. Co., Fairgrounds Drive, Manlius, N.Y. 13104. [399]

Heat gun produces a spot only 0.25 inch in diameter

By adding a model A-206-HG pinpoint adapter to a model HG-301 flameless heat gun, one obtains a heat gun that can deliver a spot of heat a quarter-inch in diameter. This



small heat spot can be used to selectively heat single components in crowded chassis or on printed-circuit boards. The heat gun itself, without the adapter, can be used for such routine functions as activating adhesives, shrinking tubing, and drying components.

Master Appliance Corp., 2420 18th St., Racine, Wis. 53403. Phone (414) 633-7791 [397]



New MCL power generators feature flexibility, high output, minimum distortion.

Main frames for 115 VAC and for 208/220/240 VAC operation. Six standard front panel plug-ins provide frequency range from 10 MHz to 2500 MHz with a minimum output of 65 watts. Two optional plug-in modules are available which produce 100 watts narrow-banded.

Single knob tuning for each plug-in provides exact frequency selection. Front panel, direct frequency readout is accurate to ± 1 percent.

Solid-state mainframe designed for minimum components, optimum reliability. Residual AM held to .1 percent, eliminating nearly all AM distortion in output waveform. Generates continuous or 1 KHz square wave pulsed output. External AM signal generator can be added with single plug-in connection. External pulse circuit is TTL compatible. Automatic VSWR protection.

Write or call for your 4-page power generator brochure: Tom Rys, MCL, Inc., 10 N. Beach, LaGrange, IL 60525. (312) 354-4350.



Terminal blocks
. . . by the roll

A dispenser system of tape-mounted nylon modules produces terminal blocks with an unlimited number of 6-32 screw pairs. Once cut to desired length, the flexible tape is slid into a track and mounted by snap-on end stops. The design permits mounting to curved as well as flat surfaces, and the rolls are packaged complete with screws.

Amp Inc., Harrisburg, Pa. 17105. Phone (717) 564-0101 [398]

If you're designing hard-copy systems, here's the laser breakthrough you've been waiting for:



The new CR135 WriteLite™ Modulated Laser from Coherent Radiation

You've been waiting for a laser-writing system that was easy to design with. And a graphics capability at a price that was easy to live with.

The new WriteLite Modulated Laser from Coherent Radiation is the first *complete* laser-writing sub-system. All the components are put together for you: the laser, the modulator, and the electronics.

Now you don't have to be a laser expert to be a laser user. The laser and modulator are integrated and pre-aligned in one small package. The 2mW output power and 150 ns rise time are guaranteed.

All you have to do is plug in your TTL input. And the WriteLite is ready to write.

You might think that having the whole package systems-engineered and pre-aligned beforehand would run up the price. Quite the contrary: \$395.00 in OEM quantities.

So now laser-writing capabilities are within your reach and within your budget.

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The WriteLite is the heart of a laser graphics system: It's a point-to-point writing system similar to video CRTs. Resolutions from 500 to 10,000 TV lines. Speed? An 8 1/2" x 11"

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The CR 135 WriteLite Modulated Laser from Coherent Radiation. For complete information, write: Coherent Radiation, 3210 Porter Drive, Palo Alto, CA 94304.

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Motorola's K1100A leads the industry with a crystal clock oscillator that has a proven track record of more than one million units. That's right . . . over one million oscillators are in use by satisfied, repeat customers. That's not all . . . we feature fast deliveries.

How versatile is the K1100A? With over 1200 frequencies already designed, and same day shipment for standard stock frequencies of 4, 4.9152, 5, 10, and 20 MHz . . . you make the decision.

Oscillators are available from 250 kHz to 32 MHz, +0.01% stability from 0°C to 70°C, TTL compatible, and standard +5V dc input.

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Communications and Electronics Inc.

64 crosspoint Self-latching reed matrix

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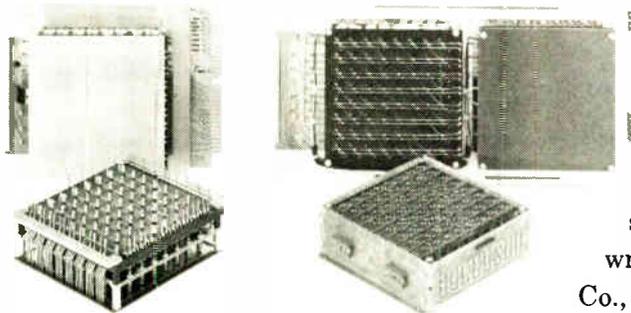
Four compact packaging formats offer engineers real flexibility in creating multi-pole switching arrays for telecommunications, process controls and automatic test equipment systems. The basic 64-crosspoint switching module is built around Clare's durable magnetic self-latching dry reed switch capsule. With Rhodium-plated contacts insuring several million operations.

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The multiple crosspoint coils are uniquely interconnected to provide coincident selection paths. Simultaneous current pulses on the X and Y axes address the crosspoints. A new selection automatically erases the previous selection. Dielectric spacing inhibits crosstalk while providing a stand-off rating at 600 Vdc on standard models, 800 Vdc as an option.

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FOR MORE INFORMATION . . .

The new 969 Series is certainly worth finding out about. A New Mini Memory Matrix catalog is now available. Also available are two "TAR" (Technical Application Reference) publications: TAR-Clare Mini Memory Matrix and TAR-Clare Self-Latching Dry Reed Relays. For more specific design information, write G. Neeno, C. P. Clare & Co., 3101 W. Pratt Ave., Chicago, Ill. 60645. Phone: (312) 262-7700.

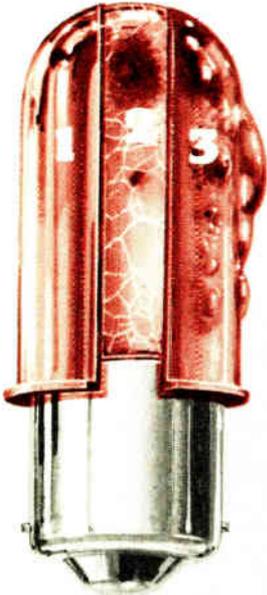
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New products

Subassemblies

Modem filters contain switches

Pair of FSK modules includes buffered switches for channel selection

In frequency-shift-keying modem applications, the frequency-switching components for the transmitter and receiver filters must be buffered from the external control circuit to prevent degradation of filter characteristics. Now, from Frequency Devices comes a pair of modular FSK filters that incorporate buffered direct-frequency-switching components inside their packages. As a result, filter gain, frequency response, and phase response are independent of the impedance, offset, and drift of the external control circuit.

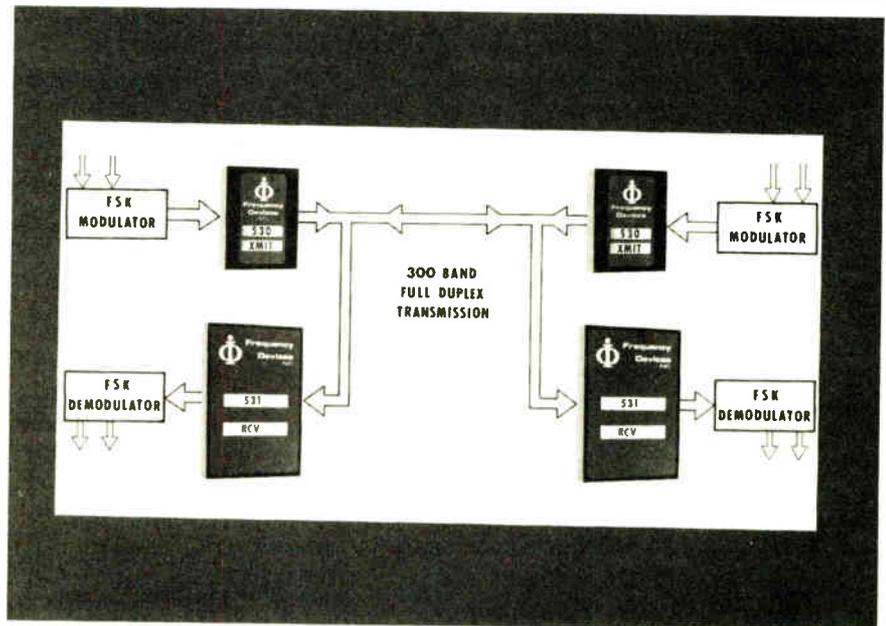
The model 530 transmit filter and the model 531 receive filter are designed to be compatible with Bell's type 103/113 answer-and-originate modems. The FSK pair permits full-duplex operation over voice-grade telephone lines at a rate of 300 baud.

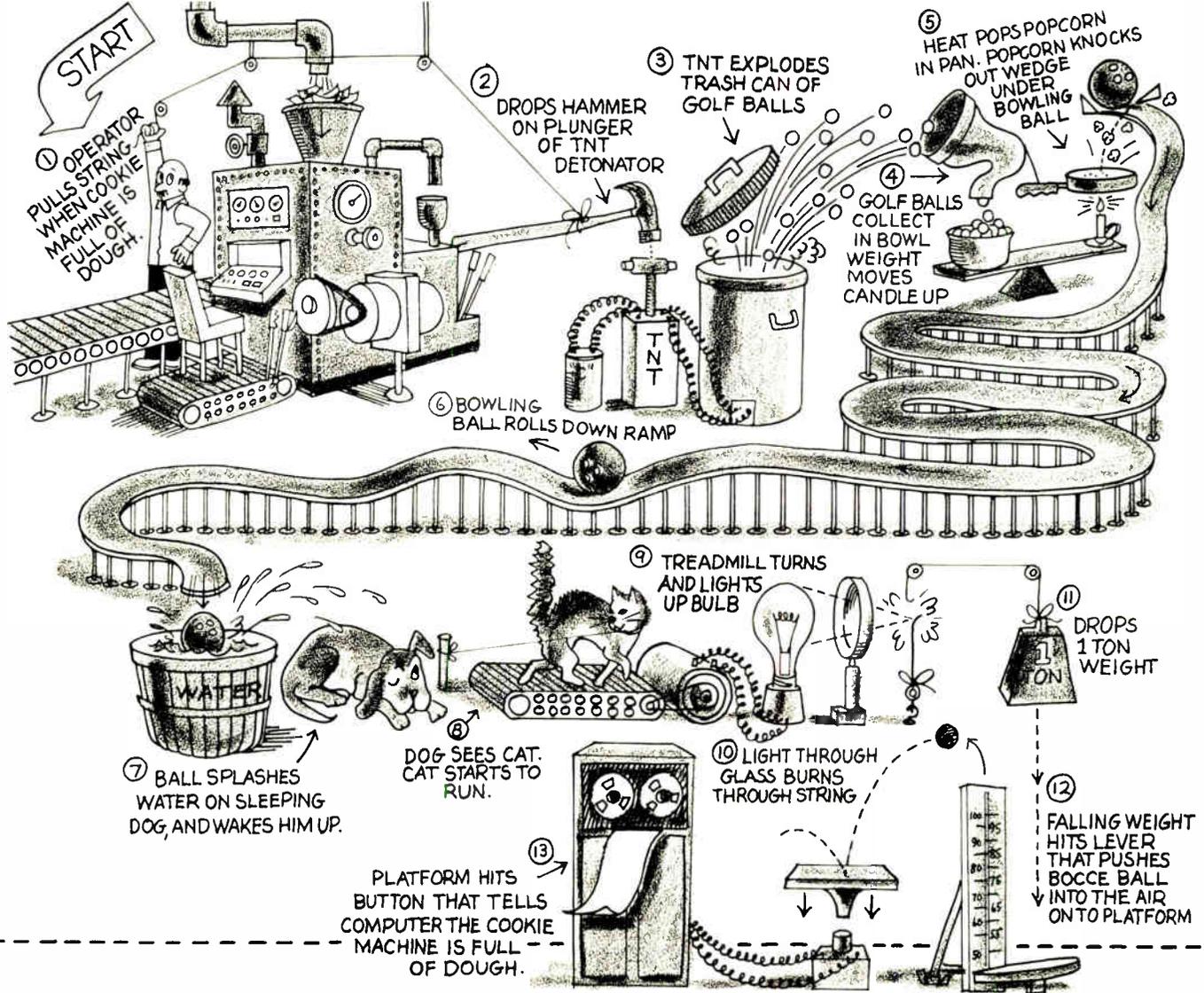
These new units also feature constant-bandwidth designs. In each model, the bandwidth (at 3 decibels down) for both of the selectable channels is essentially identical. This minimizes channel-to-channel group-delay differences and provides equal transition times when switching from one communications channel to the other.

For each module, the channel-select input can be driven directly by transistor-transistor, diode-transistor, or complementary-MOS logic. With the channel-select input open or at logic high, the passband is centered for mark/space frequencies of 1,070 and 1,270 hertz. When this input is grounded or tied to logic low, the passband shifts to mark/space frequencies of 2,025 and 2,225 Hz.

Channel gain is matched to within 0.1 dB for the model 530 and to within 0.2 dB for the model 531. At 2,025 Hz, the minimum low-channel rejection is -30.9 dB for the 530 and -50.8 dB for the 531. Similarly, the minimum high-channel (1,270 Hz) rejection is -39.9 dB for the 530 and -68.9 dB for the 531.

Both models can operate over a power-supply voltage range of ± 12 to ± 18 volts dc. With an input impedance of 100 kilohms and an output impedance of 50 ohms, each unit provides a short-circuit-pro-





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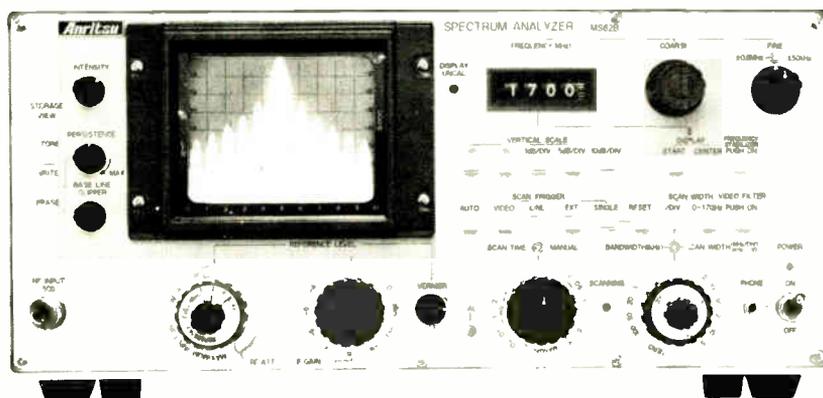
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192 Circle 192 on reader service card

New products

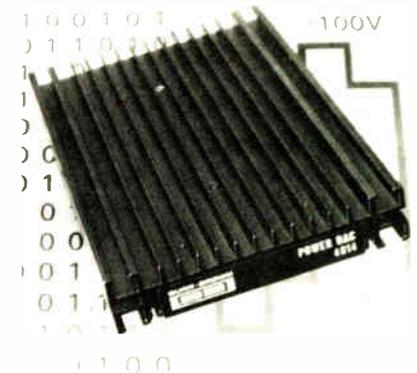
ected (to ground) output of ± 1 milliamperes. Operating temperature range for both filter models is 0°C to 70°C .

The model 530 transmit filter measures 1.5 by 2 by 0.4 inches, while the model 531 receive filter is 2 by 0.4 in. In single-unit quantities, price is \$60 for the 530, \$85 for the 531. Delivery is from stock to within four weeks.

Frequency Devices Inc., 25 Locust St., Haverhill, Mass. 01830. Phone (617)-374-0761. [381]

D-a converter puts out $\pm 100\text{ V}$ at up to 1 ampere

The model 4814 (binary input coding) and 4815 (BCD input coding) digital-to-analog converters are high-power 13-bit units that can deliver outputs of ± 100 volts at up to 1 ampere. Each consists of a d-a converter coupled to a power-output stage. Their available current drops as the voltage drops, but it never falls below 100 milliamperes. Both devices have resistor-programmable



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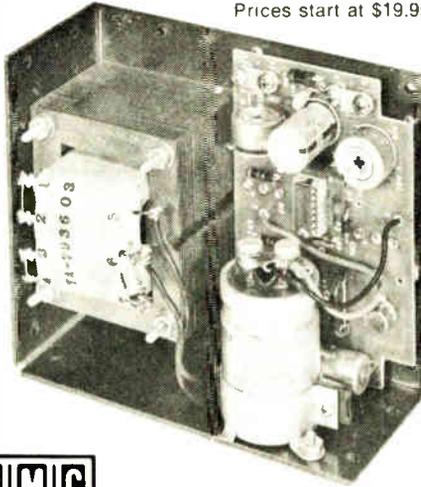
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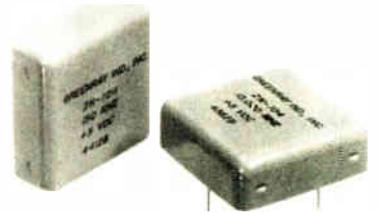
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ers can withstand short circuits of indefinite duration at 25°C. They have a maximum settling time, to within 0.01% of final value, of 100 microseconds. Price is \$249 each in small quantities. Delivery of the converters is from stock.

Burr-Brown Research Corp., Box 11400, Tucson, Ariz. 85734. Phone (602) 294-1431 [383]

Oscillator is designed for phase-locked loops

The model ZN-104 crystal oscillator is a voltage-controlled unit intended for use in low-cost phase-locked loops. It can be manufactured at any customer-specified frequency in the



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Hybrid technology makes it possible to construct the ZN-104 in a metal can measuring only 1.5 by 1.5 by 0.5 inches. In lots of 100, the oscillator sells for \$55. Delivery time is 45 days.

Greenray Industries Inc., 840 West Church Rd., Mechanicsburg, Pa. 17055. Phone (717) 766-0223 [384]

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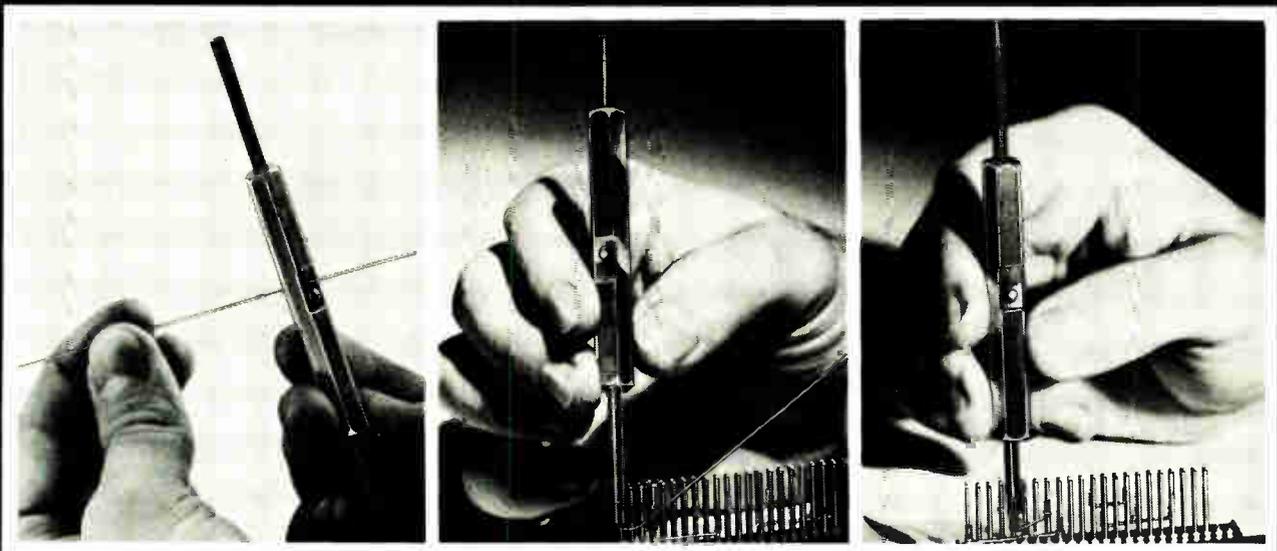
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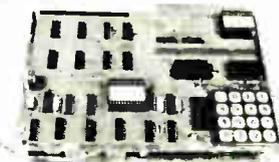
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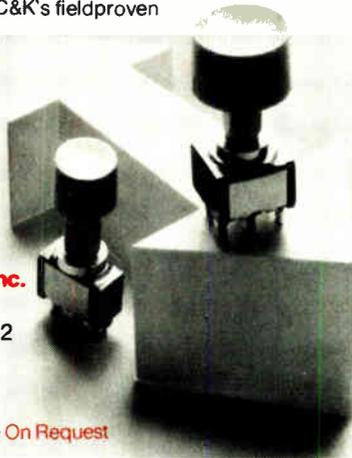
Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. Phone Eugene L. Zuch at (617) 828-8000 [385]

Digital clock movement has 0.84-inch numerals

A miniaturized electronic digital-clock movement with light-emitting-diode numerals 0.84 inch high also includes a MOS clock circuit, a power supply, and other, discrete, components. The movement, which is contained on a single printed-circuit board measuring 3.75 inches by 1.75 inches, needs only a transformer and switches to become a pretested digital clock for incorporation into a clock radio, a digital alarm clock, or an instrument panel clock. In lots of 100 pieces, the clock movement sells for \$15 each without an alarm tone, and \$16.50 with. The alarm tone is

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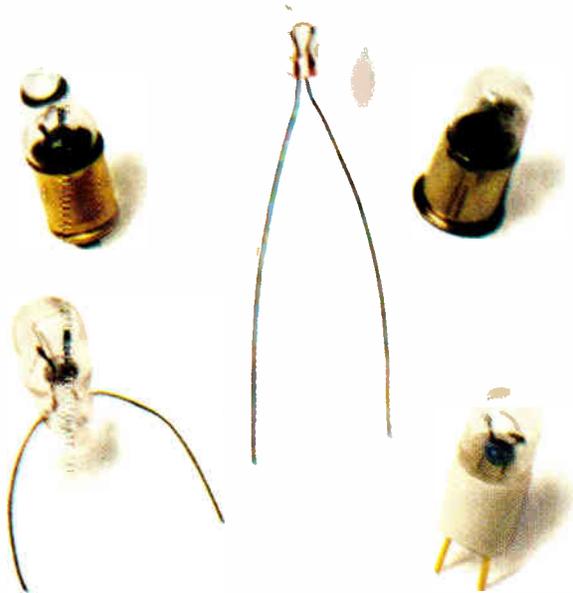
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National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. Phone (408) 737-5000 [387]

Low-cost power supply has 150,000-hour MTBF

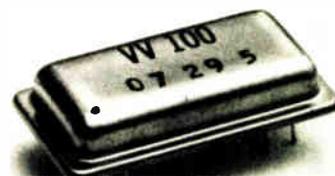
Priced at only \$31.95 in singles and \$26 for 10 and up, the model DPS5S500 power supply has a mean time before failure of 150,000 hours. The high-reliability module is a 5-volt supply with line and load regulation to within 0.5%. Maximum output current of the short-circuit-protected supply is 500 milliamperes. Housed in a case that measures 2.5 by 3.5 by 0.875 inches, the DPS5S500 will maintain its high MTBF when operated over the temperature range from 25°C to 71°C. Delivery of the power supply is from stock.

Semiconductor Circuits Inc., 306 River St., Haverhill, Mass. 01830. Phone (617) 373-9104 [388]

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Housed in a compact 16-pin dual in-line package, the VV100 fixed-gain amplifier is a direct-coupled device with a rise time of only 1 nanosecond. Designed for use with photomultiplier tubes, the amplifier has a noninverting gain of 10 and an input impedance of approximately 1 kilohm.

The amplifier requires an input terminating resistor, power supply bypass capacitors, input and output dc trims, and an output shape capacitive trim. It has a linear range





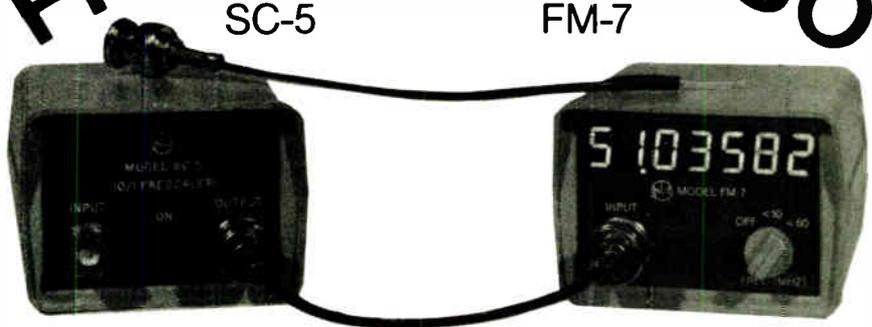
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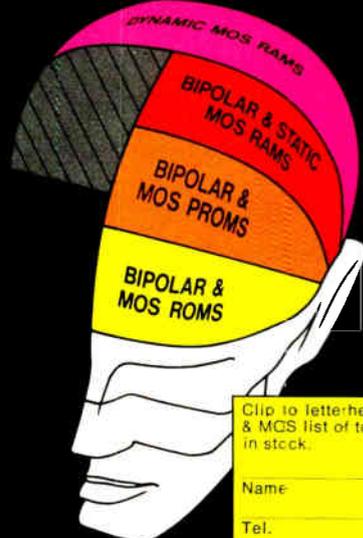
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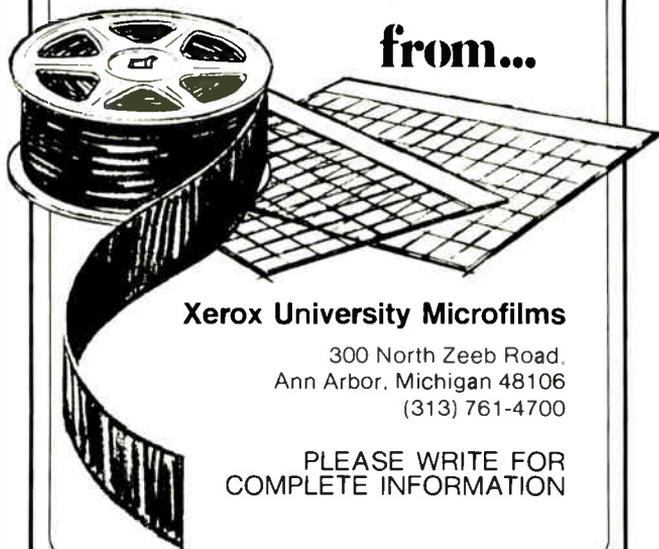
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Circle 200 on reader service card

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200

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Circle 245 on reader service card

New products

from -5 volts to $+200$ millivolts. Output drift is less than 100 microvolts/ $^{\circ}\text{C}$.

In hundreds, the VV100 sells for \$43.50.

LeCroy Research Systems, 700 S. Main St., Spring Valley, N.Y. 10977. Phone (914) 425-2000 [386]

Stepping-motor drivers have adjustable currents

Compatible with four-phase stepping motors, a family of stepping-motor drivers is offered with nominal currents of 2, 5, and 10 amperes. But, since stepping motors rarely require exactly 2, 5, or 10 A, all members of the family provide means for the user to adjust the current to meet the requirements of the motor being used. The drivers are mounted on standard 19-inch panels and include six-foot motor cables.

Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. 02138 [389]

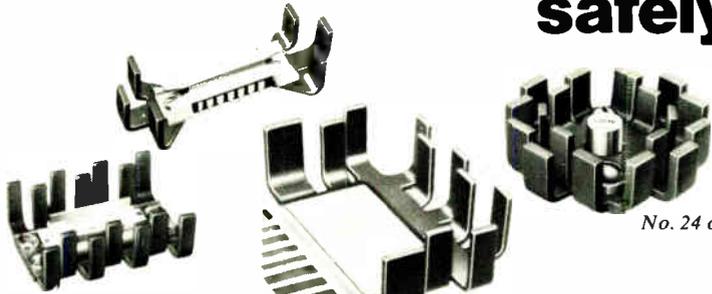
Voltage reference is housed in a standard TO-5 package

The series 840 precision voltage reference is a self-contained hybrid circuit that has been functionally laser-trimmed to provide $10\text{ v dc} \pm 0.1\%$. The ready-to-use circuit is housed in a compact standard TO-5 package. Its case ground makes it very resistant to noisy environments, and its hermetic construction makes it immune to many other environmental problems.

Applications include use as a voltage reference for data converters and as a comparator reference.

The model 840-T1 is designed for operation over the temperature range from -55°C to 125°C ; it sells for \$15 each in hundreds. The 840-T2 is specified from -25°C to 85°C and has a 100-piece price of \$12.35. Both units are available from stock. Beckman Instruments Inc., Technical Information Section, Helipot Division, 2500 Harbor Blvd., Fullerton, Calif. 92634 [390]

Now staggered fingers let you pour the power to IC's and hybrids safely



Our staggered finger heat dissipators cool better because they increase dissipating surfaces, cut re-radiation, and produce turbulence in forced air, and now they're available for IC's and microcircuits in special packages as well as standard. TO's, DIP's, .500" and .650" wide ceramics, 1"-square sealed

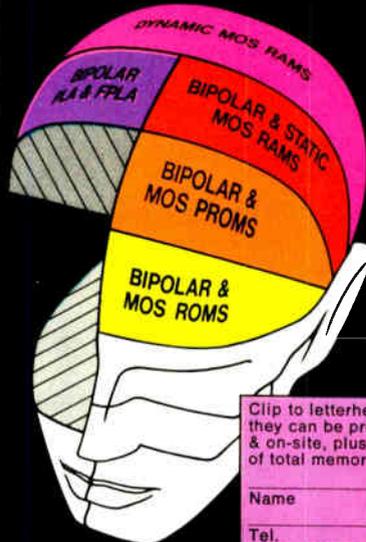
metal flat packs. We even offer models that let you pot your IC substrate directly to the dissipator and get 300% power increases easily. Ask for our new catalog. IERC, 135 W. Magnolia Blvd., Burbank, Calif. 91502, a subsidiary of Dynamics Corporation of America.



Heat Sinks

Circle 201 on reader service card

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Gain: 70 dB Min.†
Slew: 500 V/uSec Min.†
1% Settling: 100 nSec Min.†
Bandwidth: 70 MHz Min.†

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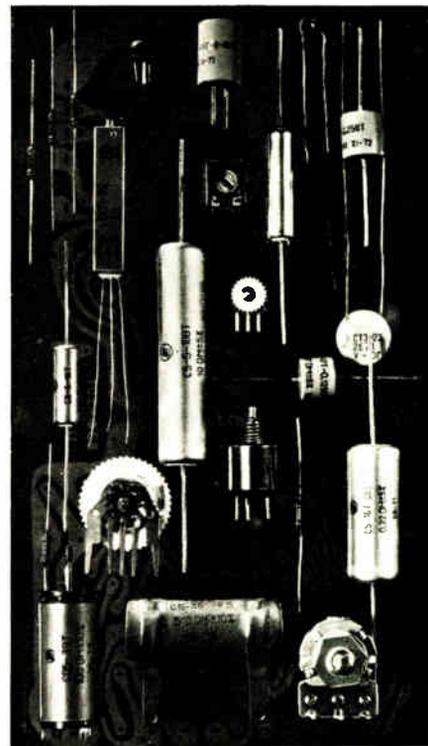
can be used up to about 600°F in air, or up to about 6,000°F in a nonoxidizing atmosphere. It is an excellent thermal and acoustic insulator, and it is well suited for use as a filter for molten metals, corrosive chemicals, and high- and low-temperature gases and liquids. A particularly attractive application of the material is in high-energy-density batteries, such as sodium/sulphur and lithium-aluminum/iron-disulphide systems, where its "caging" effect can improve cell performance. It comes in a variety of porosities. Experimental quantities sell for 25 cents per cubic inch; minimum order is \$25.

Chemotronics International Inc., 2231 Platt Rd., Ann Arbor, Mich. 48104. Phone H.C. Geen at (313) 971-4600 [476]

Gadolinium gallium garnet, which is used in the manufacture of magnetic-bubble devices, is now available from Union Carbide as 3-inch waf-



World Radio History



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Type	Resistance	Max. voltage [V]	Nom. dissipation power [W]	L [mm]	Dia [mm]	Mass [g]
MLT-1	24ohm-10Mohm	500	1.0	13.0	6.0	2.0
MLT-2	24ohm-10Mohm	750	2.0	18.5	8.6	3.5
S2-331	10ohm-2Mohm	200	0.125	6.0	2.4	0.15
S2-331	10ohm-3Mohm	250	0.25	7.0	3.3	0.3
S2-331	10ohm-5Mohm	350	0.5	10.8	4.2	1.0
S1-4	10ohm-2Mohm	250	0.125	7.5	2.4	0.22
S1-4	10ohm-10Mohm	350	0.25	10.5	3.9	0.5
SP3-22	100ohm-1Mohm	150	0.1	7.0	3.0	0.4

Exporter :

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Telex 7586

Circle 247 on reader service card

Plug-in protection for μ Ps and minicomputers

Sola's Minicomputer Regulator provides a dedicated power line plus crucial line-voltage protection.



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The portable Sola Minicomputer Regulator accepts line voltage variations from 95 to 130 volts . . . then stabilizes output within $\pm 3\%$ variation. Output remains within $\pm 5\%$ operational range even when power line voltages drop to 65% of nominal. The unit responds to all line or load variations in less than 25 milliseconds, and provides complete isolation from electronic noise. All by simply plugging it in—no need for an electrician.

The Minicomputer Regulator. Part of Sola's complete selection of line voltage regulation devices—CVS constant voltage transformers . . . computer line Solatrons for large-frame computers . . . UPS and standby power systems.

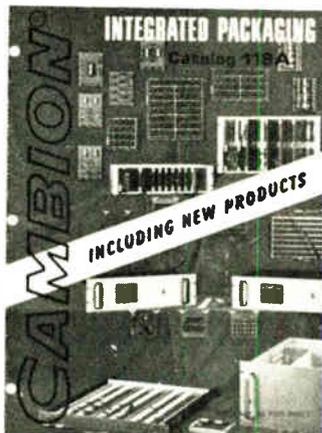
They are all in stock at your Sola distributor. Or contact Sola Electric, 1717 Busse Road, Elk Grove Village, Illinois 60007. Phone (312) 439-2800.

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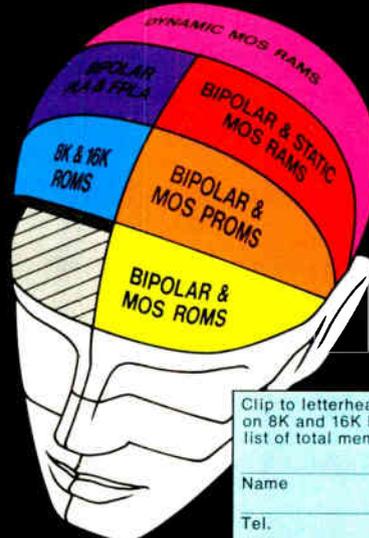
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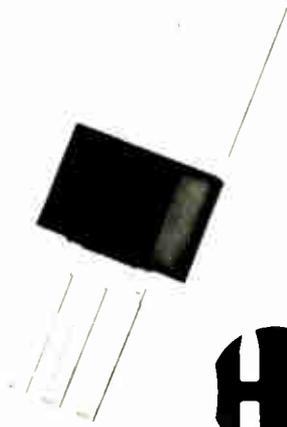
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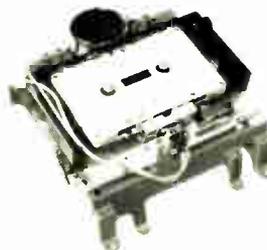
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Circle 254 on reader service card

New products/materials

ers. Previously, GGG material was only offered in diameters up to 2 in. The core-free wafers are presently being supplied in evaluation quantities. These substrates are 25 mils thick, are polished to an epitaxial finish, and sell for \$195 each.

Union Carbide, Crystal Products Department, 8888 Balboa Ave., San Diego, Calif. 92123 [477]

A solder cream formulation that combines a fine-mesh powdered solder with a noncorrosive flux and vehicle system flows at 374°F, making it useful in all standard soldering



applications. The homogenized material can be dispensed with a manual syringe or with automatic equipment. It contains no cadmium or fluorides, and is noteworthy for its long shelf life.

Assembly Systems Inc., P.O. Box 9084, Dept. S, Providence, R.I. 02940 [478]

Pressure-sensitive adhesive composites for use in the fabrication of shunt stacks, transformer core assemblies, and other transformer components can reduce labor costs by eliminating the taping or adhesive-application step in the placement of insulation. Typical products currently available with pressure-sensitive adhesives are aramid papers and Estermat composites.

Keene Corp., Chase-Foster Laminates Division, P.O. Box 4305, East Providence, R.I. 02914 [479]

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For more information, see your CSC dealer. Or write for our catalog and distributor list.

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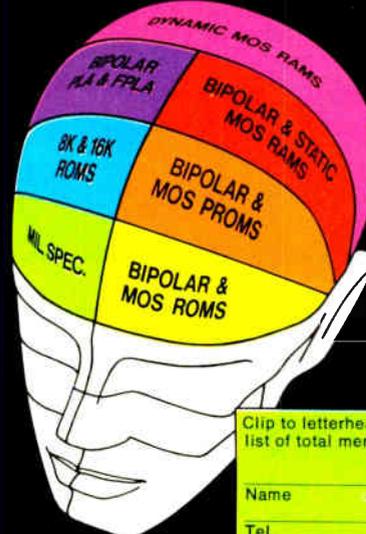
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Signetics has a total product line of memories — RAMs, ROMs, PROMs, FPLAs/PLAs and a long list

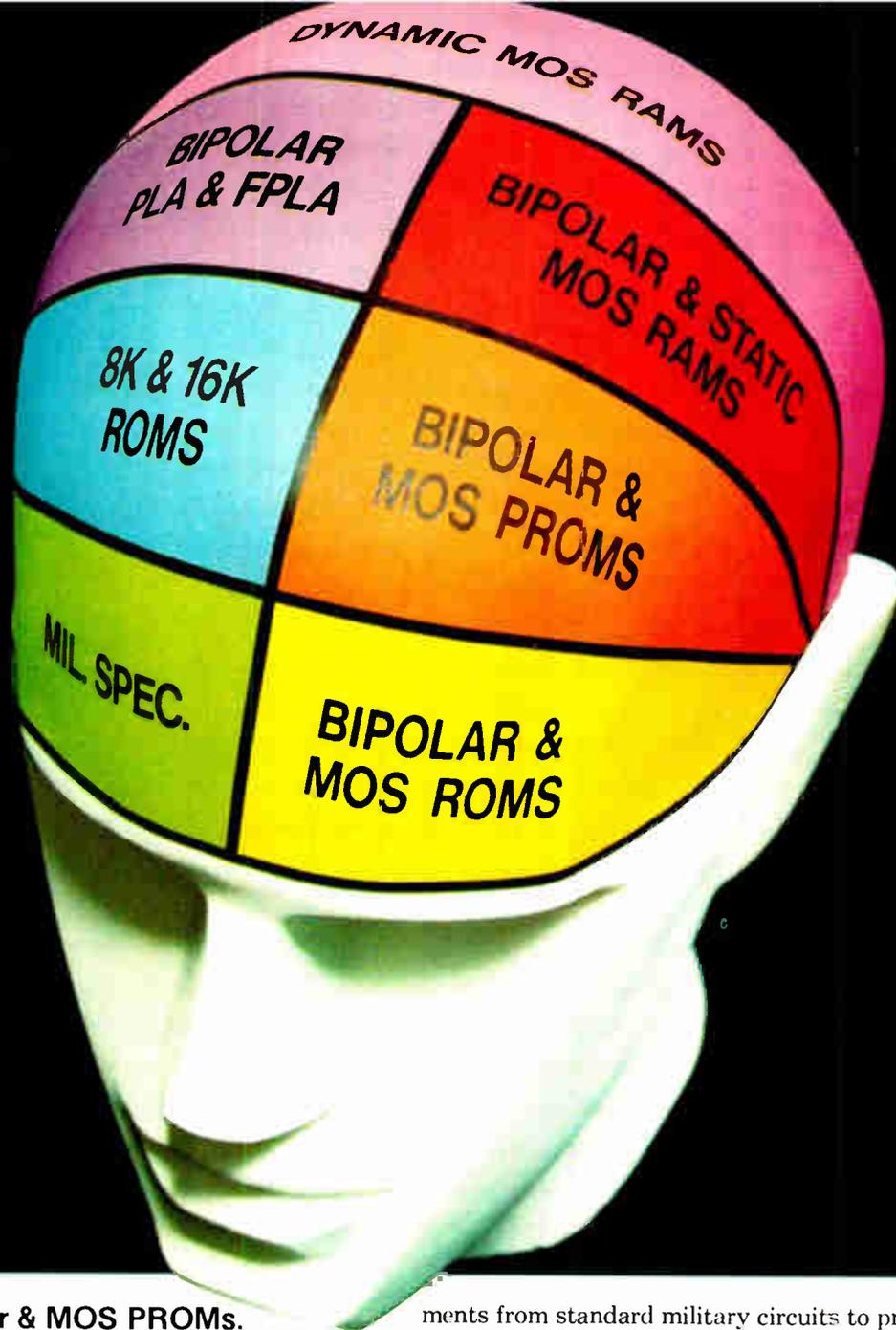
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Signetics' total line of Bipolar & MOS devices includes all the hard-to-find and in-demand devices. 24 Bipolars — 8 to 1024 bits. 14 MOS Statics — 256 x 4 to 1024 x 1. 1K x 4 and 4K x 1 available 1st quarter '77.

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My application is _____

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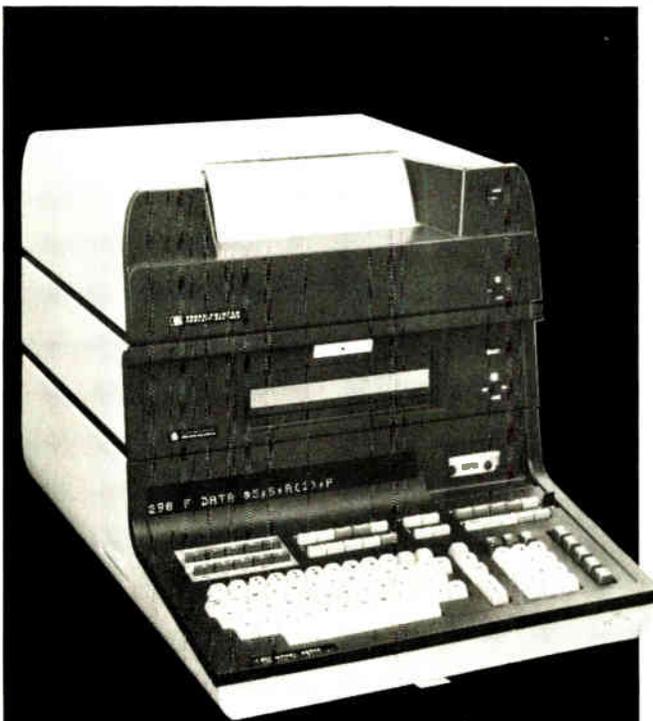
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HP 9830* users... your floppy disk is here! \$3895.

■ The FD-30 runs on cassette commands... that means **no software changes!** Because it runs on your **existing** programs.

■ The FD-30 finds files **50 times faster** than either the 9830 or the 9865A cassette drive.

■ The FD-30 **stores 5 cassettes of data** at the cost of one cassette.

■ The FD-30 applied in conjunction with Infotek's EM-30 16k-word memory and FAST BASIC ROMS gives unprecedented desk-top power.

■ The FD-30 transfers data to or from the 9830 even faster than the 9880B mass memory system. The 9880 requires 23 seconds to store a 10,000 word array via MAT PRINT. The FD-30 does this in 7 seconds via a simple STORE DATA.

■ The FD-30 **sells for a fraction of the 9880B**. And it is a far lower cost answer to most 9830 applications.

NO SOFTWARE REQUIRED!

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Within minutes, the floppy drive takes on the appearance of original equipment as it fits neatly between the computer and printer. Only four inches are added to the overall height of the system.

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New books

Filtering in the Time and Frequency Domains, Herman J. Blinchikoff and Anatol I. Zverev, Wiley-Interscience, 494 pp., \$27.50.

A Sourcebook of Modern Transistor Circuits, Laurence G. Cowles, Prentice-Hall, 360 pp., \$17.50.

Handbook of Operational Amplifier Circuit Design, David F. Stout and Milton Kaufman, eds., McGraw-Hill, 434 pp., \$24.50.

Permanent Magnet Design and Application Handbook, Lester R. Moskowitz, Cahners, 408 pp., \$39.50.

Handbook of Solid-State Troubleshooting, Hershah Gardner, Reston, 318 pp., \$15.95.

Transistor Circuit Analysis and Application, Ben Zeines, Reston, 374 pp., \$16.95.

Electronic Circuit Analysis and Design, William H. Hayt Jr. and Gerold W. Neudeck, Houghton Mifflin, 423 pp., \$15.95.

Solar Cells, Charles E. Backus, ed., IEEE Press, 503 pp., \$17.95, \$8.95 (paper).

Digital Signal Processing, Abraham Peled and Bede Liu, Wiley, 304 pp., \$16.95.

Shock and Vibration Handbook, Cyril M. Harris and Charles E. Crede, eds., McGraw-Hill, 1,322 pp., \$32.50.

Electronic Assembly and Fabrication, Gershon J. Wheeler, Reston, 207 pp., \$10.

Waveform Quantization and Coding, Nugechally S. Jayant, ed., IEEE Press, 610 pp., \$14.95.

Electrical and Electronics Graphic Symbols and Reference Designations, IEEE and ANSI, IEEE Press, 235 pp., \$19.95.

Handbook of Thick Film Technology, P. J. Holmes and R. G. Loasby,



Vector Voltmeter:
 Three outputs simultaneously available. Continuous 360° phase offset capability for phase nulling to .1°. 90°/180° switches accurate to .1 degree.



Narrow Band AC Voltmeter: Measure cross talk, power supply rejection, and other low level coupling phenomena. Automatically tracks signal frequency.



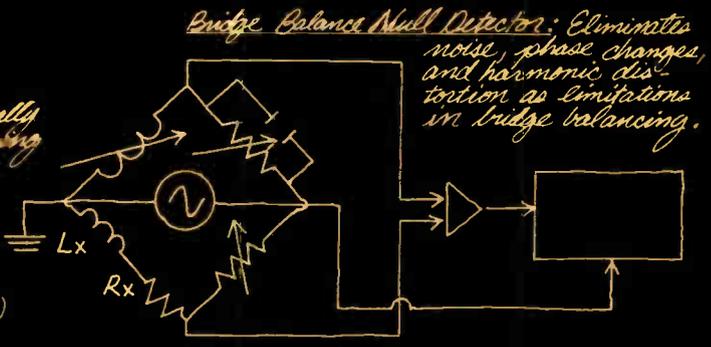
Ultra Sensitive Spectrum Analyzer: Tune manually with controls provided or sweep by synchronizing to external sweep oscillator.



Tracking Filter (measure frequency of noisy signal): Signal tracking mode phase locks internal oscillator to noisy signal.



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Bridge Balance Null Detector: Eliminates noise, phase changes, and harmonic distortion as limitations in bridge balancing.

Measure noisy signals up to 200 kHz—like you've never measured them before.

A new test and measurement tool, the Dynatrac[®] 3 lock-in analyzer, measures amplitude, frequency, phase and narrow band noise at signal levels from picovolts to volts, frequencies from .1 Hz to 200 kHz, and selectable bandwidths from .001 Hz to 100 Hz. It easily detects signals that are 100 dB below an interfering signal—a dynamic range that is currently beyond the state of the art in digital technology.

Because of its ability to measure signals in the presence of noise, there are many applications in which Dynatrac 3 picks up where the performance of vector voltmeters, phase meters, lock-in amplifiers, wave analyzers, transfer function analyzers,



and noise meters leave off. With its phase option, Dynatrac 3 measures the phase of signals completely obscured by noise with an accuracy of ±1° and resolution and stability of .1°.

Dynatrac 3 delivers trouble-free performance with RFI protection. And a floating guarded front end eliminates ground loops.

The sketches above illustrate just some of the many applications for this unique new test and measurement tool.

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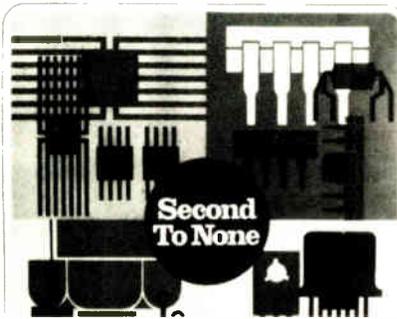


Circle 209 on reader service card

New literature

Semiconductors. The ITT line of semiconductors, including linear IC's, digital IC's, custom circuits, and discrete devices, is covered in a 40-page edition of the company's catalog. Copies are available from ITT Semiconductors, 74 Commerce Way, Woburn, Mass. 01801. Circle reader service number 421.

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Microcircuit reliability. Entitled "Digital Detailed Data," a 250-page databook put out by the Reliability Analysis Center, Griffiss Air Force Base, N.Y. 13441, presents reliability data on monolithic logic circuits by technology, by manufacturer, and by part number. The databook (Catalog No. MDR-4) contains more than 2,500 line entries, providing all the information needed for device failure-rate computation per MIL-HDBK-217B reliability prediction models. Single copies of the book sell for \$50 in the U.S. For further information, circle reader service number 422.

Line-voltage regulation. A 16-page booklet on the theory, design, and operation of line-voltage regulation equipment includes a discussion of the causes of irregular voltage, the problems it creates, and various solutions utilizing constant-voltage regu-

lation. For a copy of the booklet, request catalog No. 653 from Irv Roane, Sola Electric, 1717 Busse Rd., Elk Grove Village, Ill. 60007 [423]

Satellite communications. A 72-page catalog from Scientific-Atlanta gives details on the company's line of products for satellite-communications earth stations. Among the products that are described are antennas, antenna mounts, ground-communications equipment, and equipment for single-channel-per-carrier operation. Copies are available from M. L. Hudspeth, Satellite Communications Division., Scientific-Atlanta Inc., 3845 Pleasantdale Rd., Atlanta, Ga. 30340 [426]

Timing and control. Specifications and data on a line of timing and control components are contained in a 16-page catalog offered by North

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AVAILABLE STOP FOR EX STOCK DELIVERIES

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American Philips Controls Corp., Cheshire, Conn. 06410. Among the products contained in the catalog are ironless-rotor dc motors, solid-state relays, surface thermostats, magnetic switches, stepper motors, and elapsed-time indicators. [424]

Microwaves. The 1976 Narda catalog, a 170-page compendium of products in the 1-to-18-GHz range, contains data on many products not announced previously. Catalog No. 20 also tells about Narda's new line of GaAs FET amplifiers for communications, radar, and electronic warfare systems. Copies of the catalog can be obtained from Narda Microwave Corp., Plainview, N.Y. 11803 [425]

Adhesive-dispensing equipment. A line of equipment for mixing and dispensing epoxy resins and other adhesives is described in a 16-page

catalog that has been released by Otto Engineering Inc., 36 Main St., Carpentersville, Ill. 60110. Attn: Ronald E. Sparks [427]

Silicon on sapphire. Entitled "Silicon on Sapphire Technical Update," bulletin F-CPD-S765 describes recent advances in material and processing technology. The four-page brochure particularly emphasizes the suitability of SOS techniques for complementary-MOS circuitry. To request a copy, write to: SOS Bulletin, Union Carbide Corp., Crystal Products Dept., 8888 Balboa Ave., San Diego, Calif. 92123 [428]

Indicator lights. A broad line of incandescent and neon indicator lamps is described in a full color catalog put out by the Carr division of TRW Inc., 31 Ames St., Cambridge, Mass. 02142. Configurations illustrated in the catalog include

round, square, and rectangular, with the latter especially recommended when lettering is desired. [430]

Component packaging. A family of component mounts, spacers, and spreaders is detailed in a 16-page packaging digest put out by Bivar Inc., 1617 E. Edinger Ave., Santa Ana, Calif. 92705. Both permanent and washaway spacers are covered in catalog 576-M. [433]

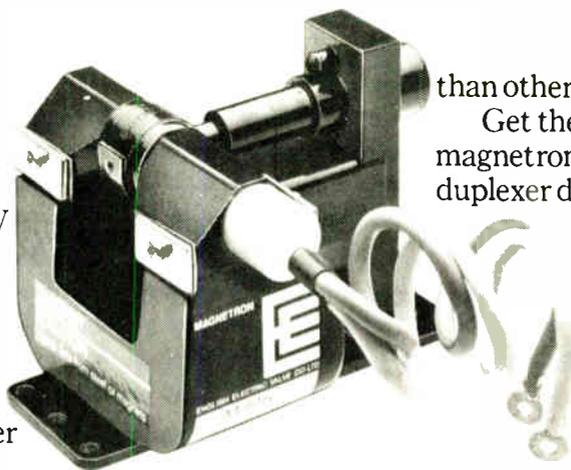


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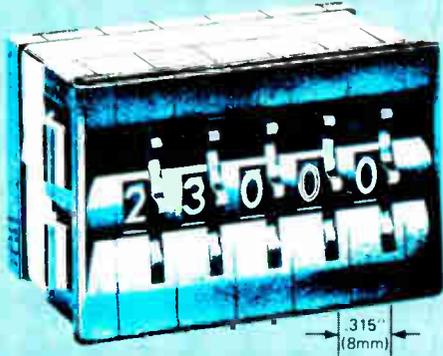
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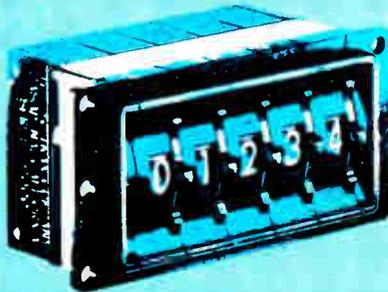
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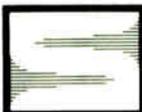
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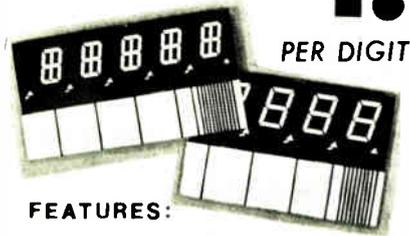
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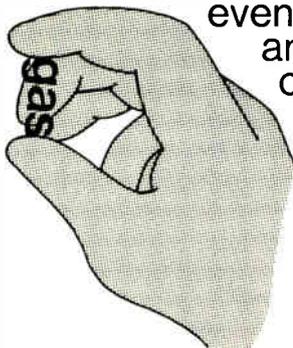
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Circle 222 on reader service card

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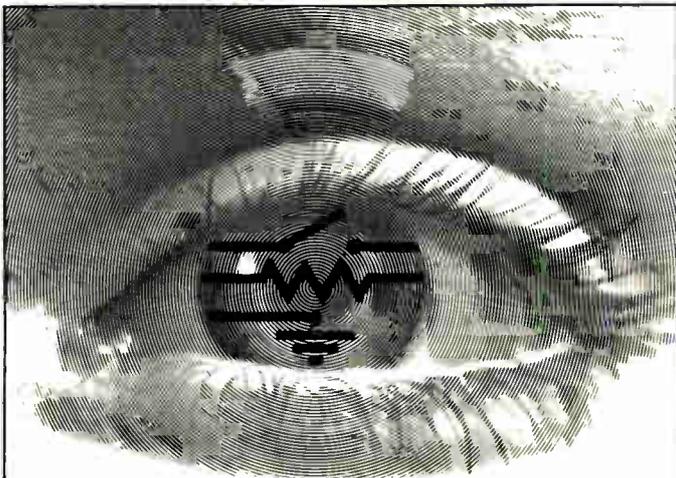
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Provides electronic insight to detect shorted or open circuits in loaded or unloaded printed circuit boards.



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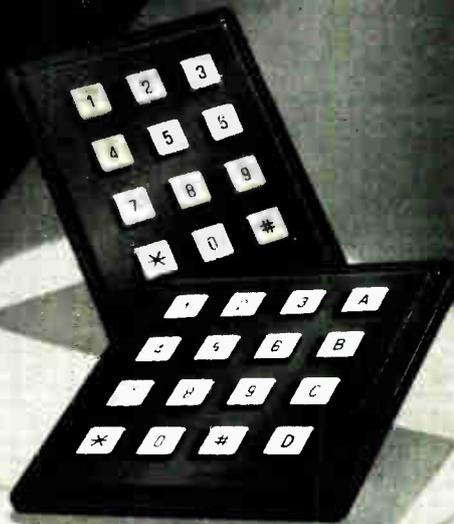
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In keeping with Bowmar's role as the innovating leader in the keyboard industry these new 12 and 16 station "Standard" keyboards are the perfect companions for many of today's keyboard applications. Available off-the-shelf, each is loaded with a broad array of Bowmar quality features.

- Gold or silver epoxy contact pads
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- Short stroke/low profile

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Name _____
Company _____
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City _____
State _____ Zip _____

 **Bowmar**

Mail to: Bowmar Instrument Corp., Dept. EN
8000 Bluffton Road, Fort Wayne, IN 46809

Solid State Sine-Cosine Synchro Converter

This new encapsulated circuit converts a 3-wire synchro input to a pair of d-c outputs proportional to the sine and cosine of the synchro angle.

- Complete solid state construction.
- Operates over a wide temperature range.



UNIT	DMD 1436-1	DMD 1430-1	DMD 1403-2	DMD 1361-6	DMD 1361-4	DMD 1193-4	DMD 1361-8	DMD 1446-1	DMD 1193-5	DMD 1193-6	DMD 1361-10	DMD 1472-2
L-L SYNCHRO INPUT (VRMS)	11.8	90	95	90	11.8	11.8	11.8	11.8	11.8	11.8	11.8	90
FREQUENCY (Hz)	400	400	60	400	400	400	400	400	400	400	400	60
FULL SCALE OUTPUT (VDC)	±10	±10	+3	±3	±3	±10	±10	±10	±10	±10	±10	±10
OUTPUT IMPEDANCE	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<10Ω	<1Ω	<1Ω	<1Ω	<1Ω
L-L INPUT IMPEDANCE	>10K	>30K	>5K	>30K	>5K	>5K	>5K	>5K	>5K	>5K	>5K	>5K
REFERENCE VOLTAGE (VRMS)	26	115	115	115	26	115	26	115	115	115	26	115
ACCURACY SIN/COS (+25°C)	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±0.5%	±6MIN	±6MIN	±6MIN	±6MIN
FULL TEMPERATURE RANGE ACCURACY SINE	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±0.5%	±15MIN	±15MIN	±15MIN	±15MIN
FULL TEMPERATURE RANGE ACCURACY COS	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±0.5%	±15MIN	±15MIN	±15MIN	±15MIN
D.C. SUPPLY (VDC)	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15
D.C. SUPPLY CURRENT	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA
BANDWIDTH	>10Hz	>10Hz	external set	>20Hz	>5Hz	>10Hz	>10Hz	>10Hz	>2Hz	>40Hz	>5Hz	external set
SIZE	1.1x3.0 x1.1	2.0x2.25 x1.4	1.1x3.0 x1.1	1.5x1.5 x0.6	1.85x0.85 x0.5	2.01x2.25 x1.4	0.85x1.85 x0.5	2x2.25 x1.4	2x2.25 x1.4	2x2.25 x1.4	2.15x1.25 x0.5	1.1x3.0 x1.1
NDTES	-	dual channel unit	-	-	-	dual channel unit	-	dual sine output unit	dual channel unit	dual channel unit	-	-
TEMPERATURE RANGE	-40°C to +100°C	-40°C to +100°C	-40°C to +100°C	-40°C to +100°C	-40°C to +100°C	-40°C to +100°C	-40°C to +100°C	-40°C to +100°C	-40°C to +100°C	-40°C to +100°C	-40°C to +100°C	-40°C to +100°C

High Precision Analog Multipliers

PRODUCT ACCURACY (MCM 1519-1) ± ½% OF ALL THEORETICAL OUTPUT VALUES OVER FULL MILITARY TEMPERATURE RANGE OF -55°C TO +125°C. ZERO POINT ERROR FOR ANY INPUT COMBINATION IS ± 2MVRMS



Features:

- No external trims required
- Distortion free AC output over entire dynamic range
- Linearity, product accuracy and zero point virtually unaffected by temperature

- All units are hermetically sealed and are not affected by external fields
- High analog product accuracy and wave quality allows dual multiplier assemblies to be matched with 1% of point over the specified temperature range
- Full four quadrant operation
- Package size, power supply requirements and other specs. may be altered to your exact requirements at no extra cost.

Specifications:

- Transfer equation: $E_o = XY/10$
- X & Y input signal ranges: 0 to ±10V PK
- Maximum zero point error (X=0; Y=0 or X=±10; Y=0 or X=0; Y=±10): 2MVRMS
- Input impedance: Both inputs 20K min.
- Full scale output: ±10V peak
- Minimum load resistance for full scale output: 2KΩ
- Output impedance: 1Ω
- Short circuit duration: 5 sec.
- Frequency response characteristics (both inputs) 1% amplitude error: DC to 1200 Hz (min.) 0.5 DB Amplitude error: DC to 3500 Hz min. 3 DB point: Approx. 10K Hz roll off rate: 18 DB/octave
- Noise Level: 5MV PK-PK @ 100K Hz approx.
- Operating temp. range: See chart
- Storage temperature range: -55°C to +125°C
- DC Power: ±15V ±1% @ 30MA
- Dimensions: 2" x 1.5" x .6"

Type No.	Product Accuracy	Operating Temperature Range
MCM 1519-1	± 0.5%	-55 C - +125 C
MCM 1519-2	± 0.5%	-25 C - +85 C
MCM 1519-3	± 0.5%	0 C - +70 C
MCM 1520-1	± 1.0%	-55 C - +125 C
MCM 1520-2	± 1.0%	-25 C - +85 C
MCM 1520-3	± 1.0%	0 C - +70 C

Precision AC Line Regulator

Total Regulation 0.15% Max.



Features:

- Low distortion sinusoidal output
- Regulation control better than ten times superior to commercial AC voltage regulators transformer product lines
- No active filters or tuned resonant circuits employed resulting in immunity to line frequency changes
- 6.5 watt output level
- Small size

- Output set to ±1% accuracy — this includes initial set point plus line, load, frequency and temperature changes
 - Foldback short circuit protection provided resulting in protection against overloads and short circuits of any duration
 - Low profile package with straight pins makes the unit suitable for PC board mount (unit is hermetically sealed)
 - Transformer isolation between all power inputs and the outputs.
- *Other units available at different power levels. Information will be supplied upon request.

Specifications Model MLR 1476-2:

- AC input line voltage: 115V RMS ±20% @ 400 Hz ±20%
- Output: 26V RMS ±1% (for any condition)
- Load: 0 to 250 MA, RMS
- Total regulation: ±0.15% maximum (any combination of line, load or frequency)
- Distortion: 2% maximum
- AC input line current: 100 MA. max. at full load
- DC power: ±15 V DC ±5% @ 15 MA. max.
- Phase angle: 1° max.
- Temp. Range: -40°C to +85°C
- Case Material: High permeability nickel alloy
- Terminals: Glass to metal hermetic seal pins

Circle 224 on reader service card

GENERAL MAGNETICS • INC
135 Bloomfield Ave., Bloomfield, New Jersey 07003 - Tel. (201) 743-2700



FEEL
the pot . . .



CLICK
the switch . . .



GANG
the modules . . .

and add "quality-touch" appeal
to your product.

FEEL THE POT . . . a smooth, quality feel, only from Bourns® 81/82 Model Potentiometers. Rotational torque range, only .3 to 2.0 oz. inch, is consistent for one, two, three or four cup assemblies.

Independent linearity of $\pm 5\%$ and low 1% CRV provide exceptional setability in both cermet and conductive plastic element types.

CLICK THE SWITCH* . . . one that really clicks, with positive action detent at either CW or CCW end. The Bourns Model 85/86 potentiometer/switch combination is rated at 2 amps in DPST style and 1 amp in DPDT. Contacts are constructed of fine silver with gold overlay. This provides exceptionally low contact resistance, for reliable operation at low level analog or logic signal levels — or any application requiring an "on-off" function.

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FEEL, CLICK, GANG . . . BEAUTIFUL!

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TYPE 9 MATERIAL

- LOW TEMPERATURE ERROR
- LOW LIGHT HISTORY EFFECT
- HIGH LINEARITY
- FAST RESPONSE TIME
- RESISTANCE TOLERANCE AT 2 Ft-C: ± 3%
- TEMPERATURE RANGE: -50 C to +75 C

TYPE	Sensitive Material	Peak Spectral Response (Angstroms)	Resistance 2 Ft-C (Ohms)	Min Dark Resistance 5 sec after 2 Ft-C	Maximum Voltage Rating (Peak & C)	Measurement Voltage	Maximum power @ 25 C
CL5M5M	1-10	5500	1.1K	2.7 MΩ	170V	10	0.5 watts
CL700L	9		25V	15.7 MΩ	100V	10	125 watts
CL900L	CdS		100K	47.4 MΩ	100V	10	950 watts

RESPONSE TIME VERSUS LIGHT

Foot Candles	0.1	0.2	1.0	10	100
Rise (Seconds)**	0.5	0.095	0.022	0.005	0.002
Decay (Seconds)**	125	0.21	0.04	0.007	0.001

MEASUREMENT DATA • All measurements at 2854 K • Cells light adapted 16 hrs at 30 Ft-C prior to test • Measurement voltage is D.C. applied voltage for measuring resistance • All readings made at 25 C ambient

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