OCTOBER 27, 1977

ANNUAL TECHNOLOGY UPDATE ISSUE

Growing families of complex digital chips strengthen the microprocessor's hold on new developments/90

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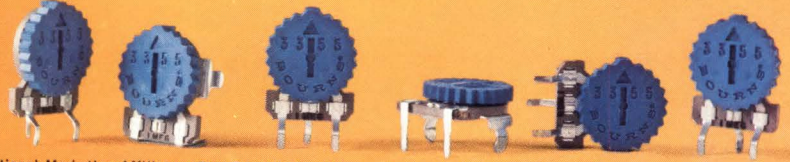
CATALOG SHEET SPECIFICATION COMPARISONS

CHARACTERISTIC	BOURNS 3355	CTS 201*	MEPCO 46X*	PIHER PT15*
Element	Conductive Plastic	Carbon	Carbon	Carbon
Temperature Coefficient	500 PPM/°C	No Spec	No Spec	1000 PPM/°C
Contact Resistance Variation	1.0% max.	No Spec	No Spec	No Spec
Power Rating	.25 W at 70°C	.25 W at 55°C	.25 W at 55°C	.25 W at 40°C
Flammability	UL-94V-1	No Spec	No Spec	UL-94
Board Wash Capability	Yes	No Spec	No Spec	No Spec

*Source: CTS Series 201 Data Sheet, Mepco Data Sheet ME1004, Piher Data Sheet F-2002 Rev 7/73



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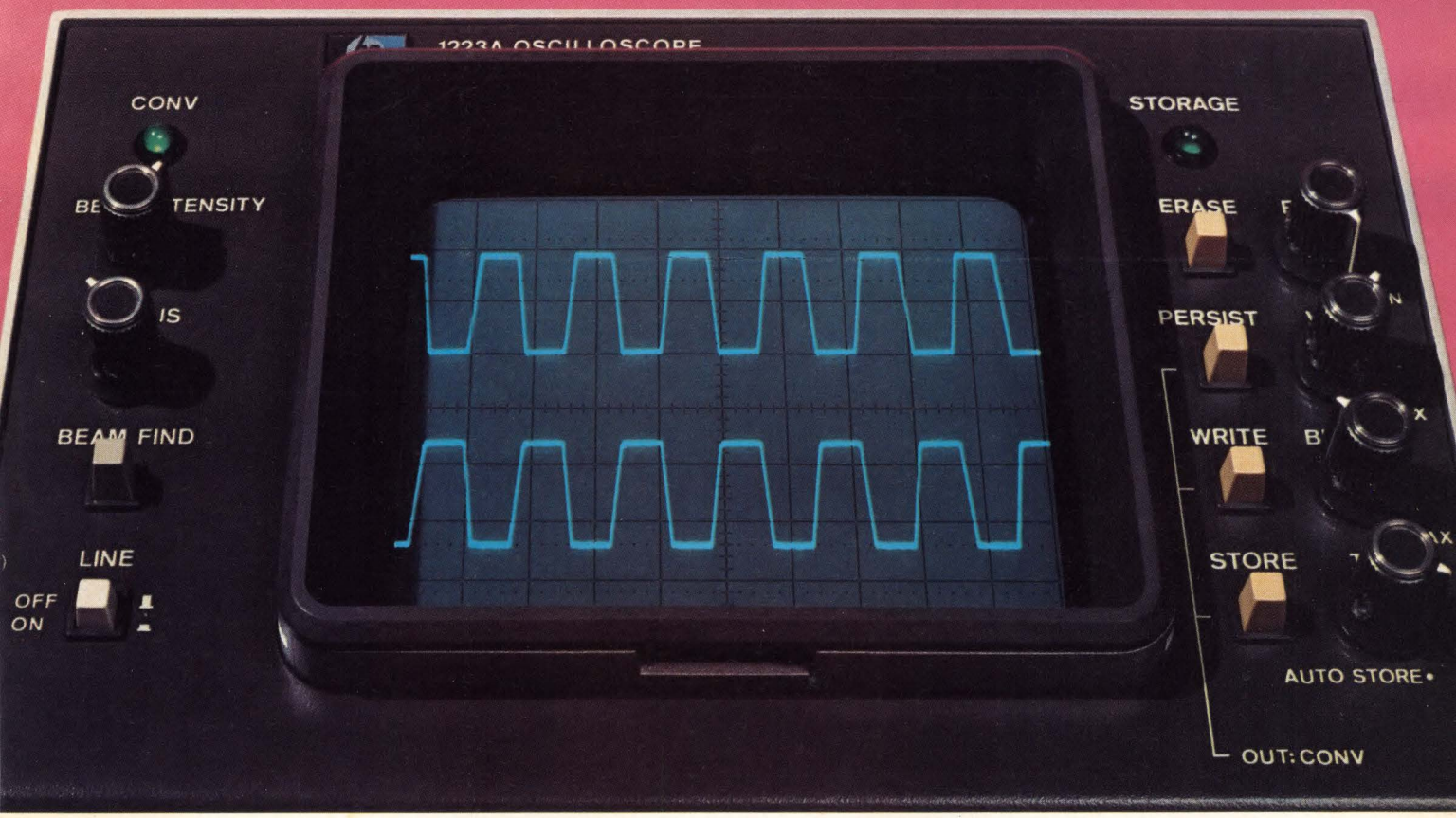

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Circle 1 on reader service card

Processor growth: can your small computer make the upgrade?

Product	Our HP 1000 and 21MX Computers	Your old favorite
Computers	21MX computers, with memory capacity of 1.8 million bytes, speeds up to 350 ns, and user microprogramming. All have compatible architecture, instruction sets, I/O and memory. *K-Series* computer on a board: $974* *M-Series* low-cost computer: $2,698* *E-Series* high-performance computer: $3,803* Instructions 70-100% faster than M-Series.	
Systems	HP 1000 includes 21MX-E computer, CRT console with soft keys and dual cartridges, RTE operating system. Fault control memory available to 1.8 million bytes. Easy to upgrade as your needs expand, with full selection of HP manufactured and supported peripherals. *Model 20.* 64K-byte memory-based systems: $21,000. 500K-byte flexible discs optional. *Model 30.* 64K-byte disc-based system, 15M-byte disc storage: $36,500. 5M and 50M-byte discs available. *Model 80.* 128K-byte data base management system with 15M-byte disc storage. HP-developed IMAGE DBM software, mag tape and line printer: $61,700. 50M-byte discs available.	
Software	*One upward-compatible family of Real Time Executives:* RTE manages 1.8 million bytes of main memory. BASIC, FORTRAN, Assembly and Microprogramming languages. Distributed Systems Networks. Measurement and control support.	

**OEM quantity 100. All other prices U.S. domestic list.*

If you've been having trouble making the upgrade with your old favorite, it's probably time you got a new one. So call your local HP sales office listed in the White Pages. Or write to Robert Puette, Hewlett-Packard, 11000 Wolfe Road, Dept. 612, Cupertino CA 95014. We don't think anyone should have to live with an incompatible family.

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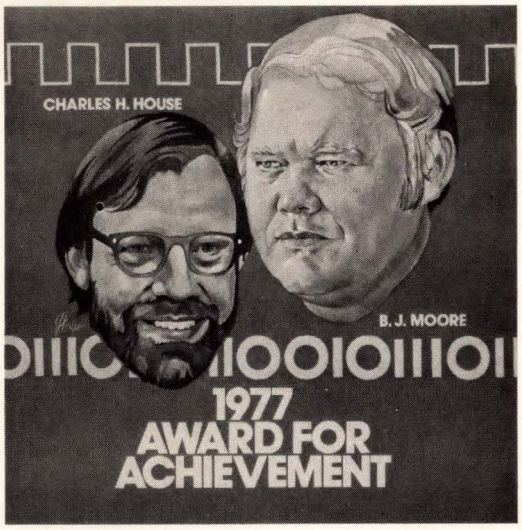
Electronics

The International Magazine of Electronics Technology

Vol. 50, No. 22 • October 27, 1977



Cover: Award goes to instrument trailblazers, 82
For the independent and simultaneous development of the first logic analyzers, *Electronics* salutes Charles H. House, engineering manager for logic-analyzer programs at Hewlett-Packard's Colorado Springs division, and B. J. Moore, president of Biomation Corp.

Cover by Art Director Fred Sklenar.

TECHNOLOGY UPDATE, 90
The past year saw remarkable and widespread advances in the application of microprocessors and large-scale integrated circuitry. Moreover, it contained the promise of many more in the near future.

Semiconductors, 92: New MOS processes set speed and density records.

Memories & Microcomputers, 96: One-chip controllers and 4-k static RAMs star.

Computers, 104: Memory-oriented designs maximize throughput.

Components, 112: Converters adjust to LSI, and bi-FET operational amplifiers emerge.

Instruments, 120: Techniques evolve for servicing LSI-based equipment.

Communications, 126: Fiber optics and LSI expand system capacities.

Packaging & Production, 134: E-beam systems arrive, and flexible circuits flourish.

Consumer, 140: The digital takeover extends to television receivers and auto controls.

The year in electronics: a chronology, 148

And in the next issue . . .
A new method of accurately measuring time . . . high throughput from an electron-beam system . . . signature analysis plus in-circuit emulation finds faults in microprocessor-based systems.

Electronics

Publisher's letter

Achievement is highly praiseworthy in any field of endeavor, and in electronics it is not only praiseworthy but tremendously influential. All around us, the fruits of electronics technology are visible, from television sets and radios to the latest consumer attractions, such as home computers and electronic games. Some of the fruits, of course, aren't so visible but are becoming even more pervasive. It's no wonder, then, that the individual achievements posted by the people in the electronics industry affect the lives and lifestyles of people everywhere.

Every year, *Electronics* magazine bestows its Award for Achievement as an acknowledgment of the vital importance of individual creativity in fueling the growth of electronics technology. Indeed the basic aim of the award is to spotlight the outstanding achievements that promote and advance technological progress or the general welfare of the electronics industries.

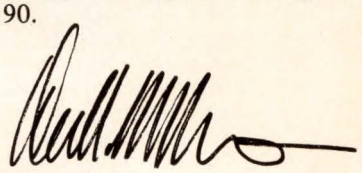
And every year, the editors of *Electronics* face the same tough task. They have to decide which of the hundreds of truly significant developments to honor with the award, isolating the one that both stands out from all the rest and best symbolizes the elusive quality that is called achievement.

The fourth annual award, which goes to Charles H. House of Hewlett-Packard Co. and B. J. Moore of Biomation Corp. for their digital-logic instruments, recognizes just such an achievement. The creation of a whole new class of instruments is not an everyday occurrence and reflects quite a creative tour de force. The fact that two quite separate approaches were taken—and independently, at that—sort of doubles the creative content.

Before these instruments, which are logic-state and logic-timing analyzers, came on the scene, digital semiconductor technology had mushroomed. However, its rapid progress was being retarded somewhat by the need to work with conventional instrumentation designed for analog circuits. Thus was conceived the idea of designing instruments specifically for what has been called the data domain. Our award winners this year not only were among the first to perceive that need, but they realized the opportunities such instruments would create and, most important, saw the ways to do the job.

While their approaches were quite different, they opened new windows for the designer. Since then, of course, the instrumentation line of both companies has expanded and there is some overlap in technique. What's more, their instrument-design departures started other people thinking about the special demands of the digital world, and other methods, such as signature analysis, have been launched.

For the full story on the *Electronics* Award for Achievement and this year's winners, turn to page 82. That story, though is just one of many features of this annual Technology Update issue. So for a summary of what has been happening in the past year in electronics, don't miss our 40-page special report starting on page 90.



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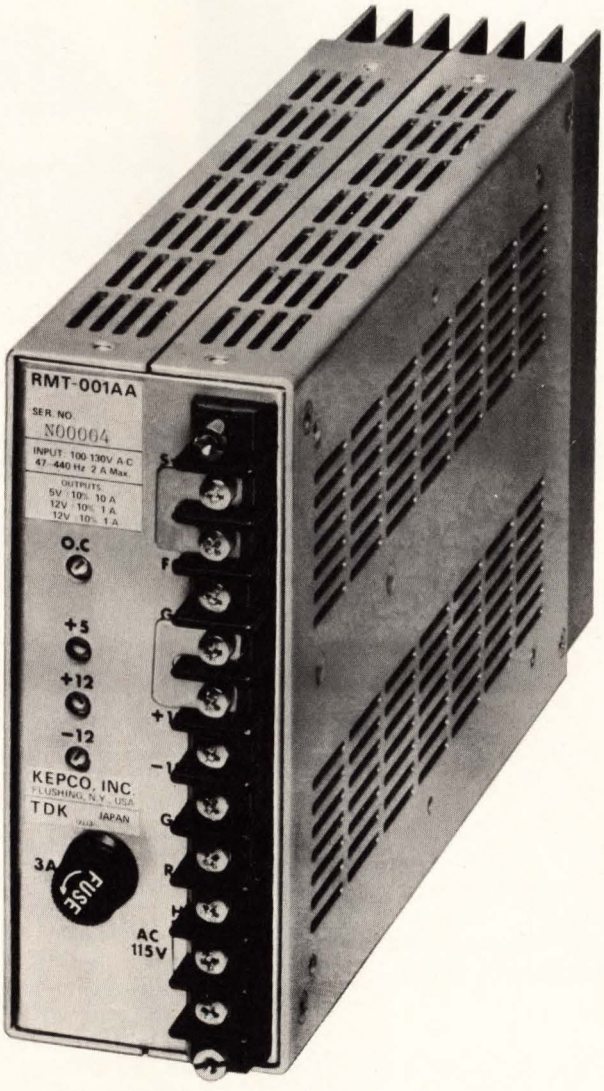
new KEPCO/TDK triple-output switching modules

for microprocessors and logic applications

The KEPCO/TDK series RMT combines a logic 5 Volt ± 10%, 10 ampere output with various combinations of auxiliary voltages (see table). All outputs are stabilized by high efficiency switching circuits.



RMT

FEATURES

- Each output protected by overvoltage monitor.
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- Remote on-off using logic level switching
- High density: more than 75 watts in less than 100 cu. in.

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MODEL	OUTPUT #1		OUTPUT #2		OUTPUT #3		PRICE
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RMT 001-AA	+5V	10 A	+12V	1 A	−12V	1 A	$329.00
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RMT 004-AA	+5V	10 A	+15V	1 A	−5V	1 A	329.00
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Custom volt-ampere combinations are available. Please consult the factory.

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Readers' comments

We have enough problems

To the Editor: Many persons, myself included, will not buy an electronically controlled car if we are given any reasonable alternative. First, we question the reliability of a complex electronic system in the harsh environment of a car, which makes a spaceship look by comparison like a baby buggy.

Second, considering the present difficulty of getting competent service, we doubt the ability of the automotive establishment to satisfactorily diagnose and repair such a system, even given elaborate monitoring facilities. Who, after all, will maintain this diagnostic equipment?

Finally, we foresee astronomical repair bills as service personnel frantically replace major assemblies to repair the myriads of subtle malfunctions not anticipated in the design of the automated test equipment.

Dale Hileman
Sphygmetrics Inc.
Woodland Hills, Calif.

So do the cities

To the Editor: I would like to suggest an optional strategy for those municipalities that cannot afford the cost of increasingly sophisticated traffic radars designed to defeat radar detectors ["Highway radar eludes detectors," Sept. 15, p. 44]. If the radar is used in the departure mode (receding target), the radar detectors are totally defeated.

Daniel A. Langiani
Gloucester, Mass.

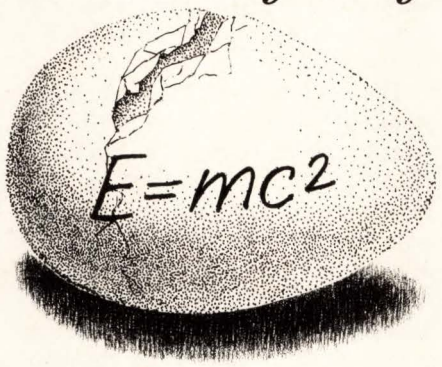
Corrections

There were several minor errors in the schematic diagram of the selectable pulse time—dead time counter that appeared in the Oct. 13 issue ["Counter and switches select pulse-train length and dead time," p. 97].

The Q output, not the $\overline{Q}$ output, of the 7472 flip-flop should be connected to G6, and pin 1 of the 7490 counters should be connected to pin 12, not pin 14. Also, the 7472 clock input should be driven by G5 and the J and K inputs connected to the 5-volt power source.

Investment Energy

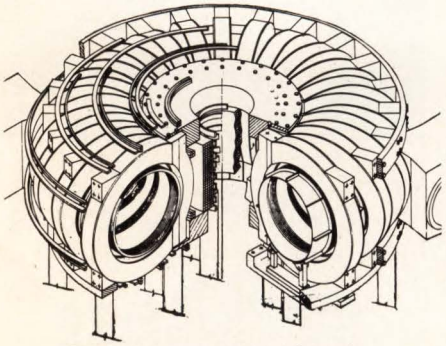
What kind of power is needed to "seed" the energy sources of the future?



THE TECHNOLOGIES which offer the brightest promise of a major contribution to tomorrow's energy economy share a common need. In all cases, a large *investment* of energy is required, before a *return* on investment can be realized.

In most approaches, this investment is an integral part of the production cycle–creating the environment in which energy generation can occur. In others, it's needed to prepare the materials and components that go into the process. But in all cases, the investment is massive...and it must be delivered with exceptional precision and managed with exceptional sensitivity.

UVC has won a position of leadership in this demanding field–through long-term participation in the research, development and testing of advanced energy systems...and the provision of power for high-energy applications in such related areas as particle acceleration, high-voltage power distribution, and laser systems.



Basic structure of the tokamak device (ORMAK) at Oak Ridge.

While the "payout" on investment in some of the fields in which we're involved may be a decade or even a generation away, we know that these are ventures of historic importance, and deserving of our best talents and highest efforts.

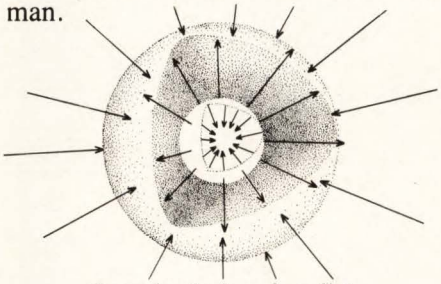
Fusion Through Plasma Heating and Magnetic Confinement

Progress continues toward the goal of achieving controlled thermonuclear reactions by the heating of isotopes of hydrogen (available in limitless quantities in the world's oceans) to stellar temperatures. Methods of maintaining such astronomical temperatures for sufficient periods of time include various 'magnetic confinement' schemes. The most promising of these are being investigated with reactors of the so-called tokamak (ORMAK) designs.

UVC equipment is presently in use, powering the neutral injection systems for heating of such reactors, at the Oak Ridge National Laboratory, Princeton University, The University of California at Livermore and Berkeley, and at private corporations funded by ERDA. These units, supplying energy for particle acceleration and deceleration, include the largest, highest-power equipment ever delivered by UVC.

Fusion Through Laser Implosion

Another dramatic approach to controlled fusion involves the ignition of thermonuclear reactions by subjecting tiny pellets of hydrogen isotopes to intense bursts of laser light. UVC has developed a wide variety of power supplies for laser fusion experiments ... including work being done at the Livermore laboratories of the University of California, where an effort is under way to generate the most powerful pulses of light ever created by man.



Laser implosion of a pellet.

Uranium Enrichment for Nuclear Power Generation

The 'enrichment' of uranium, by the separation of specific isotopes from the natural metal, is essential for the manufacture of the rods which fuel most types of nuclear fission reactors. Here, too, a laser application holds great promise for bringing new efficiency and economy to what has been an extremely costly and difficult process.

And here again, UVC power supplies are playing an important role in bringing this new technique to fruition.

What Can We Do For You?

Whether you're concerned with advanced energy systems or more conventional power problems, you too may profit from UVC's uncommon competence. If you'd like to discuss how we might add some Investment Energy to a project of your own, please call or write: Dept. E10.

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News update

■ Shipments of the large-scale digital computer built by National Semiconductor Corp. and marketed by Itel Corp. of San Francisco have been going on since the spring, and the deal between National and Itel is still in effect.

The computers are direct emulations of IBM's System 370/158, which run on IBM's own software [*Electronics*, Oct. 14, 1976, p. 29]. However, the National-Itel machine sells for half the price of the IBM 370/158, which can range upward from $2 million. The emulation also claims for itself higher performance: a minimum of 25% more throughput. Itel's sales targets are the more-than-1,000 model 158s in place.

Bernard Cole

■ Control Data Corp. and Litton Industries Inc. have finally begun fabricating what are perhaps the largest displays ever built with their technologies—and the two are using different and competing technologies. The displays, which combine standard military paper maps and computer-generated tactical display data, are being built under the joint Tactical Display System project of the U. S. Army and the West German Ministry of Defense [*Electronics*, June 10, 1976, p. 25].

The displays are 1 meter by 1 meter. CDC's technique is to place a transparent one-color (orange-red) plasma panel over the maps; Litton puts the maps over a three-color (red, green, and amber) light-emitting-diode display and shines data through the maps, says Sid Littman, program manager at the Army Electronics Commands, Fort Monmouth, N. J. Litton had problems in getting enough light to shine through the map, while CDC experienced some trouble with its basic display technology, Littman says. However, he adds, "both firms have solved their technical problems. They are fabricating displays and it looks like they got what they want." Fabricated systems should be ready by next May or June, though initial delivery was scheduled for early 1978.

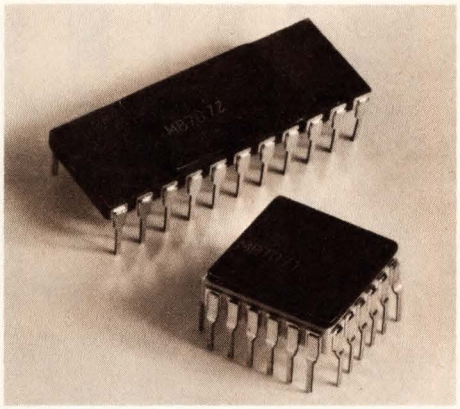
Bruce LeBoss

World's fastest memory:

Fujitsu's 7071/7072 1K ECL RAM delivers 10 ns maximum access time.

Attention, next-generation system designers! You're going to need the fastest main-frame, scratch-pad, control and buffer memory you can get. And you can get it only from Fujitsu! It's our 1K ECL RAM—the 7071/7072.

The 7071/7072 is available immediately, in volume. It delivers 7.5 ns typical access time (10 ns max.) in the H version and 12 ns typical access time (15 ns max.) in the N version. Organized in 256 x 4 format, the new Fujitsu 1K ECL RAM is fully compatible with the 10K-series family. It can be configured as a 512 x 2 or a 1024 x 1 RAM, by using the unique block select inputs. For high-density applications, it offers 0–75°C operating temperature range. Power dissipation is a low 0.8 mW/bit. The 7071 is offered in a 24-pin square package. Prefer a DIP?—the 7072 is our 22-pin model. These are the specifications and characteristics designers are asking for—and the rest of the memory world is trying to match.



Our state-of-the-art ECL process technology is at the heart of this remarkable RAM achievement. It enables us to deliver not just raw speed but consistent characteristics in any quantity you need. Plus demonstrated in-the-socket reliability. Reliability that's building loyalty among users who cannot afford to compromise their reputations.

You can't best Fujitsu when it comes to memory and memory-peripheral circuits. We deliver the broadest line by far: bipolar and MOS; size/price/performance for every application; specifications that never vary, no matter how many you need. For more details on the 7071/7072 and Fujitsu's complete memory IC product line, return the coupon or call us in Santa Clara, California for the name, address and telephone number of you local representative.

- ☐ Please send me data on the 7071/7072 1K ECL RAM
- ☐ Please send me the Fujitsu short-form product selector guide
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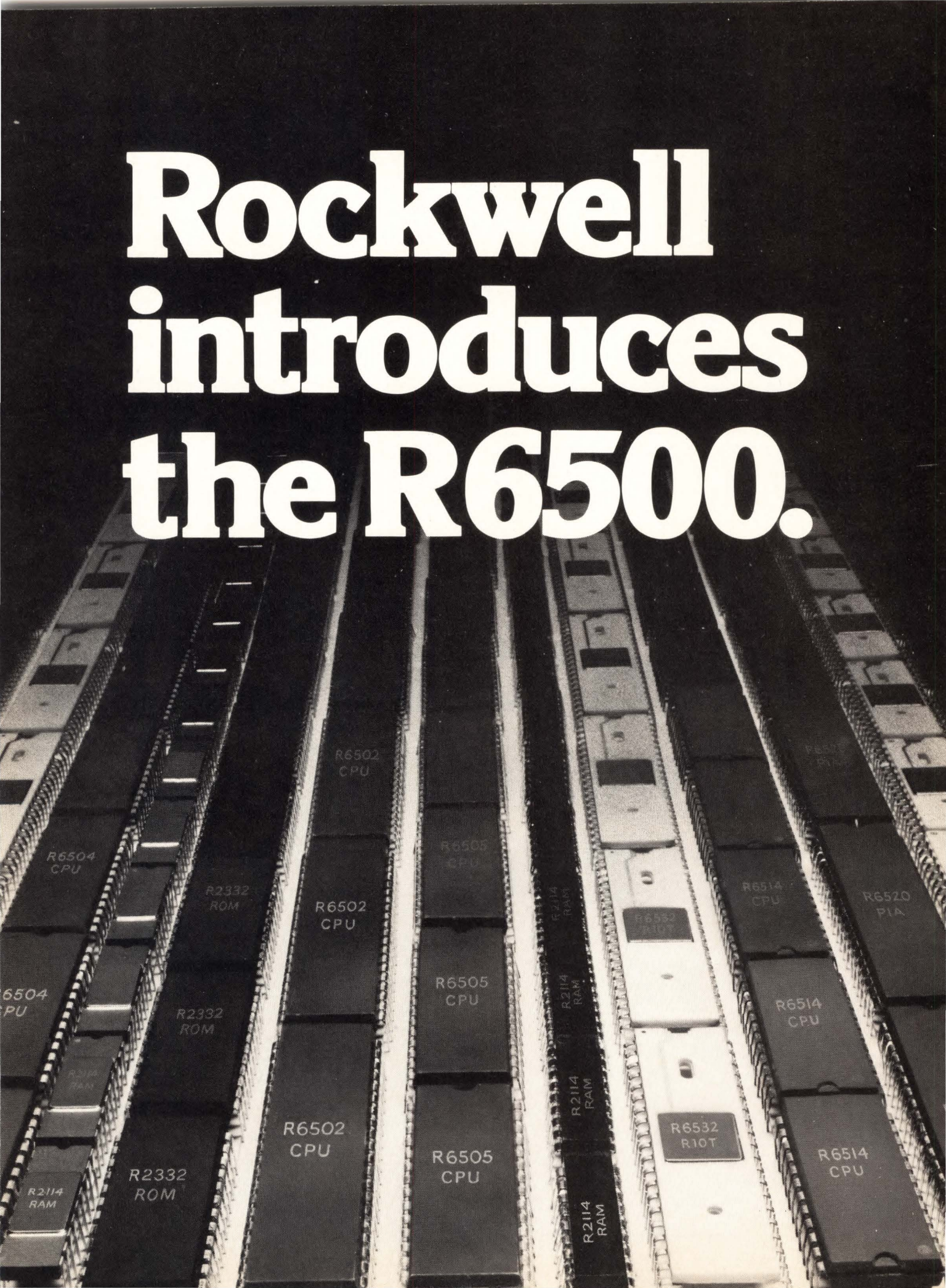
Rockwell introduces the R6500.



R6500: the third generation microprocessor system

Now you can move up to the proven 2 MHz performance of an NMOS 8-bit microprocessor, the R6500 from Rockwell.

Third-generation R6500 architecture and instructions with 13 powerful addressing modes make it easier for you to design more functions in, more cost out. And the R6500 is design-compatible with systems you may now be using.

R6500 economics are on your side

Smaller R6500 chips and single 5V power supply keep costs down as performance goes up. To get the right fit, choose from 10 software-compatible CPUs, eight versatile I/Os, ROMs, RAMs, and memory-I/O-timer circuits.

R6500 CPU Options

	40-Pin DIP		28-Pin DIP				
	R6502	R6512	R6503 R6513	R6504 R6514	R6505 R6515	R6506	R6507
Memory Address Space	65K	65K	4K	8K	4K	4K	8K
Interrupts—Maskable —Non-Maskable	Yes Yes	Yes Yes	Yes Yes	Yes No	Yes No	Yes No	No No
SYNC—Output indicates op code fetch cycle	Yes	Yes	No	No	No	No	No
RDY—Single step and slow memory synchronization	Yes	Yes	No	No	Yes	No	Yes
ϕ_1 Clock Output	Yes	Yes	No	No	No	Yes	No
DBE—Extended Data Bus Hold Time	No	Yes	No	No	No	No	No

I/O Devices

PART #	NOMENCLATURE	DESCRIPTION
R6520	Peripheral Interface Adapter	2, 8-bit bidirectional I/O ports; 4 peripheral control/interrupt lines.
R6522	Versatile Interface Adapter	PIA functions plus 2, 16-bit programmable interval timers/counters.
R6530	ROM-RAM-I/O-Timer	1024 x 8 ROM, 64 x 8 static RAM; 2, 8-bit bidirectional data I/O ports; 2 programmable data direction registers; 8-bit interval timer.
R6532	RAM-I/O-Timer	128 x 8 RAM; 2, 8-bit bidirectional data ports; 2 programmable data direction registers; 8-bit interval timer.

PLUS ROMS, RAMS...AND MORE ON THE WAY

Rockwell adds solid development support

For fast and efficient system design, Rockwell offers SYSTEM 65—one of the smartest and lowest-cost, disk-operating, complete development systems available. It's equipped with two mini-floppies, resident two-pass assembler, text editor and monitor/debug package.

KIM-1, TIM, timeshare, complete documentation, plus extensive applications engineering are also available.

Rockwell is delivering in volume now

R6500 circuits are already being produced in quantity with Rockwell's N-channel, silicon-gate, depletion load process.

R6500 devices and SYSTEM 65 development microcomputers are now available at your local Hamilton-Avnet or Schweber distributor.

And new chips are in design. The first, a fully static 32K ROM, is now in production.

For your R6500 brochure write: D-727-F, Marketing Services, Microelectronic Devices, Rockwell International, P.O. Box 3669, Anaheim, CA 92803, U.S.A. or phone (714) 632-3729.

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2. How Commercial ECLIPSE Systems answer the diverse demands business makes today on a data system.
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3. The secret of having computer power where your business needs it. Our book on CS/40 SMALL BUSINESS SYSTEMS tells.
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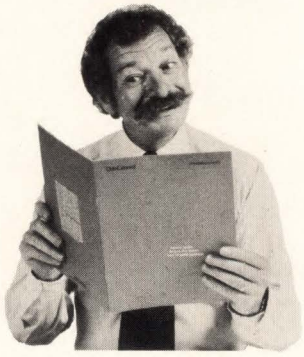

4. Describes seven important SUPPORT SERVICES that get systems up and running, then keep them there.
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5. Find out how our Real-Time Disc Operating System SOFTWARE can get you on-line fast, and keep you there.
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6. IT'S SMART BUSINESS to know how our way of doing business benefits our customers.
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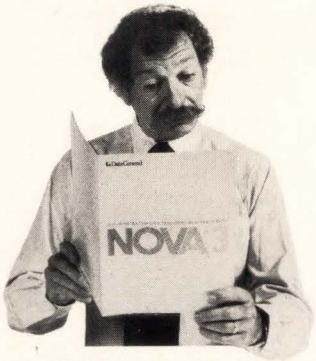

7. How OEM's solve the dilemma of keeping their system costs down with our NOVA 3 COMPUTER FAMILY.
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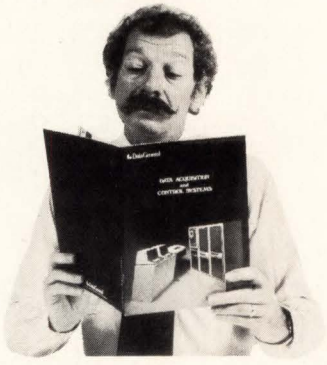

8. What you need to know about getting everything for a DATA ACQUISITION and CONTROL system from one place.
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9. The last word in microprocessor-based microNOVA systems with full 16-bit NOVA architecture.
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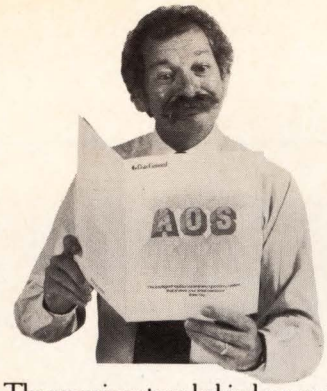

10. The amazing story behind our unique heuristic MULTI-PROGRAMMING operating system.

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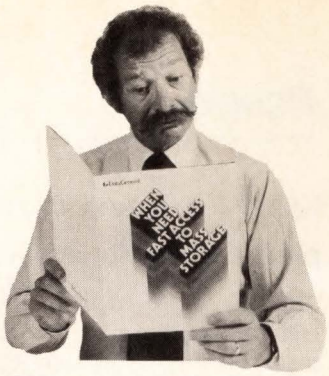

11. What to do when you need fast, fast access to MASS STORAGE.

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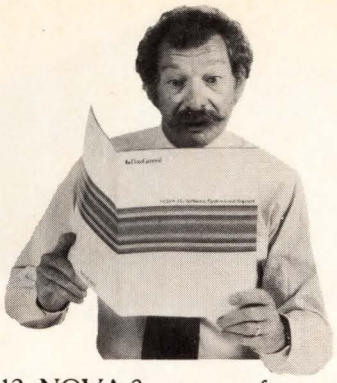

12. NOVA 3 systems, software and support let you customize a system to your application.

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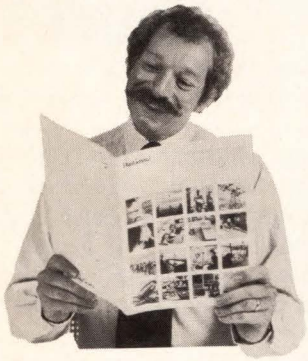

13. A wealth of information about how our computers are being used in actual APPLICATIONS.

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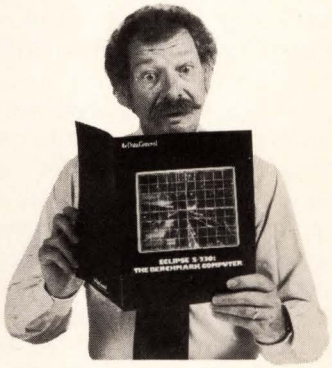

14. Wonder what sets the benchmark for big performance computer systems? Wonder no more, it's ECLIPSE S/230.

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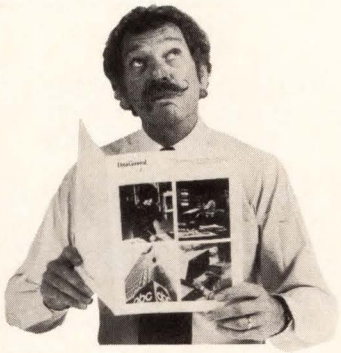

15. Is there a sensible way to use computers in DATA COMMUNICATIONS? The message comes through clear.

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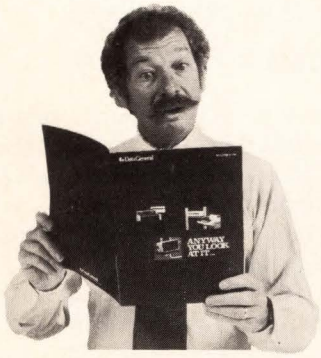

16. What's the most you can expect to get from a mid-range mini today? What you get with an ECLIPSE S/130 — the standard setter.

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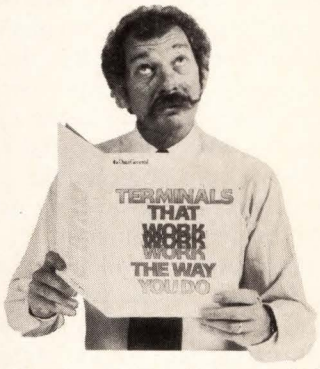

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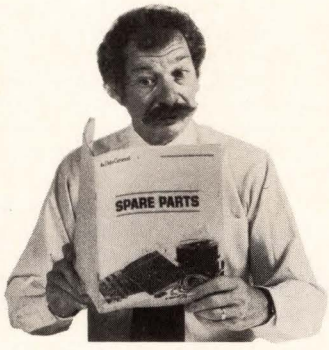

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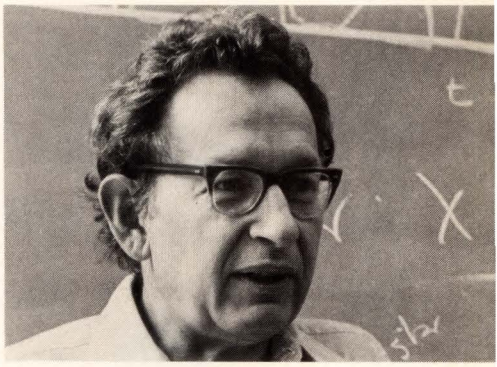
People

Nobel winner Anderson awaits practical uses for advances



Winner. New technology will find a place if the old fails to do its job, Anderson says.

"It's very hard to fight an existing technology that's doing the job," says Philip W. Anderson, consulting director at Bell Laboratories's Physical Research Division in Murray Hill, N. J., and cowinner of the 1977 Nobel Prize in Physics awarded by the Royal Swedish Academy of Sciences. Cited for his contributions during the late fifties and early sixties to the understanding of localized magnetism in metals and the formulation of the idea of localization in disordered materials, Anderson helped lay the groundwork for the magnetic-bubble and Josephson-junction (superconducting) technologies in the first instance, and amorphous semiconductors in the second.

Amorphous devices are now being applied in computer memories and as photoelectric light-sensing elements, while magnetic bubbles and Josephson devices may play roles as storage memories in telephone and computer equipment. But the mild-mannered, 53-year-old theorist, is careful in predicting other applications. "A new technology has to have enormous advantage in the face of the cost of the engineering development needed to build it up," he says.

Door opener. It will not be easy for anything to replace existing silicon-semiconductor technology because, as he points out, "all the engineering development has been done. However, if present semiconductor technology fails to do the job, then the door is open for a new technology, like amorphous semiconductors, just as vacuum-tube technology failed in computers and opened the way for transistors."

One suggested use for glassy-like amorphous devices, which should be cheaper to manufacture than crystalline silicon, has been in solar-energy converters. Anderson, who is part-time physics professor at Princeton University, cautions that though advantages may be there, practical realization is not.

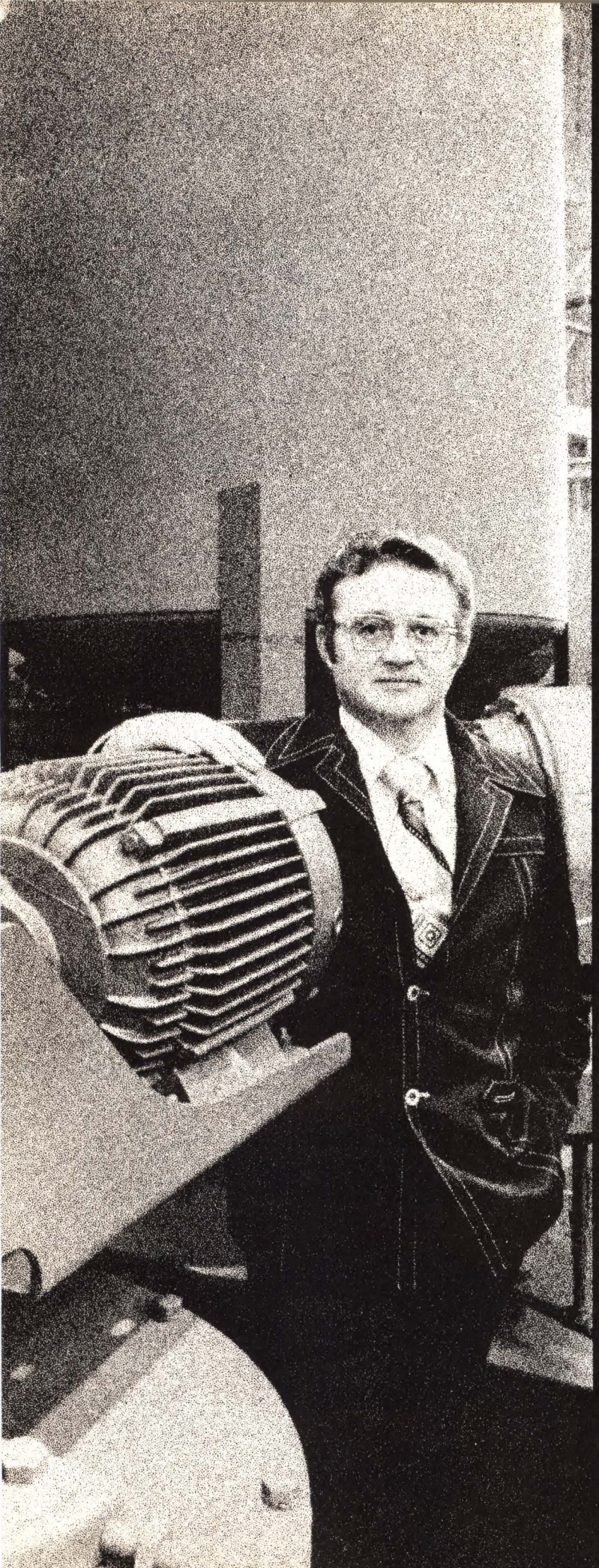
His work at present is still in the theoretical realm, delving into amorphous semiconductors and random magnetic alloys. He does express faith in at least a couple of the new technologies, saying he has "great hopes for Josephson technology as it applies to high speed computers and their use in the communications field." Likewise, he expects good things from magnetic garnet bubble-memory devices.

Ferris wants to assess impact of FCC policy

One of Charles D. Ferris' first priorities when he took over as chairman of the Federal Communications Commission on Oct. 17 was to upgrade the Office of Plans and Policy. He wants that office to make the FCC able "to forecast trends, rather than react to them" and to let the commission "assess the impact of its decisions, rather than being told about the impact by others."

If Ferris can achieve that, it will be more than his predecessors could do. Since being set up in 1971, the office has by and large been ineffectual, for lack of authority to acquire data from the FCC's other bureaus. Should Ferris change its role and image, his success will mark him as an accomplished politician.

The political skills and connections of the new FCC chairman have already attracted notice. For example, before his most recent job as general counsel to House Speaker Thomas P. O'Neill Jr., Ferris served 12 years on the Senate Democratic Policy Committee, where he rose to



"Kodak helped us set up a reprographics program that could save us more than $100,000 a year."

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"And it's certainly paying its way. We figure we'll save more than $100,000 a year for the next five years. We've reduced cost by doing photoreproduction work internally; saved drafting time through reprographic techniques; and we've gotten our files under control with microfilm."

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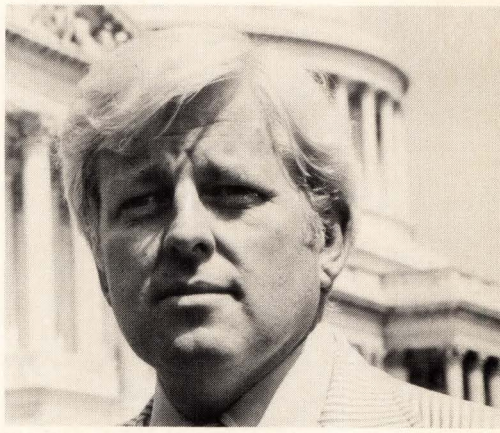
People



New head. FCC chairman Charles Ferris seeks to upgrade Office of Plans and Policy.

the post of chief counsel.

"The FCC is going to need a well-connected politician next year when Congress takes up the Bell bill," notes one industry lobbyist. Formally titled the Consumer Communications Reform Act, the controversial Bell bill—so called because of its strong support by American Telephone & Telegraph Co.—will attempt to rewrite and update the 1934 Communications Act that set up the FCC.

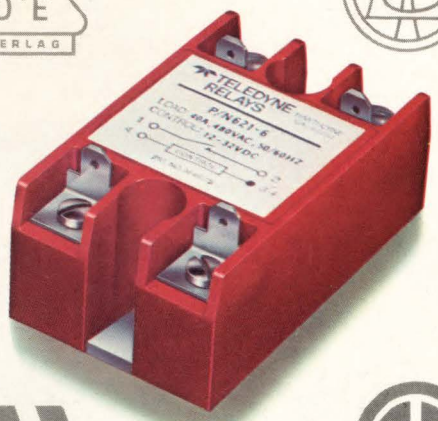
Ferris displayed one sign of his political savvy by carefully avoiding any prejudgment of the pending legislation. Calling competition and related telecommunications issues "the biggest challenge facing me," the 44-year-old lawyer cautiously observes, "the law prohibits my favoring competition just for competition, equally as it would rule out monopoly just to preserve monopoly. The goal must be what course best serves the public."

The new chairman began his career as a research physicist for Sperry Gyroscope at Great Neck, N. Y., in 1954 after receiving a BS from Boston College. But he returned there in 1961 to take a law degree, going on later to Harvard University's Advanced Management Program at the Graduate School of Business.

Ferris professes strong advocacy of government in the sunshine and says he will run "an open commission. . . . I want the public to know who I meet with and what I meet with them about."

SSR UPDATE

Our International Connection



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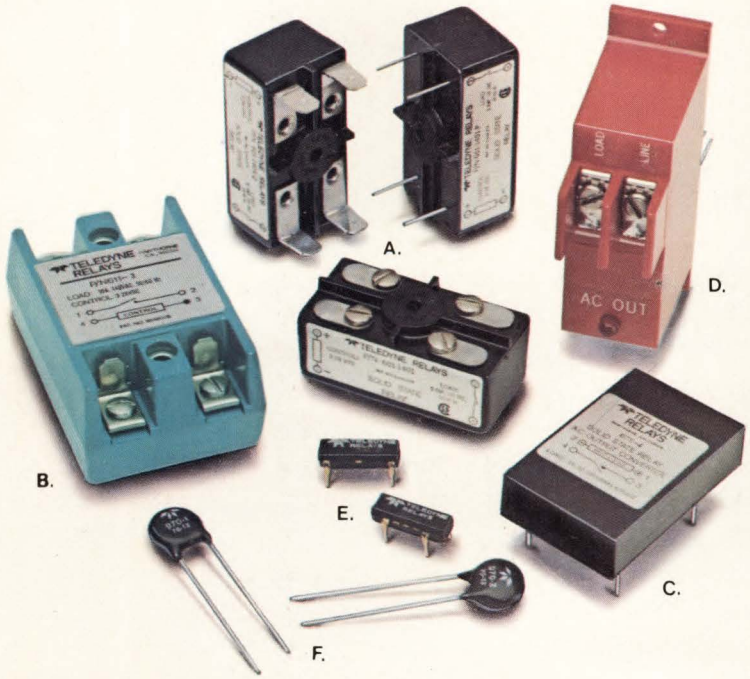

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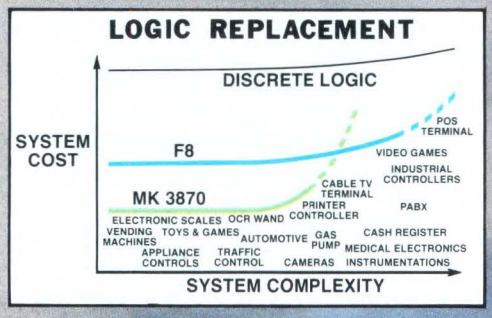
MOSTEK 3870 SINGLE
The solution to low-cost

Cost advantages increase potential applications.

Mostek's new single-chip 3870 microcomputer is the answer to maximum cost effectiveness in a wide range of control and logic replacement applications. Most obvious advantages are software flexibility, fewer components, low power and a 40-pin plastic package. The device now makes it economically feasible to replace as few as 12 TTL packages in an existing system while increasing capability. And the 3870 pinout allows applications to be implemented on single-sided PC boards, further reducing system costs.



Full-capability on one chip.

The 3870 is the first single-chip microcomputer offering full compatibility with a multi-chip processor family. The device can execute the complete F8 instruction set of more than 70 commands, providing complete software compatibility with the versatile F8 multi-chip family. It features twice the program storage as other single-chip devices—2048 bytes of ROM, 64 bytes of scratchpad RAM, four 8-bit I/O ports and a single +5 volt power supply requirement. If more memory (RAM, ROM or PROM) or I/O is eventually required, the system can be simply upgraded to the expandable MK 3850 (F8 CPU).

Low-cost, development tools.

Development represents a significant investment in your program. Mostek offers one low cost

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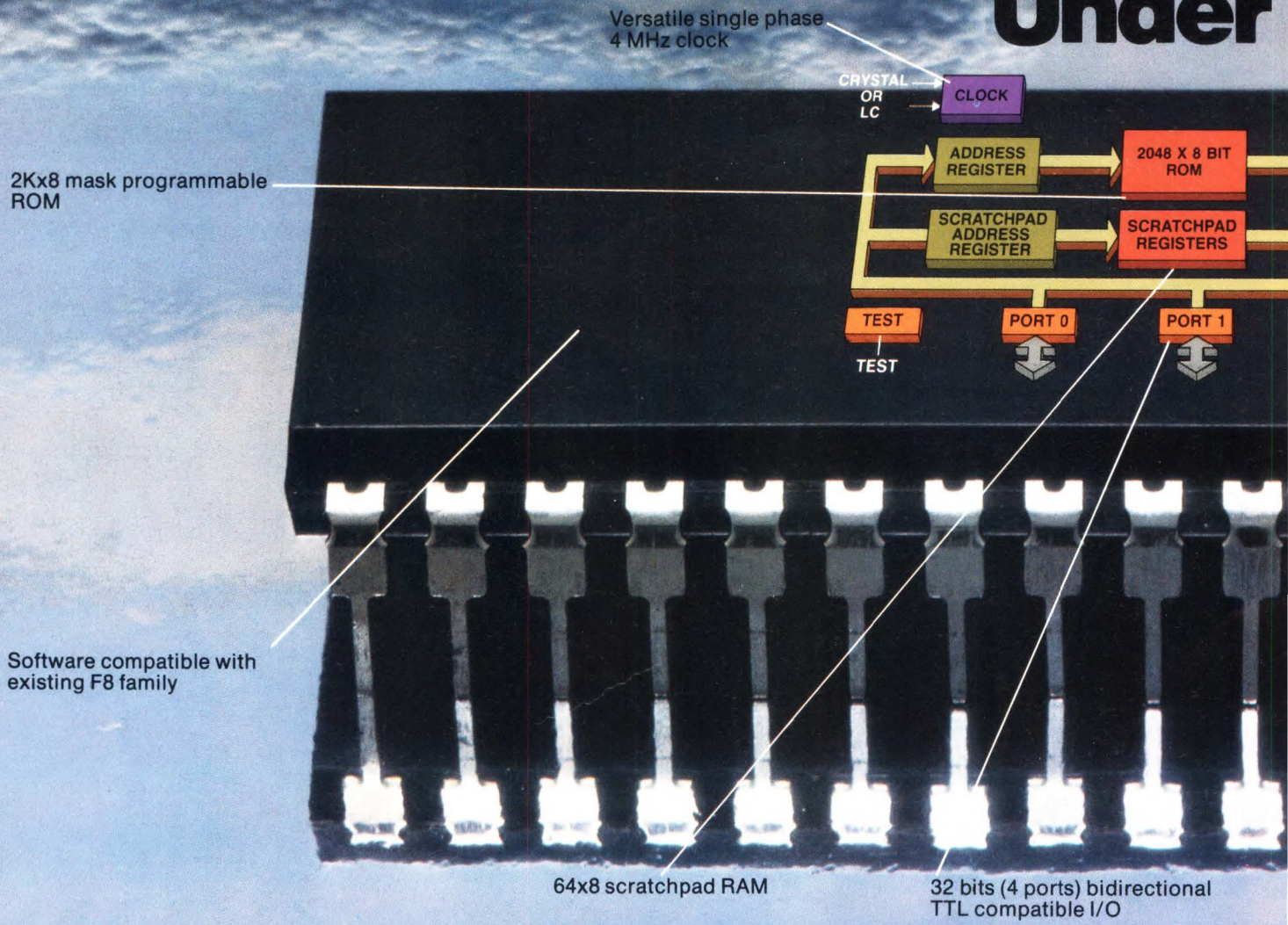

CHIP MICROCOMPUTER. logic replacement.

line that supports both the 3870 and F8 multi-chip family. Included are the Software Development Board (SDB-50/70), Application Interface Module (AIM-70), and an Emulator (EMU-70) for PROM prototyping.

With completion of software development and debugging, your 3870 prototype may be emulated for field-testing and evaluation with the compact PROM-based EMU-70. This allows exact verification of code prior to committing to mask programmed MK 3870's.

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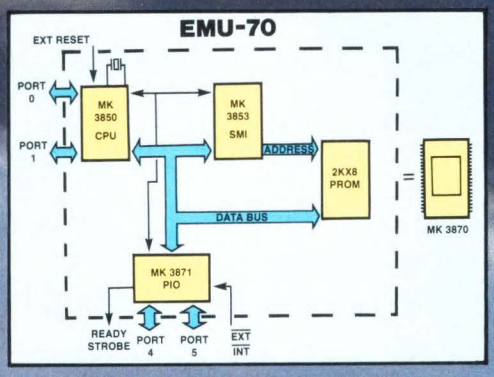

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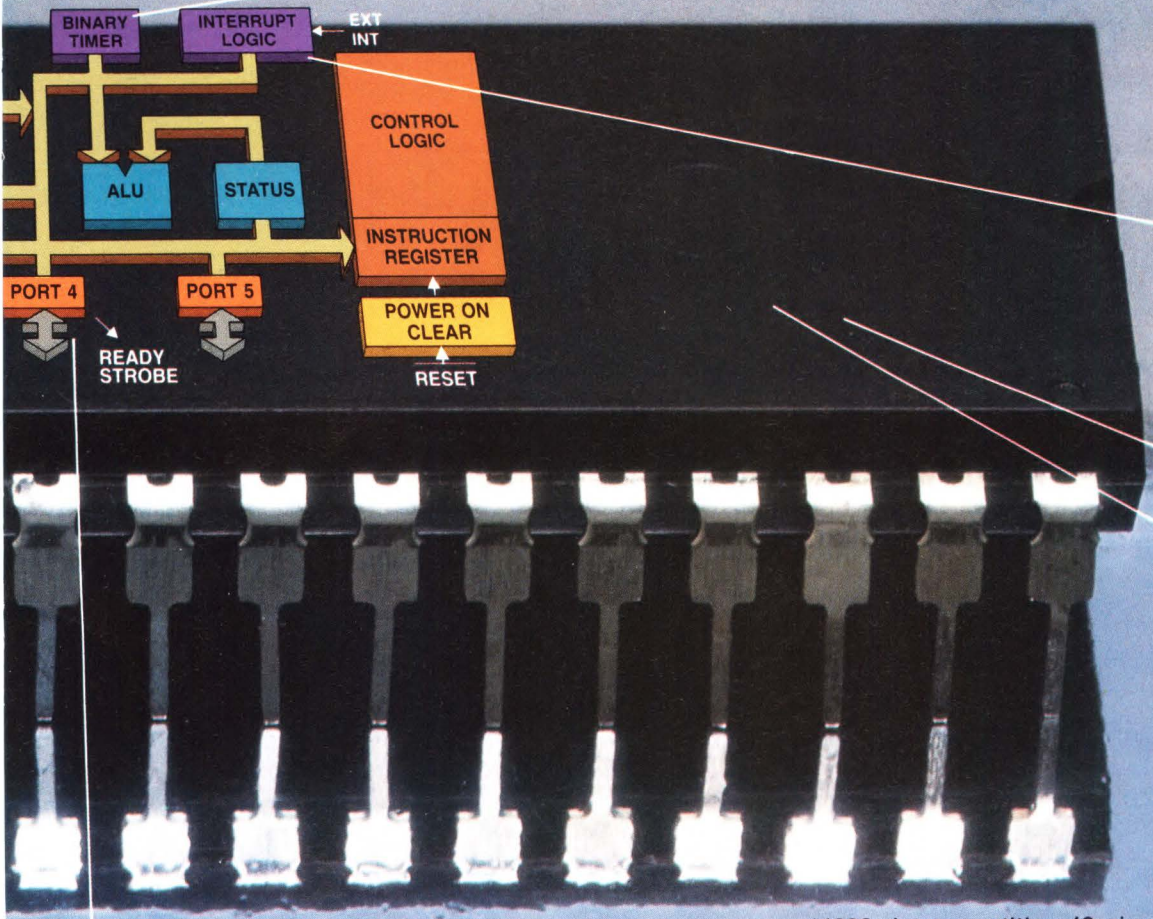

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That's the new 2147. It's a product of a new High-performance MOS technology we call HMOS. The 2147 is in production and we're delivering it now. HMOS makes it a new industry standard in high speed, high density memory. It's sure to change the way you design high performance memory systems.

In fact, the larger the cache, main or add-on memory your design needs, the lower the power consumption per bit with the 2147. A unique new power-down mode makes that power reduction possible. When the 2147 is deselected it stands by at a typical power dissipation of 50 mW —less than 15 microwatts per bit. So you can achieve major savings in cooling and power supplies, in systems large or small.

Access times range from 55 to 70 ns maximum with identical cycle times. Typical operating power dissipation is 500 mW, with

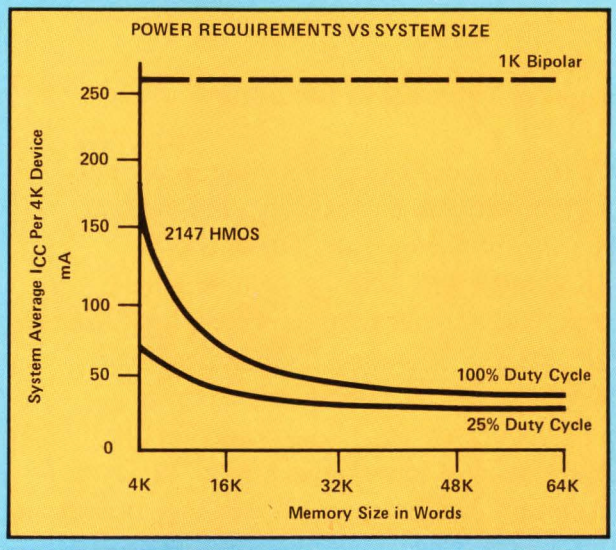
It's HMOS, the new that scoops bipolar.

worst case specs not much higher.

Throughput is always high because the 2147 can respond to select inputs as fast as to address inputs. HMOS eliminates the power-up delays of conventional power-down techniques.

On top of this the 2147 is fully static, eliminating the complications of conventional high density RAMs, such as clocking, address set-up or hold times. The 2147 operates on a single +5V supply and is directly TTL compatible. It uses the industry standard pin-out for 4K x 1 static RAMs. The chip itself measures only 158 mils square.

Now Intel has an expanded family of HMOS 1K and 4K high performance static RAMs: the recently introduced 2115A/2125A and now the 2147. Check 2115A/2125A and 2147 performance specs at right.



HMOS RAMs

	Density	Current (mA)				Access Time(ns)
		Active		Standby		
		Typ.	Max.	Typ.	Max.	Max.
2147	4K	100	160	10	20	70
2147-3	4K	120	180	15	30	55
2115A/25A	1K	100	125	N/A		45
2115AL/25AL	1K	60	75	N/A		45

Order 2147's, 2115A's and 2125A's from your local Intel distributor. Contact: Almac/Stroum, Component Specialties, Cramer, Hamilton/Avnet, Harvey Electronics, Industrial Components, Pioneer, Sheridan, L.A. Varah, Wyle Liberty/Elmar or Zentronics.

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Editorial

Engineering employment: rerun?

There is increasing evidence that a boom is in the making in engineering employment. The classified pages are bursting with recruitment ads, and at recent technical conferences the headhunters were aggressively evident. The Technical Demand Index, a barometer of the demand for technical personnel in all disciplines compiled by Deutsch, Shea and Evans, a New York recruiting firm, is at an 11-year high, exhibiting an 80% rise since a year ago. While no one is as yet willing to project a serious shortage of engineers, the competition for available people is unquestionably high. As one president of a high-technology company recently put it, "the next big problem in electronics is not in technology but in human resources."

The return of boom times for engineers should stir a strong feeling of déjà vu in those of us who have been through this before. And it should also stimulate feelings of alarm and caution as industry tries to meet the upcoming human resources problem in high-technology areas, without repeating some of the past mistakes.

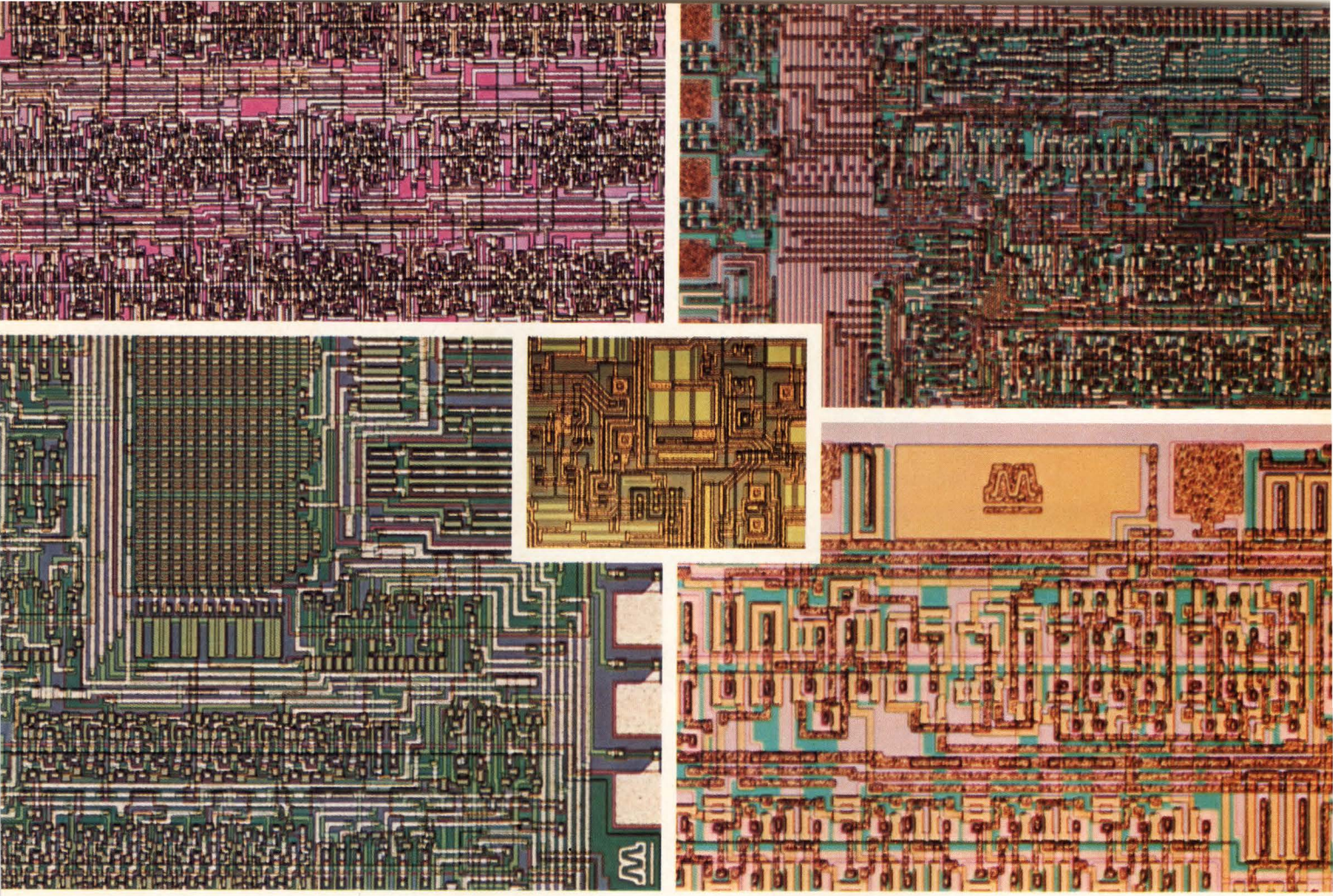
Let's just run through a reel or two from the old movie. In the good old days, there were boom times. Then, unexpectedly, an economic slowdown hit. Companies retrenched and laid off engineers. To the surprise of everyone, the slowdown worsened and lasted long enough to be called a recession. Companies retrenched even more and laid off even more engineers. Meanwhile, back at the engineering schools, great numbers of students, drawn into engineering by continuing predictions of continuing boom times, waited to enter the job market. Reel two, of course, shows the disillusionment and sobering readjustment forced on the too many who could not land or hold on to the too few jobs.

The engineering profession has just been through a good part of reel two and now it looks as if the movie is about to start over. But it's not too late to write a new scenario.

Just a year ago on this page we pointed out: "For some time it has been apparent that the nation's engineering schools are turning out more EEs than industry, Government, and academia can absorb. Incredibly, despite studies by engineering societies and warnings from a host of other informed groups, there is no evidence that steps are being taken to make sure that young people entering an engineering career path are presented with a realistic picture of their prospects for jobs after their training is completed."

Now, as companies turn once more to the engineering schools to fill the depleted pipelines, it is their responsibility as well as the schools' to present a realistic picture of career prospects and industry needs. They should work closely together to ensure that not only will industry's short-term needs be met adequately but that in the long term the baleful effects of oversupply will be avoided.

It may be that, given the dynamics of the free-wheeling electronics industries, it will never be possible to damp down the supply and demand oscillations completely. But it is essential that everyone try.



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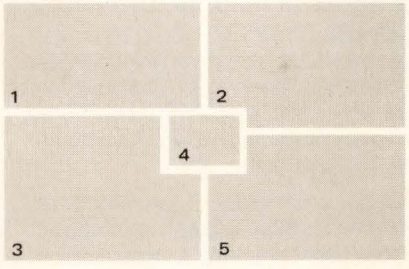
Take, for example, the multimeter circuit we designed for an instrument manufacturer. By miniaturizing functions in the circuit, we made the product more portable and more reliable. We also saved the customer a good deal of money in assembly labor—enough to amortize his development costs within a year.

Or consider the pair of ICs we developed for a CB radio manufacturer. One of the devices, a Bipolar AM Receiver, handles all functions between antenna and audio. The other chip, a CMOS digital frequency synthesizer, includes a prescaler, a PLL and VCO. Providing over 80% of the electronics required to produce a CB transceiver, this chip set is just one example of how we can combine both digital and linear processes to tailor a cost-efficient system solution.

And we are as reliable as you can get when it comes to *making* custom LSI circuits. Our proven production processes—HD/CMOS, Bipolar and the deposition of thin-film resistors on LSI chips—consistently produce high yields.

Exceptional noise immunity and high switching speeds are standard performance features—especially in our HD/CMOS circuits. And because they consume less power than microprocessor- or IC-based systems, our devices operate on comparatively smaller, less-expensive power supplies.

If your potential application requires more than a handful of standard ICs and discrete components, you ought to think about the advantages of converting to custom LSI. Contact us today and we'll help you write your own success story.



KEY: 1. DVM Circuit, 3½ digit, A/D converter; 2. LCD Watch Circuit, 6-digit, 6-function; 3. CB Scanner with ROM; 4. Cardiac Pacemaker; 5. PLL Frequency Synthesizer.

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Meetings

Asilomar Conference on Circuits, Systems, and Computers, IEEE et al., Asilomar Hotel, Pacific Grove, Calif., Nov. 7–9.

Midcon, IEEE, O'Hare Convention Center and Hyatt Regency Hotel, Chicago, Nov. 8–10.

Compsac 77—Computer Software and Applications Conference, IEEE, Sheraton-O'Hare, Chicago, Nov. 8–11.

Magnetism and Magnetic Materials Conference, IEEE, Radisson Hotel, Minneapolis, Nov. 8–11.

AAMI/FDA **Conference on Medical Device Regulation,** Association for Advancement of Medical Instrumentation and U. S. Food and Drug Administration, Hyatt-Regency Hotel, Washington, D. C., Nov. 15–16.

26th International Wire and Cable Symposium, U. S. Army Electronics Command (Fort Monmouth, N. J.), Cherry Hill Hyatt House, Cherry Hill, N. J., Nov. 15–17.

Electro-Time/77 U. S.—Design and Manufacture of Electronic Watches, International Society for Hybrid Microelectronics, Florida Chapter, Marco Beach Hotel, Marco Island, Fla., Dec. 1–2.

Semiconductor Interface Specialists Conference, IEEE, Carillon Hotel, Miami Beach, Dec. 1–3.

Chicago Fall Conference on Consumer Electronics, IEEE, Ramada-O'Hare Inn, Des Plaines, Ill., Dec. 5–6.

International Electron Devices Meeting, IEEE, Washington Hilton Hotel, Washington, D. C., Dec. 5–7.

National Telecommunications Conference, IEEE, Marriott Hotel, Los Angeles, Dec. 5–7.

1977 Winter Simulation Conference, IEEE, National Bureau of Standards, Gaithersburg, Md., Dec. 5–7.

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Communications Counters

Systron-Donner offers you a choice of no less than *four* communications counters from 100 MHz to 4,500 MHz. Small and lightweight, all of these counters feature the latest advances in high speed, precision frequency measurement.

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Our new 851 Digital Tester can give you the leverage to control those costs.

Managing a service organization is no bed of roses. It's big business. And it's continually getting more costly. Customer engineers, spare parts inventories, training, designing for serviceability, documentation, and instrumentation all contribute to these spiraling costs. Because service is so important to the success of a company, you need to indentify those elements which have the greatest leverage for your service organization.

Consider instrumentation.

Typically it is less than 5% of your overall service budget. Yet the right test instrument can have a tremendous impact on the other 95%... training, salaries, inventory requirements, travel and backup.

That's why we built the new 851 Digital Tester. It's a synergistic, new service instrument that combines the functions of many instruments in one portable package.

We know that the task of servicing digital equipment is threatening to outrun existing service resources. Your first-line customer engineers are being required to make more intricate measurements on increasingly complex systems.

With the new 851, your first-line customer engineer will be able to solve more problems in less time on the first call. That's because he can rely on the measurement and interpretation capabilities of the 851 to perform complicated tests in the field. Not only does this save you the expense of calling in the back-up engineer, but it also gives your first-line engineer the satisfaction of solving more problems on the first call.

A new concept in service instruments.

Your inventory of service instruments probably includes oscilloscopes, DMM's, counters, timers, logic probes, thermometers, and some special purpose test equipment.

A bench full of test equipment is a great resource for your customer engineer to rely on...as long as he doesn't have to travel much.

But imagine a self-contained service instrument that weighs only 13 pounds and makes most of those same measurements.

That's our new 851 Digital Tester.

The power of the 851 lies in the fact that even though this one instrument makes the measurements of a variety of test gear, it is also easy to use.

With just one turn of the knob you can dial 22 different functions to make a wide range of system measurements and tests.

851 Functions

MEASUREMENTS		SIGNAL ANALYSIS	SELF TEST
VOLTAGE	**TEMPERATURE**	**LOGIC STATE INDICATORS**	**TEST SIGNAL**
PEAK (25 ns to 25 ms)	**TIME (20 ns to 10 s)**	HI, LO, INVALID, ACTIVE	EXERCISE FUNCTIONS
AC	PERIOD	**% DUTY FACTOR**	ADJUST PROBE
DC	FREQUENCY	**COUNTING**	**READOUT TEST**
POWER LINE	PULSE WIDTH	FREQUENCY RATIO	
INPUT LOGIC THRESHOLDS	INTERVAL	EVENTS BETWEEN START AND STOP PULSES	
RESISTANCE (0.1Ω to 50 MΩ)	COINCIDENCE	TRANSITIONS BETWEEN START AND STOP PULSES	
	TRANSITION	TOTALIZE	

It's easy. Just dial a function, probe the circuit being examined, and read the results directly from the auto-ranging LED display.

And what about product support? With Tektronix, it's worldwide.

Wherever in the world your service organization goes, Tektronix is with you all the way. Service personnel at 46 Tektronix Service Centers in the U.S. as well as service personnel in 50 other countries back our products.

Put the 851 to work in your digital service environment.

The measurement capabilities of the 851 make it particularly useful for sevicing computer peripherals, small business systems, and industrial control equipment.

We had you in mind when we designed the 851 Digital Tester.

For a demonstration, visit the TEKTRONIX booth at WESCON. Detailed specifications, application notes and a color brochure are also available for your information. Please contact your Tektronix Field Engineer. Or write Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077. In Europe, write Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

New concepts in digital service

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What's
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Saturn?

MODCOMP computers are helping bring back the answers.

On August 20, the National Aeronautic and Space Administration launched the first of two Voyager spacecraft atop a Titan Centaur rocket for man's most extensive reconnaissance to date of the outer planets. In September, the second Voyager was launched. Both vehicles were placed in trajectories that will take them to Jupiter and Saturn and past several moons of both planets. The spacecraft will arrive at Jupiter in March and July of 1979, and at Saturn in November, 1980 and August, 1981. One of the Voyagers may then be targeted for the first encounter with Uranus, some 1.7 billion miles from Earth, and possibly Neptune. The decade-long journey could take the vehicles to as many as 15 different planets and satellites.

The success of the Voyager projects will be measured by the ability of scientists to track and monitor the activities of the spacecraft and process the vital data returned to Earth. These critical functions are primarily performed for Voyager and other ongoing space missions, including Pioneer, Viking and Helios, by a series of MODCOMP computers in the Deep Space Network of Jet Propulsion Laboratories in Pasadena, California, which includes tracking stations throughout the world.

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Artist's concept of Voyager Spacecraft passing Saturn—courtesy of NASA/Jet Propulsion Laboratory

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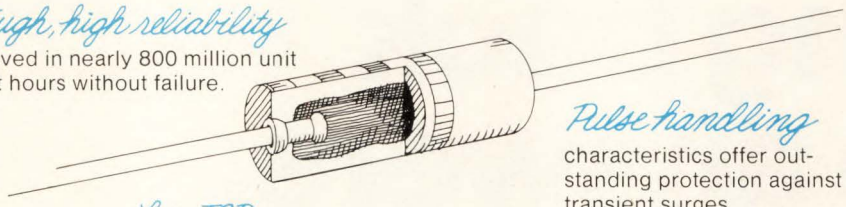

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characteristics offer outstanding protection against transient surges.

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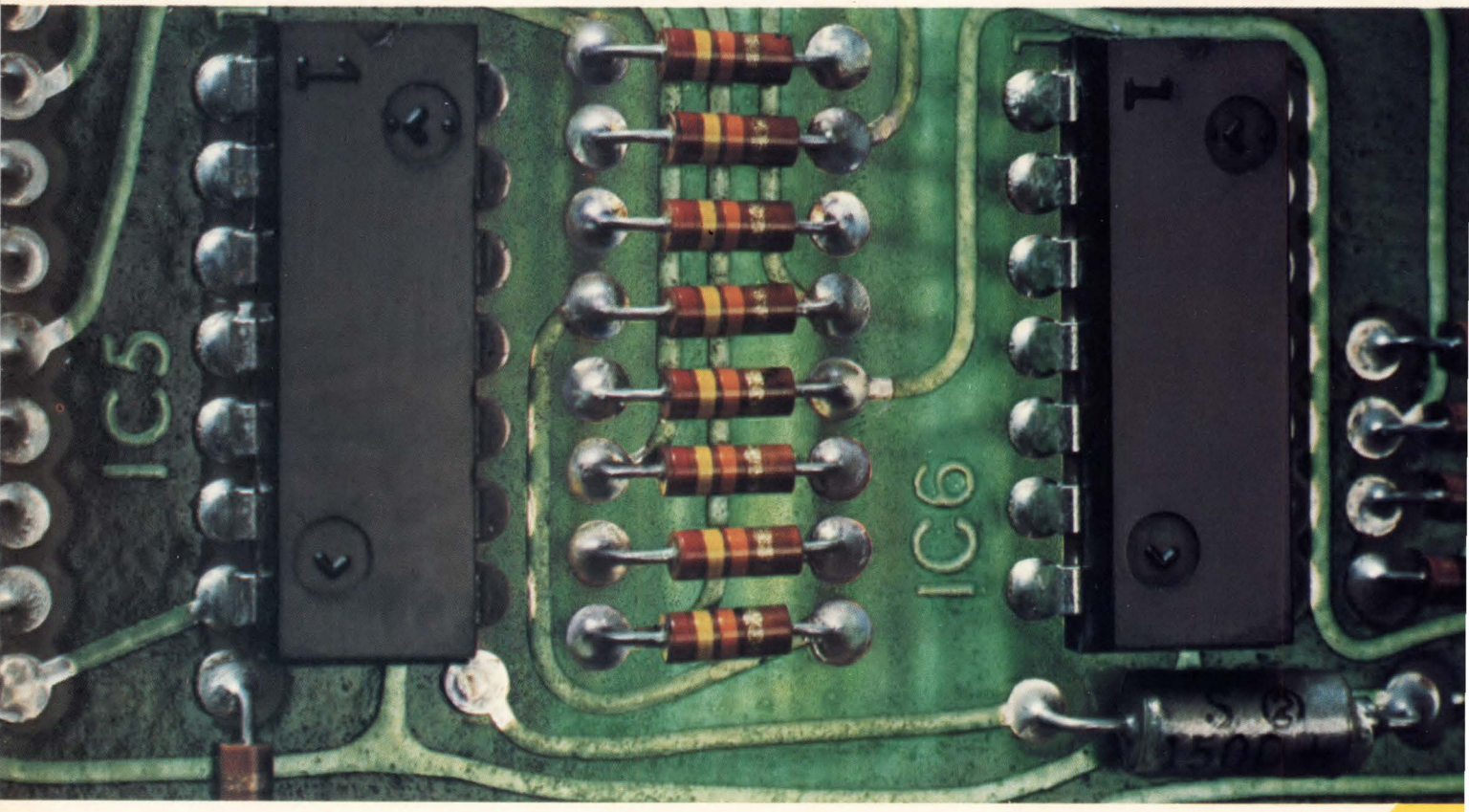

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EC146

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Electronics newsletter

DEC introducing its first 32-bit mini

Digital Equipment Corp. is expected to announce its **long-awaited entry into the 32-bit minicomputer market.** The system, to be named VAX—for virtual address extension—will prove to be a boon for PDP-11/70 users who need the additional addressing capability, but wish to continue on PDP software. With its own operating system for 32 bits plus compatibility with DEC's 16-bit systems, the VAX can directly address 2 megabytes of memory, which DEC is implementing with its first wholesale use of 16,384-bit random-access memory chips.

Push into in-circuit tester market speeded by Teradyne

Teradyne Inc., the Boston manufacturer of test and semiconductor production equipment, is making its biggest move to date into the market for in-circuit board testers with the introduction this month of its L529 assembly inspection system. The L529 prescreens loaded analog, hybrid, and digital circuit boards for between 70% and 90% of assembly and component faults prior to functional testing of the board. Earlier this year, Teradyne introduced the L429, which was limited to prescreening boards for short circuits, but the new system puts Teradyne **in direct competition with the two small companies that have dominated in-circuit testing** until now—Faultfinders Inc. and Zehntel Inc. Teradyne's Jeff Hotchkiss, product manager for in-process test equipment, expects heavies GenRad Inc. and Hewlett-Packard Co. to be close behind Teradyne into the in-circuit board test fray, and for the competition to get "really fierce."

Motorola lands memory system job called biggest of 1977

A relative newcomer to the memory systems business has made what shapes up as the biggest sale of the year. Motorola Semiconductor, Phoenix, after barely one year in the business, has signed a contract with the Link division of Singer Co., in Binghamton, N. Y., to supply 256-megabit systems, each containing 18,000 16-k 6616 dynamic RAMs, and 6800-microcomputer control to replace rotating memory disks. **Initial orders are in excess of $1 million,** potentially running as high as $20 million. Final competition was between Motorola and Intel Corp., which was offering a charge-coupled-device version.

Intel reorganizes microcomputer, components units

In response to **ever-increasing pressure, especially from small, feisty semiconductor manufacturers** like Mostek Corp. in dynamic memories and Zilog Corp. in high-end microcomputers, Intel Corp., Santa Clara, Calif., has reorganized its operations into more manageable divisions. The former microcomputer group has been split into two—a components division headed by Leslie L. Vadasz, formerly assistant general manager for microcomputers, and a systems division, headed by William C. Davidow, formerly general manager for microcomputers.

The semiconductor components side of the house, which will be headed by Edward L. Gelbach, formerly senior vice president and general manager, has in turn been divided into two divisions—a fast static and dynamic memory division headed by Ron Whittier, formerly director of engineering for components, and a static random-access-memory, erasable read-only-memory, and bipolar ROM division, headed by George Schneer. Jack C. Carsten, marketing vice president, will have worldwide marketing responsibility for components. Gelbach will also have responsibility for special component developments for such dedicated applications as automotive and telecommunications. This is the third reorganization of a

major semiconductor manufacturer in the last few months, following realignments at National Semiconductor and Fairchild.

Zilog chips in with more power; Mostek enhances 3871

Microcomputer designers can look forward to powerful new entries next year at both ends of the performance spectrum. Zilog Corp. of Cupertino, Calif., whose growing Z-80 microcomputer family was the first enhanced 8-bit multichip design, will offer two: a single-chip Z-8 version for stand-alone and minimum-chip controller configurations, and a 16-bit Z-8000 design for powerful high-end minicomputer applications. The expandable, single 5-V Z-8, which promises to be the fastest one-chipper to enter the market, can execute some instructions in as short a time as 1.5 μs using a 4-MHz clock. The part has 2 kilobytes of read-only memory, 96 bytes of random-access memory, and 32 input/output ports.

The 16-bit Z-8000, which functionally stands in the PDP-11/70 class, will include difficult-to-implement multiply and divide instructions and enough data-handling power to manage large blocks of external memory. The company will also introduce the microcomputer industry's first high-level Cobol language set, for its midrange Z-80 family, in November and Fortran in December.

Meanwhile, Mostek Corp. is planning an enhanced version of its stand-alone 3871 one-chip design by year's end. The part will have 4,096 words of ROM—the biggest program capacity of any one-chip part—and 1,028 bytes of RAM, twice as many as the 3870.

Switching transistor from Westinghouse called biggest yet

Westinghouse Electric Corp.'s Semiconductor division in Youngwood, Pa., has developed and made available what is perhaps the biggest switching transistor in existence. Designed for the industrial marketplace to eliminate problems with thermal fatigue, the new D60T series devices, **made with the firm's thyristor process,** have a gain of 15 at 50 A and a peak-power-handling capability of 200 A and 450 to 550 V. The stud-mounted devices have fast switching speeds—less than 1-μs turn-off and turn-on times.

Addenda

Memory makers are having trouble delivering enough 16-k RAMs. **Thus the heavy demand is pushing average selling price to between $20 and $30.** Mostek Corp. is the leader with 800,000 units this year, followed by Intel Corp. and Fujitsu Ltd. with another 800,000 between them. . . . To conform to industry standards and in response to the success of unlatched 16-k dynamic RAMs, Intel is producing a new part, the 2117, **that can operate either latched or unlatched.** . . . Engineers at Bell Laboratories in Murray Hill, N. J., have developed a 16-k charge-coupled-device memory **optimized for 10-megahertz operation.** While there are 65-k CCD memories, they operate in the 2-to-5 MHz range. . . . Harris Corp. has unveiled four systems designed to automate newsrooms, composition rooms, and ad departments **of smaller daily newspapers** with circulations of 20,000 to 50,000. Harris's previous emphasis was on large metropolitan dailies. The smallest of the new 2530 series, the 2531, which has four computer-linked terminals, will sell for $225,000. Other prices range to $295,000. . . . NASA is going to reorganize its headquarters **"by way of streamlining things,"** says Administrator Robert Frosch. Details are due in mid-November.

D/A and A/D Converters

DDC offers two new hi-rel four-quadrant multiplying hybrid D/A converters at competitive prices. The MDA 100 is a true 10 bit multiplying D/A converter with a full 10 bit linearity. An 11 bit linearity unit is also available. The 16 pin MDA 100 is a pin-for-pin replacement for the Analog Devices AD-7520 and the Hybrid Systems HS-331.

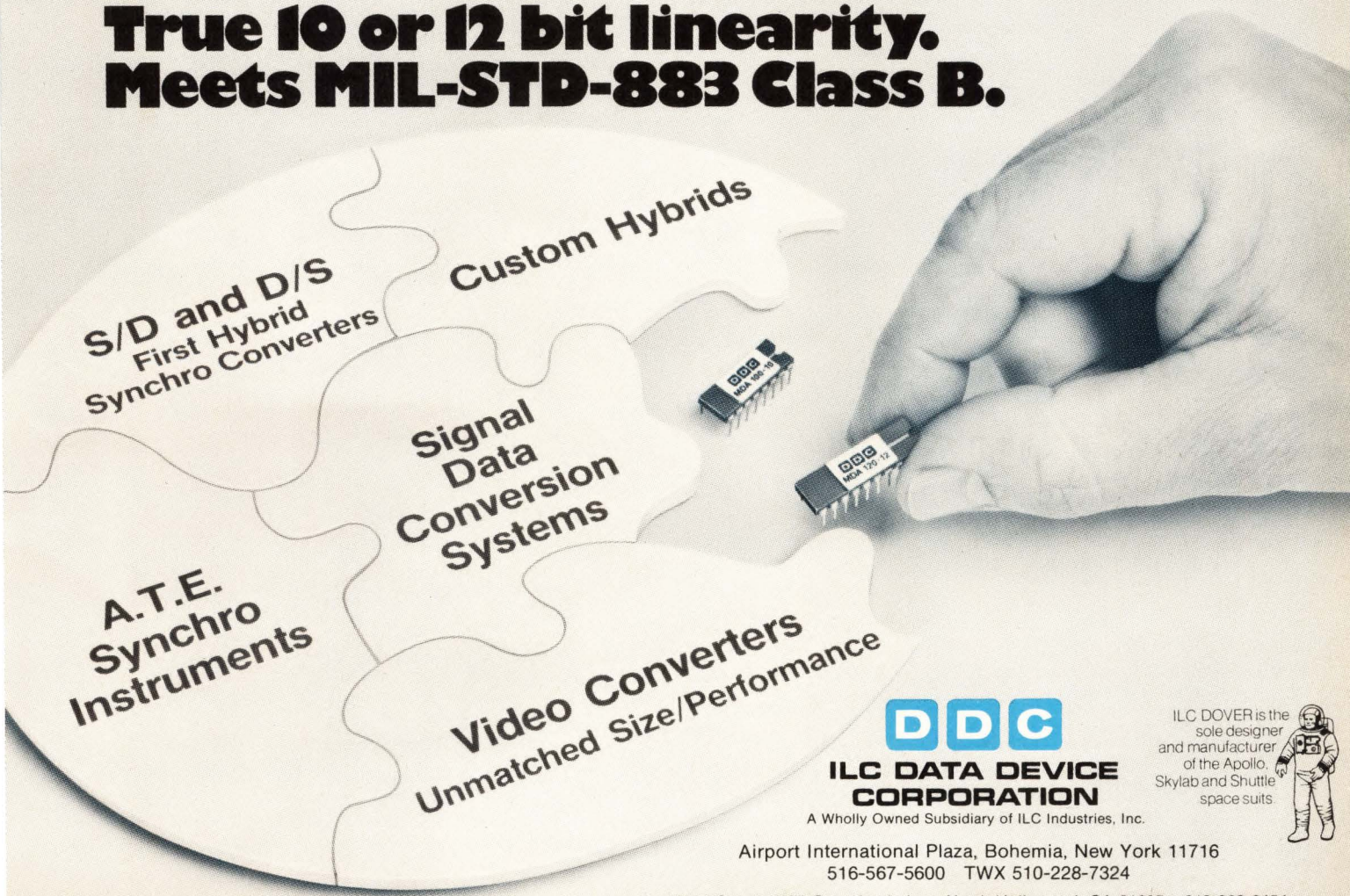
The MDA 120 is a true 12 bit multiplying D/A converter with a full 12 bit linearity. This 18 pin device is pin compatible with the AD-7521.

Exclusive internal pull-up resistors guarantee logic compatibility. DDC's usual high reliability features include welded instead of soldered lid design for the ceramic package for the most rugged military and industrial applications.

For hi-rel, high performance products DDC is your first source. Write or call your nearest DDC representative, listed in EEM, or call Mike Andrews at 516-567-5600.

New Hi-Rel Multiplying DACs from DDC

True 10 or 12 bit linearity. Meets MIL-STD-883 Class B.



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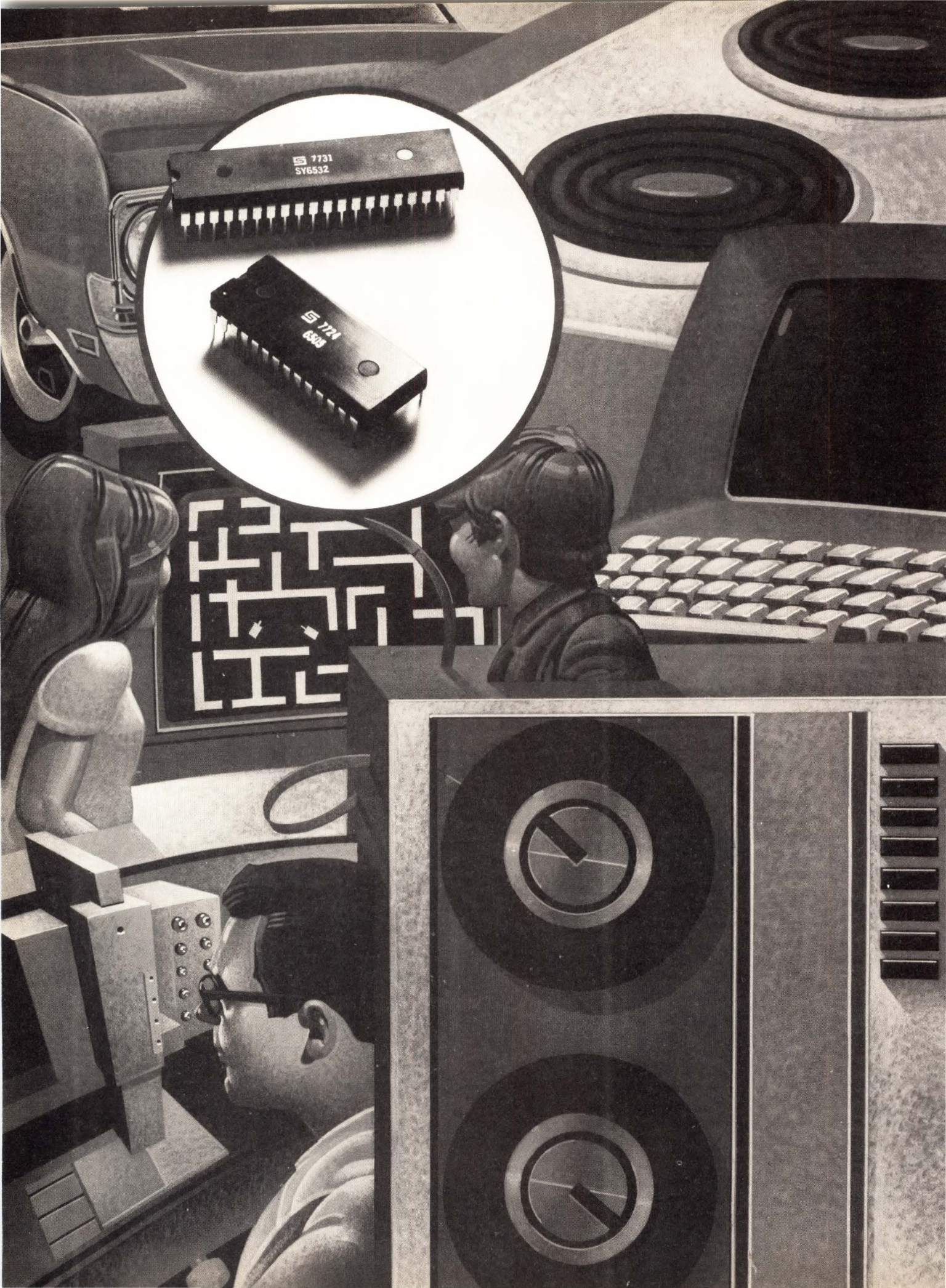
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When the chips are down

The lowest cost, highest performance microprocessor wins.

And here it is: the 6500.
A full family of nine software compatible microprocessors, with comprehensive interface circuits and all the supplementary memory you could need. The technology is N-Channel Silicon Gate with Depletion Load implementation and Ion Implantation. This means the smallest real estate coupled with high speeds and a host of performance benefits.

Low Cost.
The 6500 is already established as the most popular third generation microprocessor family. We will ship 300,000 microprocessors this year, for good reason. More capability at remarkably low cost, for the chips themselves, and for the overall system.

The microprocessor itself is low cost because:

- Smaller die than the 6800 or 8080.
- 28 pin versions available (pick the one that's right for you—pay only for what you need).
- In high volume production—the more we make the better we get and the learning curve advantages derived are passed on to the customer.

Your system will be low cost because:

- Less ROM required for programming code due to the flexibility provided by having 13 different addressing modes!!
- Minimum system requires only 2 chips. Select one of our microprocessors, add a 6530 (RAM: ROM:I/O:Timer) and you have a microcomputer system.
- Lower component costs.

High Performance.
A fast 2MHz standard.
At 2MHz, the 6500 has a potential throughput equal to a 6800 or 8080 running at 4MHz—if they could. All our microprocessors are software compatible within the group and bus compatible with the 6800. Makes it easy to improve performance and costs in existing 6800 applications.

True Pipeline Architecture.
Unusual in a low cost microprocessor, but even as the 6500 microprocessor is interpreting one instruction, it is accessing the next memory location. By doing its tasks in parallel, the 6500 attains tremendous system throughput, and overall performance you'd expect to cost much more.

Thirteen Addressing Modes and a Host of Other Advantages.
Our thirteen different addressing modes include zero page and indirect indexed, features you'd not normally look for in a low cost microprocessor, but we have them. The flexibility of these addressing modes allows you to write your programs using an average of 20-40% less code. This means a savings in the amount of ROM required.

With a choice of internal or external clocks and drivers, you can optimize the costs vs. timing control requirements.

The 6500 family operates from a single 5 Volt power supply; it has true indexing capability, two interrupt modes and addressable memory range up to 65K bytes. It offers both decimal and binary arithmetic.

Outstanding Interface Chips.
Our interface chips combine functions which required several packages in first generation microprocessor systems. All feature 8-bit bidirectional data bus for interface to the microprocessor. The SY6530 has a 1K byte ROM, 64 byte RAM, interval timer and I/O. The SY6532 has 128 bytes of RAM, interval timer and I/O. The SY6520 Peripheral Adapter has two 8-bit bidirectional data ports, four peripheral control/interrupt lines and is available at either 1 or 2MHz. It is a high performance replacement for the 6820 Peripheral Adapter. The SY6522 Versatile Interface Adapter offers all of the features of the 6520 plus latching inputs, two fully-programmable interval timers/and an 8 bit shift register for serial interface.

Compatible RAMs and ROMs.
Where the application requires additional memory, we offer fully compatible 4K Static RAMs (2114) and 16K Static ROMs (2316A, 2316B). Our mask programmable ROMs are available in two week prototype turnaround, and we're geared for rapid shipments in production volumes.

Multiple Sources, of course.
Rockwell and MOS Technology are shipping identical parts on all members of the 6500 microprocessor family and interface circuits. New designs are cross-fed among all three as part of the cross-licensing agreements. In addition to price and performance, you're assured of availability, too.

Complete Information is Free.
We want you to know all about this low cost, high performance microprocessor family. For data sheets on any or all of our products, or more detailed information, call or write to:

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Don't waste money and ruin PROMs. Move up to a first-rate programmer.

What defines a first-rate programmer?

A first-rate programmer is easy to use, safe (U.L. listed), reliable, backed with a long-term warranty, and flexible enough to handle advances in PROM technology, a combination you get only with a Pro-Log programmer.

Our systems take the mistakes out of programming.

Our Series 90 PROM Programmer walks you through the programming process so there's less chance for misprogramming. Separate sockets for master and copy PROMs make it impossible to accidently destroy a valuable master.

Vendor-approved programming, full portability, free 2-year warranty.

Using vendor-approved PROM personality modules, Pro-Log's field-proven programmers program every major MOS and bipolar PROM. They also program generic PROM families and do gang programming.

They weigh less than 20 pounds so they go where you need them. And they're backed by the longest warranty in the industry, 2 full years parts and labor.

A first-rate programmer is economical, too.

A Series 90 master control unit costs only $1,800. A Series 92 PROM Duplicator master control unit costs only $1,145. Single PROM personality modules cost from $325 to $450. Generic modules start at $350. Gang modules which program 8 PROMs simultaneously are $895. All modules come U.L. listed and fit both the Series 90 and the Series 92. Options include CMOS RAM buffer (to 4K bytes), RS-232 (terminal or modem) interface, TTY, parallel interfaces, paper tape reader, U.L. listed erase light, checksum option, and Auto-baud.*

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Optoelectronic plug-in modules aim at computers

Hewlett-Packard designs transmitter, receiver units to be linked by fiber optics for computer-interface chores

Now making headlines in telecommunications, fiber optics may next make it big in computing systems, if Hewlett-Packard Co. has any hand in the matter. To encourage such a development, it has built optoelectronic replacements for conventional line drivers and receivers.

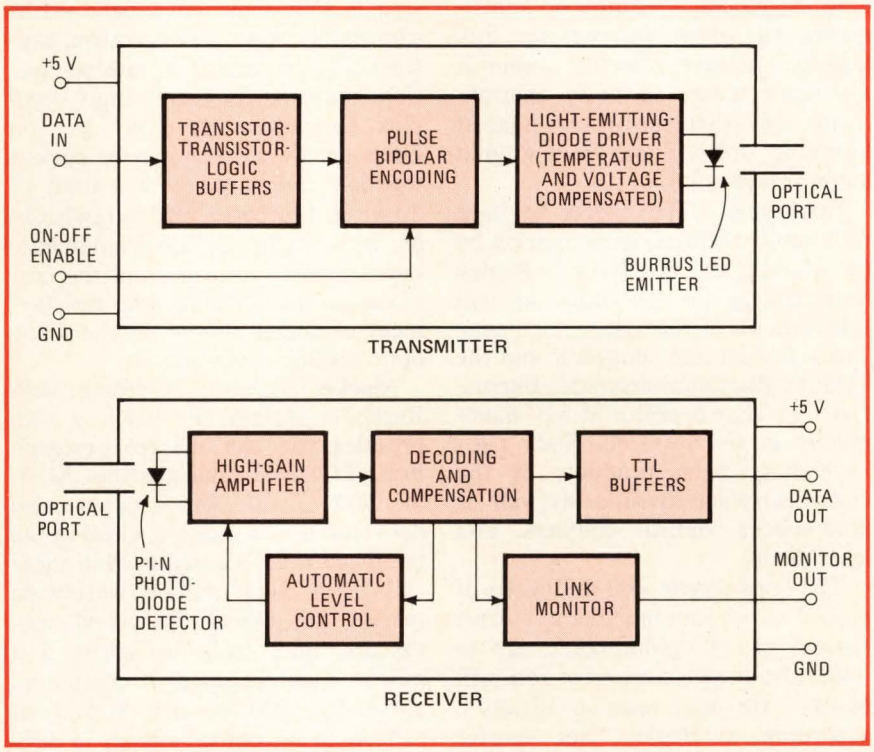
The firm's Optoelectronics division in Palo Alto, Calif., is readying a pair of transmitter and receiver hybrid-circuit modules designed to make things easy for a would-be user of fiber-optic cable. Moreover, according to HP's project manager, Del Hanson, the modules are already being tried out by a select handful of original-equipment manufacturers. These include OEMs involved in computer-to-peripheral interface and process-control applications—areas HP will concentrate on developing—as well as digital communications. HP will not say who the OEMs are. Also included are groups in other HP divisions, whose feedback should influence the final design.

System solution. "We have endeavored to solve a systems problem rather than just offer a bunch of parts the user must put together," Hanson points out. Only a 5-volt supply is needed to put a user on the air once a fiber-optic cable has linked the transmitter and receiver modules diagrammed at the right. The light-emitting-diode transmitter contains a modulator interfaced with the digital data input by transistor-transistor logic. The receiver module has a p-i-n photodiode detector and 100-decibel gain amplifier and includes automatic leveling circuitry to accommodate a wide input dynamic range.

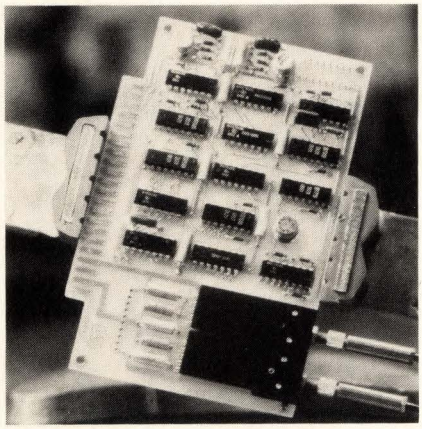
But HP has not stopped there. It has also designed into the receiver automatic monitoring circuitry that sends diagnostic pulses over the link to check for continuity even when no data is being transmitted. The optical line-coding technique on which the monitor relies is transparent to the user and has been patented by HP, Hanson says.

Each module comes in a five-pin, single in-line package with an optical-fiber connector. At 0.31 inch high, they are about the size of the small 9-v battery used in transistor radios and can be plugged right into existing data-communications systems. "They replace the line drivers and receivers that accept TTL inputs and operate over a twisted pair," says Joseph Bagley, HP's product marketing manager.

Such twisted-pair links can reach data rates of a few megabits per second, but only over relatively short distances, he explains. For longer distances, the data must be fed into



Almost complete. Transmitter and receiver modules contain the elements, like an automatic level control, TTL buffers, and link monitor, that a user ordinarily would assemble separately. All that is required now is a 5-V supply and an optical-fiber cable.



Pluggable. Pair of optoelectronic modules plug into printed-circuit board, shown with circuits for handling data-encoding chores.

modems and sent over a telephone line or dedicated in-plant line, but then data rates are more limited—to about 20 kilobits per second.

The fiber-optic modules, on the other hand, will handle far higher data rates—up to 10 megabits per second, synchronously or asynchronously—and for any distance up to a kilometer with no adjustments, Bagley points out. "With automatic leveling, the system behaves like a long TTL gate and requires no adjustments to adapt to varying link lengths," he says. Also, the system is far more secure in noisy environments and where protection against lightning and freedom from ground loops are essential.

Next year. "We expect to have fiber-optic modules on the market by the middle of next year," Bagley says. Except for the cable, HP will fabricate all of the system elements. These include the connector and the gallium-aluminum-arsenide Burrus-type LED that operates at 820 nanometers in the infrared. Such LEDs have long been products of the Optoelectronics division, as well as photodiodes, optical couplers, and laser diodes.

The LEDs deliver 100 milliwatts of optical power into the fiber at a drive current of 35 milliamperes. Up to 1 km, the system's bit error rate will be 10^{-9} for data rates to 10 Mb/s, according to Bagley. For shorter distances—up to about 300 meters—a 20-Mb/s data rate with better error rates is possible. □

Fiber optics

Computer uses stir interest at IBM

While Hewlett-Packard Co. readies its new optoelectronic modules, none other than IBM is smiling on the application of fiber optics to the computer. At least, the technology was viewed favorably by R. Gary Burke, manager of advanced networks at IBM Corp.'s System Communications division at Research Triangle Park, Raleigh, N. C., in a paper he delivered earlier this month at the International Telecommunication Exposition in Atlanta.

Burke maintains that fiber optics will be welcomed into the computer itself, not just into the telecommunications lines that link systems, because of problems insoluble with present technologies. This means that fibers could very well be replacing copper wires on a one-to-one basis, rather than being used for the multiplexing of thousands of signals that their huge bandwidths can readily permit. One reason, says Burke, is the density of interconnections required for increasingly complex computers: as many as 100 fibers per linear inch can be packed together, compared with a limit of 20 wires. Moreover, other drawbacks of wire, such as electromagnetic interference, crosstalk, and the cost of copper itself, should spur development of cheap, noise-immune fiber-optic cabling, he points out.

Market forecast. Agreeing with Burke is Helmut F. Wolf, a vice president at the market research firm of Gnostic Concepts Inc., Menlo Park, Calif. In a paper also delivered at the Atlanta meeting, he predicted that as early as 1980 there will be a $119 million worldwide market for optical fibers and connectors, and 16%—or about $19 million—will be used in computers alone. By 1990, in fact, Wolf even expects to see optical signals in data processing—involving fully integrated systems without the need for electro-optic conversion.

Burke divides the computer applications into four areas according to path length. The longest runs will be in "data-highway" applications of up to about 3 kilometers—for example, in process-control systems where wires must be run from many sensors to central computers. The fibers' small size, low cost, and immunity to interference will make them a natural for the harsh environment of in-plant networks just as soon as reliable hardware for tapping the fiber-optic cables is available, Burke says.

The second area of applications is in what Burke calls extended machine rooms: computer centers with mainframes and peripherals requiring links of up to about 300 meters. Here, fiber optics can overcome the distance/data-rate tradeoffs of coaxial cable, covering much greater distances without distortion. This is particularly important in parallel data transfer, where skew among channels is intolerable.

Burke's third computer hardware segment that could be served by fiber optics is on the level of local attachment—word-processing and small-business-system equipment in offices and contained within a diameter of 30 meters. The electrical isolation that fibers afford, as well as the ease with which they can be hidden, is unmatched by wiring.

Finally, fibers will work right down into the circuit board wiring itself, requiring lengths of 3 m and less. Here, fiber optics offering high interconnection density without crosstalk is right at home.

Hardware needed. When will the switchover from wires to fibers occur? As far as IBM is concerned, Burke refuses, of course, to say. But the transition hinges on more than IBM's desires, for qualified hardware has yet to be made available. "We need more development of output devices and receivers," Burke says, to get out of what he calls "the crystal set age," referring to the days of radio some 75 years ago. Also needed are low-cost electro-optical interfaces, he adds, concluding, "we haven't even got a single inexpensive connector yet." □

Photovoltaics

Silicon ribbon attains width of 3 inches

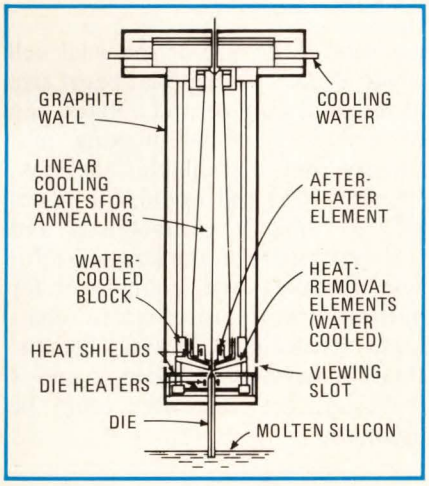
He has been able to do it only twice now—pull silicon out of a melt in a ribbon that is 3 inches wide. But for A. I. Mlavsky the feat has heartening implications. "We have proven the basic postulate that we can grow silicon consistent with the goal of cutting solar cell costs to 50 cents per peak watt," says the executive vice president of Mobil Tyco Solar Energy Corp. in Waltham, Mass. But, he adds quickly, there is still much to be done to perfect the system, which relies on the process of edge-defined, film-fed ribbon growth that his company has pioneered.

Cartridge. Until now, Mobil Tyco, formed in January 1975 by Mobil Oil Co. (which owns 80%) and Tyco Laboratories Inc. (20%), has been able to repeatably produce only 1- and 2-in.-wide silicon ribbon. For the 3-in.-wide ribbon, it has built a special cartridge, shown at the top right, that is placed above the trough-like silicon furnace. The cartridge guides and cools the ribbon as it is pulled through the same kind of die used in the company's conventional film-growth process.

Growth is initiated by touching a seed to the silicon meniscus that forms at the top of the die. The seed is then pulled up through the top of the approximately 9-in.-high cartridge, and a belt and pulley system moves the ribbon up. The shape of the ribbon, including its thickness, is controlled by the dimensions of the slit in the die.

Altogether, about 4 feet of the 3-in. p-type silicon ribbon has been pulled through at a rate of 3 in. per minute, using one cartridge at a time. The ribbon has been about 0.5 millimeter thick. Thinner ribbon—less than 8 mils thick—would be suitable for solar cells and could be grown faster. But to grow ribbon faster, and thus bring costs down, Mlavsky counts on using several sets of die and cartridge simultaneously. For example, Mobil Tyco has grown three 1-in. ribbons at a time from a single melt and has built a cartridge and furnace system capable of producing five 2-in. ribbons at a time.

The work is being done under contract to the Department of Energy as part of the Low-Cost Silicon Solar Array Project administered by the Jet Propulsion Laboratory in Pasadena, Calif. The goal of the project is to produce solar cells costing 50 cents per peak watt of electric output power by the year 1986.



Grower. Special Mobil Tyco cartridge helps cool 3-in.-wide silicon ribbon as it is pulled from molten furnace. This annealing prevents brittleness and shattering.

Mlavsky explains that the work at this point is "aimed at getting the mechanical bugs out of the design," rather than producing good-quality silicon. "It's a very complicated piece of machinery," he says of the cartridge, "and we're working at modifying its cooling and heating systems."

The cartridge overcomes one of the biggest obstacles to fast ribbon growth: brittleness and the susceptibility of the ribbon to shattering. The wider ribbon can shatter easily if it cools too quickly after being pulled through the die. To solve the problem, Mobil Tyco's cartridge incorporates heat-removal elements made up of water-cooled shoes through which gases pass to cool the ribbon and solidify it faster. Then the ribbon is reheated and cooled to relieve the stresses that could cause shattering.

As the ribbon is pulled up through a set of cooling plates, its temperature drops gradually from about 1,200°C to 600°C. The pulley and belt system that moves the ribbon through the die and cartridge is attached to the top of the latter. When the ribbon reaches an appropriate height, it is scribed and broken off, to be cut later into individual rectangles for solar cells.

How wide will Mobil Tyco eventually grow the ribbon? Mlavsky is

New high in solar panel efficiency

While continuing to refine its cartridge-growth process for silicon ribbon, Mobil Tyco Solar Energy Corp. has also reached a new milestone in solar cell panel efficiency in a panel whose cells were made with its conventional edge-defined, film-fed growth (EFG) process. A panel containing 42 cells each measuring 1 by 3/4 inch was rated earlier this month at an overall efficiency of 8.49%. Japan Solar Energy Co. recently reported efficiencies of 6.3% in commercially available panels made up of EFG-grown cells [*Electronics*, Oct. 13, p. 53]. The Japanese firm is partially owned and licensed for the EFG process by one of Mobil Tyco's parents, Tyco Laboratories Inc., headquartered in Exeter, N. H.

The Jet Propulsion Laboratory has reported panel efficiencies as high as 7.3% in panels made from circular cells that were part of a buy of 46 kilowatts of solar cells. Considering cell area alone, and not including the borders of the package, the Mobil Tyco panel has an efficiency of 9.3%. A. I. Mlavsky, executive vice president of the company, stresses, however, that the panel was carefully selected and that Mobil Tyco will not be in small-quantity production of such efficient panels until next year. "But it indicates what we can do with the EFG process," he observes.

not sure. "The size of the solar cell would depend on the final panel size in terms of current and voltage and on the kind of cell-making machinery that is available," he says. "A very large cell would, for example, be difficult to metalize, and there are limits on the sizes of diffusion furnaces and equipment for putting down antireflection coatings." Accordingly, Mlavsky believes that "somewhere between 3 and 4 inches at the narrowest could be optimum." □

Displays

TI's flat CRT is simply a flat CRT

The flat-screen replacement for the cathode-ray tube is being vigorously researched at various laboratories with such approaches as liquid-crystal, electroluminescent, and gas-discharge technologies. But why not just make a flat CRT? Workers at Texas Instruments Inc.'s corporate research lab in Dallas have done just that, building a CRT with a display area of 6 by 8 inches and a depth of only 2 in. Comparable 10-in.-diagonal tubes used in data terminals have a 12-in. depth.

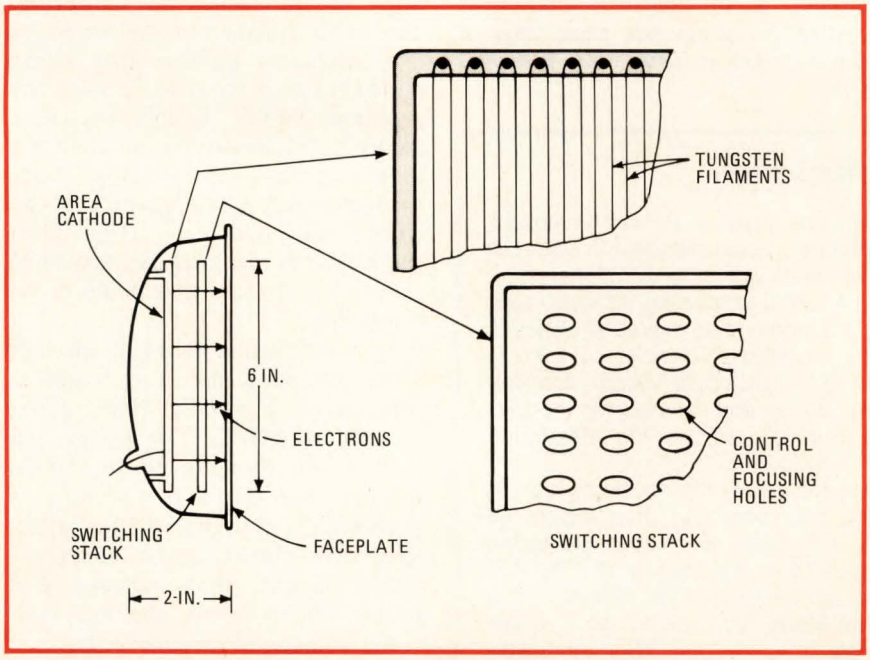
Two changes make the thin size possible, says William C. Holton, director of the advanced components lab and the group leader on the project. First, the point cathode of the conventional CRT is replaced with an area cathode (an array of closely spaced filament wires). Second, a multilayer control and switching stack is inserted between the cathode and phosphor screen.

The switching stack individually addresses each dot of the five-by-nine-dot matrix making up each of the screen's 1,920 alphanumeric characters. It consists of three layers, each with the five-by-nine hole pattern for the characters repeated 1,920 times. The first enables one horizontal character row at a time, while the second and third enable individual rows and columns of dots in each character. This reduces the number of addressing leads from the 590 typically required for a gas-plasma matrix display to only 108 for this tube, says Holton.

The cathode is actually an array of oxide-coated tungsten filament wires that generate electrons as a directly heated cathode. It takes somewhat more power than the small cathode in a conventional CRT, Holton says, but the efficiency overall is about the same, since no power is required for deflecting the beam, as it is for the conventional tube with a deflection yoke.

Characters. The present version of the TI tube, which will be described at the upcoming International Electron Devices Meeting in Washington, displays 24 rows of 80 characters each. Although gray scale is achievable with pulse-width modulation of the addressing signals, Holton says the major application appears to be in character displays.

Holton emphasizes that TI's flat CRT is very much a research project. But he notes that most of the effort up until now has been directed toward alphanumeric displays, though video displays are not being ruled out. For such uses, the major problem will be in creating finer-hole geometries for the increased resolution that is required. □



Experimental. Two-inch-deep cathode ray tube has 6-by-8-in. viewing area and relies on electrons created by tungsten filaments that stream through holes in switching stack.

Automotive

Electronics adjusts shocks, smooths ride

As American cars get smaller, can they still provide the good ride familiar with larger ones? Monroe Auto Equipment Co., the shock-absorber manufacturer, thinks it has come up with an electronic sensor that will help them do so.

Monroe's sensor replaces the mechanical height leveler that is installed as an option on about 5% of the full-size cars sold today. But instead of relying on mechanical means to sense the axle-to-body distance, the firm has placed a light-emitting diode and a pair of photosensitive resistors inside the air chamber of a standard air-spring shock absorber. Ford Motor Co. and Chrysler Corp. are reported to be testing the system, and General Motors Corp. is offering a similar electronic setup for the first time on 1978-model cars.

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SOC 2-18	2V	18.0	113	SOC 24-2.2	24V	2.2	58
SOC 2-25	2V	25.0	149	SOC 24-3.5	24V	3.5	72
SOC 5-3	5V	3.0	35	SOC 24-6.6	24V	6.6	113
SOC 5-6	5V	6.0	58	SOC 24-9	24V	9.0	149
SOC 5-10	5V	10.0	72	SOC 28-0.8	28V	0.8	35
SOC 5-18	5V	18.0	113	SOC 28-2.0	28V	2.0	58
SOC 5-25	5V	25.0	149	SOC 28-3.1	28V	3.1	72
SOC 12-1.6	12V	1.6	35	SOC 28-6	28V	6.0	113
SOC 12-4.0	12V	4.0	58	SOC 28-8	28V	8.0	149
SOC 12-6.0	12V	6.0	72	**Dual Output**			
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SOC 15-1.5	15V	1.5	35	SOC 15D-4.5	12V to 15V	4.5	115
SOC 15-3.0	15V	3.0	58	SOC 15D-6	12V to 15V	6.0	154
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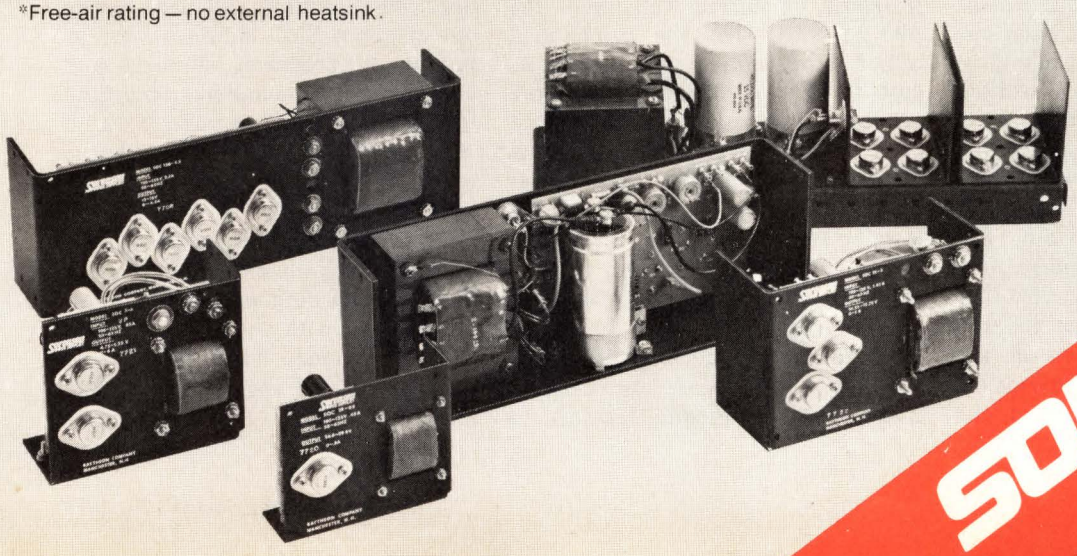

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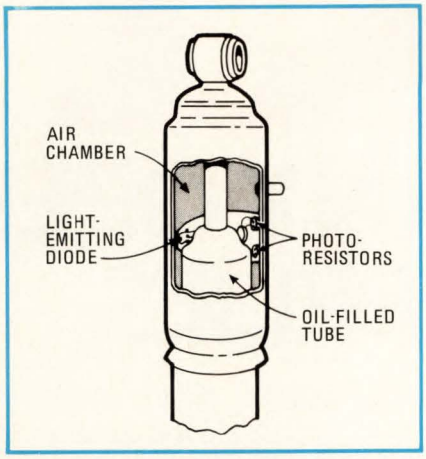

Level sensor. Oil tube is in a position to block light from diode before it strikes photoresistors to help set auto level.

combine the damping function of a piston in an oil-filled reserve tube with an air chamber that acts as a spring, help maintain a constant distance between the rear axle and the body of the car as loads are added. On trucks, such shock absorbers are usually offered with a tire-type valve, and they can be filled with air at a service station after the truck is loaded. Car manufacturers, on the other hand, have added a mechanical leveling valve and air pump to come up with a system that automatically responds to any weight added to the car, preserving the original axle-to-body distance and thus the ride quality.

Replacement. Monroe has simply replaced the mechanical leveler with an optical height sensor and electronic module. Unlike the mechanical device, it can be placed well away from the dirty and hazardous area beneath the car. "The idea of building a height sensor into an air shock isn't new, but previous attempts have been either mechanical or pneumatic and haven't worked out," says Robert W. Hegel, chief engineer for advanced engineering and research at the Monroe, Mich., firm.

In the electronic system, the photoresistors are mounted one above the other on a plastic card that curves around the inside of the air-spring chamber, as shown in the diagram. The card also contains, at the far end of the curved card, the light-emitting diode, as well as an integral four-terminal connector. Silicone rubber glues the card to the chamber wall and also provides an air-tight seal for the terminals and maintains the spring's 200 pounds per square inch pressure.

Depending on load, the oil-filled tube moves within the air chamber, blocking the LED's light from one, both, or neither of the photoresistors. An electronic module, located under the hood or in the passenger compartment and about the size of a pack of cigarettes, senses the voltage changes in the photoresistors. It contains two standard complementary metal-oxide-semiconductor quad gates and a handful of discretes.

Logically done. "When the logic sees that the resistors are both on, it turns on an air pump to fill the shocks and raise the body; when they're both off, it turns on a solenoid valve that bleeds the shocks," Hegel explains. A simple resistor-capacitor network builds in a 15-to-20-second time delay that blinds the system to normal suspension movements, such as those encountered on curves or when braking for a stop. The desired axle-to-body height can be held to within a quarter inch and is determined by the vertical placement of the photoresistors, which is different for every model car. "We can use off-the-shelf components because we're getting an airtight, light-tight, watertight chamber for nothing," Hegel says.

Monroe is not giving the price of its electronic system, which comes with an electric air compressor, but it should be tagged well under the $90 to $120 that the mechanical option now commands. Besides its cost savings, it should prove more reliable, Hegel stresses, because it reduces moving parts and is housed in a relatively benign environment. It also shaves two pounds from the leveling system.

For its electronic leveling system, General Motors' Delco Products division, Dayton, Ohio, opted to package the optical height sensor and electronic circuitry together in a 3-by-4-by-$^3/_4$-in. module fastened to the auto body above the rear axle. Height changes caused by varying loads in the car are translated to a circular motion by a mechanical linkage, and a circular shutter breaks the light path between two LEDs and two phototransistors. Voltage outputs are sensed by a custom p-channel MOS device that also sets a delay before activating the air compressor or exhaust solenoid □

Military

Defense electronics to up budget share

U. S. spending increases for military missiles and space programs will help defense electronics contractors boost their share of U. S. military outlays from 18.2% next year to about 21% in the next decade. That is the latest estimate of the Electronic Industries Association, in a forecast of military spending on electronics through fiscal 1987 for three key Defense Department categories—procurement, operations/maintenance, and research, development, test, and engineering. After discounting an estimated annual inflation rate of 6%, the association sees outlays in those categories rising an average of 3.3% a year, even though the total defense budget grows no more than 1.4% annually.

Cruise missile programs are seen as a major factor in boosting missile electronics outlays to $3.4 billion in fiscal 1982 from the $2.3 billion level in fiscal 1977, which ended Sept. 30. Spending will then flatten out at about $3.5 billion a year as production programs stabilize and development is complete, according to Rockwell International's Wendell A. Johnson, who coordinated the forecast for the EIA.

Development of the advanced intercontinental missile known as M-X, for missile-experimental, depends on the outcome of arms-limitation talks with the Soviet Union, he points out. "But if sizable portions of the future budget are allocated to M-X, the total missile

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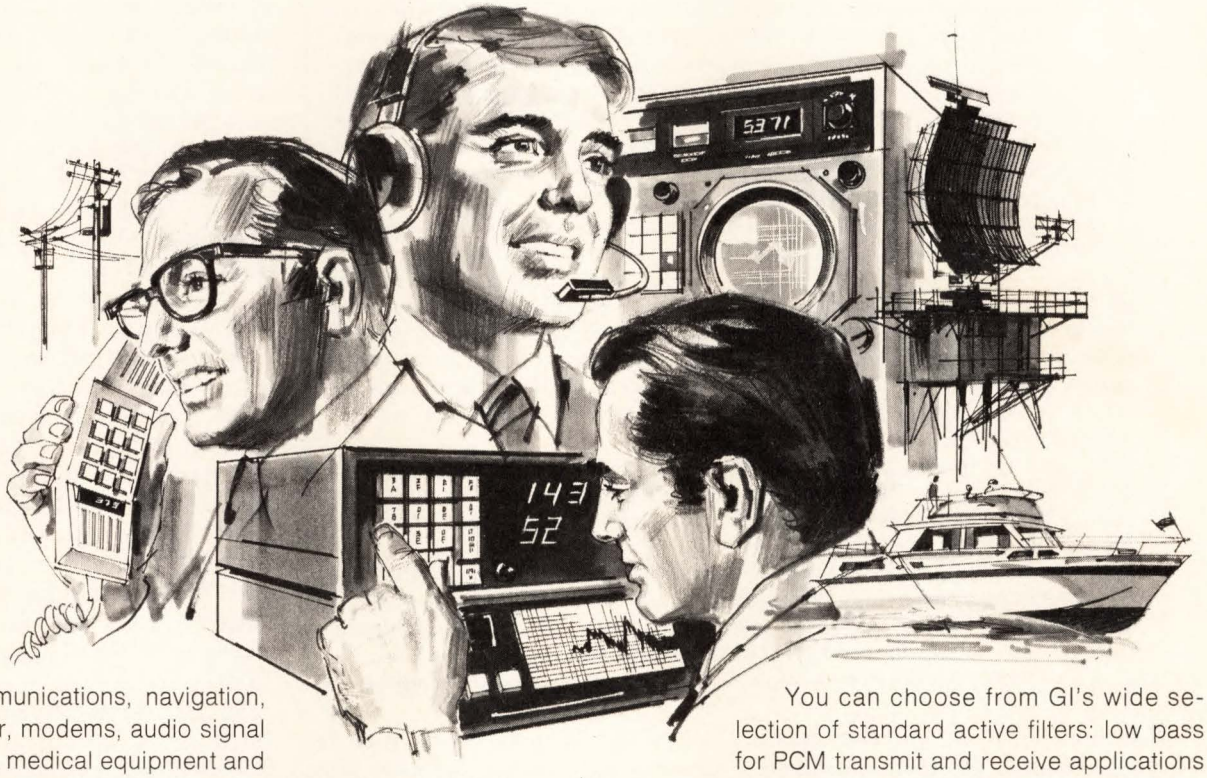

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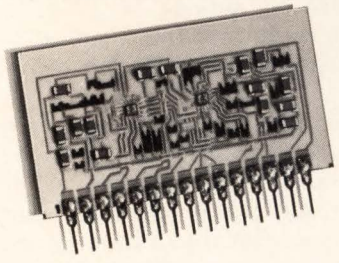

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Waiting for the Energy Department

From the newly formed Department of Energy the message for electronics companies is "wait and see." According to Fred Weinholt, a staff assistant to James Schlesinger, the new energy secretary, the conflict between Congress and President Carter over the nation's energy strategy means that any department action must be put on hold.

He told a seminar on opportunities for electronics companies in the Energy Department at the Electronic Industries Association annual meeting, held in San Francisco this month, that "about all that is certain is that there is an Energy Department and that its responsibility is energy." With a first-year budget of $10.4 billion, it already has 20,000 employees overseeing a grab bag of responsibilities from such agencies as the Interior Department (power marketing such as the Bonneville Power Administration); the Interstate Commerce Commission (oil rates); Housing and Urban Development (housing energy standards); and the old Federal Energy Administration and the Energy Research and Development Administration.

Although this conglomerate has been reorganized and split into three key divisions—basic research, demonstration, and commercial development—the exact organizational structure has not been worked out yet. "It's no use giving you names, titles and responsibilities," Weinholt says, "because tomorrow it could all be different." Except for Schlesinger and his immediate assistants, top assistant-secretary and administrative jobs have not been permanently filled. "Until the current congressional debate over the energy bill is settled, it's anybody's guess as to when the positions will be permanently filled," he says.

In spite of the organizational uncertainty, there is no shortage of contracting money. The biggest chunk—$2.8 billion—goes to the new energy technology office for work on solar, geothermal, fossil, magnetic fusion, and nuclear energy.

Under the new system, the energy research office handles basic research. Then the energy technology office will take over once a project has reached demonstration levels. Finally, the resources applications arm will launch a push for commercial development if that seems appropriate.

electronics content will rise drastically" from the projected average of 38.2%, he says.

Countering threats. Acceleration of military space programs to counter new Soviet anti-satellite satellites coupled with enhancement of U. S. reconnaissance capabilities could produce explosive growth in space electronics over the decade. Pentagon outlays are expected to climb, especially in the first half of the 10-year period. They should climb from $790 million in fiscal 1978 to nearly $1.2 billion in fiscal 1982 and then remain essentially stable through 1987. The Carter Administration is pressing to hold defense spending down over the near term, so avionics outlays are forecast to slip from the fiscal 1978 high of $3.32 billion to $3.17 billion by fiscal 1981. The increases in missile and space electronics spending are expected to offset this decline, also caused by the completion of much of the R&D for new tactical aircraft, Johnson says. Increases in missile electronics should offset losses caused by this summer's cancellation of Rockwell's B-1 strategic-bomber program.

But Johnson's forecast team sees a revitalization of the military avionics market in fiscal 1982, as a new RDT&E cycle begins for the next generation of warplanes. Outlays will begin climbing slowly, reaching a high of $4.3 billion in 1987.

On the Navy side, the association forecasts an electronics program that is essentially stable with slight growth, according to Johnson. Efforts to cut military spending could produce a small cutback in the first five years, he points out. But present estimates are that the market will climb from $1.5 billion in fiscal 1978 to $2 billion in fiscal 1982 and then grow slowly to a $2.3 billion peak by the end of the 10-year period. □

Meetings

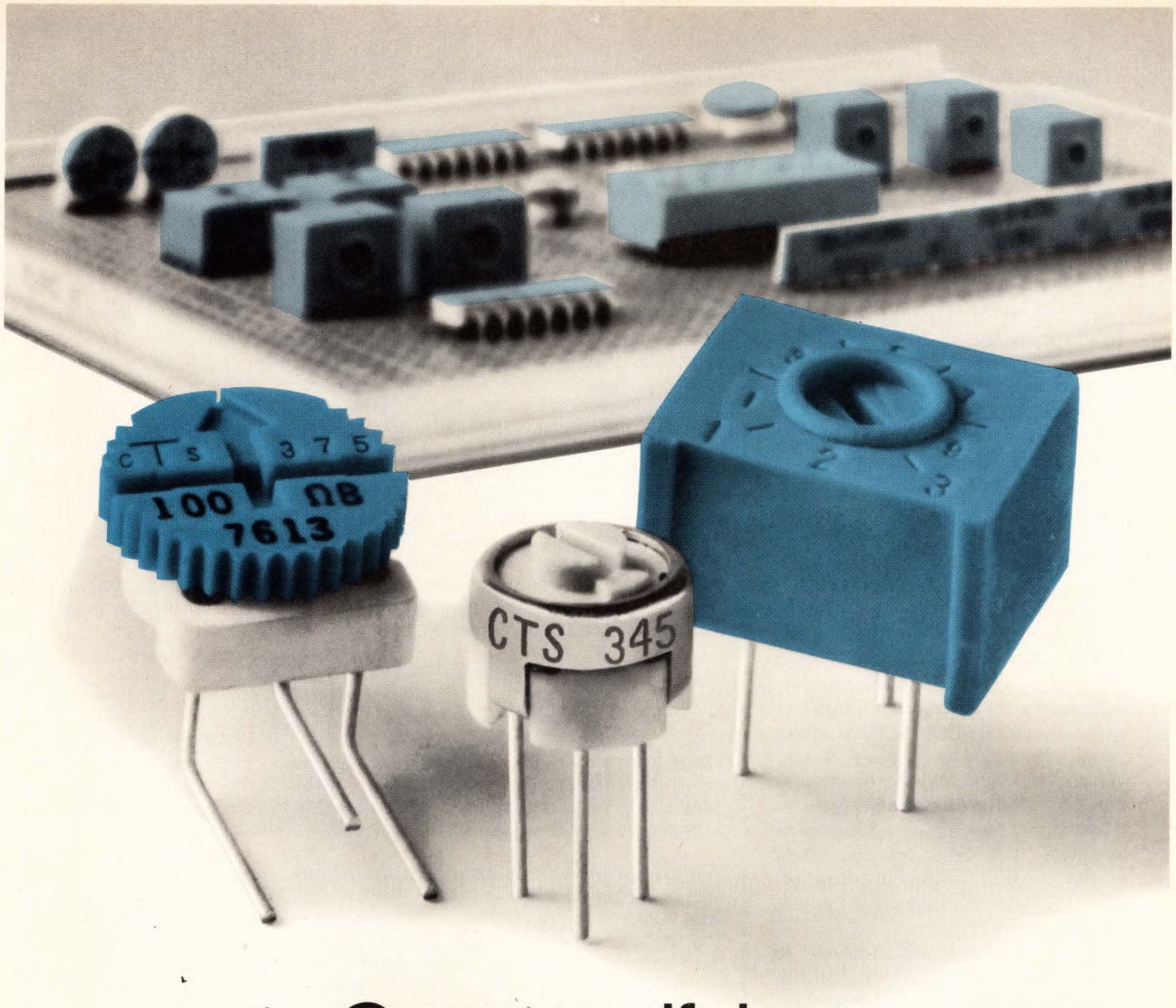
Midcon show looks like a hit in Chicago

There is now no electronics marketplace as diverse as in the Midwest, yet only five years ago most of its industries had not discovered electronics. To mark these manufacturers' interest, they will have their own electronics show next month in Chicago. Officially, it is called Midcon/77, and one wag has already titled the exhibition "the electronics show for the nonelectronics industries."

All signs point to Midcon's success, a coup for Electrical and Electronics Exhibitions Inc., the organization that runs the Electro and Wescon shows. Like its East Coast and West Coast siblings, Midcon will travel to a different city each year, so EEEI will have almost blanketed the country with alternating, regional electronics shows. Next year, Midcon will bow in Dallas, and tentative plans call for a Chicago encore in 1979 and an Atlanta site in 1980.

Backed by local sections of the Institute of Electrical and Electronics Engineers and the Electronic Representatives Association, EEEI will have succeeded in the heartland market, a geographic and industrial sprawl that has killed off other attempts at electronics shows. This year's Microfair, for example, was a Wema-planned show that did not get off the ground. Chicago's National Electronics Conference, thriving at McCormick Place in the 1960s, dwindled to nothing in 1976, although it returned this month in an abbreviated format without exhibitors.

Electronics manufacturers, however, are backing Midcon resoundingly. Some 220 exhibitors will fill almost 400 booths when the doors open Nov. 8 at the O'Hare Exposition Center in suburban Chicago. While that is not up to Electro 77's 560 booths, or Wescon/77's 687, it is well over Midcon's 250-booth pro-



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jection. Also it bucks the wait-and-see attitude of manufacturers that prevails at most new shows and is robust support for a show announced in February, after many firms had already decided where to spend their show money for the year. Attendance at the three-day affair should hit 15,000, officials estimate.

A whopping attendance, of course, is what exhibitors demand from any show, and the technical program is a major attraction for many people. Midcon has marshaled 30 technical sessions, to be housed at the neighboring Hyatt Regency O'Hare Hotel, which it hopes reflect the personality of the show's 400-mile radius.

Starring part. Fully a third of the program deals exclusively with the microprocessor, the component that has brought Midwestern manufacturers of such diverse equipment as automobiles, appliances, farm equipment, machine tools, pin-ball machines, and steel into the electronics business. Reflecting the problem of applying electronics to electromechanical gear, the sessions stress microprocessor interfacing and peripherals rather than architecture and memory.

Other sessions are devoted to process control, automotive electronics, and satellite-based remote earth sensing, for example. The program also lists four sessions on various communications topics, a pair on medical electronics, and a grab bag of others that range from advanced battery systems to product liability. Kicking off Midcon is a day-long marketing workshop pointed toward distributors and manufacturers' representatives, often the key marketing force pushing electronic technology at the industrial manufacturer.

The technical program may spell success or failure for the convention, but Midcon already boasts a number of exhibitors that have not been showing at either Wescon or Electro. These include Signetics, Macrodata Corp., Texas Instruments' Industrial Controls department, and NCR's Microelectronics division. More important, EEEI has already started signing up exhibitors for the December 1978 Dallas version, using an Electro-

News briefs

English acquire Dana Laboratories

Dana Laboratories Inc., Irvine, Calif., a leading U. S. maker of digital voltmeters and electronic counter-timers, has been acquired for $3.5 million by England's Racal Electronics Ltd. Dana will be combined with Racal Instruments Ltd., to form Racal-Dana Instruments Inc., headed in the U. S. by Webb Scroggin, Dana Labs' president. Earlier this year, a Racal company acquired Milgo Electronic Corp., Miami, Fla., in the data communications field. Dana Labs' old parent, Dana Electronics Inc., Newport Beach, Calif., retains its other primary subsidiaries, EIP Inc. and Cushman Electronics Inc.

ITT Semiconductors closing Florida site

Because of losses incurred in the manufacture of military high-reliability and certain other integrated-circuit lines, ITT Semiconductors is closing its U. S. division's wafer fabrication facility in West Palm Beach, Fla. The closure, with the loss of 300 jobs, will be completed early next year. The company will transfer production of its commercial bipolar and linear IC lines to a newly leased 160,000-square-foot plant in Lawrence, Mass., adjacent to its present discrete semiconductor production facility.

Physicist gains recognition as "Father of the Laser"

The U. S. Patent Office has granted Gordon Gould a patent for his invention of "optically pumped laser amplifiers." Says Eugene Lang, president of REFAC Technology Corp., which owns licensing rights to the patent and all future laser-related patents of Gould, "all lasers that employ optically pumped amplification will be deemed to fall within the scope of Gould's patent." REFAC is offering nonexclusive licenses to companies whose laser activities are considered subject to the patent, No. 4,053,845.

Zenith sets further cutback of U. S. operations

Further cutting back its domestic operations to maintain profitability, Zenith Radio Corp. will sell its hearing aid business later this month to Zenetron Inc. The firm was organized to take over the division by F. William Carr, oil and gas investor in Texas, and James H. Johnson, who ran the division from 1971 to 1975. Zenith, which pioneered the miniaturization of hearing aids and batteries, has had annual hearing aid sales of about $15 million. The firm earlier announced plans to move extensive parts of its color television operations offshore [*Electronics*, Oct. 13, p. 69].

FCC expects flood of interconnect registrations in November

The Federal Communications Commission expects to be inundated in November by applications from foreign and domestic manufacturers to register terminal equipment for direct connection to the nation's telephone network. The FCC opened the flood gates when it said its registration program became "effective immediately" following the U. S. Supreme Court ruling early this month upholding interconnection without the need for carrier-supplied protective couplers [*Electronics*, Oct. 13, p. 38]. To ease its burden, the FCC has published a new consolidated list of grandfathered terminal equipment that need not be registered if connected by Jan. 1, 1978. Equipment of these types must have been directly connected to the network in accordance with telephone company tariffs before May 1, 1976, and be able to function standing alone.

Expansion of CB service to 224-225 MHz rejected by FCC

A proposal to expand citizens' band radio frequencies to include 224–225 MHz has been rejected by the FCC as obsolete. The 1973 petition for the new Class E service was made by the Electronic Industries Association for CB and land-mobile radio manufacturers as a means of relief from crowded channels and high equipment costs. The fact that it took the FCC four years to reach a conclusion was blasted by the EIA, which labeled the ruling "a serious mistake" but said it plans no appeal at this time.

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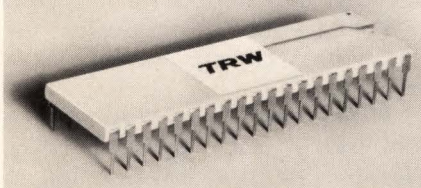

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Electronics review

Midcon-Wescon three-show alternate-city package that allows an electronics manufacturer to cover 80% of its market by attending the regional shows for two years. □

Solid state

Heat pipes added to power devices

A new word hit the power-semiconductor marketplace earlier this month. The word is transcalent, a Latin derivative meaning permeable to heat, and it is being applied by RCA Corp.'s Electro-Optics and Devices division, Lancaster, Pa., to a new family of power devices.

Samples. The devices include 250-ampere rectifiers with blocking voltages of 1,200 volts, 100-A transistors with voltages to 800 v, and 400-A thyristors. RCA is finally supplying samples after development that goes back at least to a 1972 contract from the U. S. Army Mobility Equipment Research and Development Command, Fort Belvoir, Va. Initial applications will be military, in ground-based power conditioning, for example, as well as in airborne electrical systems, motor speed control, and radar power supplies now served by "hockey-puck" and stud-mounted devices.

The high-power semiconductor-device market is now pegged at an annual $40 million and could grow to $120 million in five years, according to division vice president Ralph E. Simon. Prices for the RCA parts right now are just as hefty as the devices' ratings, ranging from $1,125 for the rectifier to $1,825 for the transistor in small quantities.

Unlike conventional devices that add bulky heat sinks and heat-dissipating fins externally, RCA bonds one end of the heat pipe directly to the wafer surface and then adds fins to the other end. Water in the sealed pipe absorbs heat from the wafer and gives it up to the fins. The results are power devices a quarter the size and 15% the weight of existing units of equivalent rating, says Simon. For example, the 250-A rectifier weighs 12 ounces and occupies less than 14 cubic inches; the 100-A transistor dissipates 500 w, weighs under 2 pounds and occupies less than 70 in.^{3}.

By this time next year, Simon expects to be making preproduction quantities and the prices to range from $400 to $800. Full production is three years away.

Westinghouse Corp.'s Semiconductor division in Youngwood, Ohio, a major supplier of hockey-puck and stud-mounted devices, "is not doing anything similar to transcalent devices," says marketing manager Stan Hunt.

Earlier this month, Westinghouse unveiled a new line of disk-type devices with new heat-sink designs that it says can handle 50% more power than earlier designs. As for General Electric Co.'s Semiconductor Products department in Syracuse, N. Y., it is studying heat pipes but has developed nothing yet. □

Heat-piped. RCA's 250-ampere rectifier weighs 12 ounces, occupies less than 14 in.^{3}

Fiber optics

Plastic cable works well in infrared

Most fiber-optic systems today employ silica-based fibers because they are good transmitters of light in the near-infrared spectrum, and it is in this area that light sources and detectors are most highly developed. But now, E. I. du Pont de Nemours & Co. has developed an all-plastic fiber cable that looks like it could take over from its silica counterpart at least in optoelectronic systems

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Analog Inputs	16 channels	●	●	●	●	●	●	●	●	●	●					●	●	●	●	●	●	●	●	●	●	●	●
	32 channels		●	●				●	●							●				●				●	●	●	
	64 channels			●					●							●				●					●		
	10mV to 10V range				●	●				●	●							●	●			●					
	0 to 10V, ±10V, ±5V ranges	●	●	●			●	●	●							●	●			●	●			●			
	1 to 5V (4 to 20mA) range	●	●	●												●	●					●		●			
	8 bit resolution			●					●																		
	12 bit resolution	●	●		●	●	●	●		●	●					●	●	●	●	●	●	●	●	●	●	●	●
Analog Outputs	2 channels	●		●		●	●		●		●	●					●		●			●		●			●
	4 channels			●					●			●	●														
	8 channels											●	●	●													
	0 to 10V, ±10V, ±5V ranges	●		●		●	●		●		●	●	●	●			●		●			●		●			●
	4 to 20mA range													●													
	point plotting	●				●	●				●	●					●		●								
	8 bit resolution			●					●					●													
	12 bit resolution	●				●	●				●	●	●				●		●					●			●
Features	programmable gain	●	●				●	●	●							●	●					●					
	100KHz throughput	●	●				●	●	●							●	●			●	●			●	●		
	program I/O & interrupt	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●		●	●	●	●
	DMA interface	●	●		●	●																					
	power required: +5V only	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●

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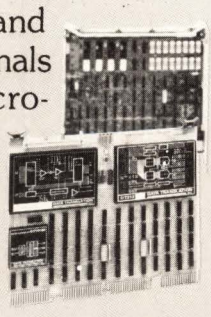

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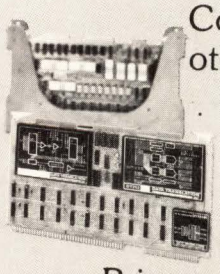

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Circle 51 on reader service card

that require short cable runs.

The advantages of plastic over glass hold just as true for fiber-optic cable as they do in the everyday consumer world: plastic more easily withstands stresses of pulling and bending. The cable loss—340 decibels per kilometer—is still higher than that of glass fibers. But Kenneth Kamm, marketing specialist at du Pont's Plastics Department in Wilmington, Del., says the plastic cable (called the series PFX-PIR) could find a niche in computer, office-machine, and industrial control equipment, wherever less than 100 meters of cable is required. At these lengths, a 50-megabit-per-second data rate is possible, and the transmission loss would be quite tolerable, he maintains. Another advantage is that the larger diameter of the core of the plastic fibers couple light from the IR source more efficiently than does silica cable.

Light limit. Previously, plastic fiber-optic cables were limited to transmission chores in the visible-light region. At the longer infrared wavelengths the vibrations of carbon-hydrogen bonds occurring in the plastic bulk materials caused very high transmission losses—around 900 decibels per kilometer. This loss mechanism is similar to that experienced in silica-core fibers caused by oxygen-hydrogen bonds. "Since plastic-bulk material consists essentially of carbon-hydrogen bonds, it was difficult to circumvent," Kamm says. "But we finally found a way to replace hydrogen with deuterium so that the resulting carbon-deuterium bond vibrations caused much less attenuation at the longer infrared wavelengths."

He says that the single-fiber PFX-PIR cables are just going on the market at a price of $2.25 per meter. Light sources would be a problem, he concedes, because the plastic operates best at 780 nanometers, whereas most conventional gallium-aluminum-arsenide lasers and light-emitting diodes are at the longer 820 nm. However, he believes sources could be tailored to the higher frequency simply by upping the concentration of aluminum. □

The complete $795 graphics plotter.

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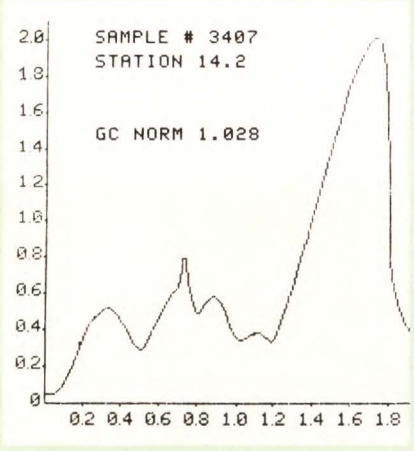

Plots fast — and prints, too

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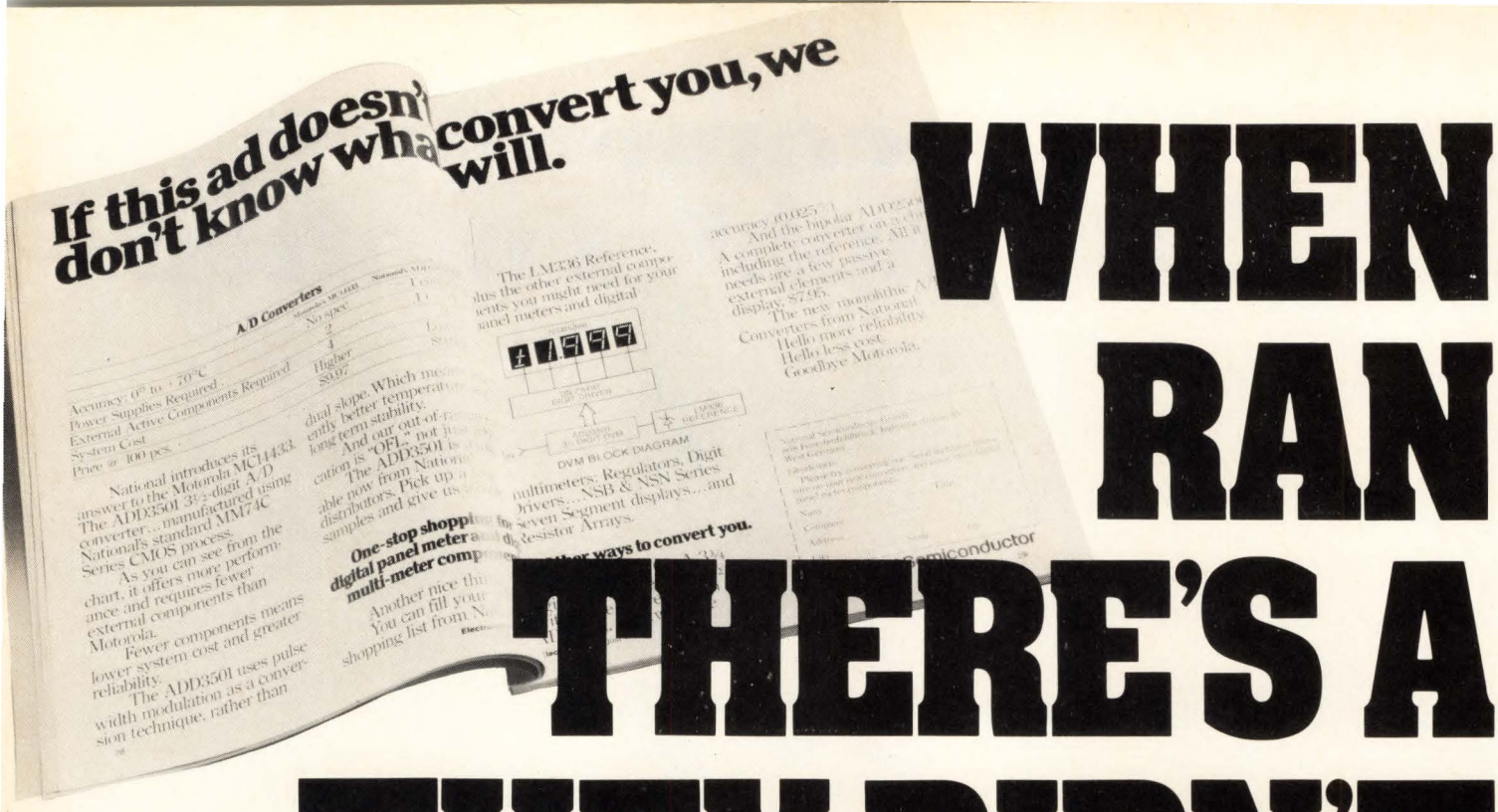

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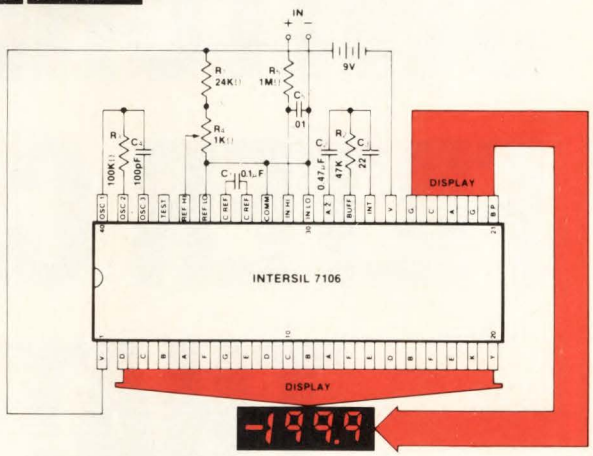

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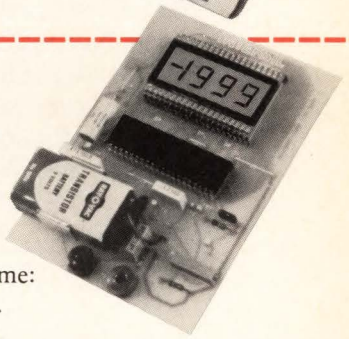

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Washington newsletter

Navy to buy X-band satcom ship terminals . . .

The Naval Electronic Systems Command wants to buy **up to two dozen shipboard X-band satellite communications terminals** based on a new Naval Research Laboratory prototype and is calling for production proposals from industry. The classified Interim High Data Rate Terminals will be used with the defense satellite communications system spacecraft known as DSCS-2 for ship-to-shore communications. Using an estimated $1.5 million in Navelex funds, an NRL team developed the first of the X-band terminals in 18 months—3 months ahead of schedule—with industry subcontractors. The first terminal, described as compact, reliable, and produced at drastically reduced cost, has been installed on a small, university-owned oceanographic research vessel and operating for about a month with the satcom satellite system.

. . . Harris Corp. seen as contender for new NRL system

One sure bidder for the IHDRT production award, say industry officials, is Harris Corp., Melbourne, Fla., which assembled the NRL terminal and also supplied the system's up- and down-converters and modem. The modular system transmits digital pulse-shift-key signals in the 7.9-to-8.4-GHz band and receives at 7.25 to 7.7 GHz. Data rate is classified.

Sharp cost reductions of up to 80% for some components were achieved **by integration of the modules at the subassembly level,** according to the NRL team headed by Charles Stillings. Team member Philemon Johnson says, for example, that the cost of the integrated high-power amplifier produced by ITT Corp., Nutley, N. J., was cut to 20% that of earlier units using subassembly integration. The ITT unit incorporates a Raytheon Co. driver for intermediate power amplification and a klystron tube and output assembly produced by two separate units of Varian Associates. Other major modules include an AN/URQ-23 frequency standard from Frequency Electronics Inc., New Hyde Park, N.Y.; antenna and power amplifier by Datron Systems Inc., Chatsworth, Calif., plus a digital servo controller to be delivered by the Naval Ocean Systems Center, San Diego.

Lockheed picks CDC's UYK-25 computer for strike system

Lockheed Missiles & Space Co. has picked Control Data Corp.'s AN/UYK-25 computer over Sperry Univac's AN/UYK-7 for the Air Force Precision Location/Strike System (PLSS). Prime contractor Lockheed, which received $120.3 million in June for full-scale development of one preoperational PLSS system, **awarded CDC's Aerospace division an initial $7.8 million subcontract.** The Lockheed PLSS is designed for tactical use against air defense systems, intercepting electromagnetic emissions from enemy detection and guidance radars used to control antiaircraft artillery and surface-to-air missiles. The UYK-25 computers, housed in a ground-based central processing center, will process intercepted emissions and feed location information to tactical control centers for air strike planning.

The PLSS computers will each have 11 core memory banks of 65,000 32-bit words with a 1.2-microsecond cycle time. All of the memories can be on line and accessed simultaneously, CDC says. The computers also will have four processors and two input/output units, plus a central processor with its own memory and I/O controller.

Washington newsletter

Three electronic materials tests set for space shuttle

Three of the first five materials-processing experiments to be packaged and flown on one of the early orbital flight tests of the space shuttle in 1979 will involve electronic technologies, according to the National Aeronautics and Space Administration. Called the Materials Experiment Assembly, the package of experiments was chosen by NASA's Marshall Space Flight Center, Huntsville, Ala., because it could be **automated and unattended in a self-contained unit** with its own power source and a minicomputer to collect data.

The electronics-oriented experiments and their principal investigators are: vapor growth of alloy-type semiconductor crystals by Herbert Wiedemeier, Rennsselaer Polytechnic Institute, Troy, N. Y.; containerless preparation of advanced optical glasses by Ralph Happe, Rockwell International, Downey, Calif.; and performance of solid electrolytes containing dispersed particles by J. Bruce Wagner Jr. of Arizona State University, Tempe.

TDMA terminals complete flight tests at Boeing

The massive triservice digital communications network known as JTIDS—for Joint Tactical Information Distribution Systems—moved one more step forward in development with Boeing Aerospace Co.'s completion of flight tests of the program's time-division multiple-access (TDMA) system one month ahead of schedule. **Terminals were installed aboard an E-3A Airborne Warning and Control System aircraft**—Awacs is the first scheduled military user of TDMA—and an Air Force NKC-135 test aircraft. The two planes communicated between themselves and two Boeing ground terminals in engineering and evaluation tests begun late in June to qualify the new communications link. A second set of flight tests is set for the spring of 1978 using a TDMA terminal with an advanced waveform now being developed.

Hughes Aircraft Co.'s Ground Systems division designed and built the basic terminal equipment now in integration testing at Boeing. The Air Force, which is managing JTIDS for triservice use, is developing other TDMA terminals for use by fighter aircraft, field soldier manpacks, and command and control centers. JTIDS will permit up to 1,000 users to exchange information securely over a single jam-resistant channel with traffic flow automatically controlled by built-in system clocks. Security and jam resistance are achieved by spread-spectrum modulation and built-in cryptographic techniques.

Europe to provide camera, solar array for space telescope

The European Space Agency will supply NASA with the faint-object camera and the spacecraft solar power array for the space telescope mission. Scheduled to be placed in a 310-mile orbit in 1983 by the space shuttle, the 10-ton cylindrical observatory will study the universe **with much higher resolution than has ever been possible before.**

Under the mid-October agreement between NASA and its European counterpart, the camera and its associated photon-counting detector will provide high-resolution imagery from the 1,000-to-3,000 angstrom ultraviolet region through the visual portion of the spectrum to the near-infrared. The camera will be able to separate objects less than 1/10 of second of arc apart and observe remote celestial objects that are nearly 100 times fainter than those observable during its projected 10-year lifetime. In return for its participation, ESA astronomers will be allocated 15% of the telescope's observation time.

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International newsletter

Britain's CAA says tests gave OK to its plane-landing system

The Civil Aviation Authority of the United Kingdom is offering its test aircraft and tracking equipment for side-by-side comparison of the British and American contenders for the next generation of instrument landing systems. The CAA says **the UK doppler microwave landing system has passed tests at Brussels International Airport, Kjevick Airport, Norway, and Stansted Airport in England**—in addition to earlier trials at Gatwick Airport outside London [International Newsletter, Sept. 15]. An earlier computer simulation at the Brussels airport gave the American time-reference scanning-beam contender a clean bill of health, while predicting that the UK system would experience unacceptable errors due to multipath reflections at certain airports. The CAA says its flight trials gave no indication of such an effect at any of the test airports. Final choice for a new worldwide standard is to come at the April 1978 conference of the ICAO, the International Civil Aviation Authority.

$30 million of TV gear for Moscow Olympics from Thomson-CSF

Thomson-CSF has won what looks to be the major contract for television equipment for the 1980 Moscow Olympics with an order worth more than $30 million. **According to Thomson, the order was won against competition from all major worldwide TV suppliers**—with RCA breathing hotly down Thomson's neck. The French firm is to provide a video- and sound-switching center that will be the world's largest when put into operation, plus a wide range of equipment for news gathering and image processing. The equipment includes 100 color TV cameras, which will supplement the 80 already in the USSR and 40 mobile microwave units, plus ancillary equipment such as color monitors and character generators.

Membrain unveils automatic test equipment aimed at U. S. market

Spearheading Membrain's 1978 entry into the U. S. market for printed-circuit-board testers will be its new MB 7700 range of board test systems, which can exercise 256 transistor-transistor-logic pins simultaneously at 5 MHz. They are the outcome of a two-year development program costing over $2.5 million, partly funded by Britain's National Research and Development Corporation. **Common to all systems is an 8-MHz bipolar bit-slice 16-bit microprocessor, which controls a floppy disk, display, and keyboard.** Membrain uses Intel's 2-bit-wide chip set stitched together with read-only-memory firmware. The driver and sense electronics associated with each test pin has been reduced to single bipolar LSI chips with semicustom designs from Ferranti Ltd. and the U. S. firm Interdesign Inc. The software is modular, and there are two test-program languages, Memtest and Atlas, the international test language.

Ferranti executives in California for Interdesign talks

In a make-or-break bid to win Interdesign, the Sunnyvale, Calif., semi-custom design company, a task force of Ferranti executives headed by Alan Shepherd, manager of the Components division and Brian Down, marketing manager of Ferranti Semiconductor Ltd., are in the U. S. for talks with Hans R. Camenzind, president of the privately held firm. **The companies have a similar approach to making and marketing semicustom designs by specially configuring the final metalization of their chips, which are otherwise standard, carefully chosen circuits.** Ferranti has reportedly raised its first offer of $92 million for a 56% controlling interest to $4.66 a share for all unsold stock—at a price of roughly $3.5 million.

THE FIRST MULTI-PROTOCOL MOS/LSI DEVICE FOR SDLC AND HDLC

NOW IN STOCK

Standard Microsystems' new COM 5025 multi-protocol communications controller, is a 40-pin monolithic IC using the COPLAMOS® n-channel silicon gate process. It replaces hundreds of IC's and operates at speeds up to 2 M baud.

The device is a universal synchronous receiver/transmitter for dedicated control and implementation of all major protocols, including bit-oriented types such as SDLC, HDLC, and ADCCP, and byte-oriented BISYNC and DDCMP. It is the first programmable chip controller approved for these protocols and the only one that processes both SDLC and HDLC protocols.

The COM 5025 is processor compatible (8 or 16 bit), and direct TTL compatible, and contains selectable protocols and a tri-state input/output bus. The data, status, and control registers are double buffered. Full or half duplex operation is provided by means of independent transmitter and receiver clocks.

Data lengths are individually selectable for receiver and transmitter from 1 to 8 bits. Data, status and control registers are linked to a master reset which initializes them to the SDLC protocol on power-up. This device also has a built in maintenance feature to test the operation of the chip by performing data loop-around internally.

The controller of the device is responsible for all higher level decisions and interpretation of some fields within message frames. The degree to which this occurs is dependent on the protocol being implemented. The receiver and transmitter logic operate as two totally independent sections with a minimum of common logic.

For bit-oriented protocols such as SDLC, HDLC and ADCCP, the COM 5025 provides bit stuffing and stripping, automatic frame character detection and generation, and residue handling. Messages which terminate with a partial data byte are accompanied by the number of valid data bits available.

Options for bit protocols include variable length data (1 to 8 bit), error checking—16 bit polynomial CRC (or CCITT), primary or secondary station address mode, APA all parties address, extendable address field to any number of bytes, extendable control field to 2 bytes, and idle mode to transmit flag characters or mark the line.

For byte-oriented protocols the COM 5025 features automatic detection and generation of SYNC characters, and options such as variable length data, variable SYNC characters (5, 6, 7, or 8 bits), error checking—16 bit polynomial CRC (or CCITT) or odd/even parity, deletion of leading SYNC characters after synchronization, and an idle mode to transmit SYNC characters or to mark the line.

COM 5025 devices are now available in quantity from SMC and their distributors.

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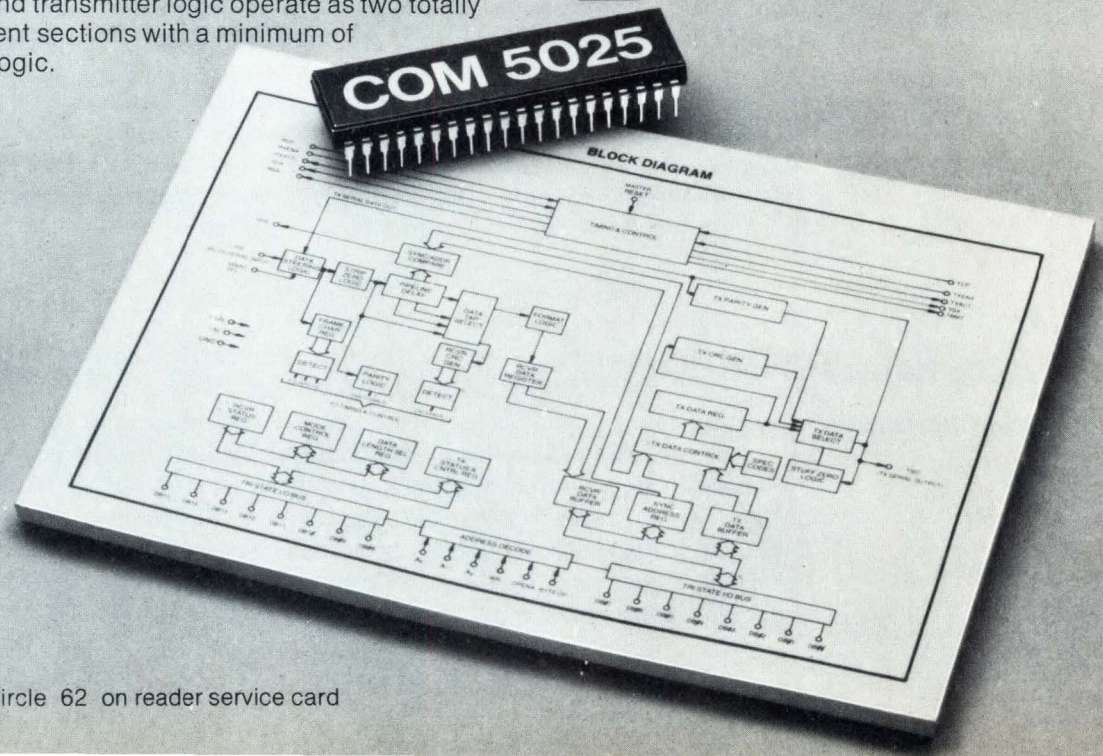


Circle 62 on reader service card

Microprocessors go to the front lines in communications, test gear

Microprocessors and other digital circuitry are answering the call to arms from Racal Tacticom Ltd., which commands a worldwide military market in high-frequency and very-high-frequency tactical communications equipment. The subsidiary of Racal Electronics Ltd. is launching a strike force of new army gear incorporating up-to-date semiconductor technology.

The new equipment includes a 400-watt tactical hf radio station that uses a chip in its antenna matching and tuning unit and two manpack hf radios and an associated 100-w station that has a semiconductor memory in its tuning unit. The British firm also is introducing a range of test gear for production and field use that includes fault-diagnosis units that use processors.

Powerful radio. The 400-w hf communication system is intended for reliable long-range communications from front-line positions to general headquarters under the most adverse conditions. The company has strapped four of its well-proven 100-w amplifiers into a single unit to produce an output usually associated with fixed transmitters.

To provide the degree of frequency agility necessary to defeat enemy jamming, the new tactical system has a new antenna matching and tuning unit, the VRA549. This unit automatically tunes to any specified frequency in the 2-to-30-megahertz band in less than 1.5 seconds.

Under microprocessor control, high-speed vacuum relays switch in reactive components to compensate for changes in antenna impedance at various operating frequencies. The processor thus minimizes the antenna voltage-standing-wave ratio, and so it minimizes the power reflected back into the transmitter. Racal already is using this technique in its 100-w units, but will not disclose the type of microprocessor it is using. Conventionally, tuning is by servo-controlled variable reactors and can take as long as 35 seconds.

The new 10-w manpack radios are half the weight and size of most competitors. By combining thick-film techniques with linear and digital integrated circuits, Racal has reduced the weight to 16½ pounds and the size to 1/5 cubic foot. The PRM 4021 covering the 2-to-16-MHz range has 140,000 channels in 100-hertz steps, while the PRM 4031 covering the 1.6-to-30-MHz range has 284,000 channels in 100-Hz steps.

When the PRM 4031 is combined with Racal's 100-w amplifier, the result is a vehicle-mounted base station for the manpacks. This unit, the VRM4145, features a programmable 10-channel frequency selector. An external encoder unit loads the predetermined channel frequencies into the digital memory within the transceiver. The memory, which incorporates a standby battery supply, sets the frequency synthesizer to the desired channel.

The operator can quickly change channels with the flick of a switch. When the VRM4145 is in this automatic channel-selection mode, the digital-logic circuitry that divides the single-crystal frequency refer-

Flick of a switch. Frequency selection in Racal field transceiver is programmable for quick channel selection. Any 10 frequencies in the range may be entered in a memory.

ence to produce the encoded channel frequencies gets the required frequency from a semiconductor shift register.

Diagnosing faults. Racal's new range of automatic test equipment includes complex test systems that will carry out digital and analog dc-to-rf tests on complete communications systems and printed-circuit-board testers capable of identifying faulty components. The equipment has been designed around Computer Automation's Naked Mini 16-bit processor. Two standouts in this range of ATE gear are fault-diagnosis systems, one that incorporates the Naked Mini and the other a rugged microprocessor-based system for field workshops.

The larger of the two systems, the RTL5, can be used to prepare and edit programs for testing new equipment. These programs also can be run on the RTL5M, which has a Motorola 6800 microprocessor controlling a floppy-disk and display unit. Once loaded with the appropriate program, the 6800 guides the operator through a series of fault-location procedures displayed on the screen.

These new systems should help Racal Tacticom keep its export drive going. Late last month, it won a $25 million contract from an unspecified North African country to supply various tactical radio systems and test gear. Also, it has sold about $126 million worth of Clansmen transceivers in the United Kingdom and elsewhere. Moreover, the firm is bidding with RCA Corp. on the U. S. Army's huge Sincgars-V combat-radio contract. The parent firm is doing well, too: it is acquiring Dana Laboratories Inc., the Irvine, Calif., instrument maker [p. 48]. □

Japan

Simple microkit serenades its user

Not every microcomputer user wants a machine that can produce electronic music in response to various simple input signals. But then, not every microcomputer user is in grade school. Yet that is the time to introduce the inhabitants of tomorrow's digital world to the computer, thinks the giant Japanese firm, Matsushita Electric Industrial Co.

Easy work. Microcomputer kit is designed for fast assembly by school-age builders.

The firm's Panakit KX-33, intended primarily for ages 12–14, combines a computer of limited ability—a controller really—with an electronic music machine of limited ability. The easy-to-assemble kit comes with firmware programming of its limited number of functions. It will cost about $155.

Simple learning kit. The kit is intended to give users an idea of the basic concepts of computer technology, including the execution of functions by combining user instructions with input signals. It also is intended to give its young operators some idea of microcomputer functioning, introducing them to the world of the central processing unit, registers, memory, and so on.

Since it is basically a controller, the computer is built around the 4-bit MN1400 microprocessor from subsidiary Matsushita Electronics Corp. In addition to the arithmetic/logic unit, the chip includes 1,024 words by 8 bits of read-only memory for the system program and 64 words by 4 bits of random-access memory, which stores keyboard data. Also in the kit are two static RAM chips with 256 words of 4 bits each, which hold the tunes keyed in for RAM storage by the user.

The Panakit includes an 8-bit latch, audio-amplifier and multivibrator integrated circuits, and a speaker. There are keyboard switches and light-emitting diodes and associated drivers for the four-digit display.

Once the kit is built, it can store any song that does not exceed its three-octave range or its storage capacity. It can also perform control tasks over a 24-hour period. As well as music, it can produce a one-minute buzzer sound; both outputs may be triggered at a set time or by keyboard actuation or an input signal. Three transducers supply input signals: a cadmium-sulphide photocell, a transducer that responds to moisture, and a reed switch that closes when a magnet is near.

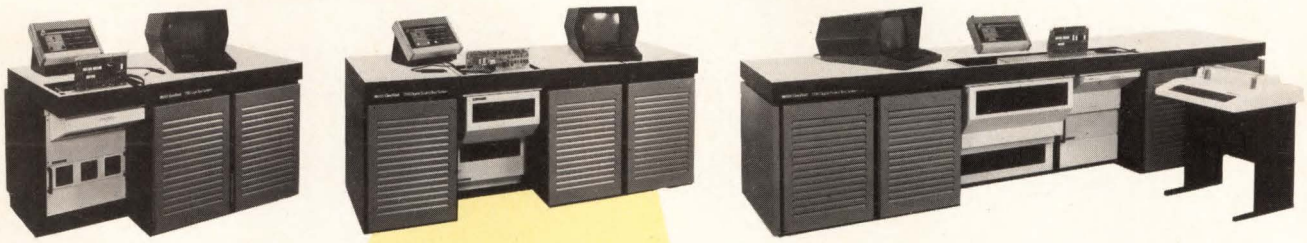
Name that tune. The user writes in a song note by note, using two hexadecimal digits from the keyboard to give the pitch and another two to give the length of the note. Hitting the increment key then writes the note shown on the display into memory and advances the program counter to the next address. Notes and pauses from a full note to 1/256 note, including dotted notes, can be programmed.

The memory can hold 127 notes—generally enough for a popular tune. Alternatively, as many as four partial selections may be programmed and addressed independently. Parents will be glad to know the music-loving child can instruct the Panakit to repeat the song a specified number of times. However, there is a knob for volume adjustment, as well as one for tempo.

The kit is designed to give the user a feeling of participation in its construction, but it is kept simple enough to stay within the limits of a first-time solderer. Thus much of it comes assembled, including line-cord wiring and wiring to the ICs.

From unpacking to tightening the last screw of the cabinet should take no more than three hours, the company says. Confident of Panakit's future, Matsushita is starting off at an initial production rate of 4,000 kits a month. □

We've Bridged the Gap



If GenRad's 1796 dynamic digital/analog board test system is too much machine for your application, and you need more performance than GenRad's 1795 digital tester normally provides, then you probably need GenRad's new 1799 Digital/Analog Test System. Our unmatched experience with board testing tells us that the 1799 is just the right system for many of today's applications.

A key feature of the 1799 is that it is an integrated system, which simply means it was **designed** as a hybrid tester. When you compare its performance with other hybrid testers on the market which are derived by adding analog capability (via IEEE-bus based instruments) to a digital system, you'll find a world of difference.

Interface for the unit under test (UUT) is compatible with that of the 1795 and with the hybrid section of the 1796. Also, the fixed or programmable digital driver/sensors operate through a universal scanner which allows either digital or analog source and measure capability at each I/O pin.

For the complete story on the 1799 Digital/Analog Test System, request a copy of our new brochure.

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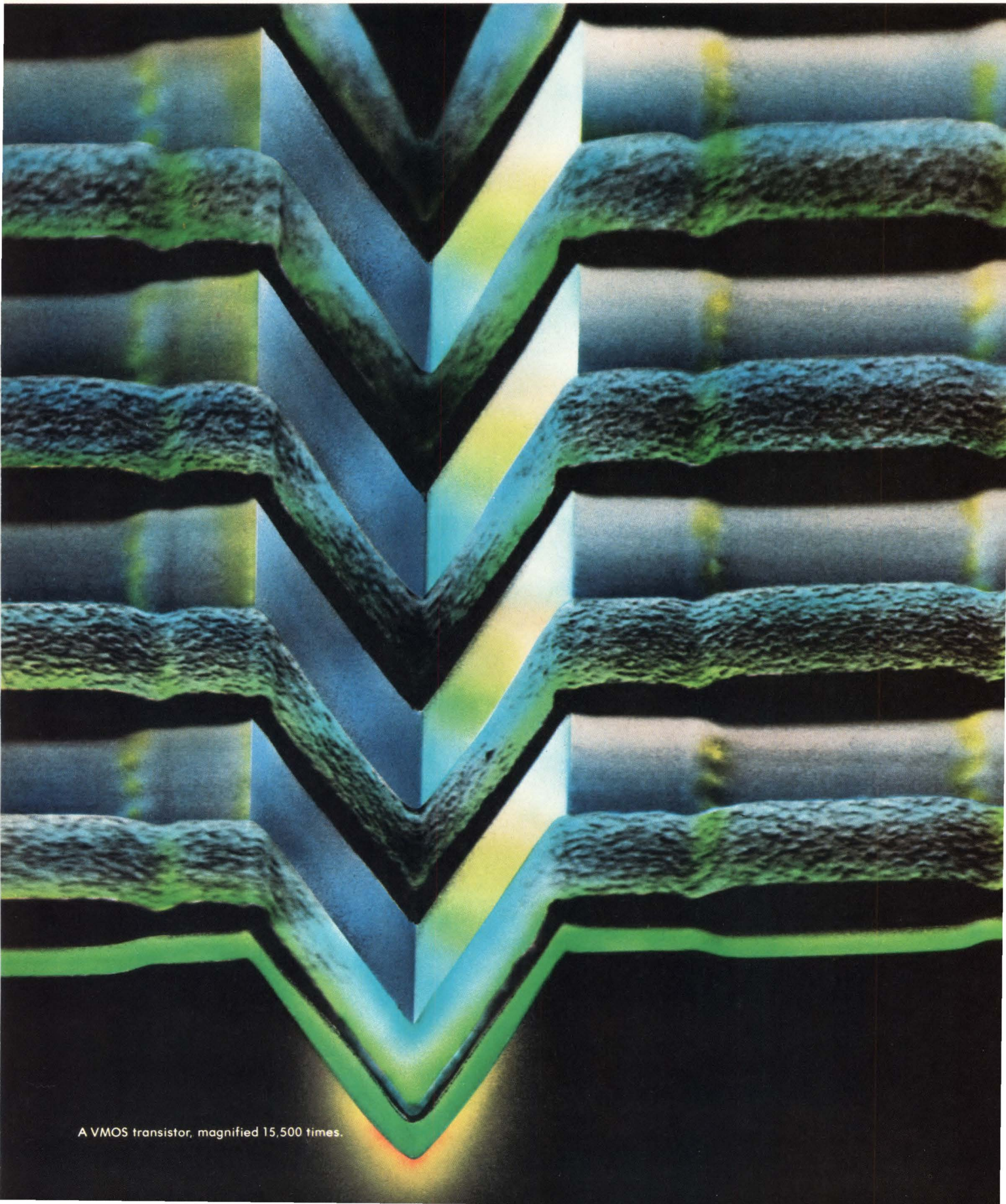
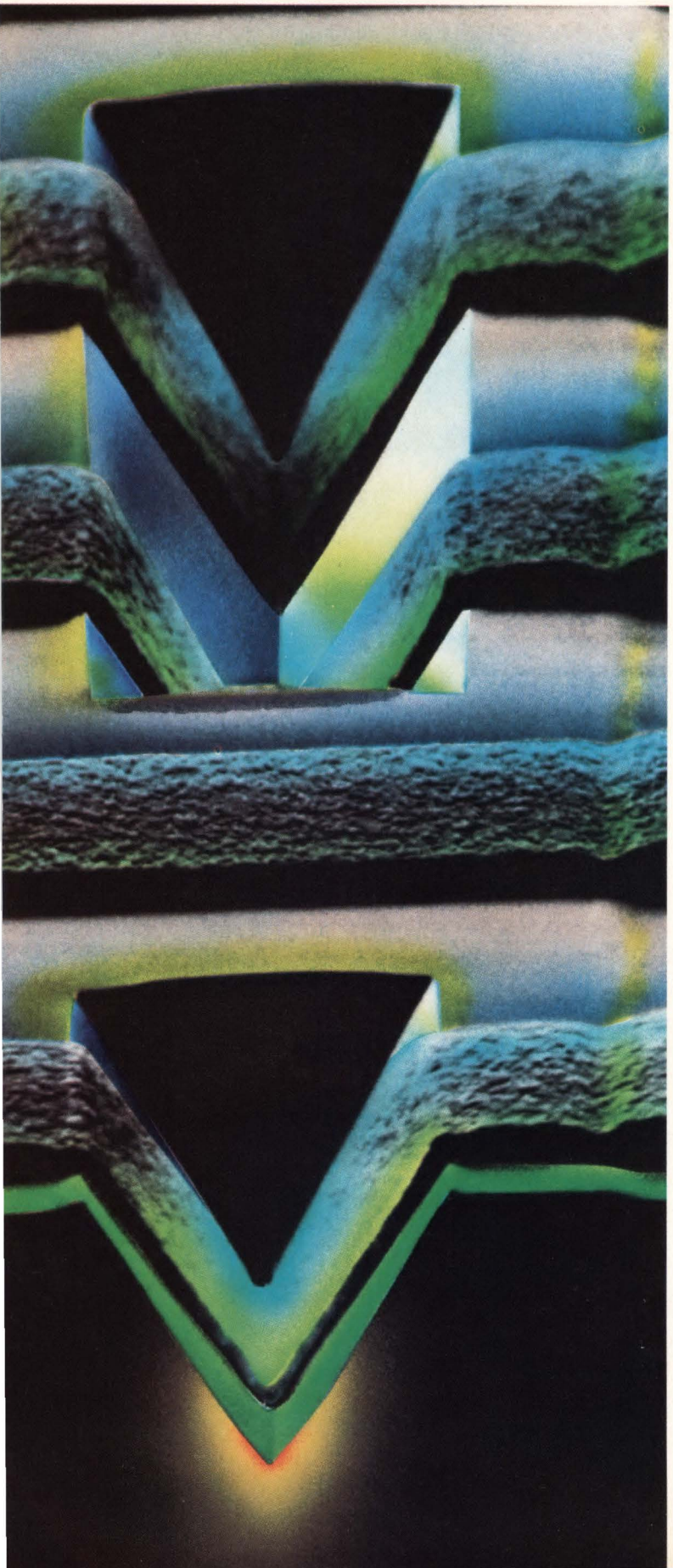
The MOS world



A VMOS transistor, magnified 15,500 times.

is no longer flat.



AMI creates VMOS. This revolutionary idea revolves around a three-dimensional transistor, etched into the silicon substrate.

The result? A circuit that's extremely fast, dense and inexpensive.

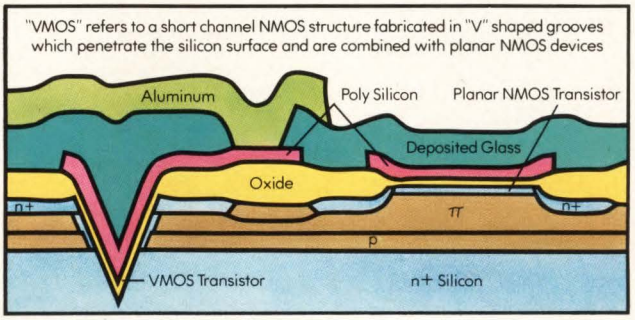
It isn't blue-sky theory. The first VMOS RAM, the 1K S4015-3, is in volume production now. And a reputable second source has committed to manufacture VMOS RAMs in 1978.

Our 35 nanosecond (typical, 45 nanosecond maximum) 1K static memory is pin compatible with the fast 1K NMOS and bipolar RAMs, and leads the way for the large family of VMOS products arriving soon. These will include:

NEW VMOS PRODUCTS AND TYPICAL ACCESS TIMES

4K fully static RAM	(1K x 4)	80 ns
4K fully static RAM	(4K x 1)	80 ns
4K fully static low power RAM	(4K x 1)	45 ns
8K fully static RAM	(1K x 8)	125 ns
16K ROM	(2K x 8)	100 ns
64K ROM	(8K x 8)	250 ns
16K EPROM	(2K x 8)	200 ns

The density permitted by vertical short-channel FETs produces VMOS circuits that are much smaller than competitive chips, increasing the speed and lowering the cost. For example, the latest bipolar 1K size is 61% larger, and the new fast NMOS 1K is 87% larger than AMI's S4015-3. And VMOS densities are achieved without stretching feature dimensions at the sacrifice of yields, as is necessary with bipolar and NMOS technologies.



In short, VMOS presents the best of all possible worlds. If you want to stay up to speed at a down-to-earth price, call your nearest AMI distributor or sales office. Or write to AMI Marketing, 3800 Homestead Road, Santa Clara CA 95051. You'll be entering the MOS world of the future.

VMOS: the new technology from AMI

AMERICAN MICROSYSTEMS, INC.

Circle 66 on reader service card

PMI's COMDAC™ companding D/A converter. When you think about what it can do, nothing seems very far-fetched.

Not long ago, we ran a little contest in one of the electronics magazines. We asked engineers to come up with the most creative ideas they could think of to put PMI's unique COMDAC—the first and only companding D/A converter—to work. We got lots of responses with exciting ideas. But the interesting part is that no less than **five** engineers said they'd had terrific ideas—but they couldn't submit them because their corporate attorneys were starting patent searches.

That's the kind of brainstorming that COMDAC has generated since we first introduced it.

The reason is simple: nature is nonlinear. People, plants, animals, water, wind—we don't live in a straight-line world. We live in a world of curves, slopes, and human response systems (ears, eyes, touch) that do not follow straight-line paths. In trying to reduce these things to digital data, or to imitate them, we've always fallen short.

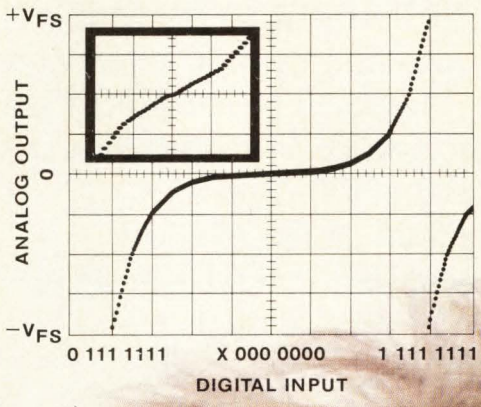
Until COMDAC.

With the help of COMDAC you **can** linearize analog signals. COMDAC **can** supply the shades of grey, the sweeping curves, the "vive la différence!" of the natural world. COMDAC uses logarithmically companded digital techniques for D/A conversion; with just eight bits, it provides the dynamic range of a 12-bit DAC—72dB or 4096:1. With that range, it can produce a convincing facsimile of the human voice, for example. Your watch radio can awaken you gently, with soothing, motherly tones, or shake you out of bed with a drill sergeant's scream—whichever is called for in your case.

Consider these applications—some of which are already a reality:

- Digitized audio—music, sound effects, voice (μP controlled)
- XYZ positioning (automated drill presses, for example)
- Motor controls
- Echo/reverb devices (for electronic guitars, electronic organs, synthesizers)
- Voltage-controlled oscillators and filters
- Servo motor controls

COMDAC™
TRANSFER CHARACTERISTICS



- Altimeters
- Waveform generation (with PROM)
- VU meters (for better response)
- Voice recognition (imagine a typewriter you could dictate letters to!)
- Tone generators
- Voice encryption
- Voice warning systems (they're already using them in aircraft)
- LOG sweep generators
- Data acquisition
- Recording studios
- Verbal response systems (like, your car could give you the word when it's overheating)

Keep in mind that COMDAC is not just a concept. It's a working reality. In the last two years, we've delivered half a million and cut the price in **half.** And since the 8-bit COMDAC can do many things a 12-bit DAC can do, think of what you will save by using a low-cost 8-bit system to do the job of the expensive 12-bit approach.

With a little bit of thought, a creative engineer—that's you—can come up with some really dazzling ideas. The surface has just been scratched. If you'd like a copy of all our contest entries, circle the bingo number below. We'll send technical literature that will help you with your application. Want a sample COMDAC? Send us a request on your letterhead.

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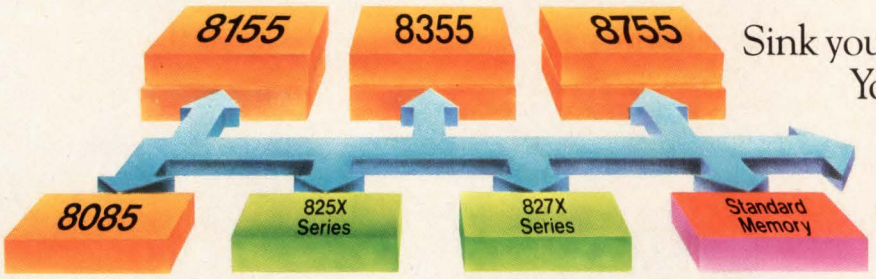
Circle 68 on reader service card

Intel delivers the 8085, designers just



Sink your teeth into Intel's new 8085. You'll find it's the only microcomputer that combines the performance, economic advantages and total support it takes to be recognized as the new industry standard. So it's no surprise that there are already four announced sources for the 8085. In fact, the deeper you go, the better the 8085 gets.

The 8085, even more than the 8080 it succeeds, is a total design solution, not just a component. It delivers higher performance, for capabilities far beyond the 8080's. It has a higher level of integration, so you can design your products with fewer components, making them more competitive and more profitable. And to help you get those products to market quicker we've given the 8085 the industry's broadest base of system and development support.

Yet the 8085 is fully compatible with the 8080. So your investment in existing designs is protected, and implementing new designs is simplified by the wealth of 8080 software and peripherals at your disposal.

It all adds up to a design solution you won't be able to resist. That's true for a broad range of applications. The 8085 can be designed in as an economical stand-alone three-chip system using the 8085 CPU, the 8155 256-byte RAM with I/O and timer, and the 8755 2K-byte EPROM with I/O or its interchangeable 8355 ROM with I/O.

You can expand this basic system for larger applications using additional RAM, ROM, EPROM and Intel's complete family of first and second generation peripheral controllers, including our four new programmable peripheral controller chips—the 8271* Floppy Disc Controller, 8273* Synchronous Data Link Controller, 8275 CRT Controller and 8279 Keyboard/Display Interface. All these components including 8755 EPROM operate from a single +5V supply.

*Available 4th Quarter 1977

the new microcomputer can't resist.

A multiplexed data/address bus permits integration of many auxiliary system functions—such as clock generation, system control and multiple interrupts—onto the 8085 chip while maintaining 8080 compatibility and the same 40-pin package. And forward-thinking engineers will realize that it is also a link to Intel's future generation microcomputer products.

No microcomputer can match the 8085 as a total design solution because no microcomputer can come close to the 8085's support base. Support for the 8085 includes the Intellec® microcomputer development system with resident PL/M, the high level programming language that can cut months off your software development time. Intellec is the only development system with ICE-85,™ providing in-*system* emulation for faster system development and debugging. Then there's application assistance, training classes and seminars worldwide. And a comprehensive development software library at your disposal.

The quickest way to get a taste of the 8085's power and versatility is with the SDK-85 System Design Kit. It's available now for only $250. You can order SDK-85 and all MCS-85™ components directly from your nearest Intel distributor: Almac/Stroum, Components Specialties, Cramer, Hamilton/Avnet, Harvey Electronics, Industrial Components, Pioneer, Sheridan, L.A. Varah, Wyle Liberty/Elmar or Zentronics.

MCS-85™ Microcomputer System Components Family

8085 CPU with system bus control, system clock generator, serial I/O and 4-level interrupt control.
8155/8156 RAM, I/O & Timer. 256-byte static RAM, 22 I/O lines, 14-bit programmable interval timer/event counter.
8355 ROM & I/O. 2048-byte masked ROM, 16 I/O lines. Interchangeable with 8755.
8755 Erasable PROM & I/O. 2048-byte UV erasable and electrically reprogrammable EPROM. Interchangeable with 8355.

Compatible MCS-80™/MCS-85™ Peripheral Components

General Purpose
8251 Programmable Communications Interface
8253 Programmable Interval Timer
8255 Programmable Peripheral Interface
8257 Programmable DMA Controller
8259 Programmable Interrupt Controller
8205 High Speed 1 out of 8 Binary Decoder
8212 8-bit Input/Output Port (Latch/Buffer)
8216/8226 4-bit Parallel Bidirectional Bus Driver
Dedicated Function
8271 Programmable Floppy Disk Controller
8273 SDLC Protocol Controller
8275 Programmable CRT Controller
8279 Programmable Keyboard/Display Interface

Performance Matched Standard Memory

Static RAM
2114 1024x4-bit, 450 nsec, 18 pin
2142 1024x4-bit, 450 nsec, 20 pin
8101A-4 256x4-bit, 450 nsec, separate I/O
8102A-4 1024x1-bit, 450 nsec, separate I/O
8111A-4 256x4-bit, 450 nsec, common I/O
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Speed vs cost in nonimpact printers

Electrographic machines turning out 20,000 lines a minute impress, but slower—and less expensive—ink-jet types could capture market

by Raymond P. Capece, Computers Editor

Electrographic computer-output printers are winning oohs and aahs in the nonimpact printer business and are bidding to all but eliminate impact machines from consideration for high-speed, large-volume jobs. The likes of IBM Corp., Xerox Corp., Honeywell Corp., and Siemens AG are making laser-based printers that spew out 8½-by-11-inch sheets of computer output with copier-machine quality.

But there is a catch. These 20,000-line-per-minute workhorses—more like printing stations, with their collating, punching, perforating, and other printshop capabilities—are a costly $250,000 each, though in most cases they are leased by first-time users. They are now competing in a constricted market populated by Fortune 500 companies that go through more than a million sheets of paper each month and are willing to pay a premium for speed. As estimated by International Resource Development Inc., a New Canaan, Conn., research firm, that market is expected to amount to $150 million for an installed base of about 1,400 machines by 1985. R. C. Bishop, marketing manager for Honeywell Information Systems Inc.'s PPS (page-printing system) group in Waltham, Mass., thinks that that estimate is too conservative. He says that more than 100 PPS machines have been installed, and "10% of our users previously had only a single-impact printer."

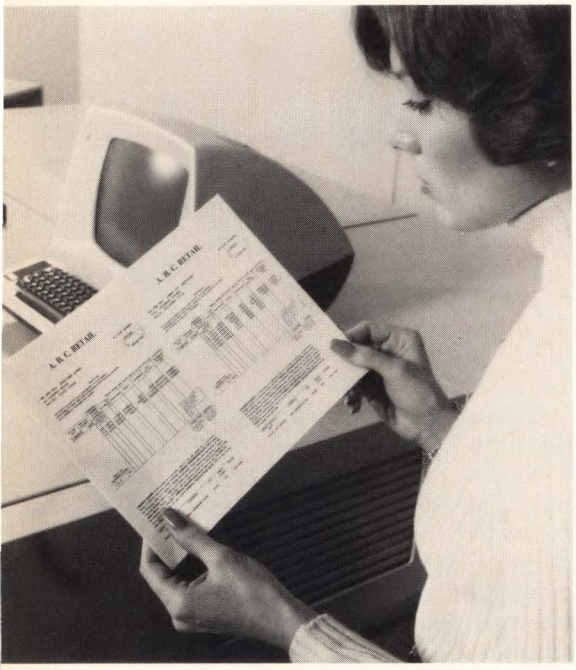
Not only that, but, Bishop says, "we think that there are more markets than just the large corporations. Any company that has two, three, or more printers could use the PPS. What's hidden from most analyses is the amount of printing done off line."

Little squirt. IBM's 6640 document printer is only midsized ink-jet printer now on market. It was introduced in June 1976.

But some informed observers therefore expect a different type of nonimpact printing to capture the lion's share of the market in the next decade or so: a less expensive ink-jet printer. They reason that, since the market for fast, high-volume machines is limited, the relatively low speed of ink-jet machines is no problem. Also, while the copier-machine techniques of the electrographic printers mean that only certain papers can be used, ink-jet types print on anything.

Plain paper. What makes that argument so powerful is the voice of Mead Corp., the Dayton, Ohio, paper maker that did $1.6 billion in sales last year. "We concluded from a study of all types of printers, including thermographic and electrographic, that the future of printing is in plain paper," says Les Jezuit, manager of printer equipment and services at Mead's Digital Systems division, which began developing its own ink-jet printer 13 years ago. "But ink-jet machines go beyond nonimpact—they're noncontact, which means that as long as you've got an ink that will adhere to the material, you can print on anything, whether it's paper, metal, or Mylar." Mead's Dijit series of ink-jet printers is designed for paper printing only, and Jezuit adds that Mead got into the printer business "actually as a defensive move, to plan the future of our paper products."

Dataproducts Corp. of Woodland Hills, Calif., also likes plain paper



Light touch. Xerox 9700, which uses a laser scanner, can perform simultaneous printing—in this case, two forms.

but feels that electrographic printers will work their way down to less costly levels. Dataproducts, a printer maker, places reliability before speed and likes 4,000 to 8,000 lines per minute as the best range for ease of paper handling.

Speed, too. But Mead is competing with press printing and is after high speed. It will soon introduce its model 2700, claimed to be the fastest printer in the world, racing along at 800 feet per minute. The speed is designated in feet because the 2700 is capable of generating characters several inches tall. In terms of standard printed lines, the count works out to about 80,000 lines per minute, to be compared with electrographic processes running at about 20,000 lines.

The speed of Mead's machines is attributable to a multiple-nozzle array of ink jets—960 of them in a full line width of 8 in. Other ink-jet machines, like those made by A. B. Dick Co., Chicago, use a single nozzle. But both Mead and A. B. Dick, which manufactures five-by-seven-dot matrix printers intended for product date-coding and addressing of forms, make stand-alone machines for off-line printing—neither is addressing the computer-output market. And while speed is a strong selling point for printing forms and other jobs competitive with offset, it appears no longer to be the major issue in computer output.

The reason: few computer users can make full use of an output of 20,000 lines per minute because then they would have to handle tons of paper per month. Ken Bosomworth, president of International Resource Development, points out:

"Taking advantage of the high-speed capabilities of the machines isn't simple. You've got to be able to load and remove quickly several hundred pounds of paper, and we've observed, just as the business-forms printshops have, that many of the big jobs shouldn't be brought in to the house. Rather, they should be done outside, off line, from magnetic

tape. There the volumes of paper could be handled better."

Honeywell's Bishop agrees that off-line printing is most practical because it does not monopolize the central processor. The PPS runs off line, and the complete system includes a tape drive. IBM's 3800, on the other hand, originally ran only on line. IBM, however, began offering off-line printing as an option—to free the computer.

Bosomworth also notes that distributed networks are driving data processing away from the centralized, high-volume output production. In many applications, putting a slow printer at a remote terminal is more practical than distributing the literature from a central location.

But a market definitely exists for printers in the range of 1,000 to 20,000 lines/min. Though it could be served by forthcoming electrographic printers, a more likely candidate is the ink-jet printer. Products in this area are undergoing research and development not only in the laboratories of such companies as Dataproducts, but at Computer Peripherals Inc., a Rochester, Mich., company jointly owned by Control Data Corp., NCR Corp., and ICL of Britain. Computer Peripherals manufactures printers and memory subsystems solely for its parent corporations and refuses to discuss the status of its development.

Available. The only midsize ink-jet machine on the market at present is IBM's 6640, originally introduced as the 46/40 document printer in June 1976, but by now widely accepted as part of IBM's Office System 6. Renting for $600 to $900 per month, the machines print on single sheets of paper and can handle envelopes as well. Operation of the printer over communications lines is an optional extra.

"The 6640 really started people seriously thinking about ink-jets again," comments Jerry Ligon, project engineer at Magnetic Peripherals Inc., the company jointly owned by Control Data Corp. and Honeywell Corp., in which CDC has controlling interest. It builds Honeywell's page-printing system, which differs from the Xerox, IBM, and Siemens printers in requiring dielectrically coated paper that is slightly more costly than plain paper. But Bishop maintains that the lower cost of his PPS hardware covers that extra expense for installations handling less than 2 million sheets of paper every month.

IBM has had the 6640 on the market for about a year now, but has been involved heavily in ink-jet research. In the last few years, it has been granted several patents, including one for charging the ink droplets as they leave an array of holes in a silicon wafer—a significant development for multiple-nozzle printing. The 6640 produces beautiful characters in several fonts, but runs at the comparatively slow speed of 92 characters per second. The printer has a single nozzle to draw its sharp characters with 117,000 droplets of ink per second. □

Electronics abroad

Hungary's strength is communications

Next to smallest country in Comecon manages to occupy spot near the top in terms of production volume and product range

by John Gosch, Frankfurt bureau manager

The contributions of Hungarians to science and technology range from the achievements of Budapest-born atomic scientists Edward Teller and Leo Szilard to the invention of holography by Dennis Gabor.

But in no branch of technology is Hungary stronger today than she is in communications. Although the second smallest of East Europe's Comecon countries in terms of population (10.6 million), Hungary rates as the Bloc's second biggest in communications, after the Soviet Union, industry officials say.

Last year, output of commercial and consumer communications equipment combined came to roughly $1.25 billion, says Endre Nagy, commercial manager of the Hungarian telecommunications industries association. Add to that roughly one third for instruments, industrial, and medical electronic systems, and some other products, and Hungary's overall electronics output in 1976 totals nearly $2 billion.

Commercial figures. Of the $1.25 billion figure, commercial communications equipment—from simple rural telephone exchanges to sophisticated microwave links—accounted for roughly 45%, Nagy says. But, at the expense of consumer communications products—which include radio and television sets, components, and much data-processing equipment—that share will increase substantially during the next decade and a half—to 50% by 1980 and to 60% by 1990.

Exports in commercial communication equipment will claim 56% of production this year, Nagy estimates. For some product categories, like microwave systems, studio gear, and telephone exchanges, "exports may well account for between 70% and 90% of production," he says. As expected, Hungary's prime customers are its partners in Comecon, which takes some four fifths of its equipment exports.

On the line. Hungarian women at the Videoton factory in the ancient town of Székesfehérvár work on printed-circuit boards intended for the firm's line of data-processing equipment.

But markets in the West and in developing countries will command more attention in the future. Telecommunications exports to hard-currency countries will more than double during Hungary's current five-year economic plan to as much as $200 million by 1980.

The backbone of commercial communications work is clearly telephone switching systems. These include crossbar rural and private automatic branch exchanges of Hungarian design and public automatic exchanges made under license from Sweden's L M Ericsson. Built mainly at the BHG Budapest Telecommunication Works and sold through the Budavox Telecommunication Foreign Trading Co., such equipment generates by far the most export business for the industry.

In the realm of computers, Hungary's main activities are meshed with those of other East European countries through Comecon's ES project. This project aims at a unified and mutually compatible line of central processors and peripherals, with each participating country contributing its share of hardware and engineering. Hungary builds small computers, remote data-processing systems, intelligent terminals, punch- and magnetic-tape units, printers, disk stores, and modems.

Entrusted with data-processing equipment production are about half a dozen firms, with the 20,000-person Videoton combine the biggest. Besides consumer products like TV sets, loudspeakers, and radios, which account for less than half of Videoton's output, the Budapest company builds the ES-1010 computer, the smallest in the ES series. Also produced are display stations,

This article is the seventh in a series that examines the electronics industries of the Eastern European Bloc, or Comecon.

terminal systems, and printers, some under license from Dataproducts Corp. in Woodland Hills, Calif.

The ES-1010, of which several hundred are said to be operating in the Comecon area, is intended primarily for commercial and scientific-technical applications. Using medium-scale integrated circuits, the system performs some 300,000 operations per second. Its main store, expandable to 65 kilobytes, is based on ferrite-core technology and the microprogram store on read-only-memory devices. Access and cycle times are reported at 0.9 and 1.1 microseconds, respectively. A channel adapter serves to interface the 1010 with other ES computers and peripherals.

"Not all of our systems are related to the ES project," says Tamás Haris, head of technical coordination at Videoton Corp., which handles the company's foreign trade activities. As an example, Haris cites the 1005, a small system in production for about two years and destined for exports, "we hope also to the West." There are two 1005 models in Videoton's equipment lineup: the two-cassette 1005-50 office computer with a matrix printer and a data display, and the 1005-70 intelligent terminal, also with a printer.

TV sets, too. For all the attention it has given commercial electronic's endeavors, the industry has not let the consumer sector slide. Statistics show 233 color or black-and-white TV receivers per 1,000 population for 1976, with total TV set production at about 300,000 units per year.

Color set production, although small, is picking up fast. From this year's level of 30,000 units, it will jump next year to 50,000, says Edith Nezvál, an economist at Videoton Corp. Her prediction for 1979 is for between 60,000 and 65,000 units.

True to form, the Hungarians are doing well in sales abroad, particularly with black-and-white portable sets in Western countries. "Prime foreign markets," says György Berkes, deputy general manager of Videoton Corp., "are West Germany, Britain, Switzerland, the Netherlands, the Scandinavian countries, and Egypt." TV exports to the West, Berkes points out, are three times those to East European countries. □

Companies

TRW logic devices spawn a division

New LSI operation hits jackpot with its first product, a 160-ns bipolar multiplier developed to 'prove the technology'

by Larry Waller, Los Angeles bureau manager

After years of searching, TRW Electronics finally has something going in the glamour end of semiconductors. Named the LSI Products division, it features what are acknowledged as the fastest commercially available logic devices. Equally pleasing, however, to TRW corporate brass and officials at TRW Electronics is where it started.

Organized in 1976 from scratch at the Defense and Space Systems Group, the operation struck instant paydirt with its first product. But swift market acceptance of that device—a 16-by-16-bit, 160-nanosecond bipolar multiplier, holding 18,000 components on a chip and performing more than 6 million operations per second—spurred growth too rapid for the space- and military-oriented group to handle.

"Our initial motive was just to prove the technology, not immediate profit," recalls Ralph W. Miller, general manager of the new LSI Products division.

Ironically, TRW had had the perfected bipolar circuit (called triple diffusion, or 3D) since about 1968 and had been turning out small quantities of it for space and defense jobs. "It was the classic problem of LSI," Miller explains, "more functions on the device than the user needs." So TRW planners picked out an application area demanding more raw speed, lower power, and more miniaturization than offered by any other device: digital signal processing, or the real-time filtering of digitized waveforms.

Despite its success, this device is already being improved, since it "represents 1973 technology." Two new versions are due early next year. One will have a speed of 100 ns, and the other will have an accumulator function added to the same chip, enabling it to do 10 million operations per second.

Because managing an advanced bipolar organization is different from running other TRW components operations (their products include rectifiers, connectors, and circuit boards), officials devised a unique relationship. Miller serves as the chief link with the parent systems group, which still handles all the wafer fabrication, expanded device assembly, testing, and research and development. Fabrication, in fact, is likely to stay at the Redondo Beach, Calif., facility, because an automated manufacturing operation can turn out as many as 250,000 0.8-inch-square chips a year, adequate for a long while. But a separate assembly-test building is planned.

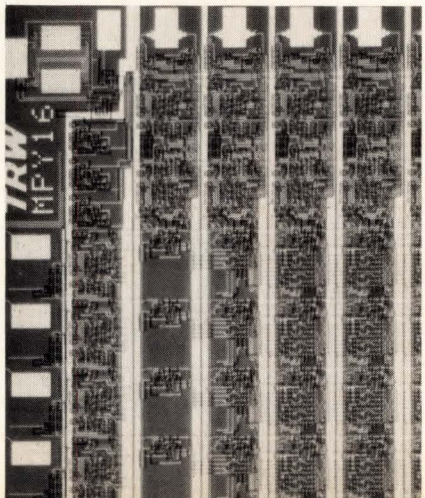
Smoothing the transition to the new division is a familiar name in the industry, Theodore H. Maiman, inventor of the laser and also TRW's Electronics Group vice president charged with bringing in new technologies. LSI Products reports through Maiman to George Hart, general manager of TRW Electronic Components divisions. The point, says Hart, is that "we're not mixing it in with everyday business. It's separate and reporting to me as far out as I can see. In five to six years, it can develop into one of our largest divisions."

Other products coming. Miller insists his division "is not just a multiplier company," but also offers a line of 8-bit data converters and shift registers, including a 256-bit, 40-megahertz unit. Furthermore, the division is likely to bring out more arithmetic elements, such as adders and subtracters. "Really, these are building blocks of general use." Maiman concurs, adding that the line should be regarded as "not components, but subsystems."

There are other possibilities besides signal processing, the market for which Miller admits is hard to pin down specifically because "it needs so much speed and complexity that it is relatively untapped." For instance, there are the allied jobs of digital switching and processing video digital signals. But Hart, Maiman, and Miller agree on one place TRW will not be: in microprocessors or mass memory.

By moving the operation out of a military environment, TRW is easing the way to profitable long-range commercial development. But a pitfall could be the inevitable competition. Among others, Advanced Micro Devices Inc. and Monolithic Memories Inc. are known to be eyeing TRW's market preserve and polishing suitable products. □

New baby. The first device from TRW's new LSI Products division is this multiplier. Chip, 280 mil², holds 18,000 devices.



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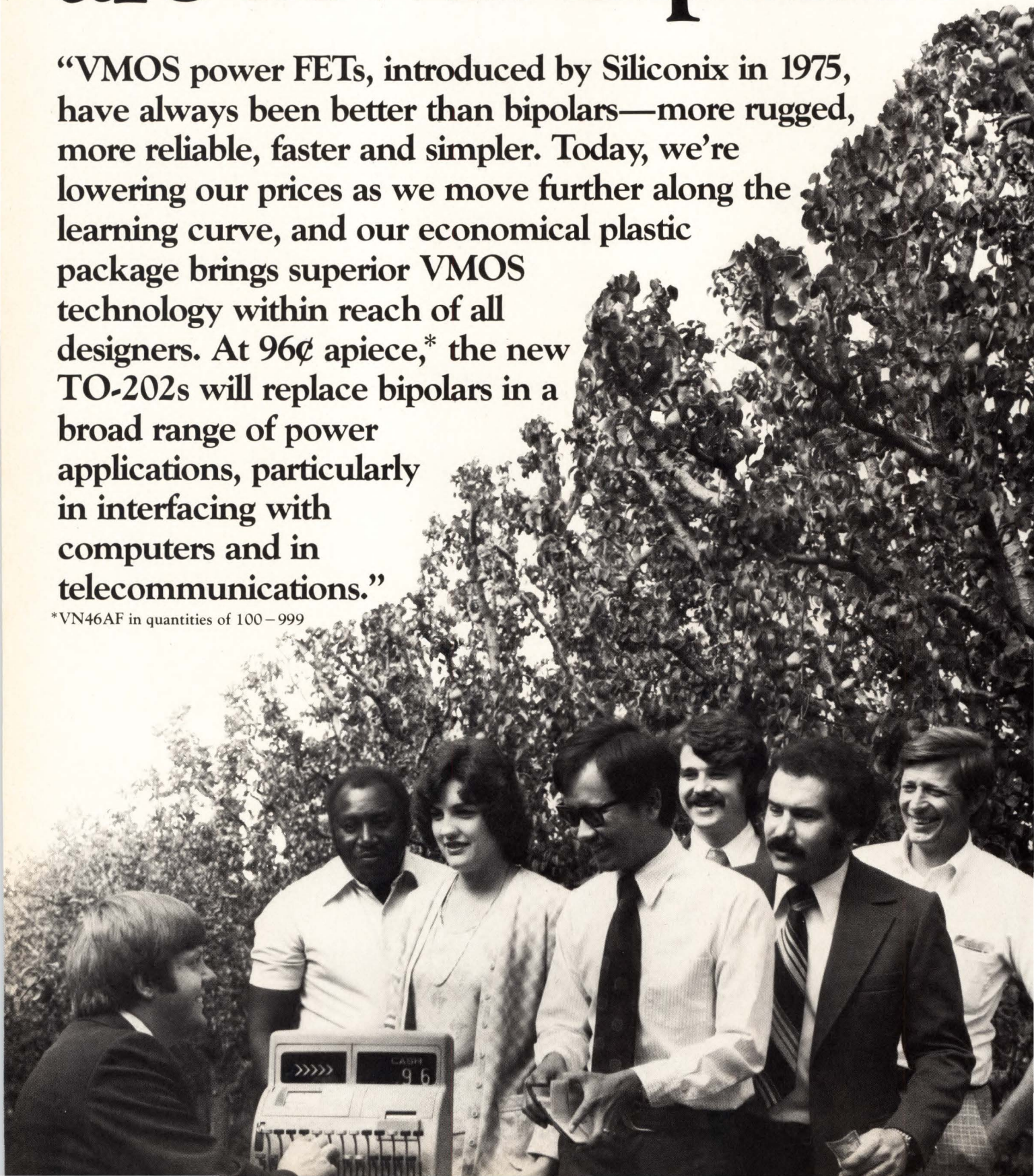
*VN46AF in quantities of 100 – 999

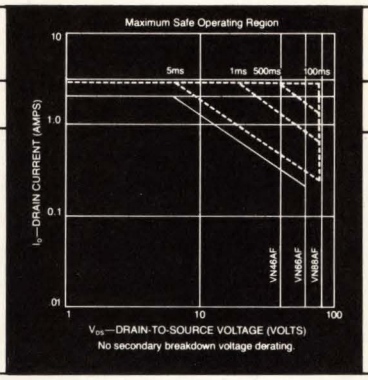


power FET prices time is up."

Siliconix VMOS power FETs in plastic: TO-202 package

Part #	BV_{DSS}	$V_{DS(on)}$ (I_D=1 Amp)	Price:1-29	31-99	100-999
VN46AF	40	3.0V	$1.33	$1.12	$0.96
VN66AF	60	3.0V	$1.39	$1.16	$1.00
VN88AF	80	4.0V	$1.54	$1.29	$1.10

All three devices are guaranteed over the temperature range of −55°C to 150°C; their maximum power dissipation is 12.5 watts, and their current rating is 2.0 amperes.



Other VMOS power FETs introduced by Siliconix are also available:

Part #	Package	P_{DISS}	BV_{DSS}	$V_{DS(on)}$ (I_D=1.0 Amps)
2N6656	TO-3	25W	35	1.8V
2N6657	TO-3	25W	60	3.0V
2N6658	TO-3	25W	90	4.0V
2N6659	TO-39	6.25W	35	1.8V
2N6660	TO-39	6.25W	60	3.0V
2N6661	TO-39	6.25W	90	4.0V

"Until 1975, MOS field-effect transistors (FETs) were restricted to small-signal, low-power applications. To control high currents, designers used bipolar devices. Then Siliconix, using Vertical MOS technology, introduced the VMOS power FET—combining the reliability of FETs with the power of bipolars.

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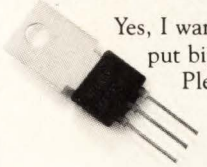
"Anyone who has designed with bipolars knows the failures that can result from thermal runaway, secondary breakdown and current hogging. You don't have to worry about these problems with VMOS power FETs; their positive temperature coefficient eliminates hot-spotting and provides uniform current density, making them fail-safe. Consider how this inherent reliability will reduce your system interruptions and maintenance costs. And VMOS power FETs are faster than bipolars in switching operations—as much as 100 times faster. With all these advantages packed into the low-cost TO-202, you'll be able to eliminate bipolars' problems completely from many system designs.

"The high input impedance of VMOS and its threshold voltage range allow it to interface directly with CMOS, MOS and TTL logic families. And the VMOS power FET is the only interface device with a switching time comparable to that of ECL, so it will interface with a simple level shift—without losing speed. These features make the TO-202s ideal for data processing applications: computer peripherals, micro- and minicomputer systems, and process control equipment. They're also ideal for use in telecommunications: as telephone relay replacements, Touch-Tone muting switches, audio amplifiers, central office systems and analog switches.

"Our new line of VMOS power FETs in plastic may mean the end of the line for bipolars. We want you to discover for yourself how they can improve system design, so use the coupon to send for our detailed brochure. To order parts, contact any of our franchised distributors: Alliance, Century, Components Plus, Future, Hamilton/Avnet, Industrial Components Inc., Pioneer Standard, Pioneer Washington, Quality Components, Semiconductor Specialists, Wilshire, Wyle/Elmar, Wyle/Liberty, or RAE."



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LOGIC-ANALYZER ORIGINATORS

CHARLES H. HOUSE

B. J. MOORE

CITED FOR TESTING INNOVATION

1977 Award for Achievement

One problem, two men, two solutions: yet both designers were right; both of their designs were needed. So Charles H. House of Hewlett-Packard Co.'s Colorado Springs (Colo.) division, and B. J. Moore of Biomation Corp. in Cupertino, Calif., developed two markedly different diagnostic instruments that were the first such electronic tools for studying, designing, and troubleshooting complex digital logic circuits and systems.

It was September 1973, at the annual Wescon show in San Francisco, when the electronics world got its first glimpse of what House and Moore had accomplished. HP brought its 1601L, a logic-state analyzer that displayed binary notation in 1s and 0s. It was intended primarily for examining software program steps or conditions on a data bus. Biomation introduced its 810-D, a logic-timing analyzer for recording, displaying, and analyzing complex timing relationships.

Together, these two 10-megahertz analyzers were major innovations in instrumentation. They gave rise to a whole new class of instruments operating in what is called the data domain, where designs more often are based on digital words or data as a function of time or sequence, than on voltage as a function of time or frequency. Logic analyzers serve the data domain in the same ways that oscilloscopes have served the time domain and spectrum analyzers have served the frequency domain.

For House, the first inkling of the problems facing digital-systems designers surfaced in late 1969 when he was investigating the use of computer-systems architecture to define a digital-processing oscilloscope program. "We were having significant difficulty debugging the DPO prototypes," he recalls.

House, circuit engineer Duncan Terry, and others working on the scope asked one another: how are other digital-systems designers, who are using serial-data interfaces and multiplexed data buses able to design and debug their gear? "It didn't take us long to discover others were having the same problems we were," he says. "It's a miracle that minicomputer makers could develop systems before such tools [as the logic analyzer] were available."

After checking with HP divisions making desk-top calculators and minicomputers, House continues, "we consequently said: 'The world doesn't need a DPO that prints out rise time and pulse width to four decimal places. Rather, it needs some simple diagnostic tools.'" Thus, HP cancelled the digital-processing oscilloscope program in early 1970 and set up an investigation of the need for digital test equipment.

Since data registration was the biggest problem House and his associates faced on prior projects, that became the first feature they set for a scope-like tool for digital-systems designers. Important in achieving this feature, House notes, was the pioneering work in parallel-pattern (AND-gate) triggering and digital delay done by HP applications engineer Ralph Reiser for the digital-processing oscilloscope.

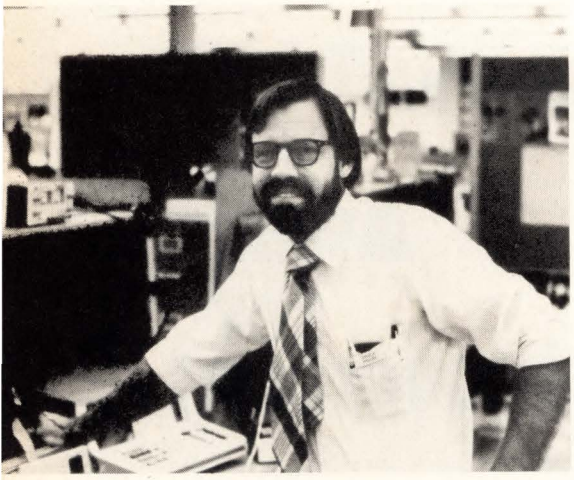
Soon added to the list were serial-word recognition and linking trigger statements. Data-acquisition structure was clearly a problem. Realizing that many channels of data were needed without significant degradation, "we put considerable effort into miniature, multiple-channel probing schemes where one adjustment controlled voltage threshold on all channels and tightly controlled timing skew between channels," he says.

By now it was late 1970 and Hewlett-Packard was developing the HP-35, its first handheld calculator. Discussions that House had with engineers on the cal-

The 1977 Achievement Award

For major instrumentation innovations that meet a vital need in the growing field of digital-systems design, the editors of *Electronics* have designated Charles H. House, engineering manager for logic-analyzer programs at Hewlett-Packard Co.'s Colorado Springs division, and B. J. Moore, president of Biomation Corp., as co-recipients of the magazine's fourth Achievement Award. The 1977 winners were the key figures in the development of the first logic analyzers. HP's 1601L, a logic-state analyzer, and Biomation's 810-D, a logic-timing analyzer, gave rise to a new class of instruments operating in the data domain.

The 1601L is a plug-in unit for HP's 180 series oscilloscopes, giving a 12-channel, 16-word-memory logic-state analyzer for 10-megahertz operation. The 10-MHz 810-D digital logic recorder stores 256 logic states on each of eight channels, displaying waveform-like timing diagrams on an oscilloscope.



CHARLES H. HOUSE

Semiconductor development almost was the career choice of Chuck House, engineering manager for logic-analyzer programs at Hewlett-Packard Co.'s Colorado Springs division. But upon graduating in 1962 with a bachelor's degree in solid-state physics from the California Institute of Technology, "I soon discovered that diffusion furnaces and Schroedinger's wave equations and I weren't compatible," he says in retrospect. "The semiconductor industry just wasn't my calling."

Happily for HP and for digital-systems engineers, House quickly settled upon the instrumentation world as his calling. During his senior year, one of his instructors had argued that instrument manufacturers must design and build equipment that is ahead of the state of the art if they are to measure the state of the art. "That fascinated me," says House, who had immediately sensed a challenge.

Since then it has been a 15-year career with Hewlett-Packard—the first two years in Palo Alto, Calif., with the oscilloscope research and development group, and the rest in Colorado Springs, Colo., where the oscilloscope operation moved in 1964.

House, who says he was "damn lucky to get out of Cal Tech," has picked up a master's degree in electrical engineering from Stanford University and a master's in the history of science and technology from the University of Colorado. Now 37 and married, he is the father of three girls and a boy, "none of whom shows any signs of becoming an EE," he says.

The House family lives near the plant in a spacious California-Spanish home. He designed the house, adapting it to the Colorado climate. Because he could not afford to build the home he wanted, he "chopped out the extraneous rooms." So there is no living room. But there is a 7-by-44-foot hallway, which helps him avoid walking into walls when he gets up in the middle of the night, keeps the lights off so as not to disturb anyone, and heads downstairs to grab a snack or do some writing.

Perhaps his nocturnal habits explain why House is known for his late morning arrivals at HP. But he is known for other things, too. He is coholder of two logic-analyzer patents relating to digital delay and pattern triggering and has two more logic-analyzer patents pending. He also was the circuit designer on Hewlett-Packard's model 1402 wideband vertical amplifier plug-in and on several other scope products.

House also takes pride in a plant nursery—"one of the best two or three in the Rocky Mountain region"—that he owns and operates in his spare time. He tends to spread his bountiful curiosity over a wide range of interests and is harassed by details. What's more, he concedes, "I've been known to be sharp-tongued and acerbic, impatient with others when they don't see what I do. But on balance, I prefer to think I'm pretty well liked by those that understand me."

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culator effort led to the addition of two more criteria to the list of features for the proposed digital diagnostic instrument.

First, the data-entry method had to be compatible with the way digital designers describe their problems. This led to a definition of state time, state sequence, and algorithmic state flow as the primary measurement parameters of interest. It also led to the second additional feature: to present the data collected with this multichannel data-indexing scheme in a way meaningful to digital-systems engineers.

To provide these features, "we wrestled with many things," says House. Eventually he and project leader William Farnbach settled on writing parallel words left to right, with event flow going from top to bottom.

Another feature the House-led team sought to provide was an overview of the system dynamics, and, again, several displays were considered. Possible formats included memory-address space on the Y axis and event time on the X axis and, "the one most liked early and eventually settled on," a simple matrix of the most significant byte on the Y axis and least significant byte on the X axis. This feature was working by late 1971, House notes, but it did not appear until early 1975, in the 1600A 16-bit logic-state analyzer.

Although the 1601L was the first complete logic-state analyzer, some of its features were in at least two predecessor instruments. In early 1970, Digital Data Corp. of Allentown, Pa., built and marketed the Diana, a two-channel-by-32-bit serial-data analyzer. House bought nonexclusive patent rights for HP. Independent of the work of House's group, many concepts from Diana were being used in the model 5000A serial-data analyzer in development at HP's Santa Clara (Calif.) division.

For Biomation, the development of 810-D logic-timing analyzer was less perplexing than the experiences of House's team. In fact, the cycle from idea to product was six weeks. The basic concept first came to Biomation engineers in 1971, after conversations with major makers of mainframe computers. Late that year, explains Moore, Biomation began planning to develop an instrument with eight logic-channel inputs for high-speed (100-MHz) digital recording. When work on the recorder began in early 1973, the instrument had been redefined as an eight-channel 200-MHz recorder. It was introduced as the 8200 in 1975.

"In August 1973, I got an idea that my subconscious told me was a good one," recalls Moore. "I knew if a market existed for the 8200, there just had to be one for a product more modest in price and performance."

While inputs for the 8200's development came from computer makers, "nobody ever came to us and said he needed a low-speed box. It was 98% intuition," Moore says. "The basic data world, at that time, was still operating at 1-MHz transfer rates, so I felt a 10-MHz logic analyzer did, in fact, have a role in the market."

The very next day he began to marshal all of Biomation's staff members to develop the 810-D and get it to market as quickly as possi-

Bill Moore would agree that it is a long way from pulling apart radios and being unable to put them back together to developing a ground-breaking piece of electronic instrumentation. But for the president of Biomation Corp., it was a natural way.

He is not quite sure what his unsuccessful teenage tinkering had to do with it. "All I know is that I liked math and science and just signed up to become an engineer when I went to college," says the 41-year-old native of Sharon, Tenn. With bachelor's and master's degrees in electrical engineering from the University of Tennessee in 1959 and 1960, he plunged straight into instrumentation design.

The first decade of Moore's career was spent almost entirely in his home state working for three small instrument companies. As a nuclear instrumentation engineer at one firm, he developed a data-acquisition system for nuclear and chemical applications. At another company, he developed a line of digital instruments, such as counter/timers, and output drivers for data-acquisition systems. At the third, he was chief engineer on a very-high-speed multichannel pulse analyzer.

Despite these accomplishments, Moore says he came to feel he was better at managing than at the detailed design of products. His belief is a major reason for his move to Biomation in 1969 as engineering vice president. "While I don't like details, I'm not bored by them," he remarks. "But, if I were a carpenter, I'd be a framing carpenter and not a finishing carpenter." However, his development of the 810-D logic-timing analyzer took as much finishing as framing.

He says the experience he gained from working at small companies, wearing several hats and seeing the various roles of engineering and marketing people, helps him to be a good manager and understand and empathize with the problems those departments face at Biomation. He also can quickly settle on the feasibility of a project. "Once I make a determination," he says, "I feel comfortable and don't worry about it. Worry is largely nonproductive."

With his two teenage daughters and wife, Moore lives in a medium-sized house in Monte Sereno, about 35 miles south of San Francisco. "It's a very rural atmosphere," he says: chickens, quail, rabbits, cats, and dogs populate the two-acre plot.

He spends most of his free time taking care of his property and animals or working hard at becoming proficient at trap-shooting. Similarly, he sets high targets for himself in business, and he finds goal setting "very invigorating." He does not hesitate to come down on people whose performance fails to measure up to their promises—because, as he puts it, "the bottom line counts." However, "you don't have to be ruthless to be successful," adds Moore, who believes he and others "achieve what we decide we can."

B. J. MOORE

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ble. "I went to our engineering department and told them I wanted a 10-MHz logic analyzer. They said, 'Okay.' But when I said I wanted it by Wescon, just six weeks away, they told me it was impossible. I then asked if anyone wanted to do it, and when they all refused, I said, 'Okay, then I'll do it.' "

The deadline made development hectic. Moore, who joined Biomation in early 1969 as the firm's third employee and engineering vice president, had assumed the presidency in 1971. In August and early September of 1973, he spent his days running the company and his evenings developing the instrument. "I was the project engineer," he says. "I did the design, fabrication, and checkout of the prototype, and even wrote the technical portion of the instruction manual."

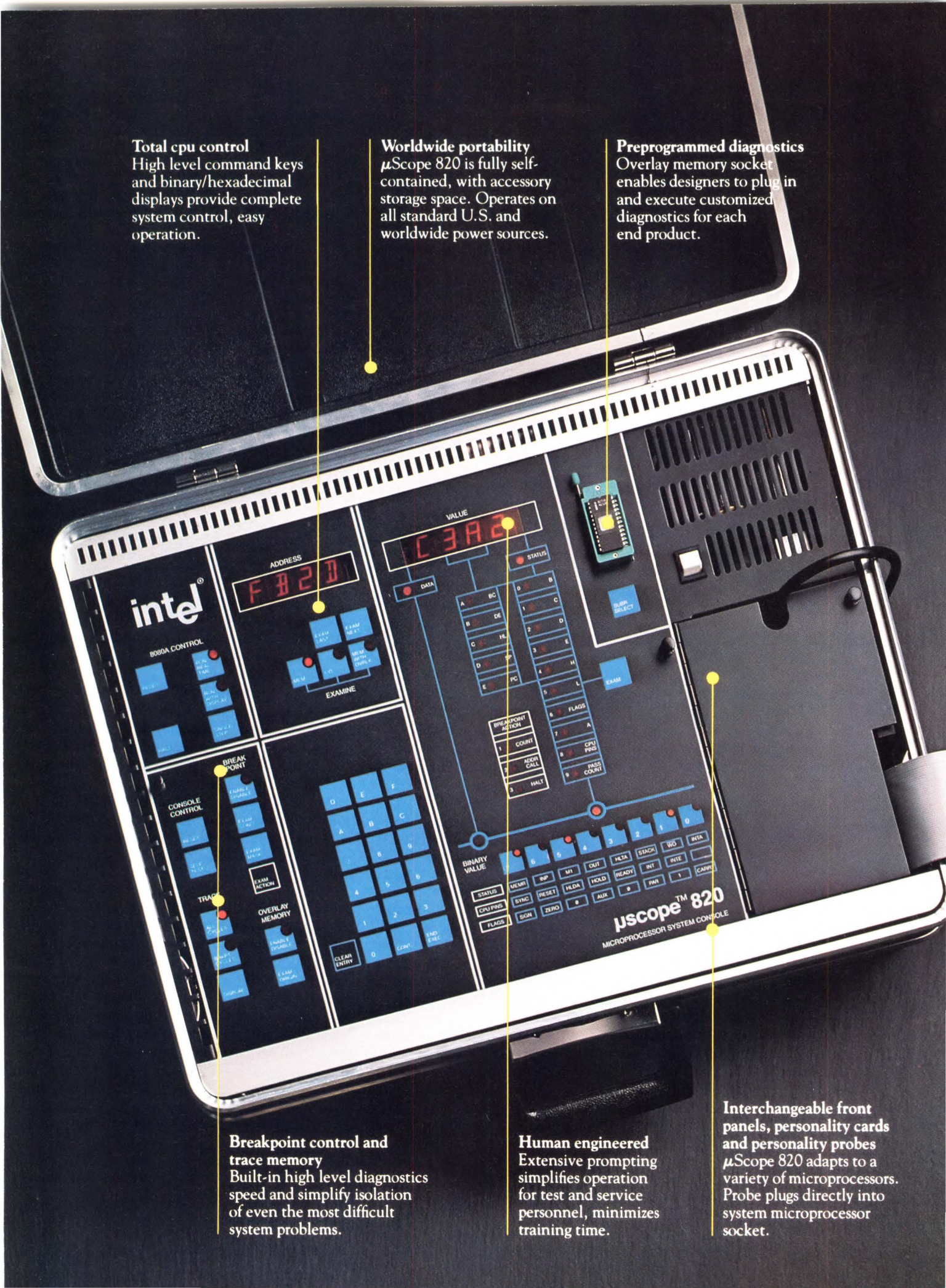
By no means does he take sole credit for developing the 810-D. "It was a case of team support rather than team leadership," he says. In those weeks before Wescon/73, "I had tremendous support from our engineering and manufacturing departments. There was a lot of overtime for scores of people." The marketing of the instruments, he adds, "was superbly done, for a small company. [Marketing manager] Dave Blecki and his people took a new concept and ran with it."

Although Biomation has since added binary notation of the logic state as a feature in some of its newer logic analyzers, that approach was never considered for the 810-D, notes Moore. House says HP did not adopt the logic-timing-diagram method "primarily because we were concentrating on the bus-transaction information of algorithmic-statement changes, and not electrical parameters of an asychronous system."

For Biomation, the 810-D's development "made the company what it is today," Moore says. "It made a step function in our growth and allowed us to participate in the whole logic-analyzer field." Perhaps more important, "it was extremely significant to industry, particularly in an economic fashion. It was a relatively inexpensive solution to a truly major class of problems."

Their manufacturers have replaced the 810-D and the 1601L with newer products, and Moore thinks that the future of the logic analyzer is bright. "I believe it is the most significant instrument to come on the market since the oscilloscope," he says. What's more, "I think we'll see a long and very exciting evolutionary process for logic analyzers as their capabilities and performance increase for a long time to come."

House concurs: "Digital electronics is going to be so pervasive in our society, in terms of controllers and computational capability in things that affect us all, that the measurement equipment to support their design, manufacture, and assurance of correct performance is destined to become an integral part of the digital-electronics revolution. In 20 years, I suspect the data-domain analysis technique will be the cornerstone of the digital-electronics industry, just as frequency-domain analysis techniques have been the cornerstone of the communications industry from its inception." □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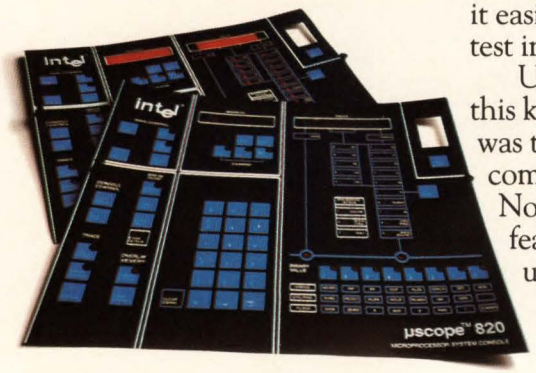

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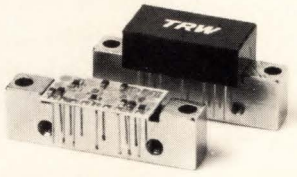

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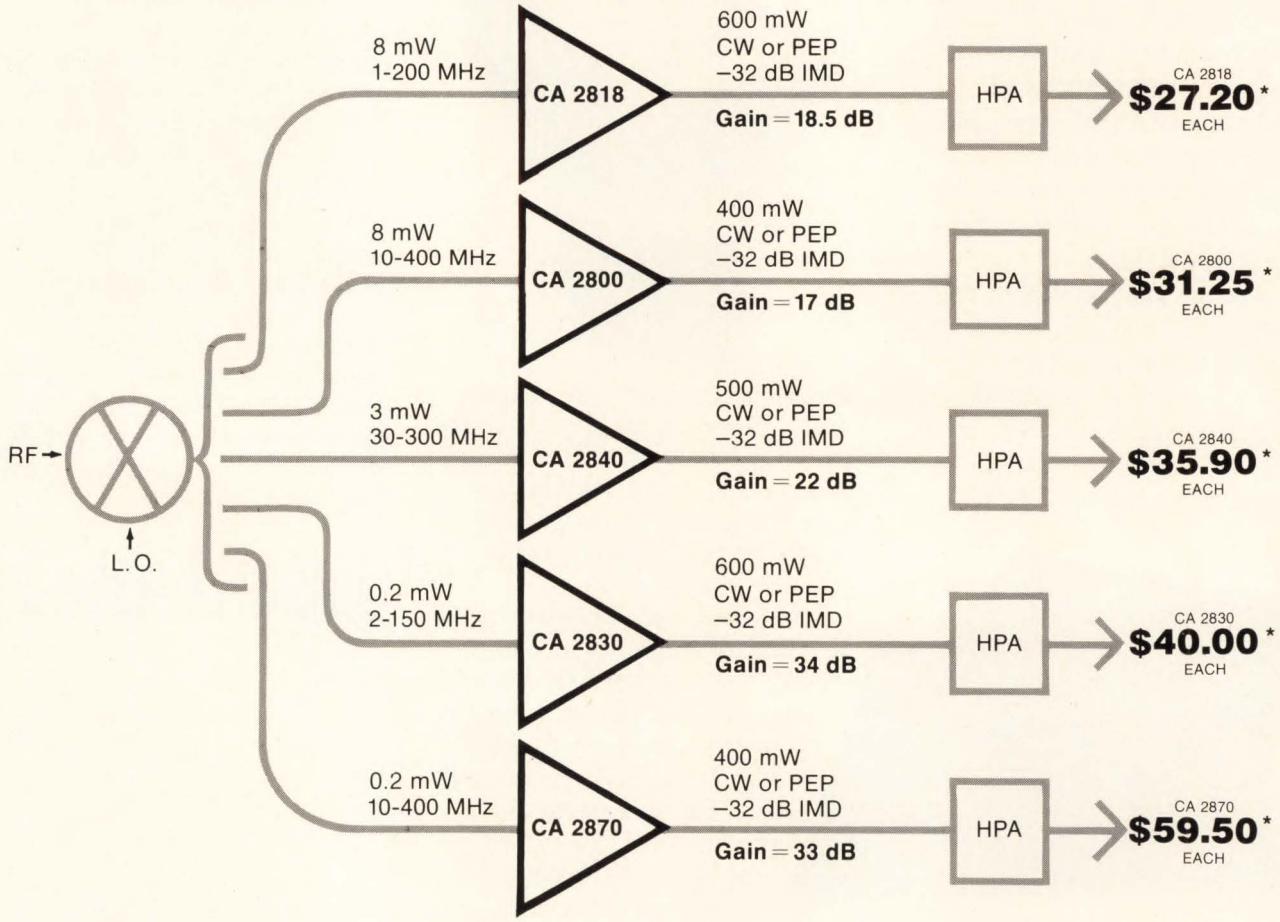

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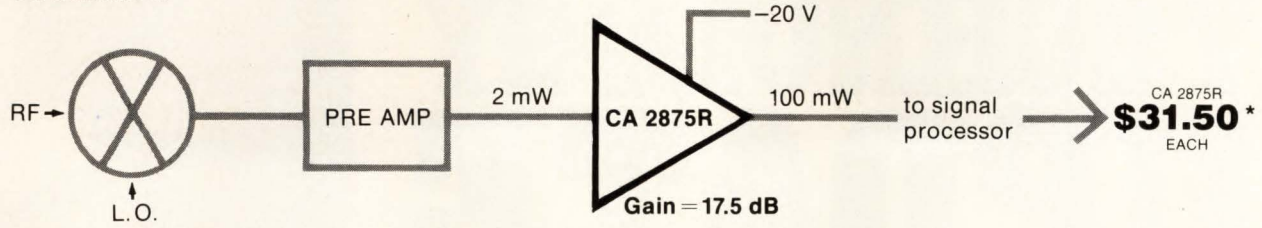

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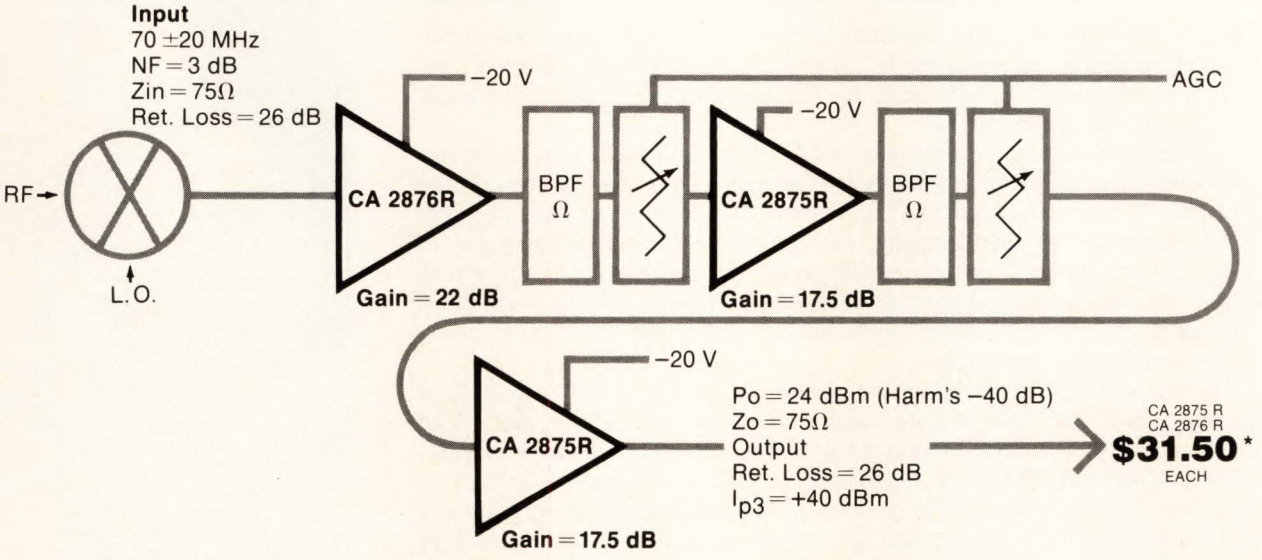

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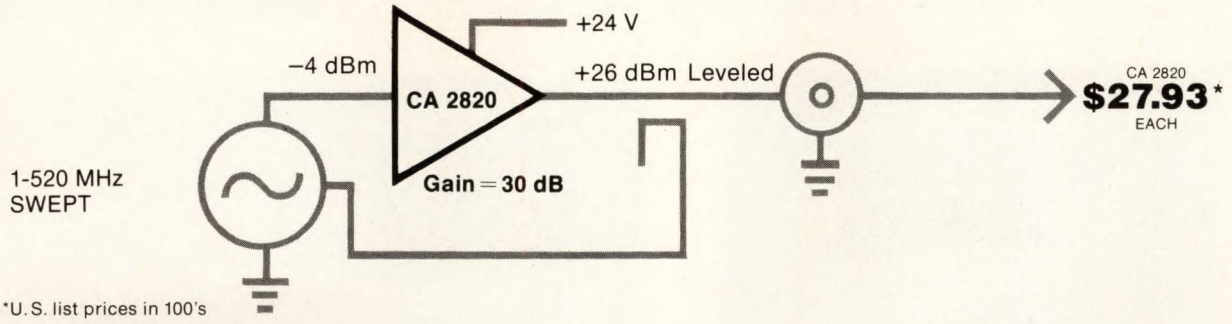

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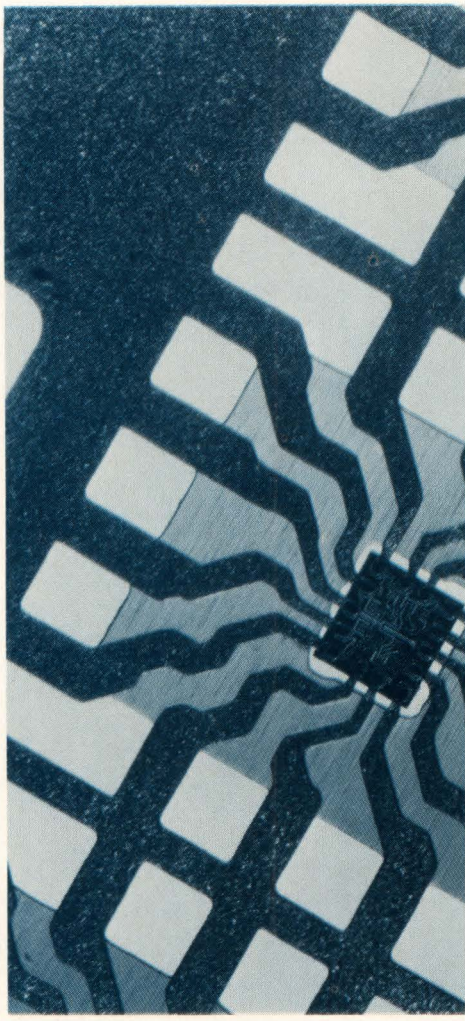
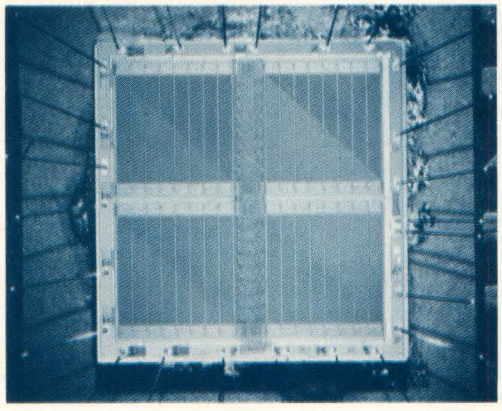
TECHNOLOGY UPDATE

In any ordinary year, the seasoned observer of the electronics scene can count on significant advances in technology that will radically affect the direction of product development. By that standard, 1977 must be considered an extraordinary year.

In semiconductors, for example, the 4,096-bit and 16,384-bit memories have become established products; and memory technology stands on the frontier of the 65-k and 262-k realm. The advent of the one-chip microcomputer is accelerating the application and acceptance of computer power in a host of new areas of application. Nor is the end in sight—already semiconductor development is moving briskly toward still denser chips and still higher performance, under the impetus of newly emerging fine-line processes.

Along with the microprocessor revolution, a major new direction is being forged for instruments—logic analyzers and other specialized instruments in the data domain. In communications, large-scale integration and optical fibers are beginning to have a discernible impact on systems. In computers, minis with extended capabilities are threatening the dominion of mainframes; in consumer electronics, technology nurtured both by the public's restless search for diversion and by the exigencies of fuel and pollution control has spurred the advent of programmable video and nonvideo games, video tape recorders, and intelligent (almost) television sets, along with computers in autos. In sum, the remarkable progress in 1977 indicates no sign of slackening.





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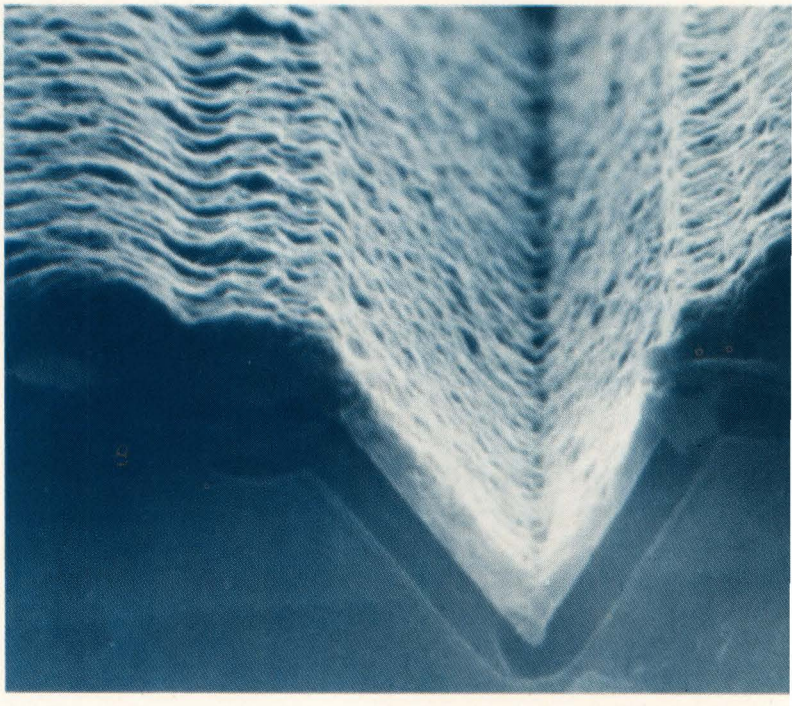

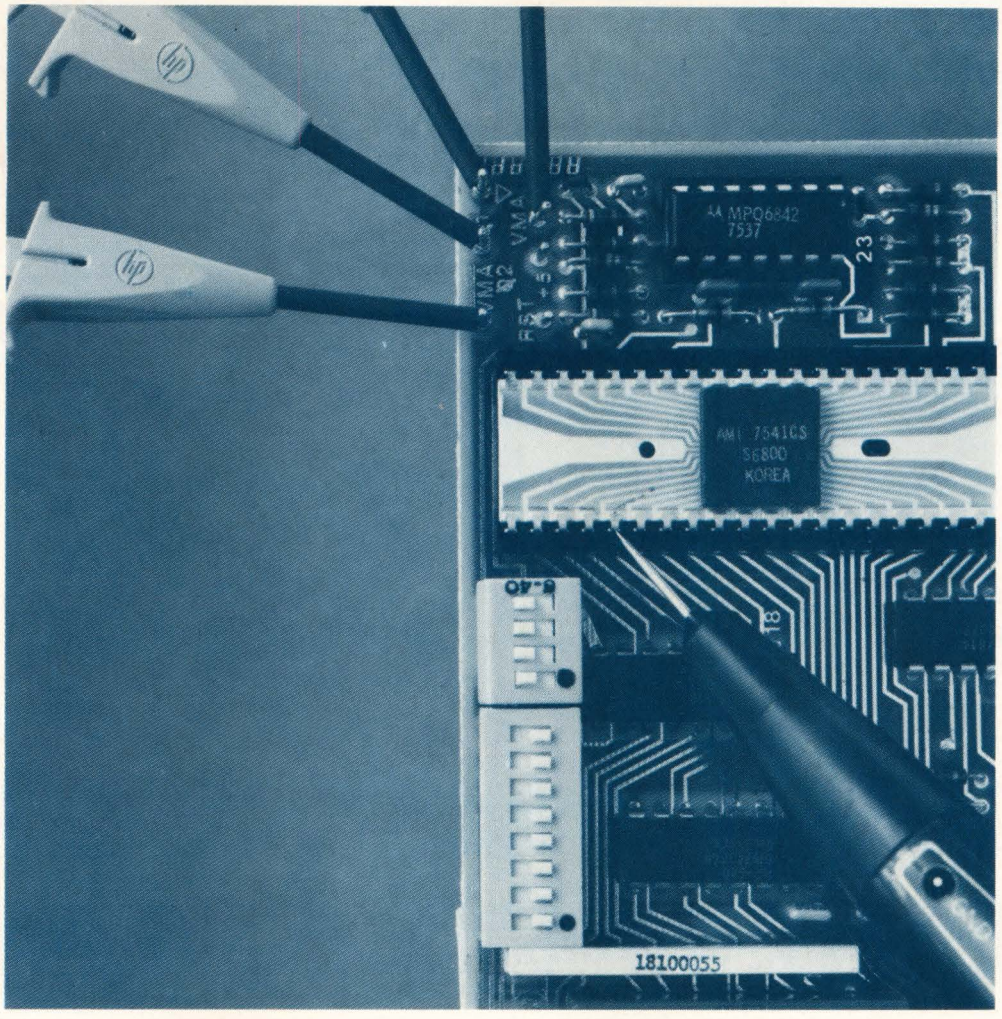
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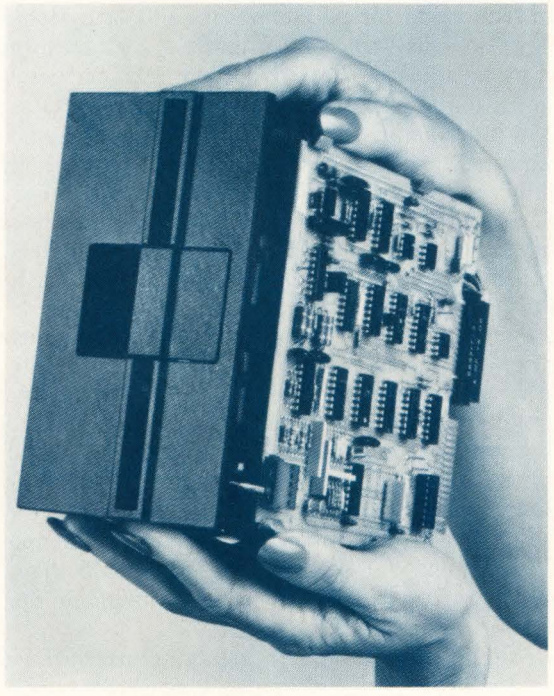
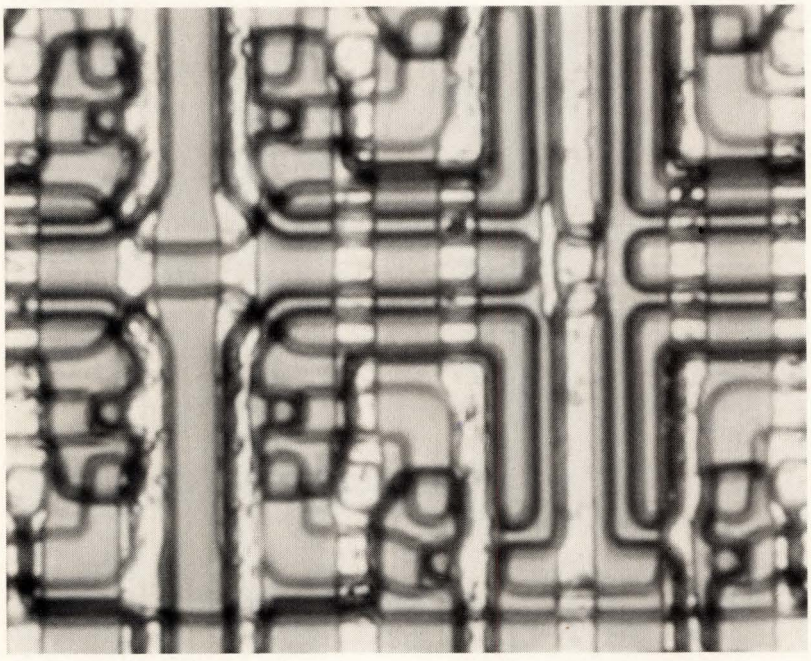




Pushing performance. This microphotograph shows a section of Intel's 50-ns 4,096-bit static RAM built with a 4-μm MOS process. This is the year when short-channel MOS processes such as this one will reach production in both memory and across the LSI logic products spectrum. The result: new levels of performance for next-generation digital semiconductors.

NEW MOS PROCESSES SET SPEED, DENSITY RECORDS

by Laurence Altman, *Solid State Editor*

☐ In semiconductors, a component and subsystem technology is on the verge of becoming a high-performance systems technology. For if the last year or so saw the optimization of established products like 4,096-bit and 16,384-bit random-access memories and 8- and 16-bit microcomputers, the next 12 months will witness the birth of processes leading to very-large-scale integration: 65,536- and 262,144-bit read-only and random-access memories, fast 16- and 32-bit one-chip computers, and VLSI peripheral chips performing entire process-control and telecommunications functions.

In short, 1978 will be a signal year in digital electronics. For the semiconductor manufacturer, it will be a time when advanced, high-risk, VLSI process technology, costing tens of millions of dollars to develop, must be put into production. For the system and equipment designer, it will be a time of radically innovative redesign around these VLSI components. Indeed, what happens in the next 12 months will determine how electronics components and equipment will be built, who will build them, and what new markets they will serve throughout the next decade.

Already key semiconductor manufacturers are jostling for a dominant position, as five high-performance VLSI processes emerge. As yet, it is too early to predict which process will capture the major portion of next-generation digital designs, but it is already possible to foretell their relative effectiveness for different applications.

The technique in widest development among American manufacturers for next-generation devices is a scaled-down, high-performance version of standard silicon-gate MOS processing—Intel Corp., Santa Clara, Calif., dubs its version H-MOS.

What makes scaling an MOS device so attractive is the familiarity of the procedure. For 20 years the industry has known that a semiconductor device's performance and density increases geometrically as the dimensions of the circuit elements are shrunk. So the trick has been to reduce the channel length, gate-oxide thickness, junction depth, and so on of their circuit elements. (For a complete discussion of device scaling, see the special report on the new LSI processing, *Electronics*, Aug. 18, p. 91). At Intel, H-MOS devices have at most 4-micrometer channel lengths, 600-to-700-angstrom gate-oxide thicknesses, and junction depths of less than 1 μm—all about one third to one half the size of these parameters in 1976 silicon-gate devices. The result is triple the performance of the old MOS devices: a 1-picojoule speed-power product, as against 3 pJ for 6-μm MOS.

Intel has already applied this 4-μm H-MOS process to a

4,096-bit fully static RAM, the 2147, which is as fast as bipolar RAMs but consumes 500 milliwatts instead of at most twice that much. Moreover, the H-MOS process lends itself with no loss of speed to power-down designs, in which unselected RAMs can idle at a mere 50 mw, a particularly attractive feature for large static systems.

The rapid success of Intel's 4-μm MOS process has caused the rest of the industry to evaluate and in some cases accelerate its scaling programs. Mostek Corp., Carrollton, Texas, for example, who from the beginning has scaled its n-channel, depletion-load MOS process, is already using a 4- and 5-μm single-5-volt process in new high-performance 4104 static RAMs and 3870 one-chip microcomputers. According to Robert Proebsting, MOS device designer, Mostek's policy is to scale devices to the limit that is consistent with high reliability. "There's nothing magical about it," says Proebsting. "We have been doing it for years, and we will continue doing it where appropriate."

Similar n-MOS programs are under way at Motorola Semiconductor, Texas Instruments, National Semiconductor, Signetics, and Fairchild Semiconductor. They are at various stages of applying scaled-MOS processes to all sorts of LSI products: microprocessor central processing units, LSI peripherals, read-only memories, erasable programmable ROMs, and dedicated chips, such as telecommunications coder-decoders, random control logic, and consumer circuits for games, television sets, citizens' band radios, and so on.

Such an instantaneous, across-the-board exploitation of a new technology is unusual, but in this case it happens because H-MOS and the other scaled processes are a direct extension of proven silicon-gate processing. Nevertheless, scaled devices are more expensive to build, needing smaller integrated-circuit patterns and stricter and more complex processing. Hence the question: does the revised process improve enough upon the density and performance of the standard silicon-gate process to be worth the added expense?

Yes, judging from Intel's instant success with the 2147. In volume, the part will cost about the same as or less than equivalent bipolar RAMs, yet it offers four times as many memory bits. Moreover, applied to microcomputers, a scaled-MOS process will result in a 16-bit CPU that is comparable in performance but lower in cost than minicomputer-type bipolar chips. For complex peripheral functions, such as floppy-disk or cathode-ray-tube controllers, H-MOS processing for the first time supplies a truly high-performance LSI approach—previous MOS or transistor-transistor-logic versions often proved either too slow or too costly for many applications.

But is it reliable?

Cost and performance aside, the tougher question for H-MOS designers is reliability. If a semiconductor device is made small enough, normally negligible second-order effects begin to obtrude and cause nonideal behavior. Eventually, the device's operation suffers from such second-order problems as charge fringing, punch-through at low voltages, and threshold voltage shifts.

NEW MOS DEVICE TYPES COMING THIS YEAR

Type	Process	Performance	
		Access time (ns)	Power (nW)
4,096-bit fully static random-access memory	silicon gate	125	500
	H-MOS	80	300
	V-MOS	80	300
4,096-bit fully static fast RAM	silicon gate	–	–
	H-MOS	50	500
	V-MOS	45	450
65,536-bit read-only memory	silicon gate	300	500
	H-MOS	250	500
	V-MOS	200	300
16-bit microprocessor	silicon gate	350	600
	H-MOS	250	500
	V-MOS	150	500
LSI peripherals	silicon gate	500	500
	H-MOS	300	500
	V-MOS	300	500
16,384-bit erasable programmable ROM	silicon gate	500	500
	H-MOS	300	500
	V-MOS	300	500

Fortunately, at the 4-μm, 600-angstrom level of today's H-MOS geometry, these second-order effects either are still too small to affect reliability or can be fixed with tight process control. The oxide must be kept very pure, and the gate-doping profiles and field-doping regions kept in line with ion implantation. After using these precautions, Intel engineers have found that their H-MOS 4-k RAMs survive accelerated life tests as successfully as any other of their memory products.

The shoot-out

While H-MOS processes are taking hold at many semiconductor manufacturers, an outside MOS technique has emerged that promises to battle them for dominance in many applications. The process is V-MOS, and its developer is American Microsystems Inc., Santa Clara, Calif.

A double diffusion in the channel region allows V-MOS transistors to operate as if they had an ultra-short, 1-μm channel while they are actually fabricated with relaxed 5-to-6-μm pattern rules. Thus they achieve high performance without the fine pattern geometry and process stringency of H-MOS.

Moreover, the V-MOS transistors are built on the slanting inner surface of a V groove, anisotropically etched into the silicon substrate to give access to the buried V-MOS source. This use of a third spatial dimension makes for very compact VLSI circuitry, capable of packing about 20% more circuit elements than H-MOS onto a piece of silicon. To top things off, V-MOS transistors, if scaled down to 4-μm H-MOS rules, will be faster and consume less power. The speed-power product is 0.5 pJ for V-MOS, 1 pJ for H-MOS.

Paper comparisons are useful, but the bottom line to

all this process activity is product performance: speed, power, cost, and availability. The question by now is how quickly and at what cost the new devices—Intel's 4-k H-MOS RAMs and AMI's samples of 1-k and 4-k V-MOS RAMs—can be put into high-volume production. Both types clearly will be more expensive to manufacture than standard 6-μm silicon-gate devices. But as for which will manage to undercut the other, IC manufacturers and users will be able to make their own evaluations this year, as H-MOS and V-MOS products take their place alongside conventional silicon-gate products (see table).

A Japanese entry

A third MOS technique that may make an impact on LSI design in 1978 comes from Japan. It is D-MOS, a planar double-diffused process that like V-MOS produces seemingly short-channel devices. Manufacturers like Nippon Electric Corp. and Mitsubishi Electric Co. have built 4-k D-MOS static RAMs and 8- and 16-bit D-MOS microprocessors for evaluation in dedicated programs. But these parts are not expected to be sold abroad this coming year.

For export purposes, Japanese manufacturers appear at the moment to be concentrating on short-channel MOS processes, similar to H-MOS. Once developed, these would be used to copy Intel's 2147 plus any peripheral chips and other devices that become U. S. industry standards.

As H-MOS and V-MOS slug it out in center ring, two more processes will attract the attention of users. They are integrated injection logic and silicon-on-sapphire. While both appear to be useful for dedicated applications, fewer and fewer integrated-circuit specialists feel they represent mainline digital techniques capable of producing a wide range of device designs at most semiconductor manufacturers.

I^2L has had dramatic success in dedicated LSI designs, such as game and watch chips, telecommunications control circuits, and mixed digital and analog circuits. But it is finding standard digital LSI designs harder to penetrate, except in very high-performance areas. Here, the line of I^3L dynamic 4-k and 16-k RAMs made by Fairchild Semiconductor, Mountain View, Calif., are being used in systems requiring access times that are shorter than the 150 nanoseconds available from n-channel MOS devices.

In the running

As for the silicon-on-sapphire process, Hewlett-Packard Co., Palo Alto, Calif., has stayed on schedule with its complementary-MOS-on-sapphire program and has introduced ROMs, RAMs, and a 16-bit CPU into its instrument and computer lines. RCA Corp. is still evaluating the SOS technique for advanced product designs, while other commercial manufacturers continue to show only theoretical interest in developing the process for some applications, at least for the next few years.

PROFILE

The man who added another dimension to MOS

It was October 1975. One of the worst semiconductor slumps in the decade had cut deeply into the profits of American Microsystems Inc. To make matters worse, AMI had invested heavily in the digital-watch business, and it hadn't worked out.

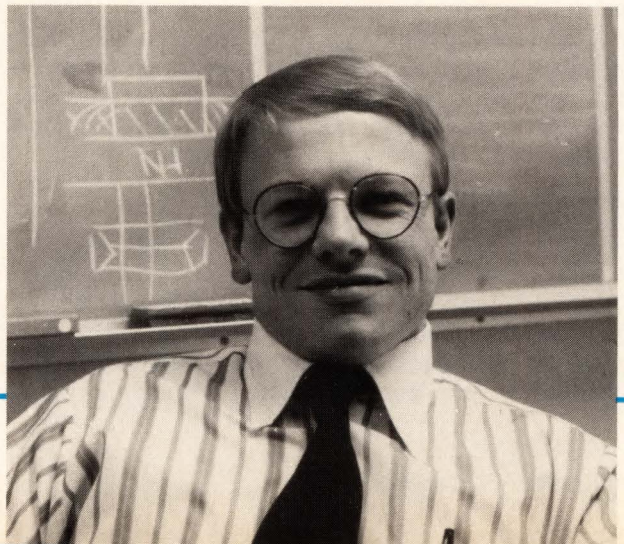
That's why its top management listened carefully when an energetic 28-year-old Ph.D. student from Stanford University's nearby integrated-circuit laboratory told them about a new metal-oxide semiconductor process that, he said, would put the Santa Clara company in the forefront of MOS device technology. Clearly, it would be a gutsy gamble, because the process was based on a radically different device structure requiring circuit elements that were built on the face of a V groove cut into the MOS substrate. It could cost several million dollars and no telling how long to get the process running in production.

Luckily, the Stanford student was a super salesman as well as a shrewd technologist, and he persuaded AMI management to go along with the idea. They are not sorry. T. J. Rodgers produced his first V-MOS memory prototype just six months after joining AMI and his first production-ready 1,024-bit static RAMs only 18 months later—and he did it for less money than anyone had expected.

The result: less than two years after Rodgers started working at AMI, the company has launched a line of V-MOS memory products that leads the MOS industry in speed and density.

Rodgers is quick to give credit to AMI management, especially Donald Trotter, vice president of research and development and his immediate boss in the early days. "Don gave us the support we needed for doing the job," says Rodgers. "He sheltered the project in times of peril, like the 4-k crash. No matter what was happening around us, we were able to do our own work. Of course, we could be pretty loose in those days since we were pushing one process for one product. All we needed was a few good people working long hours."

Things are different for Rodgers now. As newly appointed head of memory development, he has to get some six different memory products ready for production in a short time. "That takes a lot of product engineers, a lot of test people, a lot of hustling, and a lot of bucks," he says. "The game has changed."



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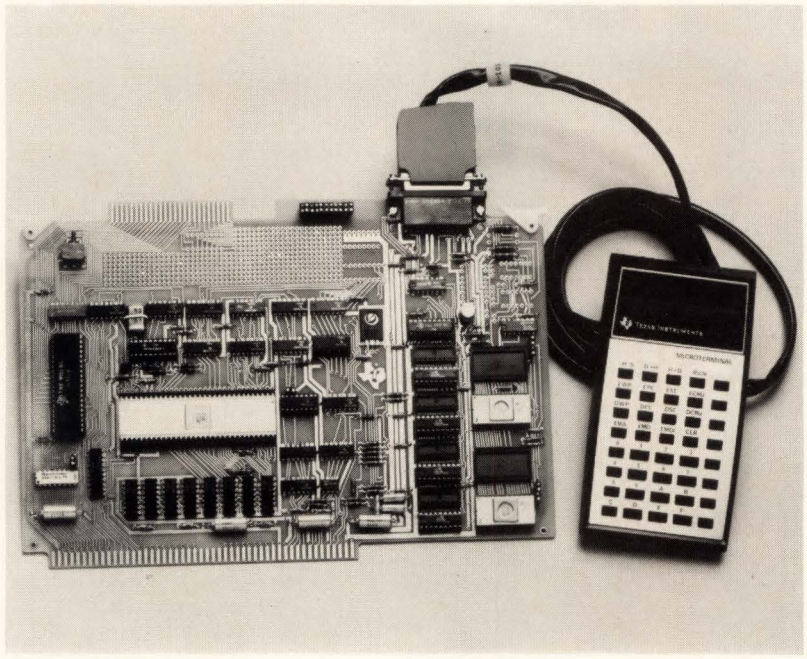

And now systems. Manufacturers of microcomputers are becoming more systems-minded. Texas Instruments' TM990 series of boards, for example, comes with a minicomputer-like debug monitor in a resident read-only memory. The family has a complete line of accessories available, including the hand-held terminal, shown here, for entering and displaying data.

ONE-CHIP CONTROLLERS AND 4-K STATIC RAMS STAR

by Laurence Altman, *Solid State Editor,* and Raymond P. Capece, *Computers Editor*

☐ Expect another big year from the chip makers as they get ready to loft a barrage of new-technology memories, one-chip microcomputers, bigger but cheaper peripherals, and a host of new microcomputer boards that extend the capability of input/output and analog interfacing.

The big story in memory is the emergence of new fast mainframe storage, made possible by a new breed of fast but modestly priced random-access-memory components. These are the under-70-nanosecond 4,096-bit RAMs. They come either in static formats built with advanced metal-oxide-semiconductor processes, such as H-MOS or V-MOS, or in static and dynamic formats built with integrated injection logic.

In microcomputers, get ready for still more powerful one-chippers—8- or 16-bit devices that can cut the parts count and cost of many controller configurations previously handled by multichip designs. Also on the way are large-scale integrated versions of complex peripheral controllers: keyboard and cathode-ray-tube controllers, data-link and memory controllers, and slave central processing units that once took tens to hundreds of costly transistor-transistor-logic packages to implement. It has indeed become an LSI world for digital-system designers.

The big 12-month push made by memory makers in static design is paying off with devices that change the rules for deciding whether to go static or dynamic in system designs (Table 1). It used to be simple: a small, slow peripheral-memory application meant static components—there was not enough memory to justify the overhead refresh and timing circuits required with dynamic types, even though they were faster and cost less per bit. For mainframe, it was just the opposite: when speed was needed and low bit cost desired, and there was enough memory to share the peripheral circuitry, the choice was dynamic.

Static RAMs: fast and power-thrifty

It is more complicated now, with a battle shaping up in very fast mainframe designs. Intel, AMI, TI, and Fairchild all have new memories with access times below 70 ns. Intel Corp. made the first move with the 2147, a 4-k device designed with its high-performance H-MOS process, and American Microsystems Inc. plans to stay neck and neck with V-groove MOS versions. Texas Instruments Inc., on the other hand, is reaching volume production with its S400-series integrated-injection-logic static RAMs, while Fairchild Semiconductor offers its dynamic line of Isoplanar I^2L, or I^3L, devices.

The 2147 from Intel in Santa Clara, Calif., breaks

new ground by combining its 4-micrometer MOS process with an elegant static design. The chip has not only a typical 45-ns access time but also an easily accessible chip-select power-down mode (50 milliwatts standby) that does not slow it down. Intel application engineers claim that, thanks to the combination of high speed and low standby power, the MOS part is getting heavy attention from mainframe designers, who have stayed away from bipolar static designs. The device also promises to capture sockets from bipolar static memories in cache systems as well. Look for heavy second-sourcing as the industry cranks up its high-performance MOS processes.

AMI will be fighting in the same high-speed territory with an impressive line of V-MOS static parts, including a 32-ns, 1,024-bit RAM, the S4015-3, that is already in volume production, and three 4-k versions. The latter, intended to compete head on with the 2147, are being offered in 1-k-word-by-4-bit and 4-k-by-1-bit configurations, each sporting a typical access time of 50 ns, and a slower, 4-k-by-1-bit low-power version. The Santa Clara, Calif., firm is also planning a 125-ns 1-k-by-8-bit device for byte-oriented microcomputer memory systems. Thus, with this wide assortment of V-MOS parts and with a strong second source (TI) committed to V-MOS technology, designers of fast memory systems will have two lines of fully available and well-supported static MOS RAMs to evaluate and compare with bipolar components.

Bipolar enhancement

Meanwhile, bipolar memory designers are enhancing their technology for an all-out battle in cache memory systems with the encroaching MOS devices. For example, Fairchild Semiconductor, in Mountain View, Calif., the largest supplier of bipolar RAMs for cache memory systems, has tightened its Isoplanar process, coming up with walled-emitter, fully implanted TTL and emitter-coupled-logic designs. The result is a 30% reduction in both chip size and access time.

Fairchild designers are also taking aim at the new under-100-ns mainframe applications, using dynamic injection-logic designs that offer a significant reduction in access time over pin-compatible 4-kilobit and 16,384-bit MOS dynamic parts. These 94481 devices range in speed from 100- to 200-nanosecond access time and 240- to 280-ns cycle time, compared with 150-ns access and 320-ns cycle times for the fastest MOS parts. Equally important, the 93481s will be useful in big-mainframe page-mode applications, giving the designers access to a memory page in 65 to 76 ns, compared with 90 and 125 ns for the MOS dynamics.

While the latest under-100-ns static devices offer designers new choices in fast mainframe and low-cost cache systems, a difficult choice must also be made in more traditional peripheral and microcomputer static memory designs. The question is whether to use Intel's fully static 2114 types, which are straightforward upgradings of the popular 2102 devices, or switch to a single 5-volt clocked part, such as Mostek's 4104 (4-k-by-1-bit) or 4114 (1-k-by-4-bit) or AMD's 9130 and 9140 types. (One-, two-, and three-power-supply parts are also available from Semi Inc.)

Some tradeoffs

The 2114 requires no setup signal, as do the 4104/4114 types, which are activated by a chip-select timing signal that is often already available in system designs. But 2114s do consume more power: from 370 to 525 mw, compared with 120 mw for the clocked 4104 parts. For the user, the choice will be heavily influenced by the size of the memory system—the lower power of the clocked devices will favor the large-system user. In any event, access times for the two types are a standoff—in the 200-to-300-ns range.

Beyond static RAMs, memory device technology will reach new levels of density and speed in 1978 as new processes and techniques are applied to read-only memories, erasable programmable ROMs, electrically erasable PROMs, charge-coupled devices, and bubble memories. In PROMs, users can look forward to 32,768- and 65,536-bit MOS devices capable of being accessed in 200 to 300 ns—two to three times faster than most of today's 16-k ROM devices. These devices will mean larger program storage at higher throughputs for less money, especially in the larger, more powerful microcomputer systems now becoming available.

The ultraviolet-light-erasable PROM moved up to the

TABLE 1: 1978 UNDER-100-NS STATIC MEMORY DESIGNS

Parameter \ Type	H-MOS 4-k 2147 type	V-MOS 1-k and 4-k types	Schottky I^2L static S400 types	I^3L (93481) dynamic 4-k and 16-k types	93415 1-k to 4-k TTL types
Density (bits)	1,024 – 4,096	1,024 – 8,192	1,024 – 16,384	4,096 – 16,384	1,024 – 4,096
Access time (ns)	50 – 70	50 – 70	70 – 100	100 – 125	30 – 70
Cycle time (ns)	50 – 70	50 – 70	70 – 100	240 – 280	30 – 70
Power dissipation					
active (mW)	500	500	450	500	750
standby (mW)	50	50	25	–	–
Package size	18	18	18	16 (multiplex)	18

Source: Electronics

TABLE 2: 1978 STATE-OF-THE-ART MEMORY TECHNOLOGY

Device type	Access time (ns)	Active power dissipation per chip (mW)	Application
4-k to 16-k MOS dynamic RAMs	150 – 300	400 – 600	large mainframe and microcomputer-based systems
4-k fully static 2114-type MOS statics	150 – 300	500	peripheral and microcomputer systems
4-k clocked 4104-type MOS statics	150 –200	120 (30 standby)	peripheral and microcomputer systems
1-k to 4-k fast MOS statics	50 – 100	500	fast mainframe, cache, or microcomputer-based systems
4-k to 16-k I^3L dynamic RAMs	90 – 125	500	fast mainframe and microcomputer systems
4-k to 16-k I^2L static RAMs	70 – 125	500 (20 standby)	fast mainframe, peripheral, and microcomputer systems
1-k to 4-k TTL/ECL static RAMs	30 – 70	500 – 1 watt	cache
32-k to 64-k MOS ROMs	200 – 500	500	fixed memory and program storage
1-k to 8-k TTL ROMs	50 – 100	700	fixed storage
8-k to 16-k EPROMs (UV-erasable)	500	500	prototype program storage
8-k EAROMs nitride types Famos types	 1 μs 500	 500 500	nonvolatile RAM; reprogrammable ROM
64-k CCD memory	1 μs	500	disk replacement; auxiliary serial memory
100-k to 1,000-k bubble memory	10 μs	500	nonvolatile disk replacement; microcomputer storage

Source: **Electronics**

16-kilobit level as manufacturers followed Intel, who invented the device, to higher densities using a more sophisticated 5-v floating-gate MOS, or Famos, process. As for electrically erasable nitride and Famos PROM devices, they too will improve in density and become more attractive in such systems as reprogrammable point-of-sale terminals and TV tuners—systems that require nonvolatile, periodic updating.

For CCD memory, 1978 will be a decisive year. The technology has finally reached the 65-k chip level—a density that makes the cost per bit low enough for system evaluation. Moreover, Fairchild, Texas Instruments, and Intel all will have 65-k devices that are fast enough (500 ns to 1 millisecond) for many microcomputer applications, where they could be used in place of floppy disks as auxiliary storage; in this case, a page of working data is transferred from the disk to the CCD for handy use during a routine and returned when the operation is completed.

Finally, there are bubbles. TI's 92,000-bit bubble chip, along with peripheral bubble drivers, detectors, and controllers, has finally given the systems designer an opportunity to evaluate this potentially attractive mass-storage technology in prototype systems. Being nonvolatile and equal in cost with mini-floppy storage, bubble systems could be used immediately in floppy-based microcomputer systems as replacements for floppies. Bubbles are now about twice as fast as conventional floppies, but most important, they should decrease sharply in price over the next few years as higher levels of bubble-chip integration (1 million to 2 million bits) become available.

Those powerful one-chippers

The appearance last year of the powerful 8-bit one-chip microcomputer marked a flowering of semiconductor techniques in data-processing applications. Intel's 8048 family, Mostek's 3870, and TI's 9940 are currently the most prominent of these chips, but all have enough processing power and real-time control capability to handle applications that formerly needed more expensive multichip microcomputers. This is especially true of configurations requiring a modest amount of memory but a lot of I/O control. For example, it is now possible to build a complex printer capable of handling many inputs with, say, a single 8048 microcomputer chip and one TTL driver instead of 12 chips from the 8080 family.

The 8-bit types differ in their details. Some are software-compatible with multichip families; others stand alone. Some have UV-erasable program options; others are mask-programmable only; and so on. But they all have in common an 8- or 16-bit CPU and an accumulator stack, 1,024 to 2,048 words of ROM, 64 to 128 words of scratchpad RAM, and ample I/O capability of 24 to 32 lines that is sometimes expandable to 256 lines. Also, they all have fairly powerful instruction sets of up to 70 instructions, including some highly sophisticated routine-interruption capability.

Manufacturers are also working on the low-end 4-bit microcontrollers, as well as shoring up their multichip high-performance line. Rockwell, TI, National, and General Instrument have boosted their low-cost ($5 and under) 4-bit capability with higher-performing devices. Rockwell Microelectronics offers the largest line of 4-bit microcomputers, the PPS 4/1 family, and has just introduced its newest member, a p-channel MOS chip, the MM76C, that incorporates a programmable counter-timer and analog-to-digital interface logic on the chip. National and TI will be offering n-channel versions of their p-MOS COP and TMS 1000 series, respectively which increase throughput and instruction capability at no extra cost. National, for example, will be offering its

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At the same time that manufacturers are boosting their one-chippers, they are upgrading their multichip families. In response to Zilog Inc.'s Z-80, an enhanced 8080 multichip system, Intel developed its high-performance 8085 three-chip set, which matches the Z-80 in memory capacity, instruction power, and throughput. Now, as other manufacturers move into the high end, they must decide whether to enhance the 8-bit family as Intel did, move straight into the 16-bit minicomputer as TI did with its TMS 9900, or do both. It appears that National and Motorola will enter 16-bit systems, while Intel and its followers will most likely do both.

More important than CPU enhancement, however, is the increased peripheral-chip capability now being offered as part of all multichip families. These peripheral controllers—CRT, data-link, keyboard, floppy-disk, and memory—are more complex than the CPU themselves, containing a high level of processing and local control. For example, the LSI versions of a CRT controller are programmable with system software to handle X, Y, scan, display, erase, and retrigger commands, all with on-chip controls. What is more, these versions do not use up any of the CPU's processing time.

The next level of integration is microcomputer boards, and here chip manufacturers have stepped up their activity, offering families of system-compatible memory, arithmetic, analog, and control boards for use directly with their multichip lines. Intel and Zilog currently lead in the number and variety of digital boards available, while TI and Motorola continue to fill out their lines.

Minicomputer makers with microcomputer products are also very active in new board entries. Besides building up I/O and special-function hardware to fill out their lines of microcomputer boards, companies like Digital Equipment Corp. and Data General Corp. now offer upwardly compatible software that allows users to move from microcomputers right into minis.

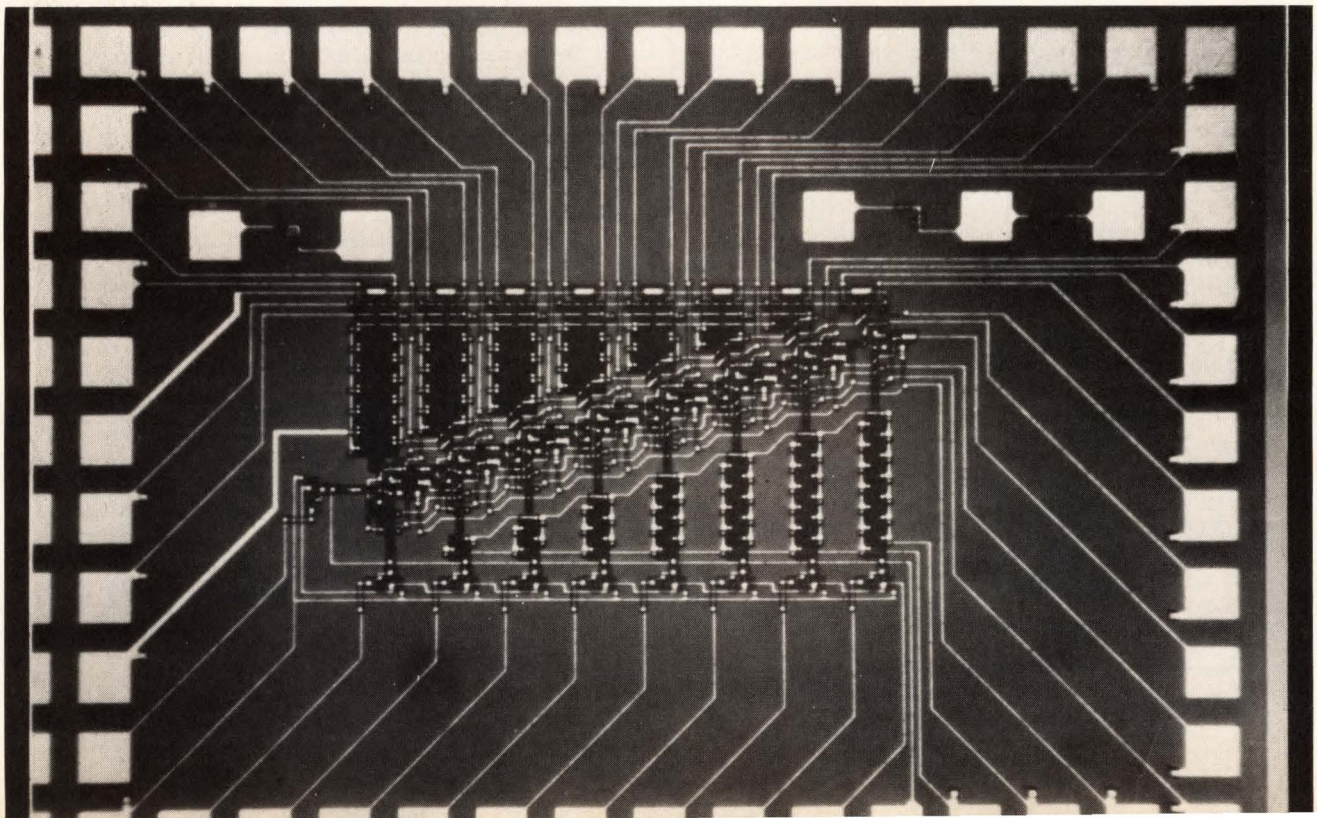
Four types of board

In general, new board entries fall into four categories: processor boards, which may be CPU only or CPU, memory, and I/O combinations; memory-extension boards that contain 64 kilobytes or more of ROM or RAM, or combinations of both, with I/O logic (some even have battery backup); special-function boards that perform fast floating-point arithmetic and calculator operations, a-d conversion, or timing functions; and I/O boards that include serial and parallel interfacing, multiline digital inputs and outputs, opto-isolation, and a wide variety of analog I/O functions for both voltage and current signals.

Of the four, the newest type is the analog I/O boards, which eliminate the tedious task of designing the interface between the microcomputer and the analog equipment it controls. They will be especially useful to digital designers who may not be conversant with analog design.

Analog boards are now readily available in a variety of configurations for direct connection to the microcomputer. They are being supplied not only by several microcomputer houses, like Intel, Zilog, Motorola, and DEC, but also by a number of non-microcomputer suppliers, among them traditional converter manufacturers like Analog Devices Inc., Burr-Brown, and Datel Systems

It adds up. For the first time, charge-coupled devices are being used for logic operations. Using CCD configurations, this 8-by-8-bit full adder-multiplier from TRW can perform additions and multiplications needed in complex signal-processing systems.



Inc., as well as specialty suppliers like Adac Corp. and Data Translation Inc.

A newcomer to the field is the very-low-cost board that is taking aim at dedicated control applications. Intel announced an under-$100 single board based on its 8085 family, for example. Though the board has no bus-interfacing capability, it has ample RAM and ROM for stand-alone applications. TI has added an entire low-cost 16-bit line, the TMS990 series. Its TMS990/100M not only includes a debug monitor in its erasable PROM, but also has a breadboarding section with empty sockets.

Microcomputer designers are also being offered new system capability as evidenced by the appearance of applications software. Programs that manage the execution of microcomputer tasks—the same as used in large computers—are more prevalent and saving designers a good deal of time. These real-time executives are either disk-based or in a relocatable software module that resides in a ROM. Intel's RMX/80, one of the latter kind, requires only 2 kilobytes of ROM.

Development systems

Microcomputer system designers are also enjoying a greater variety of more powerful development systems. Witness the growth of available systems over the last two years, when Intel introduced the first microcomputer development system for its 8080 family. Besides having development and in-circuit emulation capability for its established 8080 and 3000 microcomputer families, Intel has introduced personality boards this year for the new high-performance 8085 and the one-chip MCS-48 microcomputer family.

Indeed, powerful development systems now exist for all the established microcomputer families, supplied both by the major manufacturers of these lines and by independent instrument manufacturers. Development systems of many types have emerged from chip makers, including Zilog, TI, Rockwell, Motorola, Signetics, and RCA. Zilog's latest system, its program development station, is distinguished as a low-cost alternative to large, multi-user systems—single-disk multiple stations can be added as needed to supply many users. More general in purpose is the new Rockwell mini-floppy-based development system, which offers optional personality modules for use with other manufacturers' processors.

A new source for microcomputer design tools is the instrument manufacturers, whose development systems aim at universality. Tektronix Inc.'s system, for example, supports the 8080, 6800, and Z-80 processors. Mupro Inc.'s system provides for the processors mentioned above and for 8085 development as well. Moreover, it accommodates up to eight designers at once, while other systems in its price range are suitable only for a single designer. Multi-user systems are far more serviceable, and most manufacturers will swing over to them in the near future.

PROFILE

Big achiever on a small scale

It's young engineers like Richard Pashley that make the U. S. semiconductor industry the most innovative in the world. Not yet 30, he has played a major role in developing Intel Corp.'s new metal-oxide-semiconductor process, which he has also used in an innovative memory design. The process is H-MOS, for high-performance MOS, and the design is the 2147 50-nanosecond, 4,096-bit static random-access memory that promises to be copied by practically every semiconductor manufacturer.

Pashley's work at the Santa Clara, Calif., firm in speeding up and increasing the density of standard silicon-gate MOS was what persuaded Intel brass to stay away from bipolar technology for memory design. "The early days of 1974 were particularly challenging for us," he recalls. "I was assigned the task of making MOS as fast as bipolar. At that time the company was looking at all memory processes, including I^2L, and the more we compared them, the more we saw that everything they could do with the bipolar techniques we could do better with MOS techniques. We haven't deviated from that path since."

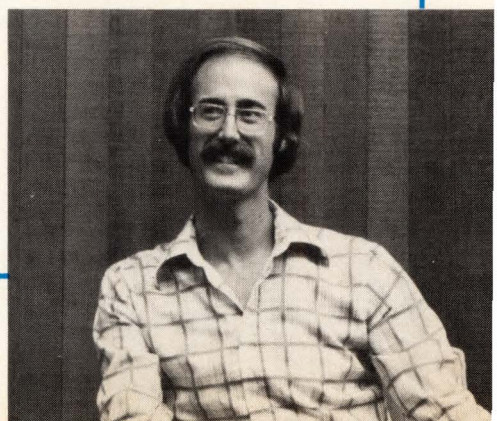
Fresh from obtaining his Ph.D. from Caltech in late 1973, Pashley was given his first job at Intel: to redesign the extremely successful 2120 1,024-bit static RAM for next-generation applications. "It involved both a process change and new circuit design," he says. "To speed things up, we added depletion loads to the process, but we had to do still better to be competitive with bipolar RAMs in cache memory design."

In 1975 Pashley hit on the technique of on-chip substrate back-biasing, which allows MOS transistors to be scaled down in size even further. That technique, coupled with some circuit tricks, produced the first 1-k MOS RAM with access in less than 100 ns and proved to the industry that MOS had a lot of life in it still.

By then Pashley had caught the eye of his superiors, who took him off the 1-k static RAM project and gave him the challenging assignment of developing Intel's next-generation MOS process, not just for memory but for microprocessors as well.

As is common at Intel, Pashley's group moved in methodically but at high speed. "We looked at D-MOS, V-MOS, and other exotic technologies, and the more we looked, the more we saw that scaling our old silicon-gate process was still the best way to get high performance, both for memory and logic applications."

Once scaling down for high performance was decided on in November 1975, Pashley's group really poured it on. It took them about five months to apply the H-MOS process to the old 70-ns, 1-k 2115, resulting in a 50-ns 2125, and another six months to design the 4-k 2147.



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MEMORY-ORIENTED DESIGNS MAXIMIZE THROUGHPUT

by Raymond P. Capece, *Computers Editor*

☐ In a total about-face, this year the central processing units are racing to stay on top of their smart peripherals' demands. They are also racing to stay ahead of each other—16-bit desktop computers pounding after 32-bit minicomputers that perform easily as well as some mainframe models.

Fueling the whole chase are the advances in large-scale integration that have ballooned memory capacity and produced powerful chip processors. With such hardware at hand, computer designers are at last free to concentrate on system throughput, which they are boosting by increasing instruction sizes, widening data channels, and reorienting architectures to exploit the abundance of cheap memory—whether as caches, lookup tables, or microcoded processor control stores.

Nor are memory-subsystem designers idle. Floppy-disk systems now have the capacities of earlier hard-disk designs, and optical-storage techniques loom, as magnetic memory pushes the limit in density.

Minicomputers in the limelight

This year, advances in system hardware and architecture boosted minicomputer throughput in particular. Some, for instance, turned into better number crunchers through incorporating special arithmetic processors. The Eclipse C/300 from Data General Corp. of Southboro, Mass., and the 8/16E from Interdata Inc. of Oceanport, N. J., are among those that acquired hardware that does single- and double-precision floating-point arithmetic about as fast as some mainframe computers.

Instruction sets, too, were refurbished, to get more out of the huge new main memories. Several million bytes of directly addressable memory—not the 65,536-bit limit imposed by a 16-bit word—is needed these days, and various memory-management schemes are bringing the 16-bit machines up to scratch, including special 32-bit instructions. The 21MX minicomputer series from Hewlett-Packard Co., Palo Alto, Calif., acquired a dynamic mapping capability that lets it address 2 megabytes if need be. The memory management system of the 16/550 from General Automation Inc., Anaheim, Calif., can handle 2 megabytes, too, and also write-protects selected blocks of data. The model 500 from Prime Computer Inc., Wellesley Hills, Mass., can address 8 megabytes and also provides for virtual memory.

As for speed of access to million-byte memories, just a few kilobytes of bipolar cache can keep it to less than half a microsecond. The trend here is towards larger, less complicated caches as memory cheapens.

In minicomputers with large metal-oxide-semicon-

ductor memories of 65 kilobytes and up, error-detection and -correction coding is becoming either a standard or an optional feature. Although it means adding 5 or more error bits to each data word, the coding corrects single-bit errors and detects longer ones. Digital Equipment Corp. of Maynard, Mass., introduced its PDP-11/60 this year with error-corrected MOS memory as standard and also began offering error-corrected MOS memory as an option on its PDP-11/70.

Nor have the input/output capabilities of minicomputers been neglected. Newly available are high-speed data channels, formerly a mainframe feature, which gives the small machines byte-transfer rates of several megahertz. Direct memory access, sorely missed in IBM's Series/1, is giving other minicomputers the entrée to new areas of real-time processing and providing further opportunities for interfacing to mainframes.

Coming up from below

Such is their success that minicomputers are under attack from below—desktop units that today are much more than glorified calculators—as well as from above—mainframe firms eager to extend downwards.

What with their simple interactive languages and prepackaged software options, the self-contained, turnkey desktop systems appeal more to scientists and businessmen than to computer programmers—deliberately so. The emphasis of the PCS-II, a product of Wang Laboratories Inc., Tewksbury, Mass., is on business applications. It offers several accounting and billing software packages and for storage has an 89,600-byte minifloppy disk. HP's 9845 is an extremely powerful desktop computer with 210-kilobyte microcartridge storage. It packs this plus a keyboard, thermal printer, and cathode-ray tube into a single case.

Small businessmen received attention from many manufacturers, who see them as a growing market for automated billing and inventory control gear. Software packages oriented towards management abounded, many of them in the business language of Cobol, for which more compilers are being provided. Typical of many small systems brought out this year was the LCC/60 ledger-card desktop computer from Monroe of Orange, N. J. Designed for general accounting, the LCC/60 is simple to operate and has the forms-handling capability needed in business applications.

Notable among the mainframe manufacturers who honored the minicomputer world with their own entries were IBM Corp. with its Series/1 and Sperry Univac with its BC/7. The Series/1, out of the General Systems division, is a 16-bit processor comparable in performance to a DEC PDP-11/34 or a Data General Nova 3/D, as shown in the table. While it is not IBM's first minicomputer—the unsuccessful 1700, which used 6-bit words, was first shipped in 1962—the unbundled Series/1 is destined for a certain market share, despite its initially minimal software.

The launch of Univac's first minicomputer, the small-business BC/7, compounded by Univac's acquisition of

MINICOMPUTERS IN IBM SERIES/1 MARKET

	Manufacturer / model					
	IBM Series/1		DEC PDP-11/34		DG Nova 3D	HP 21MX-E
	4953	4955				
DATA FORMAT						
Word length (bits)	16 +2 parity		16 +2 parity		16 +1 parity	16 +1 parity
Fixed-point operand length (bits)	16		16		16	16, 32
Instruction length (bits)	16		16, 32, 48		16	16, 32
Floating point	optional		optional		optional	standard
FP operand length (bits)	32/64		32/64		32/64	32/64
MAIN MEMORY						
Storage type	MOSFET		CORE	MOS	CORE/MOS	MOS
Cycle time (μs/wd)	0.8	0.66	0.98	0.725	0.7	0.65
Access time (μs/wd)	0.6	0.3	0.51	0.635	0.35	0.325
Minimum size (kilobytes)	16		16		4	4
Maximum size (kilobytes)	128		124		262	2,000
Parity checking	standard		standard		optional	standard
Error correction	no		no		no	optional
Storage protection	none	standard	standard		optional	optional
Storage mapping	optional		standard		standard	optional
CENTRAL PROCESSOR						
Accumulators	–		6		4	2
Index registers	–		6		2	2
Direct addressable kilowords	32		32		256	32
Addressing modes	4		8		6	7
Control storage (kilobits)	read-only store		n.a.		n.a.	ROM,RAM 8.5
	6	24				
Add time (μs)	8.4	2.42	2.03		0.7	1.94
Hardware multiply/divide	standard		optional		optional	standard
Hardware byte manipulation	standard		standard		optional	standard
Battery backup	optional		optional		optional	n.a.
Real-time clock/timer	optional		standard		optional	optional
INPUT/OUTPUT						
Direct memory access	n.a.		standard		standard	optional
Maximum I/O rate (million words/s)	0.8		2.5		1.1	0.616
External interrupt levels	4		variable		16	60

Source: Lee Walther & Co.

IBM advances. The IBM 3033 processor offers nearly twice the computing power of the 168-3 it succeeds in the System/370 family, yet it takes up half the floor space. Similar upgrades were offered for the 148 and 158-3 processors with IBM's 3031 and 3032.

Varian Data Machines, announces that the company is in minicomputers to stay. The BC/7 uses bit-slice chips for main processing and several 8080 microprocessors for peripheral control throughout the computer.

Mainframes not idle

The big news in big computers was the announcement of IBM's 3033 processor, which performs about twice as well as the 370/168-3. The computer giant followed that up with the 3031 and 3032, enhanced versions of its 148 and 158 processors, again with about twice their predecessors' computing power.

Also in the news was Amdahl Corp.'s 470V/5, subordinate to the company's popular 470V/6 that competes with IBM's 370/158. The Sunnyvale, Calif., firm also delivered an enhanced 470V/6-II this year. Another firm taking a shot at IBM was Control Data Corp. of Minneapolis, which introduced its Omega 480 series of IBM-compatible computers featuring superior performance at lower cost than models in the 370/135-to-/148 families.

Besides new models, several upgraded versions of established machines appeared as product lines were widened. Burroughs Corp., Detroit, introduced no fewer than eight new models nested in its 800 series and also announced its BSP scientific processor for number-crunching. NCR Corp. added several new computers to its 8000 series, including its 8100 family aimed at the small-business minicomputer market. Marking a thrust toward multiprocessing and networking, the Dayton, Ohio, firm is stressing interactive processing, for example, by adding interfacing capabilities to the V-8560 that simplify the hookup of several terminals.

Foreseeing the spread of distributed-processing systems, some manufacturers have set up guidelines to this application of their product lines. NCR, for example, has established guidelines that cover link protocols, data-access methods, and intranetwork disciplines. Similarly, HP brought out its DS/3000 and DS/1000 packages of read-only-memory subsystems and software that provide communications throughout any network of HP 1000 and 3000 systems.

Actually, many of the networks termed distributed processing could more aptly be called multiple-task, multiple-user systems, as which they are far more flexible than single-user systems. For example, Honeywell Information Systems Inc.'s DST 6/5000, based on the Minneapolis company's Level 6 minicomputer, supports up to four terminals in a disk-operating system. It resembles NCR's 8200 family and Harris Corp.'s network of 1600 processor family members (to which three new models were added) in that it, too, organizes interactive network approaches and reduces processing bottlenecks by running several jobs simultaneously.

Terminal fever

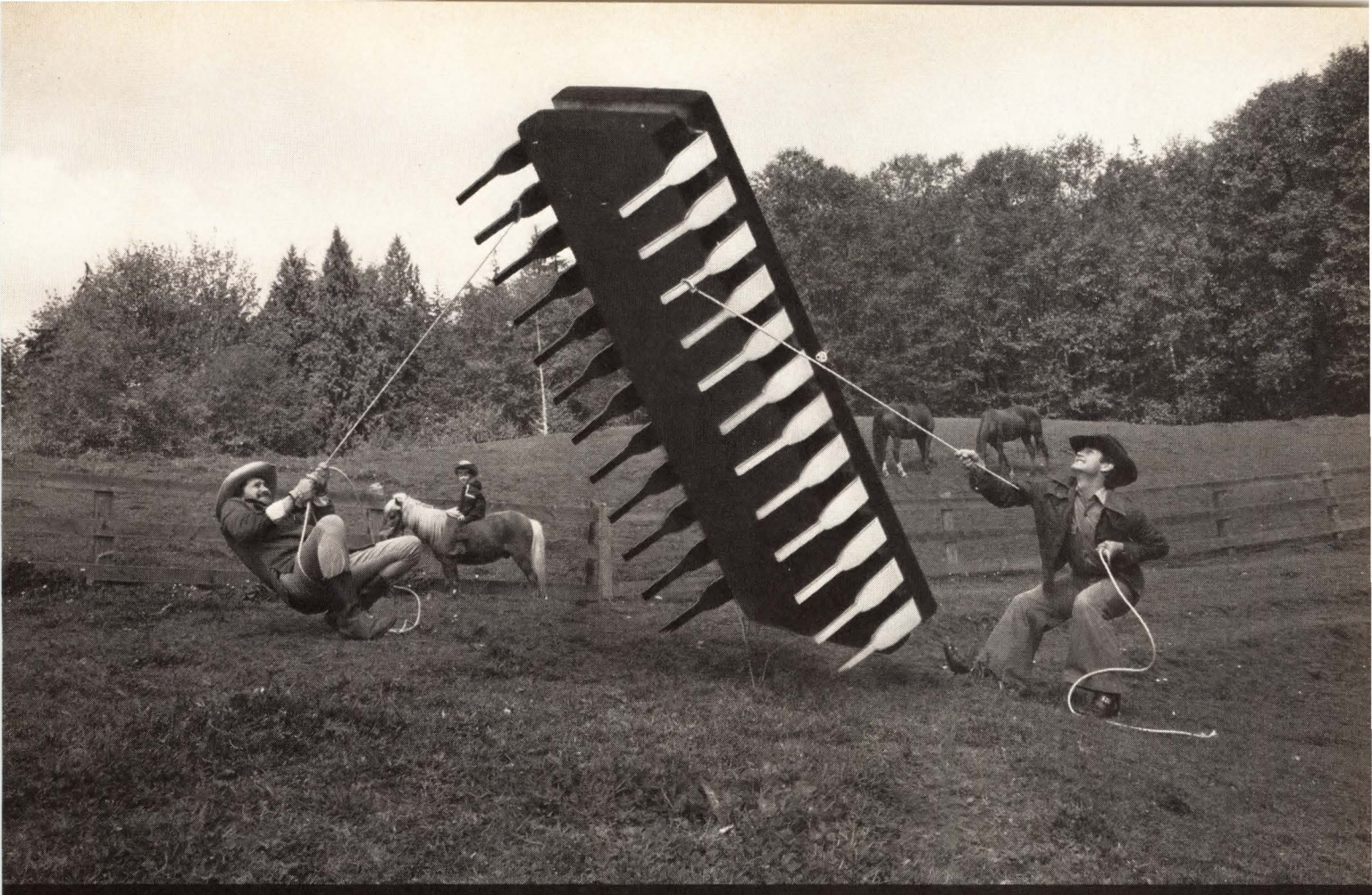
Aiding and abetting the distributed processing revolution is the evolution of intelligent terminals, some of which approach minicomputer performance. Large-scale integration has added such abilities as text scrolling, as well as the blinking, highlighting, and reverse-video of characters, selectable by the user, that can be found on terminals from Applied Digital Data Systems Inc., Ann Arbor Terminals Inc., and others. For a few dollars more, terminals like Perkin-Elmer Corp.'s Data Systems' 1200 get into editing and forms-generating capabilities.

Further up the line, highly intelligent terminals were brought out with several kilobytes of chip read-only memory for terminal programming and 16 kilobytes or more of user random-access memory. The VDP-400 from Lear Siegler Inc., Anaheim, Calif., uses a bit-slice processor chip set from Fairchild for 16-bit processing capability. Texas Instruments Inc.'s 770 terminal, with a microcartridge tape store and thermal printer, contains the TMS 9900 16-bit microprocessor.

The use of graphics terminals has widened, and the year was particularly significant for raster-scan graphics, which has brighter images and more flexible handling than storage and refresh approaches. Most raster-scan systems require lots of memory, since their picture elements are represented by bits of storage on a one-to-one basis, but cheaper semiconductor RAM assures the technology first place in graphics.

Hewlett-Packard premiered its 2648A raster-scan graphics terminal, which marked the first time a terminal used 16,384-bit RAMs, and it put them to good use in such features as panning, zooming, and rubber-band graphics creation. Ramtek Corp. of Sunnyvale, Calif., introduced its Micrographic terminal, a raster-scan graphics model with full-color display. Just as with HP's, software for graphics can be had for the unit that automatically generates graphs and pie charts.

Printing terminals, though less popular than cathode-ray-tube types, were introduced by a few firms. Texas



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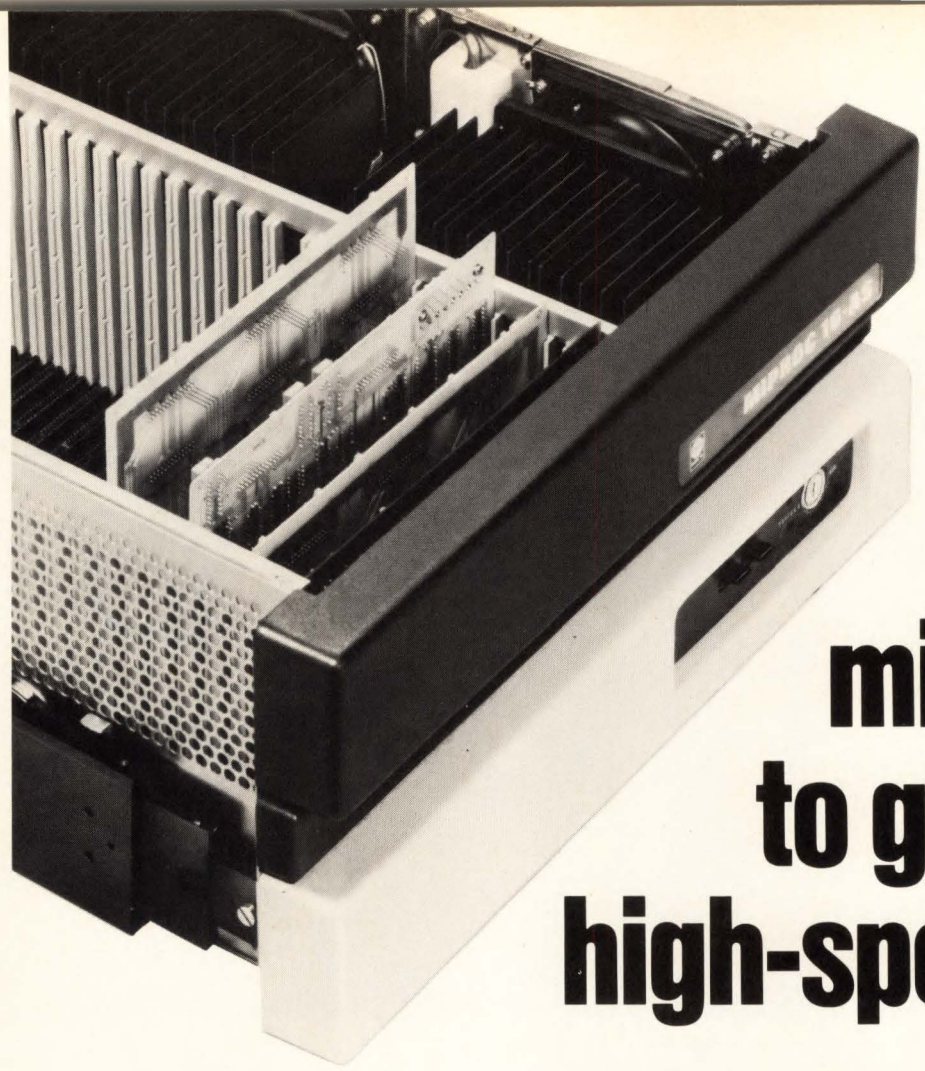

Miproc 16-AS, micropower to give you high-speed faster.

Internationally acclaimed Miproc-16 with a compute-rate of up to 4 million instructions per second is the fastest 16-bit microcomputer card family available.

Now supplied with an OEM chassis package, Miproc-16 is even more quickly brought into action.

This cost-effective application system, named Miproc-16 AS, has room for one, two or even three Miproc-16 CPU's. Smartly styled and equipped with add-in 13-slot card bay modules, fans and power supply, this new OEM chassis package eases the way into high speed microcomputing.

Instruction Power

Up to 170 instructions including multiply/divide and bit manipulation give Miproc-16 formidable processing capability.

16-bit Power

16-bit program words make programming easy. 16-bit data words maintain high precision in arithmetic operations.

Addressing Power

16-bit dual memory architecture gives 65k words of directly addressable program memory *and* 65k words of data memory with 8 powerful address modes.

Interrupt Power

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I/O Power

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High Speed Processing Power

The unique dual memory architecture combines with high speed Schottky TTL technology to execute most instructions in a single machine cycle.

Software Power

Easy to use cross-assemblers for mainframe or minicomputer make programming faster, *and* **PL-MIPROC**, a super-efficient high level assembly language.

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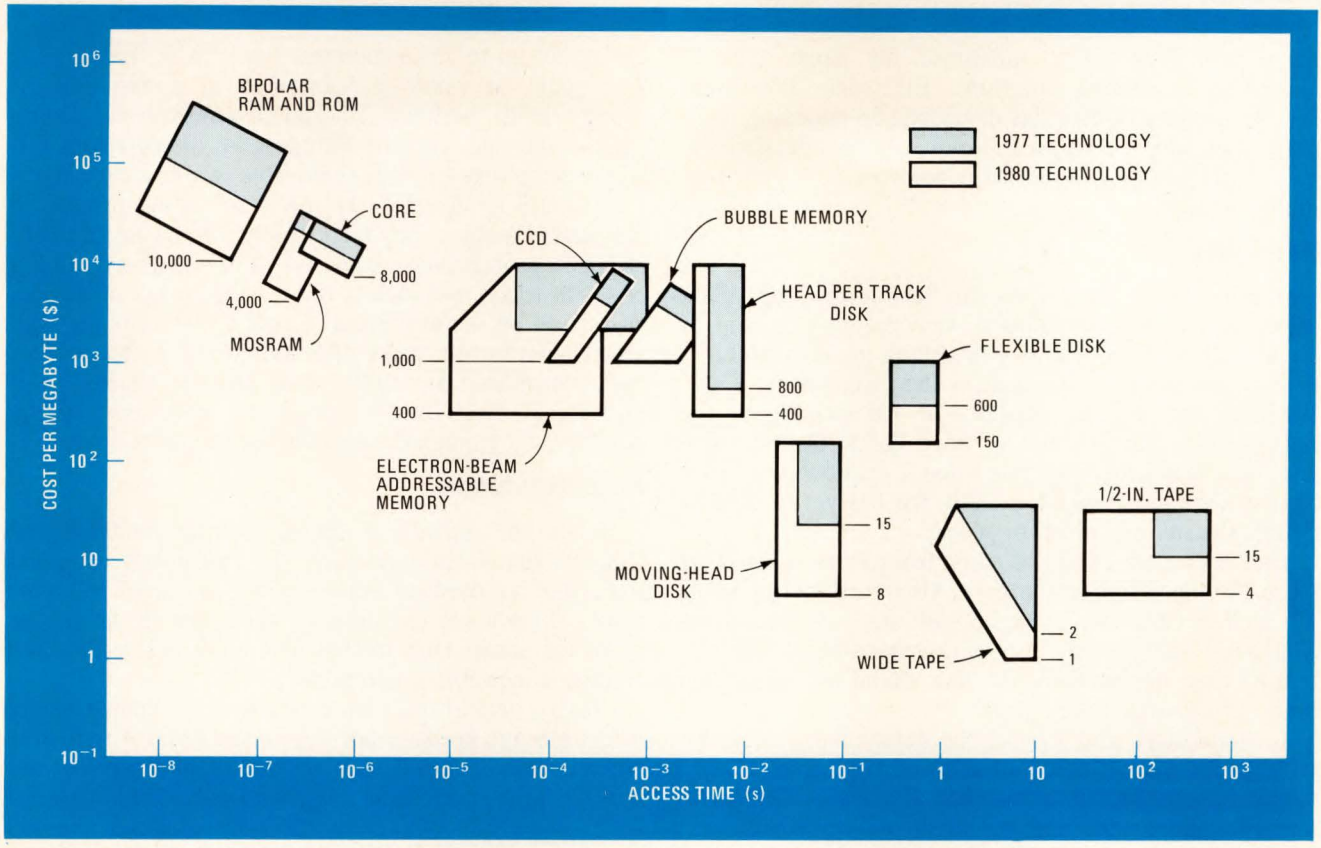


Memorable future. Reductions in cost and access time are coming to nearly all memories, as predicted by Control Data Corp. Solid-state devices are constrained by price, while magnetic memories are slow; optical techniques may provide entries in the lower left of the graph.

Instruments' Silent 700 was the first terminal to use bubble memories—two of TI's TBM0103 92-kilobit devices—for nonvolatile storage of up to 50 pages of data. The Dallas firm's terminal incorporates a thermal printer yet weighs a scant 13 pounds and is no bigger than a portable typewriter. HP announced its 2635A, which contains the company's first medium-speed printer. The printing terminal uses HP's silicon-on-sapphire technology and prints 180 characters per second bidirectionally. TI also offered a similar intelligent printer this year, its model 810.

Printer progress

This past year saw noteworthy contributions in all phases of printers, from the high-end computer-output types to the very lowest, hobby-type devices. The former was addressed by nonimpact printers with speeds of about 20,000 lines per minute. The machines that moved fastest in this category were electrophotographic units, which rival typewriters for quality of output and sometimes can also generate graphics or logos. But there was less activity this year in ink-jet printers, either the 70,000-line-a-minute racehorses or the 90-character-per-second calligraphers.

The electrophotographic printers that bowed include Xerox Corp.'s 9700, which generates digitized forms and logos from a massive data base, Honeywell's page-printing system, which, like the IBM 3800, generates forms and logos from negative plates, and the 3352 from Siemens AG. All use a laser-scanning arrangement.

At the low end of the printer class, electrosensitive printers bowed. The vague term refers to the black paper coated with a thin aluminum layer that is burned through by the discharge of current. SCI Systems Inc. of Huntsville, Ala., introduced a printer of this sort early this year that zips along at 2,000 characters per second yet costs only $300 without interfacing electronics. Centronics Data Computer Corp. of Hudson, N. H., followed with a more conventional—though slower—version. Both produce satisfactory outputs, though dislike of the metallized paper has affected acceptance.

In the higher-end line-printing market, newer band types from Data 100, Dataproducts, Centronics, and others pushed speeds up to 900 lines per minute, with printing in several fonts. Moreover, the popularity of optical-character-reading wands and devices has spawned printers that generate OCR-readable characters, like the printer from Data 100.

Magnetic storage

At the low end of magnetic tapes, microcartridges received wider exposure as they appeared in HP's desktop computers and in TI equipment. Quantex Corp. introduced a palm-sized drive to accommodate this kind of cartridge, which can store several hundred megabytes of data. The not-altogether-forgotten cassette found a

home this year—as a substitute for paper tape in machine-tool control programs. Electronic Processors Inc., Englewood, Colo., has developed an encoding technique that allows even an audio-quality cassette drive to be used for exacting numerically controlled machine-tool programming.

New disks

Among disk technologies, the flexible or floppy disk, which is now well established, saw the development of double-sided, double-density recording in the model 850 drives from Shugart Associates Inc., Sunnyvale, Calif. With an unformatted capacity of 1.6 megabytes, the floppy rivals the low end of hard disks. Double-sided recording was blessed by IBM when it introduced its two-headed version of the floppy, but IBM has yet to support double-density recording, or M²FM.

Fast-access-time floppies came from Pertec Computer Corp., Wangco Inc., and others. Also worth noting is the 5¼-inch flexible-disk or minifloppy drive introduced by Shugart Associates late last year. Originally intended for text-editing applications, it has found a substantial market in personal computing.

In small hard-disk drives, the demands of minicomputer users spurred the doubling and tripling of storage capacities. Diablo Systems Inc., Electronic Memories and Magnetics Inc., and HP all introduced drives that combine fixed and removable media for an overall storage of up to 75 megabytes. In all these devices, one disk could be removed; contained in a cartridge, it usually holds between 10 and 15 megabytes. Going against the tide, Japan's Fujitsu Ltd. introduced a 50-Mbyte drive with a totally removable two-disk cartridge.

It is safe to say that the limits are being pressed in magnetic media, beyond which increased density becomes prohibitively expensive. The estimated ceiling of 1,000 tracks per inch is only a generation of devices away, and bit density limits of even 15,000 bits per inch are also not far off, being little more than double present high densities. By 1980, disk storage density will increase at most by a factor of 10, with most of the development going on in moving-head types of drives.

An optical future

Hence the appeal of optical storage technologies. Systems have been assembled that can provide archival storage of hundreds of billions of bits on small polyester sheets. In present techniques, which are by no means perfected, lasers burn microscopic holes in the film, and storage is therefore unalterable.

Clearly, optical techniques are the most likely to meet future storage needs, especially in the form of writeable optical disks. Factors such as noncontact reading and writing, high-speed (and multiple-track) scanning with inertialess beams, and tremendous bit densities presage the victory of optical over magnetic technologies.

PROFILE

Architect of the 11/60

"Keeper of the PDP architecture"—that is how Craig Mudge describes his first assignment at Digital Equipment Corp., Maynard, Mass., which he joined in 1973. The job was one for which his broad applications experience in Australia's computer industry had been an excellent preparation.

Almost immediately he became involved in the design of the PDP-11/70, but only peripherally. By far his greatest contribution was selling DEC on the idea of architectural consistency. "I had to convince them of the importance of compatibility throughout the PDP line and on down to the LSI-11," he recalls.

This laid the groundwork for the 11/60 minicomputer, which Mudge first proposed and then moved on to design with co-workers Jim O'Loughlin and Chuck Kaman.

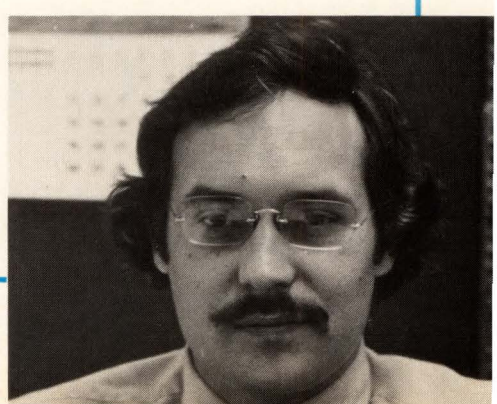
The midrange 11/60 fills an important gap in the PDP family as the constant-price successor to the 11/40. Explains Mudge: "Every machine spawns two successors: one offers the same functionality at a lower price, while the other, like the 11/60, uses technology to give more performance at the same price." This is an important notion in minicomputer evolution, and it leads to two different types of design style.

An extremely zealous designer who recently served as a visiting faculty member at Carnegie-Mellon University ("to recharge my batteries"), Mudge is especially enthusiastic about using memories instead of logic in processors—what he terms "memory-intensive" design. "Since the cost reduction in memories is proceeding much faster than in logic circuits," he maintains, "we're seeing memory-intensive design in all areas, from IBM 370s down."

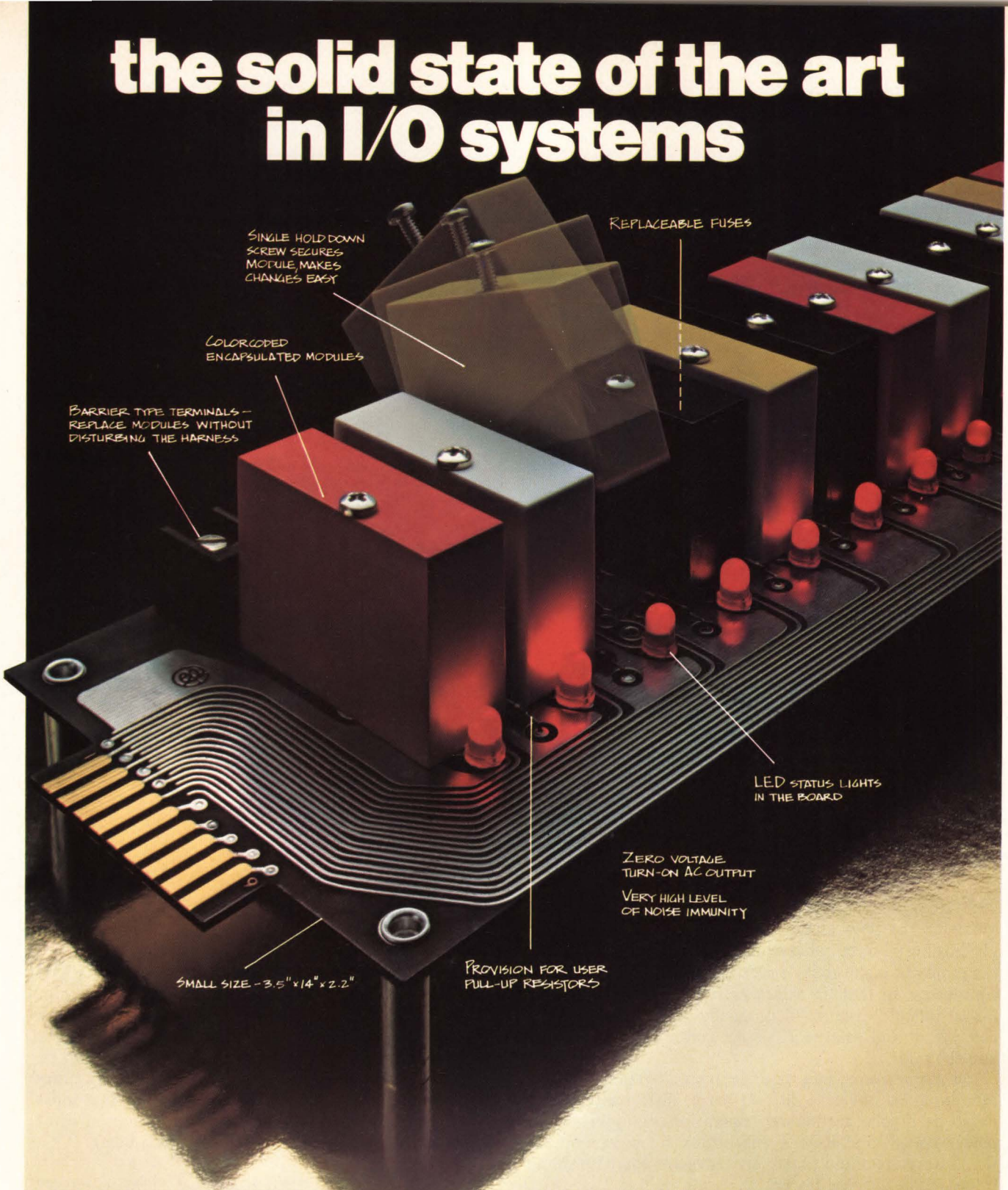
These cost-effective designs are in evidence throughout the 11/60. Lookup tables in the fast floating-point processor, read-only-memory instruction decoding, and the widespread use of caches all point to memory-oriented design. Microcode—internal instructions stored in read-only memory—is becoming more attractive in cost-conscious design, Mudge adds.

In the 11/60, microcode emulates a second floating-point processor that triples throughput—a slower, integer floating-point processor that is used in compiling the 11/60's 46 instructions. Microcode is also used in the 11/60's writeable control store—DEC's first user-microprogrammable option. Altogether, the machine has three times as much microcode as the 11/40.

"The really interesting part of design is in making the hardware and software tradeoffs," says Mudge. "Today there are actually three elements—hardware, software, and also microcode—and each of them changes with each new and very different generation of technology. Keeping track of them is really the big challenge."



the solid state of the art in I/O systems



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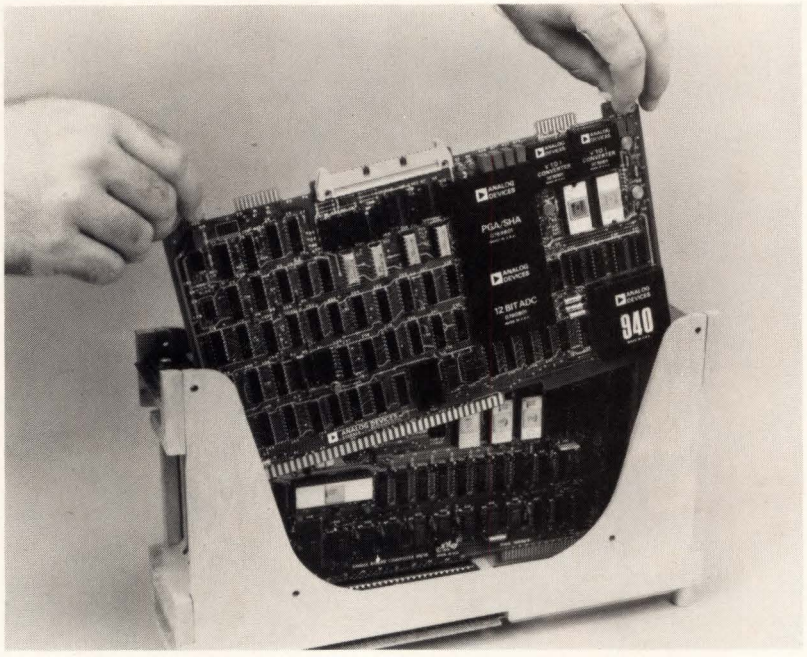


Getting on board. Analog component manufacturers are quickly moving into the microcomputer design arena with self-contained input/output analog subsystems. This RTI 1200 board from Analog Devices is a complete analog I/O subsystem that is fully compatible with Intel's SBC 80/10 microcomputer system. Typical of the analog boards becoming available throughout the industry, this unit has complete data-conversion capability and microcomputer interface logic for use with already-available system software.

CONVERTERS ADJUST TO LSI, BI-FET OP AMPS EMERGE

by Lucinda Mattera, *Components Editor*

☐ System compatibility—that's the watchword for much of the new analog technology. Now, the latest generation of data-conversion products is including all the extras to make them directly compatible with microcomputers. In fact, in this area it is becoming increasingly difficult even to distinguish between what is a component and what is a system—often the two are one and the same.

On other fronts, new semiconductor technologies are mounting an offensive in two areas historically dominated by bipolar technology: operational amplifiers and power transistors. Key to the attack by bi-FET operational amplifiers and power MOSFETs are their tumbling prices—and they are faster.

In other components, thick-film technology is spreading from resistors to relays, even electromechanical types. The result is new designs that are smaller and cheaper than their predecessors. As for resistors themselves, improved films are enhancing both temperature stability and reliability.

The biggest news in the linear area is being made by data-conversion products. To keep up with the microprocessor, data converters are beginning to resemble miniature subsystems that offer a wealth of convenience features. The new generation of devices is microprocessor-compatible, freeing the designer from the chore of putting together the interface between the converter and the microcomputer.

Most of the new converters are memory-mapped devices, thereby making available the whole array of easy-to-use memory instructions. No special software instructions are required to transfer data, and the data need not be transferred through a special register to be processed. (The latter situation can be particularly time-consuming in applications where the digitized data must be multiplexed, which is the case when the converter word is wider than the microprocessor's data bus.)

Storage latches

Along with the convenience of memory mapping, microprocessor-compatible converters provide latches for data storage—at their input if the converters are digital-to-analog or at their output if they are analog-to-digital. With these storage registers, the microprocessor need not wait while the converter cranks through its conversion. Instead, a status line on the converter tells the microprocessor when it can drop off the data to be converted (in the case of d-a units) or pick up the digitized data (in the case of a-d units).

Undoubtedly, all future converter chips will provide

SPOTLIGHTING CONVERTER TECHNOLOGY

Type		Specification	Monolithic	Hybrid
Digital-to-analog		Resolution	6 – 12 bits	6 – 16 bits
		Settling time	100 ns – 2 μs	0.5 – 100 μs
		Price	$5 – $20	$20 – $150
		Notes	Most are current output; microprocessor-compatible 8-bit devices emerging.	Most are fully self-contained; microprocessor-compatible versions emerging.
Analog-to-digital	Integrating	Resolution	10 – 13 bits	——
		Conversion time	30 – 300 ms	——
		Price	$7 – $25	——
		Notes	Two-chip sets are giving resolutions up to 16 bits.	Very little available.
	Successive-approximation	Resolution	8, 10 bits	8 – 12 bits
		Conversion time	20 – 40 μs	1 – 50 μs
		Price	$10 – $30	$40 – $300
		Notes	Microprocessor-compatible versions emerging; complete 8-bit microprocessor-compatible data-acquistion systems coming.	Microprocessor-compatible versions emerging; complete 8- and 12-bit analog I/O systems available.

some form of direct microprocessor compatibility. Among the semiconductor firms that already have or are about to have microprocessor-oriented devices on the market are, alphabetically: Advanced Micro Devices, Analog Devices, Fairchild Semiconductor, Intersil, Motorola Semiconductor, National Semiconductor, Precision Monolithics, and Texas Instruments.

Monolithic data converters are also changing in other ways. Accuracies and resolutions are getting higher, yet prices are getting lower. Eight-bit d-a chips are now down below $5, a 10-bit successive-approximation a-d chip goes for about $25, and a two-chip 16-bit integrating a-d set sells for approximately $15. Additionally, many chips now operate from a single power-supply voltage, usually 5 volts. A number of the newer devices are including on-chip voltage references, too. In general, on-chip references are good enough for 8- and 10-bit applications, but for resolutions of 12 bits or more an external reference is still the rule.

Several major breakthroughs in data conversion stand out this year. Both Precision Monolithics Inc. and Harris Semiconductor have developed single-chip 12-bit d-a converters, a feat many industry experts believed impossible. And with integrated injection logic, Analog Devices Inc. is making the industry's first monolithic 10-bit successive-approximation a-d converter to be fully self-contained.

Converter subsystems on a chip

Perhaps the most astonishing development of all is the emergence of monolithic converter subsystems. National Semiconductor Corp. now has an entire multichannel data-acquisition system packed onto a single complementary-metal-oxide-semiconductor chip, and Fairchild Semiconductor is producing an ultralow-cost multichannel a-d front-end device that relies on a microprocessor for its digital control logic. Though these new system-like chips offer only 8-bit performance, they are about one fifth the cost of similar hybrid devices or less.

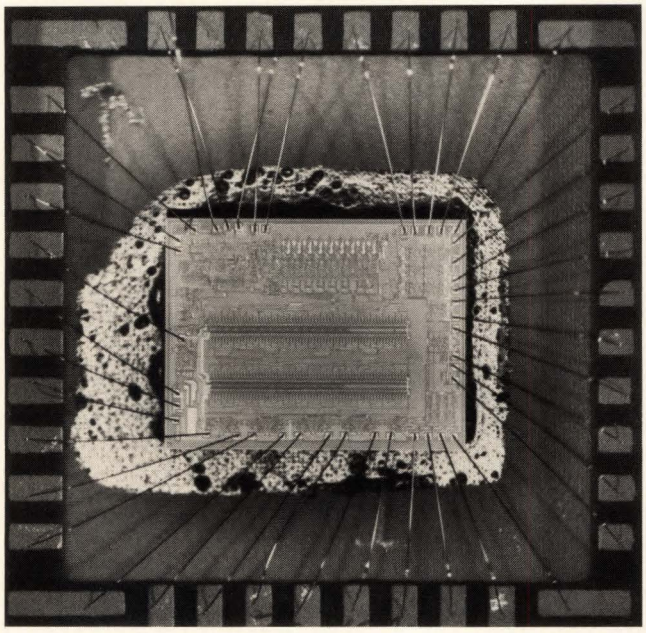
The future looks no less exciting, with high-performance, two-chip, 12-bit successive-approximation converter subsystems in the offing, and even single-chip, 4-½-digit integrating a-d converters for applications that permit slower conversion times. Also, look for more system-like converters that include additional analog-processing circuitry right on the chip, most likely in the form of a multiplexer, a sample-and-hold circuit, address decoding for microprocessor applications, or even an adjustable-gain instrumentatiuon amplifier.

Hybrid systems

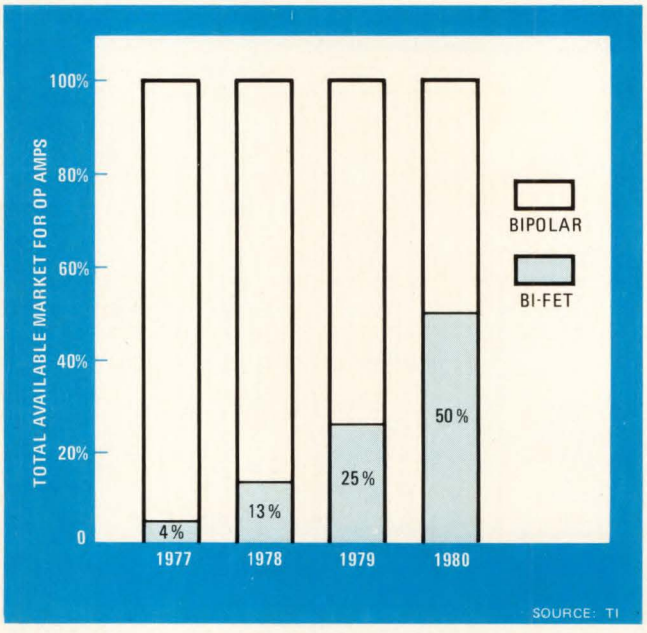
All these extras are already being incorporated in hybrids that fit into a miniature package what used to occupy one or two good-sized printed-circuit cards, without sacrificing the flexibility of a true component part. Using thick-film technology, Burr-Brown Research Corp. is building complete 8-bit analog input/output systems, and Datel Systems Inc. is fabricating complete 12-bit analog input systems with its thin-film technology. Both these system-like components offer direct microprocessor compatibility, multichannel capability, full data converters (including a clock and a voltage reference), and even some on-board signal conditioning. Prices are now running about $100 for the 8-bit devices and approximately double that for the 12-bit units.

Other manufacturers, like Micro Networks Corp., prefer to split the data-acquisition system between two packages, with one carrying the a-d converter and the other the associated circuitry. This approach permits the user to choose his converter and keeps down the power each package dissipates.

Further, hybrids are beginning to challenge data-



On the chip. The first monolithic data-acquisition system is National's 16-channel 8-bit chip, built with C-MOS technology. Compatible with most microcomputers, this a-d system succeeds in reducing analog-conversion cost fivefold.



The bi-FET move. Mixed bipolar-field-effect-transistor processing is catching on with analog designers for high-quality front-end characteristics at reasonable costs. By 1980, bi-FET input stages will be used in 50% of all op amps built.

conversion modules, although the latter are still the best way to go when high resolution, high accuracy, and fast throughput rates are needed. In fact, most of the analog I/O boards now emerging for use with microcomputer boards are being built with modules. But this situation should change as the board functions they provide are taken over by hybrids. The new hybrids are likely to include instrumentation amplifiers whose gain may be programmed with software, and even dc-dc converters for translating a 5-v logic supply up to the 15 v needed for many analog components.

Hybrid data-distribution systems are another possibility, as are the voltage-to-current converters needed for industrial applications in which current loops must be driven. The latter will probably offer full input-to-output isolation for protection from transients and noise.

Bi-FET op amps: priced to compete

In operational amplifiers, the bi-FET bandwagon is building up quite a head of steam. These devices, which combine junction field-effect transistors and bipolar transistors on the same chip, now seem to be emerging as the most cost-effective performers in the mixed-process area—with good reason. They can be made inexpensively, requiring only an extra processing step of ion implantation, and they offer good low-noise performance, broad bandwidth, and fast output slew rates.

Most important, though, this year the price of bi-FET op amps slid down to a level that permits them to compete with bipolar devices, like the ubiquitous 741, which have traditionally dominated the op-amp market. As a result of their toe-to-toe price scuffling, Texas Instruments Inc. and National Semiconductor Corp. now have the cost of single general-purpose bi-FET op amps below 40 cents, with TI's least expensive device going for 33 cents and National's going for 39 cents. These prices compare very favorably with the 25-cent price tag of the industry-standard bipolar 741, considering the notable performance advantages of bi-FETs. What is more, as usage increases, prices for bi-FET op amps will probably drop even further, although not for the next few months at least.

These devices, however, do have two significant drawbacks—a fairly high initial input offset voltage and an input bias current that doubles every 10°C. But Precision Monolithics, using a current cancellation scheme and its zener-zap trimming, has come up with a line of precision bi-FET op amps that hold input offset voltage to only 0.5 millivolt and limit bias-current doubling to approximately every 18°C.

In the coming year, the market will also see more mixed-process linears, both bi-FET and bi-MOS. The former parts will most likely be data converters and sample-and-hold amplifiers; the latter—a combination of MOSFETs and bipolar transistors on the same chip—will most probably be analog multiplexers.

Pace quickens for power V-MOS

In the power area, V-groove MOS technology is now definitely shaking up the status quo. Since last year, a small semiconductor company, Siliconix Inc., has been touting the performance advantages of the power MOSFETs made with its power V-MOS process. Now, Siliconix is no longer alone in believing in the future of power MOSFETs: at least two major semiconductor houses plan to have such devices on the market within the next

Flukemeter II.

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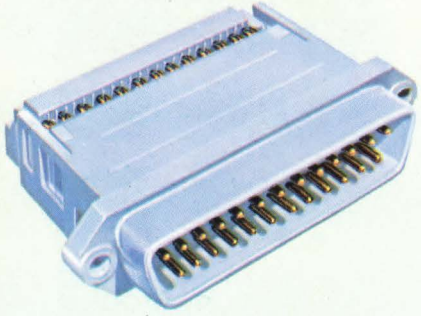

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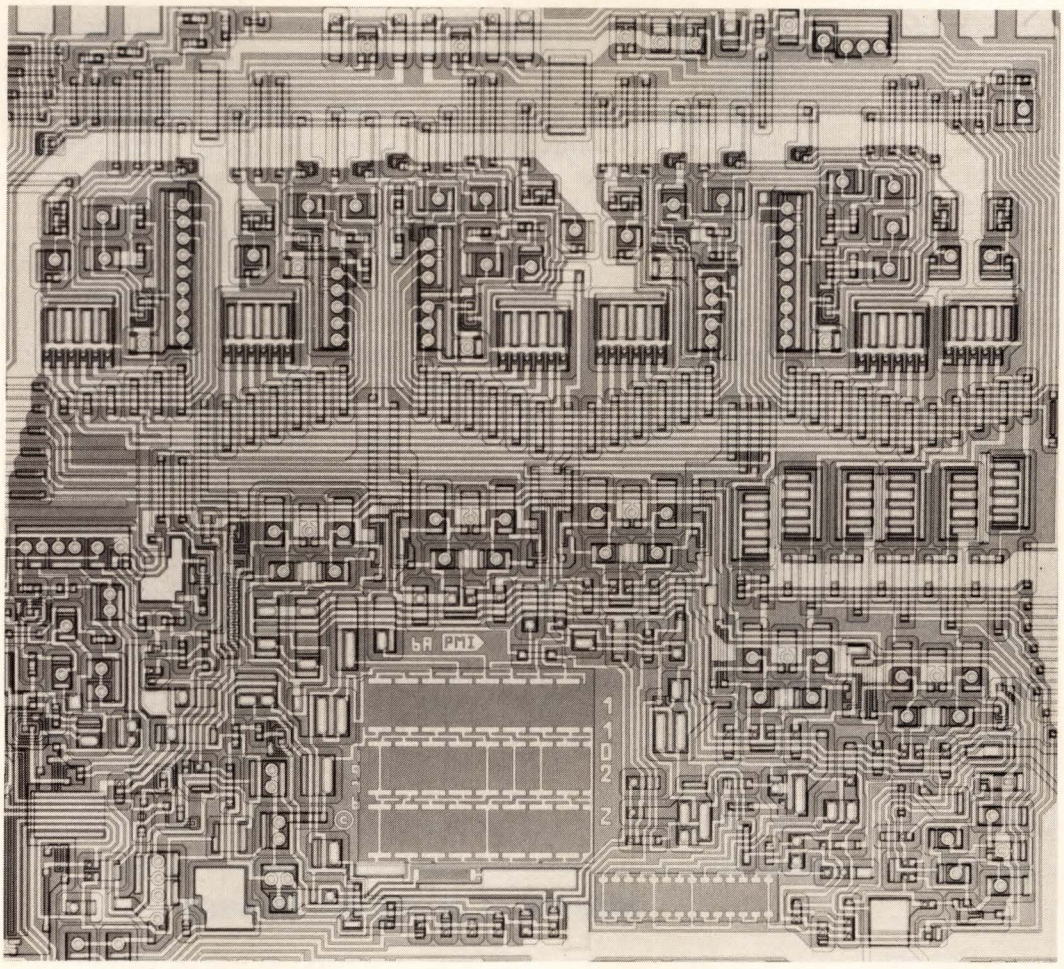


It's 12 bits good. This bit d-a converter from Precision Monolithics can do the job of hybrids costing much more. Although 8- and 10-bit converter chips have been available for some time, accurate one-chip converters capable of 12-bit resolution are just now becoming available.

few months. One of them, Fairchild Semiconductor, is busy designing several and also intends to second-source the low-frequency power MOSFETs made by Siliconix, as a small company named Supertex is already doing.

Also, Siliconix is stepping up its efforts to build high-frequency power MOSFETs for radio-frequency chores, where it appears that V-MOS really shines over bipolar technology. Appreciating this superiority, too, is Motorola Semiconductor Products, which has already made a 1-watt MOSFET for very-high-frequency applications and is planning to build higher-power devices that blanket all the rf bands. Other major bipolar power houses are now considering the viability of power FETs; their evaluations should be finished in the next three to six months.

Optical progress

Meanwhile, progress in other component areas also deserves noting. For instance, the performance of optical couplers has improved considerably. Also, these devices are now much easier to connect directly to logic circuitry. Some versions are fully temperature-compensated for transistor-transistor-logic applications, while others include up-front internal voltage regulators for easy line termination.

As for visible-light-emitting diodes, many now have internal current-limiting resistors; some even have multiple junctions for use as multicolor indicators. Lenses for LEDs are improving as well, and better junction designs are resulting in brighter devices that sometimes even have a rectangular emitting area. Visible LEDs are also playing a bigger role in switching components. More dual in-line switches are including LED indicators for instant display of, say, a logic state; relays, too, are sporting them to show on/off conditions. And they are particularly evident in the newly emerging generation of solid-state interface modules intended for microprocessor-based control systems. (Built around a solid-state relay, these modules come in input and output versions for converting an ac or dc voltage to a logic-compatible signal and vice versa.)

Plastics are becoming more common in switches, potentiometers, and trimmers. To reduce costs, manufacturers are turning to these materials for fabricating shafts, bushings, and housings. In many cases, the plastic design eliminates sealing problems, since the shaft and housing may be molded to complement each other for a simple and extremely effective trouble-free seal.

In many component areas, even electromechanical relays, dual in-line or at least integrated-circuit-compatible configurations are becoming the rule. Makers of these relays are turning to fabrication techniques that lend themselves to volume production and easy automa-

tion. Simplified all-welded designs are driving costs down, while offering increased operating reliability and longer life than their predecessors.

For low-cost, high-volume production, many solid-state relays are being manufactured with thick-film techniques, using either packaged discrete components or unpackaged chips mounted on a substrate containing thick-film conductors and resistors.

Thick film and relays

For example, employing packaged discrete devices on a thick-film substrate, Hamlin Inc. has managed to squeeze a complete optically coupled solid-state relay into a single in-line package of less than 1 cubic inch. The relay is one of the recent inexpensive bare-bones units, so it lacks an output snubber network for protection against false firing caused by transients, although it does include zero-crossover input circuitry.

Thick film is even penetrating the fabrication of some electromechanical relays. Utilizing a thick-film timing module, Struthers-Dunn Inc. has cleverly converted standard electromechanical relays into time-delay units that occupy no more space than the regular relay alone. This simple design innovation also means lower costs, knocking down the price of time-delay relays by as much as half that of competitive units.

Resistors and capacitors have by no means been standing still, although the advances in this area are of a much subtler nature. Improved inks for making thick-film resistor networks are giving rise to resistors that have a temperature stability of better than 50 parts per million and that can withstand laser trimming with no appreciable change in their characteristics. Furthermore, the coming generation of thick-film inks will require lower firing temperatures at shorter firing cycles, reducing manufacturing costs.

On the capacitor scene, the search continues for ways to upgrade the performance of aluminum electrolytics so that they may compete more directly with tantalum parts, which continue to get more expensive as the cost of tantalum goes up. In mid-1979 the ban goes into effect on polychlorinated biphenyls (PCBs), the impregnant used for oil-filled capacitors for over three decades, and this prospect has manufacturers searching for a suitable substitute. All known non-PCB materials are combustible and increase capacitor size.

Finally, quartz crystals, an often neglected component, are very much in the limelight these days because of the high-volume usage brought about by digital watches and microprocessors. To meet these new demands, crystals are undergoing significant changes, shrinking in size and yet providing increased ruggedness. In addition, improved automatic manufacturing techniques are lowering costs and yielding devices whose working frequency may be modified easily—for instance, through laser trimming.

PROFILE

Master of precision linears

George Erdi is one of today's rarities—a top-notch analog designer. Now a design engineering manager at Precision Monolithics Inc., Erdi is the man responsible for some of the most significant breakthroughs in linear integrated circuits, with a number of firsts to his credit.

At the Santa Clara, Calif., firm, he has designed the first precision bipolar operational amplifier to be compensated internally, the first precision bipolar field-effect-transistor op amps, and the first precision sample-and-hold amplifier to be made in monolithic form. Additionally, he was responsible for designing the company's voltage references and precision comparators, as well as for perfecting zener-zap trimming as a cost-effective technique for getting high performance out of a linear IC.

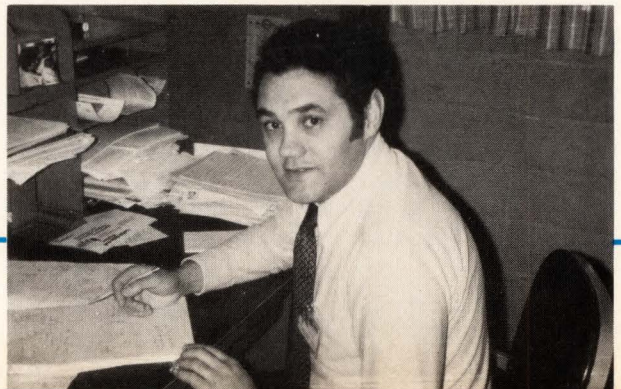
In fact, the comparators were the first linear ICs to contain compatible Schottky diodes, which Erdi used to speed up operation without degrading performance. Moreover, his design for the bi-FET op amps yielded notable improvements over existing devices—input offset voltage lowered to 0.5 millivolt, slew rate and bandwidth doubled, and input bias-current drift approximately halved.

Erdi joined PMI when it was founded back in 1969. Before that, right from school, he worked as a design engineer at Fairchild's Research and Development Laboratories in Palo Alto, Calif. During his three-year stay there, his efforts resulted in the 725, the first monolithic op amp to provide precision performance. At Fairchild, Erdi also was involved in the first attempt to build a digital-to-analog converter on a single chip. In fact, it was this work that spurred the founding of PMI by a group from Fairchild who were interested in pursuing the potential of monolithic data converters.

Born in Hungary, Erdi left his native country after the unsuccessful 1956 revolution, emigrating to Canada. He received his bachelor's degree in electrical engineering from McGill University, then followed it with a master's in EE from the University of California at Berkeley.

For relaxation, Erdi swims and plays soccer. He also takes in concerts and plays as often as possible—on a recent five-day visit to New York, he happily attended the theater every night.

Erdi is extremely excited about the future of linear ICs, for the industry is just beginning to explore the numerous possibilities that mixed processing is opening up. The ability to utilize different, but compatible, processes on the same chip, he points out, will mean circuits that offer good digital and linear performance on the same piece of silicon, as is needed for data converters.



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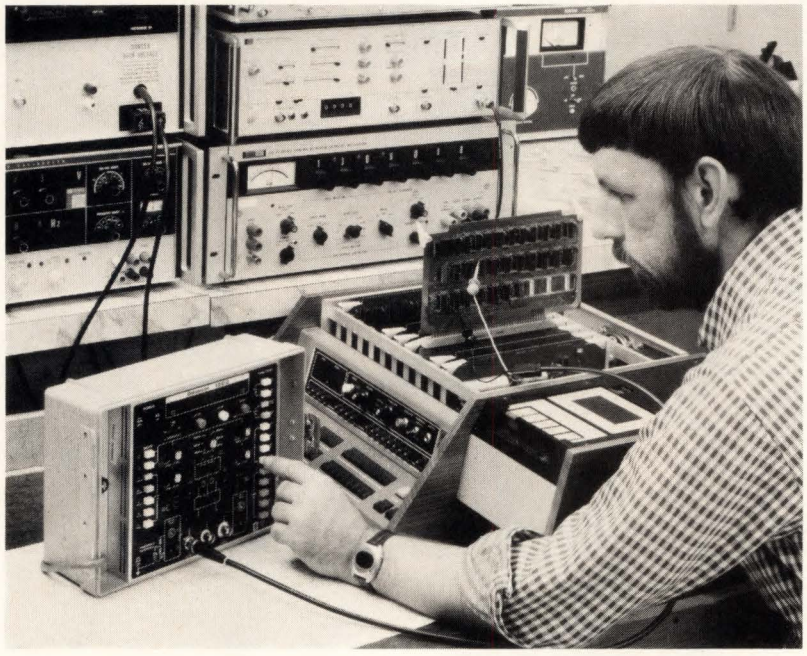
Circle 119 on reader service card



Digital troubleshooting. The Data Test Corp. tester combines a digital multimeter with a digital counter-timer in one package for troubleshooting digital systems.

TECHNIQUES FOR SERVICING LSI-BASED GEAR EVOLVE

by Stephen E. Scrupski, *Instrumentation Editor*

☐ The impact of microprocessors on instruments is proving to be more indirect than direct—but revolutionary all the same. Users of microprocessor-based equipment are urgently demanding test systems capable of servicing it, and already a few of the larger instrument companies have made significant moves toward filling this vacuum. Next year many others will also contribute to a bumper crop of service-oriented instruments, espousing many different approaches to fault diagnosis.

Generally, microprocessors have not pervaded test equipment itself to the extent that was predicted. Most instruments do not need complex controls or elaborate calculations, but must provide acceptable accuracies at ever more competitive prices. The growing ranks of low-cost, high-performance portable digital multimeters and counter-timers are evidence of this trend, and it is mainly the more complex high-speed counter-timers and spectrum analyzers that have found it profitable to exploit a microprocessor's capabilities.

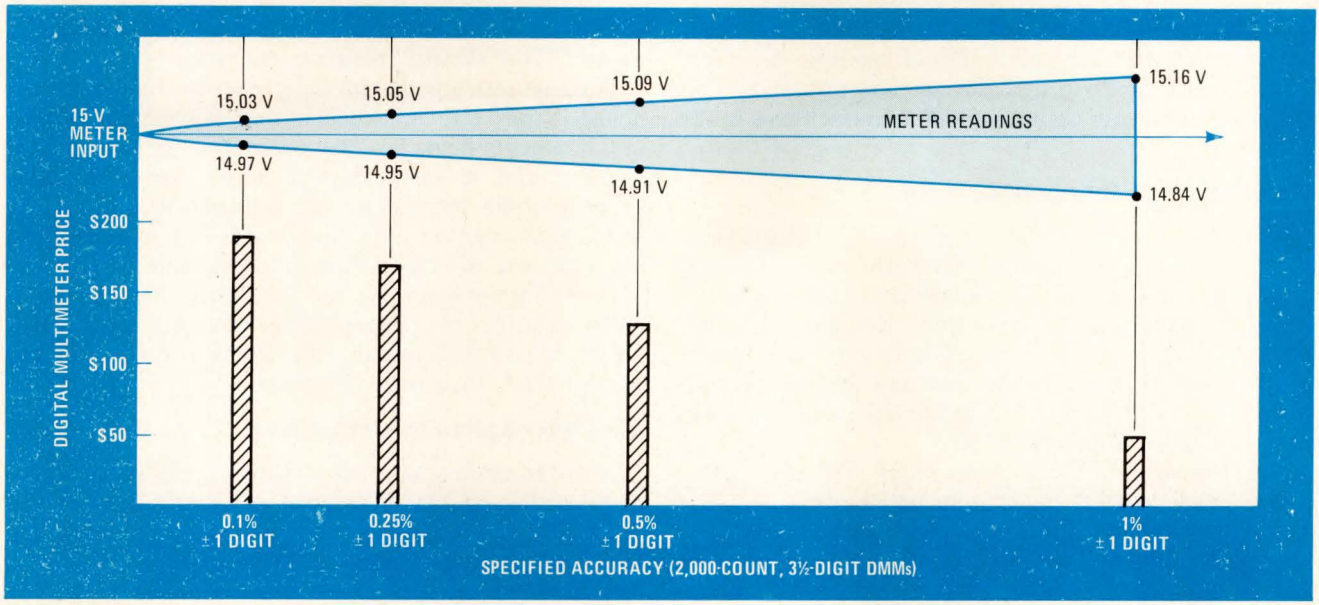
The service problem

Designers of microprocessor-based equipment are coming under increasing pressure to take service techniques into account in their original designs. Although many different service techniques are emerging, probably all of them are effective in fault isolation if the designer translates his knowledge of a particular instrument's operation into troubleshooting methods tailored to servicing it. Possible approaches range from basic time-domain and voltage-measuring instruments, logic analyzers, and in-circuit emulators adapted for testing, right on up to a brand-new technique from Hewlett-Packard Co. called signature analysis.

Signature analysis is still too new for it to be possible to judge if its impact on test-instrument technology will be an enduring one. An adaptation of the error-detection and -correction techniques traditional in digital equipment, it uses annotated schematics much as in television servicing, where the technician compares readings at test points with the readings on a schematic and traces discrepancies back through the circuit until their origin is reached.

However, the equipment to be tested must originally be designed to include the features that allow signature analysis. When it introduced the technique in March, the firm noted that upwards of 40 new HP instruments were having signature analysis designed into them as their maintenance technique.

Another approach claiming a growing number of adherents is in-circuit emulation, which has proven very



What price accuracy? For an input of 15 volts, various digital voltmeters may give different readings, depending on their specified accuracies. Height of the vertical bars represents typical prices for meters having the accuracies noted on the horizontal scale.

effective in debugging microprocessor-based prototype systems. Now it is being adapted for use with those systems once they move into the field. Intel Corp. of Santa Clara, Calif., the originator of in-circuit emulation, adapted it for servicing an instrument called the μ-Scope. By plugging the in-circuit emulation cable into the microprocessor socket in the system under test, the technician can apply the same troubleshooting techniques used in design to fault location in the field.

Now, with signature analysis and in-circuit emulation available as service techniques, what would the next step be? Combine the two—which Millenium Systems Inc., Cupertino, Calif., has done in its Microsystem Analyzer. In this unit, in-circuit emulation performs the overall functional tests, and then signature analysis takes over to track the faults down to the component level. Further, since the in-circuit emulator replaces the microprocessor, it can generate the digital patterns needed for signature analysis, which therefore need not be designed into the equipment originally.

A more conventional approach to digital servicing is being taken by Tektronix Inc. and Data Test Corp. Both supply Burroughs Corp. with a tester that combines multimeter functions (voltage, current, and resistance) with counter-timer functions (frequency, time interval, and transition counting) in a single package. Burroughs uses the instruments as service tools for its B80 series of computer systems, into which it designed features that make maximum use of the testers. However, the instruments would also be useful on other types of equipment.

Logic analyzers spread

Logic analyzers, up to this year high-priced units, are propagating downward into production testing and perhaps even into field service.

Hewlett-Packard Co.'s new $1,800 model 1602A logic-state analyzer turns into a servicing tool when controlled by a computing controller through the IEEE-488 interface bus. The 1602A stores 64 words of 16 bits each at clock speeds up to 10 megahertz. If a diagnostic procedure is written for a particular system, a troubleshooter can use a program tape to step the system through its operations, comparing the results on the light-emitting-diode display with the written procedure.

The 1602A is also evidence of two significant trends in logic analyzers—lower costs and easier-to-use functions. The $1,800 unit is completely keyboard-controlled, and its single-line LED display can show logic states in any of four formats—hexadecimal, decimal, octal, or binary. The data probe pod includes a printed-circuit-type edge connector so that it could also be connected to specially designed printed-circuit boards for fault diagnosis.

Portability will naturally be important in the field as well as in the lab. The new model 920-D from Biomation Inc. of Cupertino, Calif., a 20-MHZ unit selling for $1,295, is a portable 9.5 pounds. One unusual feature of the 920-D is the addition of an extra channel to pick up an extra bit. The unit, with basically an 8-bit-wide input, has a ninth channel to pick up, say, parity bits or to examine triggering relationships.

Up to now, logic analyzers have been either timing analyzers or logic-state analyzers. But next year should see a new generation of analyzers that will combine timing and state displays. With such equipment, the user will be able to do such tasks as capture certain timing waveforms based on triggers generated by logic states on the buses.

Until this year, the technology of portable meters has primarily been advanced through better custom large-scaled integrated circuits for analog-to-digital conversion. John Fluke Manufacturing Co.'s $169 3½-digit model 8020A, for example, contains a custom chip

from Intersil Inc. that uses dual-slope a-d conversion and gives dc accuracy of 0.25% of reading ±1 digit. However, standard a-d modules are now appearing that will make an impact on instrument manufacturers in the future.

Standard chips for portable units

Keithley Instruments Inc. of Cleveland, for example, introduced a 4½-digit multimeter with true root-mean-square capability based on standard parts, the model 178 selling for $289. At the same time, Keithley set a new industry price level for 4½-digit units with a stripped-down version of the 178 that does not include current-measuring capability but handles voltage and resistance measurements and sells for $199.

The standard a-d converter chips will also affect digital panel meters, since users will be able to build their own panel meters in their own configurations. For example, Intersil Inc. of Cupertino, Calif., has a parts kit that includes the converter chip, liquid-crystal or LED display, and other devices. Selling for $29 in small quantities and about $15 in large quantities, the chip is similar to the one Intersil designed for Fluke's 8020A but lacks many of that unit's multimeter functions.

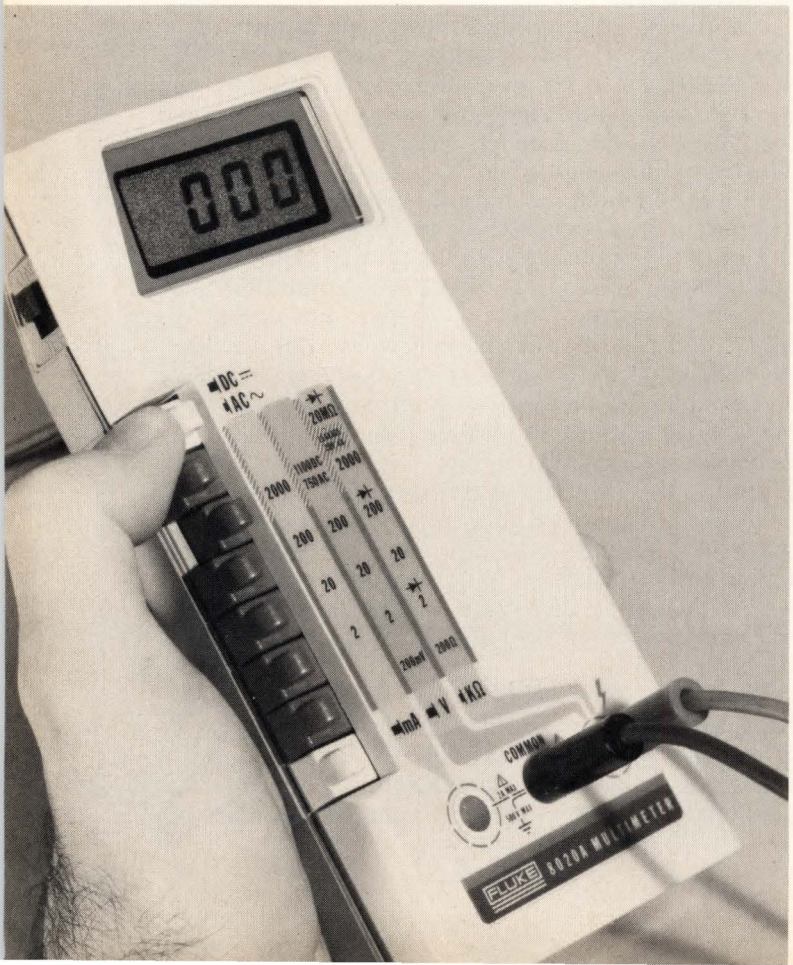
Electronic counters, on the other hand, are still being designed around custom large-scale integrated circuits, primarily because there is a narrower market for standard counter chips than for a-d converter chips. Many low-cost units appeared this year, such as the Data Precision model 585 unit, a 250-MHz frequency counter selling for $345, and the $195 Ballantine Laboratories model 5720A 80-MHz frequency counter.

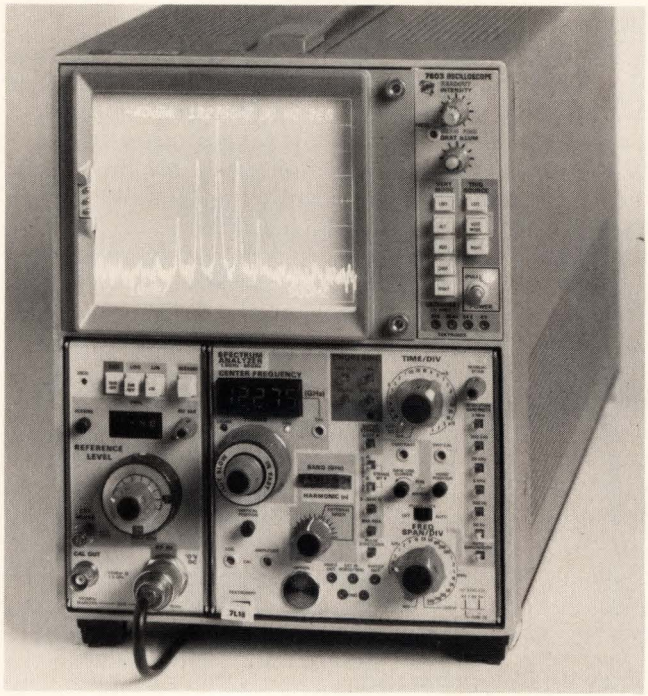
Portable instruments not only react to changing technology—they also influence it well beyond the simple measurements field, for they are major users of digital displays and in particular of liquid-crystal displays. Although this technology has gained much from the watch industry, the LCDs' low power requirements also allow the use of standard, nonrechargeable batteries in portable instruments. As the reliability of larger (0.5-inch-and-up) LCDs is proven in field usage of such instruments as the Danameter, the Weston 9000, and the Fluke 8020A, their use will spread.

Microprocessors in instruments

Microprocessors have been turning up in many instruments for such low-level tasks as controllers for the IEEE-488 interface bus and for control and computation functions in more complex instruments. Spectrum analyzers in particular, being in general more difficult to use and interpret than oscilloscopes, have benefited from microprocessors. The chips have taken over the job of setting their input controls to the optimum condition and calculating data, so that the user no longer has to read data off the cathode-ray-tube graticule. Two of the best

Spectrum analysis. The Tektronix model 7L18 spectrum analyzer plug-in unit shown below covers frequencies from 1.5 gigahertz to 60 GHz and has 30-hertz resolution up to 12.5 GHz. Digital storage lets it display previously recorded spectra for comparison with later inputs.





In hand. The Fluke model 8020A 3½-digit multimeter shown at left uses a liquid-crystal display and operates from a 9-volt transistor battery. It also has a feature new to DMMs—the ability to directly measure conductance, which lets it measure up to 10,000 megohms.

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	INVERTING OUTPUTS AND 32 mA I_{OL}	57/67S382	
REGISTER		SN54/74S374	
	32 mA I_{OL}	57/67S374	
	INVERTING OUTPUTS	57/67S376	
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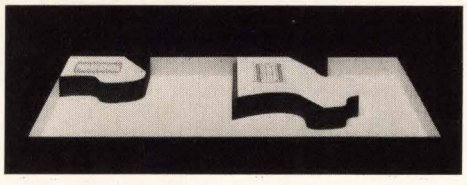

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MOTOROLA
Communications and Electronics Inc.

examples of products in this class are spectrum analyzers from Tektronix and Hewlett-Packard.

The model 7L18 from the Beaverton, Ore., firm is a plug-in unit for the Tek 7000 series oscilloscope mainframes. It covers 1.5 gigahertz to 18 GHz with direct input and can resolve 30 hertz at input frequencies up to 12 GHz. A microprocessor automatically controls the settings of the resolution and sweeps to set up the optimum conditions. An MOS memory stores traces and allows display of two traces for comparison. The HP unit, model HP-8568A, is a lower-frequency unit, covering 100 HZ to 1.5 GHz, and uses three microprocessors to control functions, calculate results, and compute correction factors. Results are displayed on the CRT along with the trace, and it, too, has a semiconductor memory for storing control settings and displays.

Enhancing with microprocessors

Next year will see many more upper-end instruments incorporating microprocessors for control and computation functions. High-quality universal counter-timers, for example, can make good use of a microprocessor to calculate time-interval averages and set trigger levels, and next year will see new instruments of this type. Dana Laboratories, model 9000, now a couple of years old, set the style for this type of instrument and is still being enhanced with new features that can be handled by the microprocessor. Also, the need for higher speeds in electronic circuitry will challenge instrument designers to develop new methods of precision time measurements down in the picosecond range. Here, the problem requires not only a microprocessor to handle computations, but also a very stable oscillator.

Use of the IEEE-488 standard interface bus for interconnecting instruments in automated test setups grew steadily throughout 1977. There now are about 300 different instruments from about 90 different manufacturers with circuitry that makes them compatible with the bus. There was growing evidence, however, of problems with bus formats not covered by the standard, and moves were afoot to create a "third party" to help in the interchange of information among users of the bus. The National Bureau of Standards, Gaithersburg, Md., has expressed interest in becoming this third party and also in serving as a source of educational material on the bus. The NBS, in fact, has been using equipment connected via the bus to automate many of its own calibration services in Gaithersburg.

One of the major technical developments from the NBS this year was the development of a portable voltage standard based on the Josephson effect. Since 1972, the legal volt has been defined in terms of the Josephson junction, and the standard now in Gaithersburg has an accuracy of a few parts in 10^8. The portable units, initially intended for circulation among various military laboratories, have an accuracy of about 1 part in 10^6.

PROFILE

Designer of a best-selling meter

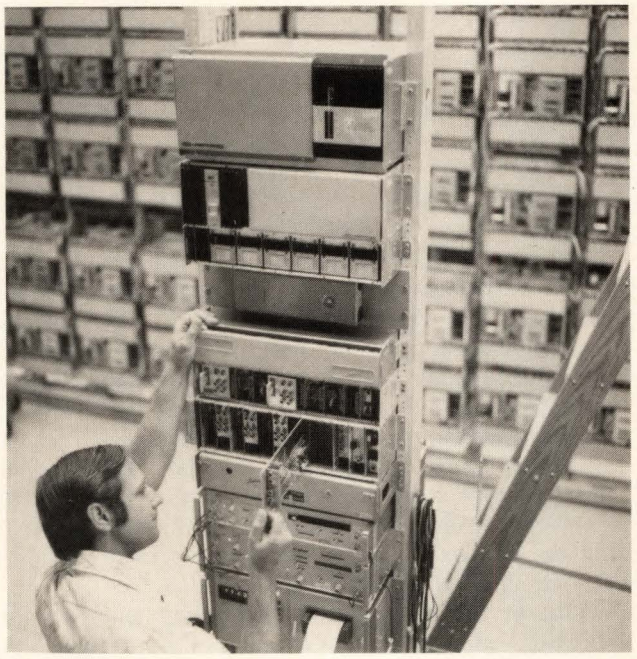
Hitting the best-seller list is no less an engineer's goal than an author's. One of the few engineers in this category is Paul Lucas, vice president of engineering at Data Precision Corp., Wakefield, Mass., whose $295 model 245 portable 4½-digit multimeter has sold about 50,000 copies. By now it is the best-selling 4½-digit DMM of either the portable or the bench type.

Lucas, Bernard Gordon, Harold Goldberg, and Robert Scheinfein (respectively, Data Precision chairman, president, and sales vice president) met to define the product back in 1972. At the time, there was nothing as small (an easily hand-held 1¾ by 5½ by 3½ inches) and accurate (0.03% ± 1 digit basic dc accuracy) as the 245 was to be. "After we decided on the package, it was my job to fit everything in," he says, "and that was a nightmare." With dc-dc converters and high-voltage display multiplexing circuitry creating interference and little room for shielding, early models read close to full scale just from the internal pickup. "It fought me every inch of the way," he says, but finally he reduced the crosstalk to an equivalent input level below 100 microvolts, the minimum resolution on the lowest range.

Once the meter went into production, in 1973, the sales curve took off. Lucas evinces little surprise at its success: "We expected to sell about 10,000 units a year, and we even did a little better than that." Why did it sell so well? "It met a need—there was simply nothing else on the market with its small size, low price, and accuracy."

Lucas, a math graduate from Boston University, has spent his entire engineering career in the Boston area, much of the time associated with Gordon, whom many consider the industry's leading expert on analog-to-digital conversion techniques. Lucas began with Epsco Inc. in 1958, where he met Gordon, then after stints at Adage Inc. and Brower Engineering rejoined Gordon at Gordon Engineering, which later spun off Data Precision.

As for the future of DMMs, Lucas notes the semiconductor makers' steady incursions with low-cost chip-display kits, from which a 3½-digit DMM can easily be assembled with the addition only of some extra signal-conditioning circuitry. Instrument manufacturers, however, have the expertise required, for example, to build accurate input circuitry for handling really low-level signals. So he expects that these companies will remain at the upper end of the meter range, where higher accuracies and higher precisions are necessary.



New look. For the first time, an optical-fiber terminal (foreground) found its way into the copper-wire preserves of a General Telephone Company of California toll office. An equipment installer is inserting a repeater board into the terminal.

FIBER OPTICS, LSI EXPAND SYSTEM CAPACITIES

by Richard Gundlach, *Communications Editor*

☐ The outpourings of messages in the communications-oriented societies of today call for ever-stronger electronic measures to contain them, and so it's fiber optics and LSI to the rescue. To multiply the cable capacity of telephone systems, optical-fiber communications links are beginning to carry actual telephone traffic in the U. S., with similar setups being readied overseas. To meet the demands for greater channel capacity and better utilization of the radio spectrum, large-scale integration and microprocessor technology are being applied in all fields—even in citizens' band radios.

Also this year, high-capacity cellular mobile radiotelephone systems are moving toward field trials. The well-established microwave radio systems are benefiting from better traveling-wave tubes that make possible single-sideband techniques, which triple the capacity of existing networks. Moving just as rapidly is satellite technology, with plans advancing fast for higher-power, high-capacity satellites and for small, less costly antennas and earth stations.

Fiber-optic technology is moving into the rigorous environment of the telephone network. This year, American Telephone and Telegraph and General Telephone and Electronics installed systems that carry customers' messages and data. These short links are bringing the wider bandwidth and hence greater channel capacity of glass fibers right into the home preserve of copper cable.

Abroad, experimental work is concentrating more on systems with performance that exceeds that of the standard telephone network. In Britain, the ITT subsidiary, Standard Telephone and Cables Ltd., successfully sent 140-megabit-per-second test traffic over a 9-kilometer link between two towns. In 1978, a similar installation in Tokyo, will carry voice and data along a 20-km route connecting four telephone exchanges of the Nippon Telegraph and Telephone Public Corp.

Other foreign efforts

Separate efforts by Philips Gloeilampenfabrieken in The Netherlands and the Centro Studie Laboratori Telecomunicazioni SPA of Turin, Italy, produced 140-Mb/s data transmission over fiber-optic links. Perhaps the highest data rate to come out of the lab is reported by NTT's Musashino Electrical Communication Laboratory. Its optic system transmits 800-Mb/s signals on a 7-km length of single-mode cables. Error rate is less than 10^{-9}.

Fiber optics is still an expensive technology, but dwindling costs are augured by several advances in both the fiber processing and the laser diodes that send the light signals. These developments include cost-effective

LSI IN TELECOMMUNICATIONS				
LSI circuits	Application			
	Telephone	Private branch exchanges	Central office	Carrier
Pulse dialers	■			
Repertory dialers	■	■		
Tone dialers	■			
Tone decoders	■	■	■	
Tone receivers	■	■	■	
Repeaters				■
Codes (delta and pulse-code modulation)	■	■	■	■
Frequency synthesizers				■
Analog companders				■
Modulator / demodulators			■	■
Multiplexers		■	■	■
Filters	■	■	■	■
Microprocessors	■	■	■	■
Memories	■	■	■	

performance hikes, as well as direct cost-cutting.

The price of the glass-fiber replacements for copper cable is crucial. Manufacturers put today's bare fiber costs at about $1 per meter, but they think volume production will drop that to about 10 cents a meter. However, Theodore A. Litovitz and Pedro B. Macedo of the Catholic University of America in Washington, D. C., have announced a process based on bulk chemical treatment rather than vapor deposition. They claim it is now capable of producing bare fibers for 10 cents a meter, and process refinement will drop the cost to a penny a meter.

Such a price break would strengthen fiber optics' bid for the telephone, cable-television, and data-link markets. But the production of these fibers outside the laboratory is still a question mark. The answer will be forthcoming: Canada Wire and Cable Ltd. and Britain's Pilkington Bros. Ltd. are licensing the technology.

As important as reducing fiber costs are the performance improvements that point the way to longer-lived, more powerful gallium-aluminum-arsenide lasers. This year Bell Laboratories reported achieving a significant goal: solid-state lasers with average projected lifetimes of 1 million hours, based on accelerated aging tests.

Another important goal is more powerful laser diodes that oscillate in a stable fundamental mode. Researchers at IBM's research center in Yorktown Heights, N. Y., are reporting development of a diode that produces an essentially round spot of light only 2 micrometers in diameter and has an optical power of 85 milliwatts, about three times that previously reported for stable round-spot devices. The small spot of the IBM diode means it can easily couple its optical power to small fibers at efficiencies higher than 70%. Moreover, it can handle data rates in excess of 100 Mb/s.

Promising work is also under way with tunable diodes, which will be an efficient way of producing the multiple channels necessary for frequency multiplexing. One route is the optical-feedback scheme being developed by Xerox's Palo Alto Research Center in California. By optically pumping various portions of a split-waveguide laser, it has tuned them over a 3-nanometer band.

Along the same lines, Cornell University researchers have demonstrated an electronically adjustable diode that has a laser line width of less than 0.05 nm. Over a 5-nm tuning range, then, there would be 100 channels that could be multiplexed. The electro-optic tuner Cornell is using can switch in 5 nanoseconds: sweeping across 100 channels at this rate gives a multiplexing bandwidth of 200 gigahertz.

Another IBM development is a novel package that makes laser arrays practical. Such an array can provide many separate data channels for communications. In display or printing applications, it can provide an entire page of information at once [*Electronics*, Sept. 15, p. 40]. The key to practicality is providing precise alignment without expensive machining by the use of the same preferential-etching technology employed in making V-groove metal-oxide-semiconductor transistors.

LSI answers the call

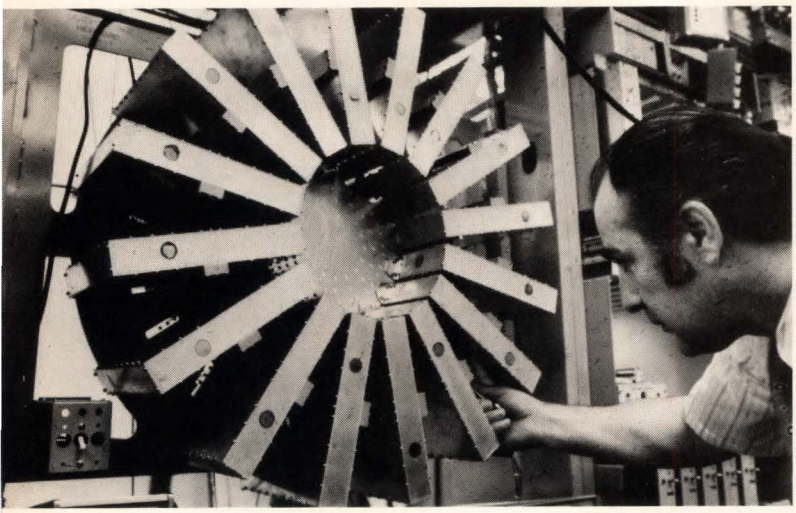
Microprocessors and other LSI circuits are providing more and more solutions to tough problems in all phases of communications technology, from mobile telephones and citizens' band radios to satellites and digital exchanges [*Electronics*, April 28, p. 93]. Continuing is the push to develop low-cost LSI coder/decoders—potentially, the most widely used device in digital communications. With digital techniques becoming more commonplace, dozens of companies are developing both pulse-code-modulation and delta-modulation codecs and the related charge-coupled-device filters.

Ahead in the race are Bell Northern Research of Canada and Intel, which are putting finishing touches on PCM codec chips that include CCD filters. Precision Monolithics Inc., which introduced the companding digital-to-analog converter chip in 1975, is offering LSI parts that combine with the converter to make an eight-channel multiplexing PCM codec.

A hybrid PCM codec developed by Stromberg-Carlson Corp. of Rochester, N. Y., is used in the computer-controlled digital telephone switch for small central offices, first installed this year. Combining five integrated-circuit chips in a package about the size of a 22-pin dual in-line package, the codec meets the stringent performance requirements of the small offices, which demand a codec cheap enough to dedicate one to each telephone line. LSI technology made this possible.

Another tack is under investigation by the British Post Office, which is looking into a combination of delta modulation and PCM to provide a codec cheap enough to be used on individual telephone lines. Nor are codecs limited to telephone networks. Satellite Business Systems plans to use 32-bit delta-modulation units on the analog voice ports in all its earth-station equipment.

Of course, codecs will not be the only LSI circuits in communications equipment. The table lists applications



Getting it all together. A Bell Telephone Laboratories' engineer checks the combiner-bay assembly, part of Bell's high-capacity mobile-telephone cellular equipment that combines the output of each of 16-channel power amplifiers into a single transmission line.

for specially designed chips in communications.

Large-scale integration also is being used in chips under development to encrypt data for secure transmission. The National Bureau of Standards has set a Government data-encryption standard that should give impetus to this development. However, it may be two years before a full range of chips is widely available.

Fairchild Camera and Instrument Corp. of Mountain View, Calif., has developed a high-speed bit-slice multichip encryption approach that will find use in many communications applications besides data terminals [*Electronics*, Sept. 1, p. 32]. Its devices should be available later this year at $30 a set—dropping to about $10 as production volume increases. Motorola and Rockwell also are moving rapidly towards marketing such devices.

More mobile-telephone channels

Today's mobile radiotelephone is a highly popular piece of equipment—so much in demand that there are too few radio channels to serve those who want to subscribe. Many subscribers also find that mobility is a loaded question, since the phones generally cannot be removed from the automobile.

To overcome the limitation on the number of channels, AT&T and Motorola are betting on the cellular approach. Such a system will achieve more efficient use of the spectrum by reusing frequencies and controlling transmission power. Each radiotelephone base station serves subscribers within the geographic area (cell) that its signal reaches. Within a cluster of contiguous cells, each is allocated a set of frequencies. Neighboring cells are assigned a different set of frequencies to avoid interference. However, cells far enough apart may simultaneously use the same set of frequencies.

By reducing the transmitted power along with the size of the cell, the same frequency can be reused more often within a given area, thus serving many more users. If more subscribers than channels exist, the cell size can be made smaller to allow several clusters to occupy an area previously taken up by a single cluster.

The user is assigned to one channel, but as he or she travels from one cell to another, the transmissions are handed off from base station to base station by a switching office. The base stations and the switching office will have sophisticated equipment that can juggle the transmissions among the available frequencies in each cell without any interruption of service as far as the subscriber is concerned. To make this cellular approach work will require extensive use of LSI and microcomputer technology for components and control systems to improve performance, minimize interference, and store and display information.

Both Motorola and Bell are putting together trial cellular systems, under the watchful eye of the Federal Communications Commission. Also, Motorola is developing a radiotelephone small enough to fit into a shirt pocket or purse and is designing its cellular system to accommodate these portables.

A new breed of CBs

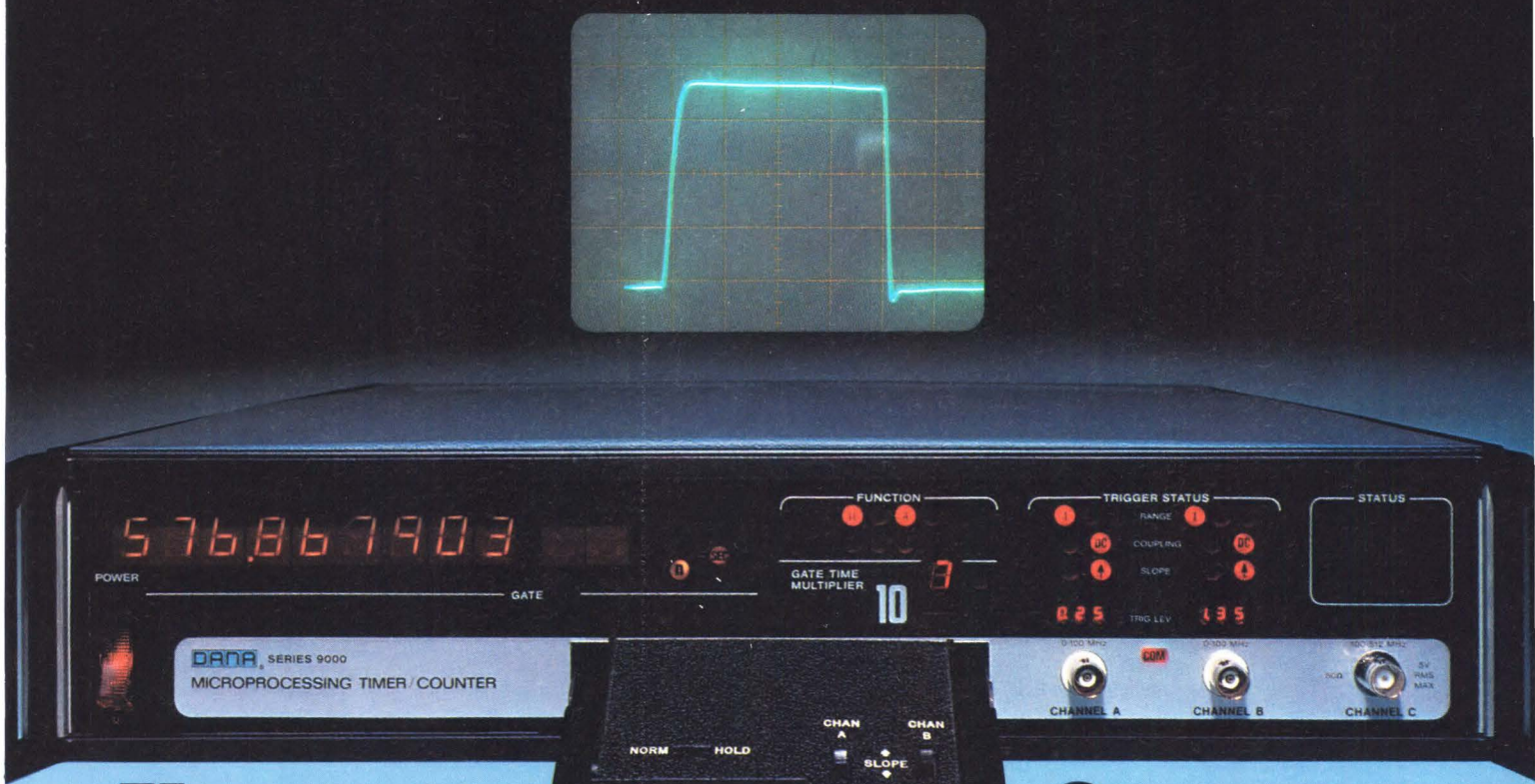
Citizens' band transceivers also are benefiting from LSI technology. This year, digital frequency-synthesizer ICs made the manufacturers' changeover from 23-channel sets to 40-channel units both easy and inexpensive. At least a dozen semiconductor manufacturers are competing for a place in the 40-channel models by offering monolithic synthesizers in both the bipolar and complementary-MOS technologies. One of the more advanced C-MOS designs is from RCA [*Electronics*, April 28, p. 77]. It even includes an on-chip voltage-controlled oscillator and requires only an external reference crystal, an RC network, and tuned LC circuit.

Such synthesizers are just the harbinger of the move to make CB into a kind of universal mobile phone. Besides providing circuits for better transmission and reception, advanced semiconductor technology is being tapped to provide easy-to-use single-sideband radios and to send coded selective-call signals, which enable a user to receive only those transmissions he elects.

Reflecting this change in direction is Texas Instruments' combination of single-sideband CB transceiver and a-m radio. The Dallas firm's models will be the first CB units to use microprocessor technology [*Electronics*, May 12, p. 31]. The circuitry uses two 4-bit TMS1100 microcomputers—one scanning the push buttons in the handset and the other automating functions in the transceiver such as eliminating the need to continuously tune a clarifier to make SSB transmissions inteligible.

Microwave radio, the workhorse of long-distance transmission of voice, data, and television traffic, is getting a technical refurbishing. The immediate problem is more traffic than existing systems can handle, so work is concentrating on cost-effectively increasing channel capacity and using computer-assisted adaptive sharing of existing and future facilities.

How fast can you measure rise time, fall time and pulse width?



Your way.

(About 5 minutes.)

1. Connect signal to scope. **2.** Adjust trace intensity. **3.** Adjust focus. **4.** Select VOLTS/DIV range. **5.** Select TIME/DIV range. **6.** Adjust vertical gain to fill screen for location of 10% & 90% points. **7.** Locate 10% point. **8.** Locate 90% point. **9.** Determine horizontal displacement between 10% & 90% points. **10.** Multiply displacement by horizontal scale factor.

That's RISE TIME. Only 9 more steps and you've got PULSE WIDTH and FALL TIME.

Our way.

(About 5 seconds.)

1. Connect signal. **2.** Push ⌐ button for RISE TIME. **3.** Push ∧ button for PULSE WIDTH. **4.** Push ¬ button for FALL TIME.

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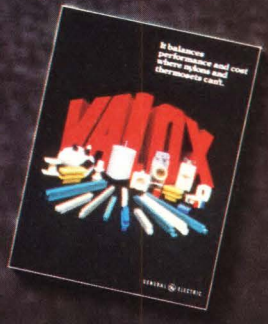

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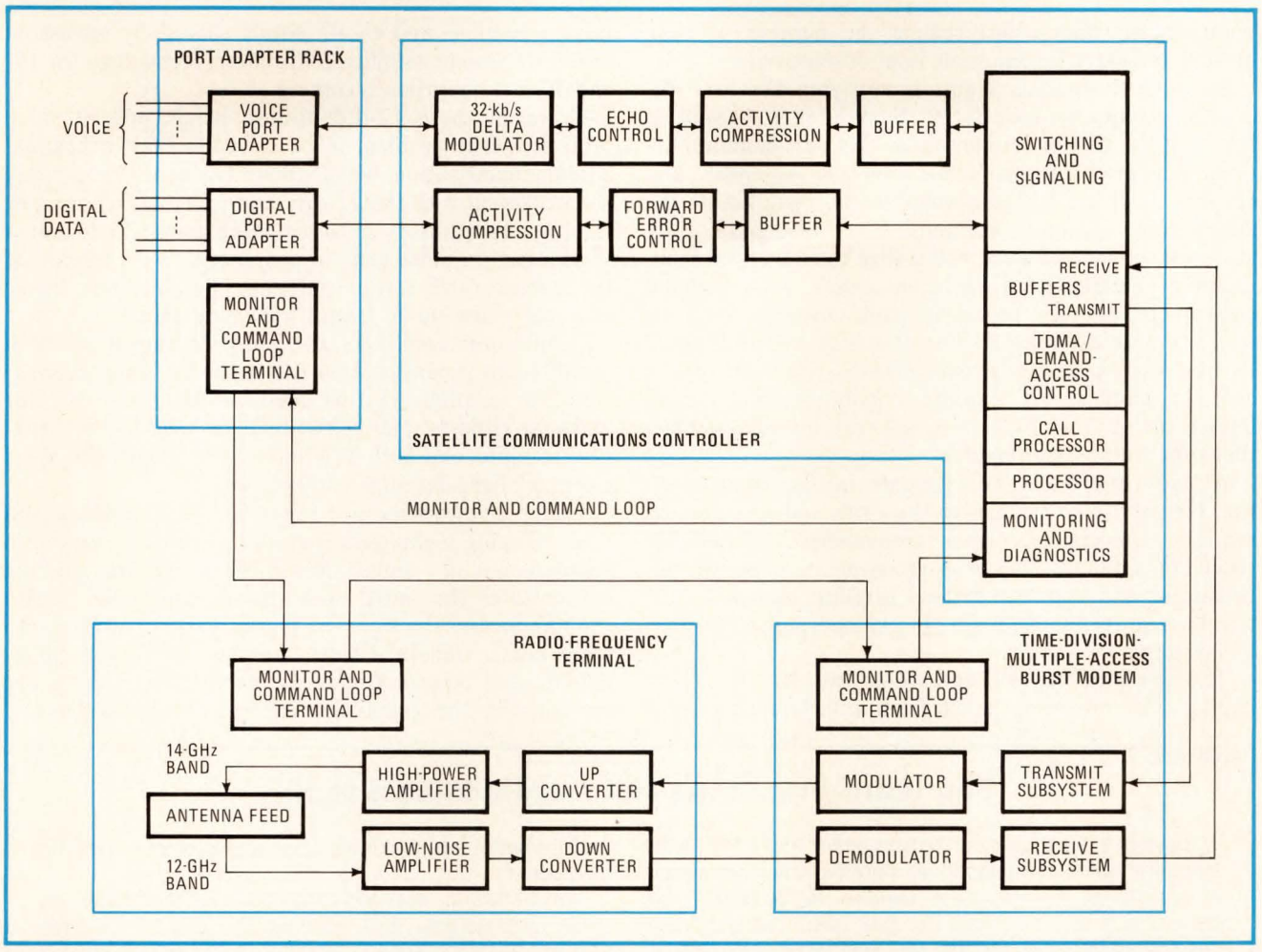


All digital. Key ingredients of SBS earth stations are the satellite communications controller that performs multiple-access, switching, and control functions and the burst modem that enables bursts of digital data to be transmitted to each satellite channel on a time-shared basis.

For example, Bell is using SSB techniques to triple the capacity of its microwave relay equipment, which handles about 70% of U. S. interstate calls. The main stumbling block was system nonlinearities, which restrict overall channel capacity. To reduce these nonlinearities, Bell is using an improved traveling-wave-tube amplifier in its transmitters, while predistorting the signals to cancel any distortions generated by the TWT.

Other advances coming

Future microwave systems will benefit from other technological advances: terminal multiplexing equipment that will more efficiently combine the 6,000 voice circuits per channel that SSB makes possible, a special microwave preamplifier to handle a-m, SSB, and conventional fm channels in a single transmitting unit, and space-diversity antennas to counter fading. The move towards digital transmission will benefit from developments in digital-switching and multiplexing technology, as well as improvements in solid-state components.

The growth of satellite communications is just getting started, but its role as an important means of transmitting voice, data, and TV signals is already assured. To help the space systems cope with increasing volumes of traffic, several technical advances are going into the generation of satellites that will go into orbit within the next three years.

The trend clearly is towards putting more power and circuit capacity into the satellites at higher frequencies. Such frequencies reduce interference from terrestrial communications while allowing lower-cost earth stations with smaller antennas and greater bandwidth. The increased capacity comes from frequency-reuse techniques with dual polarization of antennas in transmit and receive and beam-steering schemes that permit continuous real-time reassignment of channel capacity to accommodate the varying needs of users.

New technology for satellites

For example, the Intelsat V satellite will carry K_u-band spot-beam antennas that will use dual-polarization, multiple, shaped beams. Its complex transponder with 27 channels switchable between various antenna coverages will use 43 TWT amplifiers (almost twice as many as in preceding satellites), 15 solid-state receivers using microwave IC technology, and novel contiguous-

band output filters that reduce the number of such devices necessary for the same level of selectivity.

Satellite Business Systems is readying the first all-digital satellite network for U. S. coverage. As well as lowering the cost of sending data, this new communications network features small low-cost antennas and cheaper earth-station equipment to be installed at the subscribers' business locations. The all-digital, fully switched, private network will utilize the advanced technique of time-division multiple access with demand assignment, thereby providing each customer with its own communications net. The networks can be tailored to meet each customer's requirements, and each will be able to allocate its satellite capability dynamically among the earth stations in its network in order to meet real-time traffic requirements.

Already in orbit is the experimental Canadian satellite, Hermes (formerly called the CTS), and it is proving out the concept of higher frequencies and smaller receiving antennas. Japan is readying its experimental broadcast and communications satellite that will help develop the technologies for its planned domestic satellite system.

The new satellites will operate in the 12- and 14-GHz bands, thus providing relief from interference on the heavily used 4- and 6-GHz bands shared by terrestrial links and present satellites. Moreover, technology for 18- and 30-GHz operation is coming on fast.

However, these 12-GHz-and-up bands present some problems. One problem to be solved is that orthogonal antenna polarization, which allows frequency reuse, may not work well with the 12-GHz-and-up bands. Moreover, satellite transmitters must be more powerful to get a good signal-to-noise ratio in conjunction with the use of the smaller earth-station antennas. For instance, heavy rain may cause signal fading or even outages.

High-power amplifiers are being developed for both satellite and ground-station use at these higher frequencies. For example, Litton made a 200-watt TWT for Hermes; Hughes' 100-W TWT will be used in the Japanese satellite; and both Telefunken and Siemens in West Germany have developed 500-W TWTs.

Under investigation are electronic beam-steering and beam-shaping techniques that will put more power into selected satellite signal transmissions. Beam steering concentrates the signal on a specific area, while beam shaping focuses the signal so that it does not overlap into other areas. General Electric's Space division in Philadelphia and NASA's Goddard Space Flight Center are investigating the technology required for such systems.

PROFILE

The team that made fiber-optic links a reality

Achieving a practical fiber-optic system that could withstand the rigors of a telephone operating environment and of installation by someone besides highly skilled lab personnel is no small task. But Bell Telephone Laboratories researchers did just that last year when they demonstrated a link working in a simulated operating telephone environment in Atlanta, Georgia. The fiber-optic system not only worked well with existing telephone equipment, but the cable was pulled through telephone ducts and mass-spliced without any handling of individual fibers.

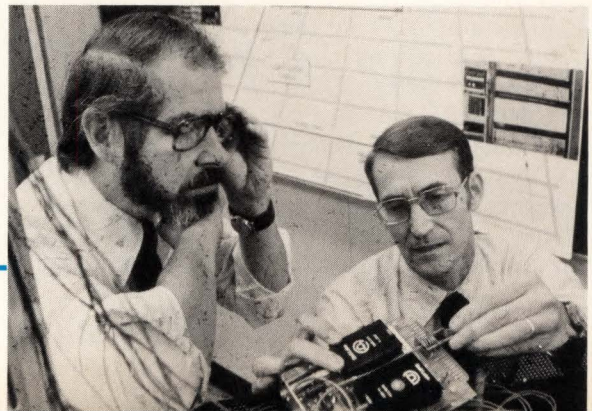
Although many individuals contributed to that breakthrough, which paved the way for a similar real-world installation in Chicago this year, three Bell Labs engineers played major roles in making the first practical fiber-optic telecommunications link a reality.

Joe Mullins (center) guided the electronics and systems design. The only physicist in the trio, he never had any doubts about the electronics needed for the link. But he remembers saying skeptically, "The day I have a demountable fiber-optic connector, I'll believe it."

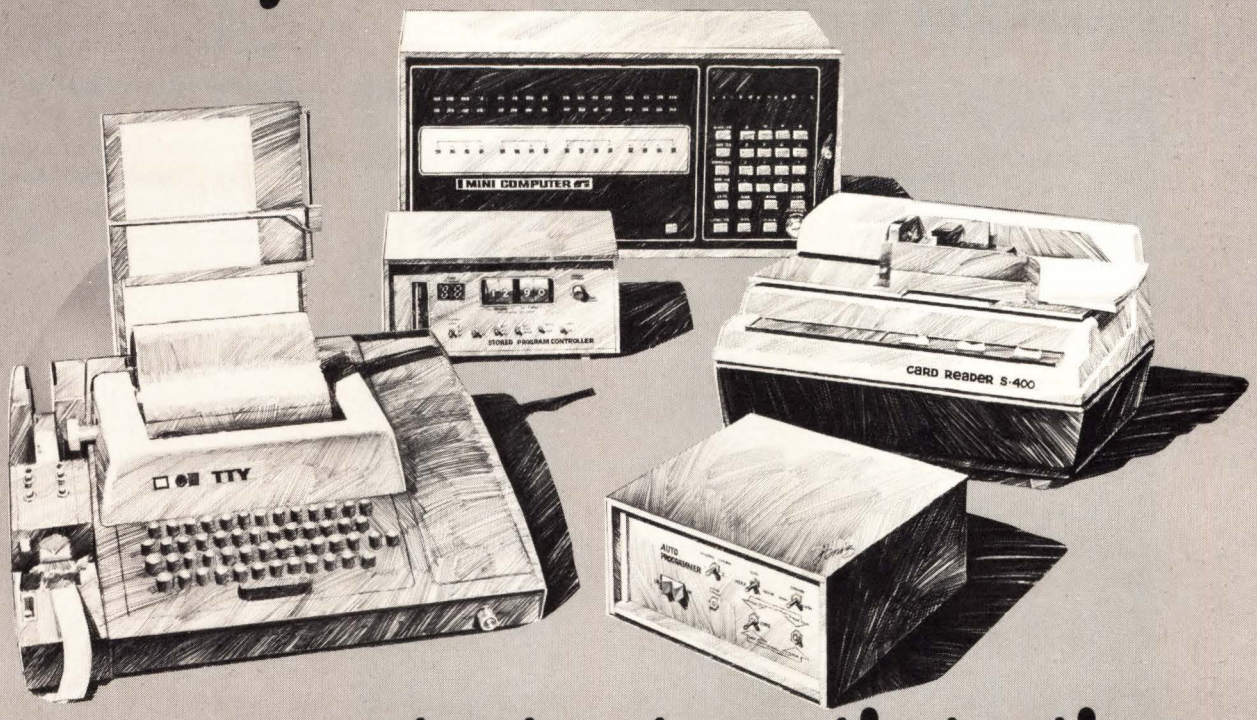
Of course, that day did come, but not without many moments of anxiety, according to Jack Cook (left), who was responsible for the interconnections and system characterization. "The problem of molding the single-fiber connectors for the telephone distribution frames with sufficient accuracy to assure low-loss connections was solved almost at the last minute," he says. "Western Electric's Engineering Research Center took standard stock brass tubing and formed it into a double cone that precisely centered the fibers."

Mort Schwartz, who was responsible for the cables, the cable connectors, and installation, saw the biggest problem as taking existing technology and simplifying it so that workers with no special skills could handle the fiber-optic links as easily as twisted pairs of wire. "Right now we can do splicing more quickly and simply with optical fibers than we can with standard twisted-wire cables," he says. "And we are making splice cases not much bigger than the fiber-optic cable dimensions."

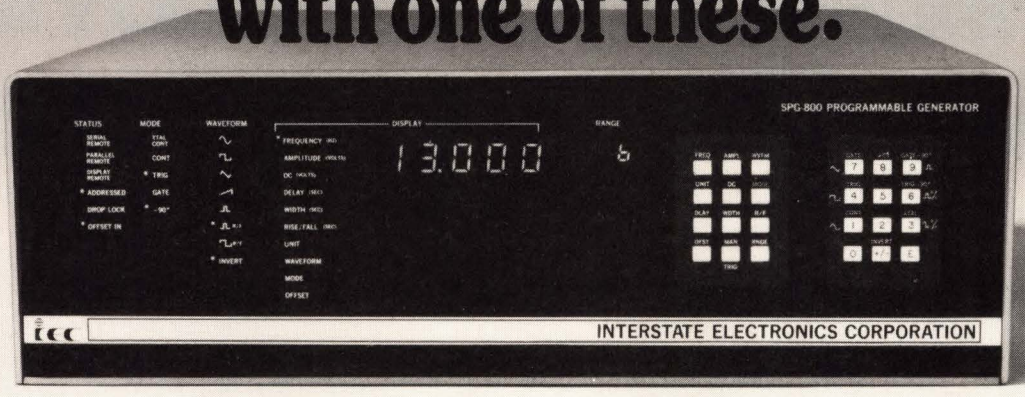
All three are involved in Bell's ongoing fiber-optic program and are anxious to see how everything holds up under long-term exposure to harsh environments. They agree that optical fibers will not replace metallic conductors until devices, connectors, and fibers all come down in price. But they are convinced such drops will happen fairly soon. Also, they feel what is needed are longer-wavelength sources in the 1,200-nanometer region where fiber losses are less and and there is less of a problem with material dispersion, which limits the system range and bandwidth, especially when light-emitting diodes are used.



If you have one of these...



...you can start automatic testing with one of these.



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All you need is one of the units pictured, the new SPG-800 Synthesized Programmable Generator, and a little do-it-yourself effort. Just use one of the units pictured to store your test procedure program with simple instructions to command the SPG-800 (and any other programmable instruments you use) and you're off and running.

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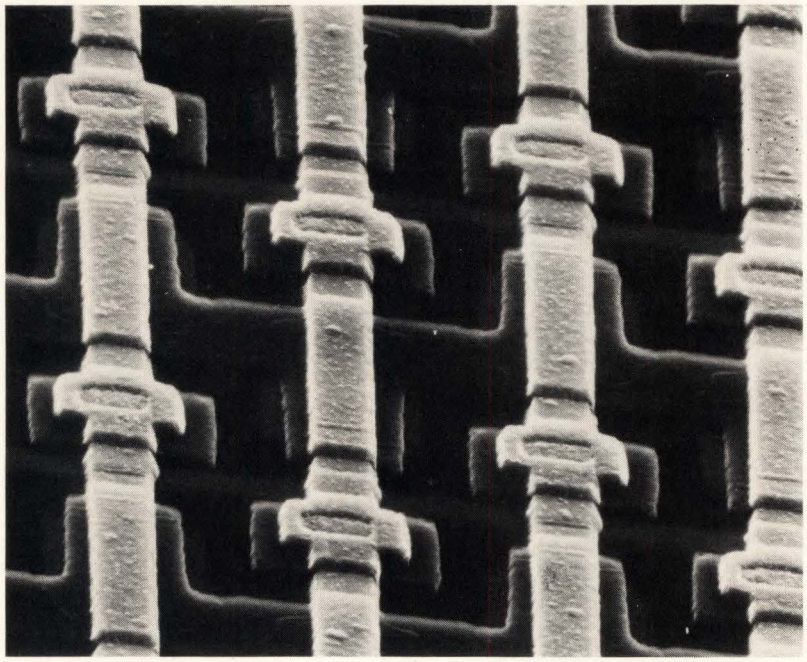


Electron-beam effects. An 8,192-bit FET RAM chip made with IBM's Vector Scan electron-beam lithography system typifies the next LSI generation. The scanning electron-beam micrograph shows the 2-μm-wide metallization lines and 1.25-μm-long gates on the chip's surface.

E-BEAM SYSTEMS ARRIVE, FLEXIBLE CIRCUITS FLOURISH

by Jerry Lyman, *Packaging & Production Editor*

☐ The fine-line circuit patterns of today's advanced LSI are forcing semiconductor manufacturers to buy new and more refined lithographic and etching equipment. Last year's densest, large-scale integrated circuits could get away with the 5-micrometer line widths possible with contact printing and wet etching. But by now the move is towards 2-μm and eventually submicrometer resolution, which demands at least optical projection methods or electron-beam lithography, plus dry plasma etching.

As for the chips already emerging from the new equipment, some will undoubtedly be mounted on flexible printed-circuits, suddenly a popular choice for many industrial and commercial applications. Others may end up on bumped film-carriers, the latest approach to production-line chip handling.

Given this context, the year's most important development—the one that will have the biggest industrywide impact—is the appearance and acceptance of commercially available electron-beam systems for the manufacture of IC masks. Until 1977, most large systems of this kind were designed and constructed in house by such firms as Texas Instruments, IBM, Bell Labs, Japan's Cooperative Laboratory, the Sescosem division of France's Thomson-CSF, Germany's Siemens AG and the Elcoma division of Philips of the Netherlands. Most machines are for precision mask manufacture, but two—IBM's ELI and the Japanese machine—are high-throughput machines for computer-controlled direct exposure of patterns on silicon wafers covered with a light-sensitive resist. The direct exposure of wafers is the ideal lithography method, because it eliminates the mask-making step and automatically compensates for wafer distortion, but it is cost-effective only on high-throughput machines.

During 1977, redesigned commercial versions of Bell Labs' EBES mask-maker have come from Etec Corp., Hayward, Calif., and Varian Associates' Extrion division, Gloucester, Mass. The $1-million-plus machines, Etec's MEBES and Extrion's EBMG-20, take about an hour to expose a wafer up 5 inches in diameter. Extrion recently sold its first system to the mask-making firm of Ultratech Inc. in Santa Clara, Calif., while Etec has already delivered a unit to Fairchild Camera and Instrument Corp. and has another ready to go to RCA's Solid State division.

By the end of next year, there will be at least a dozen commercial electron-beam machines in operation, and for the next two to three years, their main use will be to make master masks for use in optical projection lithography. But once IC technology moves to line and space

resolutions of less than 1 or 2 μm, direct electron-beam exposure of the wafer will be required. At that time, semiconductor makers will need systems with throughputs approaching IBM's ELI, which now handles 22 2¼-inch wafers per hour.

Meanwhile, optical projection lithography is becoming an increasingly important production technique. It has proven more cost-effective for LSI than contact printing, since it prolongs mask life and offers higher wafer yield.

Virtually all of today's projection printing of LSI wafers, both in the U. S. and abroad, is being done with machines produced by Perkin-Elmer Corp., Norwalk, Conn. Built around a reflecting optic system, these units are 1:1 projection systems (the mask reproduces the entire wafer pattern and not just the individual chip pattern).

Projecting the present

The firm's latest model has an improved condensing lens for shorter exposure times. It can expose 90% of a 4-inch wafer and has an automatic load feature that permits cassette loading of wafers. All the Perkin-Elmer machines are manually aligned and can expose lines and spaces 2 μm wide with an alignment error of 1 μm.

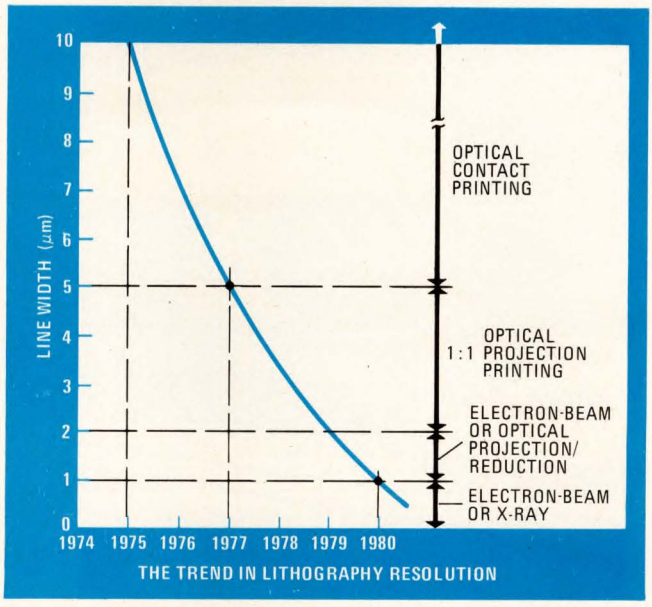
Cobilt, a division of Computervision Corp., Santa Clara, Calif., is developing a 1:1 system that will automatically align wafers as large as 5 inches in diameter. This machine should become available next year.

Another type of optical printer now becoming available to IC manufacturers is the reduction-projection system. The mask in this case is much easier to manufacture, being an enlarged (4× or 10×) image of a single IC pattern cut out of a chrome plate. Through this reticle the system projects a reduced image onto a wafer, then gradually steps the reticle and repeats the exposure across the entire wafer. Resolution is significantly higher than with the 1:1 projection system.

For instance, the FPA 141 from the Japanese firm of Canon Inc. uses a 4× reticle that can print 0.89-μm-wide lines in a positive resist and 1-μm-wide lines in a negative resist. Alignment accuracy is 0.125 μm, and maximum wafer diameter is 3 inches. Throughput is 30 wafers an hour.

The Netherlands' Philips Gloeilampenfabrieken has an in-house computer-controlled wafer/mask-alignment system based on the reduction-projection principle. Called the silicon repeater (SIRE), this system projects IC patterns with a 5:1 reduction ratio onto a wafer. Minimum resolution is 2 μm, alignment accuracy is 0.1 μm, and maximum wafer size is 4 inches.

The latest machine of this type comes from GCA Corp.'s Burlington division in Burlington, Mass. Its type 3696 optical photorepeater exposes wafers to the image from either a 10× or 5× reticle and then step-and-repeats this image across the wafer, which may be up to 4 inches in diameter. With a 10× reticle the system can achieve resolutions of 1.25 and 1.5 μm with a throughput of 20 wafers per hour. A 5× reticle changes resolution to 2 μm and throughput to 30 to 35 wafers per hour. A fourth machine of this type is in development at Ultratech Corp., Santa Clara, Calif.



Shrinking lines. Today's integrated-circuit geometries, fabricated by optical and projection printing, are at the 5-μm level. By 1980, demands for 1-μm details will see the first large-scale employment of direct electron-beam exposure of silicon wafers.

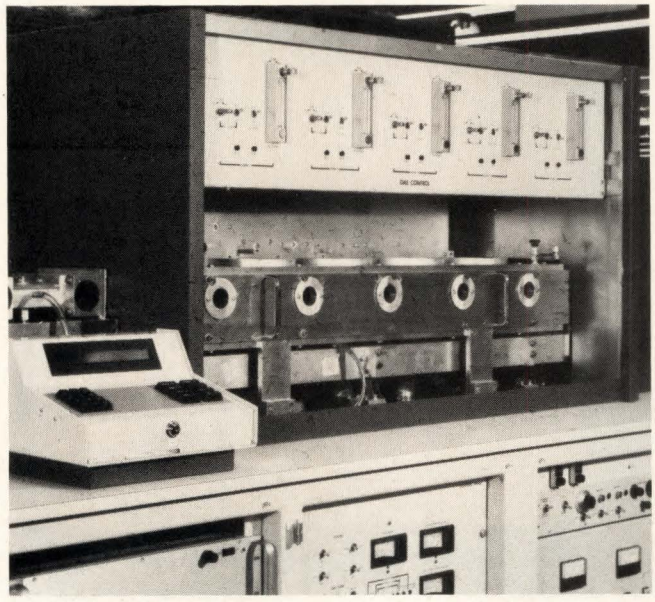
The new reduction-projection machines will compete with electron-beam systems for wafers with pattern details in the 1-to-2-μm range. Prices of commercial step-and-repeat optical projection units are about a third of the $1.5 million electron-beam units. In addition, the less costly systems have greater throughputs than present commercial electron-beam machines.

The evolution of integrated-circuit lithography from contact printing to the present state of the art is shown above. By 1980, when line widths of 1 μm will be required, direct electron-beam exposure and X-ray methods should take over.

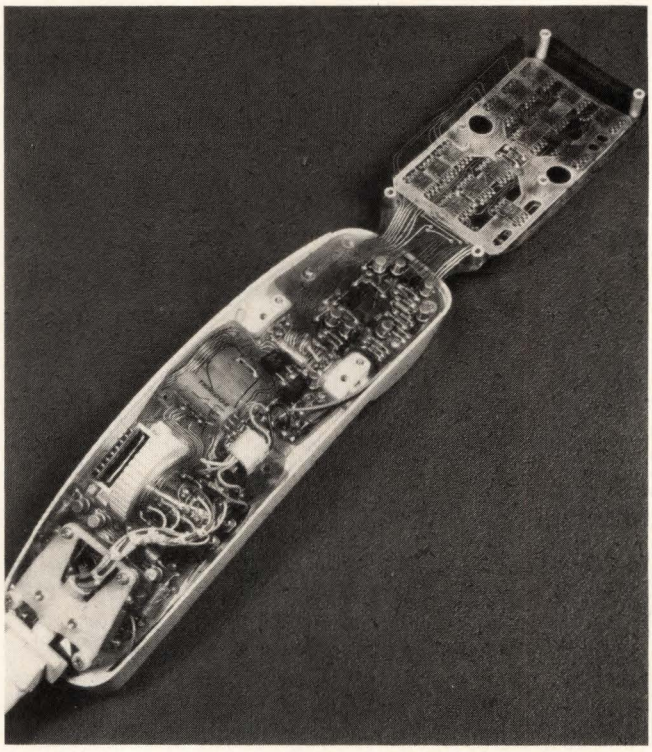
Plasma processing

As the IC industry moves to near-micrometer line widths, plasma etching is gradually displacing wet etching. Using a cloud of ionized gas as the etchant, it will be found in most new IC processing lines because of its higher yields and easier disposal vis à vis the environment. This same basic method also is being used to deposit silicon nitride on IC wafers.

At present, plasma processing is in transition, changing over from cylindrical reactors, which produced a quality of etching that could vary widely from wafer to wafer, to parallel-plate types, which produce a more uniform electric field. Also, unlike the older units, which could etch only silicon dioxide or silicon nitride, the parallel-plate equipment can etch aluminum because of the longer life of its plasma particles. For instance, two new plasma reactors from DW Industries, Sunnyvale, Calif., and International Plasma Corp., Hayward, Calif., can etch into aluminum—a development that could



Production plasma. Cassette-to-cassette wafer handling, microprocessor control, and high throughput are important features of LFE Corp.'s System 8000 for plasma deposition of silicon nitride. These same features should appear on future plasma etching systems.



Flexible phone. Flexible circuitry lets the electronics designer bend his system to fit into an irregularly shaped volume. Shown is a sophisticated application of flexible circuits in an avionic intercom headset from Telephonics, a division of Instrument Systems Corp.

herald the elimination of all wet IC etching.

A drawback of all plasma etchers and depositors is that throughput still hovers around 40 to 50 wafers per hour. IC firms would prefer something closer to the wet-etching rate—say 150 wafers per hour.

Also, the present machines require manual loading of wafers onto a platform. The first not to do so is an in-line silicon-nitride-plasma deposition system manufactured by LFE Corp., Waltham, Mass. The system 8000, illustrated above left, automatically transfers each wafer from a cassette through a load lock that preheats them and evacuates the processing region to the low-micrometer range. The wafer then enters the processing region upon command from a microprocessor controller, receives a preset amount of silicon nitride, and is made to exit through an unload lock into a cassette receiver. Wafer throughput can be as high as 90 wafers per hour.

The LFE machine, which is not a parallel-plate unit, approaches what IC manufacturers would like to see in other depositors or in plasma etchers—in-line capability and high throughput. The future should bring larger, microprocessor-controlled, parallel-plate reactors with in-line capability. Also, etching versions of their new units will be able to handle all the materials commonly encountered in present MOS and bipolar processes.

A flexible explosion

In the fields of packaging and interconnections, one of this year's biggest stories is the growth of flexible printed circuitry. Probably 10% of all printed circuits produced will be of the flexible type, now that the material problems are solved and the approach is winning acceptance.

Flexible circuitry is changing electronics designers' approach to commercial and consumer packaging. They are getting away from the standard mother-daughter rigid board or card-file approaches and starting to emulate military systems by fitting the electronics wiring and components to the shape of a unit, whether it is a camera, telephone, or pacemaker. The photograph above on the right shows how complex electronic circuitry is squeezed into the headset of an airline intercom at Instrument Systems Corp.'s Telephonics division, Huntington, N. Y. Without the multiplanar packaging feature of flexible circuitry, this packaging solution would have not been possible.

Within the next few years there should be many new developments within this field. Flexible circuits subtractively etched with fine lines less than 1 mil wide (10 mils is the normal width now) should be used more and more, particularly for designs in which bare chips or film-carrier devices are bonded directly to a flexible substrate. Multilayer flexible circuits also should start acquiring nonmilitary uses.

It is already fairly usual to stiffen a flexible substrate with a bare rigid board. This has been done to enable the flexible printed circuit to support fairly heavy components. But the future will see the combination of flexible circuits with rigid boards become more usual. The two will be connected through common plated-through holes, and the flexible portions will fan out into many planes. A combination rigid and flexible multilayer board will unite the best features of the two types

Finally, simpler and cheaper connectors for flexible

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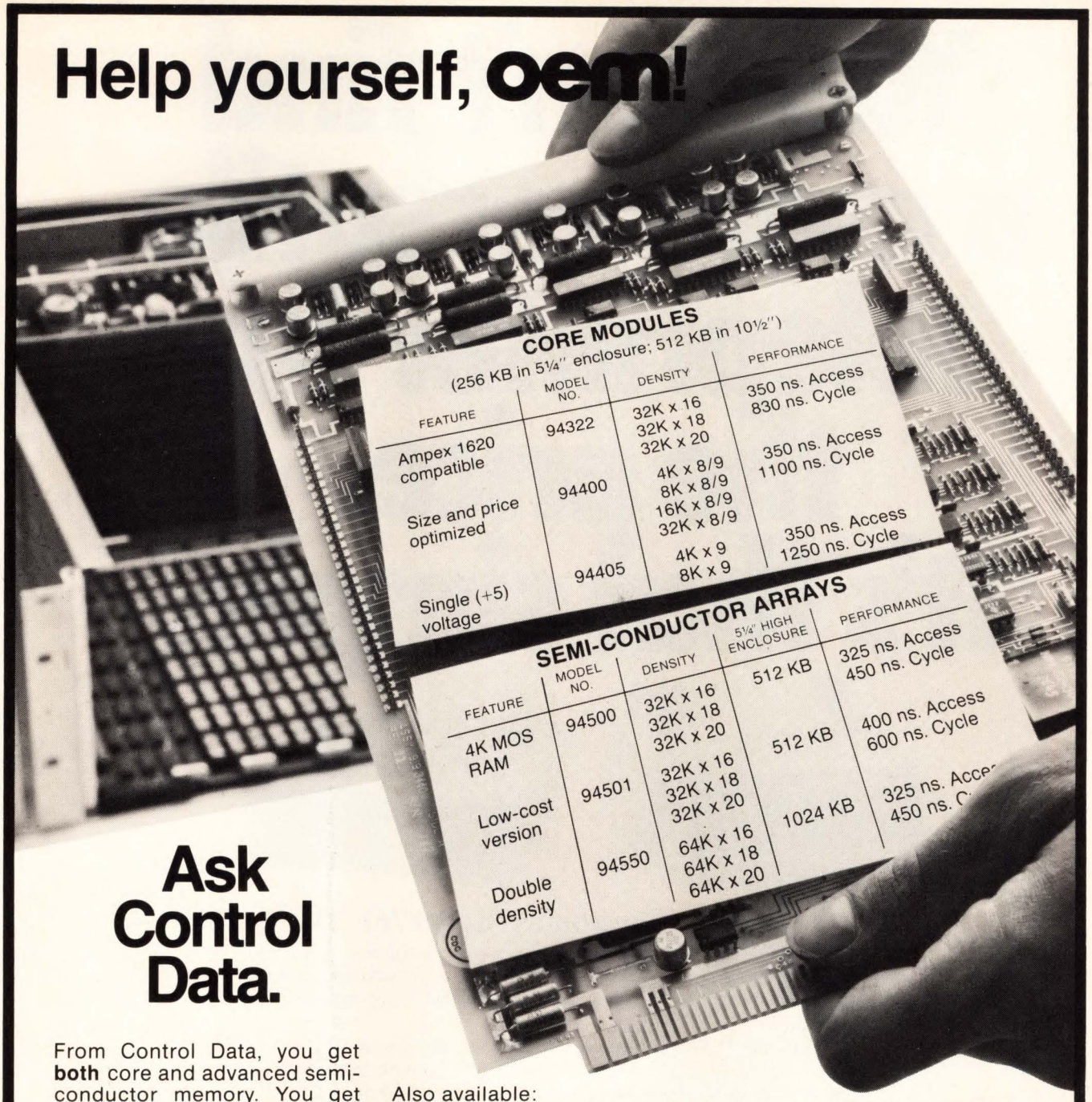

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circuitry should appear, as should a lower-cost material with properties approaching Kapton's good high-temperature properties and solderability.

Bumped film-carriers

A new development in the film-carrier technology, a carrier with bumps, may allow an even greater use of this method, which is so well suited to automation. Normally a film carrier is either a sprocketed, nonconductive film having a copper surface etched with IC interconnections or else a thin all-copper sprocketed strip with IC interconnects etched out. Both systems need special chips to which raised, metallic input/output pads have been added. The bumped chips are then automatically gang-bonded to the inner leads of the carrier's IC interconnection patterns.

These two kinds of film-carriers are available from at least four companies: International Micro Industries, Cherry Hill, N. J.; 3M Co.'s Electronic Products division, St. Paul, Minn.; Fortin Laminating Corp., San Fernando, Calif.; and the Dyna-Tape division of Dyna-Craft Inc., San Fernando, Calif.

In house, IC manufacturers have used the approach to put high-volume small-scale ICs on film, adding bumps to, say, transistor-transistor-logic devices destined for plastic dual in-line packages. But few of them have proved willing to supply customers with appropriately bumped chips, and this dearth has slowed the spread of film-carrier techniques into the hybrid field, where chips on film could be bonded directly to ceramic substrates.

Last year, though, Pactel Corp. of Westlake Village, Calif., changed things somewhat by adding bumps to the carrier, not the chip. But then it did not supply the polyimide tape in anything longer than short strips—fine for a developmental hybrid application but not the reels that a production facility needs for mass-bonding of chips to film.

An easing of this situation should occur early next year, when Dyna-Tape will come out with reels of a metal-bumped film-carrier in 11- and 14-mm widths. Chips mounted on it will not be isolated from each other and will therefore be untestable. So within the year there will be a follow-up product, a 19-mm-wide film-carrier that is testable as well as bumped. Like the first tape, it will be available in reels.

The new freedom to bond conventional chips to film carriers will affect two areas: IC companies at present not supplying chips on film-carrier, and the hybrid field. With the new bumped tape, it will be possible for any IC house to supply large or small quantities of conventional chips either in reels or on strips of tape. The small quantities of chips bonded to tape are especially needed in the thick- and thin-film hybrid field. Hybrid companies, experienced in all types of bonding, will now be able to order their own custom tapes and bond the chips to the film themselves.

PROFILE

The man behind the gun

The gun counts for a lot, if not quite everything, in scanning-electron-beam microscopes and electron-beam lithography systems, and in the newer equipment it is a lanthanum-hexaboride electron gun. Providing much higher brightness, better mechanical stability, and much longer life than previous tungsten units, it was developed in 1967 by Alec N. Broers of IBM's T. J. Watson Research Center, Yorktown Heights, N. Y.

Broers, a native of Australia, is one of the pioneers in electron-beam lithography. As far back as 1963, at Cambridge Instruments in England, he was using an electron beam to expose submicrometer patterns on resists. In 1965 he joined IBM as research staff member, and in 1977 he became an IBM fellow. Throughout that time he has worked on developing precision electron-optical equipment and applying it to microscopy and microcircuitry.

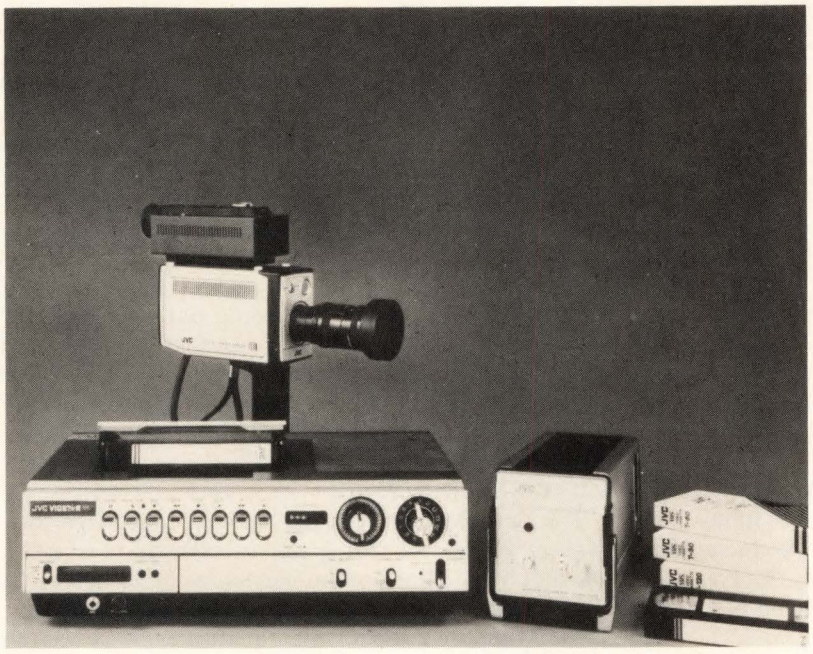
By the mid 1970s, Broers had succeeded in building a surface scanning electron microscope around the lanthanum-hexaboride gun that achieved a resolution of 50 angstroms, as compared with the 150 angstroms occasionally achieved by commercial instruments. More recently, a member of his group at IBM, Oliver C. Wells, conceived a new low-loss imaging method, which Broers incorporated into the microscope to improve its resolution to 20 angstroms, corresponding to a smallest resolvable surface feature of 7 angstroms or less.

As he improved the resolution of scanning microscopes, Broers exploited their ever smaller electron spot sizes to fabricate experimental ultraminiature devices. Already in the 1960s, he and members of his group had fabricated transistor structures with 0.5-micrometer line widths and acoustic surface wave transducers with 0.15-μm lines on 0.5-μm centers.

More recently, a group reporting to Broers designed and built the Vector Scan One (VS1) electron-beam lithography system [*Electronics*, May 12, 1977, p. 89] and with it did the lithography for an 8,000-bit memory chip with 1.25-μm lines.

Last year, Broers went still further, with a new technique that produces 80-angstrom-wide lines and spacing. This technique has great scientific potential, since it may permit the manufacture of the first practical X-ray lenses and of super-lattice-like field-effect-transistor structures.

Says Broers: "There is still a lot of growth potential in scanning-electron-beam lithography. Advanced electron-optical concepts and faster control electronics should increase their throughput. Another important trend will be a major overall reduction in their cost."



VTR takes off. Coming onto the market is a deluge of home video-cassette-tape recorders developed by Sony Corp. in the Beta format, and Victor Co. of Japan in the VHS format. Shown is JVC's two-hour-play unit.

DIGITAL TAKEOVER EXTENDS TO TV AND AUTO CONTROLS

by Gerald M. Walker, *Consumer Editor*

☐ At least two microprocessors in every garage and one watching the chicken pot pie: Herbert Hoover would approve of the American home of the next half decade. The nation's first engineer President would also appreciate the staggering potential that digital electronics and large-scale integration have for change in the daily life of the consumer.

This year marks the return of video technology into the consumer-products spotlight. Television games are mushrooming, TV-set tuning is going even more automatic (thanks to microprocessors and similar chips), and video-tape recorders for the home are poised for a takeoff. In fact, entertainment-electronics makers are betting that home VTRs will be as big a market sensation as color TVs were, especially when technological advances knock the $1,000 price tag down. Technological spinoffs are the still-infant audio tape and disk players that use pulse-code modulation for ultrahigh-fidelity sound reproduction.

Of course, other consumer areas have seen technological advances in the past year. Calculators have extended their range in both directions: simple devices that hover around $10 in price and expensive units that rival computers. More programmable appliances are certainly on the way, although for the moment the field is the property of microprocessor-controlled ovens. But perhaps the most significant momentum in the incorporation of digital electronics into consumer products is found in the design of everyone's favorite appliance: the automobile.

Home VTRs gear up

Japan's electronics makers have more than 20 years' experience with video-tape recorders and can point to even longer-term familiarity with audio tape players. So it should come as no surprise that the force behind the development of home VTRs is from the Far East rather than from America.

The two chief formats for home VTRs—the Beta format pioneered by Sony Corp. and the Video Home System pioneered by Victor Co. of Japan—are undergoing intensive development to reduce tape use. Such a reduction gives longer play, which is at the heart of a successful low-cost unit (the devices now cost about twice as much as the TV sets with which they work).

In their standard-play mode, systems using either format will record an hour's program on the equivalent of less than 2 square meters of tape. In their extended-play modes, they require less than 1 m^2 of tape. In 1969, the standard Japanese VTR format took 9 m^2/hr.

TABLE 1: COMPARING BETA AND VIDEO HOME SYSTEM FORMATS

Feature	Beta Sony Corp.	VHS Victor Co. of Japan
Recording time	1 hr (2 hr)	2 hr (4 hr)
Tape speed	4.0 cm/s (2 cm/s)	3.34 cm/s (1.67 cm/s)
Video track width	58.5 μm (29.2 μm)	58 μm (29 μm)
Relative tape speed	7 m/s	5.8 m/s
Fm carrier frequency		
white peak	4.8 MHz	4.4 MHz
synchronization tip	3.5 MHz	3.4 MHz
Chroma frequency	688 kHz	629 kHz
Audio track width		
monaural	1 mm	1 mm
stereophonic	0.35 mm	0.35 mm
Head cylinder diameter	74.5 mm	62.0 mm
Azimuth angle	7°	6°

( ) = long play mode

Source: Matsushita

The Sony models and the VHS units manufactured by Matsushita for the American market are helical-scan, two-head units that use ½-inch tapes. Although the two formats have many similarities, they are not compatible (see Table 1). But the way they both have achieved reduced tape consumption is to narrow the video tracks to slightly under 60 micrometers and to eliminate guard bands between the individual tracks.

However, these developments mean significant pickup of signal from adjacent tracks, and they require measures to eliminate the crosstalk. Separate methods overcome luminance and chroma interference between adjacent tracks. Shifting the azimuth of the two heads in opposite directions from the perpendicular to the track obtains interference rejection between frequency-modulated luminance signals on adjacent tracks.

To deal with the chroma problem, the Beta and VHS recorders use different phase-shift schemes—but they end up with similar results. The phase of the chroma carrier is manipulated during recording and playback so that the two successive horizontal video lines played back on the same track are in phase, but those of comparable lines on adjacent tracks are 180° out of phase. When the successive chroma signals are added together, they cancel the signal from adjacent tracks.

The work that is going into perfecting extended-play versions of VTRs is part of the drive to enhance their commercial potential. Such add-ons as a microphone and a camera will bring those units that can record and play back into the realm of home TV studios. Of course, the VTRs can play back cassettes furnished from other sources—some U. S. entrepreneurs are supplying cassettes of first-run movies (not always legally).

If digital encoding can bring a television studio into the home, it can also bring in the sound of a concert hall. So reason the Japanese electronics firms that are working on pulse-code modulation for tape and disk audio players. The tape systems make it possible to record and play back what the Japanese are calling super hi-fi, using a VTR. The disk system operates like an optical video disk in that a laser encodes information on the disk with playback by a laser scan.

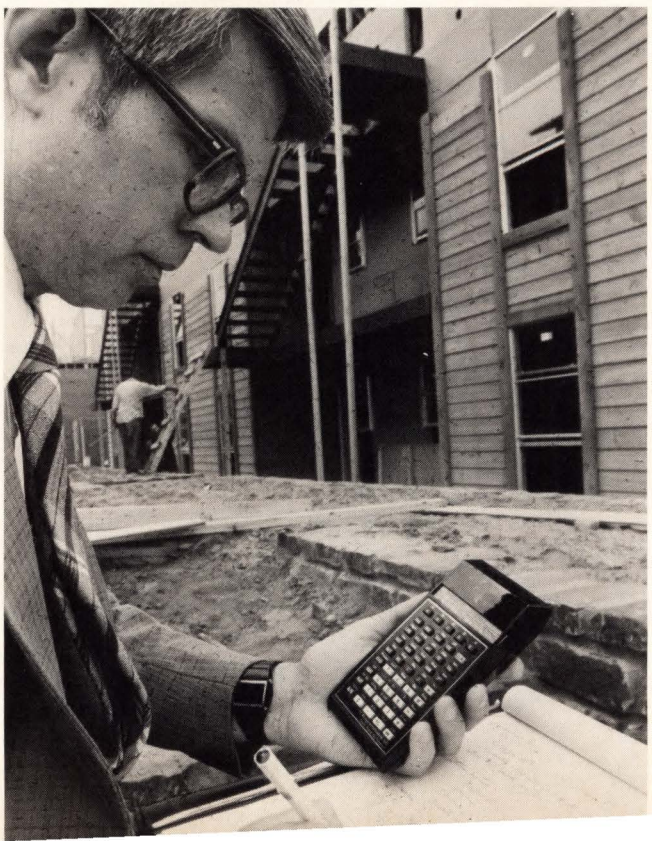
PCM for audio buffs

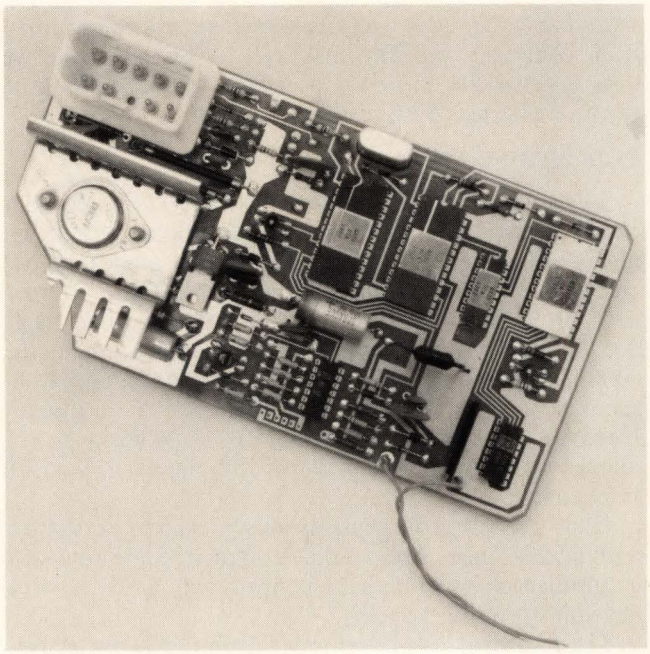
Sony was first to introduce a PCM adapter that converts the video channel of its Betamax VTR to an ultrahigh-fidelity stereo tape deck. The analog-to-digital converter and coder convert incoming audio into a 1.762-megabit-per-second PCM stream on the tape. The decoder and digital-to-analog converter return the stream to original audio, which is fed into an amplifier-speaker system. The system features a frequency response flat within 1 decibel from 2 hertz to 20 kilohertz. Harmonic distortion is less than 0.03% at all frequencies.

High performance such as this is bound to attract audiophiles, once prices of the equipment come down. So a number of other Japanese firms are hard at work developing similar systems.

The PCM disk also holds great potential in the stereo-buff market. So far, Sony, Hitachi, and a group headed by Mitsubishi have all announced development of disk systems. Again, other Japanese firms are also hard at work on it. Since the records will be the key to the success of these players, all the participants have agreed that there should be a standard format. But the audio industry has a sorry history on standardization; to wit,

Programmed. The Texas Instruments model 58 and 59 calculators have a library of 16 programs for special applications. The program modules that plug into the back of the calculator may be altered if necessary by entering changes through the keyboard.





Spark advance. The Chrysler Corp. lean-burn spark-advance system, introduced as a two-board analog system, has been designed into a microprocessor-based digital control. In test runs this year, it consists of controller, ROM, RAM, and C-MOS I/O chips.

two different long-playing speeds, two incompatible four-channel stereo systems that have not made it, and three different tape formats.

Similarly, there are two formats vying in PCM disks. The Mitsubishi and the Hitachi types use frequency modulation while Sony has what the firm calls delayed modulation, which permits longer playing time. To avoid dropout problems, these systems are using redundancy of about 50% extra bits to correct for errors. Mitsubishi and Sony use helium lasers in their players, and Hitachi has a space-saving solid-state laser.

The disks are quite similar to those used in optical-laser video players developed by Philips in Europe and MCA in the U. S. They spin at 1,800 revolutions per minute, with pick-up by reflection of a laser beam positioned by three servo systems.

LSI into the driver's seat

Driven by ever-tightening Federal regulations for emission control and fuel economy, automotive electronics has shifted into high gear [*Electronics*, Sept. 29, p. 83]. The design effort includes lean-burn spark-advance systems, exhaust-gas recirculation, fuel metering or electronically controlled carburetors, and electronic fuel-injection systems.

But there also is gradual replacement by electronics of electromechanical parts such as headlamp controls, windshield-wiper controls, and the like. In addition, electronic ignition systems and voltage regulators are going into second and third LSI generations, primarily to gain greater integration and thus more compact units.

Auto companies around the world are working toward the day when the various control systems can be combined into a set of microprocessors. A major design hurdle is the need for reliable, low-cost sensors linked to the processors. For instance, the same temperature and speed inputs are used by two or three different engine controls. Table 2 gives a rundown of potential automotive applications for electronics.

Perhaps the next major challenge in arranging the microprocessor systems that will control the cars of the 1980s will be multiplexing. Experimental multiplexed systems have been designed with fiber-optic transmission and with conventional three-wire loops. Both types have proved successful, but cost is still a stumbling block.

Even though car designers may combine two or three engine-control microprocessors into just one device, other processors will be added for other functions, such as diagnostics, multiplexing, radio tuners, and so on. So by the mid 1980s, cars could contain from four to eight microcomputers.

TV's digital pace steps up

Automatic color controls were an important feature of last year's TV sets, as was the tripotential gun from Zenith. Refinement of the controls continues, and the tripotential gun seems on its way to more widespread adoption—and to finding competition. But the big news in the coming year will be the development of more versatile digital tuning, often incorporating infrared remote tuners that circumvent the interference problems sometimes encountered with ultrasonic signals.

The trend toward adding such features as memory, push-button channel selection, and digital readouts began a year ago, and it became increasingly clear that microprocessors would be employed to control the variety of jobs that these tuners must perform.

U. S. manufacturers are showing interest in dedicated chips for their tuners rather than general-purpose microprocessors. For instance, sets from GTE-Sylvania's Entertainment Products division, Batavia, N. Y. use the General Instrument Omega system: a microprocessor-like n-channel metal-oxide-semiconductor control, a nonvolatile electrically alterable read-only memory, an n-MOS display driver, and a complementary-MOS digital-to-analog converter.

General Electric's Portsmouth, Va., Television Receiver department has a tuner with a similar chip, designed around phase-locked-loop channel-selection. GE also is featuring an infrared remote control—the first among U. S. set makers.

Quasar's Japanese parent, Matsushita, has developed a custom microprocessor for the Franklin Park, Ill., set maker. Besides channel selection, the device controls a frequency search, ramping the tuning voltage to the varactor diodes to sense the presence of a TV signal.

A much more elaborate microprocessor application shows up on a Blaupunkt-Werke GMBH receiver. Besides tuning, the three-chip Fairchild F8 processor turns the set on and off at times programmed into its memory as long as one year in advance. It also uses stored data to

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control contrast, brightness, color saturation, and volume for each channel [*Electronics*, Sept. 2, p. 36].

The F8 in the West German set also implements a tuning function called step search, in which channels without a transmission signal are skipped during automatic tuning. It also turns the set off once a station stops transmitting. In fact, the Blaupunkt set may serve to acquaint its owner with the versatility that programmable appliances can bring to the home.

A year ago, Zenith Radio Corp. of Chicago was trumpeting its new picture tube with a tripotential gun. While the tube itself elicited no interest from other TV manufacturers, the gun has. With its extended-field lens, the gun improves picture sharpness by reducing spot size 50% compared to that of conventional bipotential guns. Zenith is supplying the gun in its conventional picture tubes to other TV set makers.

Now RCA Corp.'s Picture Tube division in Lancaster, Pa., is bringing out a tube with a bipotential gun that it claims achieves a spot size almost equal to that of the tripotential tube. Improved focus comes from a redesigned beam-forming optical system and an increase in the voltage on the focusing electrode from 5.5 kilovolts to 8.5 kv. Moreover, the gun does not require the fourth 12-kv focus electrode of the tripotential gun.

More ground rules for games

The increasing rough and tumble of the TV-game business has induced equipment makers to offer more games and more varied playing features. For the upper price bracket, the answer has been mating a microprocessor with digitally encoded tape-cartridge programs. Fairchild's programmable game, using an F8, has been joined by Bally, and Atari to name two. Some of these use custom-designed microprocessors, and others use standard devices such as the CP 1600 and PIC 1650 from General Instrument Corp., Hicksville, N. Y.

However, devices that the game maker can program are not the whole ball game. To cover a wider range of prices and game types, both GI and Texas Instruments Inc. of Dallas have introduced families of standard circuits around which a manufacturer can build a number of different game packages. For example, GI's new Multigame Basic Circuits let the games maker choose among four basic games chips and then add playing features or other games with additional chips. Similarly TI's Universal Game Circuits provide various combinations of standard circuits to construct a game tailored to the intended selling price. The intent behind these offerings from both companies is the same: to avoid the high front-end investment and long lead time of dedicated chips while approaching the variety of the programmable units.

One-chip games here

The wave of the future may be signalled by TI's recent introduction of the first of a family of single-chip games. By next year, the family will include strategy and action games, possibly with color and digital scoring, and all at highly attractive prices.

TABLE 2: ELECTRONIC SYSTEMS FOR THE AUTOMOBILE

Closed-loop engine control	Sleep detectors
Dual-displacement engine control	Automatic vehicle guidance
Electronic fuel injectors	Road coefficient detector
Automatic cruise control	Multiplexed wiring
Automatic brakes	Engine knock-limiting control
Automatic diagnostic systems	Low-tire-pressure indicators
Exhaust-gas regulation	Digital dashboard display
Radar crash sensors	Emergency location transmitter
Vehicle blind-spot detectors	Alcohol ignition interlock

Source: General Motors

But the big news in electronic games does not include TVs at all. It is the move of microprocessors into self-contained games coming out from the traditional toy makers like Parker Brothers, Milton Bradley, and Mattel. In these games, the processor acts as another player and the displays are implemented with light-emitting diodes or liquid crystals. So far, the applications require no new technical developments, but the field is in its infancy and the game makers are deadly serious about their electronic future.

The basic hand-held calculator has become so cheap that it is almost a back-to-school item just like a lunch-box. So development has swung to the programmable calculators at the other end of the spectrum. In fact, as the distinction between key-programmable and card-programmable units has blurred, the offerings are getting closer to becoming miniature computers. For example, TI's Programmable 59 features plug-in read-only memories. Each 40,000-bit module may contain 5,000 program steps, and once the program is inserted into the calculator, it may be changed from the keyboard. The ROM modules may be used with 3-in.-long magnetic program strips that slide into the calculator to record the revised program.

Another feature of the Programmable 59 that may spark emulation is its ability to repartition program and memory, much like a computer. The 10 MOS random-access-memory chips provide a capacity of 960 program steps. The program can be shifted in 80-step blocks, each of which provides 10 more registers, up to a maximum of 100. Thus the calculator, set up for complex operations with few variables that require more program steps than data storage, can be altered to handle short programs with many numbers. Such programs usually require more data storage than they do program steps.

The fierce shakeout raging in the American digital-watch market is taking precedence over development of

new solid-state circuitry. There is more attention to displays, with liquid crystals staging something of a comeback over LEDs because they can be multiplexed to increase reliability. Electrochromic and electroluminescent displays also look like they will be getting attention. On the high end of the market, the calculator watch is showing up from several firms. Hewlett-Packard, for one, has designed its new HP-01 watch for time-oriented calculation.

Since battery life is a sticky point with digital watches, attention is shifting to that component. Solid-electrolyte lithium cells have recently been introduced in watches and calculators. Such cells offer energy densities of 150% to 200% greater than cells with liquid organic electrolyte. For instance, lithium-iodine solid-state batteries have an energy density of 0.6 hour per cubic centimeter at 2.8 volts. Another important feature of the electrolyte is its self-discharge rate: lithium iodine has less than 5% self-discharge in 10 years, which makes it ideal for a digital-watch application.

If there was ever any doubt that the microprocessors would make it big in the home, the programmable microwave oven overcame it. Microwave units had been around for years, but there was little interest among consumers until programmable ovens came along, featuring ease of use as well as precision timing.

Now the name of the game is to expand the programmability. Tappan Appliance Corp., Mansfield, Ohio, incorporates the TMS 1100 microprocessor from TI into a range that offers programming of time and temperature cooking—as do other new models—plus a feature that lets the cook program the cooking cycle well in advance by punching in the starting time.

What with programmable TV tuners, programmable games and programmable ovens, consumers are becoming familiar with digital electronics' adeptness at performing familiar tasks and its possibilities for extending digital control into untapped areas. The progress of the home computer probably holds the key to full-scale development of the electronic home, but the thrust to bring interactive information systems into the home is another vital ingredient.

PROFILE

The three who perfected GE's automatic color control

Ever since the top management of General Electric Co.'s Television Receiver department in Portsmouth, Va., set out to be among the technological frontrunners, its design staff has pushed unconventional development efforts. Perhaps the most significant is the automatic color control based on the external, vertical-interval-reference signal [*Electronics*, March 31, p. 25]. This receiver feature, which takes advantage of a broadcast industry standard designed to provide uniform color transmission from one channel to another, posed several knotty problems for three GE engineers identified with the project.

One of the early problems was the standard itself. "We wanted a couple of changes in the standard to make it more convenient to use in the receiver," says Michael Palladino, manager of advanced circuitry and display engineering (center in photograph). However, it was so far along it could not be changed. So, notes Palladino, a member of the Electronics Industry Association committee responsible for drawing up the standard, "we had to find a way to use the signal as is."

Palladino, 51, who received a bachelor's degree in electrical engineering from the University of Washington in 1951, conducted the feasibility study for incorporation of the VIR feature into GE's color sets. Just as he likes to do his own auto-mechanic work, he did the circuit development and breadboard work on the prototype system.

The GE design team soon faced another headache. "In the first experimental transmissions by the networks, we very seldom had VIR signals available to us. That made it tough to evaluate the receiver's operating characteristics," notes the 25-year veteran of the TV department.

As the broadcasters got their act together and as more of them transmitted the VIR signal, GE began converting its concept into a practical, cost-effective module. That became the responsibility of Sanjar Ghaem (left), manager of the color TV electrical design engineering group. The 41-year-old Iranian received his BSEE in 1960 from Chicago Technical College. Although he has 13 U. S. patents in the TV field, the 17-year GE veteran's role was to coordinate VIR activities, "rather than actually contributing to the solution of any problems," he says.

Perhaps the biggest headache in the program, notes VIR project leader Howard Holshouser (right), was designing a system immune to noise. Holshouser, 35, and holder of a BSEE degree from North Carolina State University in 1967, did the nuts-and-bolts work to get the system in form for production.

However, notes the 10-year GE designer, "we had to deal with white noise, Gaussian noise, and pulse noise generated by passing cars," among other signals that look just like the VIR signal. To make the technique work in that environment, he derived a solution for which a patent application has been filed. "We came up with a group of different circuits that collectively performed the function, but individually weren't worth a dime," says the holder of two other patents.

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CHRONOLOGY

October 1976

- Lithic Systems Inc. introduces first single silicon chip housing all the active functions needed for an a-m transceiver. *Oct. 14, p. 32*
- Interactive fiber-optic CATV network to begin two-way tests with 300 subscribers near Osaka, Japan. *Oct. 14, p. 39*
- Better than 10% efficiency is reached with 10-by-10-cm solar cells developed by Germany's AEG-Telefunken for terrestrial applications. *Oct. 14, p. 55*
- Siemens of West Germany announces the model 3352 electrophotographic laser printer, which scans a maximum of 70,000 characters per second *Oct. 28, p. 64*

November 1976

- Electro-optic crystal modulator developed by Sperry Rand allows direct modulation of light beam, permitting switching and multiplexing of optical bit streams. *Nov. 11, p. 32*
- I^2L chip, providing PLL frequency synthesizer for CB radio, developed by Motorola in Japan. *Nov. 11, p. 53*
- IBM announces its entry into the minicomputer market with the Series/1. *Nov. 25, p. 41*
- Solar Technology International uses thick-film screened-on inks to put contacts on silicon solar cells. *Nov. 25, p. 53*
- The industry's first single 5-V ultraviolet-light-erasable PROM technology is developed by Intel for 8-bit single-chip microcomputer (8748) and stand-alone 16-k erasable PROM (2716). *Nov. 25, p. 99*

December 1976

- U. S. National Bureau of Standards decides to adopt the encryption algorithm proposed by IBM. *Dec. 23, p. 42*

January 1977

- Federal Communications Commission approves the use of antennas 4.5 m in diameter for receive-only CATV earth stations. *Jan. 6, p. 33*
- Motorola wins contract to supply General Motors with microcomputer chips for various control functions in GM's cars over the next few years. *Jan. 20, p. 31*

February 1977

- Sperry Univac introduces its first small business system, the BC/7. *Feb. 3, p. 35*
- Joint Electron Device Engineering Council (JEDEC) writes a standard for a family of 50-mil-spaced LSI chip carriers and sockets for pc board use, allowing interchangeability of five different types of chip carriers. *Feb. 3, p. 44*
- Bell Laboratories gives first bubble memory a trial in a Michigan Bell Telephone Company switching office. *Feb. 17, p. 38*
- Hewlett-Packard discloses a 16-bit microprocessor chip built with C-MOS-on-sapphire technology, for high-performance control applications. *Feb. 17, p. 82*

March 1977

- Industry's first high-performance 5-V MOS processes emerge from the labs of Intel and American Microsystems. Intel (H-MOS) and AMI (V-MOS) both promise 1-k and 4-k static RAMs that rival bipolar performance (access times below 50 ns) and 65-k ROMs with speeds under 200 ns. *March 3, p. 32*
- A shapable magnetic shielding material, Metshield, made of a soft-magnetic glass, is announced by Allied Chemical Metglas Products. *March 3, p. 138*
- FCC approves 800-MHz cellular mobile radio-telephone system proposed by Illinois Bell Telephone for Chicago test. *March 17, p. 32*
- West German research institute invents the fluorescence-activated display, FLAD, which exhibits the same low power dissipation as the LCD but yields much higher light intensity. *March 17, p. 55*
- With its high-performance linear bipolar process, Precision Monolithics makes the first 12-bit d-a converter in monolithic form. *March 17, p. 130*

Significant advances in electronics technology reported over the past year in *Electronics*

April 1977

- IBM announces the System/34 business computer. *April 28, p. 30*
- A high-speed digital facsimile machine produced by 3M Co. sends a 300-word letter in about 20 s when transmitted at the unit's top speed of 9,600 b/s. *April 28, p. 36*

May 1977

- Texas Instruments introduces first microprocessor-based 40-channel combination a-m and single-sideband CB radios. *May 12, p. 31*
- Philips Gloeilampenfabrieken develops a reduction-projection mask aligner with an alignment accuracy of 0.1 μm. *May 12, p. 32*
- For the first time, Burr-Brown builds complete microprocessor-compatible analog I/O systems as thick-film hybrids in IC-compatible packages. *May 26, p. 106*

June 1977

- Xerox Corp. introduces the 9700 electrophotographic nonimpact printing system, which runs at 21,000 lines per minute. *June 9, p. 26*
- Researchers at Japan's Cooperative Laboratory develop an electron-beam lithography system that completes a pattern directly on a wafer in half the time taken by competitive equipment. *June 9, p. 33*
- First 16-bit microcomputer chip, from Texas Instruments, the 9940, is industry's most powerful single-chip controller. It has 128 bytes of RAM and 2,049 bytes of ROM, can address 32 bits of I/O, and handles 16-bit words. *June 23, p. 118*

July 1977

- Using I^2L, Analog Devices for the first time puts a self-contained microprocessor-compatible 10-bit a-d converter on a single chip. *July 7, p. 25*
- Bell Labs scientists report on GaAs solid-state lasers with projected lifetimes of 1 million hours — 100 years of operation. *July 7, p. 26*
- Motorola's Government Electronics division introduces modules and boards that implement the NBS encryption algorithm. *July 7, p. 40*
- Hewlett-Packard introduces first instrument using C-MOS-on-sapphire technology, the 2240A measurement and control unit. *July 7, p. 128*
- The first digital switch, built by Stromberg-Carlson, for small central telephone offices is cut over in Georgia. *July 21, p. 25*
- IBM develops an integrated package containing all the electro-optical elements of a fiber-optic transmitter. *July 21, p. 35*

August 1977

- First commercial bubble system for mini-floppy replacements in microcomputer systems is introduced by Texas Instruments. System includes 92-k memory chips and LSI peripherals for building semiconductor versions of mini-floppy disks. *Aug. 4, p. 81*
- With thin-film hybrid technology, Datel shrinks an entire microprocessor-compatible, 16-channel, 12-bit data-acquisition system into a single IC-compatible package. *Aug. 18, p. 35*
- Motorola wins contract to supply Ford Motor Company with a custom microcomputer for fuel and emission control on 1980 cars. *Aug. 18, p. 42*

September 1977

- Industry reaches the 65-k level in ROM chips as three suppliers introduce devices: American Microsystems' ROM is the first to use V-MOS technology; Mostek and National Semiconductor use silicon-gate processes. All boast access time below 300 ns. *Sept. 1, p. 26*
- From National Semiconductor comes the industry's first monolithic data-acquisition system. The ADC 0816 has an 8-bit a-d converter, 16-channel multiplexer, input-address latches, and buffered three-state output latches. *Sept. 1, p. 34*
- First of the sub-100-ns 4-k static memories built with Japanese-developed D-MOS technology emerges to challenge U. S. dominance in market. *Sept. 15, p. 39*
- Philips develops resistless, additive pc process for fine-line printed wiring. *Sept. 15, p. 42*

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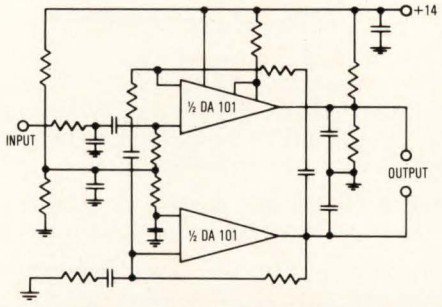
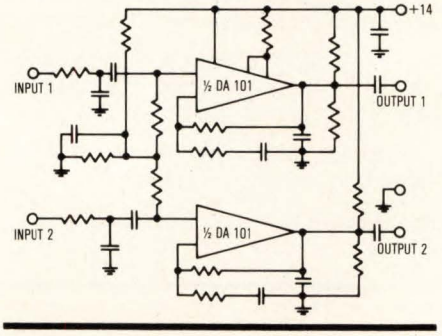
AUDIO BRIDGE CIRCUIT



TWO SEPARATE AMPLIFIERS CIRCUIT



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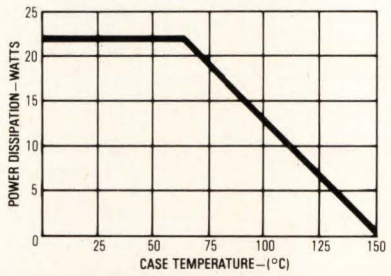

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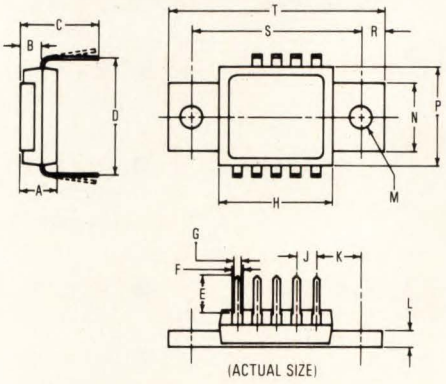

SYMBOL	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A		.220		5.59
B	.127	.133	3.22	3.38
C	.423	.443	10.746	11.254
D	.628	.632	15.95	16.05
E	.215	.225	5.463	5.717
F	.044	.048	1.13	1.21
G	.015	.019	0.39	0.47
H	.644	.650	16.37	16.52
J	.095	.105	2.413	2.667
K	.275	.285	6.983	7.237
L	.086	.096	2.183	2.437
M	.122D	.128D	3.100	3.25D
N	.369	.379	9.373	9.627
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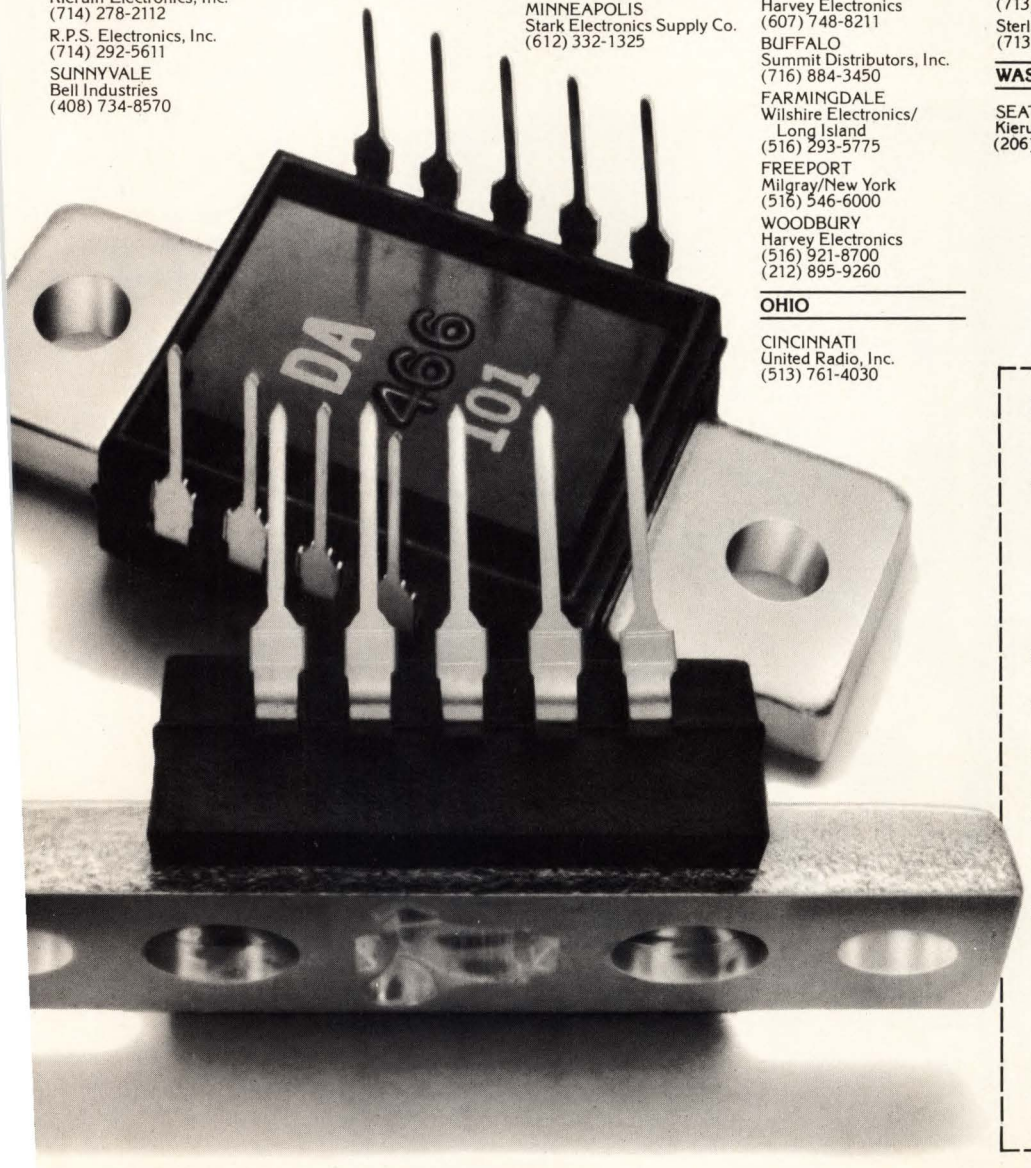

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SABRE VII
makes no compromise with quality and performance... Why should you?

No other IRIG tape recorder/reproducer gives you all these capabilities. System prices from less than $15,000.

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- Direct bandwidths to 2 MHz
- FM bandwidth from DC to 500 kHz
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Amazing? Yes, and because of the same superior engineering, SABRE VII also controls tape speed accuracy to within ±0.10% and extends tape and head life through enhanced tape handling. Options include FM calibrator, remote control, voice, IRIG tape servo, rack mount kit, shuttle, sequential record and/or reproduce and anti-vibration mounts. **SABRE VII doesn't compromise with quality and performance. Why should you!**

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Circle 152 on reader service card

Board has analog and digital outputs

Interface card for SBC-80-type systems provides four digital outputs and choice of two or four analog outputs for minimum system cost

by Mike Riezenman, New Products Editor

One of the ways in which money is sometimes wasted in computer-controlled systems is in the use of expensive digital-to-analog converters to perform simple digital tasks like actuating relays or turning on indicator lamps. The problem has been that, until now, output boards for most microcomputers have provided either all analog or all digital outputs, but not both. If you needed lots of each kind, this was fine. But the small-system designer who needed two or three digital outputs and one or two analog outputs had to buy an analog board and use a few of its high-resolution d-a converters as simple logic drivers.

For users of Intel SBC-80 series single-board microcomputers, the RTI-1201 real-time interface board solves this problem by providing a mixture of outputs on a single card. Furthermore, most of its more costly features are offered as options, so the user can carefully select only those that he really needs.

Basically the board is an eight-channel unit with four software-controlled logic drivers and either two or four 12-bit d-a converters. If desired, the converters can be provided with voltage-to-current converters that produce 4-to-20-milliampere current-loop outputs.

The four digital logic drivers are open-collector outputs rated for 30-volt operation and each is capable of sinking a continuous current of 300 milliamperes. The analog outputs have five ranges that can be selected by the user by means of wire-wrappable jumpers: 0 to 5 v, 0 to 10 v, ±2.5 v, ±5 v, and ±10 v.

Easy to use. The RTI-1201 has many features and capabilities that reduce the effort required to interface a microcomputer with the real world. Among the features included are d-a converter readback, memory mapping, and card selection.

D-a converter readback, which is simply the capability for reading back the converter's input data, can be an important convenience since it eliminates the need for scratchpad memory or software overhead to store data written into the converters. Any time the data is needed it is available at the converters.

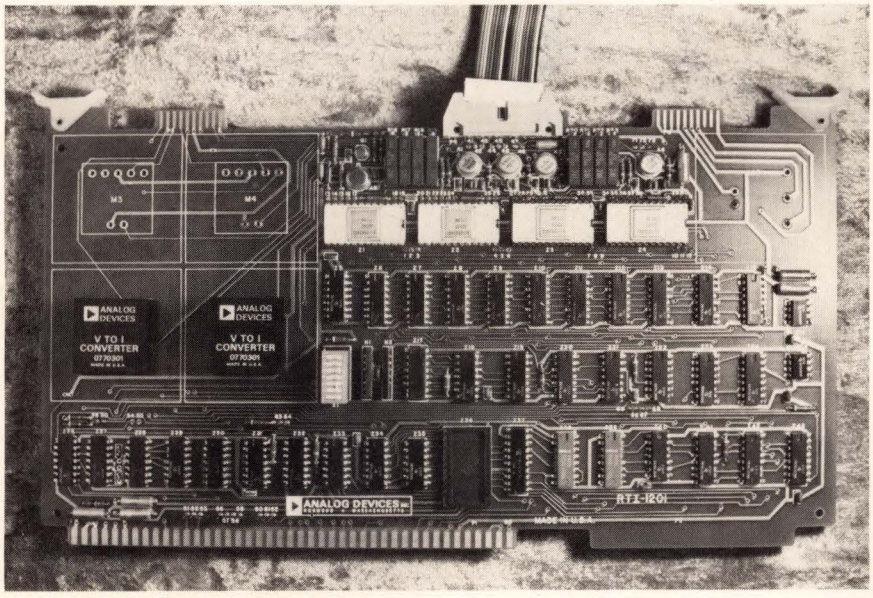
Memory mapping allows the RTI-1201 to interface with the microcomputer as a 1,024-byte block of memory. This lets the system designer take advantage of all of the 8080 memory reference instructions.

The card-select capability allows as many as 16 RTI-1201s to share the same block of memory locations. Analogous in some ways to memory paging, this feature is particularly useful when it is desirable to use the same subroutines with more than one RTI-1201.

Power. The RTI-1201 must be powered by a ±15-v source. If none is available, a dc-to-dc converter can be provided to allow the board to run off the microcomputer's 5-v supply. In small quantities, the converter adds $75 to the price of the board.

Without the dc-to-dc converter, in quantities of one to nine, prices for the RTI-1201 range from $298 for the basic four-driver, two-converter configuration to $579 for a board with four drivers, four d-a converters, and four voltage-to-current converters. Other standard configurations include four drivers, two d-a converters, and two v-i converters for $398 and four drivers and four d-a converters for $379.

Analog Devices Inc., P. O. Box 280, Norwood, Mass. 02062. Phone Fred Pouliot at (617) 329-4700 [338]



Semiconductors

Rectifiers have linear drops

10-ampere ion-implanted diodes have reverse-recovery times of 50 nanoseconds

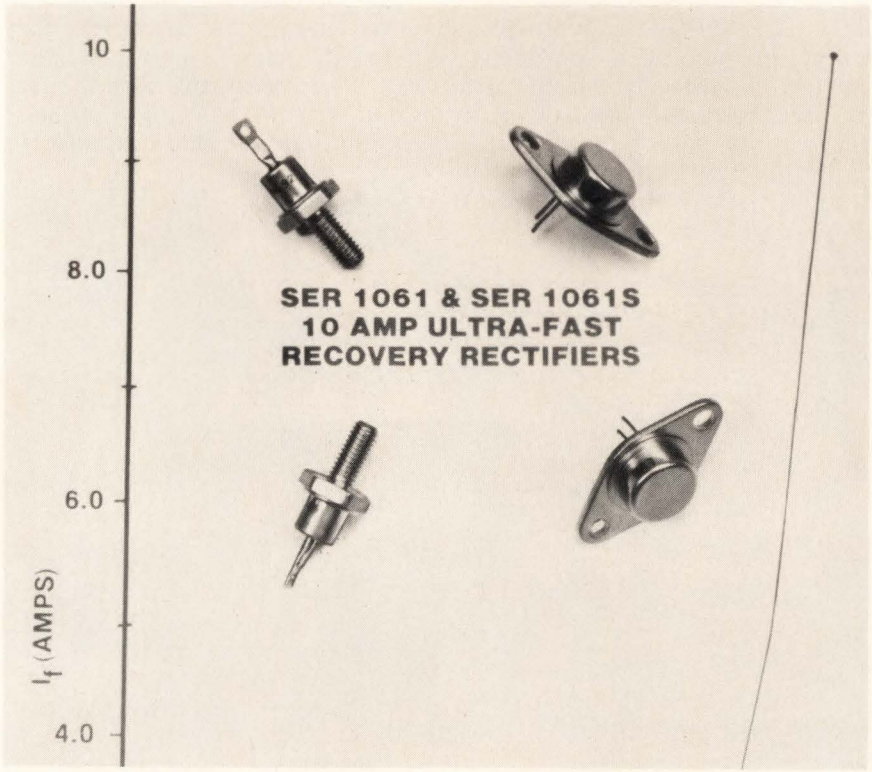
Designed for multiple-output switching power supplies, two 10-ampere rectifiers offer linear forward-voltage-drop characteristics that, in some cases, eliminate the requirement for regulating circuits. In fact, Solid State Devices Inc., manufacturer of the rectifiers, guarantees these forward-voltage drops throughout the 1-to-10-ampere operating range of the rectifiers.

Compared with Schottky diodes for the same switching-power-supply applications, the SER 1061 and SER 1061S are "lower-priced and more stable linear performers," claims Arnold Applebaum, president of Solid State Devices. Priced at less than $2 in large quantities, the rectifiers simplify power-supply circuitry, according to Applebaum.

Maximum instantaneous forward-voltage drop at 10-A forward current is 0.907 volt, and these forward drops are guaranteed: a difference of 0.25 V is specified between 1 A and 5 A, 0.10 V between 5 A and 10 A. These linear characteristics are often within the overall specifications of common power supplies, he notes, especially when full-wave bridges are used. For more accurate supplies, regulating circuits are dictated, primarily because of copper losses.

The devices offer a 50-nanosecond reverse-recovery time when measured from a 0.5-A forward current, traversing to −1 A and recovery to 0.1 A. Maximum full-cycle average reverse current is 2 mA at 100°C. No derating is required for reverse leakage up to 80% peak-inverse voltage at 150°C, and the operating range is −65° to 200°C. Peak repetitive reverse voltage is 50 V while rms reverse voltage is 35 V. Peak repetitive forward current is 40 A and peak surge current is 200 A, both at 100°C.

The key to attaining precise



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In the unlikely event that repairs should be necessary on the development system, Leasametric will initiate either in-house service or a replacement system within 24 hours—at no additional cost.

Leasametric will also make available a special hot line telephone number to assist you in solving any operational problems.

Our 18 fully-stocked Inventory Centers across the U.S. and Canada will provide on-going technical assistance and dedicated service whenever needed.

Call your nearest Leasametric Rental Inventory Center listed below for immediate shipment of the Tek 8002 or further details.

Leasametric

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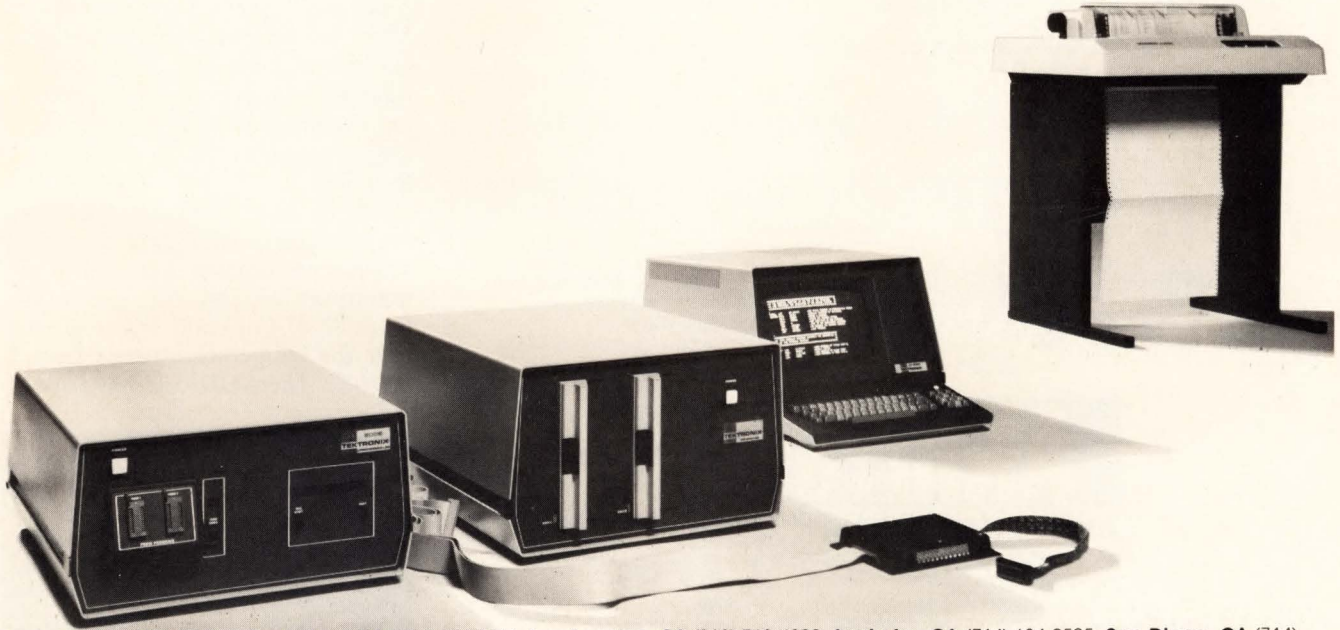
822 Airport Blvd., Burlingame, CA 94010



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TOLL FREE NUMBERS: Outside California 800-227-0280; **Outside New Jersey** 800-631-7030; **Outside Maryland** 800-638-0838; **Outside Illinois** 800-323-2513.

control over forward-voltage characteristics while decreasing switching time is use of the company's ion implantation process, Applebaum says. Conducted in a high-vacuum chamber using a solid ion source, the implantation technique allows accurate impurity placement 200 to 300 angstroms below the epitaxial surface with virtually no lateral migration, he says.

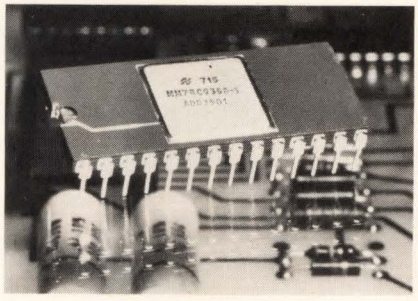
Electrically identical, the two rectifiers are packaged in different cases. The SER 1061 is housed in a TO-66 package while the S model comes in a D-14 stud-mounted package. In 100-unit quantities, they are priced from $3.40 to $4, depending upon case style and forward-voltage drop. Delivery is from stock to 30 days.

Solid State Devices Inc., 14830 Valley View Ave., La Mirada, Calif. 90630. Phone (213) 921-9660 [411]

C-MOS chip is almost a complete a-d converter

The model ADD3501 (also known as the MM74C935-1) one-chip converter device needs only an external voltage reference and a few nonprecision passive components to form a complete analog-to-digital converter. Add digit drivers and a light-emitting-diode display, and the unit becomes a 3½-digit panel meter that will operate from a single 5-volt dc supply.

The C-MOS circuit uses an integrating pulse-modulation conversion scheme to provide high noise immunity at low cost. Maximum error is 0.05% of full scale +0, −1 count over the temperature range from 0° to 70°C. The ADD3501 has a multi-



Berg Minisert Sockets display "high reliability" on Tektronix Oscilloscopes

The Berg Minisert™ is a miniature, low-profile P.C. socket which allows .400"-tight board-to-board spacing. The Minisert provides positive, functional reliability over repeated insertion/withdrawal cycling; its elastomeric seal keeps out contaminants.

Tektronix likes the repeated pluggability the Minisert socket affords in using transistors, LED's, lamps, IC's and other components. Tektronix has found it can rely on Berg Electronics . . . to supply the product and the application machines that precisely meet its interconnection needs.

Berg is experienced. We read interconnection needs like Tektronix reads waveforms. We have the products, the background and the back-up to do the job. Your job. Let's work on it, together. Berg Electronics, Division, E. I. du Pont de Nemours & Co., New Cumberland, Pa. 17070—Phone (717) 938-6711.

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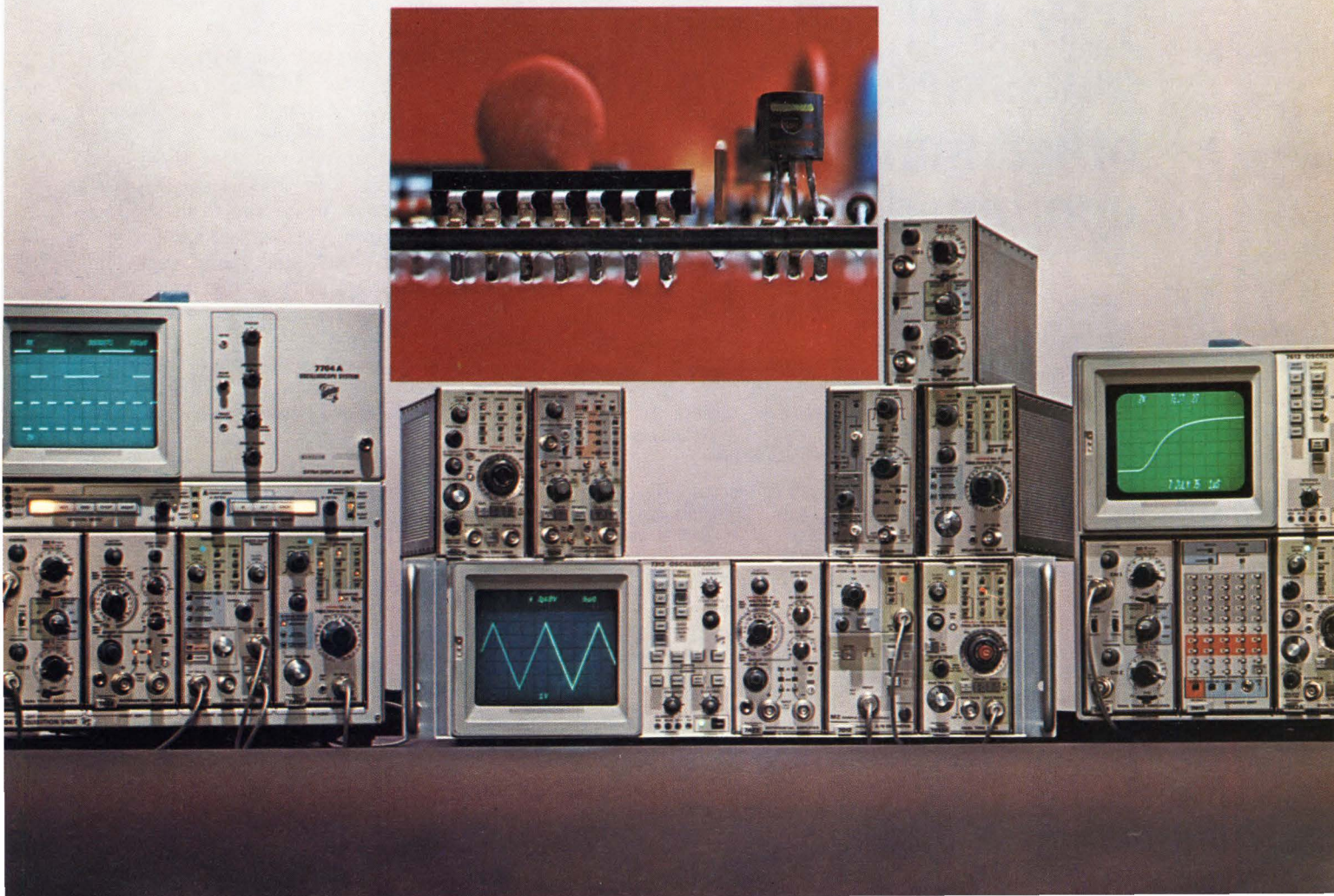
Circle 157 on reader service card

We serve special interests—yours!



New products

plexed seven-segment output capable of delivering 40 milliamperes of peak output current per segment. Other features include automatic polarity detection and indication, overflow indication including polarity, and a maximum reading rate of 10 conversions per second. The converter is housed in a 28-pin dual in-line package and has a 100-piece price of $9.95 (plastic package) or $10.95 (ceramic package).

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. Phone Jerry Zis at (408) 737-5225 [414]

Replacement op amp needs no compensating capacitor

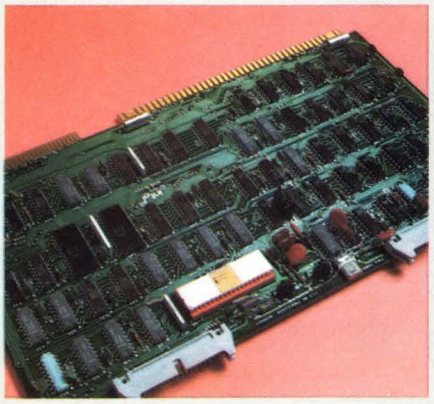
Designed as a replacement for the popular LM108/308 operational amplifiers, the OP-12 is an internally compensated unit that replaces both the op amp and an external 30-picofarad capacitor. Since elimination of this capacitor is particularly important in hybrid-circuit applications, the OP-12 is offered in both packaged and chip forms. A companion unit, the OP-08, is similar to the OP-12 except that it requires external compensation.

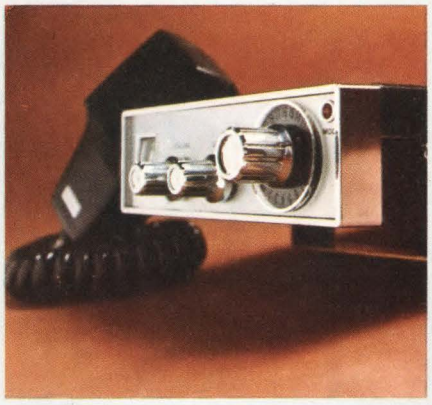
Key specifications of the top-of-the-line OP-12AJ and OP-08AJ include a maximum room-temperature input offset voltage of 150 microvolts, a maximum worst-temperature input offset voltage of 350 μv, a maximum offset-voltage temperature coefficient of 2.5 μv/°C, and a minimum open-loop gain of 40,000 at a load resistance of 5 kilohms. These units operate from −55°C to 125°C and sell for $20 each in hundreds. Op amps that have relaxed specifications over the same temperature range go for as little as $6.50 each, while units that operate from 0° to 70°C range from $6 each to as little as $2.50 in the same 100-to-999 quantities.

Uncased chips, which are available only from the factory, have hundred-piece prices from $1.50 to $6.70 each.

Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, Calif. 95050. Phone Donn

P/rel™ Bio-Mechanical Interface to the Digital World





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When you need design flexibility, Standard Grigsby's P/Rel will do the job. No other programmable rotary switch offers the design engineer as much versatility, with as low a cost, as the P/Rel switch.

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Circle 159 on reader service card

New products

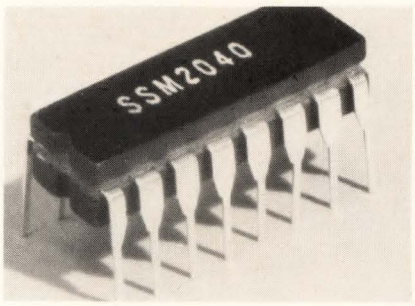
Soderquist at (408) 246-9222, Ext. 183. For information on the packaged devices, circle reader service number 415; for the chips, circle number 416.

8,192-bit PROM runs fast and cool

An 8,1092-bit field-programmable read-only memory from Fujitsu combines high speed with low power consumption. The MB 7055/7060 PROM has a maximum chip-enable time of 150 nanoseconds (60 ns typical) and a maximum access time of 250 ns (150 ns typical). It uses a single 5-volt power supply from which it draws only 0.04 milliwatt per bit for a total power consumption of less than 330 mw. The three-state 7055 and the open-collector 7060 are available immediately in sample quantities. Volume deliveries are scheduled for the end of the year.
Fujitsu America Ltd., 2945 Oakmead Village Court, Santa Clara, Calif. 95051. Phone Bob Freischlag at (408) 985-2300 [413]

Monolithic filter offers voltage control

The model SSM 2040 voltage-controlled filter is a monolithic four-section device that can be used to synthesize almost any type of active filter—low-pass, high-pass, band-pass, notch and all-pass. The unit operates in the audio range and is primarily intended for use in electronic musical instruments. Samples are available at $10 each.
Solid State Music, 2102A Walsh Ave., Santa Clara, Calif. 95050. Phone John Burgoon at (408) 246-2707 [418]



"Until now, we'd been mistaking access to processing for access to answers."

Problem: It takes more than a desktop processor to organize output into its simplest, most usable form.

A personal computer can shave timeshare expenses, but do nothing about trimming the fat off alphanumeric answers. You can give up the power of a mainframe without the promise of more intelligent, instantly visible data.

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From interfaces and firmware to hard copy units, data storage devices, printers, plotters, graphic tablets and proven software, Tektronix provides plug-in capability to customize the 4051 to your special needs.

A graphics answer is the most concise of all possible solutions. The 4051 can eliminate the hand-plotting and mental gymnastics that users of alphanumeric-only systems take for granted. It lets you instantly unscramble data and interactively experiment with graphs, charts, maps and models. With exceptional simplicity. With almost the speed of thought.

You command up to 32K of off-line processing power. With a graphically beefed-up BASIC language. With complete editing and versatile graphic-oriented software.

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The 4051: Its Graphics keep working when other systems quit. Yet it can pay for itself in less than a year in timeshare savings alone. Call your local Tektronix Sales Engineer, or write:

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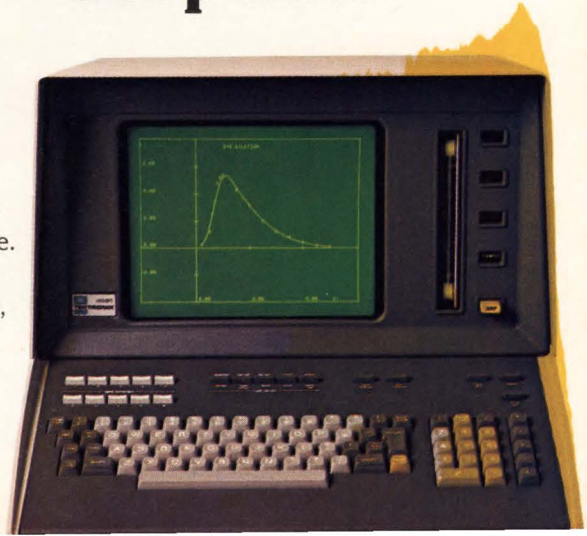

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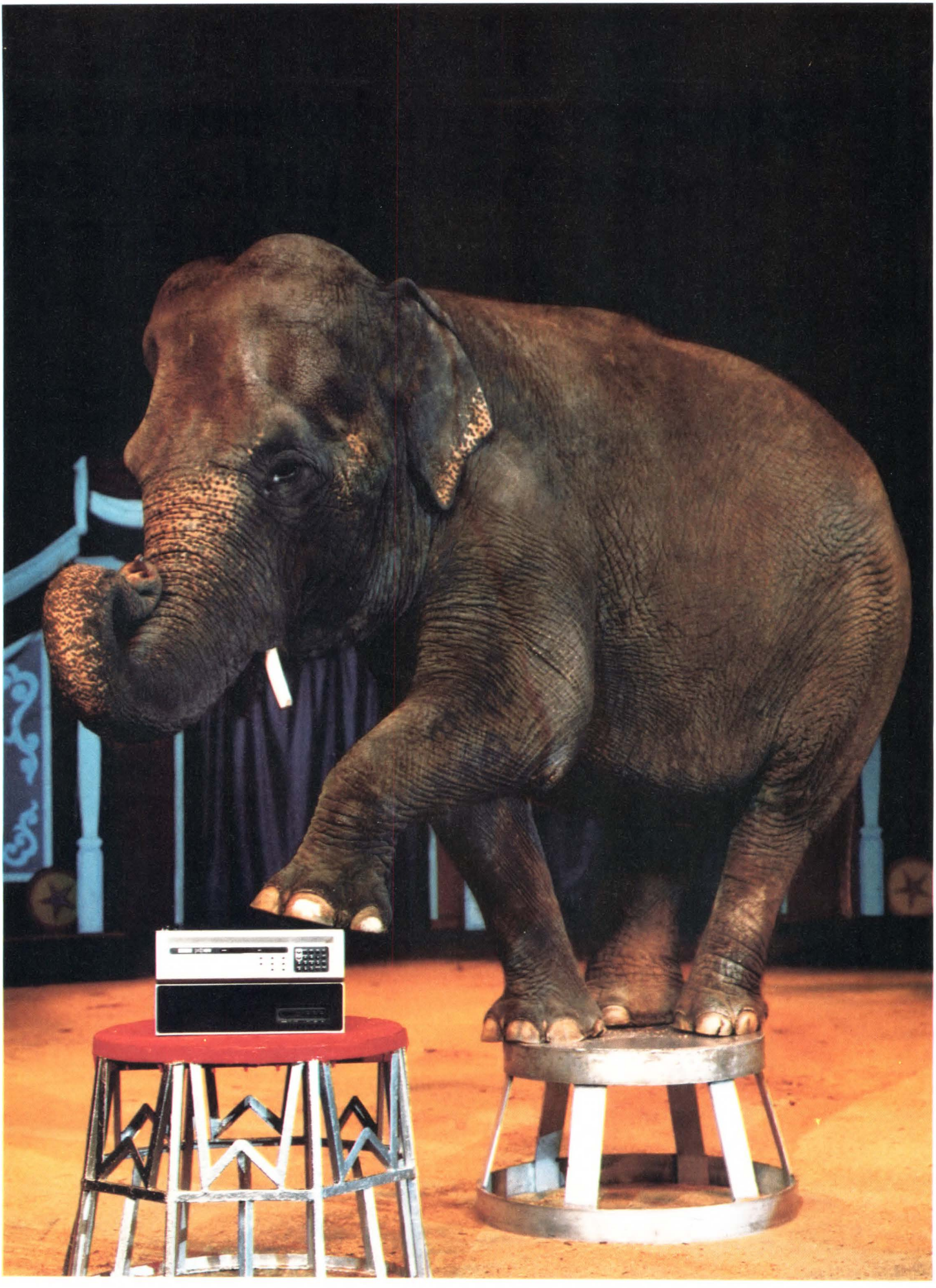
Circle 161 on reader service card

OEM prices available



Digital announces a PDP-8 with an enormous memory.

Something big has just happened to the world's most famous small computer. In fact, something enormous.

Digital has just put 128K of memory into the PDP-8.

This act is brought to you by a powerful new memory management option called KT8-A. And by two new MOS memory modules that fit large amounts of memory into small amounts of space. Simply by adding these 16K or 32K modules in whatever combination you choose, you now expand your PDP-8/A into something bigger. What's even better, you can mix MOS and core. And that means you can protect your program in non-volatile core while you expand your data base in MOS.

And thanks to the KT8-A all this memory is under new management. Not only does the KT8-A let you address up to 128K words of memory, but it also offers you memory relocation and memory protection, while asking little in operating system overhead so you get faster system performance.

What's the cost of these enormous advancements? That's the next attraction.

The new PDP-8A MOS memory models are available at prices that are as crowd pleasing as their performance. Three models to choose from – the 8A205 with 16K, the 8A425 with 64K and the top of the line 8A625 with 128K.

They're the new big-memory Eights from Digital. Step right up.

Large memories aren't our only new trick.

New hardware and software improvements are also in the PDP-8 spotlight.

The VK8-A is a new low cost PDP-8A option that provides high quality video output plus keyboard and printer interfaces. Video character generation uses a super-sharp 9x9 dot matrix for high resolution on single or multiple CRT monitors up to one thousand feet away.

Also new for PDP-8 users is MACREL/LINKER – a sophisticated assembler with MACRO facilities that lets you implement, expand and update your system faster while reducing software development time.

And last but not least there's DECNET 8 – a series of software protocols that let you form your own PDP-8 network.

The PDP-8. Bigger. Smaller. And better than ever.

A short while ago, we made big news with DECstation 78. A low-end system that set new highs for ease of use and simplicity.

Now we're expanding the PDP-8 family up, as well as down, and that means new opportunities for OEMs and end-users alike. Look into what's happening with PDP-8s. Call your nearest Digital sales office today.

Or send the coupon to PDP-8 Marketing Communications, Digital Equipment Corporation, 129 Parker Street, PK3-1/M34, Maynard, Massachusetts 01754. European headquarters: 12, av. des Morgines, 1213 Petit-Lancy/Geneva. In Canada: Digital Equipment of Canada, Ltd.

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E10277

Circle 163 on reader service card

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1050 Kifer Road, Sunnyvale, Calif. 94068 TWX: 910-339-9211 (408) 732-5330

Data Handling

Graphics board is versatile

Changing the plug-in memories on this peripheral changes its resolution

The MTX-512 family of one-card graphics controllers comprises units that can be easily programmed to provide dot matrixes with four different resolutions: 256-by-256, 256-by-512, 512-by-512, and 256-by-1,024 points. The last extends nearly to the limit of television scan monitors.

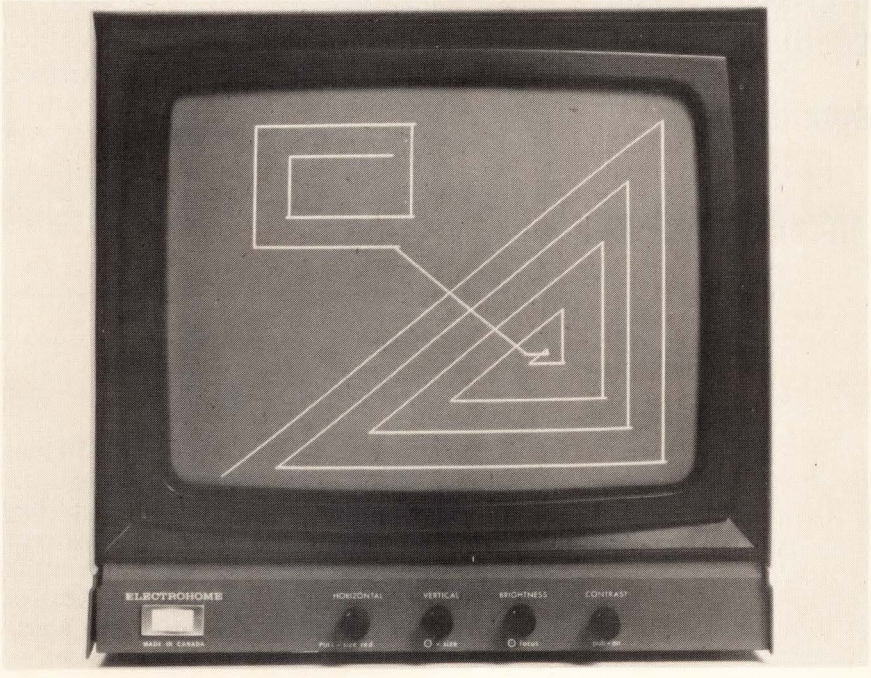
Designed to exploit the interchangeability of 16-pin dynamic random-access memories of different capacities, the controllers are basically interface devices between minicomputers or microcomputers and TV monitors. By loading them with the right size RAMs (4,096-bit, 8,192-bit, or 16,384-bit) plus a couple of control programmable read-only memories, the manufacturer provides the user with the resolution he needs at a price that reflects the volume production of a single standard product. The prices of the cards vary only because of differences in the prices of the RAMs that go into them.

In addition to variable resolution, controllers in the MTX-512 family offer several other important features. They can be stacked and their outputs combined to obtain color or gray-scale images. They can be synchronized to an external generator for broadcast applications. And they use a simple XY addressing scheme to minimize the address space in the host computer dedicated to the graphics function.

Simple, yet powerful, the addressing scheme handles each dot individually. Two directly addressable registers are incorporated for selecting a given dot. This allows two computer memory locations to address up to 262,000 bits of refresh memory. The entire refresh memory can be erased at once, if desired. And the host computer can read its contents at any time.

The first two cards in the MTX-512 family are designed for Digital Equipment Corp.'s PDP-11 Unibus and LSI-11 bus structures. Both buses use the powerful 16-bit PDP-11 instruction set. This eases operator manipulation of the high-resolution display.

The cards are supplied with

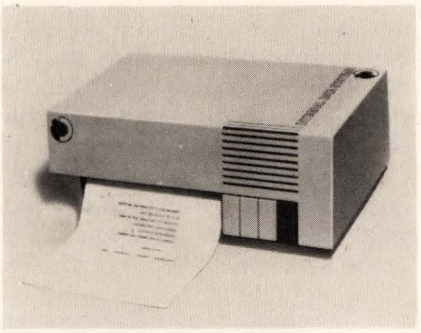


enough information for the user to adapt them for use with other computers using a standard 16-bit parallel input/output port. Initial prices for the cards are as follows: $895 for the 256 by 256; $1,095 for the 256 by 512; $1,390 for the remaining two.

Matrox Electronic Systems, P.O. Box 56, Ahuntsic Stn., Montreal, Que. H3L 3N5, Canada. Phone (514) 481-6838 [361]

Dot-matrix impact printer sells for $745

Priced at only $745 in singles, a dot-matrix impact printer for both minicomputer and microcomputer systems is capable of banging out up to 120 characters per second with up to 132 characters per line. The unit is a complete system, ready to plug in and operate. It features an RS-232

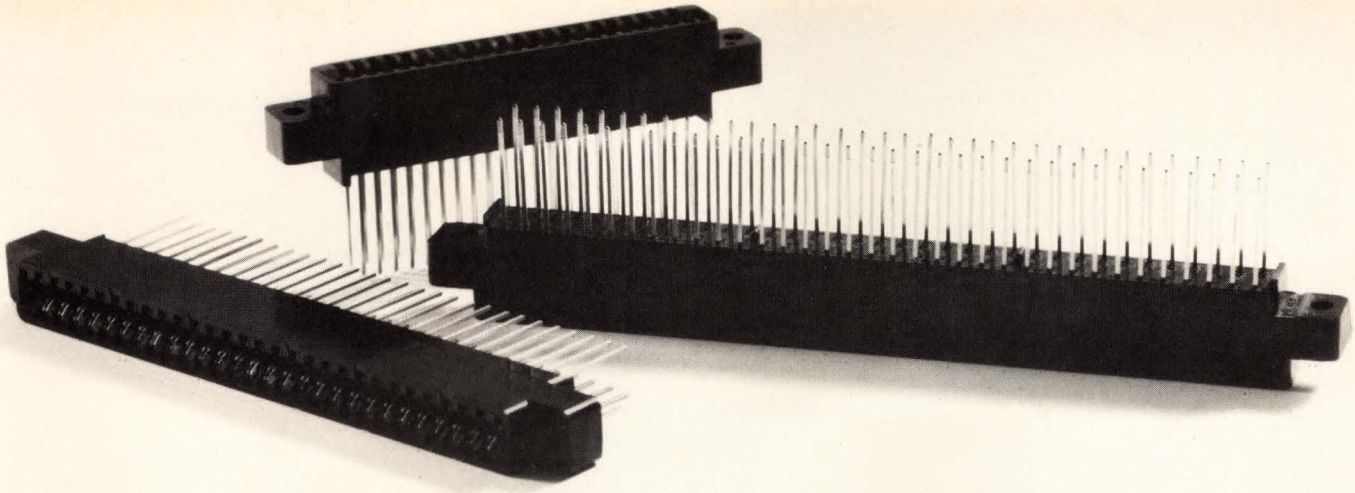


and current-loop serial interface, enhanced-mode (double-width) characters, and selectable line and character sizes.

Integral Data Systems Inc., 5 Bridge St., Watertown, Mass. 02172. Phone (617) 926-1011 [365]

Core memories fit DEC minicomputers

Three models of the ARM-1170 core memory are totally transparent alternatives to, or replacements for, the MJII and MKII memories used in the PDP-11/70 computers made by Digital Equipment Corp. According to the manufacturer, their adoption can about halve the cost of an



Presenting our better-mouse-trap line. No frills at all.

When you cut price without cutting quality, soon no one thinks of it as a cut price. That's where our Norsman line of Wire-Wrap* P/C connectors is headed. Here's why:

The insulator — it's tough, resilient, non-conductive — everything you need in a Wire-Wrap body. And it's made out of low cost phenolic, not the higher cost diallyl phthalate (if you need to meet mil specs, we have that in one of our other lines).

Contacts are semi-bellows and gold-plated — but plated with our unique AuTac (TM) process. You get .000050" gold plate all along the mating surfaces for a sure, gouge-proof, pop-off-proof contact — but that's it. No wasted gold.

And you can find the size you need — Norsman is a full line from 15/30 to 50/100 contacts, in either .100 or .125 contact centers.

The whole Norsman idea is as simple as it is old: keep performance up and cost down. It works.

Send for details. We haven't told you everything.

*Wire-Wrap — registered trademark of Gardner-Denver Company.

Tell me everything. ☐ Send me detailed literature.

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Company _____ Telephone _____

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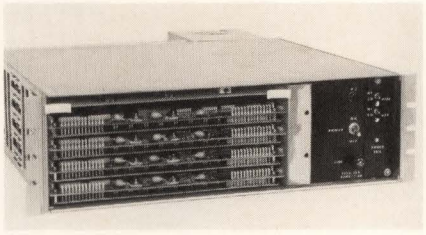
CONNECTORS

Viking Industries, Inc./21001 Nordhoff St./Chatsworth, Calif. 91311/(213) 341-4330

New products



equivalent amount of DEC memory. The units are available in increments of 65,536 16-bit words up to a maximum of 2,048 kilowords. Two- and four-way interleaving are possible for enhanced throughput. With four-way interleaving, the effective cycle time is 345 nanoseconds.

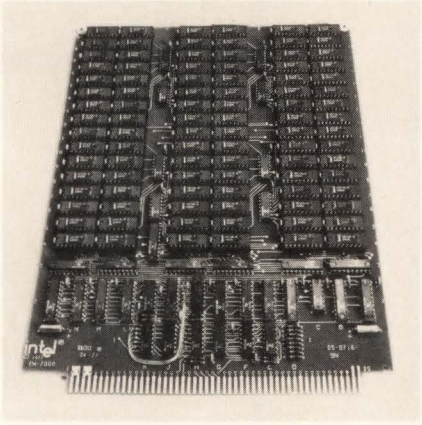
Prices vary with model and capacity: the Mod A sells for $43,205 with 512 kilowords, the Mod B is priced at $12,875 for 128 kilowords, and the Mod C gives 256 kilowords for $23,865. All three units are available for immediate delivery.

Ampex Corp., 200 N. Nash St., El Segundo, Calif. 90245. Phone Clyde Cornwell at (213) 640-0150 [364]

Static-RAM system can be organized in many ways

The in-7000 static semiconductor memory system offers users a wide range of memory capacities and organizations. It can provide word sizes from 6 to 96 bits and capacities of 16 to 256 kilowords. The system uses a single 5-volt dc power supply and can be furnished as either a board or as a chassis.

The basic board has a capacity of 16,384 words of up to 24 bits and,



Have it your way.

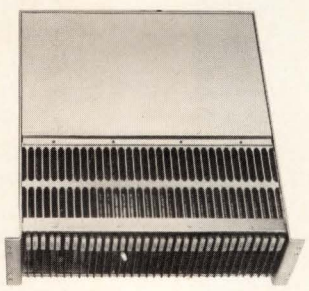
Bit by bit our Standard Modular Memory lets you make every word count.

The Standard.
768K x 16 in one 5¼ x 19 inch chassis.

Need more?
You can address up to *eight* of our MSC 2601 Standard Modular Memory units for up to 6144K x 16.

Want it your way?
Our field-proven MSC 2601 uses dynamic 16K RAM elements. You can organize each card 16K x 1 to 64K x 9. Multiple cards give you almost any word and bit size you want.

Any way you like it.
Up to 14,155,776 bits in one MSC 2601.



MSC – 2601

When you like it.
Access time up to 350 nsec. Cycle time as fast as 450 nsec.

Together in the rack.
RETMA rackmountable or freestanding. Self-contained with power supplies and forced air cooling. Battery backup available, too, for nonvolatile storage.

And for another way.
If you want 4K RAM our static or dynamic versions will let you have your way with up to 192K words.

Our way.
We use fewer components and low power for high reliability. Multiple source, full specification components tested, assembled and then systems tested under worst case operating conditions.

The MSC 2601, Standard Modular Memory... We set the standard.

Monolithic Systems corp.
14 Inverness Drive East
Englewood, CO 80110
303/770-7400

Circle 169 on reader service card 169

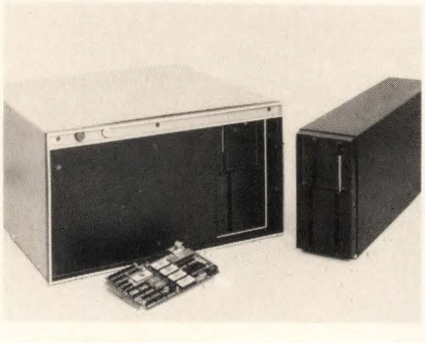
New products

read and write cycle times range from 250 to 500 nanoseconds. Two chassis are available. One includes a power supply and blowers and holds up to six cards. The other holds up to 33 cards and requires external power and fans. OEM prices range from 0.28 cent per bit for the cards with 24-bit words to 0.5 cent per bit for complete systems. Delivery time is 90 to 120 days.

Intel Memory Systems, 1302 N. Mathilda Ave., Sunnyvale, Calif. 94086. Phone Connie Magne at (408) 745-7120 [366]

IBM-compatible diskette system holds 1 megabyte

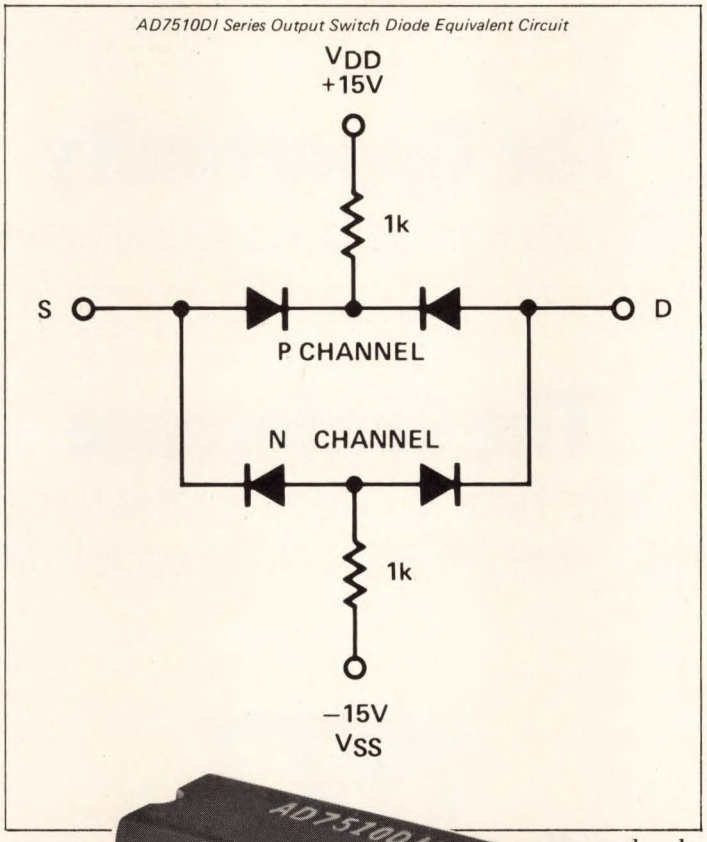
A series of IBM-compatible mass storage systems built around the fast PerSci diskette drive is available with capacities up to 1 megabyte of formatted data. The new systems incorporate model 277 dual diskette drives and are available in a variety of configurations: one- or two-drive (two- or four-spindle) systems complete with microprocessor-based controller, power supply, and cabling enclosed in a 19-inch rack-mountable chassis; one- or two-drive systems with power supply but no controller; and a compact, low-profile system that, when mounted vertically, measures only 4.5 inches wide and contains a single dual drive and a power supply.

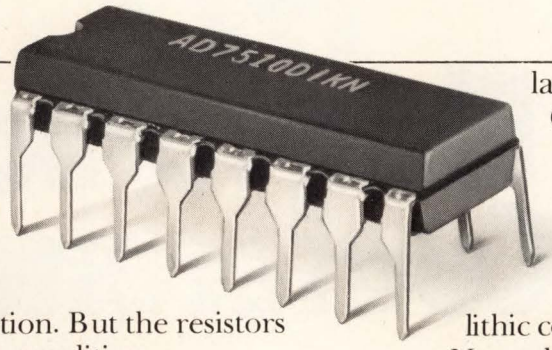


Prices for the systems range from $3,995 for the two-drive system with the controller to $1,630 for the one-drive system without the controller.

PerSci Inc., 12210 Nebraska Ave., West Los Angeles, Calif. 90025. Phone (213) 820-3764 [363]

Overprotection can affect a CMOS switch for life.





But not Analog Devices' AD7510 family of DI CMOS analog switches. They belong to a whole new generation. With positive overvoltage protection, but without any inhibition on performance.

We accomplished it through a unique design, utilizing "on-chip" resistors in series with the power supply. It provides as much as ±25V overvoltage protection. But the resistors only switch in when an overvoltage condition occurs. So normal performance never suffers. And you get both the main assets of an analog switch: a low "ON" resistance of 75Ω and a low leakage current of 400pA.

The equivalent circuit of the output switch element shows that, indeed, the 1 kΩ limiting resistors are in series with the back-gates of the P- and N-channel output devices—not in series with the signal path between the S and D terminals.

This design, combined with our dielectrically-isolated CMOS fabrication process, prevents latch-up. And allows TTL/CMOS direct interfacing.

We also included two other measures of security. Silicon nitride passivation to ensure long term stability and monolithic construction for reliability.

Now when it comes to protecting CMOS switches so they can survive in the real world, Analog Devices knows best. Write for our 8-page technical bulletin on the entire family of DI CMOS protected analog switches, to Analog Devices, the real company in precision measurement and control.

ANALOG DEVICES
The real CMOS switch company

Analog Devices, Inc., Box 280, Norwood, Massachusetts 02062. East Coast: (617) 329-4700, Midwest: (312) 894-3300, West Coast: (213) 595-1783, Texas: (214) 231-5094. Belgium: 03 38 27 07, Denmark: 97 95 99, England: 01/94 10 466, France: 686-7760, Germany: 089/53 03 19, Japan: 03/26 36 826, Holland: 076-879251, Switzerland: 022/319704 and representatives around the world.

The Threat

Japanese trade and technology

The Opportunity

Today's microprocessor explosion

The Conference

Learn how to cope with the threat
and make the most of the opportunity.

1977 Electronics Conference

December 7-8
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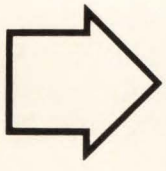


1 How to cope with the Japanese trade and technology threat.

The gathering wave of Japanese technology: What will the impact be? Japan's share of the semiconductor market is still small and its share of the computer market is even smaller. But the Japanese have set their sights on these targets and their progress in the past couple of years has been startling. *Wilfred J. Corrigan,* Chairman and President, Fairchild Camera and Instrument Corp. Other speakers to be announced.

What must American companies do to keep their technological edge? In the past the U.S. electronics industries have been the world's unquestioned technological leaders. A serious challenge is developing now in semiconductors, computers, fiber optics, and other areas. In the past couple of years, Japanese research and development programs have begun to close the gap, and it is the Japanese government that is financing much of the R & D. *J. Fred Bucy,* President, Texas Instruments Incorporated.

The Labor Department's Response to the Japanese Challenge: Greater Japanese penetration in the market means fewer jobs for U.S. workers. Deputy Under Secretary of Labor for International Affairs will give the Labor Department's plans for action. *Howard D. Samuel,* Deputy Under Secretary for International Affairs, U.S. Department of Labor, Washington, D.C.

How to succeed in business with the Japanese: Experts will outline some of the different ways of doing business with the Japanese, listing the advantages and potential pitfalls of each. *Bernard V. Vonderschmitt,* Vice President and General Manager, Solid State Division, RCA Corporation. *Terry Wong,* Director, Business Development, Microelectronic Devices, Rockwell International Corporation.

How American electronic companies can win the battle for foreign markets: Some portions of the Japanese marketing effort—financing terms, for example—are tough to counter, but other tools are available to U.S. companies. *Richard Hodgson,* Senior Vice President, International Telephone and Telegraph Corporation.

Japan versus the U.S.: The government response: Richard Heimlich will discuss the Carter Administration's response to the question of Japanese competition and describe what steps the Office of Special Trade Negotiations is taking. *Richard W. Heimlich,* Assistant Special Trade Representative for Industrial Trade Policy, Office of the Representative for Trade Negotiations, Washington, D.C.

How can domestic electronics firms respond to the Japanese marketing threat in the U.S.? Leading experts from the U.S. industries will give their insights into steps U.S. firms can take to cope with the Japanese challenge. *L. J. Sevin,* Chairman of the Board, Mostek Corporation.

2 The potential of microprocessors: What is going to happen?

The outlook in microprocessors: Where are they going next? Microprocessor development is far from complete. One of the leading microprocessor experts will tell you how he sees microprocessors developing. *Leslie L. Vadasz,* Vice President and Assistant General Manager, Microcomputer Division, Intel Corporation.

The microprocessor universe: What's out there? What are the advantages of choosing a one-chip microprocessor? What are the advantages and disadvantages of 8-bit and 16-bit systems? What are the cost-performance tradeoffs of chips versus boards? *Colin Crook,* Group Operations Manager, Microproducts, Semiconductor Group, Motorola, Inc. *Andrew C. Knowles,* Vice President/Group Manager, Digital Equipment Corporation. *Malcolm B. Northrup,* Vice President, Microelectronic Devices, Electronic Devices Division, Rockwell International Corporation. *James Van Tassel,* Manager, MOS Microprocessor, Texas Instruments Incorporated.

How to get started in microprocessors: What can a microprocessor do for your company? What will be the likely effect of microprocessors on your industry? *Eric Garen,* Vice President, Integrated Computer Systems.

3 The economy and the markets: Where are they going?

Electronics markets in the coming year: A preview. *Electronics* publisher Dan McMillan and Executive Editor Samuel Weber will give a special preview of the annual *Electronics* market forecast, looking at worldwide market prospects. *Dan McMillan,* Publisher, *Electronics. Samuel Weber,* Executive Editor, *Electronics.*

Where is the economy going and what does it mean for you? Will the economy lose steam by mid-1978? What does future economic growth rate mean for the inventory levels electronics firms should maintain? If capital spending takes off, what should that mean for your business? *Douglas Greenwald,* Vice President—Economics, McGraw-Hill Publications Company.

Subassemblies

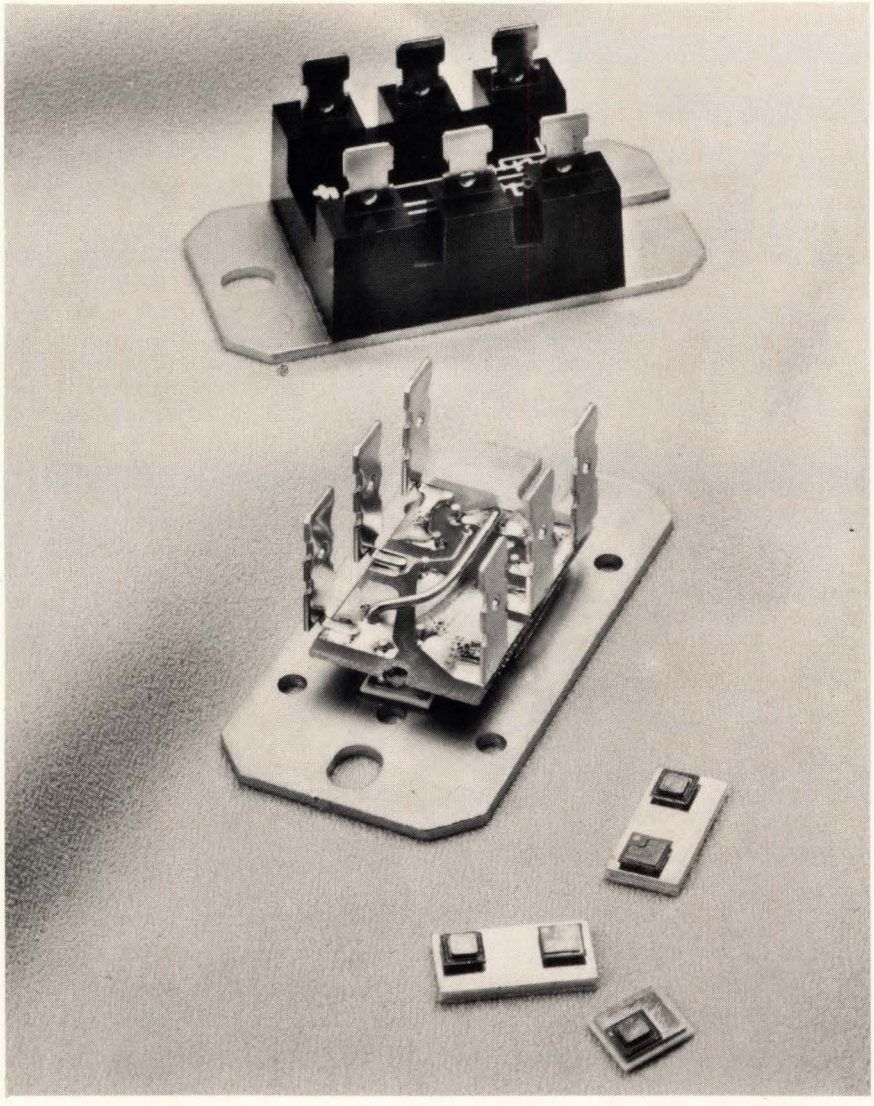
Hybrids built from submodules

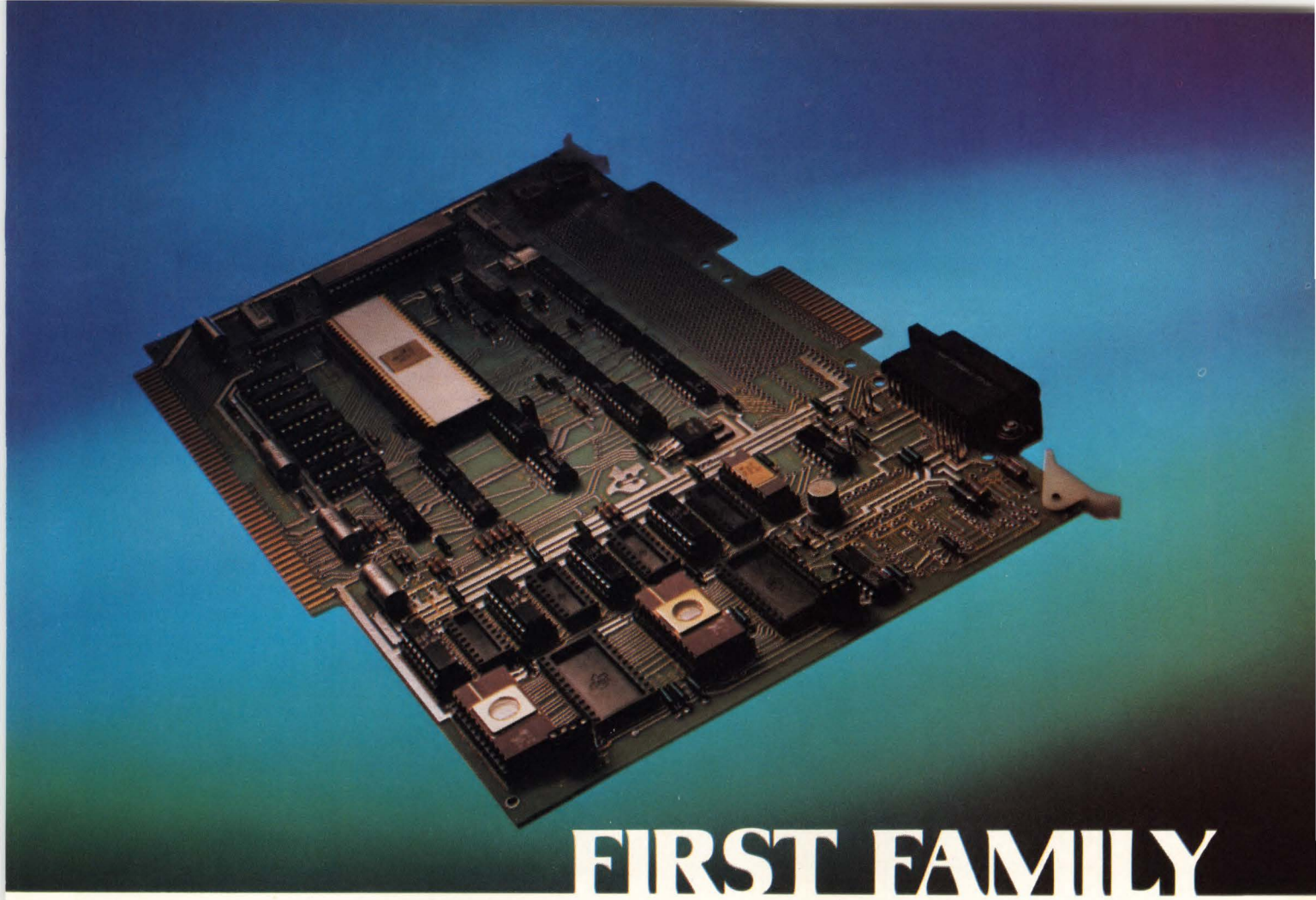
Power circuits of 25-A type include bridges, doublers, and an ac switch

Using a submodule approach to construction, FMC Corp. has become the fourth company to enter the market with encapsulated hybrid power-module assemblies. Already in the business—estimated by FMC at $1.7 million a year in sales and growing at an annual rate of 45%—are International Rectifier Corp., General Electric Co., and Unitrode Corp. [*Electronics*, Sept. 29, p. 132].

The FMC devices, called Power-Mods, consist of a family of five single-phase, 25-ampere-type, encapsulated hybrid bridges of transfer-molded construction.

Directly intermountable and interchangeable with all standard 25-A hybrids on the market, the Power-Mods are available in circuit configurations that include hybrid bridges with or without freewheeling diodes, an ac switch, a doubler with diode and silicon controlled rectifier, and an SCR doubler. The company's packaging method also permits various custom configurations, subject only to the limitation that the assembly have no more than six





First low-cost, 16-bit μP modules. For OEMs. From Texas Instruments.

The new TM 990 Series. Fastest, easiest way to get a microprocessor-based design to market. Ideal for μP evaluation. And a cost-effective production alternative.

First in TI's new series: TM 990/100M. A TMS 9900 microprocessor, I/O circuits, 1K x 16-bit EPROM and 256 x 16-bit RAM on a single 7½″ x 11″ board. Pretested and ready to go.

The EPROM, which includes a self-contained software monitor (TIBUG™), is expandable to 4K x 16 bits. The RAM to 512 x 16 bits. Also on board: 16 lines of programmable parallel I/O, TTY current loop or RS 232 terminal interface. Two programmable interval timers; 15 external hardware interrupts. Plus a user prototyping area. All control, address and data lines are fully available to facilitate expansion to extremely large systems.

Leadership price
At a single unit price of $450.00, the TM 990/100M is an economical means for checking out what TI's 9900 microprocessor can do. And at a 50-piece price of $315.00, it is attractive for production runs.

More modules coming
A TMS 9980-based CPU module. A ROM/RAM memory expansion module. An I/O expansion module. A microterminal for data entry/display. A line-by-line assembler in EPROM.

9900 First Family compatibility
The TM 990 Series modules are supported by the new advanced AMPL™ software development system. And are fully compatible with all members of TI's 9900 First Family. So you can move to the TMS 9900 components level. Or to TI's 990/4 microcomputer. Easily. Economically.

Order the TM 990/100M today from your TI distributor. Or for details, write Texas Instruments Incorporated, P.O. Box 1443, M/S 653, Houston, Texas 77001.

TEXAS INSTRUMENTS
INCORPORATED

93141

Circle 175 on reader service card

external terminals.

Applications for the assemblies include dc motor controls, battery chargers, solid-state circuit breakers, generator exciters, lighting control, temperature controllers, cathodic protection, and power supplies.

In FMC's submodule approach to construction, all semiconductor elements are glass-passivated and mounted on a copper-clad ceramic substrate. The submodule provides efficient thermal spreading and transfer through the copper pad, plus 2,500-volt base-plate isolation through the ceramic. Each SCR (or each SCR and diode pair) and the freewheeling diode are mounted on separate submodules.

At this point, before hybrid assembly, each submodule is fully tested. This greatly enhances the consistency of the final yield and therefore the reliability of delivery schedules, the company points out.

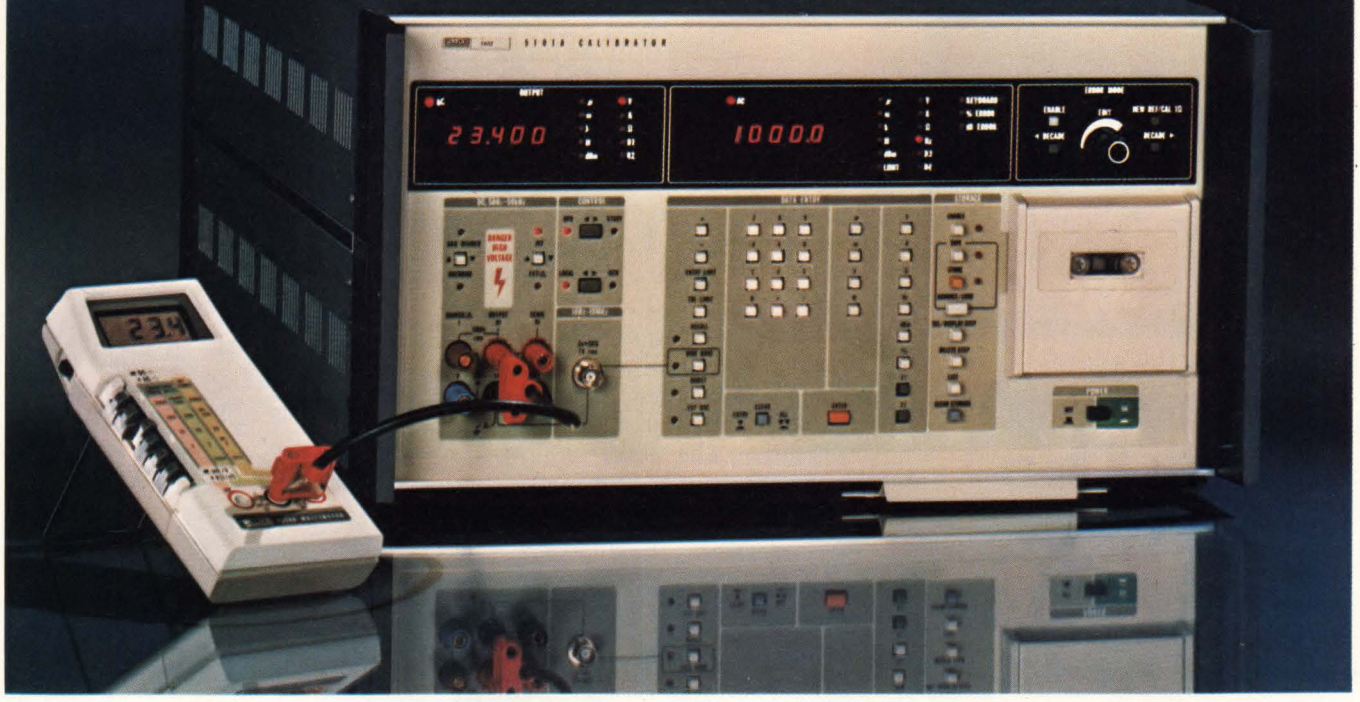
Next, the submodule is mounted on a heat sink and the elements interconnected with a thick-clad epoxy-glass circuit board. The complete encapsulated assembly is then formed by means of a transfer-molding process.

Each hybrid is labeled with a decal that shows the circuit diagram, thus permitting quick identification of type and of terminal connections.

In the PowerMod family are two single-phase half-wave hybrid bridge circuits—one with a freewheeling diode for use in applications with inductive loads. The ac switch, also a member of the new family, is rated at 50 A and consists of two thyristors connected antiparallel. The fourth configuration now available is an SCR and rectifier doubler, rated at 35 A, that can be used in parallel with a single-phase bridge to form a three-phase bridge, increasing maximum load output substantially. The fifth standard configuration is an SCR doubler—two SCRs in series with a center tap—is also rated at 35 A. Two or three units can be combined to make a single- or three-phase full-control bridge circuit.

A typical price, in lots of 1 to 24 pieces, is $28.75 each for the 30-A, 600-v bridge with freewheeling

Recalibrate.
(Your thinking and your budget)



Our new 5100/5101A calibrators can calibrate VTVMs, VOMs, 3½-, 4½- and most 5½-digit DMMs around, in a fraction of the time it takes you now! (It's a cal lab in a box! All at an average price under $9,000.)

For $10,000 to $15,000, you *could* invest in an intricate maze of instruments that takes a wizard to operate. Or, you could fill a room with computer-based hardware and expensive talent. About $100,000 worth.

The Fluke μP-controlled alternative.

We've designed the new 5100A and 5101A for production test, QA and cal lab applications that need large system flexibility at a fraction of large system cost.

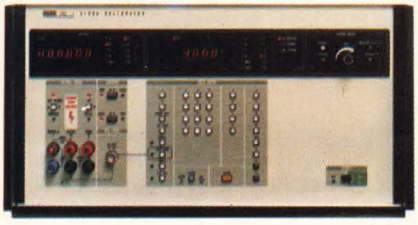
The heart of our new meter calibrators is a microprocessor that eliminates mechanical switches—the largest contributor to failure in conventional calibrators.

And, you can enter your tolerances in dB, volts or percent. The μP converts for you! For safety, store current or voltage limits and protect both your operator and the meter being calibrated.

Microprocessor control also facilitates scaling (for linearity checking), and makes your calibrator a *rangeless* instrument, always selecting the proper range for maximum resolution, *automatically!*

Automation or economy? Fluke has both.

The 5100A is perfect for manual bench operation or integration into your existing cal system to upgrade it to Fluke standards of calibration excellence. Priced at $6,995*, you save dollars but don't sacrifice accuracy or overall performance.



For perfection in automated calibration, you'll want the 5101A with its *mini-tape cassette reader,* a unique new feature that allows you to store up to 58 calibration settings, including limits and tolerances. Only $8,995*.

Both models have a friendly calculator-type keyboard. And, both have the RS232 or IEEE 488 system options you want for remote operation or hard-copy printouts of results.

Call (800) 426-0361, toll free. Ask for complete technical specs or the location of your local Fluke office or representative. Or, write: John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043.

*U.S. price only.

Command Performance: Demand Fluke Calibrators.

FLUKE®

2010-8001

For Literature circle 274
For Demonstration circle 177

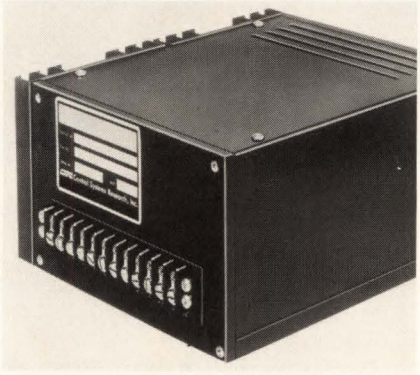
New products

diode. Single units are available from distributors' stock. Delivery time for quantity orders is three to six weeks.

FMC Corp., Semiconductor Division, 800 Hoyt St., Broomfield, Colo. 80020. Phone Brian Bachman at (303) 469-2161. [381]

Dc power amplifier delivers 100 watts

A linear power amplifier for driving dc torque motors, servo motors, and other loads requiring proportional power up to 100 watts features adjustable current limiting, a full-power bandwidth of 5 kilohertz, and complete protection against short circuits, excessive input voltage, and overheating. The model 100 PMA is an operational-type amplifier with a



single-ended output stage that gives it much the same drive flexibility as standard op amps. Powered directly by the 115-volt ac line, the amplifier carries an unconditional two-year guarantee.

Servo Products Group, Control Systems Research Inc., 632 Fort Duquesne Blvd., Pittsburgh, Pa. 15222. Phone Jim Dudiak at (412) 566-1200 [383]

Voltage follower slews at 3,000 volts/microsecond

The model 9963 voltage follower and current booster combines a minimum input resistance of 10^{10} ohms with a small-signal bandwidth of 200 megahertz and a minimum slew rate

We've lowered the cost of environmentally-qualified terminals.

Interstate Electronics has developed a new family of ruggedized plasma display terminals that cost significantly less than any comparable military terminals.

Because Interstate Electronics—and nobody else—gives you "next generation" plasma display electronics. Through innovative circuit integration, we've reduced terminal size, weight and electrical complexity. As well as price.

The PD Series can be specified for a variety of military environments—sheltered, shipboard and airborne.

Each model offers:

- *4,000 character display capability*
- *Complete graphics capability*
- *Extremely fast transfer rates (up to 50K baud)*
- *Inherent memory and selective write/erase to free computer time*
- *Extremely long panel life*

We also offer a complete selection of options, including:

- *Touch panel input*
- *Special function keys*
- *Programmable character generator*
- *Multiple input/output capability*
- *Software support packages*

Interstate can help you select the optimum terminal configuration for your requirements. Give us an opportunity to discuss your operational environment and performance needs.

Write or call Don Poulos, Products Manager, Computer Products, Interstate Electronics Corporation, 707 E. Vermont Ave., Anaheim, CA 92802. (714) 635-7210 or (714) 772-2811.

INTERSTATE ELECTRONICS CORPORATION

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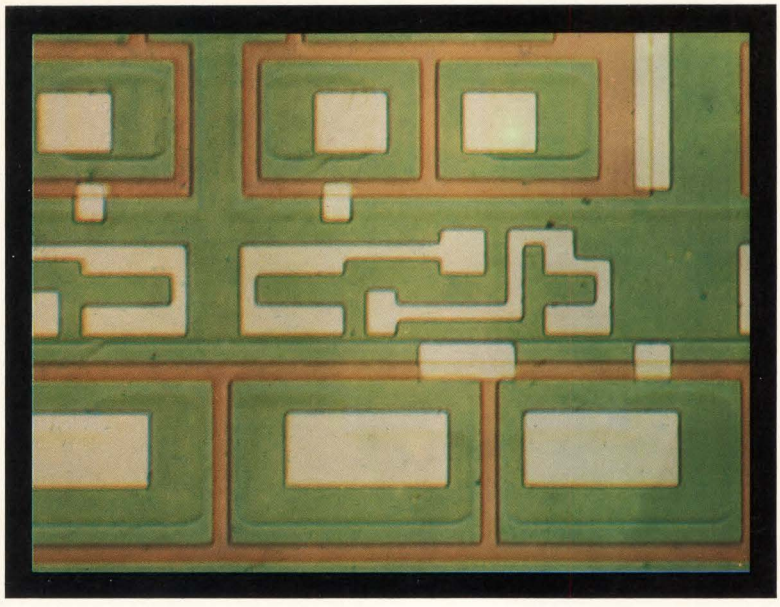
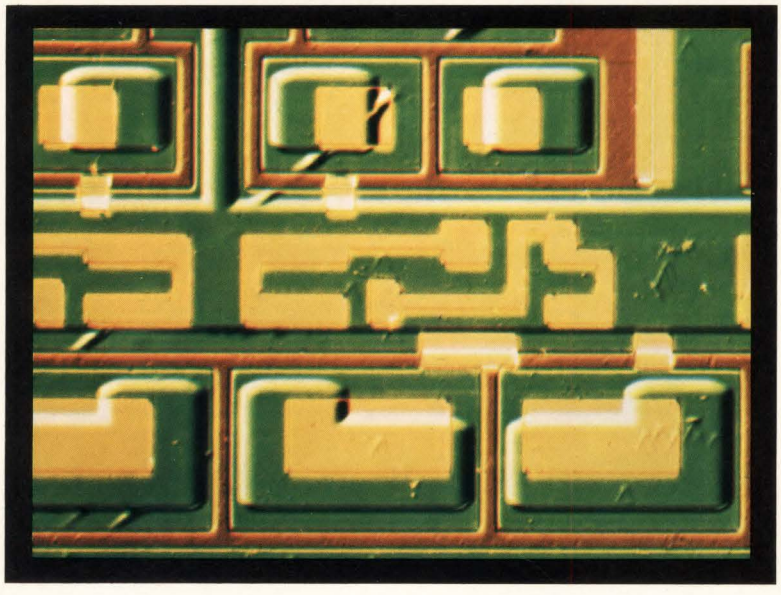
Circle 179 on reader service card

If this is all you're seeing,



this is what you're missing



The AO® DICV Differential Interference Contrast Microscope makes the big difference.

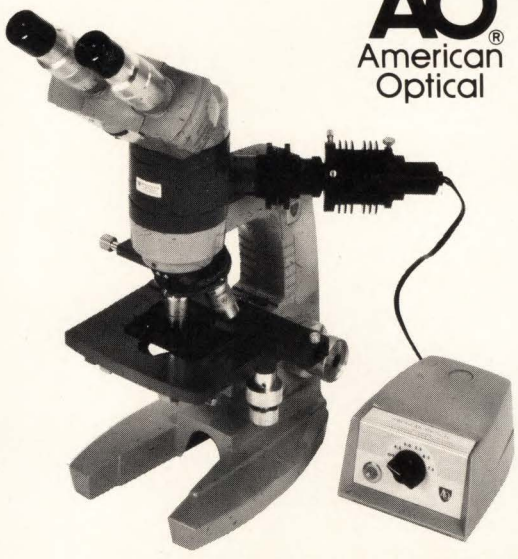
With a standard brightfield microscope you see only what is shown in the top sample.

Now look at the bottom sample. The AO DICV Microscope can help you see surface irregularities, inclusions and faults long before final testing. Long before you have invested more production time and money in a circuit or component that is defective.

By using incident light, after Nomarski, the AO DICV Microscope reveals significant detail in outstanding relief through vivid contrast enhancement.

So, if missing detail is costing you money, you can't afford to overlook the AO DICV Microscope. For details or a demonstration see your AO Dealer or write American Optical, Scientific Instrument Division, Buffalo, NY 14215.

AO® American Optical

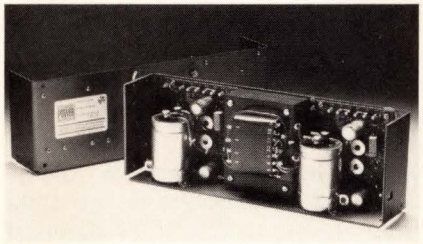


of 3,000 volts per microsecond. The dc-coupled amplifier also has a full-power bandwidth of 50 MHz, a maximum bias current of 100 picoamperes, and a maximum offset-voltage drift of 400 microvolts per °C. Voltage gain is typically 0.96, with 0.92 specified as the minimum. The 9963 is electrically similar to National's LH0063 and is housed in a standard 24-pin dual in-line package. It sells for $44 in unit quantity, $39.50 each for three to nine pieces, and $35.50 each in lots of 10 to 29. Delivery is from stock.

Optical Electronics Inc., P. O. Box 11140, Tucson, Ariz. 85734. Phone Mrs. Mac at (602) 624-8358 [384]

Multi-output supplies are adjustable over a 20% range

A line of multiple-output power supplies for general industrial electronics applications—particularly in computer and microprocessor



systems—includes units with voltages from 5 volts dc to 28 v dc, all adjustable ±10% about their normal values. The supplies are offered with current ratings from 1 ampere to 12 A and with such standard features as: complete isolation between outputs, current limiting, short-circuit protection, universal ac inputs for 115/230 v ac at 47 to 440 hertz, and UL recognition. Among the available options are overvoltage protection.

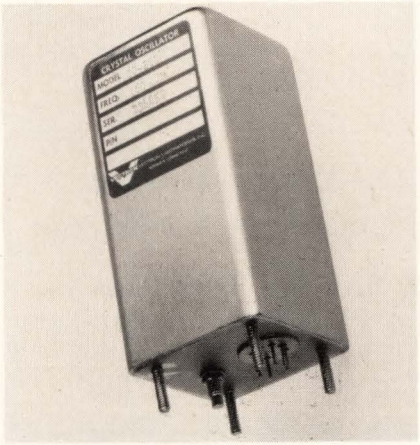
General specifications include line and load regulation to within 0.1%, 0.1% ripple, 50-microsecond response time, 0.02%/°C temperature coefficient, and 0°C to 50°C operating-temperature range. Prices for the units, designated the SPS-D and SPS-T series, range from $104 to

New products

$139 with delivery from stock.
Standard Power Inc., 1400 South Village Way, Santa Ana, Calif. 92705. Phone (714) 558-8512 [386]

Oscillator drifts less than 1 part in 10^9 per day

Available at any fixed frequency up to 200 megahertz, the model CO-220 very-high-frequency crystal oscillator is a compact unit with a



long-term drift rate of 1 part in 10^9 per day. Standard output power is 7 dBm, with 13 dBm available as an option. Other options include voltage control of frequency and operation from −55°C to 75°C. The standard temperature range is 0°C to 50°C.
Vectron Laboratories Inc., 121 Water St., Norwalk, Conn. 06854. Phone Larry Jawitz at (203) 853-4433 [385]

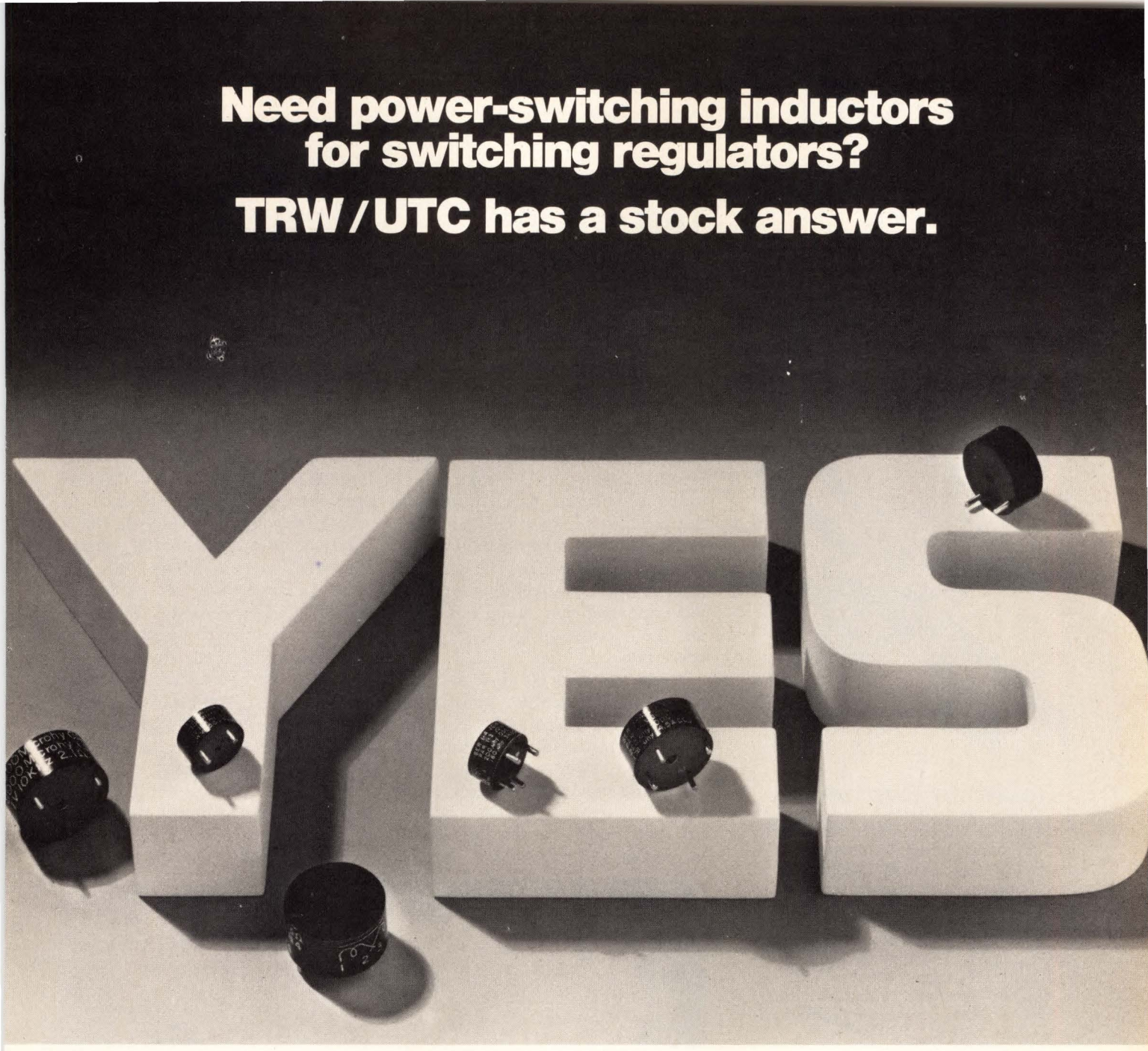
LC oscillators cover 20 MHz to 200 MHz

A voltage-controlled LC oscillator, model P-414, holds frequency deviation to ±10%. The unit is available at any frequency from 20 megahertz to 200 MHz, and it is stable within ±0.5% over the range from 10°C to 60°C. Power output is +7 dBm into 50 ohms. The P-414 is priced at $70 each in lots of 1,000. Delivery time is 8 to 10 weeks.
Greenray Industries Inc., 840 West Church Rd., Mechanicsburg, Pa. 17055 [387]

← Circle 182 on reader service card

Need power-switching inductors for switching regulators?

TRW/UTC has a stock answer.



Introducing the SR series, a family of miniature high-performance, power-switching inductors.

Our SR Inductors reduce size and weight. Now you have off-the-shelf power-switching inductors with performance advantages over your in-house capabilities.

Low temperature rise and low loss characteristics combine to give the SR series high performance with maximum reliability. With an inductance range of 8 to 10,000 UHy, a DC current range from .8 amps to 15 amps, SR Inductors have low losses in the 3 to 100 KHz frequency range, making them ideal for use in switching regulators and AC filter-choke applications.

Compact and easy to install, the SR family has pin terminals for mounting on PC boards. Available with double windings, which when brought out to four terminals permit series, parallel, center-tapped or transformer connections.

Available from stock in three sizes. Type SRA measures 7/8-in. OD by 7/16-in. height; SRB measures 1-3/16-in. OD by 9/16-in. height; and SRC measures 1-3/8-in. OD by 3/4-in. height.

Check your authorized TRW/UTC local distributor for immediate off-the-shelf delivery or contact TRW/UTC Transformers, an Operation of TRW Electronic Components, 150 Varick Street, New York, N.Y. 10013. Area Code: 212 255-3500.

TRW UTC TRANSFORMERS

ANOTHER PRODUCT OF A COMPANY CALLED TRW

New products

Communications

Test set cuts operating costs

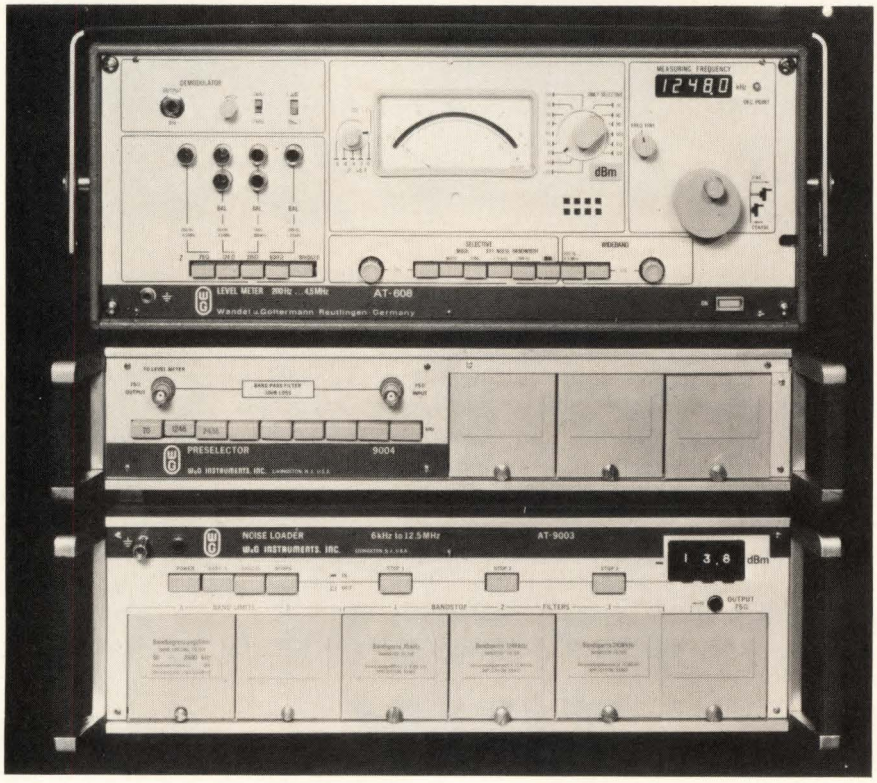
Instrument package checks baseband parameters for low-capacity systems

Operators of small—say, one master group—telephone systems must make the same basic baseband measurements as are made on larger systems but typically must do it on a much smaller budget. The problem has been that available high-quality test equipment has suited the needs and pocketbooks of the large-system operators.

W & G Instruments Inc. has attacked this problem by putting together an instrument package called the RBTS (for radio baseband test system), which saves money by sacrificing bandwidth but not precision. The main difference between the RBTS and a more expensive instrument is that the new package can only handle systems with up to 960 voice channels. This covers a large number of low-density systems such as those operated by railroads, automotive and trucking fleets, small telephone companies, and large corporations with their own private networks.

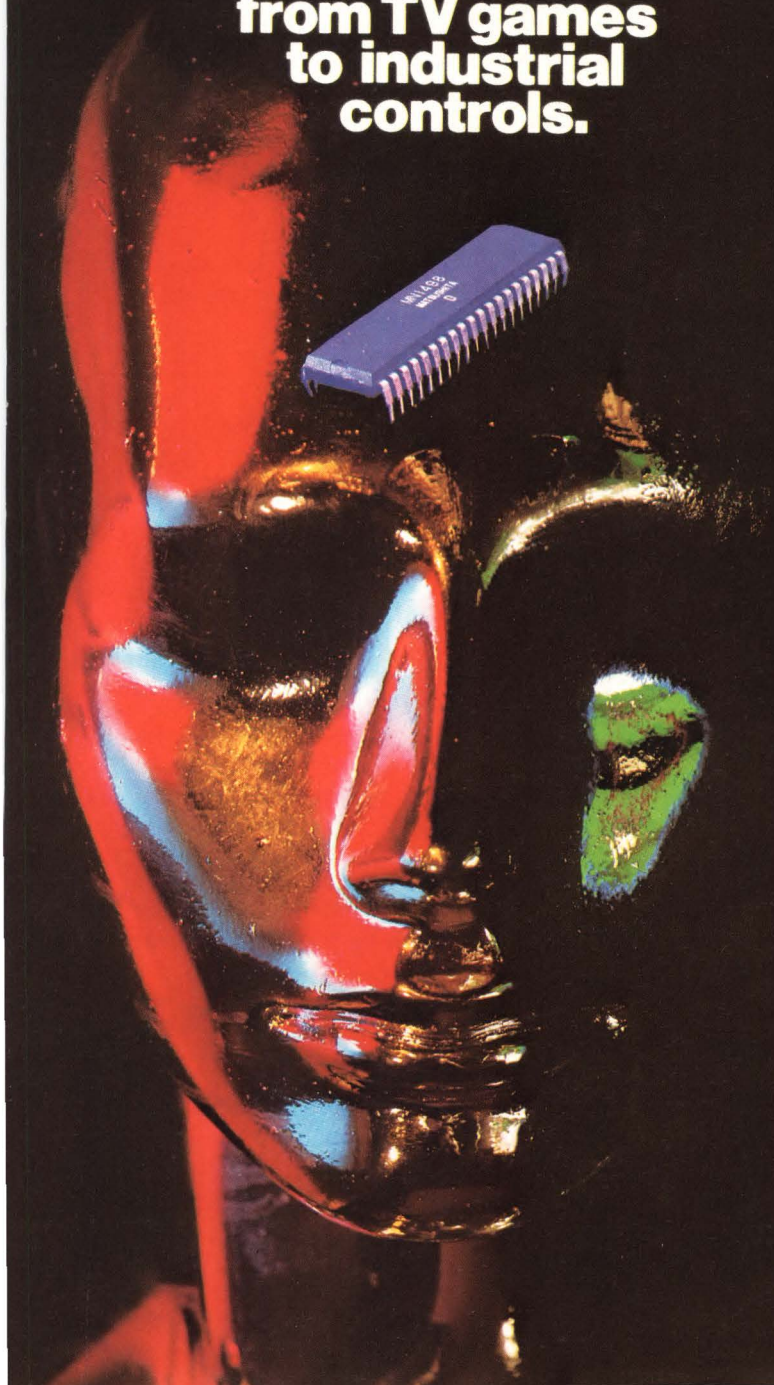
The RBTS is essentially four instruments in one: a selective level meter, a wideband meter, a voice-channel meter, and a broadband noise loader. The selective level meter measures pilot tones, carrier leak, and system frequency response. It also can be used for system alignment and to search for spurious tones. The wideband meter measures total system load and, in conjunction with the noise loader and a set of filters, makes noise-power-ratio measurements. The voice-channel meter measures voice level, voice-channel distortion, and voiceband switching tones. Because its output is extremely flat, the noise loader serves as the signal source when measuring system frequency response.

The key bandwidth-limiting component of the instrument package is its multipurpose AT-608 level meter. In its wideband mode, this unit acts

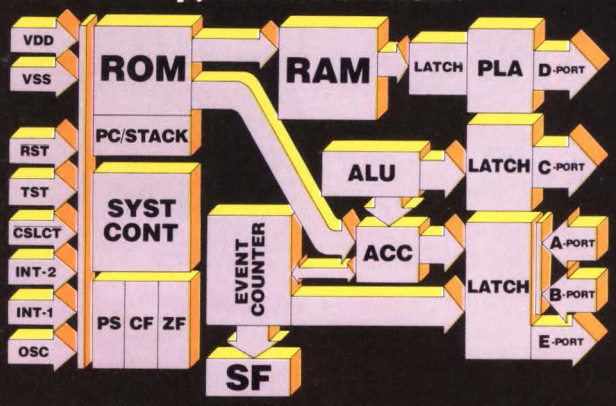


4-bit, one-chip micro-computers

Brainy enough for anything from TV games to industrial controls.



Block diagram of MN1400 with on-chip, 1024x8-bit ROM.



Now Panasonic offers you a whole family of TTL compatible, one-chip microcomputers. So you can choose the combination of features and capabilities that are most cost-effective for your application. From appliances to gas pumps and electronic scales, to copiers, POS and intelligent terminals, tractor controls and countless others.

Why pay for costly I/O interfacing when Panasonic puts it all on the chip?

Our MN1400 family is ideally suited for control functions with its extensive array of on-chip I/O facilities. There's an 8-bit presettable counter/timer, a clock generator, an arithmetic logic unit, and several input and output ports. Units are available with a self-contained 1024x8-bit ROM and a 64x4-bit RAM memory.

Still more flexibility and efficiency from Panasonic.

For flexibility, our instruction set contains up to 75 instructions. To give you TTL compatibility, all our family members operate on +5V. And for extra computing speed, we've utilized N-channel E/D MOS construction.

Panasonic can help you cut development time and costs.

Our Evaluator, the MN1499, can help you design, evaluate and debug programs quickly. In addition, software is available for a number of applications.

The Panasonic family of one-chip microcomputers.

Package		MN1400 40-Pin Plastic DIP	MN1402 28-Pin Plastic DIP	MN1498 40-Pin Plastic DIP	MN1499 64-Pin Ceramic DIP
Power Supply		+5V	+5V	+5V	+5V
Instruction Cycle Time		10μs	10μs	10μs	10μs
Instruction Set		75	57	68	75
Instruction Memory	Instruction ROM	Internal 1024 x 8 bits (8192 bits)	Internal 768 x 8 bits (6144 bits)	External 1024 x 8 bits (8192 bits)	External 2048 x 8 bits (16384 bits)
Total on Chip RAM		64 x 4 bits (256 bits)	32 x 4 bits (128 bits)	64 x 4 bits (256 bits)	64 x 4 bits (256 bits)

16-bit microprocessors, too.

They're ideally suited for a wide variety of computer peripheral and business machine applications. Designed with minicomputer architecture LOCOS MOS N-channel construction for optimum speed and thruput efficiency.

For complete information and prices, write to Panasonic Electronic Components, One Panasonic Way, Secaucus, N.J. 07094; or call (201) 348-7269.

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Circle 185 on reader service card

New products

as a root-mean-square-responding power meter over the frequency range from 200 hertz to 4.5 megahertz. In its selective mode, it offers bandwidths of 500 Hz and 1.74 kilohertz over the range from 2 kHz to 4.5 MHz. An optional 25-Hz filter extends the range down to 200 Hz.

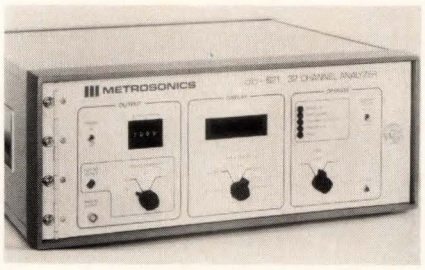
The system's 9003 noise loader is a simplified version of the Wandel and Goltermann RS-50 white noise source, manufactured in the U. S. by W & G Instruments. It provides a flat noise output across the band from 6 kHz to 12.5 MHz, band-limited by selectable plug-in filters. In addition to two band-limiting filters, the 9003 can accommodate three plug-in band-stop filters and a pre-emphasis network.

Supplied complete with a roll-about cart, the RBTS sells for $5,355 without filters and about $6,600 including filters for a 300-channel communications system.

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

32-channel instrument analyzes telephone noise

Designed to monitor up to 32 telephone lines, the db-621A multichannel distribution analyzer is a stand-alone instrument for the determination of amplitude distribution functions for periods that last up to 99 hours. The unit samples each channel 10 times a second, converts the analog sample into a 6-bit binary number, determines which of 64 possible levels that number represents, and adds one count to the register associated with that level. The instrument can thus automatically scan its registers and generate



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MALLORY

Circle 187 on reader service card

a distribution function plot (histogram) for the test period. It can also compute and display the long-term root-mean-square level for any channel at any time during the test. Data is displayed on a six-digit light-emitting-diode readout, or it can be printed on an accessory column printer. Alternatively, the data can be converted to analog form and plotted on an XY recorder.

Metrosonics Inc., P. O. Box 18090, Rochester, N. Y. 14618. Phone (716) 442-0760 [403]

Acoustic coupler kit sells for $130

The Pennywhistle 103 acoustic coupler kit provides half- or full-duplex data communications using ordinary telephones. The kit sells for $129.95

plus $3.50 for postage and handling (plus 6½% sales tax in California) and has a delivery time of four weeks. A three-stage active filter on the modem eliminates problems caused by harmonics of the signaling frequencies.

M & R Enterprises, P. O. Box 61011, Sunnyvale, Calif. 94088. Phone (408) 738-3772 [404]

Multiplexer puts 31 signals onto one voice channel

A microprocessor-based analog multiplexing system that accommodates up to 31 independent signals delivers analog outputs at its receiving station with an error of no more than 0.35% of full scale. Connection between the transmitting station and the receiver is by means of a single

Four very small ways to improve on your PC design.

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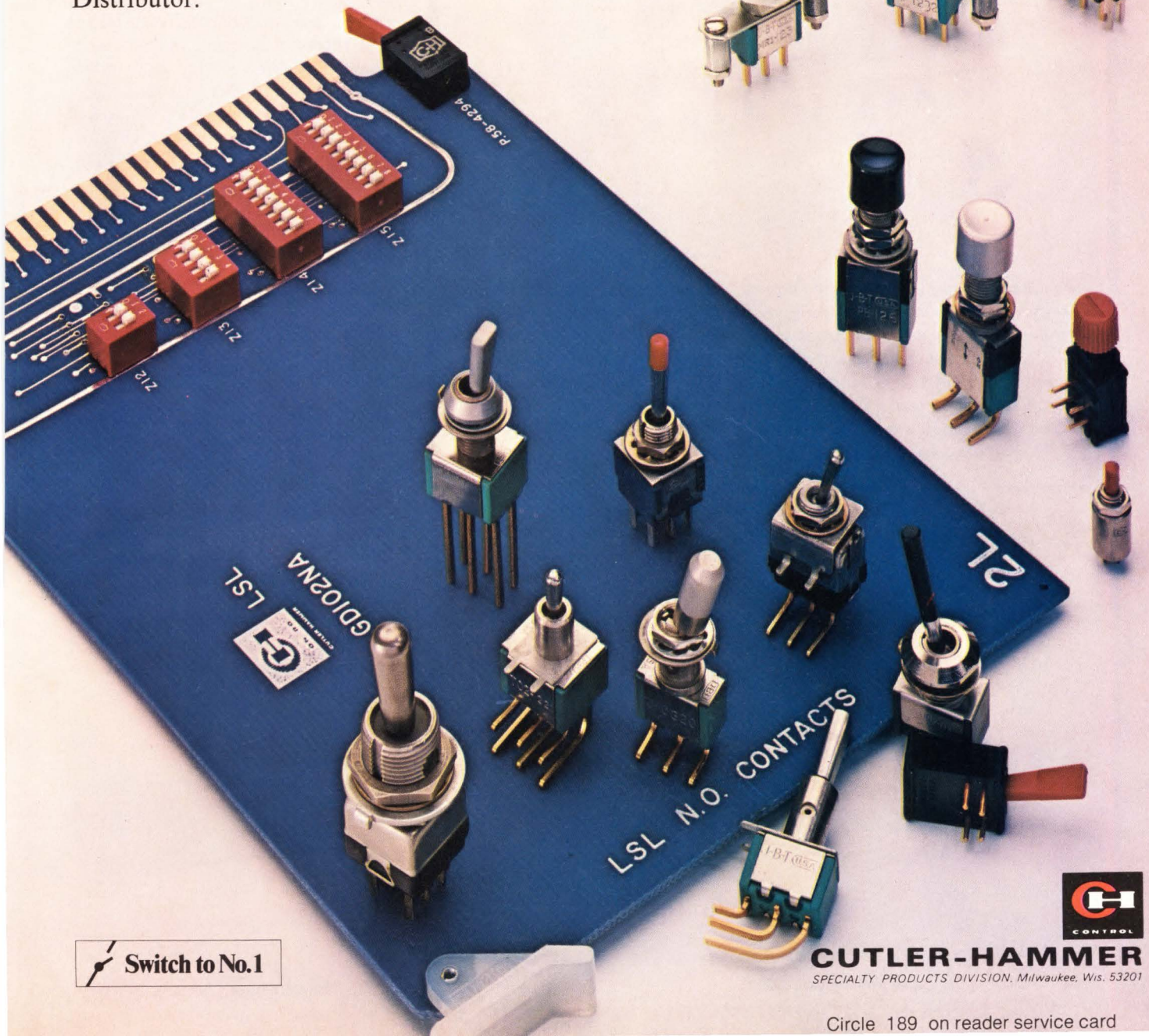
To improve your next design in any number of small ways, contact your Cutler-Hammer Sales Office or Switch Distributor.



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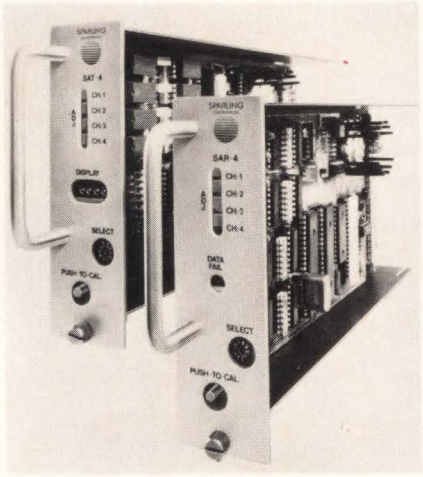
SPECIALTY PRODUCTS DIVISION, Milwaukee, Wis. 53201

Circle 189 on reader service card

New products

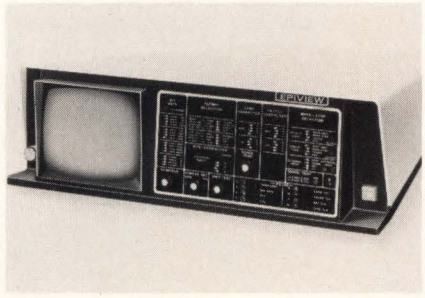


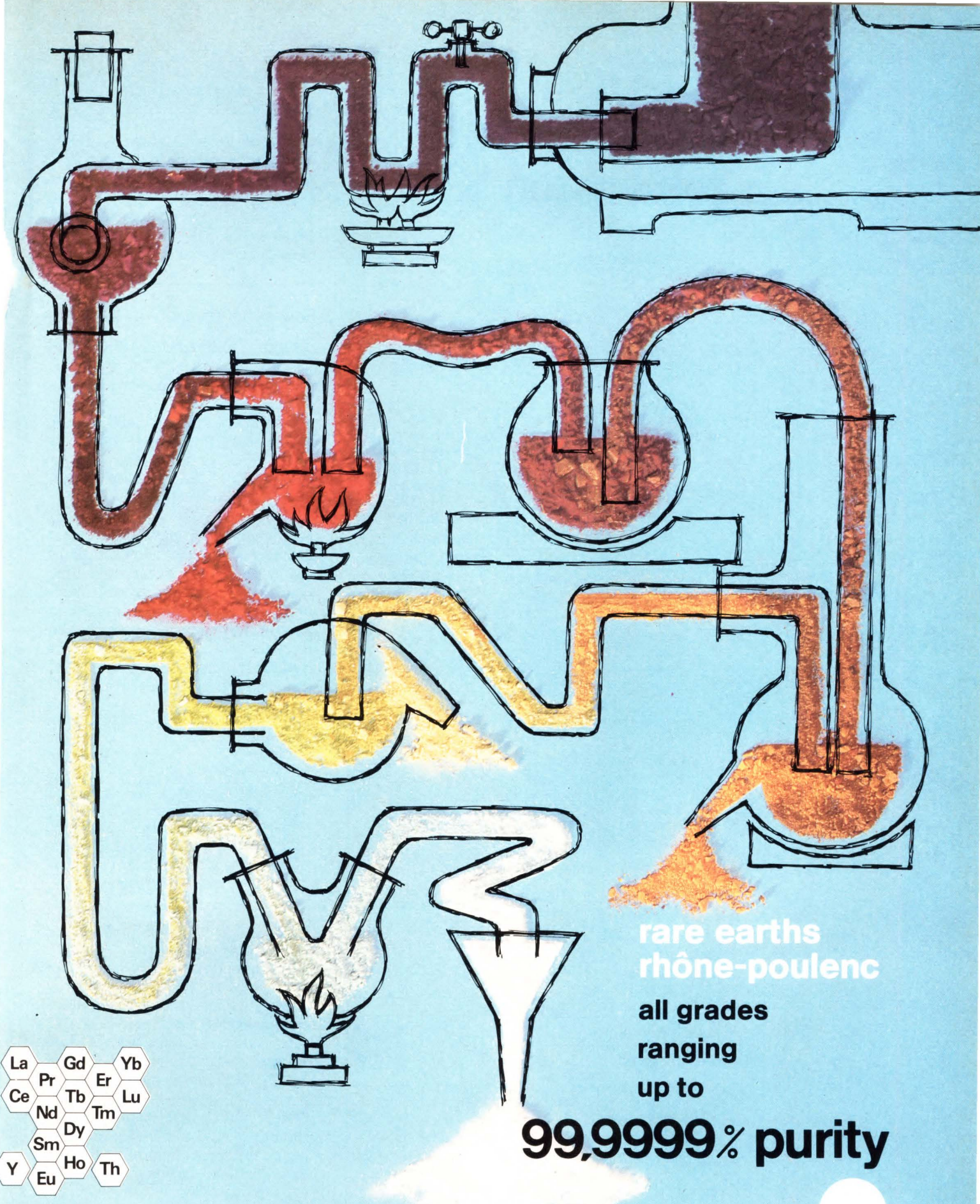
voice channel. The system is modular, being built up from one-, two-, three-, and four-channel transmitter and receiver modules. A basic one-channel system sells for $650, while a four-channel setup goes for $1,125. Thus a 31-channel system would sell for something approaching $9,000. For complete details, ask for PDS-480.

Sparling Division, Envirotech Corp., 4097 N. Temple City Blvd., El Monte, Calif. 91731. Phone (213) 444-0571 [405]

Data monitor operates up to 100,000 bits per second

The Epiview data-communications line monitor is an inexpensive instrument that accepts full-duplex data in either synchronous or asynchronous modes at rates up to 100,000 bits per second. In its standard configuration, Epiview displays data on an integral 5-inch cathode-ray tube, with selected segments highlighted by character blinking or reverse imaging. In addition to providing a real-time display, the unit can be





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Circle 191 on reader service card

connected to an Epitape recorder, which stores data for later analysis. A single Epiview instrument sells for $3,300.

Epicom Inc., 592 N. Douglas Ave., Altamonte Springs, Fla. 32701. Phone Roy Ostrander at (305) 869-5000 [406]

Fast-synchronizing modem runs at 1,200 and 2,400 b/s

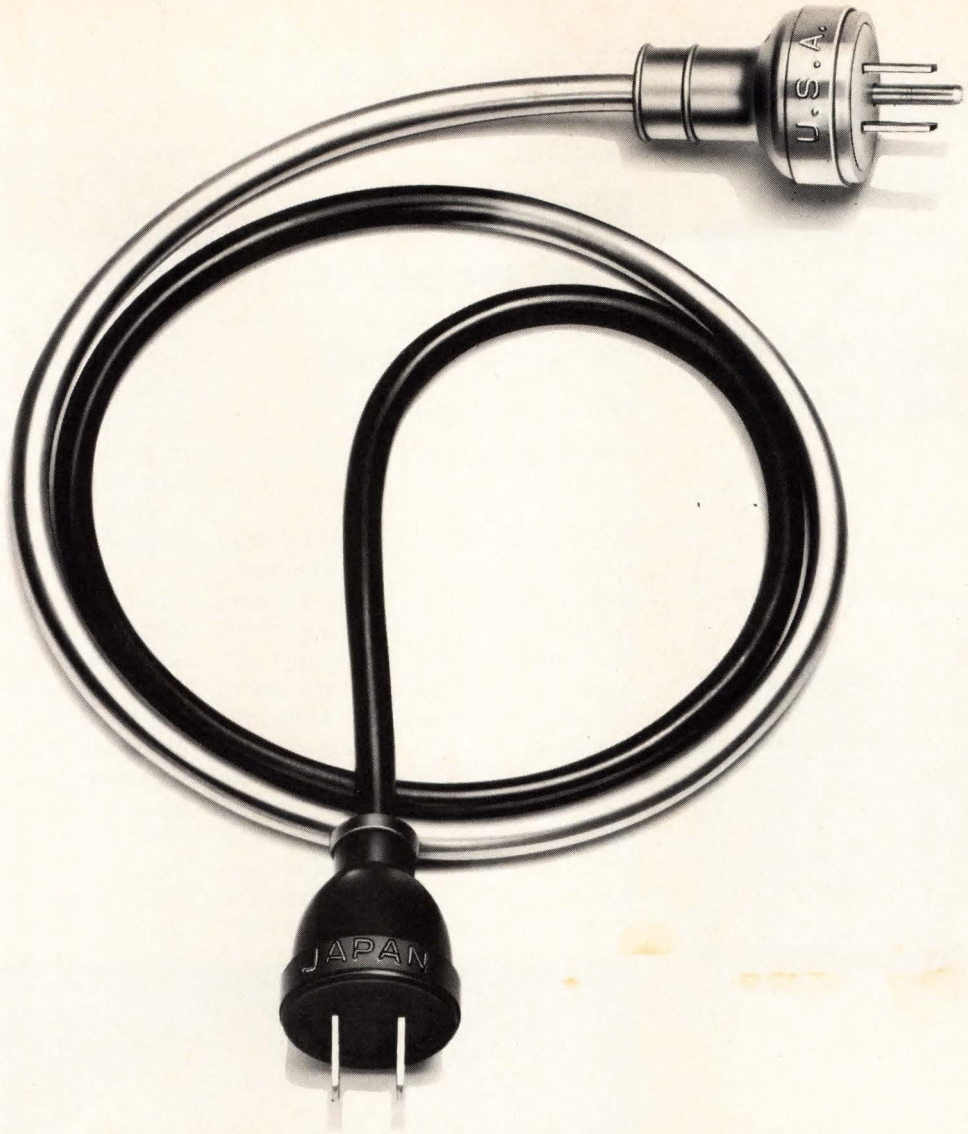
The 2400 LSI data modem is a fast-synchronizing device intended for operation at 1,200 and 2,400 bits per second over two- or four-wire dedicated lines or over the dial-up network. Its fast synchronization suits it well for applications in multistation polled networks and point-to-point communications. Built-in local digital and analog loopback diagnostic capabilities reduce the time required to localize system malfunctions. To further simplify its use, a built-in test-pattern generator and receiver pattern detecter are included for both installation and troubleshooting. No external test

equipment is required to install or troubleshoot the modem.

When operating over the direct distance dial network, automatic answer circuits enable unattended call answering if a type CBS or CBT data coupler is used. In the auto answer mode, an answer tone of 2,025 hertz is generated for 3 seconds to switch over type 801 devices or to alert manual calling stations of call completion, depending on the application. In singles, the dedicated-line version of the 2400 LSI sells for $789.

Penril Corp., 5520 Randolph Rd., Rockville, Md. 20852. Phone (301) 881-8151 [407]

Circle 193 on reader service card →



Interconnection with Japan.

We are not thinking of a submarine cable across the Pacific. The non-stop flights available now are definitely an ideal way to get there, but, if you are involved in electronics, you will probably find yourself with a plug in your hands and no place to plug it in.

Why not leave aside the long exchanges of letters of inquiry, the overseas calls with words sounding quite clear but with meanings you can't really grasp.

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Industrial

Monitor offers dual set-points

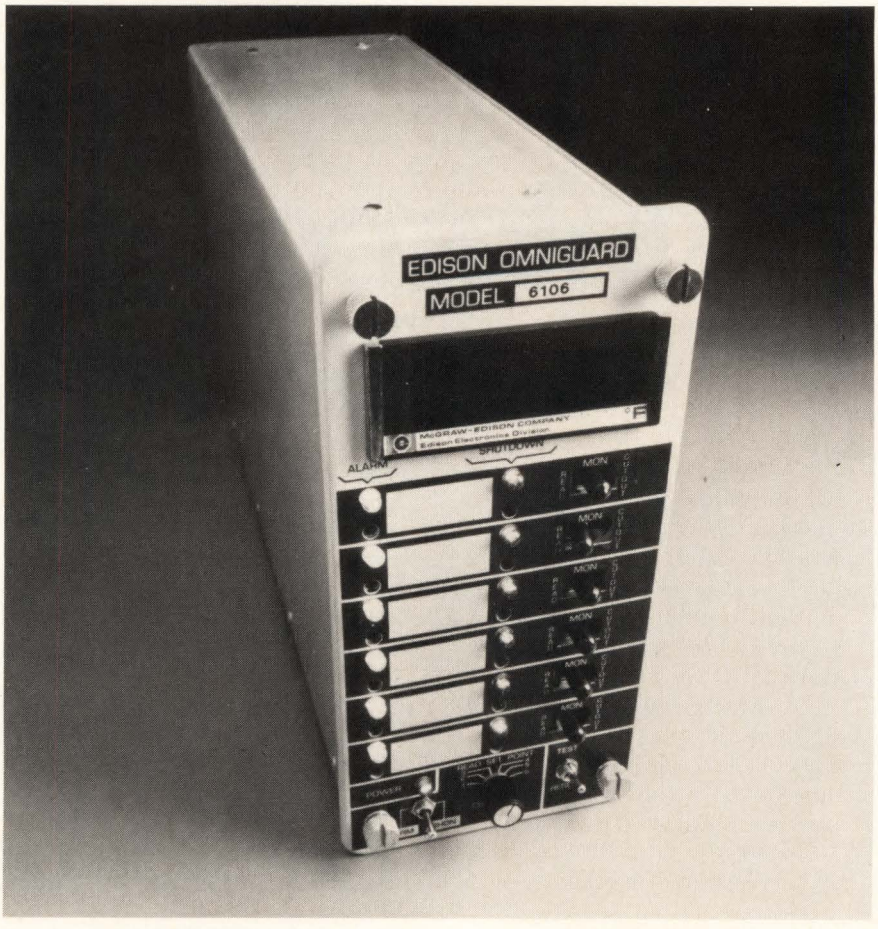
Six-channel temperature unit provides alarm and shutdown control functions

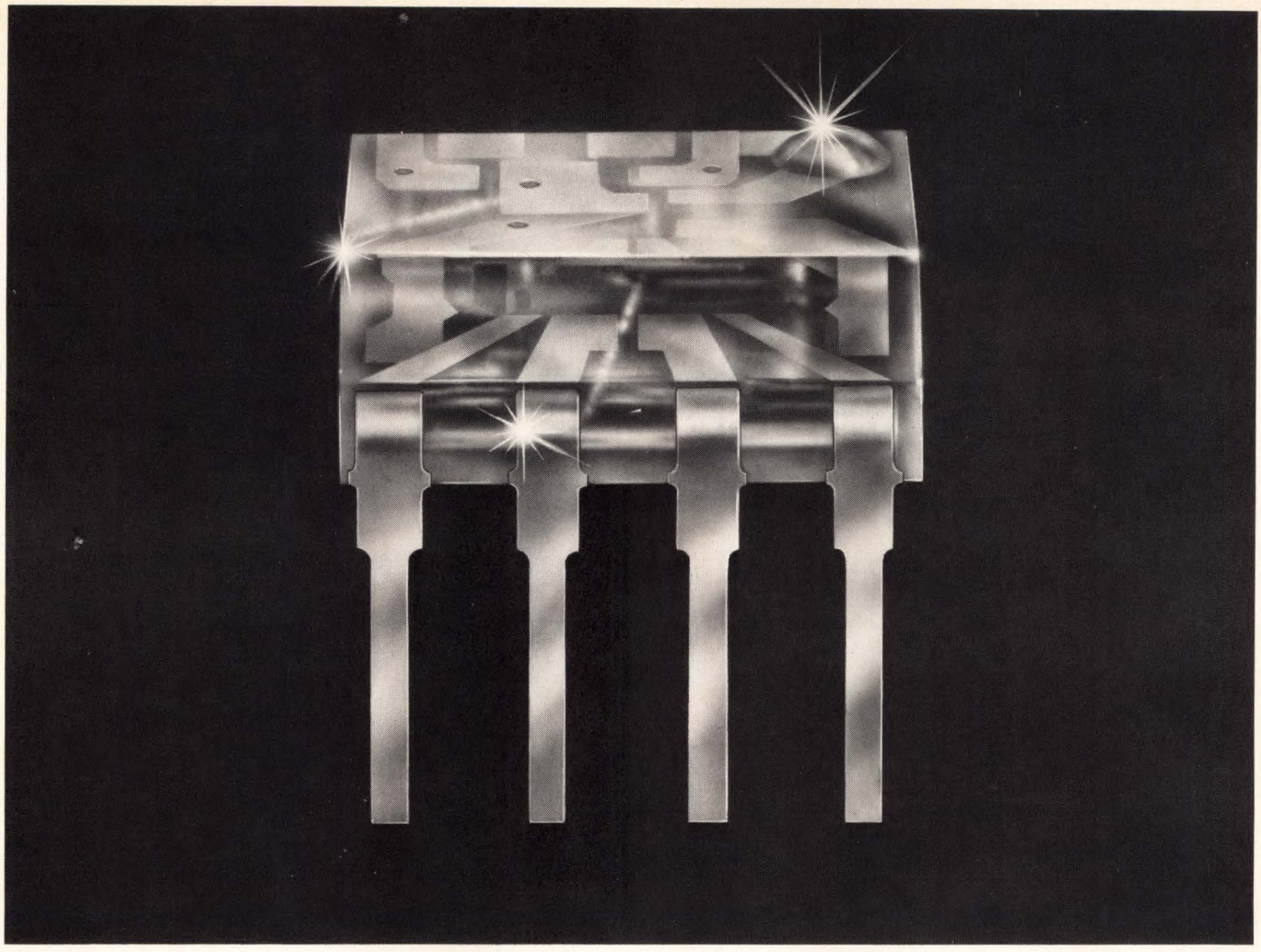
Back in the dark ages, when solid state was represented by something that tinkled in a highball glass, temperature monitors lacked both dual setpoints and front-panel adjustments. In a typical application, the user wanted, and still wants, his intrumentation to respond to two temperatures. At the lower one he wants an alarm to sound or a light to indicate possible trouble; at the higher one he wants automatic shutdown. If he can't get a dual-setpoint monitor, he will need two monitors per point—an expensive proposition.

A second annoying aspect of early monitors was their method of calibration. A resistance decade box was substituted for the resistance temperature detector (RTD), and the monitor was adjusted to read correctly at known resistances. The problem with this approach is that the sensor can be located hundreds or even thousands of feet from the monitor.

Enter the Omniguard 6106 six-channel temperature monitor. Since the unit is a dual-setpoint instrument, it provides all the necessary monitoring for six points with no need for doubling up.

The 6106 can monitor six separate two- or three-wire copper, nickel, or platinum RTDs continuously and simultaneously. A digital display can be set to show the alarm and shutdown set points for each channel as well as the actual RTD temperatures. Each channel has its own electromechanical shutdown relay with iso-





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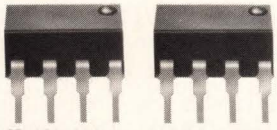

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litronix

Circle 205 on reader service card

lated single-pole single-throw contacts. In addition, a seventh relay is activated if there is an alarm.

Each channel has its own indicator light for alarm signals and a second light that goes on when the channel is shut down. Once a channel goes into a fault mode, be it alarm or shutdown, a reset switch must be pressed to get it out of that mode. Removing the fault condition is not enough. Automatic reset is available as an option.

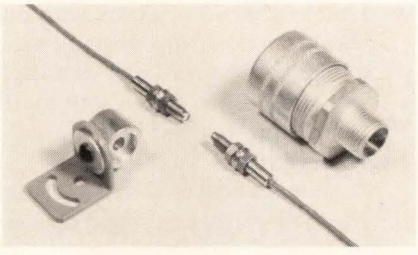
Other key features of the Omniguard 6106 include linearizing circuitry that normalizes each channel for a specific RTD and failsafe operation that causes the output relays to open up if the monitor loses power. And for those people who still do not like digital readouts, analog meters are available as an option.

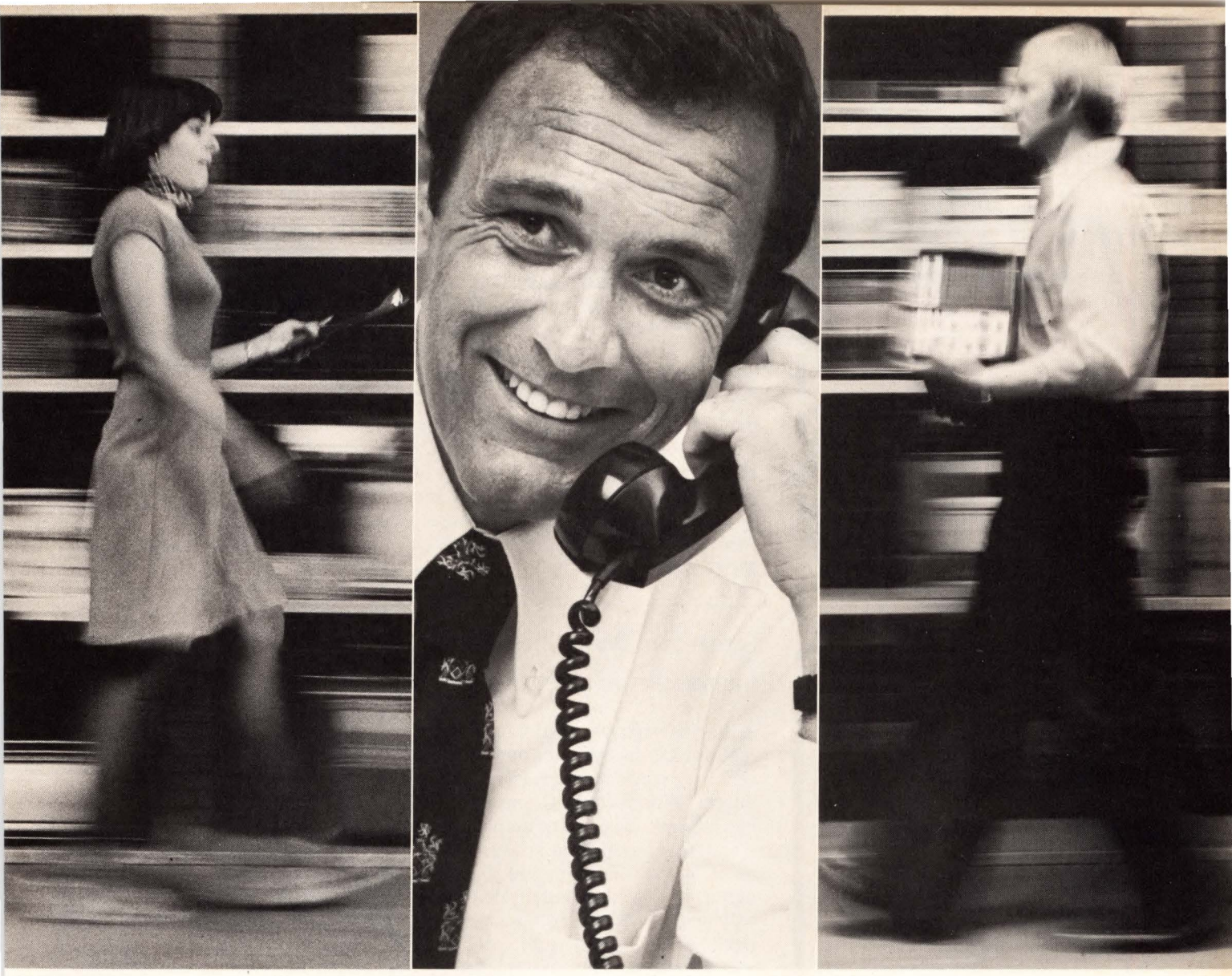
The price of the standard six-channel monitor with a digital display is approximately $1,400. Small quantities are available from stock, with large orders requiring six weeks. The instrument is expected to be stocked in large quantities by January.

Edison Electronics, McGraw-Edison Co., Grenier Field Municpal Airport, Manchester, N.H. 03103. Phone Kent Threlfall at (603) 669-0940 [371]

Object detector has diameter of 0.25 inch

A subminiature source/receiver, consisting of a light-emitting diode and a photodetector, is designed to detect the presence or absence of objects in a wide variety of industrial applications. Packaged in a rugged, watertight, stainless-steel housing that measures 0.25 inch in diameter by 1.5 in. in length, the sensor has an operating range of 25 feet in the





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Circle 207 on reader service card

New products

transmitted-beam mode and 1 foot in the reflected-beam mode. The UL-recognized device can operate from −40° to 185°F.

To form a working system, the type 40BY1/47BY1 subminiature sensor combination is used in conjunction with a standard type 22 series 4000 LED photoelectric control, which contains the system modulation and demodulation circuitry, power supply, control logic, and output device.

Photoswitch Division, Electronics Corp. of America, One Memorial Drive, Cambridge, Mass. 02142. Phone S. L. Davis at (617) 864-8000 [373]

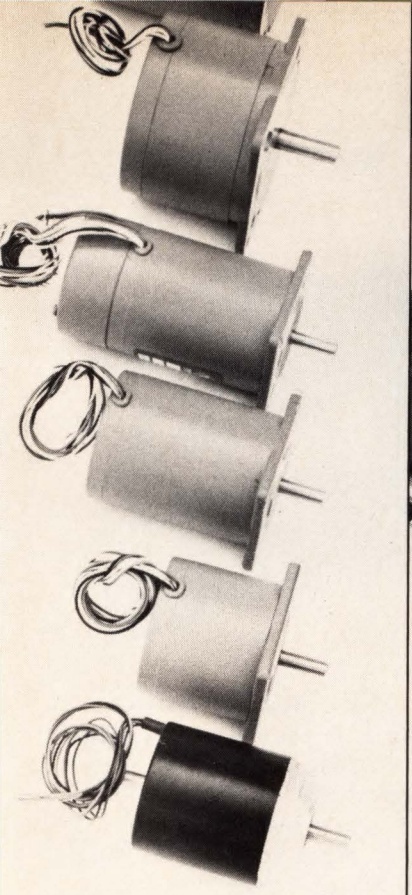
Signal conditioners connect transducers with instruments

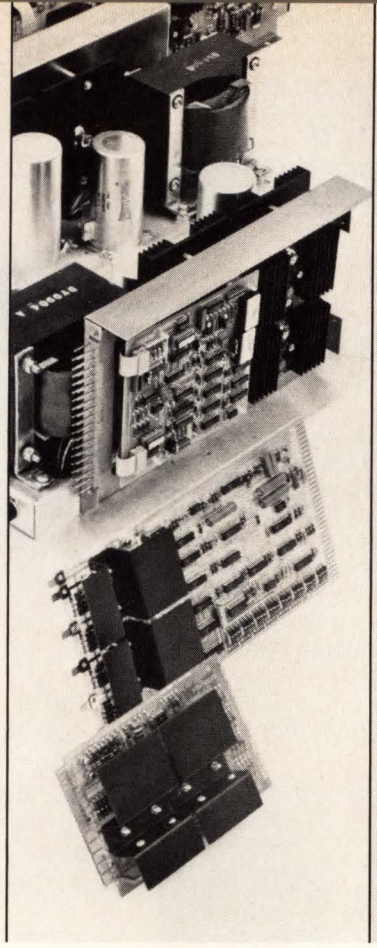
A line of signal-conditioning interface units is designed to connect load cells and strain-gage pressure transducers with recording and control instruments. The units amplify the transducer signals and produce either a 4-to-20-milliampere current output or a voltage output of 0 to 1 volt or 0 to 10 v. The units have a maximum nonlinearity of 0.1% and a maximum temperature-induced error of 0.3% of reading per 100°F. Frequency response is within 3 decibels from dc to 2 kilohertz.

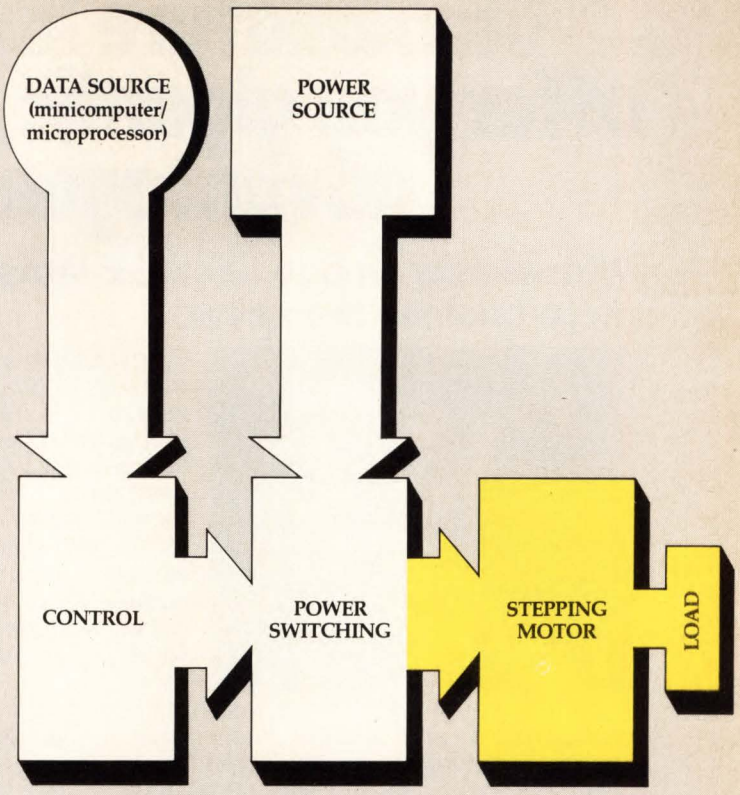
Tyco Instrument Division, 4 Hartwell Pl., Lexington, Mass. 02173. Phone (617) 861-7450 [375]

Precision load cells have little moment sensitivity

BBP series load cells have a moment-insensitive design that gives them a maximum off-center-load error of 0.05% per inch. The high-accuracy units are available with capacities of 1, 2, 5, 10, and 20 pounds. They have a minimum rated output of 2 millivolts per volt. Nonlinearity is no more than 0.02% of rated output, and repeatability is within 0.01% of rated output. The cells are temperature compensated for operation between 50°F and







A 15-minute course in stepping motor technology.

The makers of Slo-Syn® stepping motors and controls bring you another in the series of technical cassette tapes.

A full 15 minutes on the technology of stepping motors:

As digital actuators for high performance positioning systems.

As incrementing output devices in microprocessor control systems.

As the alternative to servos, pneumatics or hydraulics for sequencing, rotating, cycling, positioning.

For a modest $5.00, the recognized leader in stepping motor technology will move you step by step through the essentials. This cassette covers the subject from maximizing torque during acceleration to damping, stability and positional accuracy. Stepper control methodology and the applications best suited for either permanent magnet or variable reluctance motor types are discussed in a clear, concise manner. And more. All designed to put your company a step ahead.

A step ahead in positioning.

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Circle 209 on reader service card

#2

Second in a series

☐ Yes, I would like_____ cassette(s) on stepping motor technology. Enclosed is $5.00 (check or money order) for each cassette.

☐ In addition, send me tape #1 "Stepping motor controls" at $5.00.

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Title _____

Company _____

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120°F. Their principal use is expected to be in parts counting, packaging, weighing, and similar precision applications.

Hottinger Baldwin Measurements Inc., 17 Mercer Rd., Natick, Mass. 01760. Phone (617) 655-0950 [374]

Power monitors protect three-phase motors

Designed to protect motors against burnout caused by abnormalities on the power line, a series of power-line monitors will remove all power from a three-phase motor if it senses a lost phase, low voltage, phase reversal, or a phase-angle shift. A failure-indication lamp turns on when the monitor is activated.

Three adjustable voltage ranges are offered: the model 3P120 covers phase-to-phase voltages of 85 to 125 volts ac, the 3P240 covers 160 to 240 v ac, and the 3P480 covers 340 to 480 v ac. Prices for all units range

METSHIELD™ Fabric. The first major advance in magnetic shielding in 50 years.

This is the magnetic shielding product whose time has come.

Increased sales of electronic equipment, a trend toward miniaturization and intensified regulatory considerations have put increased emphasis on EMC.

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Now you have such a shielding. METSHIELD™ magnetic shielding fabric—a wholly new flexible product made from Allied Chemical's METGLAS® amorphous metal alloys.

Because of its exceptional strength and flexibility, METSHIELD fabric retains its full shielding effectiveness during fabrication and use.

This reliability of performance—plus the ease with which METSHIELD fabric can be fabricated—enables you to use magnetic shielding as a preferred method to achieve electromagnetically compatible system designs. And METSHIELD fabric now comes in 40" (1 meter) widths for even greater design flexibility.

Discover how this remarkable material can help meet your shielding needs. Phone John Dismukes at 201-455-4031 or Jack Thorp at 201-455-3306. Or return the coupon.

Check boxes for information on METGLAS® alloys and METSHIELD™ fabric.

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- ☐ Fabrication
- ☐ Grounding and contacting
- ☐ Other (specify)_____
- ☐ Send me sample of METSHIELD fabric

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Company_____

City/State/Zip_____

Mail to: Metglas Products, Allied Chemical Corporation
7 Vreeland Road, Florham Park, NJ 07932

Allied Chemical
Metglas Products

from $38 to $49.50 depending upon quantity. Delivery is from stock.
Amtron Corp., P. O. Box 2783, Norman, Okla. 73069. Phone (405) 364-6143 [376]

Predetermining hour timer resolves five digits

The HVS15 predetermining hour timer is a five-digit electromechanical unit that provides 9,999.9-hour resolution—a previously unavailable level. All five digits can be preset. When the timer counts down from the preset number and reaches zero hour, it operates a 1-ampere single-pole double-throw relay.

Available in 50- and 60-hertz models, the timer can be supplied with either electrical or manual push-button reset. It sells for $90 in hundreds. Delivery is from stock.
Kessler-Ellis Products Co., Atlantic Highlands, N. J. 07716. Phone Leslie Gleason at (800) 631-2165 [377]

Temperature controller is only 3⅝ inches deep

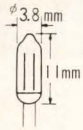
Temperature controllers in the Micro 2000 series are true plug-in instruments even though they measure only 3⅝ inches in depth. A deviation meter that spans ±50° is standard. Model 2000-B instruments

are rated at 7 amperes at 120 v ac or 5 A at 240 v ac. Model 2000-T units use solid-state relays and have a 1-ampere continuous-current rating.
Athena Controls Inc., 20 Clipper Rd., West Conshohocken, Pa. 19428. Phone Bob Long at (215) 828-2490 [378]

SUPER MINIATURE
Neon Glow Lamps

Dimension: mm

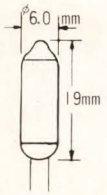
Circuits Volts ····· AC 105-125
Series Resistance ····· 150KΩ
Nominal Current ····· 0.3mA
Total Flux ····· 20mlm MIN.
Average Life Hours ··· 30,000



NL-8S

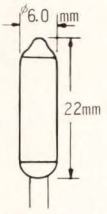
CLEAR-GREEN
Fluorescent Glow Lamps

Circuit Volts ····· AC crDC 105-125
Series Resistance ····· 33KΩ
Nominal Current ····· 1.6mA
Total Flux(MIN.) ····· AC:120mlm,DC:130mlm
Avg. Life Hours ····· AC:30,000 DC:40,000



NL-35/G

Circuit Volts ····· AC 105-125
Series Resistace ····· 27KΩ
Nominal Current ····· 1.5mA
Total Flux ····· 90mlm MIN.
Avg. Life Hours ····· 20,000



NL-21/G

● MAIN PRODUCT

NEON GLOW LAMP, XENON FLASH LAMP,
RARE GAS, DISCHARGE LAMP.
MINIATURE : BLACK-LIGHT, UV-LIGHT,
FLUORESCENT COLOR-LIGHT.

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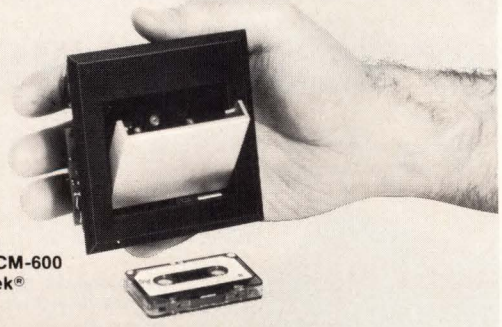

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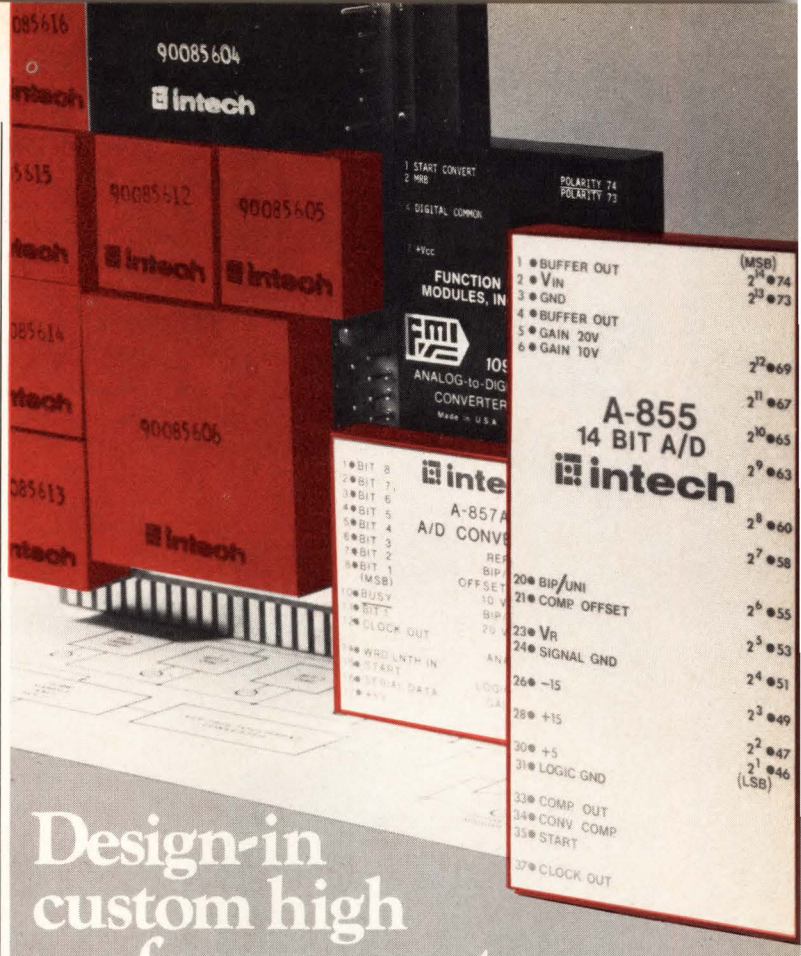
Circle 36 on reader service card



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Whether you're looking for high resolution and/or high speed for commercial or military applications, there's a broad line of A/D "cost performers" that you should, *and can*, take a look at today. For example:

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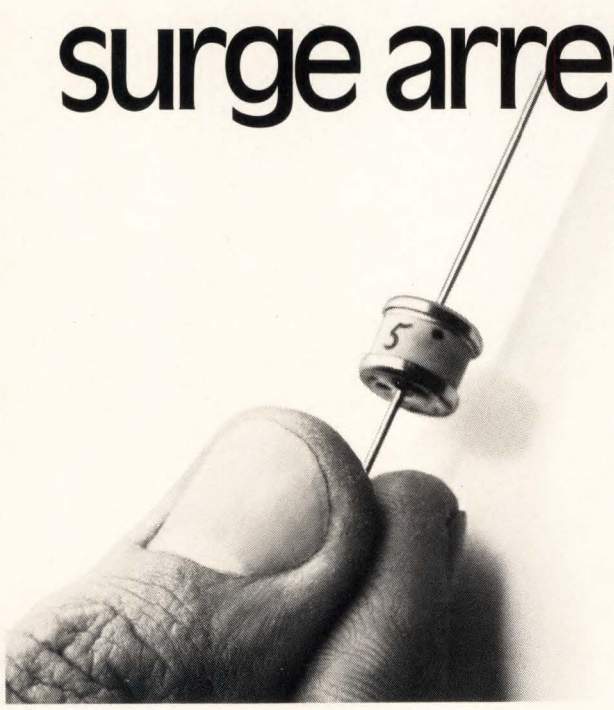
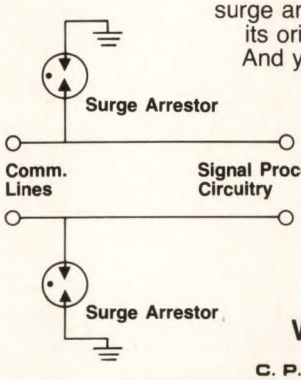
Circle 213 on reader service card

What the heck is a surge arrestor?



This tiny device protects equipment from induced overvoltages due to atmospheric disturbances or accidental contact with power lines. It's generally connected from a signal line to ground.

How does it work? The surge arrestor has a high impedance when the voltage across it is less than its striking voltage. (Striking voltages range from 75 volts to 1000 volts depending upon the application.) When the striking voltage is exceeded, the surge arrestor changes impedance from greater than 10,000 megohms to mere milliohms in about 1 microsecond. The overvoltage is discharged to ground through the surge arrestor which then returns to its original high impedance state. And your equipment is protected.



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3101 W. Pratt Avenue, Chicago, Illinois 60645

Circle 214 on reader service card

At +125°C you can burn your fingers on some DAC's our 4058 stays cool

Because this new, hybrid 12 bit DAC was specifically designed for the temperature range −55 to +125°C. It is not merely a top-end selection of commercial DAC's, where you don't know today what tomorrow's yield will be.

Your application may not need the full temperature range nor the hermetically sealed metal DIP. But for a lot of industrial applications these and other features of the new DAC offer you vital safety factors. For example, it is produced to MIL Std 883 giving extremely high reliability. It has a very low temperature drift of 5 ppm/°C gain, 10 ppm/°C max. offset.

And if you want to fly with it, the 4058 is shock, vibration and acceleration tested - its already being used in the new MRCA.

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3½"

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New products

Components

Resistors have low thermal emfs

Precision components mix ruggedness and stability with tolerances to 0.005%

Vishay's S102 resistors have long been known for their superior long-term stability and low temperature coefficient. Now, by taking the Bulk Metal technology that underlies the S102 and combining it with an improved fabrication process called unit construction, the manufacturer has added increased ruggedness and reduced thermal emf and created a new resistor called the S102C. The new units are designed to meet or exceed all requirements of MIL-R-55182/9, Characteristic Y—the military's toughest resistor specification. Their thermal emf of 0.3 microvolt/°C difference in lead temperature makes them especially applicable to low-level dc switching.

Key to the performance of the new resistors is their use of flattened "paddle leads" for connection to the resistive element. A single weld bonds each lead to the etched Bulk Metal element; the assembly is then sealed in silicone rubber and encapsulated in a compression-molded case.

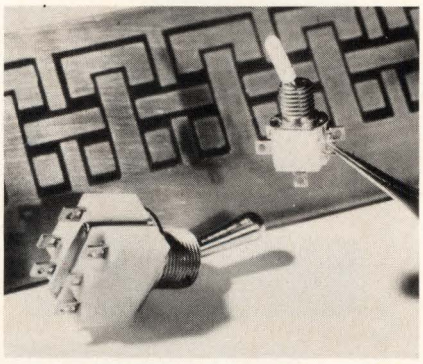
This new design ensures lead integrity, provides excellent resistance to moisture and high temperatures, and improves load-life stability. At the same time, the advantages of the standard S102 resistors are retained. The new units exhibit the same low noise, low temperature coefficient, tight tempco tracking, and superior high-frequency performance as the earlier units.

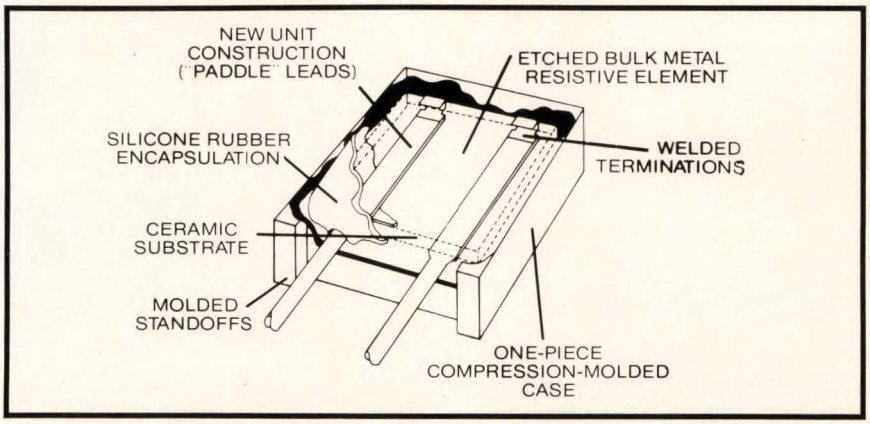
Currently available resistance values range from 1 ohm to 100 kilohms, while tolerances go from 0.005% to 1%. Complete details are set forth in Bulletin R-800A.

Vishay Resistive Systems Group, 63 Lincoln Highway, Malvern, Pa. 19355. Phone (215) 644-1300 [343]

Toggle switches can be used in microwave region

Series 10 subminiature toggle switches are low-capacitance devices (shunt capacitance is about 0.4 picofarad) that can be used effectively up to about 2 gigahertz. The switches do not need shielding to provide high isolation. Designed for low-energy applications, they are useful whenever space is at a

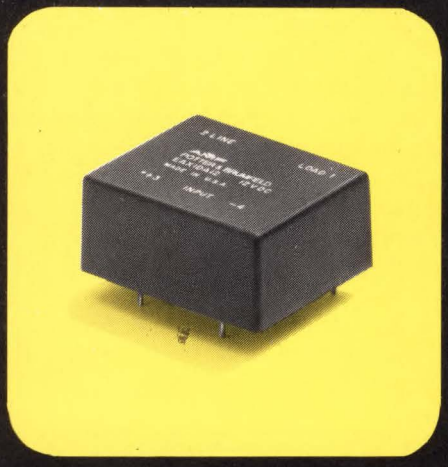




Now you can get 3 different types of solid-state relays from P&B.

That's P&B solid-statesmanship.

Specify P&B solid-state relays for wide choice, top performance, fast delivery. Three designs–103 ratings and voltages–now available from your local distributor. Get P&B experience–nearly two decades of designing solid-state devices.

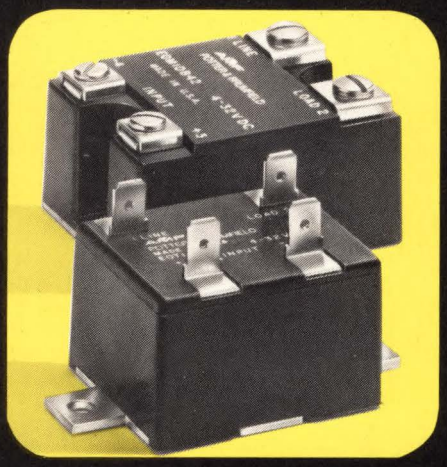


New EAX Series. Solid-state 1.2 ampere AC relay. Transformer coupled. Zero current turn-off.

Low cost, solid-state relays that can be driven directly by logic circuitry (TTL, MOS, HTL, and others). For switching solenoids, fractional hp motors, heating elements, contactors and small lamp loads.

Thyristor switch controlled and isolated by a pulse transformer circuit. Terminals for printed circuit board mounting (0.1″ grid).

Expected life of over 100 million operations. Temp. range: storage, −40°C to +85°C. Operating ambient, −10°C to +55°C.

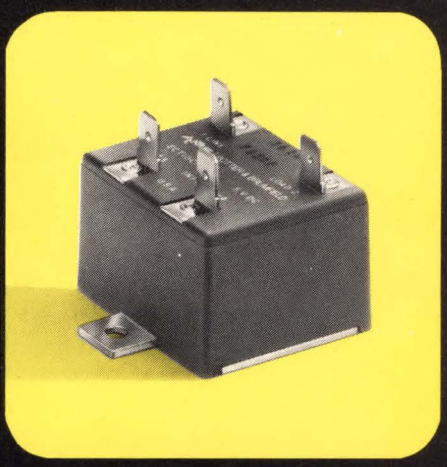


EOM/EOT Series. 0.1 to 20 amperes. All solid-state opto-coupled AC relays.

Medium power, 120/240 VAC 50/60 Hz switches. Controlled and isolated by opto-electronic coupler. For use as ON/OFF switch for loads through 20 amperes. EMI and RFI are greatly reduced due to zero voltage turn-on and zero current turn-off.

An ideal component for interfacing between the logic output of TTL, HTL, or MOS circuitry and such AC loads as solenoids, motors, lamps and transformers.

Expected life greater than 100 million operations. Temp. range: storage, −40°C to +85°C. Operating ambient, −10°C to +55°C.



ECT Series. Solid-state Hybrid relay. Reed triggered triac. 0.1 to 32 amperes.

Medium power, 120/240 VAC 50/60Hz solid-state switches controlled and isolated by a reed relay, packaged for direct chassis mounting. Intended for switching AC loads such as solenoids, motors, lamps and transformers through 32 amperes. AC and DC actuation available.

Advantages: long life, high inrush switching capacity and input/output isolation provided by the reed relay.

Expected life greater than 10 million operations. Operating ambient, −10°C to +55°C.

Standard models have .250″ quick-connect terminals. .187″ and .205″ also available.

Ideal applications for P&B solid-state relays include process controls, instrumentation, life support equipment, alarm devices, machine tools, vending machines, dryers, photocopiers, lighting and traffic controls.

See your P&B representative or authorized P&B distributor for specifications on his 103 off-the-shelf solid-state and hybrid relays. Or, write Potter & Brumfield Division AMF Incorporated, 200 Richland Creek Drive, Princeton, Indiana 47671. 812/386-1000.

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Circle 217 on reader service card

premium. Series 20 miniature toggle switches are similar devices. They are somewhat larger, perform up to 1 GHz, and can be mounted on a printed-circuit board. Both series are double-pole double-throw devices and are optionally available with one set of poles shorted. The switch bodies are made of Teflon, the contacts of gold-plated fine silver.

Small quantities are available from stock. For one to nine pieces, the series 10 switches sell for $5.50 and the series 20 for $6.50.

Instru-Mech Inc., 1275 Bloomfield Ave., Fairfield, N.J. 07006. Phone Dave Demarest at (201) 575-1860 [344]

Dpdt DIP relay stands only 0.38 inch high

Standing only 0.38 inch high, a double-pole double-throw electromechanical relay housed in a dual in-line package fits well within 0.5-inch spacings when mounted on a printed-circuit board. It fits standard 16-pin sockets, and its footprint is the same as those of similar, but taller, units.

The unit is extremely sensitive: its coil requires a maximum of 200 milliwatts at pull-in. The relay can switch a resistive load of 1 ampere at 28 volts dc and can carry 5 A. Life expectancy is in excess of 10 million cycles for low-level loads. Typical operating time is 4 milliseconds; typical release time is 1 ms.

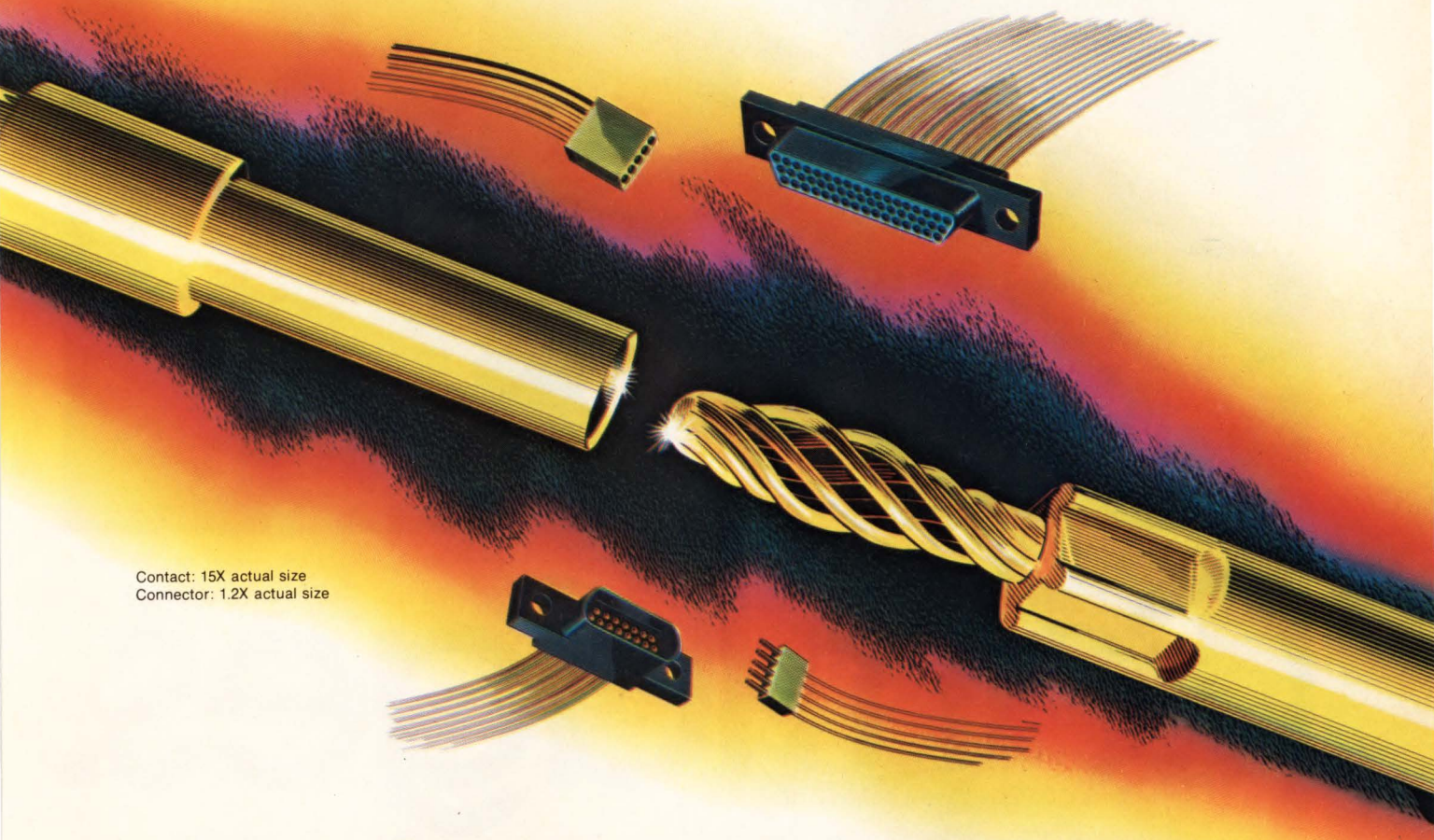
Allied Control Operation, Control and Systems Division, Gould Inc., 100 Relay Rd., Plantsville, Conn. 06479 [345]

Single-turn pots will last 5 million shaft rotations

When it is expected that a potentiometer will be more or less continuously adjusted by its end user, it becomes important to consider the effect of shaft rotation upon the pot's life. Pots in the 6180 series have a conductive-plastic element that gives them a life expectancy some 500 times greater than that of carbon composition pots—5 million shaft rotations versus 100,000. They can thus reduce field repair time, expense, and frustration in a wide variety of equipment. The various pots in the series are electrically similar; they differ only in bushing and shaft dimensions. All provide a 1-watt power rating at 70°C, a maximum operating temperature of 125°C, a maximum output roughness of 0.1%, fabrication from nonflammable materials, and essentially infinite resolution.

Beckman Instruments Inc., Technical Information Section, Helipot Division, 2500 Harbor Blvd., P.O. Box 3100, Fullerton, Calif. 92634 [346]

Dura-Con*: Smallest connector Tough as the biggest.



Contact: 15X actual size
Connector: 1.2X actual size

Use it your way or ours

So small you can barely see it, yet the Dura-Con contact has better performance and is more dependable than almost any other connector, regardless of size.

These remarkable characteristics are the result of the unique spiral spring design of the male contact, which provides seven points of contact on the female. For example:

Shock resistance: No discontinuity, 20 shocks, 500g
Vibration resistance: No discontinuity, 10 to 2000g. .06″ double amplitude or 50g. (6 nanosecond sensitivity)
Durability: 500 mating cycles minimum
Temperature: −65° to +275° F

Where space, weight or signal path reduction is required, the Dura-Con, with its 0.050″ contact spacing, cannot be excelled.

The Dura-Con connector system is available in strip (up to 20 contacts) and "D" rectangular (9, 15, 21, 25, 37 and 50 contacts) configurations from stock, or it can be adapted to your custom design or termination requirements. Contact your TRW Cinch Connector distributor or field sales office or write to TRW Cinch Connectors, 1501 Morse Avenue, Elk Grove Village, Illinois 60007, (312) 439-8800. CC-7716

*Trade Mark TRW Inc. Licensed by New Twist Connector Corp.

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- 10 billion hours of device time logged by Reliability Inc. in our burn-in facility in Houston — nation's largest
- CRITERIA units now in operation in many major manufacturers of solid state devices

"Let me demonstrate our cost effectiveness for your plant... for small lot or production quantities."

Call Bob Burton, (713) 666-3261.

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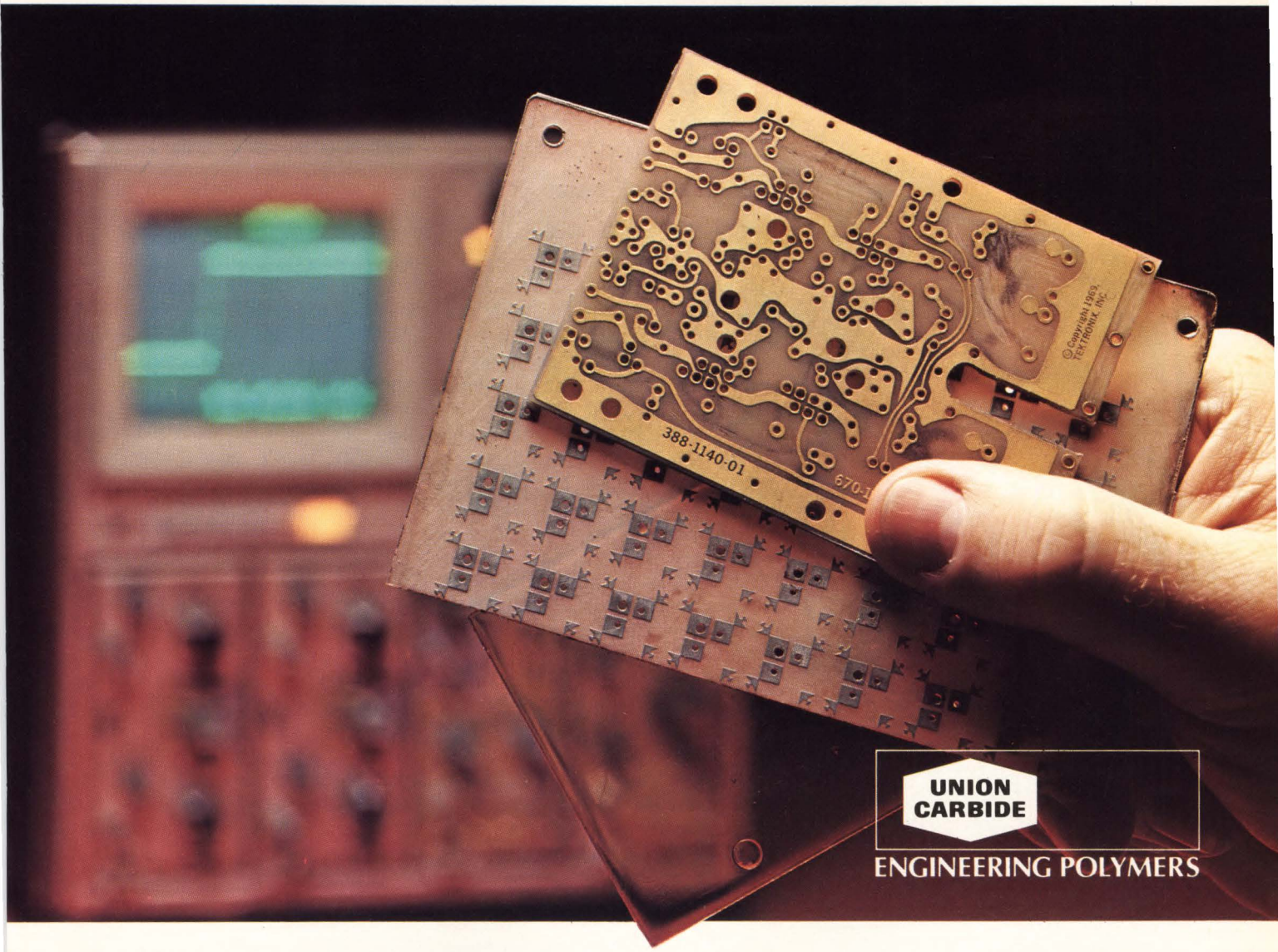
Telex: J 47879

If you could cut base material cost from $15 or $30 down to $3 per square foot, how much would you save next month?



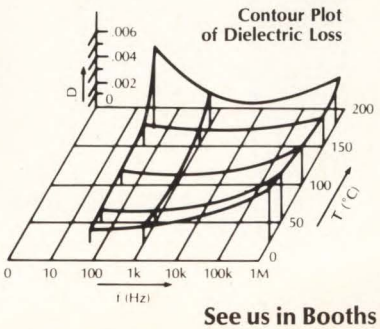
Maybe $10,000 per month? More? Less?

Well, Tektronix, Inc. of Beaverton, Oregon thought the savings impressive enough for their high frequency circuit boards to switch from polyphenylene oxide to an extruded polysulfone (UDEL Polysulfone, of course) just 1/16 of an inch thick.

Their processing costs are about the same as for other base materials with similar electrical properties. Even the quality and yields (c. 80%) are close on. But since they stopped using copper clad polyphenylene oxide they also get a use temperature 100 deg. F. *above* that material.

Polysulfone outperforms other materials at a lower cost in high frequency applications because of its excellent electricals (see graph) plus all these advantages:

- withstands 500 deg. F. wave solder bath for 5 secs.
- good notched Izod: 1 ft-lb/in.
- impressive chemical resistance
- ink and adhesive baking at 320 deg. F.
- good peel strength
- and polysulfone can be *molded* with stand-offs, holes of all sizes, and any shape, to save machining and finishing time.



How much more can we tell you here? Write for full data using the coupon below or the reader service card.

Maybe I can cut my high frequency circuit boards cost by 90%. Let me look at your data on UDEL Polysulfone

Name _____

Title _____

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Address _____

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City _____

State _____ Zip _____

Mail to:
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270 Park Avenue, New York, N.Y. 10017.

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Circle 221 on reader service card

New products

Instruments

Calibrator has 50-ppm accuracy

Microprocessor-controlled instrument calculates errors and tolerances

The model 5100A microprocessor-controlled calibrator is a highly flexible instrument with output accuracies and capabilities sufficient to cover the calibration of simple analog multimeters, 3½- and 4½-digit multimeters, and even some 5½-digit precision instruments. It produces dc voltages to 1,100 volts with accuracy to within 50 parts per million, ac voltages to 1,100 v at frequencies of 50 hertz to 50 kilohertz, ac and dc currents from 10 microamperes to 2 A, and eight resistances from 1 ohm to 10 megohms.

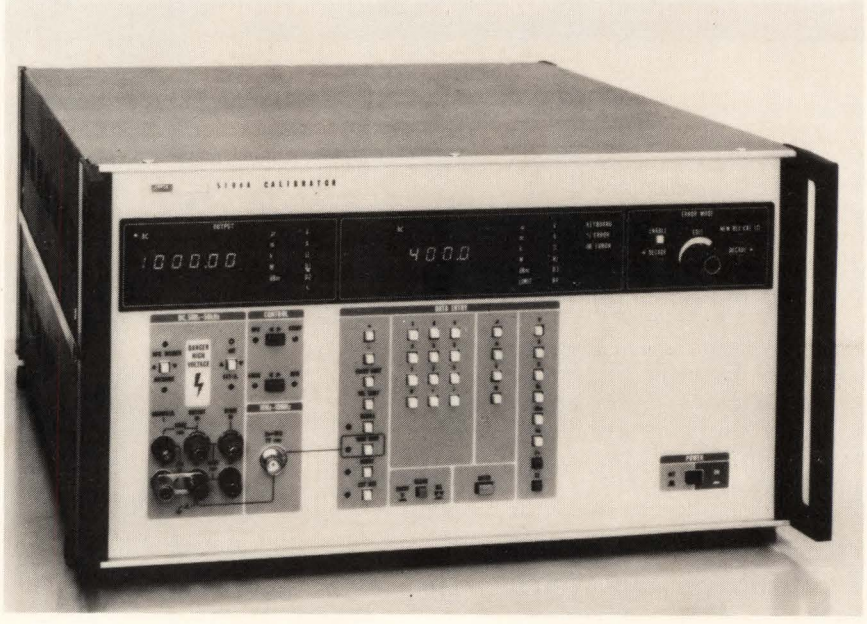
Among the many features made possible by the unit's microprocessor are: entry limit, which is a number that may be placed in memory so that the operator may not call for an output that exceeds the limit; lead compensation, in which the resistance of the test leads is subtracted from the reading of the unit under test; scaling, which allows any fraction of full scale to be selected with the tolerance automatically calculated and displayed as a percentage; and editing, which allows a single rotary control to change any number originally selected from the keyboard.

In addition to the model 5100A, Fluke is producing the model 5101A—a similar instrument that incorporates a built-in tape cassette for the permanent storage of frequently used test procedures. The 5100A sells for $6,495, while the 5101A is priced at $8,495. Delivery time for the former is 60 days; for the latter it is 180 days.

John Fluke Mfg. Co., P.O. Box 43210, Mountlake Terrace, Wash. 98043. Phone toll-free (800) 426-0361 [353]

Snap-around probe measures ac and dc currents

Built around a Hall-effect flux sensor, a noncontacting current probe called a Current Gun measures currents from dc to 1 kilohertz when it is plugged into almost any voltmeter, multimeter, or oscilloscope. The snap-around probe has two basic ranges: ±10 amperes full scale and ±100 A full scale. In each



TURNKEY 620 SYSTEMS FROM NEFF USING THE HP 9825 CALCULATOR..

the logical next step in data acquisition.

You're involved in a scientific, engineering, or industrial project that could use a high performance, low cost data acquisition system. But you know that system integration and software costs of most systems actually exceed the hardware. And your need is now, so you want a system that will take data immediately with minimum user training.

Our turnkey 620S was designed for you.....

620S is a sophisticated data acquisition system with amplifier-per-channel or differential multiplexer analog signal processing and using the H.P. 9825 computing calculator for system control, data analysis and recording.

Neff systems are known for high performance and the 620S is no exception. Consider 0.1% accuracy with 50kHz channel scanning rate, fullscale input sensitivities from 5 millivolts to 10 volts, up to 256 channels or 2048 channels fully expanded, and 120dB rejection of common mode voltages up to 300 volts. Selectable data filters, simultaneous sample and hold and input signal conditioning are but a few of the many available features.

The Hewlett-Packard 9825 calculator provides the 620S computer performance with the operating convenience of a calculator. Programming is simple with HPL, an easy to learn, high level language designed for scientists and engineers. Standard features include a live-keyboard, alpha numeric printer and cassette recorder. Up to 24K memory is available. Plug-in peripherals include floppy disk, line printer, x-y plotter, and tape punch. It also attaches to H.P. Interface Buss.

A complete, integrated data acquisition system thats easy to use — thats our turnkey 620S.

Like to know more? Call us today at 213-357-2281 or write for our free brochure.

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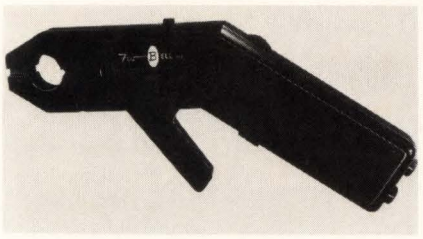
Tel. (213) 357-2281 TWX 910-585-1833

Circle 223 on reader service card

New products



case the output voltage is 1 volt when the current equals the full-scale current. Accuracy is within 2% of output.

To increase the sensitivity of the probe, the user can wrap several turns of the current-carrying conductor through the probe jaws. Since the probe is essentially a current-to-voltage converter, it allows the user to measure the ac and dc components of a complex current separately. The dc is the reading obtained on any dc voltmeter, and the ac reading is obtained by using an ac voltmeter that blocks dc. High-quality dc-coupled ac voltmeters will provide readings of the effective total current.

The Current Gun is a battery-operated device that can be used with mercury, alkaline, or nickel-cadmium cells. It requires four AA cells and will run for 60 hours on mercury, 30 hours on alkaline, and 8 hours on Ni-Cad. It sells for $165.

F.W. Bell Inc., 4949 Freeway Drive East, Columbus, Ohio 43229. Phone (614) 888-7501 [354]

Unit generates words and pseudorandom sequences

The model 8000 digital word generator is a two-channel instrument with a 16-bit word length capability for each channel. In addition to producing programmed words, the unit can generate pseudorandom sequences with lengths from 7 to 65,535 bits.

The model 8000 can run on its

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Circle 225 on reader service card 225

own internal clock or on an external time base. It can run continuously, manually by means of a single-cycle push button, or when remotely triggered. It sells for $995.

Dytech Corp., 2725 Lafayette St., Santa Clara, Calif. 95050. Phone (408) 241-4333 [355]

6-kV surge generator tests interrupters

By plugging a model 281 programming network into a model 424 surge generator/monitor, a user can produce isolated 6-kilovolt peak ac or ringing surges for testing ground-fault interrupters, uninterruptible power supplies, and other equipment that may be subject to surges on the ac power line. The delivered surge has a frequency of 100 kilohertz, a rise time of 0.5 microsecond, and a decay rate of 40% for each peak following the initial surge.

KeyTek Instrument Corp., 220 Grove St., P.O. Box 109, Waltham, Mass. 02154. Phone Peter Richman at (617) 899-6200 [356]

4-watt amplifier covers 1 to 1,000 megahertz

The model 4W1000 instrumentation amplifier is a linear device that delivers a minimum of 4 watts over an instantaneous bandwidth that extends from 1 to 1,000 megahertz. Its gain is fixed at a minimum of 36 decibels and is flat to within 1.5 dB. The amplifier is unconditionally stable: it will operate without oscillation or damage regardless of the magnitude or phase of the source and load impedances. The input and output impedances are 50 ohms, and the maximum input standing wave ratio is 2:1. The basic lab amplifier sells for $2,700. An OEM version, which requires an external source of 2.3 amperes at 28 volts dc, is priced at $2,100.

Amplifier Research, 160 School House Rd., Souderton, Pa. 18964. Phone Dan Roth at (215) 723-8181 [357]

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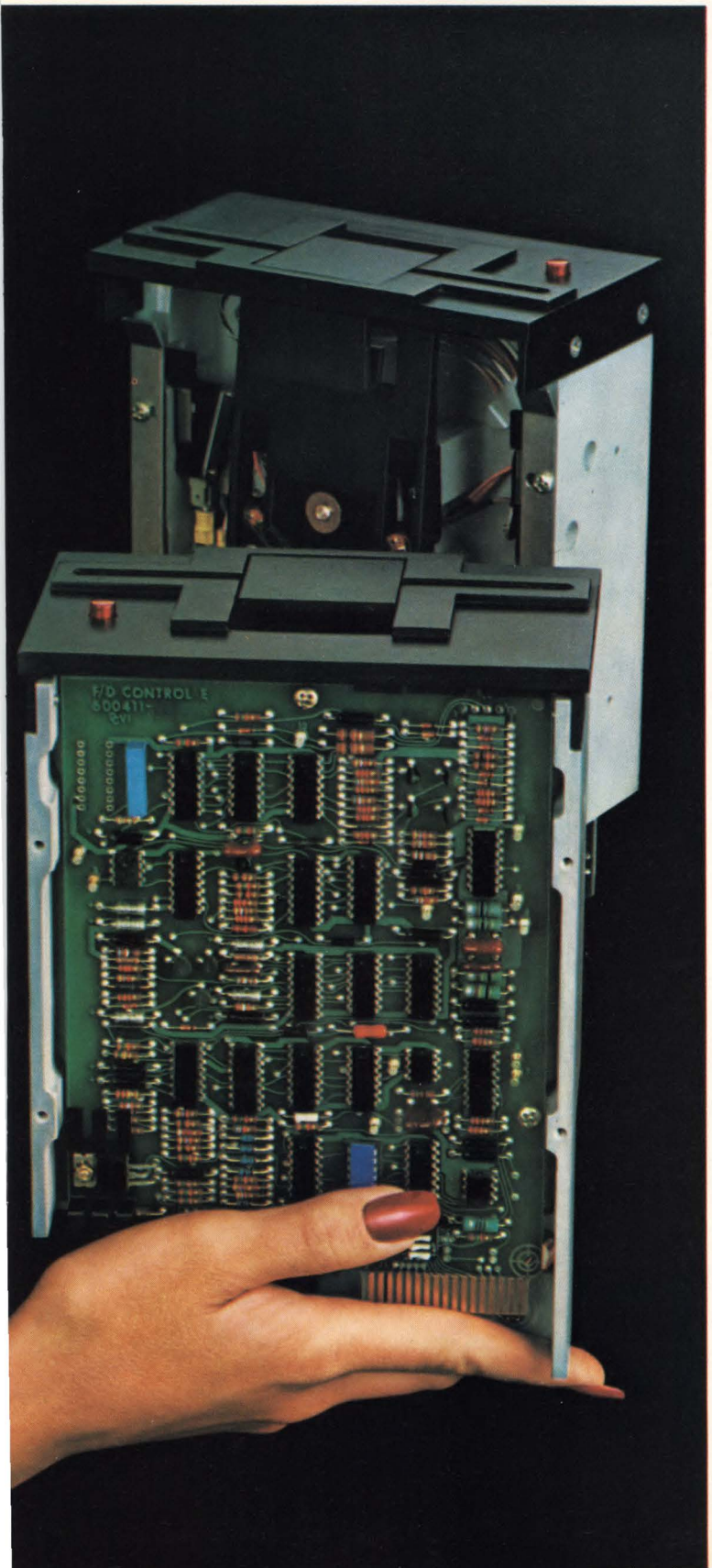

Pertec's 40-track double density Microfloppy®—compatible with Shugart's 35-track; comparable to no other μC disk drive.

Bottoms up. Here's where a second source leaps to the head of the class. Pertec's FD200 Microfloppy® offers big system performance—with no redesign—to OEMs using 5¼" diskettes. (For 8" applications, our FD514 is interface compatible with Shugart SA800.)

FD200: Fully compatible with Shugart SA400. Same dimensions, same mounting holes, same interface signals, same power connector. But unplug their 35-track drive, plug in FD200...and suddenly you're into the only double density, 40-track recording available to date for μC applications.

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Compatible to IBM standard. Through our inventive electronics, it's the same proven read/write head that's built a solid track record for Pertec, in thousands of minicomputer flexible disk drives worldwide.

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And Pertec cuts the number of PCBs in half. Not two, but only one quick-disconnect board—to simplify field maintenance, boost system reliability, reduce spares stocking.

The cost-efficiencies of our FD200 Microfloppy are so indisputable, we expect fast turnovers with microcomputer OEMs. Jump in.

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To make a complete line of pushbutton controls, you need more than pushbuttons.

Pushbuttons from MICRO SWITCH's AML (Advanced Manual Line) have always been attractive to designers. Because they look so good. And because they're so easy to mount and wire.

But now, the AML series is even more appealing. Because now there's a variety of rocker and paddle switches to choose from, including dual lamp and dual color. Which means now you can perform just about any function with a harmonious display. You don't have to compromise.

AML controls also look appealing to the people who have to do the wiring. All are designed with the same depth for single level termination, regardless of switch or terminal type.

There's easy snap-in mounting from the front, PC board mounting or subpanel mounting using individual, strip or matrix hardware.

Which means mounting is simpler. Wiring is simpler. Engineering time is reduced. And total installed cost is lower.

Plus, they offer solid state, electronic control or power switching in the same size housing. All AML devices are designed to meet international, UL and CSA standards.

Displays include split screen, hidden color, and a unique three-segment lens cap indicator. The choice of lamps includes T-1¾ wedge base, neon and LED.

AML has it all —pushbuttons, indicators, and now, paddles and rockers. But to see how good-looking AML really is, contact us for a personal demonstration.

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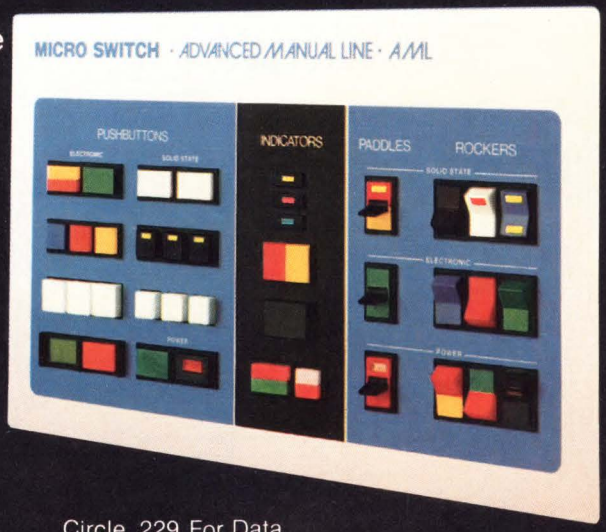

Circle 229 For Data

New products/materials

Silver-epoxy adhesive Tra-Duct 2924 is a two-part conductive composition for critical high-temperature bonding and sealing applications. Usable up to 190°C, the material combines the thermal and electrical conductivities of silver with the adhesive properties of epoxy resins. It is especially recommended for the assembly and repair of electronic modules, integrated circuits, waveguides, radio-frequency shields, and similar applications in which conventional soldering techniques are difficult.

Tra-Con Inc., Resin Systems Division, 55 North St., Medford, Mass. 02155. Phone Jim Hart at (617) 391-5550 [476]

Electrically conductive inks for screening onto printed-circuit boards are solderable, thermosetting materials with a consistency suitable for use with 225-mesh nylon screens. E-Kote 3065 is an economical silver-alloy composition with a dc sheet resistivity of 0.2 ohm per square. E-Kote 3066 is filled with pure silver and, in the same 1-mil thickness, has a resistivity of 0.1 ohm per square.

Acme Chemicals & Insulation Co., Division of Allied Products Corp., P. O. Box 1404, New Haven, Conn. 06505. Phone Tony Bianco at (203) 562-2171 [477]

High-permeability nickel-iron, grain-oriented silicon steels, and other specialized magnetic metals are now available in several new lamination shapes for use in making transformers. Of particular interest to telephone-equipment manufacturers is the Long E 250, an improvement over the long-used EE250, according to the manufacturer. The LE250 has a magnetic path length of 2 inches.

SGL Electronics, 300 Harvard Ave., Westville, N. J. 08093 [478]

A metal-cleaning agent called Clepo 146-E can be used to deoxidize and desmut aluminum and most of its alloys and to activate beryllium-copper and phosphor bronze before silver plating. The nonchromated, fluoride-free, moderately acidic formulation is designed for use at room temperature.

Frederick Gumm Chemical Co., 538 Forest St., Kearny, N. J. 07032 [479]

Gates introduces the future in energy cells.

There's now a new energy source that's a superb alternative: Rechargeable, sealed lead-acid batteries from Gates.

We call these batteries the future in energy cells. And for good reason.

They have all the product advantages you need plus economic advantages that may well give a new dimension to your product pricing.

Advantages: Gates Energy Cells are as compact as nickel cadmium or gelled type cells. And they are completely sealed, so that no acid vapor can leak out (they also include a self-sealing vent for extra safety). Gates Energy Cells provide low internal impedance for high discharge rates (more than 100 amps from the D cell and 200 amps from our X cell for short periods of time). And can be operated or stored in any position.

Gates Energy Cells offer great packaging flexibility. In fact, our individual cell availability allows you to choose your own specific voltage (in 2-volt increments) and current, as well as configuration.

Just as important as what Gates Energy Cells have to offer is what they don't have to offer. Like outgassing problems. Or cell reversal. Or "memory" problems.

Because Gates Energy Cells are made from low-cost materials that are readily available, they're very high in watt-hr. per dollar value. Which means that if you specify them, you'll probably save your company more than a few dollars. And make yourself into something of a hero in the bargain.

To find out more about the future in energy cells, circle our reader service number or write us. We'll send you *free* literature containing features, application information, ratings and specifications. George Sahl, Gates Energy Products, Inc., 1050 S. Broadway, Denver, CO 80217.

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E-10

Circle 231 on reader service card

New literature

Solid-state amplifiers. A detailed discussion of solid-state amplifier products is presented in a 32-page catalog. The amplifier families that are covered include TO-8, wideband, radar- and communications-band, and intermediate-power solid-state amplifiers, and medium- and high-power limiters. Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif. 94304. Circle reader service number 421.

Microwave bandpass filters. Catalog no. 778 describes a full line of microwave bandpass filters, from helical resonators and coaxial cavities in the low range to rectangular waveguides in the high range. A detailed comparative summary, giving the filter series characteristics, is provided at the beginning. The rest of the catalog features detailed descriptions and performance data for each filter series. Lorch Electronics Corp., 105 Cedar Lane, Englewood, N. J. 07631 [422]

Making accurate measurements. Application note 13, explaining how a calibrated spectrum analyzer can be used for making accurate measurements of either amplitude-modulated or frequency-modulated signals, is available from Marconi Instruments, Division of Marconi Electronics Inc., 100 Stonehurst Ct., Northvale, N. J. 07647 [423]

Magnetic shielding. The availability of products and services for making magnetic shielding is detailed in a brochure from the Mushield Co., 121 Madison Ave., Malden, Mass. [425]

Monochips. A line of linear and digital semicustom integrated circuits is presented in a 16-page full-color brochure. A new linear circuit, a 91-by-110-mil chip containing 460 components, designated the MO-F, and a newly developed n-channel metal-oxide-semiconductor digitial chip, designated the MD-A, are highlighted. Characteristics of the various integrated components are provided. A separate section of the brochure contains information to

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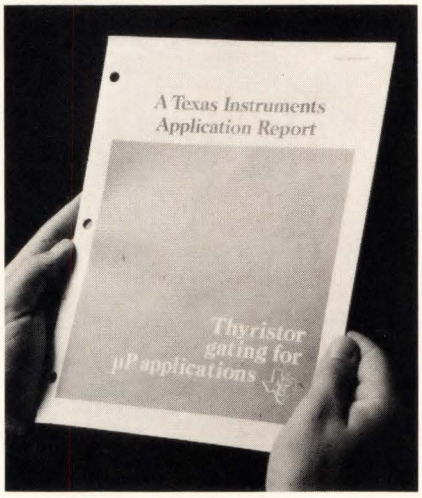
Circle 233 on reader service card

New literature

help engineering personnel assess the cost effectiveness of the monochip approach. Interdesign Inc., 1255 Reamwood Ave., Sunnyvale, Calif. 94086 [424]

Thyristor gating. An 11-page report, "Thyristor Gating for Microprocessor Applications," discusses the use of some of the most common thyristors, triacs, and silicon controlled rectifiers in microprocessor-based control systems for appliance and



industrial-control applications. Microprocessor control of triacs, electrical isolation of gate drive, transient noise problems, and protection from circuit malfunction are discussed briefly as well. Texas Instruments Inc., Inquiry Answering Service, P. O. Box 5012, M/S 308 (Attn: CA-191) Dallas, Texas [426]

Piezoelectric accelerometers. An eight-page catalog discusses how internally preamplified piezoelectric accelerometers can replace charge-coupled piezoelectric accelerometers in low-temperature applications while simultaneously improving vibration measurement accuracy. Discussion of each model's individual capabilities and its most suitable engineering applications is provided along with a picture. An additional two-page chart enhances this discussion, providing complete electrical, mechanical, and physical data for each accelerometer. Accelerometer installation data is also given. BBN

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3100-48	100	5-48	48	495
3100-28	100	5-48	28	495
3050-48	50	5-48	48	425
3050-28	50	5-48	28	425
3025-48	25	5-48	48	395
3025-28	25	5-48	28	395
9525-48	25	5-24	48	250,295,365
9525-28	25	5-24	28	250,295,365
9584	10	5V-5KV	28	210-310
9589	6	5V-5KV	28	190-280
9567	3	5V-5KV	28	180-270
9583	1	5V-3KV	28	200-280
1205	25	5-28	12,24,28,48	198
1000	10	5-24	5,6,12,24,28,48	115,125,140
1600	6	5-24	5,6,12,24,28,48	89,99,109
1300	3	5-24	5,6,12,24,28,48	79,89,99
1100	1	5-24	5,6,12,24,28,48	59,65
HC	max. 3	5-300	5,12,20	49,59,69
HCH, N, E	max. 3	5-300	6,5,12,15,20,24,28	49,59,69
AC-DC				
4200	200	5-48	115	845
4100	100	5-48	115	450
4050	50	5-48	115	425
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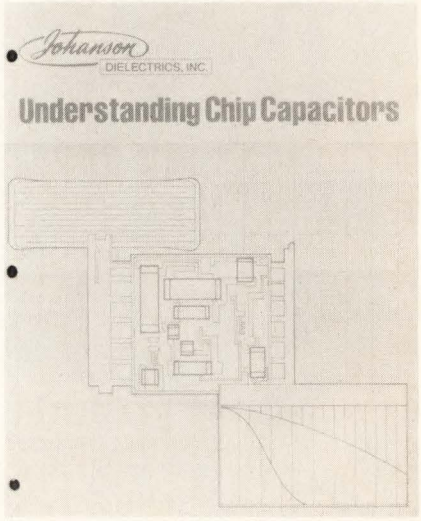
New literature

Instruments Co., 50 Moulton St., Cambridge, Mass. 02138. Phone (617) 491-0091 [431]

Magnetic media measurements. A 12-page brochure describes successful techniques used in magnetic media measurements. It is geared for the user of high-speed computer and telemetry recording equipment. Described are typical patterns that cause stress to the system and detection of stress locations using the measuring system. Tau-tron Inc., 11 Esquire Rd., North Billerica, Mass. 01862 [427]

Chip capacitors. A reference handbook presents a detailed discussion of ceramic-chip capacitor technology. Topics discussed include elec-



trical properties, classes of dielectrics, testing parameters, and choosing the correct chip. Johanson Dielectrics Inc., Box 6456, Burbank, Calif. 91510 [428]

Semiconductor products. A 148-page cross-reference and product guide is an excellent aid for those engineers who need a quick replacement for any semiconductor product. It includes how to locate the replacement device, how to verify the replacement device, and what to do if a cross-reference replacement is not found. The products cross-referenced are: paired complementary transistors, zener diodes, high-voltage components, field-effect tran-

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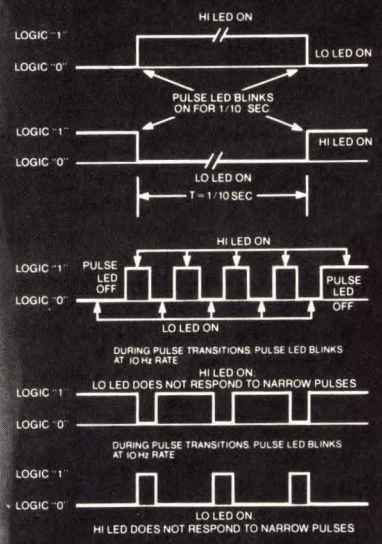
Weight 3oz. (.085Kg)

Power leads detachable 24" (610 mm) with color-coded insulated clips; others available



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Interchangeable probe tips—Straight tip supplied; optional alligator clip and insulated quick-connecting clip available.

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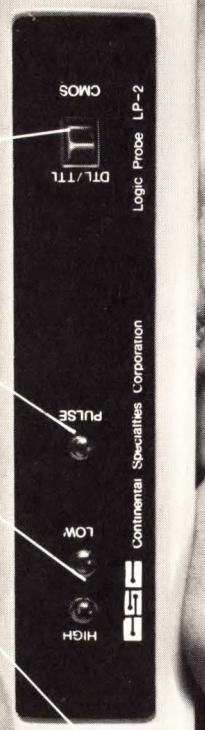

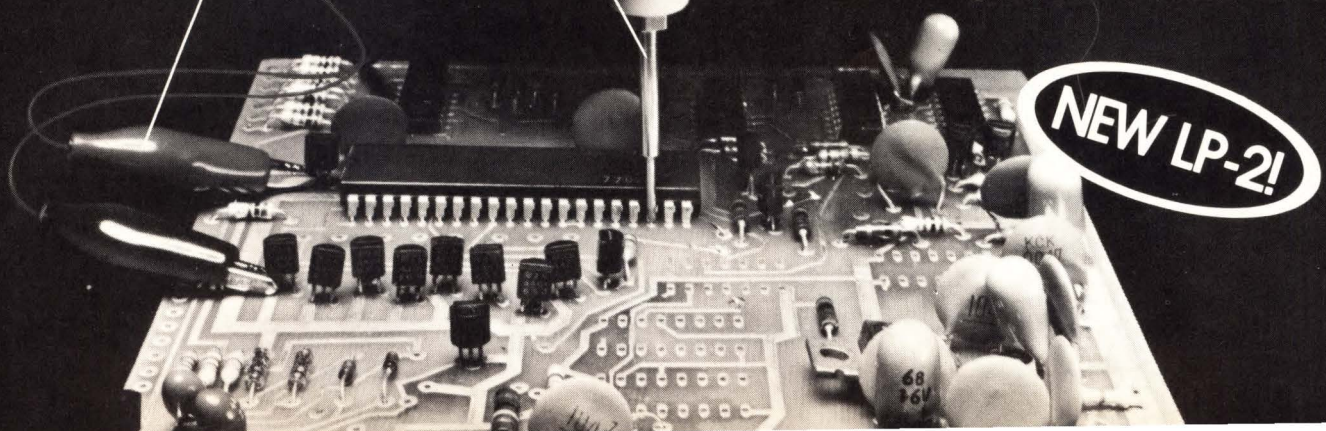

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New literature

sistors, and others. P. R. Mallory & Co., 3029 East Washington St., Indianapolis, Ind. 42606 [432]

Potentiometers. A line of single- and multi-turn potentiometers in wirewound, conductive-plastic, or hybrid versions is described in a short-form catalog. Electrical, mechanical, and environmental specifications are provided for both military and commercial use. Duncan Electronics Inc., 2865 Fairview Rd., Costa Mesa, Calif. 92626 [429]

Density conversion. Engineers, designers, and draftsmen can easily convert material density to other units of measurement. A chart, which shows the conversion of density to specific volume and equivalent weight, is a quick reference. Some common measurements and their equivalents are given at the bottom of the chart. Technical Wire Products Inc., 129 Dermody St., Cranford, N. J. 07016 [430]

Ceramic substrates. An eight-page brochure provides illustrations for alumina and beryllia ceramic substrates, packages, and assemblies that can be designed to an engineer's specifications. Drawings and dimensions are given for nine types of leadless-inverted-device (LID) carriers. A separate section is provided explaining the advantages of the leadless inverted devices. Plessey Frenchtown, 8th and Harrison Sts., Frenchtown, N. J. 08825 [433]

C-MOS timekeeping. Complementary metal-oxide semiconductors have been used in the area of precision timekeeping for a while. A short history of this is provided along with the products available for the engineer in an eight-page brochure. Discussed are the functions of quartz-analog timekeeping systems including: the crystal-controlled oscillator, the frequency divider, and the electromechanical clock movement. A graph is provided if you want to design your own circuit. Solid State Scientific Inc., Commerce Dr., Montgomeryville, Pa. 18936 [434]

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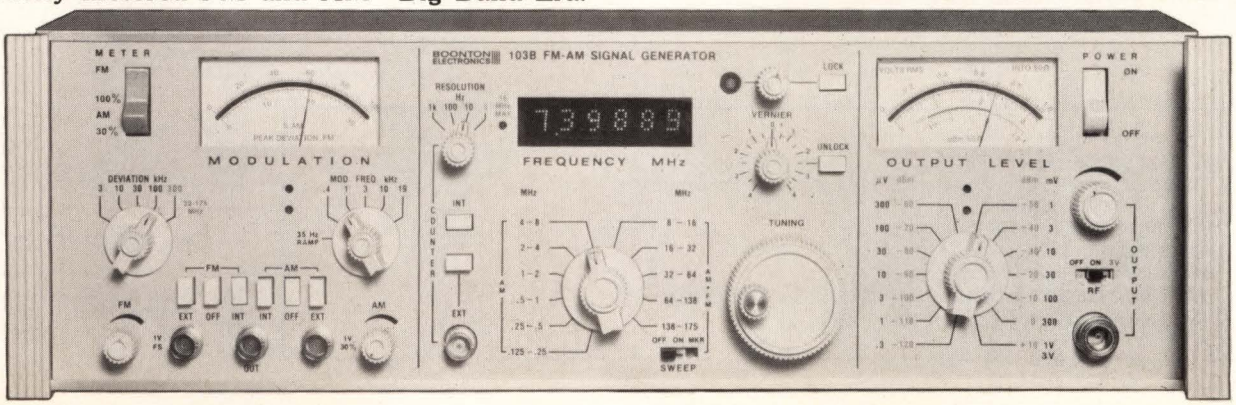

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Contact: Robert Norton

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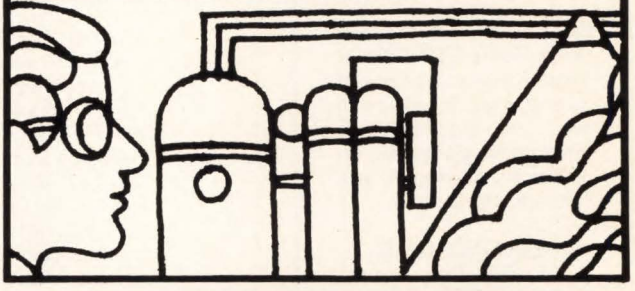

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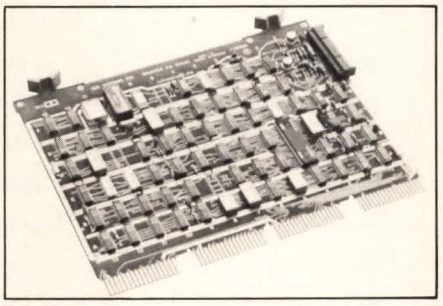

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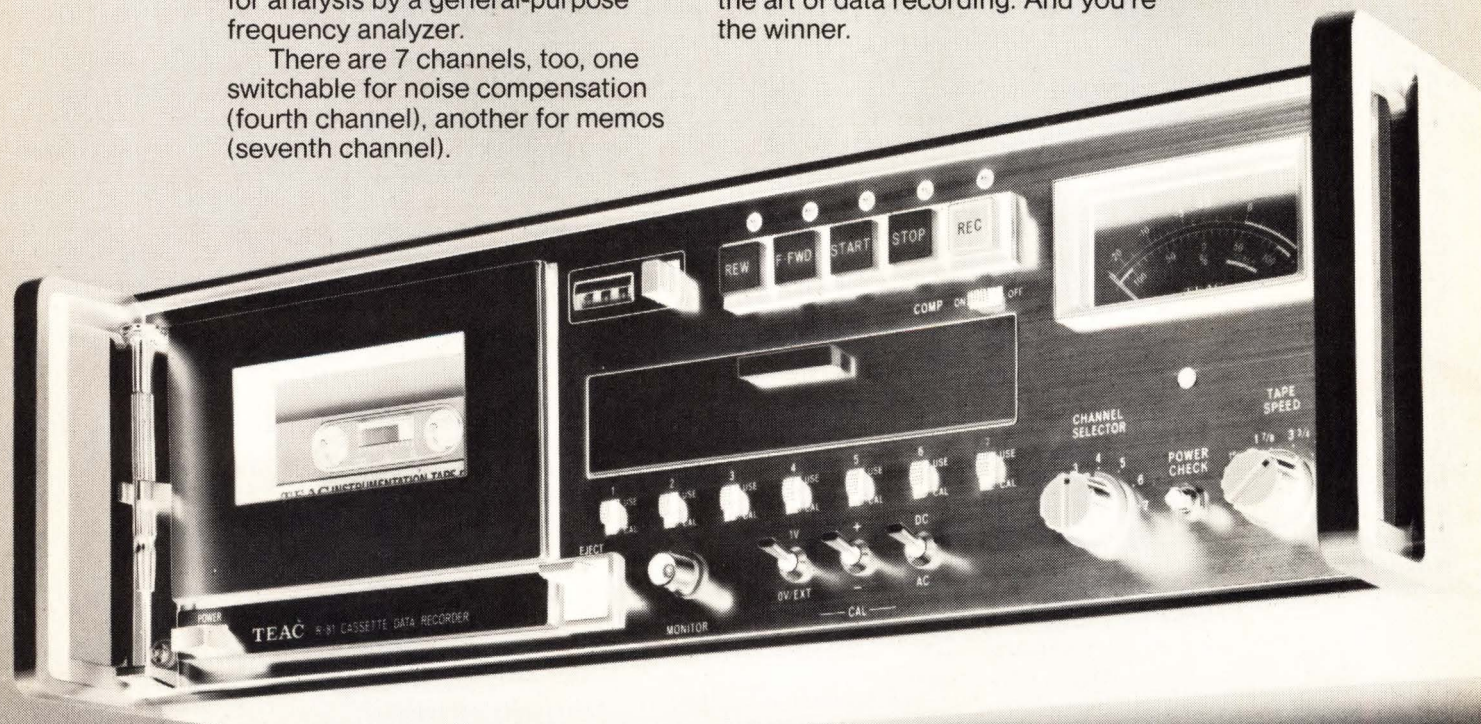

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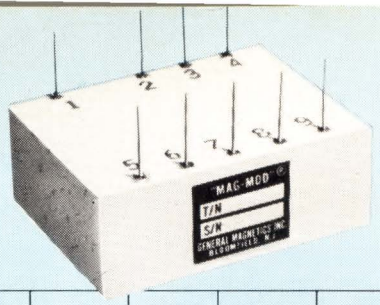
Circle 257 on reader service card

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.
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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 SIN / 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
NOTES	–	dual channel unit	–	–	–	dual channel unit	–	dual sine output	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

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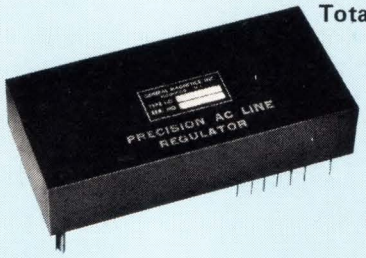
Specifications:

- Transfer equation: Eo=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 mounting (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:

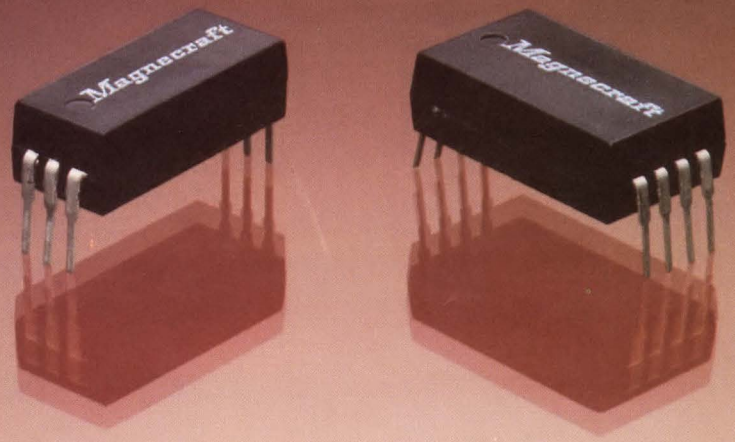
- AC input line voltage: 115V RMS ±20% @ 400 Hz ±20%
- Output: 26V RMS ±1% (for any condition)
- Load: 0 to 250 MA, RMS
- Total regulation: ±0.15% maximum (any combination of line, load or frequency)
- Distortion: 2% maximum
- AC input line current: 100 MA. max. at full load
- DC power: ±15 V DC ±5% @ 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 258 on reader service card

GENERAL MAGNETICS • INC
135 Bloomfield Ave., Bloomfield, New Jersey 07003 - Tel. (201) 743-2700

A single, double, or triple pole, compact, printed-circuit-mounted, immersion-proof, .310 high, IC and µP compatible, off-the-shelf, reed relay.

The MIP*



It's available in a variety of standard contact combinations . . . single pole: 1 Form A, 1 Form B, and 1 Form C . . . double pole: 2 Form A and 2 Form C . . . triple pole: 3 Form A. And, both .1 and .150 pin spacing is offered.

The modular MIP is epoxy molded and completely immune to standard printed circuit board cleaning processes.

Complete information and specifications are available in our MIP Catalog. Write or call Magnecraft Electric Company, 5575 North Lynch, Chicago, Illinois 60630. 312/282-5500.

Magnecraft®
ELECTRIC COMPANY

*Molded In-Line Package

Circle 901 on reader service card

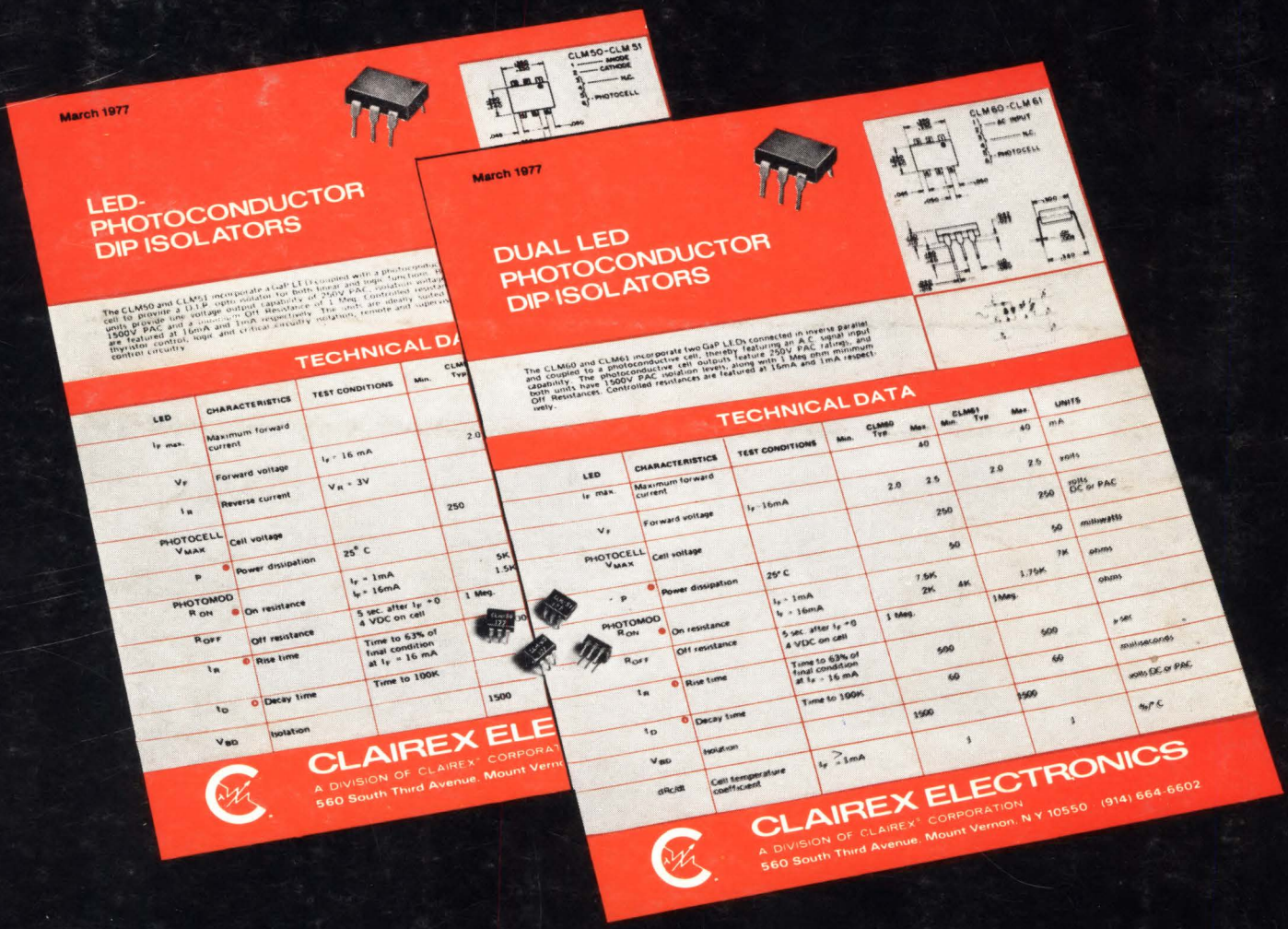
First in the Industry!
LEDs with PHOTOCONDUCTORS in DIP OPTO-ISOLATORS

Clairex has developed these four LED/photoconductive cell isolators in the conventional dual-in-line package. They are truly an industry first! The inherent slower speed response of a photoconductive cell, as compared to a silicon detector, provides an ideal unit for noise and transient immunity.

All four units have a photoconductive cell output capability of 250 volts PAC along with an isolation voltage of 1500 PAC. They also feature a minimum R_{OFF} of one megohm and guaranteed R_{ON} maximums at If biases of 16 ma and 1 ma respectively.

The CLM 50 and CLM 51 incorporate a GaP LED with a photoconductive cell for both linear and logic functions. The CLM 60 and CLM 61 feature two GaP LEDs connected in inverse parallel in their input circuits to facilitate an a-c input signal to the isolator.

For complete details or anv other assistance with your opto-electronic problems, call 914-664-6602 or write Clairex®, 560 South Third Avenue, Mount Vernon, New York 10550.



CLAIREX ELECTRONICS

A Division of Clairex Corporation

Circle 902 on reader service card