JULY 21, 1977

EERS, PART 2: HOW TECHNOLOGY IS CHANGING THE EE'S JOB/95

Fast processor emulator debugs peripheral circuits/108
How to design active filters with gyrators/115

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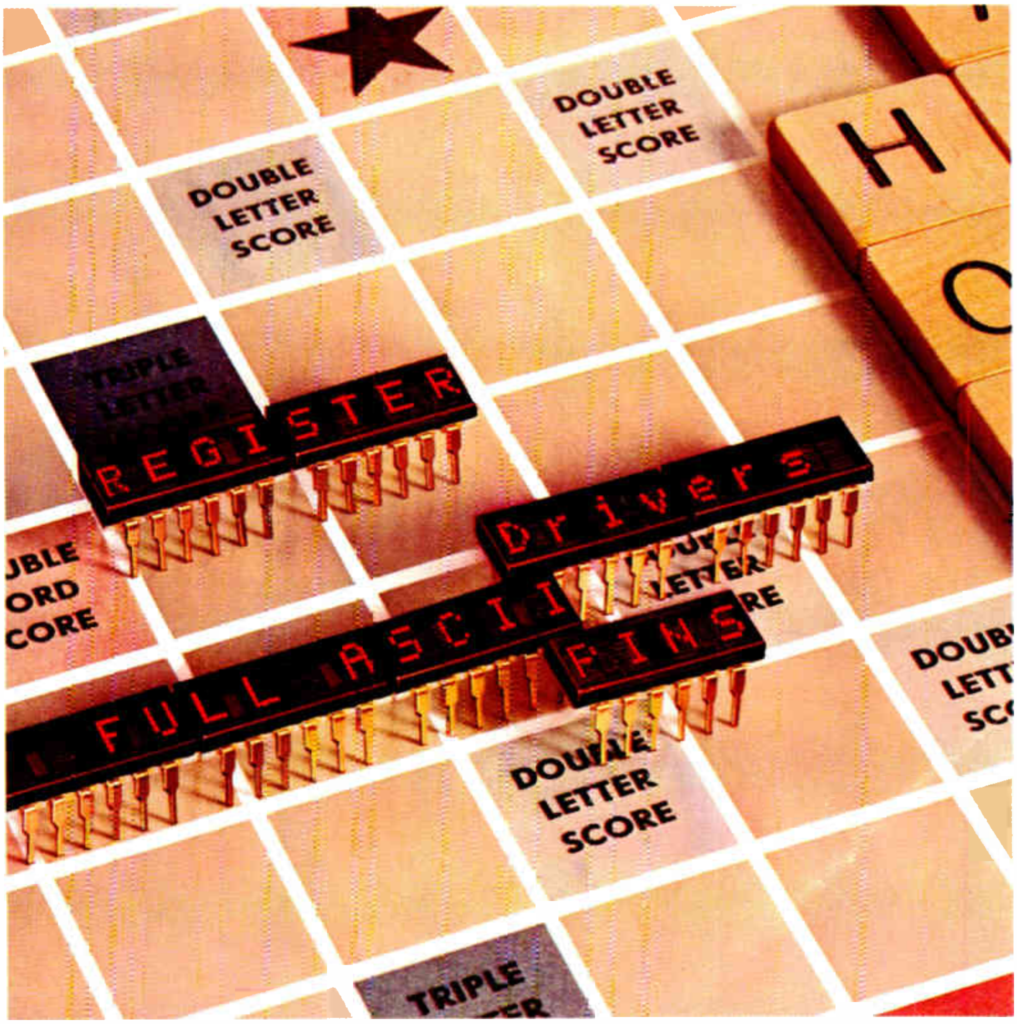

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Electronics
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Highlights

Cover: IC production takes on new look, 81

The makers of integrated circuits are upgrading their production-line technology to meet the zooming demand for their products and to keep up with increasing device complexity. Especially in the steps that turn raw wafers into finished ICs, the manufacturers are adopting highly automated equipment and advanced production processes.

Intel Corp. supplied the photograph used in the cover illustration.

How Hamilton-Avnet does it, 72

The kingpin firm among electronic component distributors has grown fivefold and stayed solidly in the black since the early 1970s. As much as anything, the secret seems to be hard work and close attention to detail.

EEs mull microprocessor's impact, 95

The changes wrought by the microprocessor are significantly affecting their careers, electronics engineers report in this second part of a series on EEs and their jobs. Interviews across the country disclose wide-ranging opinions on how to deal with the impact.

Solid-state relays get popular, 134

Tumbling prices, compatibility with integrated circuits, and no-frills models are enticing users to adopt optically isolated solid-state relays. This product update examines the technology that made the advances possible.

And in the next issue . . .

Using magnetic-bubble memories in systems . . . part 3 of the EE career survey . . . a new generation of fast static random-access memories.

Electronics

Publisher's letter

Gyrators, explains Tom Lynch, the author of the article that starts on page 115, permit the engineer to design filters that have nearly ideal performance—without the drawbacks of conventional inductors and without the sensitivities of other active-filter circuits. "Most people don't believe the gyrator works, so you have to argue for it," which is just what Tom does in his article. "In the end, though, they become convinced," he adds.

Lynch, who works at the Electronic Systems division of Bunker-Ramo Corp. in Westlake, Calif., is an electronics specialist in the analog design section. In this capacity, he spends about half his time on power supply design, and the other half is split between fiber optics and filters.

In 1966, he earned a master of science in circuit technology at UCLA, where he earlier received his engineering degree. His first job, which lasted only one year, was with the then SDS Data Systems in Pomona, Calif. His second job was with Bunker-Ramo, and he has been there for the last 10 years.

Tom is actually an unusual source for an article about the gyrator, because his primary design specialty is switching-mode power supplies—fairly hefty ones that deliver from 1 to 2 kilowatts at up to 30 amperes.

"With power supplies, you must design perfect circuits and have a complete understanding of them," he says. "Because if you don't, when you have a failure, it's catastrophic—the supply blows up." In contrast, "turning on a poorly designed linear circuit, like a filter, causes it to distort—so what!"

"I couldn't take power supply design on a continual basis. It got so I'd never throw the switch on at the end of the day. I'd rather wait until the next morning, because I didn't want to risk ruining my evening."

Unlike many other engineers, he regards filter design as a "pleasant interlude." His first on-the-job exposure to the gyrator was in 1975, when he used it to design a double-tuned filter for a sono buoy. That is when he discovered that most literature on the gyrator was highly theoretical, rather than practical, while trade magazines and other literature extolled the virtues of the state-variable circuit, another form of active filter.

Moreover, most books about passive inductance-capacitance filters made design very difficult, because they assumed ideal components—elements with infinite Q and no loss. Therefore, his article takes a big step toward easing problems in designing gyrators.

During his lunch hour and other breaks, Tom takes time out to work on another kind of project, raising watermelons and green beans in a small plot allotted to him by his firm. In this activity, he has lots of company: Bunker-Ramo has somewhere around 45 on-the-job gardeners in all. At home, he tends a less conventional garden by raising tomatoes hydroponically—that is, growing them in a nutrient solution with a sterile medium.

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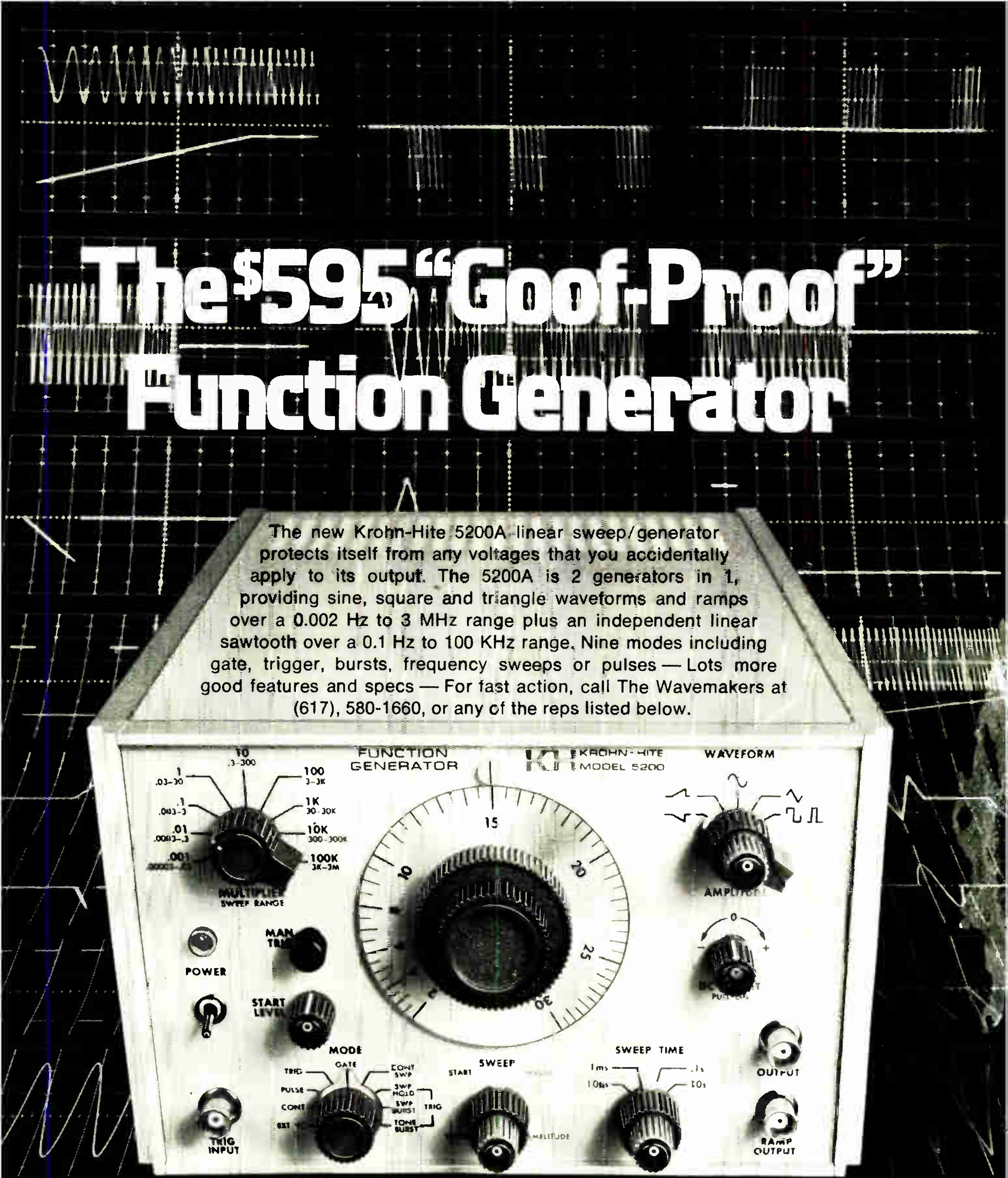

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Circle 5 on reader service card

Readers' comments

Getting even more crowded

To the Editor: I am very interested in making a major personal contribution to electronic technology, and I have noted that, to SSI, MSI, and LSI, we have added VLSI.

Before again being preempted, I would like to propose the last two terms in the series: ELSI (extremely large-scale integration) and ULSI (ultimate large-scale integration). To provide flexibility beyond the ultimate, I am proposing that ULSI be defined as two gates on an electron. This will provide for U^2LSI, U^3LSI (four gates and eight gates, respectively), etc.

I hereby donate this system to the public domain for use without any royalties.

John T. Coughlin II
Bay Village, Ohio

A belated thank you

To the Editor: That "eye-catching painting" on the cover of your June 9 issue is the work of Japan's Katsushika Hokusai. Japan may borrow extensively from Western ideas and sometimes give insufficient acknowledgement of this, but Hokusai is one of that country's great masters of the art. Give credit where credit is due.

Malcolm F. Reed
Fort Lauderdale, Fla.

■ *Other readers have joined Mr. Reed in pointing out that the inspiration for our cover was one of Hokusai's early 19th century woodblock prints. Our failure to acknowledge our indebtedness was inadvertent.*

Corrections

Solving complex matrices by hand can be a frustrating and error-prone experience [Calculator Notes, May 12, p. 121], but obtaining the equations for the matrix can be even more difficult.

Although voltage V_1 was calculated correctly from the given matrix, the equations do not match the circuit in the figure. The correct matrix equations are:

$$(-1-2j)\,V_1 - 2V_2 + j\,V_3 = 0$$
$$V_1 - V_3 = -120 + j90$$
$$-j\,V_1 - 2V_2 + (-1+2j)\,V_3 = 0$$

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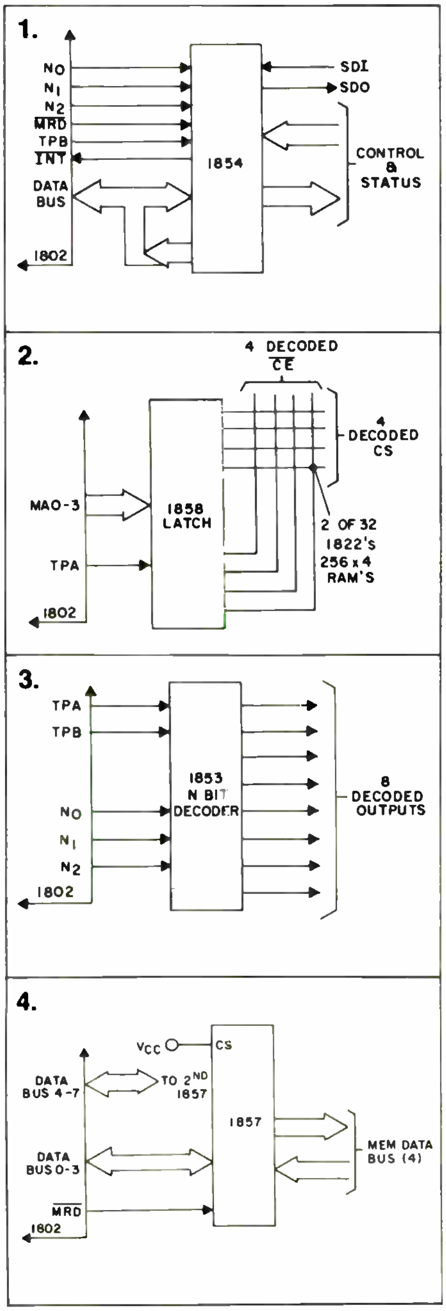

3 N-bit decoder

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News update

■ After signing an agreement with RCA Corp. a year ago [*Electronics*, July 22, 1976, p. 48], Hughes Aircraft Co.'s Solid State Products division is second-sourcing the CDP1800 family of C-MOS microprocessor components. The first of the products from the Hughes division, in Newport Beach, Calif., are the HCMP 1802 central processing unit, the HCMP 1824 random-access memory, and the HCMP 1852 input/output port.

The CPU provides system control, information handling, and computational operation, while the RAM is organized as 32 registers of 8-bit words for a temporary storage of data or instructions. The I/O port acts as a buffer interface to adapt peripheral devices to the 1802's data bus.

According to a Hughes spokesman, additional circuits in the 1800 family are scheduled for introduction over the next few months. These include the HCMP 1831 and 1832 mask-programmable 4,096-bit static read-only memories, the HCMP 1854 universal/asynchronous receiver/transmitter, the HCMP 1833 and 1834 8,192-bit ROMs, the HCMP 1853 n-bit I/O decoder, the HCMP 1856 and 1857 bus buffers, and the HCMP 1858 and 1859 memory address latches. Support software also will be made available for the various components.

The 8-bit circuits are designed for numerous microprocessor applications, including replacement of low-end minicomputer, hard-wired digital logic, and analog and electromechanical controllers. Architecture of the new circuits, called Cosmac by RCA, was designed to provide a compact instruction format for fast, accurate programming. Small system operation requires no interface chips between components, and built-in direct memory access with the microprocessor providing addressing and data-transfer control between memory and peripheral devices.

RCA has signed a similar agreement with Solid State Scientific Inc. of Montgomeryville, Pa. [*Electronics*, March 31, p. 38]. **Bruce LeBoss**

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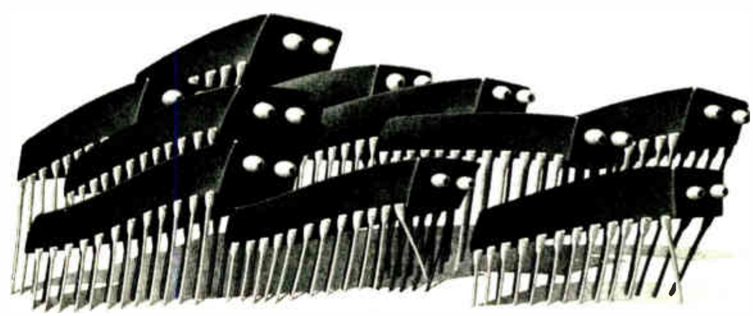

2K x 8. We also have a 3508, organized 1K x 8.

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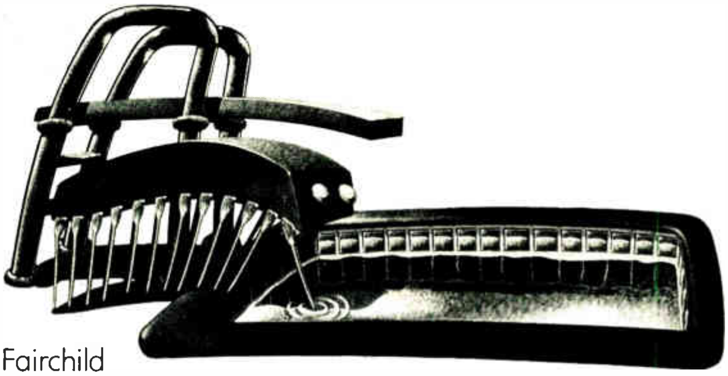

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Editorial

A U. S. view of Japan's semiconductor push

Members of the Semiconductor Industry Association met recently with Robert Strauss, President Carter's special trade representative, to discuss how the U. S. semiconductor industry sees the problems of trade with Japan. At the meeting with Strauss were John Welty, vice president of Motorola Inc. and general manager of its Semiconductor Products group, who is chairman of the SIA; Wilfred Corrigan, president and chairman of Fairchild Camera and Instrument Corp.; Robert Noyce, chairman of Intel Corp.; L. J. Sevin, chairman of Mostek Corp.; Charles E. Sporck, president of National Semiconductor Corp.; and Thomas A. Skornia, vice president and general counsel of Advanced Micro Devices Inc.

The group issued a white paper outlining why they are worried about Japan as a growing threat to their industry. Because Electronics *considers this issue of the utmost importance, here is the text of that position paper.*

The worldwide electronics market will exceed $90 billion in calendar 1977. Underlying this business is a $6 billion semiconductor market. The semiconductor technology is the determinant technology fueling the growth of electronics and, most important, controlling the rate of change in computer and communications products. It is thus the seminal technology of the electronics age. The country which excels in it will hold the key to future worldwide industrial and military leadership.

The U.S.-based semiconductor industry has been a leader in the world market for semiconductors (currently more than $4 billion of worldwide semiconductor consumption is produced by U.S.-based companies). Technological capability has been the basis for this leadership. This technological capability and the attendant leading role in world markets for semiconductors and perhaps more important the resultant leadership of U. S. computer manufacturers (based on the technological superiority of the semiconductor components used in their equipment) is being challenged by the Japanese in an atmosphere created by them of decidedly unfree trade.

Although there are many factors in this unfair trade in Japan, the overwhelmingly important factor is that of government coordination and subsidy of the Japanese semiconductor industry in its attack upon the world semiconductor market.

That attack involves the assembly of five Japanese companies, Nippon Electric Corp., Tokyo Shibaura Electric Ltd. (Toshiba), Hitachi Ltd., Fujitsu Ltd., and Mitsubishi Electric Corp. under the direction of the Ministry of International Trade and Industry in a joint development program of advanced semiconductor devices.

This development program is financed by the Japanese government in excess of $250 million. This large government subsidy is granted in spite of the fact that all of the prior listed companies are billion-dollar electronics corporations.

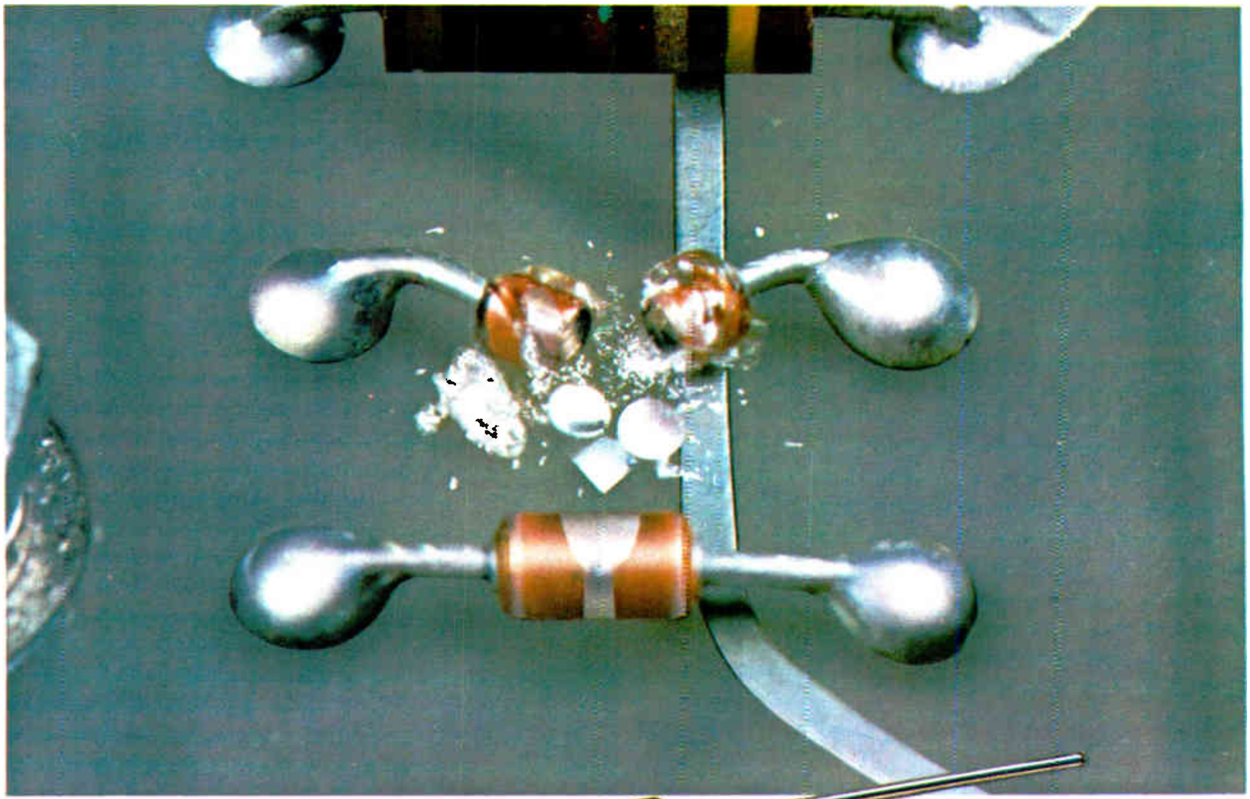
The U. S. semiconductor industry believes very strongly in free trade. However, this present Japanese cartel represents a large departure from that concept. Our industry is no longer competing with industrial companies but indeed is competing with a Japanese cartel under the direction and financial support of the Japanese government.

In no way can the U. S. semiconductor industry or the U. S. electronics industry allow this situation to continue.

We must and we will find a means to return this critical industry to an environment of free trade.

We are seeking our Government's advice and cooperation in resolving this problem.

What we put in makes ours better



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People

Hwang's laser diodes aim at HeNe units

Reliable. C. J. Hwang predicts 100,000-hour life for his new gallium-arsenide diodes.

Gallium-arsenide laser diodes are on the verge of taking over from helium-neon lasers, heretofore the workhorse of laser-based electronics equipment, according to C. J. Hwang. The takeover is the reason that Hwang, one of the Bell Laboratories developers of the laser diode more than a decade ago, has become president of General Optronics Corp., a company organized in New York City last month.

The 39-year-old electrical engineering Ph. D. from Taiwan believes he has licked the biggest diode problem—lifetime. "Our units will operate for 100,000 hours," he says in a mild but confident manner. "The key is a fabrication process that produces a laser with substantially greater quantum efficiency and less series resistance than others on the market, and less than half the threshold current."

Production soon. Hwang says he will have production devices—with 10 milliwatts output from 0.75 to 0.87 micrometer—packaged with feedback and modulation control circuitry coming from a facility in Plainfield, N. J. during this quarter. Prices are not firm yet, but considering "all our improved characteristics," they will be competitive with diode and helium-neon gas lasers on the market, he says. Laser diodes sell for about $300, and gas lasers used for such equipment as video-disk systems and optical readers sell for about half that figure. However, Hwang points out that the gas lasers are considerably bulkier, requiring optics and large power supplies.

Hwang's improvements also include a better defined laser waveguide resulting in devices that are more linear up to full power output—a must, he points out, for community-antenna television and other analog modulation applications. Other applications include facsimile copiers, optical recorders for storage and playback, and optical communications systems.

The 100,000-hour life figure for the double heterostructure devices is, of course, based on extrapolation of lifetimes observed under accelerated test conditions. From knowledge gained during the last four years developing and testing laser diodes at HP Laboratories, Palo Alto, Calif., and earlier at Bell, Hwang is convinced that such extrapolation is entirely accurate.

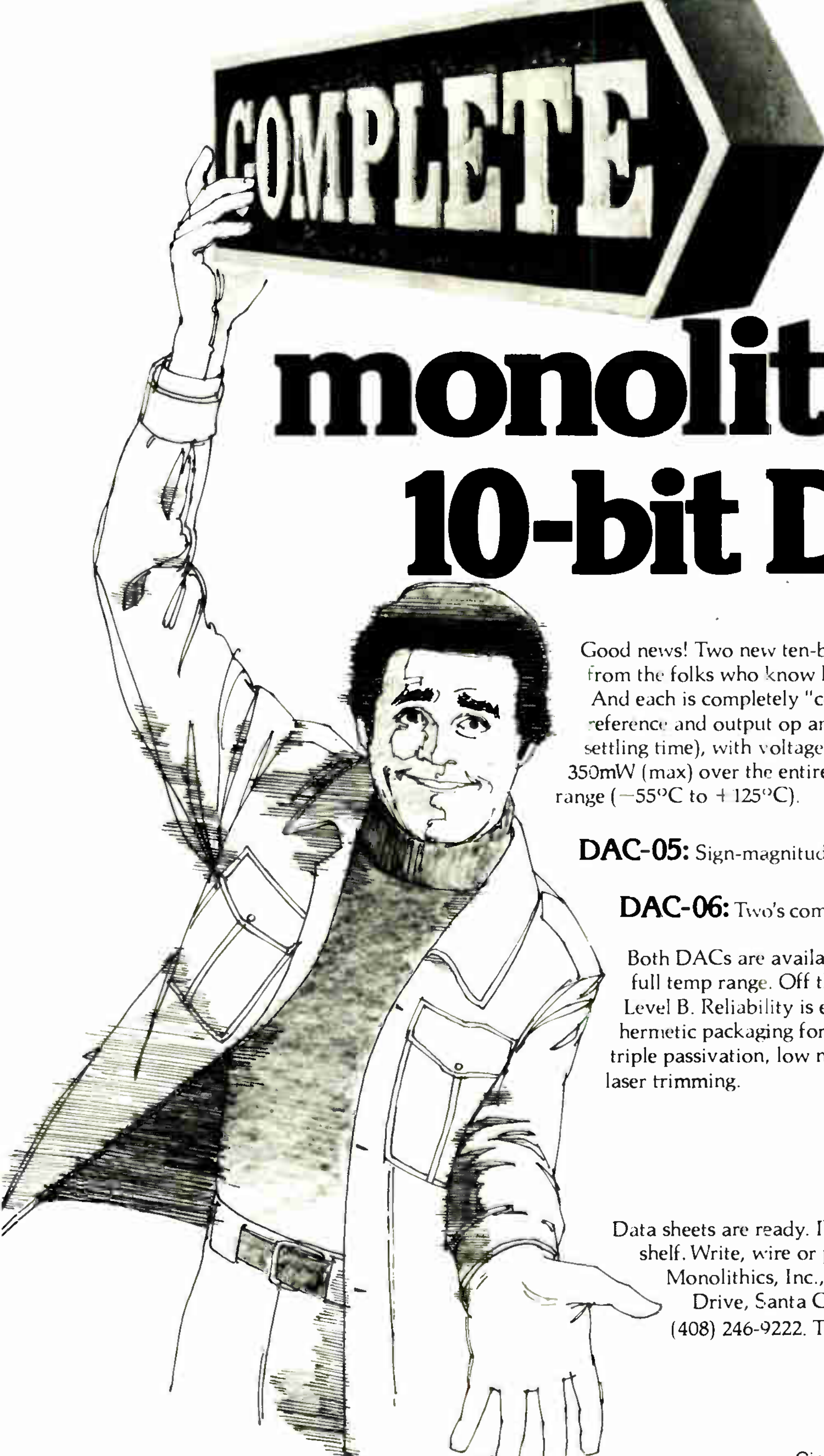
ICL's Taylor sets U.S. plans for British computer maker.

R. J. (Spud) Taylor is counting on a barrage of products to make ICL Ltd., the $650 million British computer maker, a big name in the U. S. market. Last month, the firm introduced its upgraded versions of Singer Corp.'s System Ten business computers, thus demonstrating "a total ICL commitment to the U. S. market," says Taylor, president of ICL Inc., the U. S. subsidiary. "Under Singer, the product was already a market leader." ICL's new 220 series increases the medium-to-large business systems' processing capabilities by a third and considerably enhances storage capacity.

Taylor moved from England to his Atlanta headquarters nine months ago, as ICL wrapped up its acquisition of parts of the Singer Business Machines division and, later, Singer's Cogar Corp. With Control Data Corp. and NCR Corp., it also jointly owns Computer Peripherals Inc.

"Strategically, it's our view that

PMI announces two COMPLETE monolithic 10-bit DAC's.



Good news! Two new ten-bit digital-to-analog converters from the folks who know how to make them monolithically. And each is completely "complete." Includes internal reference and output op amp. They are fast (1.5 μsec settling time), with voltage outputs, yet consume only 350mW (max) over the entire military temp range (−55°C to +125°C).

DAC-05: Sign-magnitude coding (sign-plus-ten-bits).

DAC-06: Two's complement coding.

Both DACs are available now specified over the full temp range. Off the shelf to MIL STD-883A Level B. Reliability is enhanced by 100% burn-in, hermetic packaging for all parts, PMI's famous triple passivation, low noise process and no laser trimming.

Data sheets are ready. Parts are on the shelf. Write, wire or phone. Precision Monolithics, Inc., 1500 Space Park Drive, Santa Clara, CA 95050. (408) 246-9222. TWX: 910-338-0528.

PMI ®

People

From England. Spud Taylor likes the American attitude on applying technology.

we have to get involved in the U. S. in a big way, if ICL—the parent company—wants to double its revenue every five years," says the tall, trim Englishman. "And whether we like it or not, business attitudes in the U. S. are so progressive that the usage of the technology, though not necessarily the technology itself, is more advanced in the U. S. than anywhere in the world. The best way to follow that progress is not by watching what happens, but by getting involved in it."

Expansion. Taylor plans enhancements for other products under his bailiwick, including adding new disks and software to the 1500-series intelligent terminal, acquired with Cogar.

To help double this year's estimated $25 million shipments by 1979, Taylor is looking for further acquisitions. "We want to buy or set up a joint venture with a micro- or minicomputer manufacturer in the U. S. for additional technical capability," says Taylor, who joined ICL in 1963 from University College, London, with a bachelor of science in physics. "And we're looking at acquisitions on the marketing side, at companies like software houses and service organizations."

Taylor says he will also bring a new large computer, with a price starting at $500,000 to a U. S. test market next year and will begin building it here in 1979. And shipments of a new point-of-sale terminal—an upgrade of a Singer design—should start in 1979, too.

How do you buy quality in a sea of look-alike switching power transistors?

Specify by name.

The name, General Electric, assures that you have specified Darlington transistors designed and produced by the world's most experienced manufacturer of power semiconductors. GE innovations in power switching technology began with the first SCR. They have included development of the TRIAC, pellet glassivation, heat transfer and over twenty years' application experience compiled in the GE SCR Manual and Data Handbook.

New GE 5060 medium speed and GE 6060 high speed Darlingtons give you General Electric's latest step forward in this tradition. Rated 400v/25A, they are available at competitive prices in TO3 packages for AC/DC off-line switching regulator power supplies, uninterruptible power supplies, motor controls and ignition. For more information and a free sample, call your GE electronic components sales engineer or write on company letterhead to General Electric Co., Electronics Park 7-49, Syracuse, NY 12301.

222-02

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GE5062	400	25	8.10	6.00	4.40
GE6060	300	25	9.03	6.65	4.75
GE6061	350	25	9.50	7.00	5.00
GE6062	400	25	11.50	8.50	6.23

There's more to GE semiconductors than meets the eye

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Intel delivers the 2147. memory technology

Imagine a 4K fully static RAM that runs at bipolar speed yet cuts power consumption dramatically, all in a standard 300-mil wide 18-pin DIP.

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

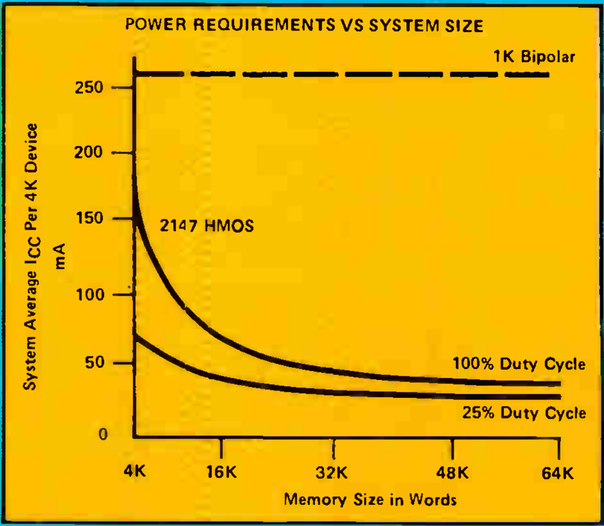
It's HMOS, the new that scoops bipolar.

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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Meetings

Conference on Active Microwave Semiconductor Devices and Circuits, Cornell University, Ithaca, N. Y., Aug. 16 – 18.

NBS Seminar on Time and Frequency: Standards, Measurements, and Usage, National Bureau of Standards, Boulder, Colo., Aug. 22 – 26.

21st International SPIE Symposium, Society of Photo-Optical Instrumentation Engineers (Bellingham, Wash.), Town and Country Hotel, San Diego, Aug. 22 – 26.

Product Liability Prevention Conference, IEEE, New Jersey Institute of Technology, Newark, N. J., Aug. 24 – 26.

Intrasociety Energy Conversion Engineering Conference, IEEE, Sheraton Park Hotel, Washington, D. C., Aug. 28 – Sept. 3.

7th European Microwave Conference, Microwave Exhibitions & Publishers Ltd. (Sevenoaks, Kent, England), Bella Center, Copenhagen, Denmark, Sept. 5 – 8.

Compcon Fall, IEEE, Mayflower Hotel, Washington, D. C., Sept. 6 – 9.

Ineltec 77: Exhibition of Industrial Electronics and Electrical Engineering, Ineltec Exhibition Secretariat (Basle, Switzerland), Basle, Sept. 6 – 10.

Fall meeting of Electronics Division of American Ceramic Society, ACS (Columbus, Ohio), Queen Elizabeth Hotel, Montreal, Canada, Sept. 18 – 21.

Wescon 77, IEEE, Brooks Hall and Civic Auditorium, San Francisco, Sept. 19 – 21.

13th Electrical/Electronics Insulation Conference, IEEE *et al.*, Palmer House Hotel, Chicago, Sept. 26 – 29.

Fifth Data Communications Symposium, IEEE and ACM, Snowbird, Utah, Sept. 27 – 29.

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ELEC-TROL

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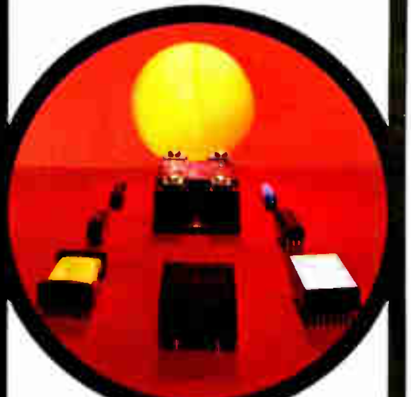

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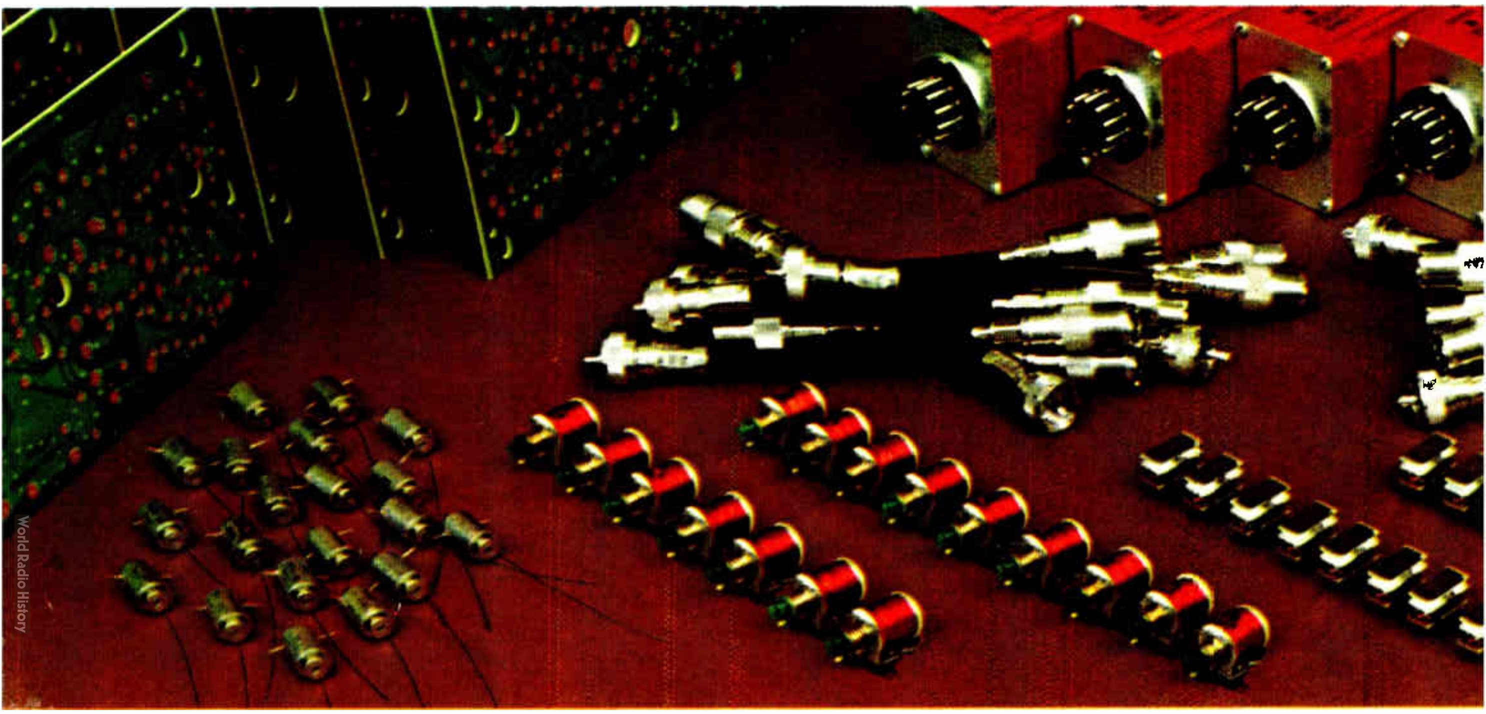

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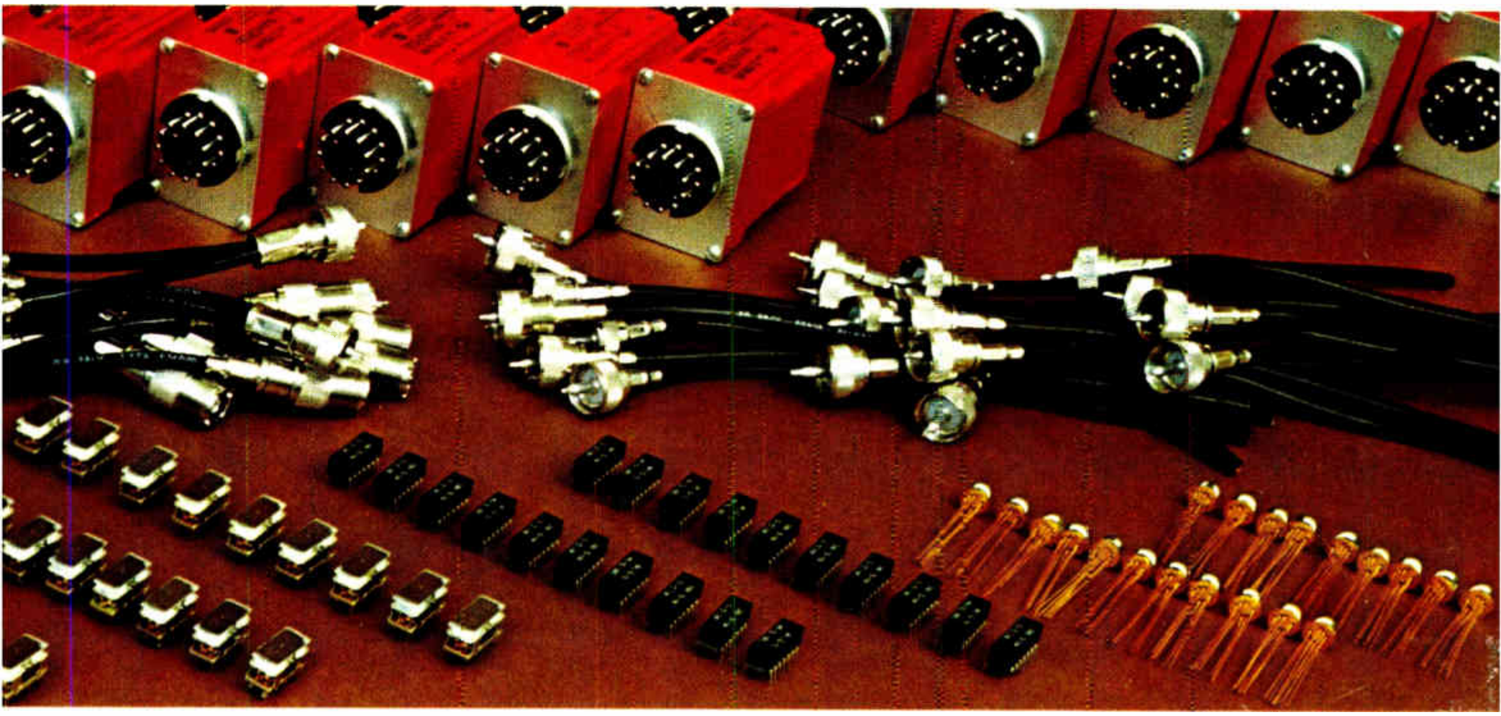

That's why Polaroid selected a Hi-G Magnetec solenoid to actuate the shutter on the SX-70 and the Pronto Land Cameras. Why Raytheon relies on the quality and performance of our Defiance printed circuit boards, counts on our prompt delivery at competitive prices. And why Hi-G commercial relays are on the job in scores of Foxboro control systems.

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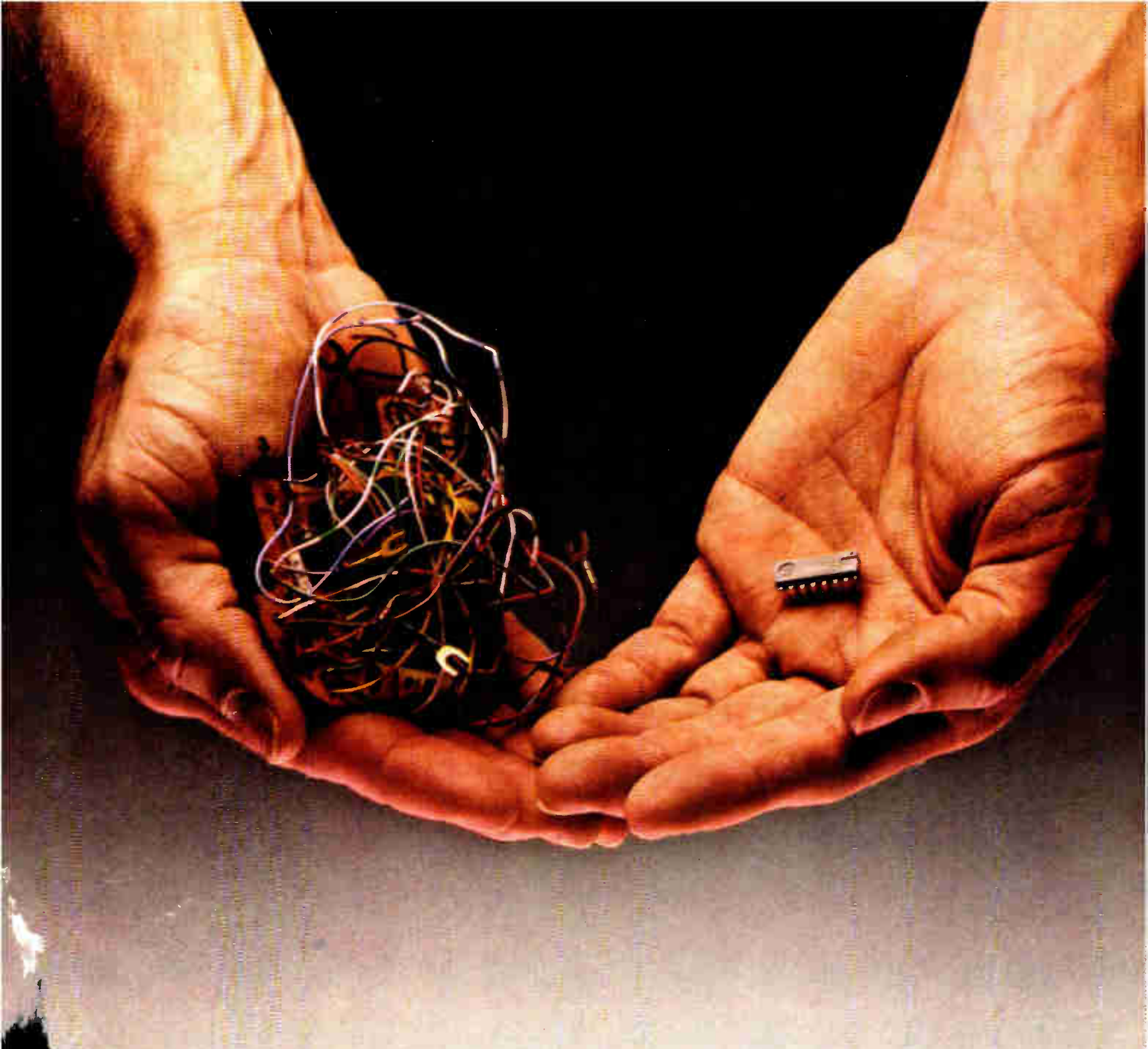
Remember our name.



Tek interested in beam-indexed CRT technology

Tektronix Inc. is studying a variety of color displays for use in future data terminals, including the beam-indexed color cathode-ray tube. The tube, which dates back to the mid-1950s when it was under development at Philco Corp. and General Electric and was called the "Apple" tube, can display characters much more sharply than conventional shadow-mask-type color CRTs, which suffer from convergence problems across the screen. The beam-indexed tube uses **a single electron gun rather than the three guns of the shadow-mask type,** hence its better convergence. Tek has built a 6-inch feasibility model at its Wilsonville, Ore., facility, and now is moving on to a 19-in. developmental version, which will display 35 lines of 80 characters each. Among the major problems remaining are getting uniform phosphor deposition and forming the stripe structure of the red-green-blue triplets.

A Tek spokesman says that each of the feasibility models has certain deficiencies, and there has not yet been a definitive management decision on any single technology. Meanwhile, the company says it expects to rely heavily on its direct-view storage-tube technology, both for existing and planned products requiring high-resolution capability.

First digital switch for small offices cut over in Georgia

The first computer-controlled digital switch for small central telephone offices has just started operating. The action is expected to **accelerate a trend toward replacement of analog switches** in offices handling less than 500 lines to meet anticipated demands of electronic funds transfer, electronic mail, credit card verification, and facsimile transmission.

The initial installation was cut over last week in the Richmond Hill office of Coastal Utilities Inc., an independent phone company serving several small Georgia towns. The equipment is a recently developed 500-line System Century digital switch from Stromberg Carlson Corp. of Rochester, N. Y. The switch, using large-scale integration, utilizes several Digital Equipment Corp. PDP-11 processors and a proprietary coder-decoder by Stromberg that is inexpensive enough to use on a codec-per-line basis.

According to Leonard A. Muller, president and chief executive officer of Stromberg Carlson, the telecommunications subsidiary of General Dynamics Corp., the firm plans similar installations in mid-1978 for North-Coast Telephone Co., a Wisconsin independent. And Northern Telecom of Montreal, the Bell Canada subsidiary, plans to install its smaller digital switches in U.S. locations this fall.

Fujitsu reviews plan for drive in U. S. OEM market

Japan's Fujitsu Ltd. is reevaluating its plan to attack the U. S. OEM market for computer peripherals. **The firm says it will decide in the next few weeks whether to go ahead** with its aggressive design to turn out products for that market at the plant of Fujitsu America Inc. in Sunnyvale, Calif. Meanwhile, manufacturing preliminaries have begun on some new products that will be previewed next month at IFIP Congress 77 in Toronto. They will be small rigid-disk drives, including a 50-megabyte removable-cartridge unit with what Fujitsu calls the fastest access time on the market.

Industry insiders believe that Fujitsu's decision to rein in at least for the time being is due to the fact that while its drives are removable, there's a great deal of competition also from nonremovable media drives.

Electronics newsletter

U. S. contract for bus-location system due next month

A contract to design, build, install, and test an automatic vehicle-monitor system in Los Angeles will be awarded to one of four competitors, probably next month [*Electronics*, Aug. 21, 1975, p. 49]. The system will pinpoint the location of 200 Southern California Rapid Transit District buses **to within 300 feet 95% of the time** and will fix when they pass their time checkpoints to within 15 seconds either way. Those are the specifications laid down by the Department of Transportation's Urban Mass Transit Administration.

Fairchild Space and Electronics Co. of Germantown, Md., chalked up the best performance in tests conducted recently in Philadelphia by DOT's Transportation Systems Center, Cambridge, Mass. Fairchild used a signpost system, as did Hoffman Information Identification Inc. of Fort Worth, Texas. Hazeltine Corp. of Greenlawn, N.Y., employed a pulse-trilateration technique in the Philadelphia tests, while Teledyne Systems Co. of Northridge, Calif., opted for a Loran-C system. The winner of the second phase will get about $4 million for a central control system, including minicomputers and displays, transmitters, and transponders for the signposts, if such a system is chosen, and related communications equipment.

Photolithographic system achieves 1.25 – 2-μm resolution

Amid all the brouhaha about the virtues of electron-beam lithography for semiconductor mask making, GCA Corp. is squeezing as much mileage as it can out of its photolithographic systems. In the fourth quarter it will begin deliveries of a substantially modified type 3696 Mann photorepeater that will allow the machine to step and repeat patterns directly on the wafer, without a mask. At the same time, the company is developing its own electron-beam system for later introduction [*Electronics*, Feb. 17, p. 26].

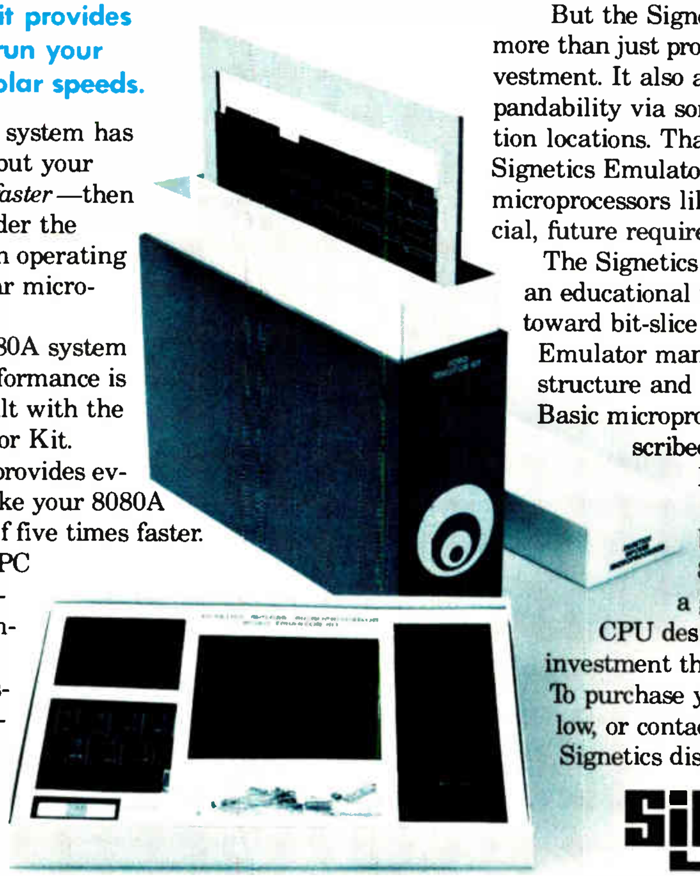
The 3696 was introduced in late 1975 by the company's Burlington, Mass., division. Development of additional software, plus new optics and a new wafer stage holder, will enable the machine to produce geometries from 1.25 to 2 micrometers, using a reticle generated at 5 to 10 times that scale, and then photoreducing the pattern before stepping and repeating it. Company officials maintain the system can compete with today's electron-beam pattern generators **because the associated projection printers that make the masks are limited to minimum geometries of 3 to 5 micrometers.** The system, called DSW, will sell for $315,000 to $325,000—some $50,000 more than the original 3696—and handle up to 35 4-inch wafers an hour.

Addenda

Prices continue to come down for simple logic analyzers, units that store and display logic states of various signal paths in a digital system. Biomation Corp. of Cupertino, Calif., **has a new unit selling for $1,295** that handles nine channels and stores 256 bits per channel. The unit, the 920-D, operates at up to a 20-megahertz sample rate, and any 1-MHz scope can be used with it to display the logic waveforms on the nine channels. . . . Hughes Aircraft Co., whose space group last year lost the Intelsat V program to Ford Aerospace and Communications Co., has bagged an **$11 million contract to supply traveling-wave-tube amplifiers for the satellites.** Hughes' Electron Dynamics division is committed to start delivery of a new lightweight TWT amplifier in June 1978 to the Ford subsidiary.

Speed Up Your 8080A Without Changing Software.

This $299 Emulator Kit provides all that you need to run your 8080A system at bipolar speeds.



If your MOS 8080A system has reached its speed limit, but your software is crying *faster, faster*—then it's time for you to consider the dramatic improvement in operating speed offered by a bipolar microprocessor.

Converting your 8080A system from MOS to bipolar performance is neither costly nor difficult with the Signetics 8080A Emulator Kit. Priced at $299, this Kit provides everything you need to make your 8080A system run an average of five times faster.

The Kit contains a PC board and all the components necessary to assemble a Schottky-bipolar version of the 8080A system. Included are all control, timing and bus interface circuits—plus a comprehensive manual which concisely presents all support documentation, along with a microcode listing.

When you apply the Signetics Emulator to your 8080A system, your software will hardly know the difference. Except for the faster timing loops, the software you've developed and debugged for your MOS 8080A system will run directly on the Signetics Emulator.

But the Signetics Emulator does much more than just protect your 8080A software investment. It also allows for microprogram expandability via some 150 empty microinstruction locations. That means you can adapt the Signetics Emulator instruction set to other microprocessors like the Z-80, or to your special, future requirements.

The Signetics Emulator Kit also works as an educational tool for 8080A users moving toward bit-slice processors. In fact, the Emulator manual covers the application, structure and operation of bit-slice CPUs. Basic microprogramming concepts are described, and then applied to the Emulator's bit-slice design.

Whether you want to boost the speed of your 8080A system, or simply get a good headstart on bit-slice CPU design—you won't find a better investment than this $299 Emulator Kit.

To purchase your Kit, use the coupon below, or contact your local franchised Signetics distributor.

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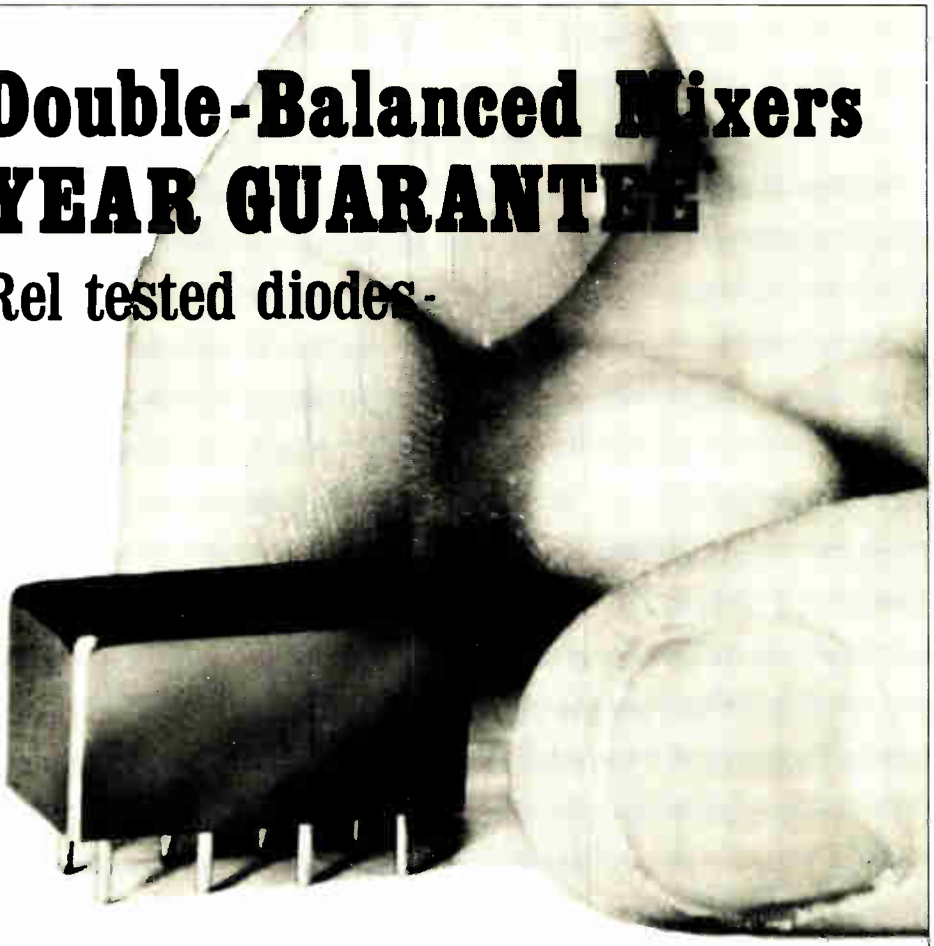

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	LO-IF	45	35
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16/Rev/B

Instrument aims at simplifying chores of servicing

Portable, multifunction tester ordered by Burroughs from Data Test does the job of several separate units

A small California company will supply computer giant Burroughs Corp. with a new breed of diagnostic service instrument, one that combines in a single enclosure the functions of many separate instruments. Initially, several hundred of Data Test Corp.'s portable Datatester 1200 will go to Burroughs field service force, and it is believed the requirements of Burroughs alone, with its worldwide data processing installations, could reach well into the thousands. In volume, Data Test is putting the price of the instrument at $1,200.

Contenders. "We have been working with a number of companies toward the development of a portable, multifunction unit for more than five years," says Ray Challis, manager of technical planning at Burroughs in Detroit. "The problem has been too many instruments—one for each type of measurement—and instruments such as oscilloscopes" that demand too much skilled, diagnostic capability on the part of the technician.

Other problems Challis cites with the usual service instrumentation include high cost, nonstandard designs unsuited for field diagnostics and calibration needs, and lack of portability. In addition, he points to the present lack of skilled technicians and the costly training that is required. "The Datatester unit seems to resolve many of these problems," Challis says. However, Burroughs may yet buy instruments from other suppliers as well.

Helper. Somewhat bulkier than an attache case, the portable Datatester 1200 multifunction circuit-tester does the job of several separate instruments, including a digital multimeter and a frequency counter and timer. It also counts digital-logic transitions.

The Datatester 1200 is "based on a totally new approach to complete circuit analysis," says James Roberts, president of the eight-year-old, Concord, Calif., manufacturer of automated circuit-board testers. His products generally sell for $10,000 to $60,000 each, and gross sales this year are expected to be $2 million. Although the company is close-mouthed as to the details, its new approach reportedly resembles the low-cost fault-isolation method called transition redundancy check that it developed for its board testers. That method employs counts of digital signals at important nodes and logic boundaries to describe proper system operations.

Somewhat similarly, the Datatester 1200 analyzes logic pattern streams by counting the number of times the logic pattern goes from a 0 to a 1 state. The company has just recently received a number of patents for the process.

The overall result is that the model 1200 can take the place of a digital voltmeter, voltohmmeter, frequency meter and timer, duty cycle meter, peak-reading ac voltmeter, logic probe, integrated-circuit and

More service instruments coming

Look for a flood of new portable and easy-to-use diagnostic instruments aimed at making troubleshooting electronic equipment less trouble. Almost anyone with something for debugging prototype microprocessor-based systems on the lab bench could conceivably convert it into a field-service tool. The tasks to be done are roughly comparable; the skills of the operator differ. An engineer who may also be a part-time programmer will be debugging the prototype; a technician with much less training will be doing the job in the field. So the conversion process is basically one of making the instruments easier and simpler to use, with a more automated approach to fault isolation.

Microcomputer development systems, which help debug both hardware and software, and logic analyzers, which store and display bit patterns that aid in tracing faults, are the instruments most readily convertible to field service. One of the first such systems was Intel Corp.'s model 820 U-Scope [*Electronics*, June 9, p. 34]. The size of a brief case, the unit exercises the central processing unit in the equipment being serviced with diagnostic programs aimed at fault isolation. Price is under $2,500, whereas Intel's Microprocessor Development System with its cathode-ray-tube display and floppy-disk store goes for more than $12,000.

Hewlett-Packard Corp. has developed a signature-analysis technique for trouble-shooting microprocessor-based systems [*Electronics*, March 3, p. 89], which it may extend to a range of instruments. Also working in the field are Systron-Donner Corp., John Fluke Manufacturing Co., and Tektronix Inc., which is understood to be planning to introduce a digital service instrument family that will include: portable protocol testers, logic analyzers, board and microprocessor-equipment testers, a general-purpose interface bus tester, peripherals and communications testers, and an interactive systems diagnosis unit.

logic-board tester , and the scope itself , according to Paul Thomas, chief engineer for the instrument at Data Test. "The 1200 is basically a troubleshooting tool," he says. "It's not designed for detailed analysis, but to look at specific faults in a system. The idea is to allow a field-service technician to determine if there is a fault and where, so he can replace the entire board or subsystem and take the faulty unit to a service center where more sophisticated, special-purpose instruments can find out the why and how of the malfunction."

The portable unit measures about 12 inches wide, 8 inches high, and 6 inches deep. It can perform 18 functions, spanning 18 ranges, including measurements of ac and dc volts and current, resistance, frequency and frequency ratios, period and time intervals, duty cycle, signal slope and width, two-signal coincidences, event totalization, plus and minus peak values, and digital-logic transition counting. In addition, it can be used as a logic analyzer, storing logic-state cycles on the data and address busses.

Operating features of the instrument include autoranging for making measurements rapidly and automatic placement of the decimal point on the unit's 5½-digit, half-inch-high, light-emitting-diode display. It can deal with all digital-logic families and will automatically compare an input signal to a previously set threshold and display the result on pass/fail lamps on the front panel. It also indicates when the operator has selected incompatible combinations of mode and function.

The future. Data Test executives expect the worldwide market for portable instrumentation for field-service applications to be in excess of 100,000 units over the next few years, and growing. In later years, says Roberts, this kind of unit will intrude heavily into the marketplace traditionally occupied by instrumentation oscilloscopes. The company is planning additional versions of its portable 1200 for introduction in 1978. □

Consumer

Board games grab microprocessors

The top echelon at Parker Brothers Inc., which in 1935 brought the world Monopoly, the century's most popular new board game, must have stood with tears in their eyes last Christmas as customers passed them by in favor of the new breed of electronic video games. But the General Mills Inc. subsidiary, in Salem, Mass., is striking back and applying a microprocessor, no less, to its first electronic board game.

"Code Name: Sector," a submarine chase-and-sink game, goes into production next month. The movement of the sub is controlled by the microprocessor, which also tracks moves made by pursuing destroyers. These are plotted by hand on a 12.25-inch-square plotting board. Light-emitting diodes display tracking data. Two to four persons can compete to sink the sub first, or one can play against the sub itself.

The microprocessor gives the game a remarkable complexity. "It provides an intelligent fifth player that reacts to what has happened and then, based on its sequential logic, takes action," points out Arthur Venditti, manager of product development at Parker. "But the sub is also able to react randomly—for example, it has over 25,000 start possibilities involving position, depth, and direction."

The game has other unpredictable aspects. For example, should two pursuing destroyers collide, the offender is knocked off course to a new position. Sometimes the sub course is changed at random by the microprocessor. Incredibly, the sub can shoot back. Again, the shot is dealt with unpredictably; for example, if a destroyer is hit, it is assigned to a new position on the board randomly.

TI module. The guts of the game is supplied by Texas Instruments Inc. on a 2.25-by-3-in. gold-plated printed-circuit board. The key element is a single-chip microprocessor

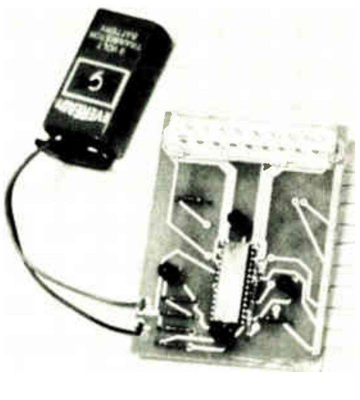
Other games feature microprocessors, too

Others besides Parker Brothers Inc. have microprocessor-based toys and games on the market or are readying their introduction. Toy industry leader Mattel Inc., Hawthorne, Calif., has three with football, auto racing, and missile-attack themes. They are about the size of a handheld calculator and retail for under $30. Each employs a custom-chip version from Rockwell International Corp's PPS 4/1 microprocessor family. Each also has a rectangular array of light-emitting diodes that are energized to create moving lines and bars. In the auto racing game, for example, a car symbol must be controlled to avoid obstacles while it works against a time limit.

Milton Bradley Co. in Springfield, Mass., has a pair of games built around microprocessors from Texas Instruments Inc. One, "Electronic Battleship," is a board game that even simulates the noise of explosions and missiles speeding to target. The other, "Comp IV," is a game involving guessing at numbers.

from TI's low-end TMS 1000 line, designated the TMS 0970. The 4-bit, p-channel metal-oxide-semiconductor chip "is about the same as the 1000 but specialized with on-chip, direct-digit-drive capability so that no other circuitry is needed to drive the display," says Ed Hartnett, a product marketing engineer at TI's MOS division in Houston.

The displays consist of a half-dozen seven-segment light-emitting diodes that provide such information as range from the destroyers to the sub, and ship speed and location. There are also four discrete LEDs, which indicate the destroyers' compass heading, and axial-lead current-limiting resistors. As for inputs, the pc board is connected to a TI-built Klixon keyboard that takes commands from buttons on the game's combat information center. A 9-volt battery powers the unit.



Game guts. TI board in Parker's sub chase game holds microprocessor, resistors, discrete LEDs and, under lenses at top, segmented LEDs. Wires go to keyboard.

A 1,024-bit read-only memory in the microprocessor stores the instruction set for playing the game, according to Robert Doyle, the 41-year-old inventor of the game who brought the idea to Parker in 1975. A programmable logic array acts as a binary-coded-decimal-to-seven-segment decoder for driving the LEDs. In addition, a random-access memory with 64 4-bit words stores changing data, like ship positions, speeds, and compass headings, Doyle says. One pair of the RAM's 4-bit words also holds a number that changes constantly at the unit's clock rate of more than 100 kilohertz. It is this number that triggers the game's random actions.

More coming. "Code Name: Sector" is just the first of a succession of electronic board games for Parker, says Edward A. Radding, Parker's marketing manager. "We've made a commitment, and we're hard at work on next year's games," he says. "We've known for several years that electronic games were in our future, but we didn't feel the price was right until inexpensive microprocessors came along."

Retail price of the game will be somewhere between $30 and $45, depending on the type of sales outlet, says Radding. Although Radding will not discuss his costs, TI's Hartnett gives some indication of what they could be. By next year, in volumes of more than 100,000, the microprocessor could sell for under $2, he says. □

Military

SOS microcomputer has 3-MHz speed

For really dense, high-speed and low-power circuits, the military turn to silicon-on-sapphire technology. So a two-chip 8-bit SOS microcomputer slice that reaches a new level of functional complexity [*Electronics*, March 31, p. 47] has the Army very much involved. It is called Atmac, for advanced technology microelectronic array computer, and the Army paid for much of its development at RCA Corp.'s Advanced Technology Laboratories in Camden, N.J.

The services' preferred 8-bit microprocessor has been the 8080, but "for many applications where both the high-speed and low-power requirements exceed the capability of the 8080, we have no microprocessor to turn to," says Randy Reitmeyer, a project engineer in the Army's Electronics Technology and Devices Laboratory at Fort Monmouth, N. J. But with Atmac, that situation is about to change.

Reitmeyer expects Atmac will be especially effective in applications that include array or matrix manipulation and computation. Among the applications that the Army has in mind are electronic warfare and countermeasures and communications systems involving speech compression. Other uses could include sonar signal processing and navigation data processing.

Expandable. With computation capability on one chip and program control on the other, the SOS microcomputer is expandable in 8-bit units to form computers with word lengths of 16, 24, 32 bits, and more. In what will probably be its most common implementation—a four-chip 16-bit microprocessor—the Atmac consumes less than 200 milliwatts per chip, or less than 750 mw total.

As an 8-bit slice, the microcomputer has a repertoire of 189 instructions, or twice as many as the 8080. Operating at a data rate of 3 mega-

Air Force, Navy also like sapphire

The Air Force and the Navy also have set their sights on RCA's silicon-on-sapphire devices for even higher-speed processor applications. Under work supported by the Air Force Avionics Laboratory at Wright Patterson AFB in Ohio, engineers at RCA's Missile and Surface Radar operation in Moorestown, N. J., have designed, constructed, and tested a programmable pipeline (fast-Fourier-transform) processor using C-MOS-on-sapphire technology.

These FFT processors are the key elements in a programmable waveform processor that has been the vehicle for initial development of radar signal-processing hardware. Six special SOS circuits were developed for the program, including a 9-by-9-bit multiplier, 9-bit adder, dual 8-bit scaler, retiming register, floating-point logic control, and programmable shift register. Three of these circuits also have been used to develop an image bandwidth-compression system for the Navy, which supported the development of the adder, says Lloyd Martinson of the RCA engineering staff.

The FFT devices are tailored in size for subarray handling of linear frequency-modulated pulse-compression and synthetic-aperture processing. "The SOS technology permits the application of LSI and 10-MHz operating speed with low-power consumption," Martinson says. Real-time processing speed as high as 20 MHz is achieved by halving an input sample and sending the data to be processed by two parallel channels, each operating at a 10-MHz clock rate.

The power consumed by using the SOS technology is much lower than with other technologies, says Martinson. For example, the SOS circuits in the programmable waveform processor are in five functional hybrid module types. One module, called the complex multiplier, contains nine SOS circuits and consumes 2.5 watts at 10 MHz. "We did the equivalent module in TTL, and it took 130 circuits and 35 W at 10 MHz." In contrast, he adds, "C-MOS would require about the same number of circuits as TTL. But it consumes more power than SOS because of its lack of integration, while providing one third the speed."

hertz, it can execute a typical instruction (composed of two machine cycles) in 280 to 350 nanoseconds, three to four times faster than the 8080. Moreover, it executes simple single-cycle instructions such as add, subtract, and array computations, in 100 ns.

The data-execution chip contains an 8-by-8 register stack that serves as eight general registers, each 8 bits wide. The chip also has a high-speed arithmetic unit and an extensive amount of logical processing circuits. The 255-by-260-mil chip has 4,561 devices.

Chip #2. The second chip, the instruction and operand fetch unit, controls instruction sequencing and data-memory addressing. It includes an indirect address register stack, address update adder, instruction program counter and counter stack, interrupt control logic, direct memory access request logic and the system clock. It contains 4,974 devices, the equivalent of 1,250 gates, on a chip area of 259 by 272 mils. Like its partner, it has 67 input/output pads, a nominal operating voltage of 10 volts, and is housed in a 64-pin dual in-line ceramic package.

Standard cells. A major contribution to the SOS microcomputer's development came from Army-funded programs that produced a set of standard logic cells and computer-aided design programs for routing logic automatically. Without these tools, "we wouldn't have attempted the Atmac design," says Paul Wright, director of the RCA Labs. "It would have cost us about three to four times more if we had approached the design in the conventional handcrafted manner." Moreover, "the Atmac architecture wouldn't fly if implemented in another technology," Wright says. "We can keep the number of chips down with SOS, thereby eliminating delays from the interconnections between packages that would be present in a complementary metal oxide semiconductor." The lower power consumption of C-MOS, he adds, can be retained and even reduced with SOS.

The Atmac is now in two fully operational systems at RCA, along with associated software and test tools, to demonstrate functional feasibility. By the end of this month, RCA expects to begin qualifying it for use in military hardware. □

Minicomputers

HP uses 16-k chips in megabyte memory

Reacting quickly to the latest semiconductor technology seems to be characteristic of Hewlett-Packard Co., the minicomputer and instrumentation maker. The firm was the first to design in the 4,096-bit random-access memories that bowed in 1975 and is currently working the budding silicon-on-sapphire technology into its systems [*Electronics*, May 26, p. 99]. Now HP is hustling the new 16,384-bit RAMs into its 21MX line of minicomputers.

As a result, it is squeezing into the 12¼-inch-high minicomputer over a million bytes of main memory—the largest built-in semiconductor memory for a minicomputer yet. Priced at $59,800, the new machines will be available next month.

Quadrupling the data capacity of each memory board to 128 kilobytes was almost as easy as substituting 16-k chips for the 4-k devices used previously, since the two parts are packaged identically. But anticipation of a higher probability of bit errors in the expanded memory array prompted HP to offer error-correcting circuitry as an option for the enhanced-memory machine.

Applications. To pay almost $60,000, users must have a strong need for a million bytes of solid-state memory. Demand for it lies in several areas: very fast processing, where the time spent swapping data to and from disk memory, for example, must be eliminated; and especially where reliability is essential and the mechanics of disk systems cannot be tolerated.

Hewlett-Packard also expects the 21MX to go where main frames are needed, but where the environment is too harsh and the space too limited. The 21MX minicomputers are built ruggedly, specified for operation over a temperature range of 0° to 55° Celsius and at a humidity of up to 95% at 45°C.

According to Richard W. Anderson, general manager of HP's Data Systems division in Cupertino, Calif., the 16-k chips are supplied by Mostek Corp., with potential second sources including Intel Corp. and Texas Instruments Inc. Anderson says he actually feels "safer with the 16-k chips than with the 4-k-chip situation of a few years ago," when many manufacturers each had different designs. He is confident not only that other manufacturers will line up behind Mostek's 4116, but that the error correction will eliminate most chip-failure problems.

"The memory itself is reliable," explains Anderson. "But even with 16-k RAMs the component count is getting larger—and a megabyte of memory needs error correction."

Hamming code. The fault-control, or error-correction technique, used in the 21MX minicomputers is the same Hamming code approach HP uses in its 3000-series general-purpose computers. Basically, the technique appends 5 bits to each word to generate an error code. This code is then checked against one stored in memory during each access, and any error is either corrected or reported.

The additional 5 bits of error correction required for each of the 512,000 16-bit words that make up the 1,024,000 8-bit data bytes use up a lot of additional 16-k RAMs—160 in all. They are mounted on two separate check-bit boards that fill up two of the minicomputer's 10 available memory slots.

The fault-control system automatically corrects all single-bit errors, and can detect all double-bit errors and most errors of 3 or more bits. Errors of greater than 3 bits are very

News briefs

IBM develops integrated fiber-optic package

Scientists at International Business Machines Corp.'s Research division in Yorktown Heights, N. Y., have developed an integrated package containing all the electro-optical elements of a fiber-optic transmitter. The package contains a semiconductor laser array, a cylindrical lens, and an array of optical-fiber light guides mounted on a silicon wafer, which also contains thin-film drive electrodes for the lasers. An anisotropic etch combined with photolithographic techniques produces grooves having a shape controlled precisely by crystalline planes in the silicon. These grooves automatically align the optical elements to the optical axis of the package.

Time Computer divesting itself of Pulsar digital-watch business

HMW Industries Inc. of Stamford, Conn., is discontinuing its solid-state-watch business, and its Time Computer Inc. subsidiary in Lancaster, Pa., has agreed to sell the Pulsar and Time Computer brand names and all of its digital-watch inventory to Rhapsody Inc. of Philadelphia on undisclosed terms. Rhapsody, which sells watches and jewelry, will distribute the Pulsar line and produce solid-state watches under Time Computer Inc.'s patents.

Lockheed to develop Air Force strike system

The Air Force Systems Command's Aeronautical Systems division at Wright-Patterson Air Force Base in Ohio has selected Lockheed Missiles & Space Co. of Sunnyvale, Calif., to begin full-scale development of the Precision Location/Strike System. The PLSS is an electronic system designed to detect and strike from standoff positions a wide variety of targets—emitters like radars, as well as nonemitters—in all kinds of weather, day and night. The contract authorized was only $200,000, but additional amounts could total up to $120 million. Lockheed topped the Boeing Co. of Seattle, which conducted a parallel investigation.

RCA wins Army battlefield sensors pact

RCA Corp.'s Government Communications Systems division in Camden, N. J., has beaten American Electronic Laboratories Inc. and GTE Sylvania Inc. to an $8.9 million contract to fabricate engineering development models of the Army's Remotely Monitored Battlefield Sensor System. Rembass, as the system is called, will use magnetic, seismic, seismic/acoustic, and infrared sensors that can be put into place by artillery shells, as well as by hand or high-speed aircraft [*Electronics*, April 14, p.77]. The sensors will detect disturbances caused by the passage of heavy objects and will report by data link to a distant monitoring site. But unlike prior sensors, Rembass "classifier" sensors will be able to determine the nature of the detected object, whether personnel or a wheel or tracked vehicle. The Army Electronics Command at Fort Monmouth, N. J., issued the award.

New tester organization formed on West Coast

A number of major manufacturers and users of automated test equipment have banded together to form a new trade organization called the Automated Test Equipment Association. The members are instrument makers like Hewlett-Packard, Fluke, Tektronix, and Systron-Donner, as well as Burroughs, American Microsystems, and Rockwell International. Principal aims are establishing standards, monitoring Government legislation, and setting up a trade show for automatic test equipment. Cal Edmonds, sales manager at Data Test Corp. of Concord, Calif., is president.

Unitrode aims at temperature-sensitive semiconductor switch

Unitrode Corp. of Watertown, Mass., a manufacturer of discrete power semiconductors, is launching a development program for a temperature-sensitive semiconductor switch designed by Cutler-Hammer Inc. of Milwaukee. A two-state switching semiconductor that triggers at a threshold temperature is an unusual device, with just about next to nothing like it being offered in the marketplace. Unitrode declines to disclose details of the unit.

unlikely, says product manager David Carver. "Each bit in a word is read from a separate RAM," he explains, "so an error of 3 bits means three RAMs failing at once."

The error correction allows HP to claim an inordinately high mean time before failure of about 6,000 to 8,000 hours—a tenfold increase over the system without fault control, as well as over other manufacturers' computers, according to Anderson. □

Military

Air Force wants new bomb scorer

It's probably not widely known—but it's no secret, either—that the Air Force has 11 bombing ranges in the U. S. over which bomber crews fly simulated bombing runs. The sites include Holbrook, Ariz.; Bayshore, Mich.; and Bismarck, N. D.; and the pretended targets include factories, dams, reservoirs, and grain elevators. But the equipment at the ranges—radars, analog computers, displays and communications equipment—dates from World War II. To update the sites and make the scoring more accurate, the Air Force will issue a request for proposals for a new system in September.

Update. To be called Seek Score, it will consist of precision-tracking radars, minicomputers, displays, and Government-furnished ultrahigh-frequency radios as the communications links. The radars will also have television trackers on the antenna to provide azimuth and elevation information on bombers flying as low as 200 feet, while the radar provides the range.

Capt. James Troutman, Seek Score program manager at the Electronic Systems division, Hanscom Air Force Base, Bedford, Mass., says the RFP will be for one preproduction system, with an option to buy 20 more. He stresses that the Air Force wants off-the-shelf equipment.

For example, Army Nike-Hercules radars being turned over to the Air Force might be used. Existing ground-detection bombing radars are also candidates. They include the AN/TPD-1C, AN/TPQ-39 and the Trail X radar. These are radars operating at 9.3 to 9.5 gigahertz. The computer will probably be a 16-bit minicomputer with 24,000 bytes of memory, and the displays will show area maps that include the targets, the intended and actual course of the aircraft, plus the bomb-release and impact points.

Tone signal. As the bomber approaches the tarket, Troutman explains, it must stay within a prescribed corridor. A crew member flips a switch, initiating a radio-frequency tone received at the radar site. The tone ends when the bomb-release switch is triggered.

With that data, plus the tracking information, the computer will determine where the bombs would have landed, showing if they would have hit the target or by how much they would have missed it. Data can also be printed out for hard-copy record keeping, important to strategic air command crews during periodic operational checks.

Troutman says the radars will have an accuracy of a tenth of a milliradian, which is two to five times better than the accuracy of present ones. And, except for the transmitters and displays, Seek Score will be all solid-state. □

Solid state

Marking process tags semiconductors

The use of microscopic multicolored particles to mark semiconductors is being explored by the Joint Electron Device Engineering Council as a solution to the problem of counterfeit JAN military devices. Jedec, the solid-state standards group sponsored jointly by the Electronic Industries Association and the National Electrical Manufacturers Association, is scheduled to receive its initial briefing on the technique at its Aug. 30–31 meeting in Chicago, according to Jedec's Jack Hessman.

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GI also makes a full line of memory circuits—ROMs, RAMs and EAROMs—for the CP-1610 system. Applications encompass telephone switching networks. Process control systems. Intelligent terminals. Programmable TV games. Data acquisition and digital communications processors to name just a few. And the GIMINI microcomputer hardware / software system will help simplify your development time.

Whatever product you make, we have or can create the circuits to make it do its job better, more reliably, at lower cost. After all, our business is creating and making microelectronic circuits—millions of them for all kinds of needs.

Write or call today and find out how our new CP-1610 16-bit microprocessor system can cut your design and production costs. General Instrument Microelectronics, 600 West John Street, Hicksville, N.Y. 11802, (516) 733-3107.

We help you compete.

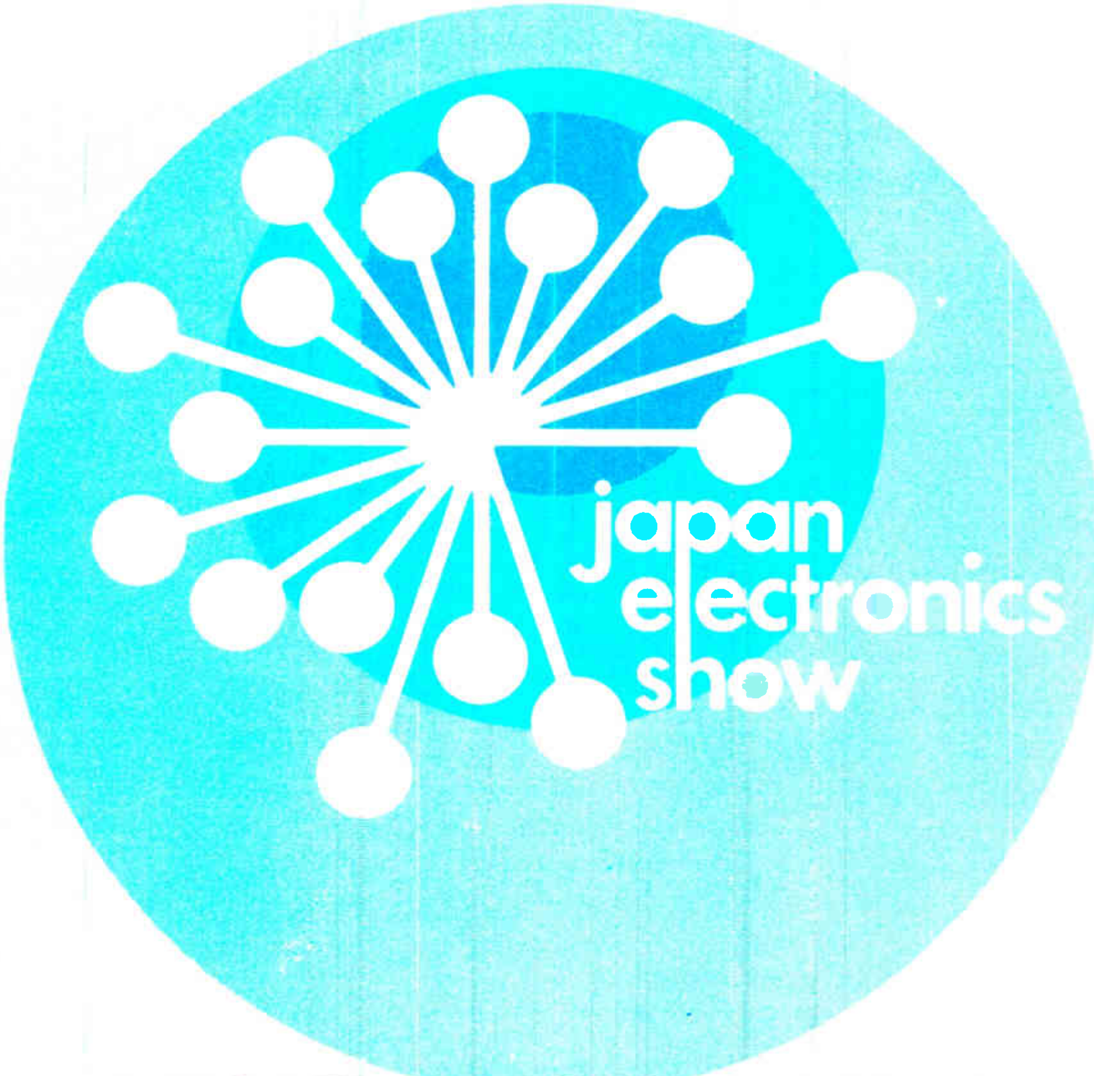
GENERAL INSTRUMENT CORPORATION
MICROELECTRONICS

The patented product-identification process, developed by 3M Co., St. Paul, uses microscopic alkyd melamine flakes called microtaggants, each containing seven distinct colored layers. The layer colors and sequence can be changed to provide millions of possible identification codes for manufacturer, product type, and even the date and time of manufacture. The particles can then be mixed in a paint or other solution and sprayed on a semiconductor's cover when the device is assembled.

Invisible to the naked eye, the microtaggants can be viewed with a pocket microscope of 40× to 100× magnification and are available with ferromagnetic and/or fluorescent properties. In the latter case, an ultraviolet light causes the fluorescent layers to glow, making them easy to locate, according to 3M. If microtaggants were adopted for use in semiconductors, their removal from a device by a counterfeiter would signal a questionable lot. Proponents of the marking technique also point out that a code or codes unique to product lines or types could be assigned to the individual manufacturer, who would then be sold only particles carrying those codes.

Questions. The big "ifs" in the semiconductor industry's adoption of the 3M process now rest with both its potential users and the supplier. Jack Sargent of 3M's New Business Ventures division emphasizes that Jedec discussions are only preliminary, and he questions whether there is sufficient volume in Mil Spec semiconductors for microtaggants—sold at $25 per lb—to warrant 3M supplying it. Sargent points out that the particles' initial use in the explosives industry—for tracing products used in terrorist bombings—may run to 300,000 pounds annually.

Most semiconductor makers are not yet familiar with details of 3M's development and reportedly themselves question the costs of additional manufacturing operations in a highly price-competitive market. Some also question whether as manufacturers, they have any legal obligation to mark product lines. □



OCTOBER 14-19 1977 OSAKA

JAPAN ELECTRONICS SHOW '77

Place	:	Osaka International Trade Fair Grounds (Minato-ku, Osaka)
Sponsor	:	Electronic Industries Association of Japan (EIA-J)
Exhibit Hours	:	10:00 a.m. to 5:00 p.m.
Exhibits	:	Electronic equipment, parts and related products
Admission	:	Free, Visitors will be registered at the entrance

For details of the Japan Electronics Show '77 (16th), please write to

JAPAN ELECTRONICS SHOW ASSOCIATION

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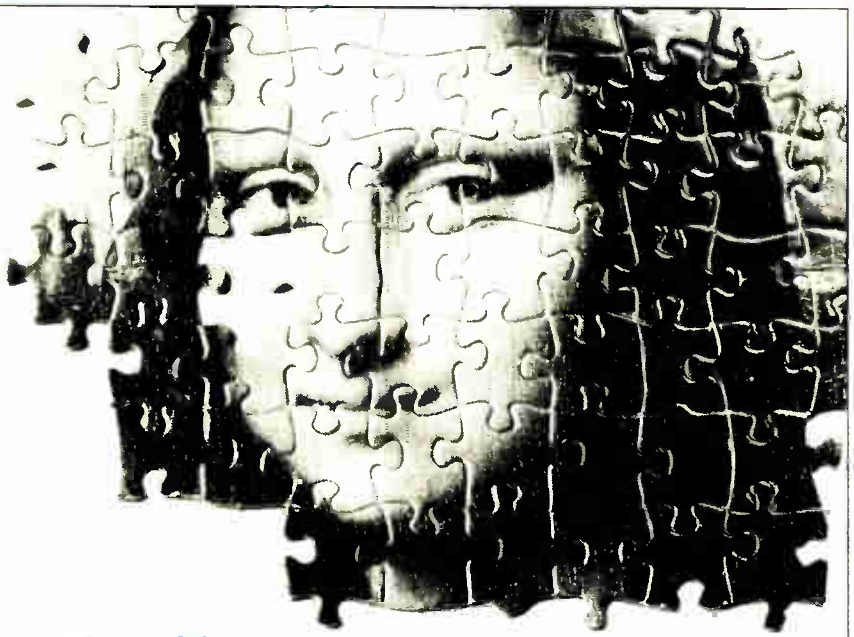
Osaka Oct. 14-19



This one piece is a very important part in forming the whole

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The role of electric parts and components is to let the whole fully perform its function. Alps Co.'s electronic parts are being widely used in everything from items for personal and industrial use to fields playing an important role in the society, such as medicine, education, communications, etc. The major reason for this is that the parts are highly dependable. In addition, this is a result of their responding to the changes of an increasingly sophisticated and advanced era while they're being brought to perfection through progress in various fields of technology.
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Circle 40 on reader service card

APPEAR SWITCHING REG. TOPS 700 LATEST.

A revolutionary develoqment by Tohritsu offers you improved reliability as we utilized L.S.I. in the control circuit to be said complicated in order to reduce a great number of parts and also you are able to save the cost and the space.

Specifications

- Input — A.C. 120V ± 15%
- Reg. line — less than 0.2%
- Reg. load — less than 1.0%
- Efficiency — more than 70%
- Prot. functions — over load and over current
- M.T.B.F. — 100,000h
- Weight — 2.1 lb
- Dimension — 0.95(W) × 7.9(L) × 2.17(H) inch

Table

Model	Out put voltage (V)	Out put current (A)
TOPS700- 4	4	15
TOPS700- 5	5	15
TOPS700- 6	6	12
TOPS700- 9	9	8.5
TOPS700-12	12	5.5
TOPS700-15	15	5.5
TOPS700-18	18	3.5
TOPS700-24	24	3.5
TOPS700-28	28	3.0
TOPS700-36	36	1.8
TOPS700-48	48	1.8

TRI

Tohritsu Tsushin Kogyo Co., LTD.
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Looking for agent.

Circle 173 on reader service card

Maybe TOKO Converters will convert you!?

We think so. Otherwise we would not have bought space in this publication.
Below are some of the specifications of the new TOKO DC-DC converter Modules,
F • M • K Series and E (floating type) Series. For complete details,
please circle on the reader service card.

FMK-Series

● **1-Channel PLUS Output** Input, Vin: +5V±10%
Output, Vout: +6V±4% to +24V±4% for different types
Current, Io: 7-13mA to 100-167mA, depending on type
Conversion Efficiency: 65-75%

● **1-Channel MINUS Output** Input: +5V±10%
Output, Vout: −5V±4% to −20V±4% for different types
Current, Io: 7-13mA to 100-200mA depending on type
Conversion Efficiency: 55-75%

● **2-Channel PLUS MINUS Output** Input, Vin: +5V±10%
Output, Vout: ±6V±5% to ±20V±5% for different types
Current, Io: ±3-25mA to ±12-84mA depending on type
Conversion Efficiency: 55-70%

E-Series (Floating Output)

Input, Vin: 5V±10%; 12V±20%; 24V±20%
Output, Vout: 5V±6%, 12V±5%, 24V±5%
±12V±6% and 15V±6%
Current, Io: 150-300mA, 25-125mA,
15-60mA, ±12 ±63mA and
±10 to ±50mA
Rated Output, Po: 1.5W
Conversion Efficiency: 60-65%
Regulation:
VS Input Current, ±1.0 to ±1.5%
VS Output Current, ±4.0 to ±8.0%

TOKO is known worldwide for precision electronic parts, highest quality and dependable performance.
TOKO sales offices in the U.S.A., West Germany, United Kingdom, and Hong Kong. Eleven other offices and ten factories in Brazil, Korea, Taiwan, Hong Kong, Singapore, Malaysia and Malta.

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● COILS FOR RADIO, TV & STEREO MPX ● COIL BLOCKS
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● POLYVARICONS ● TOKO-SCHADOW MINIATURE PUSHBUTTON SWITCHES ● KEYBOARD SWITCHES
● WIRE MEMORY SYSTEM ● MICRO COMPUTERS TOKOM-80 ● IC MEMORY ● SEMICONDUCTORS
● PULSE TRANSFORMERS ● DELAY LINES
● DC-DC AC-DC CONVERTER MODULES

Circle 41 on reader service card

SUPER MINIATURE
Neon Glow Lamps

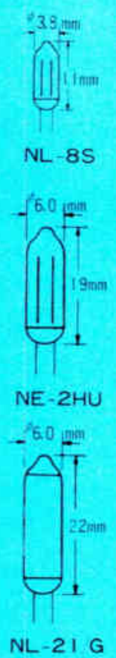
Rated Voltage···AC 100V
Rated Current···AC 0.3mA
Total Flux···20mlm MIN.
Starting Voltage···AC 75V MAX.
External Resistance···150KΩ

ULTRA-HIGH BRIGHTNESS
Neon Glow Lamps

Rated Voltage···AC 100V
Rated Current···AC 5mA
Total Flux···500 mlm MIN.
Starting Voltage···AC 85V MAX.
External Resistance···8.2KΩ

CLEAR-GREEN
Fluorescent Glow Lamps

Rated Voltage···AC 100V
Rated Current···AC 1.5 mA
Total Flux···90 mlm MIN.
Sterting Voltage···AC 75V MAX.
External Resistance···27KΩ



● MAIN PRODUCT

NEON GLOW LAMP, XENON FLASH LAMP,
RARE GAS, DISCHAGE LAMP
MINIATURE : BLACK-LIGHT, UV-LIGHT,
FLUORESCENT COLOR-LIGHT

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Circle 174 on reader service card

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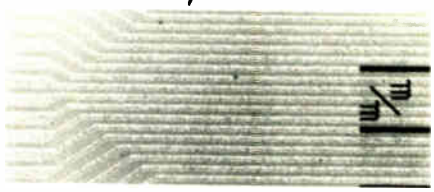
Lines & Spaces
by screen printing technique

custom production



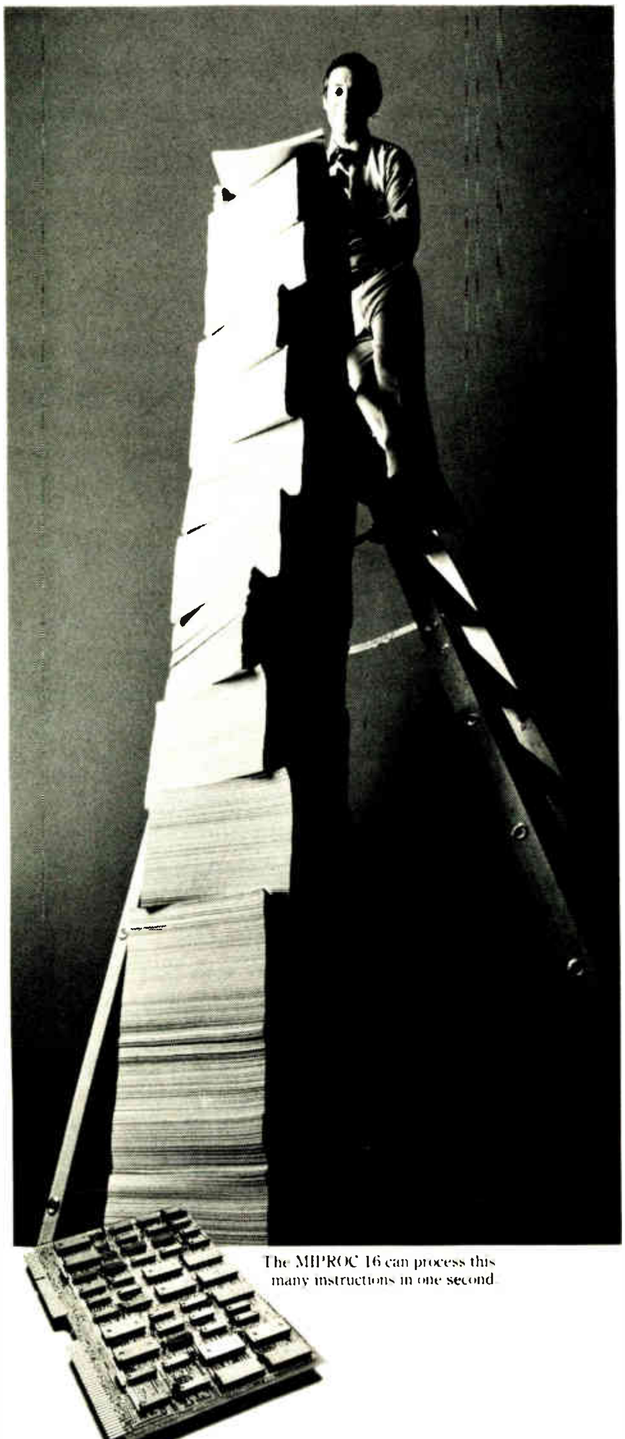
☐ Low cost ☐ Mass production

Applications
1. Plasma display panel
2. Thermal printer head
3. Multi layer HIC etc.

MFP corp.
25-1, Minami-cho 6-chome, Fuchu,
Tokyo, 183 Japan Tel. 0423-68-3341

Circle 175 on reader service card

Introducing 4 MHz microcomputing



The MIPROC 16 can process this many instructions in one second.

Meet the Plessey MIPROC 16, a 16-bit computer-on-a-card that's faster than any other mini- or micro-computer made.

The MIPROC 16 is available in three versions, with throughputs of 2, 2.85 and 4 million instructions per second. With 82 powerful 16-bit instructions that eliminate costly, time consuming microprogramming and hardware design and debugging. With an optional 10 MHz DMA channel.

And with all the software and hardware support you need for your high speed signal processing, FFT analysis, process control and communications systems, including ruggedized versions for military applications.

With all this, the Plessey MIPROC 16 is available for as little as $500 in quantity.

What are you waiting for? Get the details today.

In the USA: Plessey Microsystems, 1641 Kaiser Ave., Irvine, CA 92714, tel: (714) 540-9931.

In the UK: Plessey Microsystems, Water Lane, Towcester, Northamptonshire, NN12 7EG, tel: (0327) 50312.

Plessey Microsystems

State-of-the-art brought down to earth

We've just re-invented the FFT

And frankly, never has it looked so good.

Because now you can do your FFT spectrum analysis and signal processing with new Plessey modules that are half the size and less than half the cost of the software or hardware analyzers you're paying for now.

The new Plessey FFT modules are built around our high-speed 16-bit MIPROC 16 microcomputer, so you can add them to your mini- or microcomputer-based systems, or use them as stand-alone processors. Either way, you get a transform characteristic of 1024 complex points in 610 ms (model SPM-01) and 237 ms (model SPM-02); programmable analog and digital processing; and an OEM-quantity price of under $2,500.

This combination of versatility, black box simplicity and a refreshingly low price could be the best thing that has ever happened to the FFT. For complete information, contact us today.

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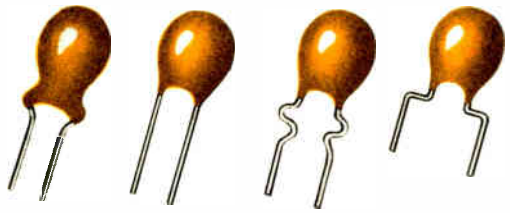
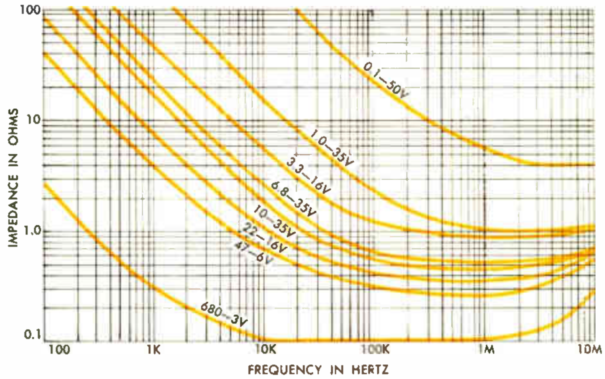
BEST COST/PERFORMANCE resin-coated SOLID-TANTALUM CAPACITORS



New Sprague Type 199D Capacitors Give You the Most for Your Money

LOWEST COST, YET IMPROVED PERFORMANCE. Prices competitive with any other capacitors of this type, domestic or offshore. Max. impedance in ohms @ 10 kHz guaranteed for every capacitor. Lower d-c leakage currents, lower dissipation factor.



Plus these additional advantages . . .

SUPERIOR EPOXY ENCAPSULANT

Flame-retardant, moisture-resistant resin will not crack or chip under temperature extremes.

CHOICE OF LEAD CONFIGURATIONS

Straight (2 configurations), hockeystick, or lock-in crimp with .100", .200", .250" lead spacing.

STANDARD TOLERANCES: ±20%, ±10%

±5% available on special order.

PROVEN CAPACITOR TECHNOLOGY

From the pioneer in solid-electrolyte tantalum capacitors.

RAPID DELIVERY

Up to 999 pieces off-the-shelf from Sprague Industrial Distributors. Larger quantities 4 to 8 weeks ARO.

For price and availability information call your Sprague district office or sales representative. For complete technical data, write for Engineering Bulletin 3547B to: Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Mass. 01247.

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 Circle 44 on reader service card

Contractors hit rules favoring agency awards in house

Four Government aerospace and electronics contractors' groups are calling for changes in recent Federal service contract rules on the grounds that these rules encourage the bureaucracy **to perform services in house at the expense of competitive procurement.** Joining forces to make their case before the Senate in mid-July were the Aerospace Industries Association, Electronic Industries Association, National Council of Technical Service Industries, and the National Security Industrial Association.

The four associations told the Senate subcommittee on manpower and personnel that the June ruling by the Office of Management and Budget reducing the Government employee retirement cost factor, used to figure services' costs, to 14.1% from 24.7% dealt "a crippling blow" to industry bidders using higher cost figures. But they urged that the Defense Department be required to use the 14.1% factor in figuring service contract costs instead of "the old, totally discounted 7% computation factor" called for in the fiscal 1978 defense authorization bill that requires its use through March 15, 1978. Unrealistically low factors for computing Federal employee pension costs "have often tipped the scales in favor of in-house performance," the associations said.

FAA seeks better taxi radar with award to Cardion

The Federal Aviation Administration has awarded $1.5 million to General Signal Corp.'s Cardion Electronics division, Woodbury, N.Y., for an engineering model of a new airport ground radar for tracking aircraft on runways. Known as ASDE-3, **the radar is the third model in the airport surface detection equipment series** and will be designed to remedy deficiencies in the ASDE-2. It will have greater rainfall penetration, present a clearer picture under all light conditions, and provide greater reliability and maintainability than its predecessor. Following test and evaluation at FAA's New Jersey test center beginning in October 1978, the ASDE-3 is planned as a replacement for 13 ASDE-2 systems now in operation at 13 major airports.

Fall proposals set for Navy-Air Force airborne ECM

Proposals to develop a new airborne self-protective jammer system for joint use by the Navy and Air Force on tactical fighter and attack planes will be sought in October by the Naval Air Systems Command. The ASPJ countermeasures package is **for use initially in the Navy's new F-18 and A-18 aircraft,** approximately 800 of which will be bought if the program makes it unscathed through the fiscal 1979 R&D budget review now in preparation. Retrofitting the Navy's F-14 fleet and other aircraft with the ASPJ is also proposed. The first teaming agreement to compete for the ECM package was disclosed earlier this month by ITT Avionics division, Nutley, N. J., and Westinghouse Electric's Defense and Electronic Systems Center, Baltimore. But many other competitors are expected to bid on the program.

Three more top posts filled by White House

The slow pace of filling key high-technology jobs in the Carter Administration picked up in July with the recruitment of **one industry official by the General Services Administration and two internal promotions at the Department of Defense.** Frank J. Carr, head of Westinghouse Electric Corp.'s technology applications programs, was named commissioner of GSA's automated data and telecommunications service, which bought $700 million in data-processing equipment last year. At the Pentagon, Robert J.

Hermann was named to the new post of principal deputy assistant secretary for communications, command, control, and intelligence, while Robert A. Moore was named defense research and engineering deputy for tactical warfare programs.

Hermann served last as special assistant for strategic warning and combat information systems to NATO commander Gen. Alexander Haig Jr. Moore had been tactical technology chief for the Defense Advanced Research Projects Agency. Hermann and Moore join Ruth M. Davis, DDR&E deputy for research and advanced technology, in filling the top Pentagon management jobs [*Electronics*, June 9, p. 50].

DARPA challenges materials engineers on superconductors. . .

Six engineering challenges have been laid before the Air Force Materials Laboratory, Dayton, by George Heilmeier, Defense Advanced Research Projects Agency chief. They include looking "beyond silicon" to surface passivation and ion implantation into III-V compounds and development of large-scale, thin-film superconducting Josephson junction devices. Appearing at the lab at the end of last month, Heilmeier said the two technologies will be required if the Pentagon is to achieve its goal of processing information at subnanosecond rates.

. . .Heilmeier's 'wish list' includes pushing silicon to IR frequencies

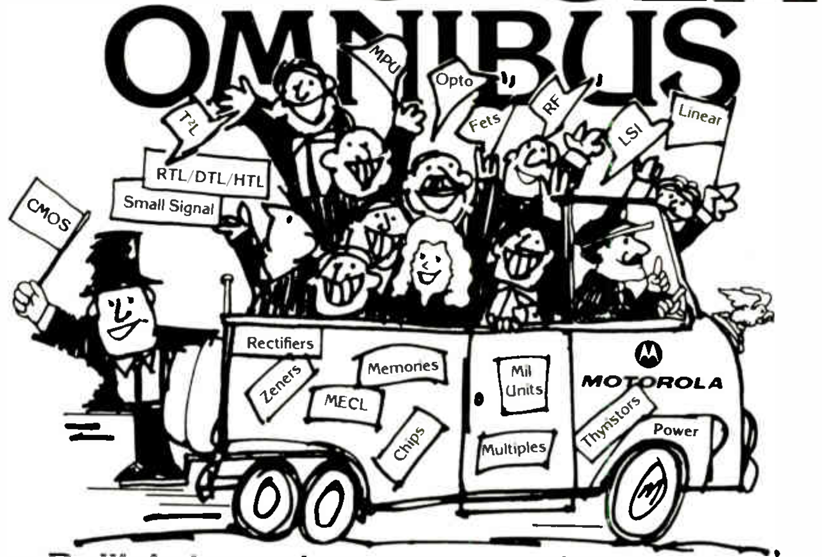
DARPA's Heilmeier also called for extension of IC circuit processing, including silicon, to infrared frequencies to permit IR detection and signal processing on the same chip. This could lead, he said, "to building block chips with 10,000 detectors for future million-element systems."

Heilmeier also expressed concern with Defense Department's high costs for low-volume purchases of special-purpose LSI circuits, calling on electronic materials engineers to develop IC circuit-processing models so reliability can be achieved in small purchases without "the costly 'human wave' approach to inspection" now required.

Heilmeier's other challenges:

- Materials-defect controls on a much larger scale to achieve ICs with 10 times the complexity of current devices.
- Better understanding of materials interactions with electron and ion beams leading to data storage devices with 10^{14} bit capacities for rapid access.
- Improved III-V materials for higher power solid-state power sources "from microwave to millimeter-wave frequencies" plus cheaper radomes to handle both IR and RF radiation for use with "launch-and-leave" missiles.

MOTOROLA OMNIBUS



Rollin' along the routes to right design

Superpower* Schottkys

unprecedented performance at high temps.

Motorola's new state-of-the-art MBR7545 power Schottky rectifier is rated for 150 A peak, 50% duty cycle square wave output, 20 kHz 150° junction (90°C case), AT RATED REVERSE VOLTAGE!

The 20 to 40 V MBR7520 series of Schottky barrier devices employs epitaxial construction with oxide passivation, and has AVALANCHE characteristics for transient immunity! Lower leakage current allows no derating for reverse power.

Motorola offers the broadest line from 0.5 A to 75 A and at highest V_R—45 V—for larger ranges of input V from off-line supplies. Extremely low V_F, as much as 0.1 V less, can save you up to 20% in power at 100 A over other types. Super-high case and junction temperature capabilities (175°C peak) afford smaller heat sinks, higher reliability . . . up to twice the amount of heat dissipation than also-rans.

Even dv/dt is upped . . . 1,000 V/ μs for the '7545. And θ_{JC}. It's just 0.8°C/W instead of the usual 1.0 for more reliability and efficiency.

And that's what Schottkys are all about—efficiency in high-frequency switching. The new MBR7520—7545 units will be the new standards in those designs. Price for the prime MBR7545 is $7.95, 100-up.

Send for data sheets and spec-by-spec, side-by-side comparison of this new standard with the SD51. A real eye-opener.

Also available are new 35 A DO-4s and 60 A DO-5s with similar capabilities. □ A

M.O.D. Adventures in processing

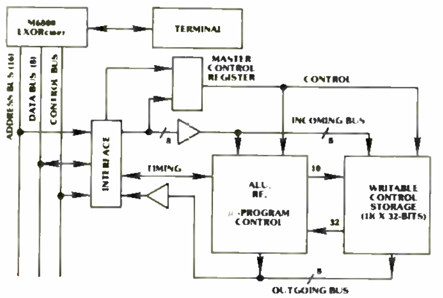
with MECL 10800 LSI

Nowhere is the number-crunching power and flexibility of microprogramming more aptly demonstrated than in this high-speed, bipolar LSI processor.

Called M.O.D. for Microprogrammed On-Line Demonstrator, it's an 8-bit arithmetic processor built from the MECL 10800 family.

Slave to an M6800 MOS EXORciser* system, the M.O.D. has a 1K x 32-bit writable control store, extensive micro-instruction set (including BCD), and 17 working registers. Operating with a 10-MHz clock rate, a single precision binary floating point multiply requires 37.6 μs. The M6800 system allows a user to read, load and dump WCS as well as run microprograms.

M.O.D. SYSTEM BLOCK DIAGRAM



There's a new handbook describing the M.O.D. in detail and it's available only through your local Motorola Field Applications Engineer. It shows processor structure, gives microprogramming techniques and examples as well as lots of other nitty-gritty. Just call him on the phone and fork over $1.50.

*Trademark of Motorola Inc.

Motorola Announces NE592/SE592 Diff Amp

Here's a linear gem for magnetic memories, communications, display and video recorder systems: the NE/SE592—a monolithic, two-stage, differential output, 90-MHz, wideband video amplifier.

It has fixed gains of 100 and 400 without external components and adjustable gains from 400 to 0 with one external resistor. The input stage has been designed so the circuit can function as a high-pass, low-pass or band-pass filter with the addition of a few external reactive elements between the gain select terminals.

Available in plastic and ceramic DIPs or metal can versions and in two temperature ranges (0° to 70°C and -55° to 125°C) it's particularly useful in magnetic tape or disk file systems using phase or NRZ coding and in high-speed thin-film or plated wire memories.

Prices are good, $1.10 to $2.95, 100-up, delivery's excellent. □ B

Let's talk about

digitizing voice with I^2L Interface ICs

How'd you like an interface IC that multiplexes many voice channels on a single pair of wires, switches telephone PBX and scrambles for secure communications?

Try a continuously variable slope delta modulator, or CVSD. It's a simple alternative to more complex conversion schemes in systems requiring digital communication of analog signals.

S/N ratios of the recovered signal do not vary with distance when using digital transmission; and multiplexing, switching and repeating hardware is more economical and easier to design. The CVSD A-to-D is well-suited to digital communications and is an economical, efficient means of digitizing inputs for digital transmission.

The MC3417L military version and MC3418L telephone-quality CVSDs are firsts. They'll soon see use in telephone, PBX, military and commercial security, because they provide a breakthrough into practical, mass-producible telephone codes.

Features include one-chip encode and decode functions with digital input for selection . . . comptible I^2L-linear bipolar technology . . . CMOS-compatible digital output . . . input threshold selectable. The '3417 has a 3-bit algorithm for 16 kHz and below clock rates and the '3418 4-bits for 32 kHz and higher.

The loop offset and current matching of the '3418 have been laser-trimmed to allow outstanding idle channel performance in commercial telephony.

'3417, 100-up, $6.95; '3418, $7.95.

Send for an applications-oriented data sheet and complete technical article. □ C

The lowest-cost

challenges the 4K RAM field

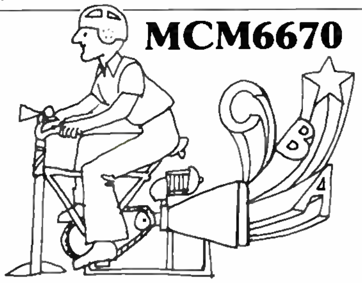
Of all the 4K dynamic RAMs that have achieved popularity, our 4027 is the industry standard. And priced better than 40% below competitive types at current prices. The challenge for 4K memory leadership is on.

Motorola's highly reliable N-channel silicon gate technology results in a 4096 x 1 organized RAM designed for high-performance, lowest-cost applications in mainframe memories, buffer memories, and peripheral storage. It's a second source for the MK4027.

Three speeds are presently offered, each in plastic and hermetic 16-pin dual in-line packages. The first has a maximum access time of 150 ns, and the second and third are 200 ns and 250 ns versions. The first has maximum Read and Write cycle times of 320 ns, and the others are 375 ns. The low-power dissipation is 27 mW max, standby, and 470 mW typical, active.

Each of the 64-row addresses is refreshed every 2.0 ms in this one-cell design. All inputs are TTL-compatible, and the output is three-state TTL-compatible. Power supply pins are at the corners of the standard 16-pin packages for optimized board layout. Our 100-up prices for the fast, faster, and fastest MCM4027Ps are $6.60, $6.90, and $8.20. ☐ D

MCM6670



newest ROM character generator

The MCM6670 is mask-programmable, a horizontal scan (row select) character generator with 128 characters in a 5 x 7 matrix. It complements our broad line of 128c x 7 x 9 and 128c x 9 x 7 character generator ROMs.

A static 8K ROM in an 18-pin package, with diagonal corner supply pins, it operates at a max access time of 500 ns from a single +5 V power supply. It's TTL-compatible.

You specify the content of the 6670 by programming a single photomask. Photomask encoding is computer-aided for quick, economical, and efficient implementation of the bit pattern.

In operating the 6670, a seven-bit address code selects one of the available characters, and a three-bit row select chooses the correct row to appear at the outputs. The rows can be sequentially selected to provide a seven-word sequence of five parallel bits per word for each selected character.

In plastic, the MCM6670 is $8.15, 250-up (minimum quantity), after a one-time mask charge. ☐ E

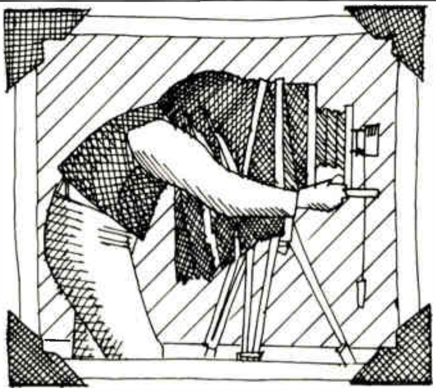
MPS6172 complements MPS5172

for 11.5¢

The lowest-priced industry-standard plastic transistor now has a PNP complement . . . and it's equally low-cost!

The MPS6172 is a true, spec-for-spec matchup with the '5172 . . . h_{FE} range of 100 to 500 at 10 mils . . . 0.25 volts V_{CE} (sat) max . . . one-piece, injection-molded Unibloc* package . . . etc.

Use it for general-purpose, low-level amplifier applications where you don't want to spend much more than a thin dime or so, 100–up. For either one. ☐ F



Get a better picture

with 1,400 V Horizontal Darlington

Wide-screen advantages are here with the 8A MJ10011—brilliantly conceived to combine output transistor with damper diode, provide an order of magnitude increase in gain and equal the performance of discretes, such as the BU208, in all critical parameters such as t_f, SOA, $V_{CE\ (sat)}$ and thermal stability.

It does all that plus furnishing better-than-discrete cost effectiveness.

This new unit allows options never before available. The transistor has nominal h_{FE} of 40 at 5 A compared to 3 for the discrete BU208. This allows sat V typically less than 2 V at 4 A with only 200 mA of base drive whereas a discrete needs **2 A** drive for comparable sat V. This modest demand greatly simplifies drive circuitry and is well within IC technology needed to produce an integrated driver plus oscillator which would direct-drive the MJ10011.

The integrated diode section functions as well as existing discrete damper diodes and provides a path for the yoke current during negative swing of the scan cycle with about 1.2 V drop at 4 A.

And an ac coupling capacitor from the driver to the Darlington input offers built-in protection from excessive current flow which otherwise destroys the output if the horizontal oscillator locks up.

Thermal stability is ensured through proprietary glass passivation and specially-constructed TO-3 packaging providing high voltage and low thermal resistance capabilities. Large glass insulators around B-E pins maximize creepage paths and resist arcing. Header thickness is optimized for typically 0.6°C/W θ_{JC} without sacrificing strength.

100–up is just $3.50. ☐ G

Recently introduced is one of the best-conceived, high-performance bipolar processor functions available today . . . the MC10803 memory interface. It's the communication or interface link between main system processor and main memory or peripheral section.

It controls bidirectional flow of data to and from the main processor and, in parallel with data transfer, it generates or formats memory addresses. The latter is accomplished with an on-chip ALU. By placing an ALU at the processor, peripheral port memory addressing can be done in parallel with the main ALU complex operations.

Introductory price for the '10803 is $40 in quantities of 100. Of course, it's in the new 48-lead quad in-line QUIL* package.

ALU to you

If you haven't heard of the MC10800M 4-bit ALU, listen up.

Fully characterized over the MIL range of -55° ambient to 150°C T_J, you can use it in applications from space satellites to the Alaskan oil field. Or, if you're not into stuff that heavy, use the standard MC10800 ALU characterized from -30° to +85°C ambient just like the standard MECL 10K series logic family.

Whichever you do, you've got the MECL heritage behind you, developed over years to its present level of LSI sophistication and performance. Speed—performance—system density. MECL LSI.

And militarily speaking

. . . we're the only ones with JAN MECL! The six units found on MIL-M-38510/60 are now available from Motorola . . . the first and only source to be drafted!

JM38510/06001BEB	10501 Quad NOR Gate
JM38510/06002BEB	10502 Quad NOR Gate
JM38510/06003BEB	10505 Triple OR/NOR
JM38510/06004BEB	10506 Triple NOR Gate
JM38510/06005BEB	10507 Triple EXOR/EXNOR
JM38510/06006BEB	10509 Dual OR/NOR

MECL Memory magic . . .

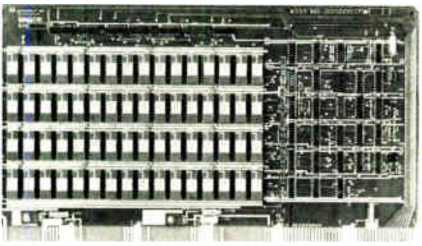
Memories complete MECL's magnificent story. There's a new 256 x 1-bit memory with a max access time of 15 ns available in sample quantities—the MCM10152 RAM. Pinouts and function are the same as the popular MCM10144. And the MCM10139 is a new 32 x 8 programmable ROM. It too is accessed in 15 ns and is sample-available.

Others in the MECL memory production bag are:

MCM10143	8 x 2 Multiport Register	10 ns
MCM10144	256 x 1 RAM	26 ns
MCM10145	16 x 4 Register File	15 ns
MCM10146	1024 x 1 RAM	29 ns
MCM10147	128 x 1 RAM	12 ns
MCM10149	256 x 4 PROM	25 ns

Do it with MECL. It's quicker! ☐ H

Standard add-in, add-on and microcomputer memory systems expand the capability of popular mini's and micro's



Board and cabinet level memory sys-ems are relatively new in the product mix of the Motorola Semiconductor Group but Motorola's memory system people are old hands in the field. It's not so surprising then, hat in a short time our line of add-in, add-on, nd microcomputer memory systems has grown to nine standard board-level systems, selection of chassis, and a creative custom apability.

MMS80810—Here's a high density 32K x 8 or 16K x 8 memory that's designed for 8080A ystems, so it's SBC80/10-compatible. It's ast, with a max access time of 450 ns. A re-resh cycle is generated by on-board logic, asynchronous to the MPU, and it has on-board address select jumpers for locating 32K words in a 64K word memory map in ndependent 8K segments. Even the SBC80/0's originators don't have this one.

MMS1110—This one's a 16K x 16 LSI-11† ompatible memory that mounts directly nto the H9270 backplane slot. All timing, ontrol and bus interface logic are included. t's compatible with the DEC Q Bus†. It's ast, low power, and at $790 in the 25 quantity, low cost. An 8K x 16 version is 420 and a 12K x 16 board is $650 in the ame 25 lots.

MMS1116—A high speed, fully expandable 6K x 16 PDP-11 add-in memory. The MMS1116 mounts directly into the MF11 backplane used with PDP-11/05, 11/10, 1/35, 11/40, and 11/45. Complete hardware nd software compatibility. With DEC's nemory management, this system can pro-ide up to 124K words of main memory. Maximum access time is 400 ns. At $1,100 n quantities of 25, it's very economical, too.

MMS1118—Another PDP-11 add-in mem-ry, this one 16K x 18. It's designed for the PDP-11/04 and PDP-11/34, and plugs into he modified UNIBUS†. The MMS1118 is ast, with a max access time of 550 ns, com-act, and low cost, with a 25 quantity $890 rice tag. It has short circuit memory pro-ection, too.

MMS3400—The 3400 is a 64K x 9 or 32K x 8 building block memory for large systems. combines high-speed access time of 450 ns nax, low P_D of only 30.6 W contin-ous DMA operation and modular expand-bility—configuration for up to 256K words er system is practical. Asynchronous or Handshake refresh modes are options and ither word or byte mode may be selected with use of an on-board jumper. The 3400 lso provides short circuit memory rotection.

M6800-based systems benefit, too

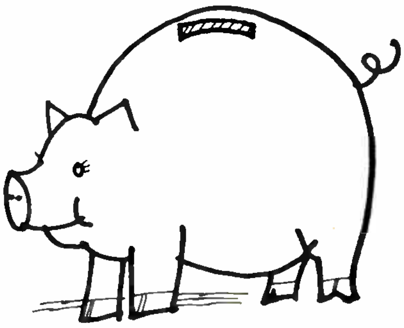
MMS68100—This 16K x 8 memory was designed to provide a fast, low-cost, high-density board to simplify the design of M6800-based systems. "Hidden Refresh" relieves the MPU from time wasting refresh cycles. Refresh is transparent to the system. Address select jumpers on the card permit user defined addressing. Cost of the 16K x 8 system is only $465 in quantities of 25, and there's an 8K x 8 version for just $285.

MMS68102—Non-volatility is the key to this 16K x 8 EXORciser* compatible memory. Battery backup circuitry consumes only 0.3 W @ +12 V in the backup mode. A multi-layer card makes the MMS68102 very compact. Access time is only 350 ns. Prices are surprisingly low; $735 for the 16K x 8 and $465 for the 8K x 8, in quantities of 25.

MMS68103—Here is a 16K x 8 memory with edge connector pin assignments just like both EXORciser and Micromodules. On-board refresh makes the system look static and improves throughput by reducing MPU overhead. It, too is fast, yet inexpensive.

MMS68104—Call this one the kit companion. It's an ultra low cost, $395 each, 16K x 8 memory design to provide the maximum amount of memory at the least expensive price for hobbyists and users of the MEK6800DII kit. ☐ I

†Trademark of DEC



50A, 500 V Switchmode* Darlingtons

Save Blood, Sweat, Tears & $ $

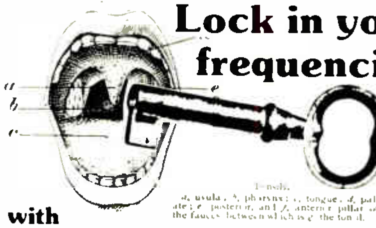
How about saving at least 25% in bucks and an infinite amount of wear and tear on yourself in switching regulator design? The fastest, highest-current, highest-voltage power switching transistor around can do it for you!

The MJ10015-16 SuperPower* Darlingtons are designed for high-voltage, high-speed power switching in inductive circuits where fall time is critical . . . regulators, inverters, solenoid/relay drivers and motor controls.

Where they really shine is in large switching regulators by eliminating, or drastically reducing, paralleling. With these, the paralleling and matching is already done—all you do is plug 'em in and watch 'em go: 180 ns typical fall time . . . 1 μs inductive storage time . . . 25 min gain at 20 A . . . 450 and 500 V BV_{CEO}! ☐ J

*Trademark of Motorola Inc.

Lock in your frequencies



with these PLL frequency synthesizers

Motorola has taken the industry standard phase-locked loop frequency synthesizers and made them for operation over a wider voltage range and to higher temperatures. They are the MC145104, 06, 07, 09, and MC145112.

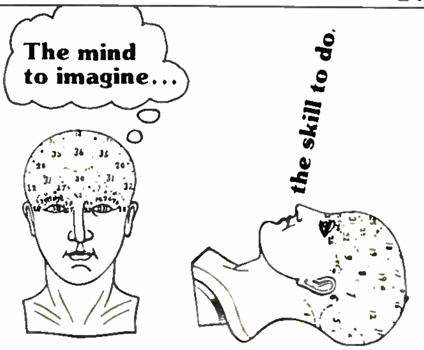
The MC145106 is the full pinout star performer in this family of monolithic CMOS devices designed for applications in equipment such as CB and FM transceivers. The other units are all limited pinout versions. The operating temperature range is -40° to +85°C, the full standard industrial range. A single supply in the +4.5 to +12 V range is all that's required.

The device includes an oscillator/amplifier, a 2^{10} or 2^{11} divider chain for the oscillator signal, a programmable divider chain up to 2^9 for the input signal, and a phase detector. The phase detector controls a voltage-controlled oscillator.

Our replacement chart works this way:

MC145104 for SM104, MM55104, MM55114
MC145106 for MM55105, MM55116
MC145107 for SM5107
MC145109 for SM5109
MC145112 for SM5106

☐ K



—in every mainstream technology.

Technology in ECL. Technology in TTL. Technology in MOS.

That's what we've got, and in every processor, logic and memory category.

We've been around a long time in ECL and MOS logic, we've innovated with 6800 and 10800 processors and we've intro'd some great RAMs, ROMs and PROMs.

Last, but not least: 54/74LS . . . we've turned raw silicon into fine-tuned LS TTL product in just 2 months. The circle (or square matrix) is now complete. Motorola is a leader in every mainstream technology.

Put it all together with our overwhelming discrete capability and our leadership in linear interface and you've got what Motorola is all about—the most complete semiconductor technology from here to there. And no other can make that claim.

LINEAR INTERFACE AND DISCRETES

	ECL	TTL	MOS
MPU	10800	2900	6800
LOGIC	10K	LS	CMOS
MEMORY	1K RAMs PROMs	4K, 8K PROMs 1K RAMs	4K Static RAMs 4K, 16K Dynamic EAROMs ROMs

8K EPROMS

— 450 ns or 300 ns

'77's new 8K EPROMs provide two different speeds: 450 ns for the MCM68708/ MCM2708 and a faster 300 ns for the MCM68A708/ MCM27A08. All are pin-compatible with our MCM65308 and MCM68308 mask-programmable 8K ROMs, and upward compatible with the 16K MCM65317 and MCM68316E mask-programmable ROMs, for low cost and high volume applications. The 68708 and 68A708 are bus compatible with the M6800 microprocessor family.

They are organized as 1024 bytes of 8 bits and use three power supplies. These highly reliable 8K EPROMs are available now in 24-pin ceramic packages specified for a 0° to +70°C temperature range. The 450 ns 68708 and 2708 are $32.00, 100–up; $37.50, 100–up, for the 300 ns parts. ☐ L

Alterable Automotive Speed Controller Resumes Speed

On Simple Driver Command

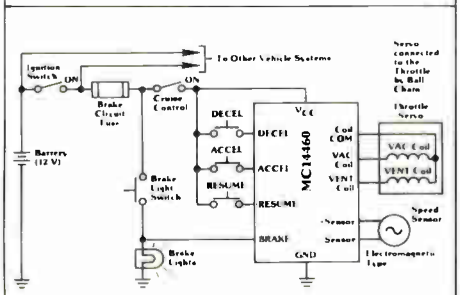
Sophisticated vehicular highway speed control is now as simple as designing in a new CMOS LSI component with a speed sensor and throttle servo.

Motorola's MC14460 is an automotive speed control processor which continually trims a throttle positioning servo for maintenance of an alterable stored reference speed. The stored reference speed is trimmed up or down by ACCEL or DECEL commands from the driver.

A brake input interrupts the processor's control, but a simple RESUME command from the driver returns the vehicle to the most recent stored speed.

The MC14460 has both master oscillator and pulse oscillator on the chip, and all inputs are diode protected. It features internal redundant brake and minimum speed checks, and uses low frequency speed sensors. No throttle position feedback is required.

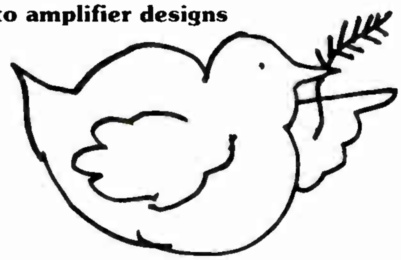
TYPICAL AUTOMOTIVE CRUISE CONTROL APPLICATION



☐ M

Peace & quiet return

to amplifier designs



with 0.5 dB NF 2N6428-29A TO-92

If you're familiar with audio devices, you know you can't get much below 1 dB NF at about 100 μA without creating an uproar in design compromise.

Well, we've got the new '6428 series and it offers 0.5 dB typ at 100 μA and 5 V. It's quietly taking over the low-level, low-noise amplifier world.

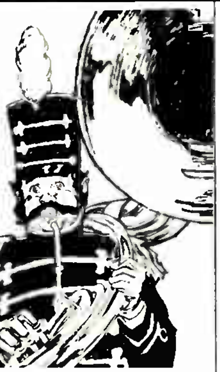
A major technological breakthrough made it possible. Without shooting off our mouth on too many secrets, we use virtually defect-free material—no voids or displaced lattice. Then we employ nitride-passivated die with improved designs. Then we use epoxy-packaging with greater moisture resistance which also affords long-term reliability.

And we'll sell it to you for just 40¢–55¢, 100–up.

They've just been JEDEC-registered and are available in any quantity from the Quiet Zone of your Motorola distributor or sales office. Ahhhhh . . . ☐ N

Wideband RF Amps

Offer Ultra-Linearity & Response Flatness



A series of 4 wideband RF modules covering 1 to 250 MHz and 10 to 400 MHz ranges provides state-of-the-art linearity.

Designed for radio and cable communication systems plus RF instrumentation and operating from either 13.6- or 24-volt power supplies, the MHW590-93 amps offer ±1.0 dB gain flatness over their bandwidth. Typical G_{PE} is 36 dB and the units are spec'd for high-performance systems with a source and load impedance range from 50 to 100 Ω.

Performance and reliability is due to hybrid, high-rel type construction of gold metallization on alumina substrate, fluxless solder reflow process for component attachment to the substrate, and laser-trimmed resistors. ☐ O

Master Semi Selection

with a Master Semi Selector Guide

Here's the new-edition cornerstone of our exclusive Update System . . . 250 pages of up-to-date perspective on all available Motorola components—from Micro-Ts to memories.

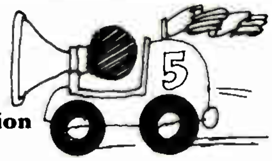
It lists, in alpha-numeric sequence, every standard product in the vast Motorola inventory and divides this total offering into a variety of major product categories, with sufficient technical info to permit an intelligent, first-order evaluation. Preferred devices are highlighted.

Master your semi selections now . . . find out the most suitable device for your specific application.

Check the proper box on the coupon. . . then check your local OEM sales rep or distributor for the very best of semiconductors. Motorola's. ☐ P

Beep Beep

for HV Ignition Darlington



Make way for MJ10012 400 V silicon power . . . it's designed specifically for the high-voltage, high-current, harsh environmental needs of automotive applications.

With a rated operating temperature range from -65°C to +200°C, the 10 A metal TO-3 extends by 50°C the limits of previous high-SOA Darlingtons for demanding auto markets. Nobody else can touch that. It's also useful in switching regulators and motor control.

Nobody else can touch the SOA either–3.5 A at 50 V; or the power dissipation–100 W; or the h_{FE}–300 at 3 A. Even P_D is double the competition–100 W at 100°C.

Or the price–just $2.75, 100–999. That's just HALF what others ask. Oh, there is a similarly-priced unit . . . in plastic. But with only HALF our specs. ☐ Q

TTL RAM

has the speed you need to write/read.

Bipolar, has intro'd another fast-access RAM with all the features you need for high-performance applications. You can get to it in 30 ns, typical.

The MCM93415 and MCM93425 are 1024-bit read/write RAMs organized 1024 words by 1 bit.

They're made with full decoding on-chip, separate data input and data output lines and an active filter chip select. Both are fully compatible with standard DTL and TTL logic families and the '425 has a three-state output to drive bus-oriented systems and/or highly capacitive loads. The '415 is open-collector.

Both provide non-inverting data output, 15 ns typical chip select, 500 mW typical PD and replacement of F-troop's 93415 and 93425.

You'll want 'em for buffer control storage, high-performance main memory, bipolar bit slice and high-speed microprogram control memory storage applications.

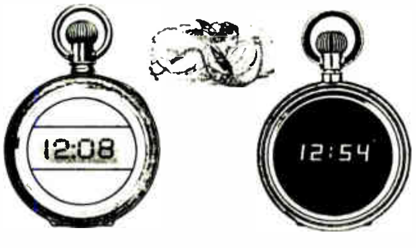
Just $9.75 for the plastic DIP and $11.00 for the ceramic, 100–up. Send for the data sheet. ☐ R

Keeping Time

LED or LCD

Whichever way the digital timepiece market eventually goes, Motorola has the standard CMOS circuits and custom capability to match.

The better established LED timepieces are ideally served by the fully integrated 6-function, 4-digit MC14470 circuit. It's fabricated with our low threshold metal-gate technology and designed to interface easily with LED alphanumeric displays of 9-segment first and second digits. Display segment and digit drivers are on-chip. Other chip features include a four-year calendar, interdigit blanking and switch-contact debouncing. Functions include hours with minutes and seconds, day-date and month-date.



LCD displays have been steadily claiming greater support in the marketplace, and Motorola has kept pace with the trend with a raft of new offerings. Of these the MC14482 is the most versatile. It's a fully integrated 6-function, 4-digit circuit with 5-function options. Because the versatility of the circuit allows operation with four different function options, it can be a real inventory reducer. The different display formats are 6-function, Slant-R, 6-function Bar-*a*, 5-function standard U.S., and 5-function European.

Other LCD timepiece circuits available include the MC14480, a 5-function, 4-digit circuit that replaces the S1424A, TP0232/0233, MM58118/58120, and the MM58117/58119. Our MC14479 is a mirror image of the MC14480. The standard 6-function, 4-digit circuits are rounded off with the MC14481, which interfaces with a 3-1/2- or 4-digit display with an additional segment above and one below the colon.

Motorola's keeping time with the way the world keeps time. □ S

Challenge of the month!

— Our TO-220 vs Anybody's.

We tested. We compared. We documented. We *published*.

We know, for instance, we had no failures at all after 750,000 device-cycles of 1 minute on/1 minute off at $\Delta T_J = 75°C$. Try that with others.

We know we had less than 1% failure after 8-1/2 million device-cycles at $\Delta T_J = 100°C$. The best of our "competitors" had twice that many failures.

We know Motorola TO-220s have orders of magnitude less failures than others in temp cycling, pressure cooker, high-temp reverse bias and thermal shock. Because we tested and compared.

Our new TO-220s have the nitty-gritty. 2-1/2 times stronger, lead-free, die-attach solder. Cross-hatched die bond areas that control solder thickness and minimize bond degradation. Moisture barrier moats around bond area. Ultrasonic wire bonding. Glass passivation. Heavier, rugged, flat copper leads. Industry-proven mold compound. In-process QA controls at all critical points. Etc., etc., etc.

Motorola TO-220 is designed better than anyone else's to last longer.

Prices are lower, too. Series-by-series and quantity-by-quantity. And even though we 100% test all spec'd electrical parameters INCLUDING SOA, they're still lower than others. (continued)

We've even got Switchmode* units ready to take over your high-voltage needs from 350 to 400 V. Included are all the specs you need to design and characterize high-frequency, 100°C inductive applications.

2N-, TIP- and MJE-types are available now from distributor or factory from 1 A to 15 A, EpiBase* and diffused mesa with more types arriving constantly. A special brochure can be had including rel-report, data sheets, selector guide and . . . the lowest prices around. □ T

*Trademark of Motorola Inc.

TO-3, TO-66 DE-flation and the prices come tumblin' down

An average 12-1/2% price cut on seven commodity power transistors now brings Motorola prices about 10% lower than others!

We've cut the 2N3055 and it's PNP complement MJ2955 6¢ apiece . . . the 2N6569 and its complement 2N6594 6¢ apiece and the 2N3054 driver and its complement 2N3740 7¢ apiece.

And you'll notice we price NPNs and PNPs equally. We're the *first* and *only* source to give you this advantage!

Close on the heels of this cost-saving are decreases in 40 other TO-66 prices—at an average of 45%!

75 additional TO-3 standards have been cut an average of 35%, too. You can now get all the quality, reliability and delivery you want in a TO-66 and TO-3 at the lowest prices in town:

Part	Description	100-Up Old	100-Up New
2N3738	225 V/2 A Power Switch	$1.25	$1.14
2N3441	160 V/3 A Amplifier	2.50	0.75
2N5430	100 V/7 A Amplifier	6.65	2.10
2N5052	200 V/2 A Power Switch	3.35	2.50
2N3442	140 V/10 A Gen'l Purpose	1.75	1.10
2N6228	140 V/6 A Gen'l Purpose	4.28	1.10
2N6338	100 V/25 A Switch	7.15	3.75

Move up to Motorola quality—and low price!

All Aboard! Motorola Omnibus • Rollin' along the routes to right design.

(Coupon Missing?) Send inquiries to Department LDC, Motorola Semiconductor Products Inc., P.O. Box 20912 Phoenix, AZ 85036

◇ A MBR7520-45
◇ B NE592/SE592
◇ C MC3417L/3418L
◇ D MCM4027P
◇ E MCM6670
◇ F MPS6172
◇ G MJ10011
◇ H MC10803
◇ H MC10800M
◇ H JAN MECL
◇ H MCM10143
◇ H MCM10144
◇ H MCM10145
◇ H MCM10146
◇ H MCM10147
◇ H MCM10149
◇ I MMS80810
◇ I MMS1110
◇ I MMS1116
◇ I MMS1118
◇ I MMS3400
◇ I MMS68100
◇ I MMS68102
◇ I MMS68103
◇ I MMS68104
◇ J MJ10015-16
◇ K MCM145104-112
◇ L MCM68708/A708
◇ M MC14460
◇ N 2N6428-29A
◇ O MHW590-93
◇ P Selector Guide
◇ Q MJ10012
◇ R MCM93415/425
◇ S MC14470/79-80/81/82
◇ T TO-220 Power

For complete product itineraries, fill in and send to:
Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036

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WHY ARE MORE LEADING COMPANIES AND UNIVERSITIES BUYING DEC® FROM FIRST COMPUTER?

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Everyone can qualify for discounts, which range up to 20%. Special discount plans for qualified educational and OEM organizations are available.

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Prompt delivery of factory-fresh DEC® components and products is provided off-the-shelf. Plus, we also stock DEC 11V03®, DECLAB® equivalent, and 11/03 Computing Systems, and can rapidly deliver both standard and customized systems.

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Each customer and order is handled on a personalized basis. We can help you configure your system or select the proper component. Expedited delivery, rapid replies to information requests, and courteous treatment are assured.

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We will custom build systems to your specific requirements, with no resulting delays in delivery. We can package your system in a functional yet attractive desk, and provide additional memory, interfaces, terminals, and peripherals.

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Valuable software enhancements for each DEC 11V03®, DECLAB® equivalent, or 11/03 Computing System delivered by First Computer are provided from our continually growing software library. Custom configurations are built to order, fully integrated, and tested prior to shipment.

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Because all of our systems are [illegible] DEC, we can provide for on-site field service by DEC's own factory trained technicians world-wide.

7. WARRANTY
We provide the same warranty as DEC®, plus, ask us about our priority exchange plan.

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We offer short-term rental or long-term leasing of complete systems. Ask about how these programs can help you meet your system acquisition and budget requirements.

WHAT THIS MEANS TO YOU

COMPLETE SYSTEMS
Standard or custom DEC 11V03®, DECLAB® equivalent, or 11/03 Computing Systems with a $1,000 savings and shipment in 30 to 60 days.

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A complete stock of LSI-11® and 11/03® products for immediate delivery—at ATTRACTIVE DISCOUNTS.

Call "FIRST" *first* to find out how much money and time you can save. Call [illegible] at (212) [illegible]-1050.

FIRST COMPUTER CORPORATION
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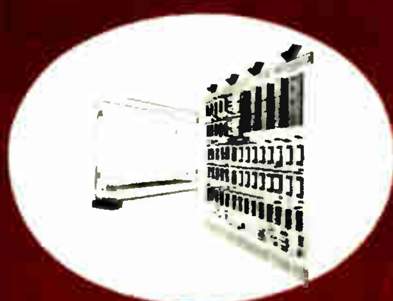
Call "FIRST" first

11/03 Computing Systems



LSI-11® Components

DEC 11VO3® Systems

® Registered trademark of Digital Equipment Corp., Maynard, Mass.
Circle [illegible] on reader service card

Bipolar version of 2708 PROM said to be faster, more reliable

A Japanese bipolar replacement for the 2708 8,192-bit programmable read-only memory uses only half the power to achieve twice the speed of the MOS part. **Fujitsu Ltd. engineers say they developed the new device because they needed a pin-compatible part with higher reliability than the 2708.** They say other advantages of its two versions, the three-state MB7055 and the open-collector MB7060, include operation from a single 5-volt power supply and faster programming (200 milliseconds or less).

Power for the 4.3-by-5-millimeter chip is 525 milliwatts maximum, 350 mw typical. Access time is 450 nanoseconds maximum, 280 ns typical. The sense current for reading is only about 500 microamperes. The writing power supply has a constant current of 200 milliamperes and is clamped at a maximum voltage of 28 v.

Gas laser sales to reach $225 million worldwide

This year's sales of gas lasers and their power supplies for commercial applications **will reach $225 million and will grow by about 20% a year in the future,** says Otmar Hintringer, a sales director in the Components division of West Germany's Siemens AG. His worldwide forecast excludes the Eastern Bloc countries. Hintringer puts the 1977 U. S. market at nearly $160 million and Japan's at something under $30 million. Western Europe takes the remaining $37 million or so, with West Germany accounting for almost a quarter of that amount. The gas laser market is between 70% and 80% of the total laser systems market, he says.

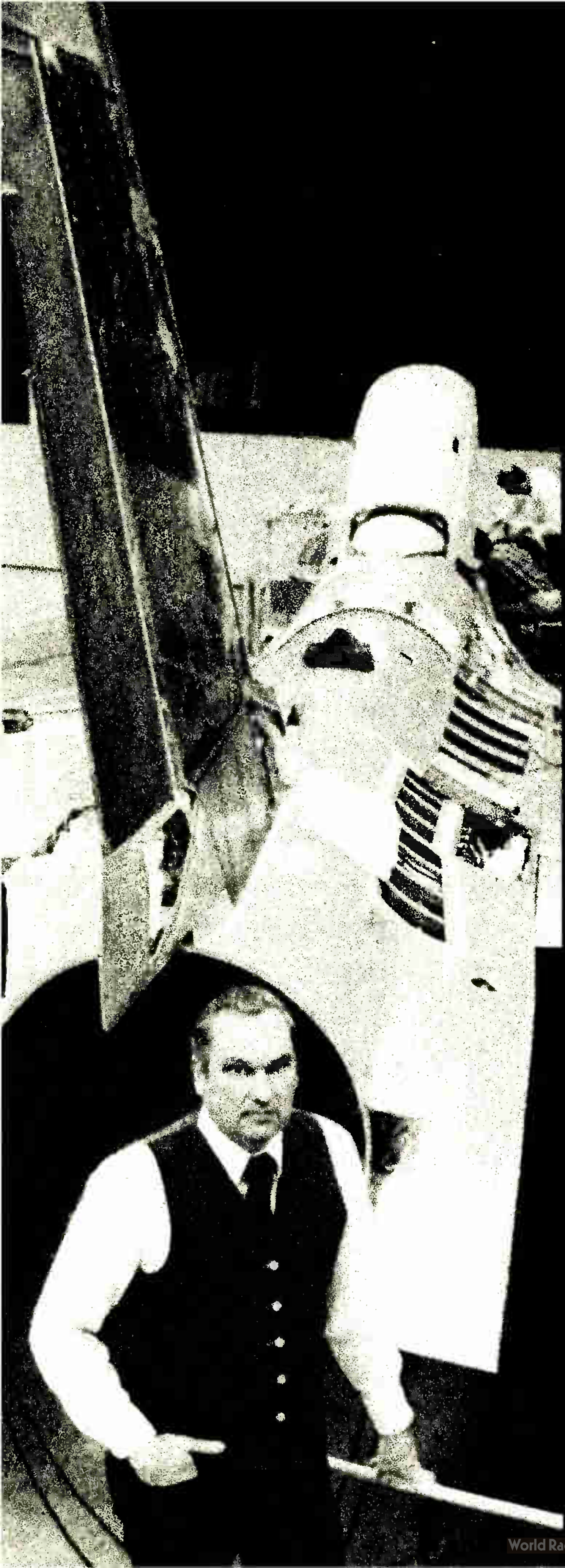
Synthesizer gives computers voices that sound human

Computer-controlled speech that actually sounds like a human's will come from systems equipped with a speech synthesizer developed by West Germany's Heinrich-Hertz Institute and the post office's research center. **Distinguishing the synthesizer from others is the virtually unlimited vocabulary from a small amount of hardware,** the developers say. With only 250 sound elements stored in various configurations in a 65,536-byte memory, the unit combines, chops, mixes, and otherwise manipulates them to produce almost any word in the cadence and inflections typical of the human voice. The portable synthesizer can be used with as many as 200 voice-output channels, because fast multiplexing techniques are employed. It is intended primarily for the automatic information systems German postal authorities may adopt.

Japanese firm launches 'smallest' video-tape recorder

What its manufacturer calls the world's smallest and lightest video-tape recorder is in production in Japan, with Funai Electric Ltd. hoping to offer the unit in the U. S. early next year. A 60-by-162-by-120-millimeter camera weighs 1.5 kilograms, including its 1½-inch picture-tube monitor. The 213-by-254-by-105-mm recording unit weighs 4.3 kg, with its two 6-volt storage batteries.

A Funai executive points out that the VTR is completely self-contained, because the camera monitor can be used for playback and because one charge of the batteries is sufficient to record, rewind, and play back an entire tape. Price, including camera, recorder, a combination power supply and charger, and miscellaneous equipment is 298,000 yen, or about $1,110. Japanese VTR makers generally agree that the 300,000 yen barrier must be cracked for a system to sell well.



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Kodak

Circle 54 on reader service card

Data-entry terminal also serves to marry remote computer and instruments

There are probably more than 200 measurement and control products that meet the interface standards for programmable instrumentation. So Hewlett-Packard Co. was cautious about promoting the role of its French-developed 3070A real-time-applications terminal, introduced last fall, in managing such equipment—until it was sure that the software and available support were adequate to cope with any one of these devices.

Hewlett-Packard at Grenoble, France, the center of the company's efforts in data-entry systems, is now confident it has just that. With the 3070A selling well as a real-time data-entry terminal in countries like Japan, the company is beginning to disclose just what the unit can do as part of what is called the HP-Link.

The firm argues that with the advent of the standard interface bus, the measurement-and-control-device engineers need concern themselves less and less with interconnection and interfacing problems. The HP-Link, a conceptual term to represent the hardware and software involved, allows single instruments or clusters of instruments to be connected through the 3070A to a remote HP1000 computer system.

The link is made up of a computer interface board, a shielded twisted-pair cable as long as 4 kilometers, and as many as 56 3070A terminals. Terminals may be plugged and unplugged without disturbing the others on the line, and the system has a very high noise tolerance. Data is passed between terminals and the HP-Link via photocoupling devices—an approach that is especially suited to industrial environments in which intractable noise problems often arise.

The communications module in the 3070A converts serial messages from the computer to standard parallel bus commands before transferring them to the keyboard-display module in the 3070A or any of the instruments attached to the system. It also converts parallel data to serial for transmission to the computer.

P-channel chips. At the heart of the communications module is a p-channel metal-oxide-semiconductor chip supplied by Efcis, the Grenoble-based semiconductor firm belonging to the French atomic energy agency. The chip—the first such device Hewlett-Packard has bought out of house—is equivalent to 3,400 transistors. It carries out a range of functions including the message conversion, the decoding of device addresses by synchronizing time windows in the time-division multiplexing system, and automatic error detection and retransmission. The error-detecting code is included in the serial-link protocol.

The chip samples each bit eight times, deciding by majority vote what the bit value is. It then performs a redundancy check, based on the properties of polynomial divisions, with a formula that gives 100% protection on all errors of single bits, 2 bits, odd number of bits, or bursts of less than 6 bits.

A typical use, says the company, is the automatic measurement of the transfer characteristic of a voltage-controlled oscillator—frequency out as a function of voltage in. Results can be printed locally on a ticket for attachment to the tested unit.

The measurement setup consists of a digital-to-analog converter to generate 10 digitally controlled analog inputs to the oscillator under test. Each converter output voltage is measured with a digital voltmeter, while each output frequency is measured with a counter.

Control signals to the instruments

LEDs sending TV signals

Light-emitting diodes are providing the infrared propagation of television signals in a Tokyo test of a setup that may serve as the prototype of a transmission system for TV broadcasts and high-speed data signals. The Japanese do not have the microwave channels available for such transmissions, as do the U. S. and other countries. Turning to infrared transmission avoids the licensing required for radio, while eliminating the need to secure a route for passage of a cable.

Engineers from Yagi Antenna Ltd. are using gallium-arsenide LEDs from Hitachi Ltd. These units have much longer lives than do semiconductor lasers or gas lasers. They also are smaller, less expensive, and less dangerous to the eye than gas lasers.

Erection of the prototype system about a year ago was simple and inexpensive. Transmitting and receiving antennas are on top of two buildings about 70 meters apart with a heavily traveled street in between. Tests have shown that the system is not bothered by heavy rain or light snow.

The 8,400-angstrom LED has an output of about 30 milliwatts with a driving current of 150 milliamperes. The current is amplitude-modulated by about 50% to intensify and modulate the light output. The receiver uses a p-i-n photodiode followed by preamplifier, automatic-gain-control, and video-amplifier circuits.

In the tests, the modulating signal is a single-baseband video signal. However, the LED has a frequency bandwidth of about 40 megahertz, so three multiplexed video signals can be amplitude-modulated on the diode output for increased capacity, or a single frequency-modulated subcarrier can be transmitted for increased range.

and the measurement results are connected to the system through the 3070A terminal. Results are printed on the local printer. Using a typical HP1000 system configuration—with little other activity in progress—the measurement can be completed in less than 10 seconds. □

West Germany

Radar begins riding the rails to keep track of train's progress

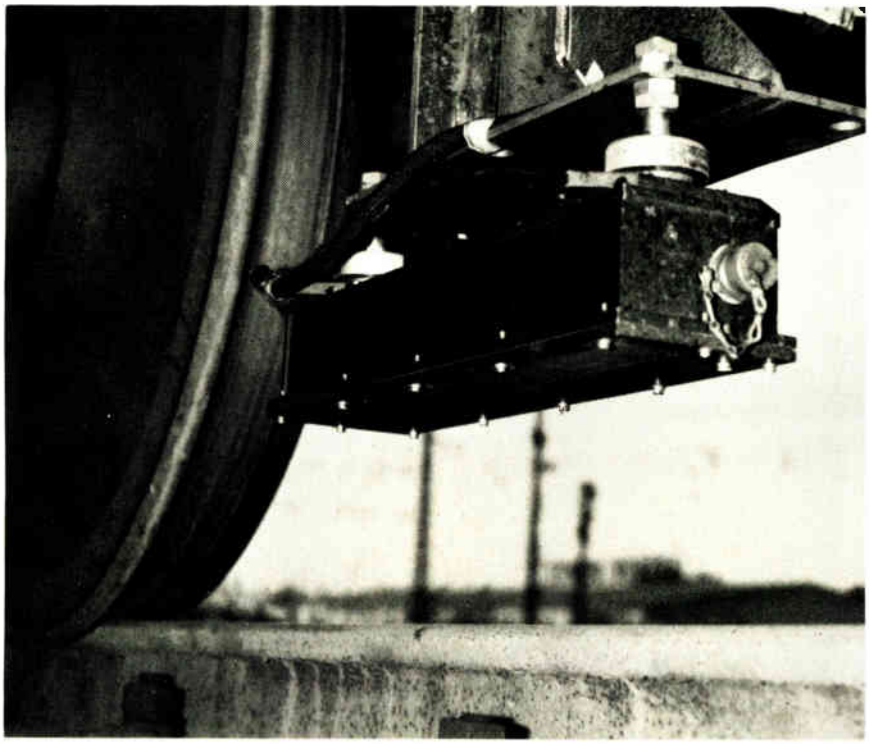
Measuring the progress of a train trip by radar-based techniques instead of by tried and tested mechanical methods sounds a bit like electronic overkill. But a train-mounted radar-doppler system is just what engineers at West Germany's AEG-Telefunken have developed for train speed and distance measurements.

Why such an elaborate technique for a job that can easily be handled by mechanical means? The country's Federal Railways is investigating a scheme in which the location of moving trains can be continuously monitored by radio, and it wants to be able to pinpoint the train positions at any instant with a high degree of accuracy.

The radar-doppler system provides that accuracy. It measures distances to within 0.1%—a value that cannot be obtained by a mechanical system connected to a rotating wheel. Only a contactless method can give reliable data, maintains Hans-Joachim Peters, a section chief at AEG-Telefunken.

Two-part system. Developed at the company's laboratories in Ulm, the system is called the vsb-radar (v, s, and b are the German symbols for velocity, distance, and acceleration, respectively). The system consists of two parts: the sensor and an adapter.

The sensor is a 3.5-by-4-by-18-inch unit housing the antenna, microwave portion, the power supply, and the evaluating circuitry. It is mounted on the locomotive's undercarriage (see photograph). In the cab is the adapter unit containing the monitoring circuitry and the system interfaces.



Accurate fix. Using radar-doppler principles, sensor unit above measures railway train's speed with ± 1% accuracy and distance from starting point with ± 0.1% accuracy.

The sensor's slotted-waveguide antenna, which was developed especially for close-range measurements, radiates high-frequency energy downward onto the ground. By using well-known radar-doppler principles, the system then determines incremental distances from a reference point. From these, it derives speed and acceleration data by differentiation processes.

Designed to withstand the rough railroad environment, the vsb-radar also measures speed and acceleration to within an accuracy of ±1%. The range over which this accuracy can be maintained extends from 0.2 kilometer per hour to 300 km/h.

Good reflection. The AEG-Telefunken designers chose an operating frequency around 35 gigahertz. At that high a frequency, good reflection characteristics are obtained even from rusty steel, concrete, asphalt, sand, or snow-covered surfaces. Also, the high frequency makes possible a highly concentrated beam from a compact antenna. Further, good resolution is achieved at 35 GHz. Depending on the radiation angle, distance increments from 4 to 6 millimeters can be distinguished by the radar.

The energy source in the system is a temperature-stabilized self-mixing 35-GHz Gunn oscillator. Its frequency drifts by no more than 5×10^{-6}/°C. The radiated power is from 5 to 15 milliwatts. The energy reflected into the antenna enters the oscillator, and the resulting doppler-frequency signals are amplified and filtered. The doppler-frequency oscillation is then converted into digital signals. These signals are applied to the evaluation circuitry for the necessary processing.

The speed information is shown on an indicator in the driver's cabin. Signals representing distance increments are sent by radio to a central control station. There, other data that the railway needs is derived. □

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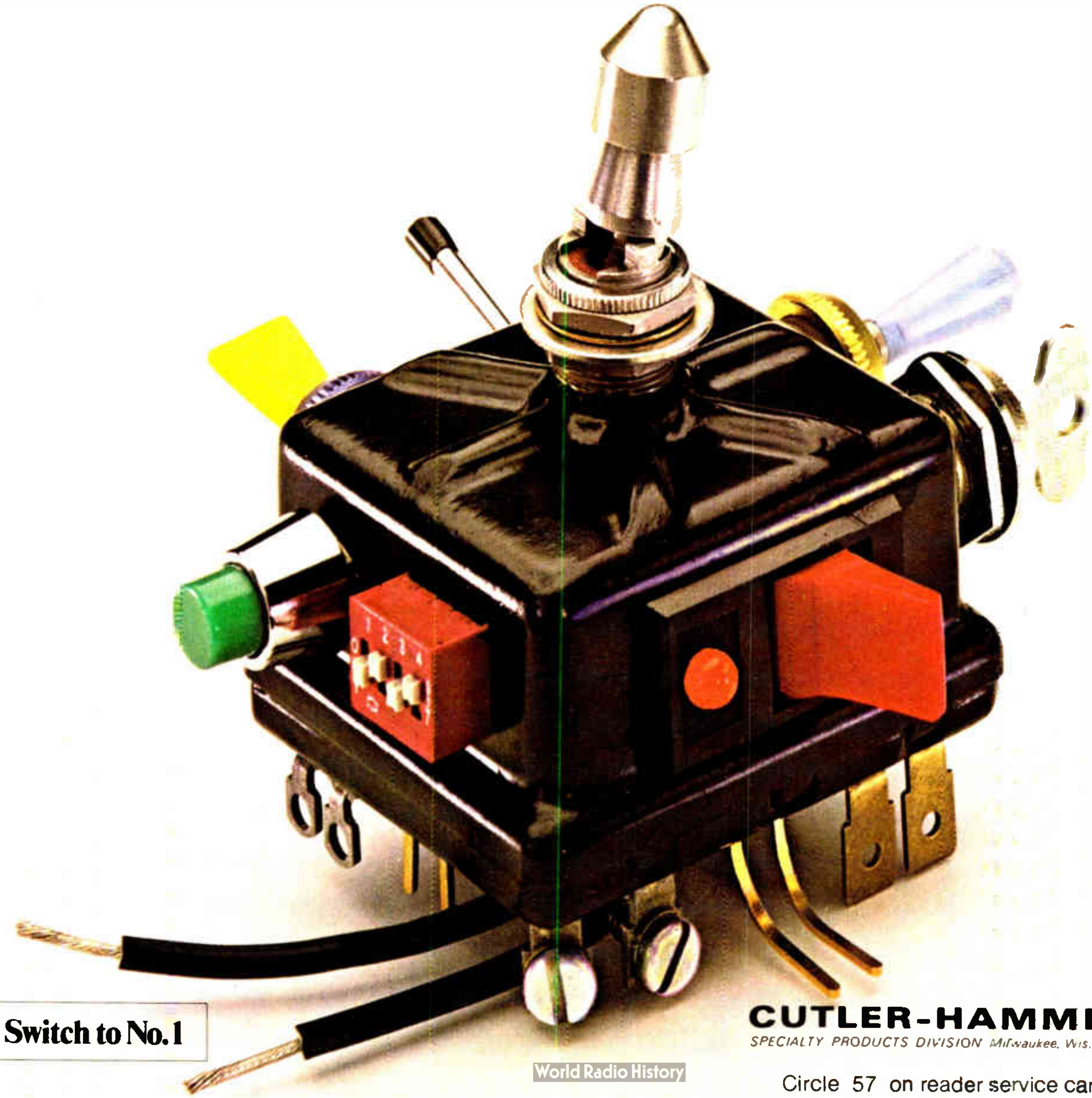

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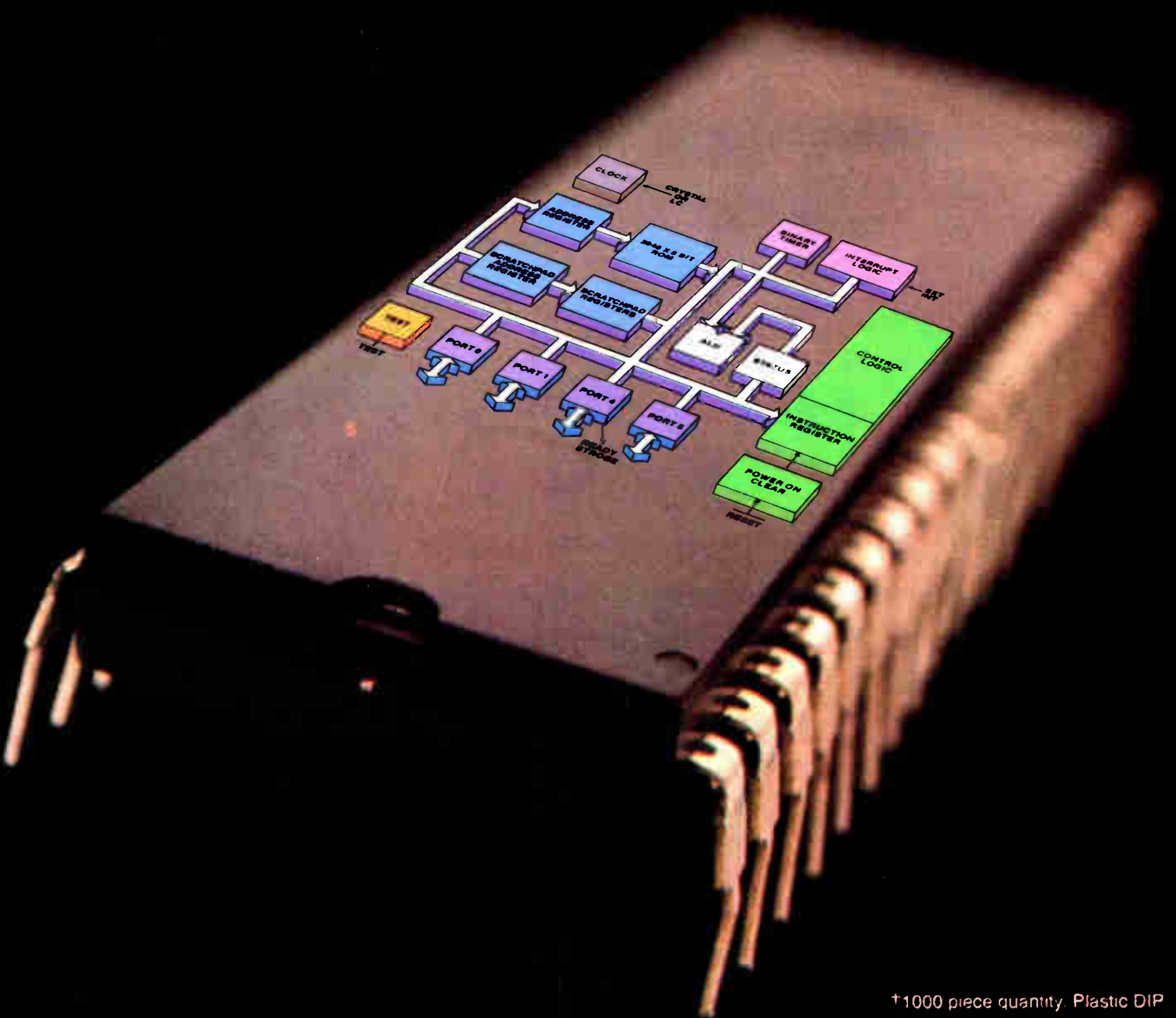

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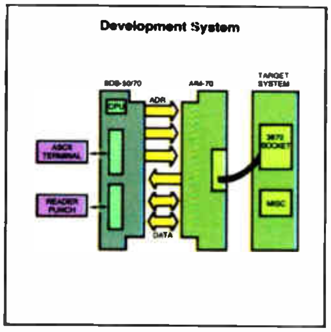
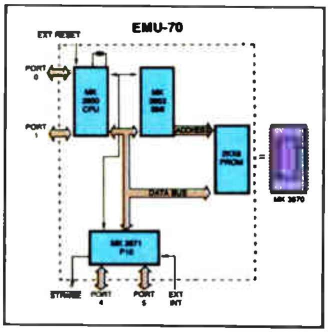
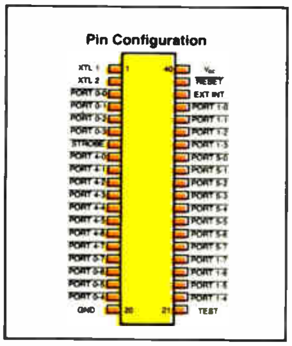




F8 Software Compatibility.

Mostek's new MK 3870 is the first single-chip microcomputer designed with complete system capability and offering full compatibility with a multi-chip processor family. It features twice the program storage of 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. 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.



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*** The MK 3870-based VAB-2: a typical example of logic replacement.**

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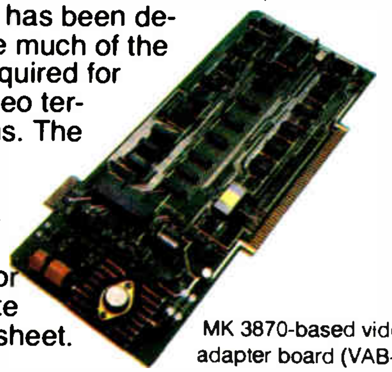

MK 3870-based video adapter board (VAB-2).

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A GIANT STEP...

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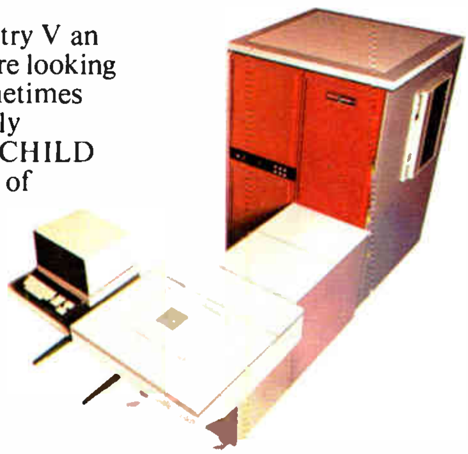

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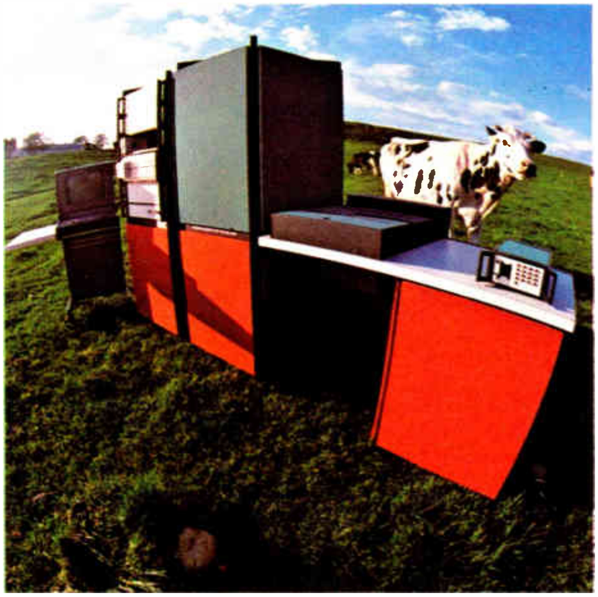

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Bulgaria: not just yogurt

Country claims title in per-capita export of calculating and computing gear plus the second spot in the proportion of electronic shipments

by Arthur Erikson, Managing Editor, International

If they search hard enough, astute players of numbers games find some product category where they rank as the world leader—if you take into account size. So no one would be particularly surprised if Bulgarian officials proclaimed that their land with its 8.7 million people produces more yogurt per inhabitant than any other. They also claim the per-capita championship in quite another category—exports of electronic calculating and computing equipment. What's more, they rank Bulgaria second only to Japan in the proportion of electronic and electrotechnical hardware in total exports.

Because the country's currency, the lev, is not freely convertible, it is hard to check out these claims, made late last year in an economic analysis by the official press agency, Sofia Press. But the mere fact that Bulgarian officials went on record with them says a lot. The country undoubtedly stepped up output of electronics hardware substantially during the five-year plan that ended with 1975 and figures to mark another strong advance during the seventh such plan, which runs through 1980.

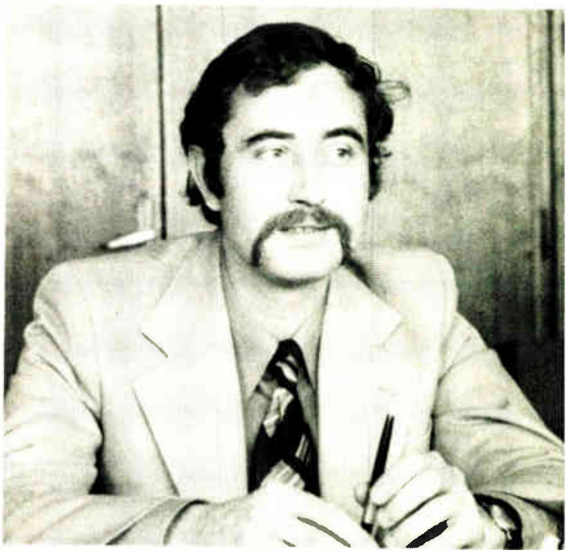
All told, output of electronics and electrical equipment spurted about 20% a year during the sixth plan, pushing the level for 1975 up to nearly 2½ times what it was in 1970. Although Bulgarian officials do not release the absolute figures, they do say that the sector accounted for 10% of total industrial output in 1975, the latest year for which statistics are available. With some 2.4 billion leva listed as the contribution by industry to the gross national product for that year, the output can be pegged very roughly at somewhere around $2 billion at the official exchange rate of 0.97 lev to the dollar.

This article is the second in a series examining the electronics industries of the nations of the Eastern European Bloc, or Comecon.

Much the same sort of growth has been set for the plan now under way. In an article published last year in the Bulgarian magazine EI, the journal for the electrotechnical and precision-instruments industries, Jordan Mladenov, minister of electronics and electrotechnics, spelled out some of the ambitious targets that Bulgarian electronics industries will be shooting for. For computer-related equipment, the 1980 output is slated to be up by 225% over the 1975 level. For telecommunications equipment, the rise planned is 230%. For semiconductors, it's 240%, and for automation equipment, 327%.

At the same time, there will be a thorough reworking of the product mix. Some 600 new items, ranging from capacitors to computer peripherals, will go into the catalogs of the three associations that produce practically all of the country's electronics hardware—Resprom, Izot, and Elektronni Elementi.

Automation drive. One main overall goal for the seventh plan is to boost Bulgaria's industrial output by between 55% and 60%. That cannot be done by brute force—the days have long since past when massive shifts of workers from farms to factory were possible—and so it is no surprise that automation is very much in the planners' minds. In fact, there is a special program, Automation VII, to speed the introduction of computers and automatic controls into basic industries, like steel and chemicals, and into crea-



Technologists. Peter Konakchiev, above, heads computer-assisted-design program while Ivan Tenev, below, runs R&D unit at electronics ministry.

ture-comfort sectors as well.

The Bulgarian state committee for science and technical progress has Automation VII under its wing. Broadly sketched, it calls for some 30 regional computer centers to service nearby state-owned enterprises and for the heavy use of minicomputers in plants. Most of the regional centers have started up already, and eventually all of them will be interconnected by a data-transmission network, so that facet of the program seems well in hand. There is also a drive, led by Peter Konakchiev, to foster computer-aided design.

For Automation VII, the hardware mostly comes from Izot, says Michael Kitov, an automation expert. The mainstay machine for general-purpose use is the EC 1022, Bulgaria's major contribution to the RJAD series of compatible computers produced by the Comecon countries, Rumania excepted. It is an improved version of the EC 1020 that Izot first started producing five years ago. The new machine can have as much as 512 kilobytes of main memory and processes data at a rate of 80,000 short operations per second, It can handle as many as eight magnetic-tape units and eight disk files.

In minicomputers, the mainstay machine will be the Izot 310, just getting into production. "It's a control computer similar to the PDP-8," Kitov says. Unfortunately, the disk operating system of the Izot 310 differs from that of the PDP-8, so Bulgarian users cannot tap the extensive software developed for the pioneering American machine. But they do have active exchange of programs with the Soviets and other Comecon countries.

To come. There will be more. "By the end of the plan we will have a computer in the category of the PDP-11," Kitov predicts. Although the EC 1022 has only been in production for about a year, there is a follow-on computer on the schedule: the EC 1035. It will roughly match the IBM 370/145.

Meanwhile, Izot continues to grind out substantial quantities of desk calculators and pocket calculators. Exports of calculators alone totalled more than 113,000 units in 1975. The desk calculators, which include programmable types, are built around a set of four metal-oxide-semiconductor chips produced in Bulgaria. As for pocket calculators, sold under the tradename Elka, they range from simple four-function types to scientific models. "We buy the chips from all over, wherever we get the best price," says Ivan Tenev, head of the research and development division at Bulgaria's ministry of electronics and electrotechnics. The displays—light-emitting diodes—are imported as well.

Along with computers, communications equipment is coming in for considerable attention during the seventh plan. The job of meeting the targets here goes to Resprom, the state association for enterprises that turn out telecommunications equipment, consumer electronics, and medical electronics. In his article for the EI journal last year, Resprom deputy general Ivan Dimitrov reported that the association planned to boost output 215% by 1980.

To increase production. Micheal Kitov, an automation expert, spearheads state's drive to speed automation in Bulgaria.

Much higher rises are in store for some categories of telecommunications equipment, Dimitrov's figures show. Output of automatic telephone-exchange equipment, for example, will climb to 2.4 times the 1975 level. Microwave-link equipment will multiply more than sevenfold. Although they tend to stick with the Bloc for computer know-how, the Bulgarians have ventured onto Western turf for some telecommunications equipment. They have a license from West Germany's Siemens, for example, for their quasi-electronic crosspoint telephone exchanges. For microwave links, they bought the know-how from NERA of Norway.

Less TV. Because of the emphasis on telecommunications, the relative importance of consumer goods will continue to dwindle. Radios and television sets accounted for about half Resprom's output five years ago. By 1980, the fraction will drop to a little more than one fourth. All the same, there will be enough sets to meet consumers' demands, according to Dimitrov.

The showrooms of radio-TV outlets in downtown Sofia, the country's capital, bear Dimitrov out. In mid-June, they appeared well stocked, albeit with a limited selection (by Western standards) of black-and-white sets. At the bottom of the line, a 22-inch set with a rotary tuner was ticketed at 150 leva, a markdown of nearly one third from the original 230 leva. At the top of the line, was a black-and-white 26-in. set with push-button tuning, selling for 300 leva. Some shops carry a small, slickly designed Russian-made portable: it goes for 215 leva.

Output of TV sets in 1975, at 123,600 units, was actually lower than the 1970 figure, but penetration by the end of the sixth plan was 58 households out of each 100, pointing to a drop-off in demand for the receivers.

Although Izot and Resprom have to go outside for things like large-scale-integrated calculator chips and for the chips they need for their recently-begun digital-watch production, they can count on the components-producing group Elektronni Elementi for most of their needs. The components association currently produces a wide range of silicon bipolar transistors including power types, MOS chips for desk calculators, and quartz crystals, for example. During the seventh plan, there will be a drive to get into production on linear bipolar integrated circuits, optoelectronics, and new types of ferrites, among many other things. □

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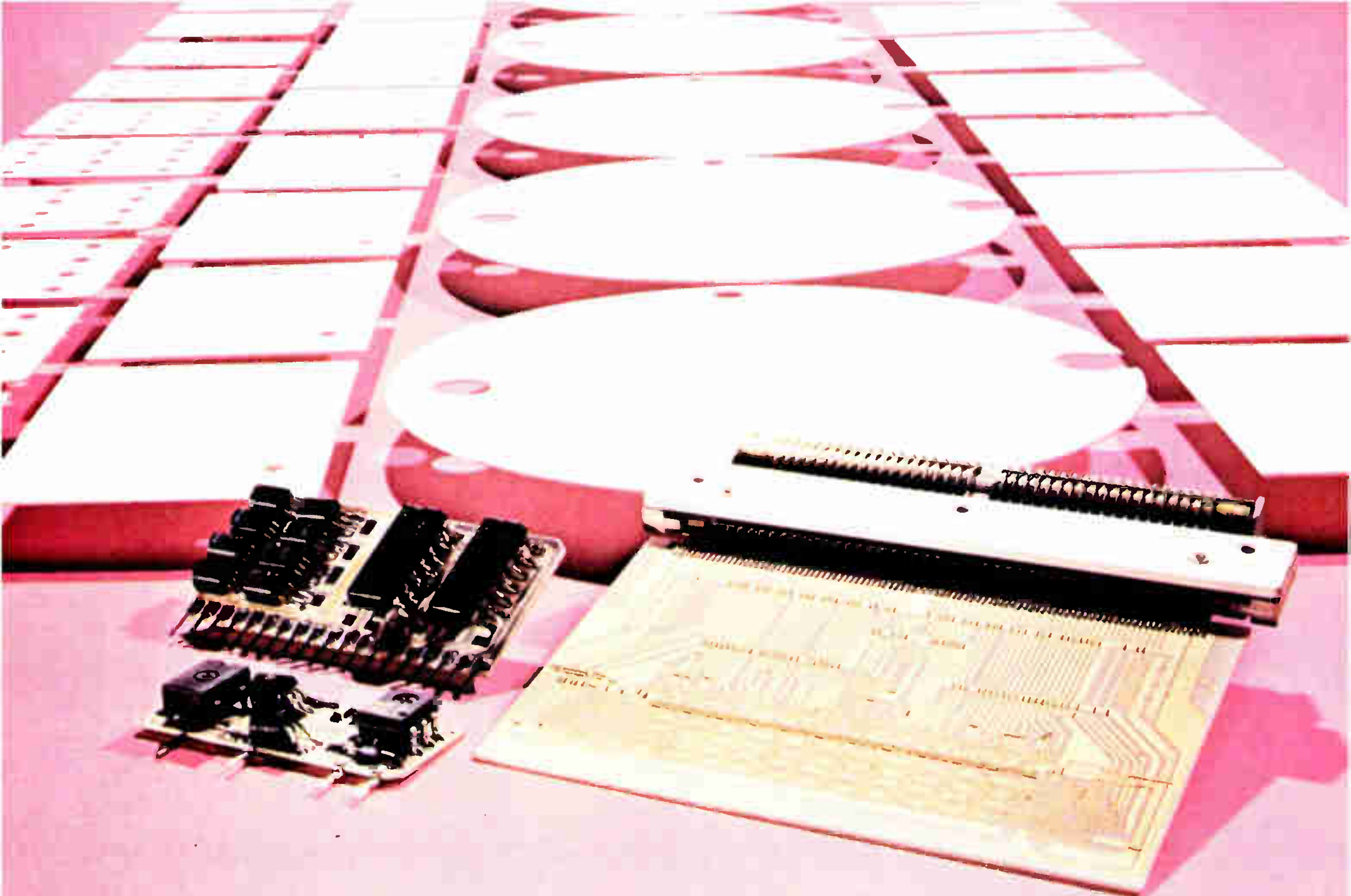

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Circle 68 on reader service card

Military electronics

Cruise's electronics help kill B-1

Successful tests of Tercom guidance and navigation subsystem, combined with missile's low price, help end manned bomber era

by Ray Connolly, Senior Editor

Now that the manned bomber has slipped a notch closer to joining the battleship as a weapon of the past, Washington representatives of military avionics contractors are anxiously awaiting the Pentagon's bid to Congress for funds to accelerate development of cruise missiles and related programs. They hope to recover some of the $1.4 billion that the Air Force proposed for purchase of five B-1 bombers in fiscal 1978.

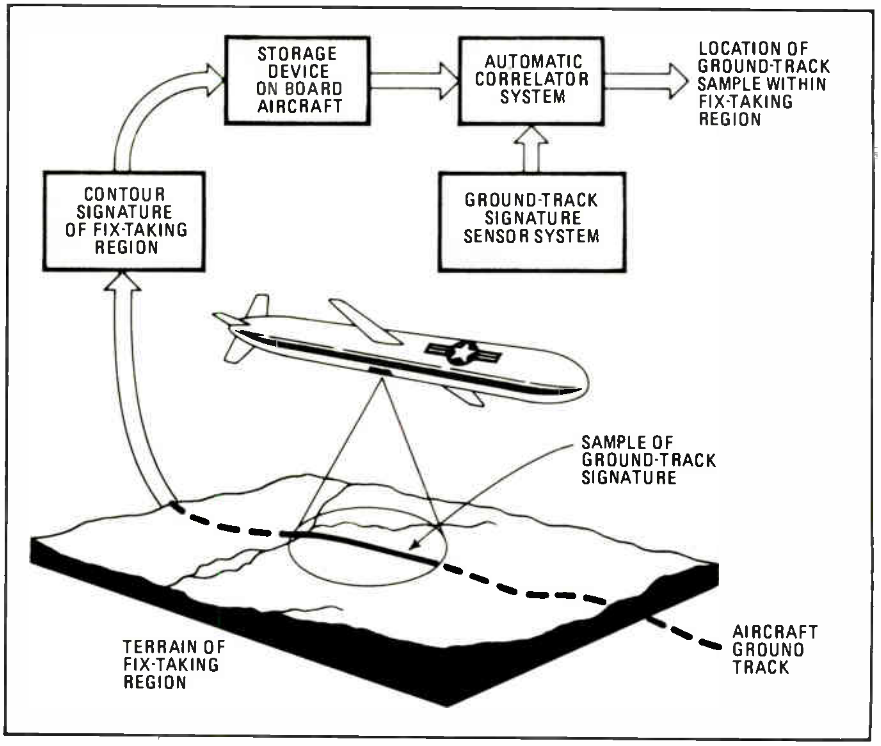
But few Air Force officials were able to recover fast following President Carter's unexpected cancellation of Rockwell International Corp.'s costly program: nearly $25 billion for as many as 244 B-1s at an estimated $102 million a copy. "Now I know how the Navy must have felt after Pearl Harbor," mused one Air Force general. "The President took us completely by surprise." [See "Avionics job losses less severe," p. 70.]

If the destruction of the B-1 program can be attributed to a single weapon other than its own escalating costs, defense officials agree it is the test performance of the common guidance and navigation system for the air- and sea-launched cruise missile. Known as Tercom—for terrain correlation matching—the system is produced by McDonnell Douglas Corp., St. Louis, using a principle developed by E-Systems Inc. of Dallas.

Tercom uses digitally programmed data acquired from satellite photographs and stored in the missile's minicomputer memory to determine its course and flight path. The real-time computer compares inputs from its radar altimeter and a reference altitude sensor with its stored terrain profiles until it finds a match. Any course corrections required for the missile to proceed to its set target are made by the computer. The missile then drops under enemy ground-based radar to fly a map-of-the-earth pattern at between 100 and 180 feet. The B-1 has flown as low as 200 ft.

Successful. In flight tests, Tercom works very accurately, says Defense Secretary Harold Brown, and has permitted missiles "to fly lower and have a lower infrared signature than we thought possible." So far the Navy/General Dynamics sea-launched Tomahawk is further along with 22 tests, while the Air Force/Boeing AGM-86 has completed six, Brown says. But he wants to accelerate the Boeing program so that the AGM-86 may become operational with late model B-52G and B-52H model bombers by 1980 and even sooner.

Air Force missile requirements could eventually lead to a total purchase of 5,000 plus another 1,000 spares—if all 240 B-52G and H models are modified to carry 20 missiles each, 8 from wing pods and 12 internally. "That's about $3.6 billion for missiles alone, figuring $600,000 a shot," says one Air Force official. Added is another $700,000 per plane to adapt the B-52 fleet,



Tercom. Contour over which missile flies is matched against digitized terrain signatures in computer. When best match is made, Tercom updates navigation system.

plus $1 million for improved avionics systems.

A Navy purchase of as many as 2,000 of the $750,000 Tomahawk cruise missiles for launching from submarine torpedo tubes could generate another $1.5 billion program. In addition, the Air Force is exploring the option of developing a ground-launched version of the cruise missile for possible use in tactical situations with either conventional or nuclear warheads.

Both services also were scheduled to get a total of nearly $403 million for their separate research and development programs in the fiscal 1978 budget that begins Oct. 1 [*Electronics*, Feb. 17, p. 36]. But these requests are expected to increase sharply.

Nevertheless, Brown anticipates that the cruise missile option will cost $5 billion to $10 billion less than a full B-1 production run. How much cheaper will "depend on what we do in other areas," he says. President Carter and Brown have already committed themselves to improving tactical field forces using conventional weapons and increasing maintenance and the availability of spares for weapons already in the field. But Brown also hints that cruise missile capabilities can also be enhanced with electronic countermeasures and counter-countermeasures as well as "by programming evasive action."

Cost growth. Adding ECM and ECCM hardware to cruise missiles, as well as programming evasive tactics into their flight-control computers, "could run their cost by up as much as 50%," says one Air Force program source. If correct, this would escalate the unit production price of the Boeing AGM-86 to $900,000 from the present estimate of $600,000. Other officials contend that 50% figure is too high, because it is based on the cost of outfitting the Air Force missile. "You can't validly use a percentage figure since the air-launched and sea-launched missiles have different price tags," one Pentagon source explains. The peculiar aerodynamic requirements of the submarine-launched Tomahawk push its unit production cost estimates up nearly one third above that of its air-launched cousin—even though both missiles have much in common.

But cruise missile advocates argue that the addition of expensive penetration aids to the new systems would still make them cost-effective compared to other strategic weapons such as intercontinental missiles. Says one: "Even if cruise missile costs rise to around $1 million apiece—and they probably will eventually—they will still cost only half as much as a Minuteman III in terms of 'cost-kill' ratio.' □

Avionics job losses less severe

With B-1 bomber technology research and development programs to continue in lieu of production, all is not lost with the Air Force effort—although that is no solace to prime contractor Rockwell International Corp. Its Southern California B-1 division is in the process of laying off more than 8,000 of its 13,000 workers. All told, the B-1 program directly accounted for 24,000 jobs last year around the country at plants of Rockwell, engine supplier General Electric Co., avionics aircraft integrator Boeing Co., and subcontractors. About 70% of these are expected to be lost.

But avionics suppliers like Cutler-Hammer's AIL division in Deer Park, N. Y., are not expected to suffer as severely as airframe suppliers, since R&D on their efforts probably will continue if it is potentially useful in upgrading the B-52 or other aircraft. Texas Instruments Inc., too, loses more potential business than work in hand as supplier of the B-1 terrain-following radar. Air Force officials also say the radar could be picked up for other applications after TI delivers the third and last B-1 unit.

As Defense Secretary Harold Brown put it, the B-1 program was responsible for advances in technology, particularly in navigation, radar, and electronic countermeasures. Development, test, and evaluation of B-1 subsystems in these and other areas will continue, he explains, since much of this will be applicable to other programs, like the B-52.

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SOC 5-10	C	5	10.0	8.0	6.5	72
SOC 12-1.6	A	12	1.6	1.3	1.0	35
SOC 12-4.0	B	12	4.0	3.0	2.5	58
SOC 12-6.0	C	12	6.0	5.0	4.2	72
SOC 15-1.5	A	15	1.5	1.2	1.0	35
SOC 15-3.0	B	15	3.0	2.6	2.2	58
SOC 15-5.0	C	15	5.0	4.2	3.5	72
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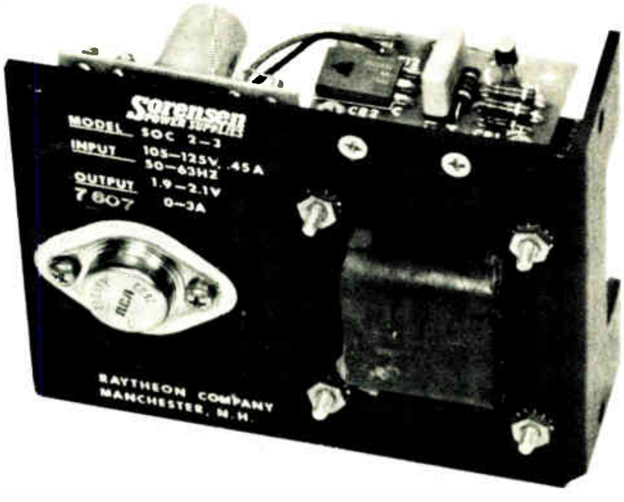

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Companies

Hamilton-Avnet does what works

Sometimes unorthodox procedures, along with 'war room' and personal touch with its employees, keep components distributor on top of the heap

by Larry Waller, Los Angeles bureau manager

Call him Tony. Hamilton emphasizes that he really runs a series of small businesses and strives to keep a personal touch.

How Hamilton-Avnet became—and stays—kingpin of electronic component distributors "would make a Harvard Business School professor turn over in his grave." That opinion comes not from a rival in the heavily competitive distribution field, but from an officer of this Avnet Inc. subsidiary who adds: "We do things that work, not because a book says we have to."

At their brand-new Culver City, Calif., headquarters, president and founder Anthony R. Hamilton and his officials often use athletic and military jargon to describe their company. Hamilton—called Tony by vice presidents and shipping clerks alike—proudly shows off his "war room," where line-by-line results of his 35 locations are charted. Also he discusses his "S.W.A.T. team," troubleshooters who close in on any company problem anywhere in the country. Similarly, senior vice president for operations William C. Cacciatore proclaims: "Harmony and coordination win ball games," and "We're all in this together, and management is a strong chain."

While such terminology might be dismissed as business cliches, Hamilton-Avnet results speak for themselves. For its 1977 fiscal year ended June 30, Avnet's electronics marketing group (largely the Hamilton subsidiary) will report nearly $290 million in sales and expects to maintain its 1976 4.9% profit margin.

Furthermore, Hamilton-Avnet has grown more than fivefold and stayed solidly in the black since the early 1970s despite two recessions that nearly pushed some major distributors under. As often noted, the distribution business is one where high-leverage companies do very well in good times, but slide further when things get tough.

Think small. Hamilton is not loathe to share his operating formulas, offering a voluminous explanation to everyone. Basic is the concept that "I hope I never forget we operate a series of small businesses." Since each location is close to the customer, "providing perfect service every day" becomes the goal.

While most distribution executives agree with these unexceptional principles, Hamilton maintains that he spares nothing to make them work. For example, he keeps his own door open and his phone ready to advise any of the 12 regional or 35 local managers. "They can expect quick and specific decisions on all problems," he promises. Also, Hamilton, Cacciatore, and the executive committee meet all day each Monday to catch and solve problems early. "We're close to our business," says Hamilton, "and there's quick communication from top to bottom." The small-business nature of distribution shows up in the firm's average order size of $150—yet sales are running at a $1.15 million daily rate.

Rewards. But it is motivation of his 2,000 employees at which Hamilton works the hardest. There are money awards for warehouse people and shippers who keep error rates down, and prizes for assemblers who are neither late nor tardy. Quarterly lunches for up to 150 workers at a time give each a chance at "Tony's pot of gold." Here, bills from $1 to $100 are put in a gilded fishbowl, and each gets to draw. "I get the chance to look each one in the eye," Hamilton says, "and they know that I appreciate them." The incentives appear to pay off with a stable group of motivated workers.

Another place where the firm has gone its separate way is in inventory, warehousing, and shipping. It has stuck with a largely manual system based on old-time Cardex files, which proved more reliable and flexible than computer-driven automated networks that competitors rushed to install. With this 10-year-old system, Hamilton/Avnet prom-

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ises one-day service to anywhere in the country—"and routinely delivers it," a competitor admits. Now, however, the company is slowly developing its own real-time system, based on distributed processing.

On the management level, too, the company has had the same group intact for seven years with most executives having 10 years or more service with the company. In distribution, where executives shift often, continuity ranks as a big plus for the firm.

Perspective. These are principles that Hamilton brought with him when he left Lear Inc. in 1957 to found his own business. "A lot of the majors in those days lacked perspective of what they were or wanted to be," he recalls. What he had in mind was a "specialty distributor, with a limited number of lines but spread over a wide area." Also, a very large inventory was necessary, since a customer almost never would come back if a component was not stocked. Keeping this perspective has been the lodestar of the company's growth, Hamilton says. He merged his firm into Avnet in 1962.

Assessing Hamilton's success, a rival executive says, "It combines classic ingredients. They have an abundance of financial resources for cash requirements. They have built a very effective service system, and Tony has identified and trained outstanding people."

For the years ahead, Hamilton sees "change coming into the business and we're trying to recognize it and keep up." Principally, this means going all out in selling microcomputers, peripherals, and even software. In this, the firm is a leader, having invested "close to $5 million on a national basis," he says.

As recently as two years ago, Hamilton says, "I wouldn't have thought this business would move so fast," but his firm saw a vacuum it decided to fill. "Intel, for one, didn't believe we could do it, but now they're happy." Hamilton/Avnet passed break-even on microcomputers in December 1976, and although profits are not up to those of components, they are improving. ☐

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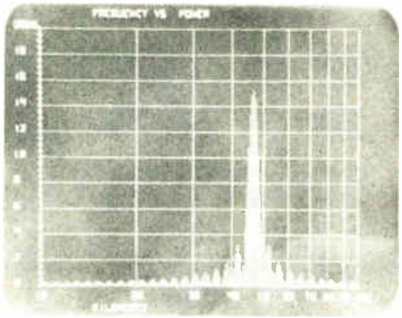

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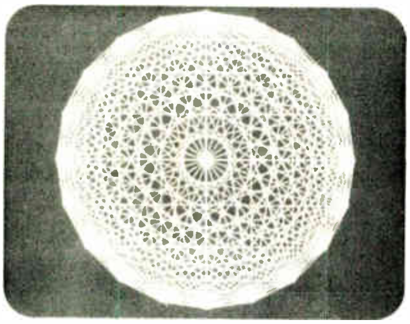

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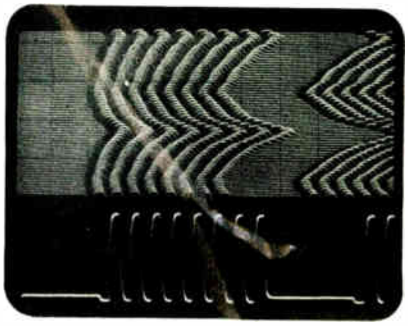

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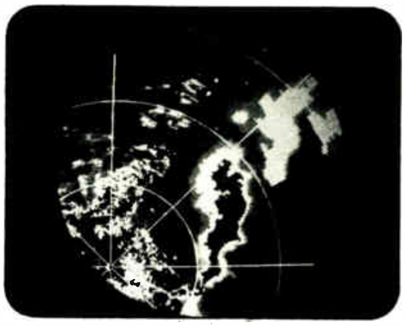

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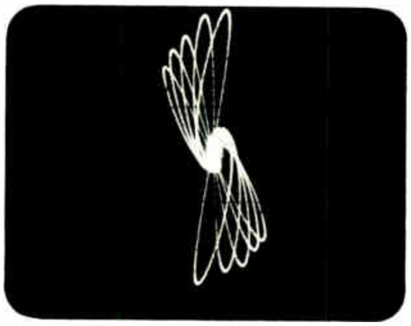

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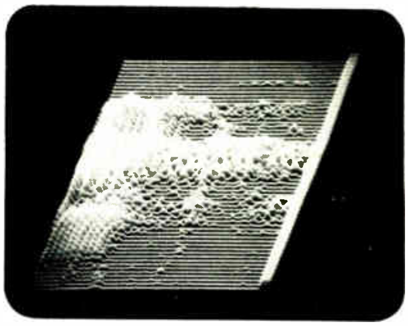

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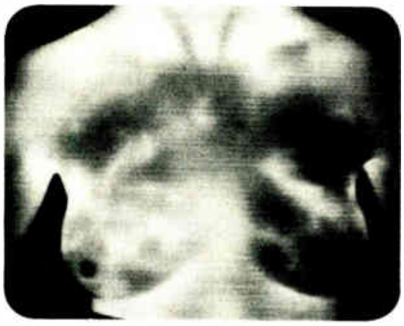

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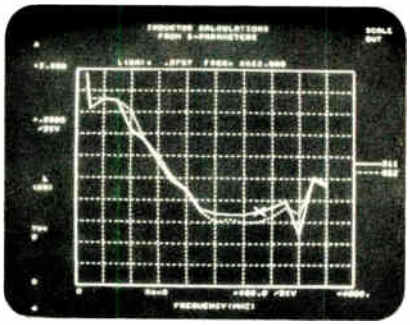

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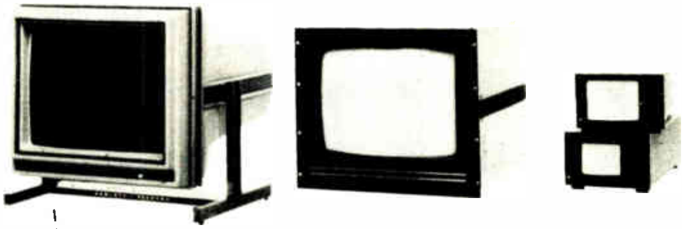

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Consumer electronics

IC makers leery about air bags

Federal Government's mandate that all cars have passive restraints by 1984 conjures up memories of short-lived seatbelt interlock

by Gerald M. Walker, Consumer Electronics Editor

Passive safety restraints in automobiles, including the controversial air bags, will be installed in large cars sold in the U.S. in the 1982 model year and in all new cars by the 1984 model year—unless Congress overrides Secretary of Transportation Brock's July decision. But semiconductor makers are unenthusiastic.

Should the air bag come out of limbo and become the favored safety feature, sales of electronic devices for these systems will obviously increase significantly. As presently designed, the air bag requires a controller and acceleration-deceleration sensors. Likely to be included, at least in the early models, is an onboard recorder to register the performance of the bag in an accident. And chances are that the auto companies will want a diagnostic function as well.

Cushioned. Demonstration shows one airbag emerging from steering wheel, second coming from dashboard for passengers.

But despite the potential sales gain in the offing, semiconductor firms presently supplying large-scale-integrated devices to the car makers for other functions are not too excited. One reason: the Government's safety mandates have a way of stalling before they are out of the garage. Semiconductor firms still wince at the memory of being stuck with large inventories of seatbelt-interlock circuits when that requirement was scrapped by Congress in response to complaints from consumers about being inconvenienced.

Perhaps the real reason that the electronics suppliers are not elated by the air bag requirement is that the electronics does not provide much of a challenge—that is, the technical problems to meet the requirements have been solved. To most, the issue is political.

Typical is the response of Jerry Crowley, director of National Semiconductor Corp.'s Automotive Electronics group in Santa Clara, Calif. "We have supported the air bag development with discrete circuits, but we won't commit funds beyond that until we hear from Detroit," he says. "The air bag system would probably take a custom complementary-metal-oxide-semiconductor package. With some of the large cars coming out with dashboard-mounted microprocessor trip computers, it might be possible to put the air bag control into the processor with a little added input/output."

For their part, the auto companies quickly bristle at any safety device that would be required on all cars, particularly if it might affect sales. Their complaint is that the air bag will add $250 to $300 to the cost of the car. Besides, they are not completely convinced of the air bag's reliability and performance in the field. Even General Motors, which has the most experience with air bags in actual use, says it has not had enough accident information—actual deployments of the bags—to be sure how many lives they will save.

Chrysler Corp., which has pioneered electronics innovations, has been the most outspoken of the auto makers against air bags. Nevertheless, the company is investigating to see which type of restraint would best suit each car. At Ford, the feeling is that buyers will get a choice of an air bag or a passive-restraint seatbelt. □

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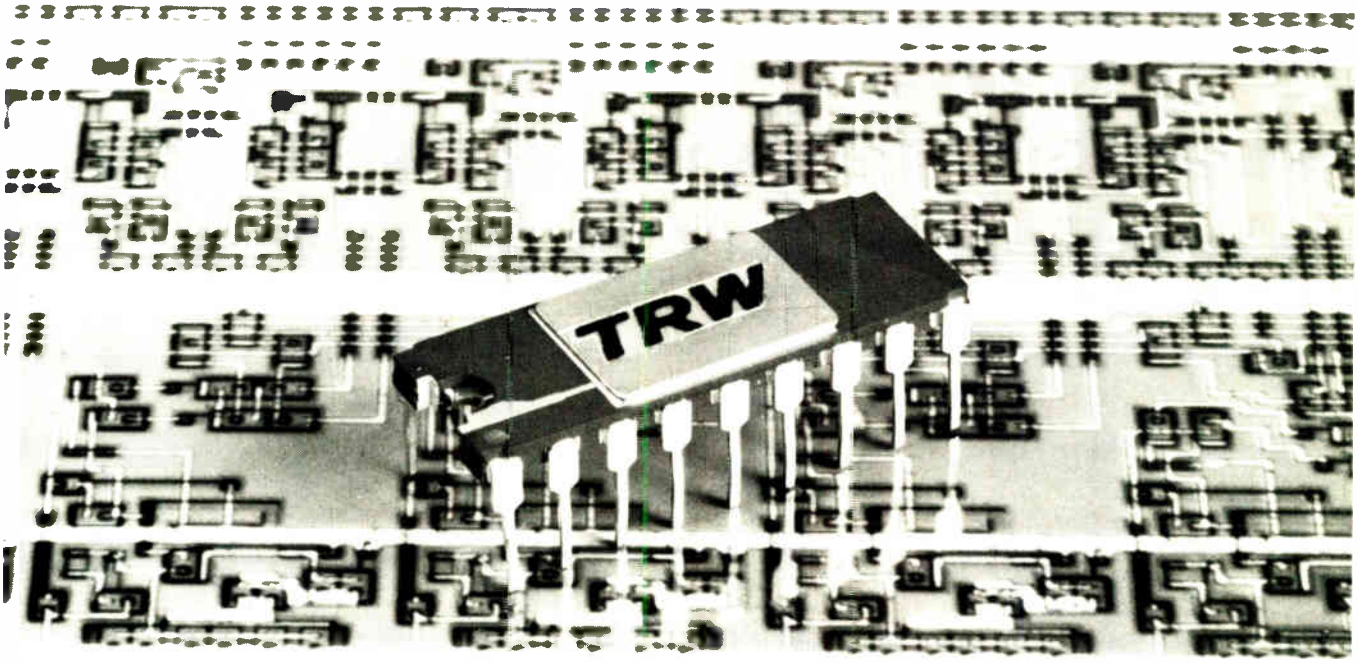

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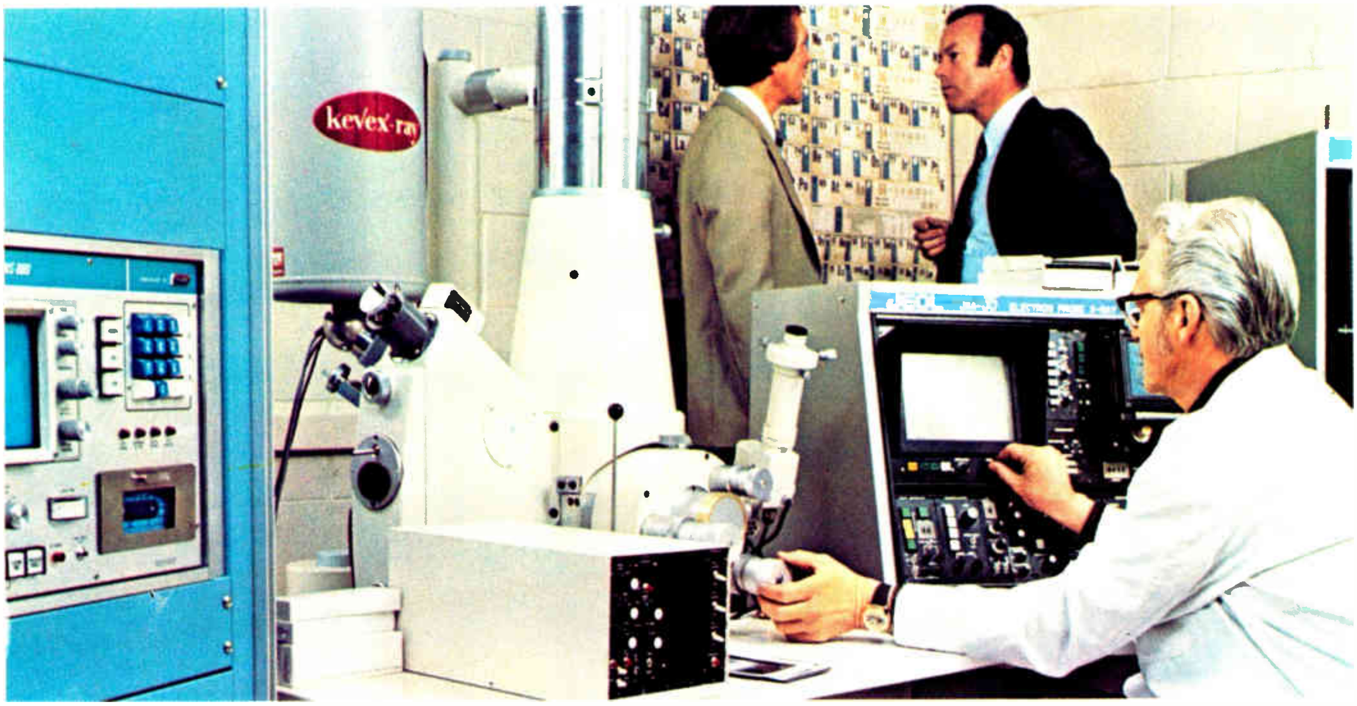

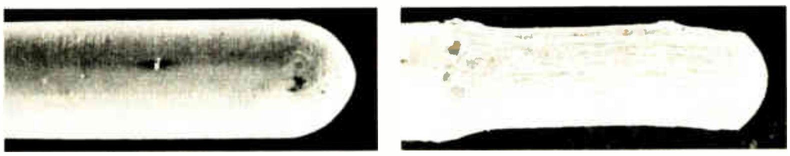

Dramatic difference in wear between contacts utilizing the unique AMP Bonded Lubrication Process and ordinary contacts is shown by these scanning electron microscope images.

Through the electron microscope, the dramatic improvement AMP Bonded Lubrication makes in contact life and performance is clearly evident.

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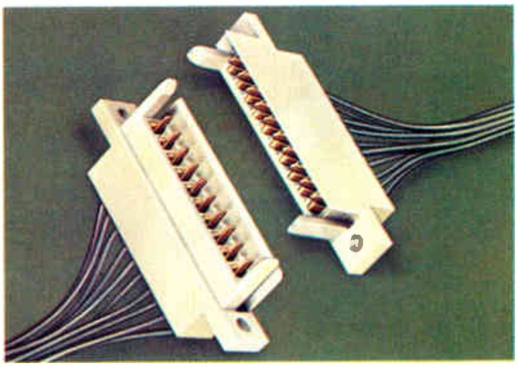

significantly lowers the insertion forces when mating high-pin count connectors. Now Bonded Lubrication can be applied to a variety of contact geometries without compromising electrical performance.

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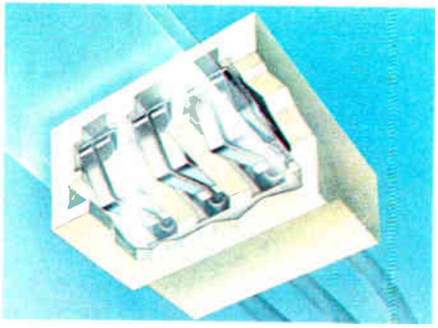
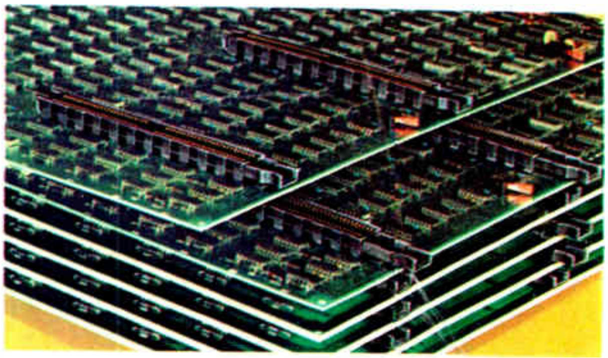
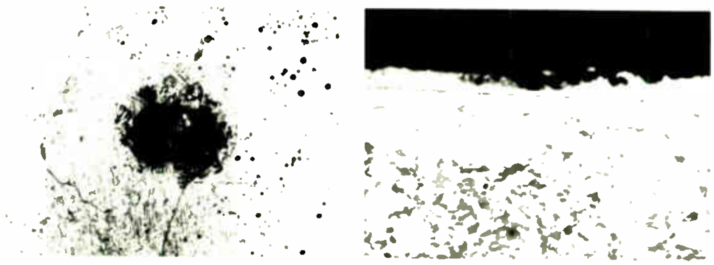
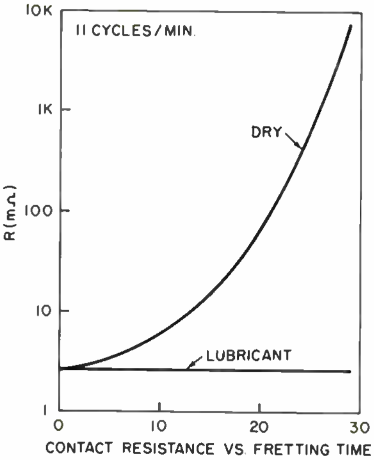






AMP's Materials Research Laboratory pictures of surface oxidation and fretting corrosion on non-lubricated contacts.



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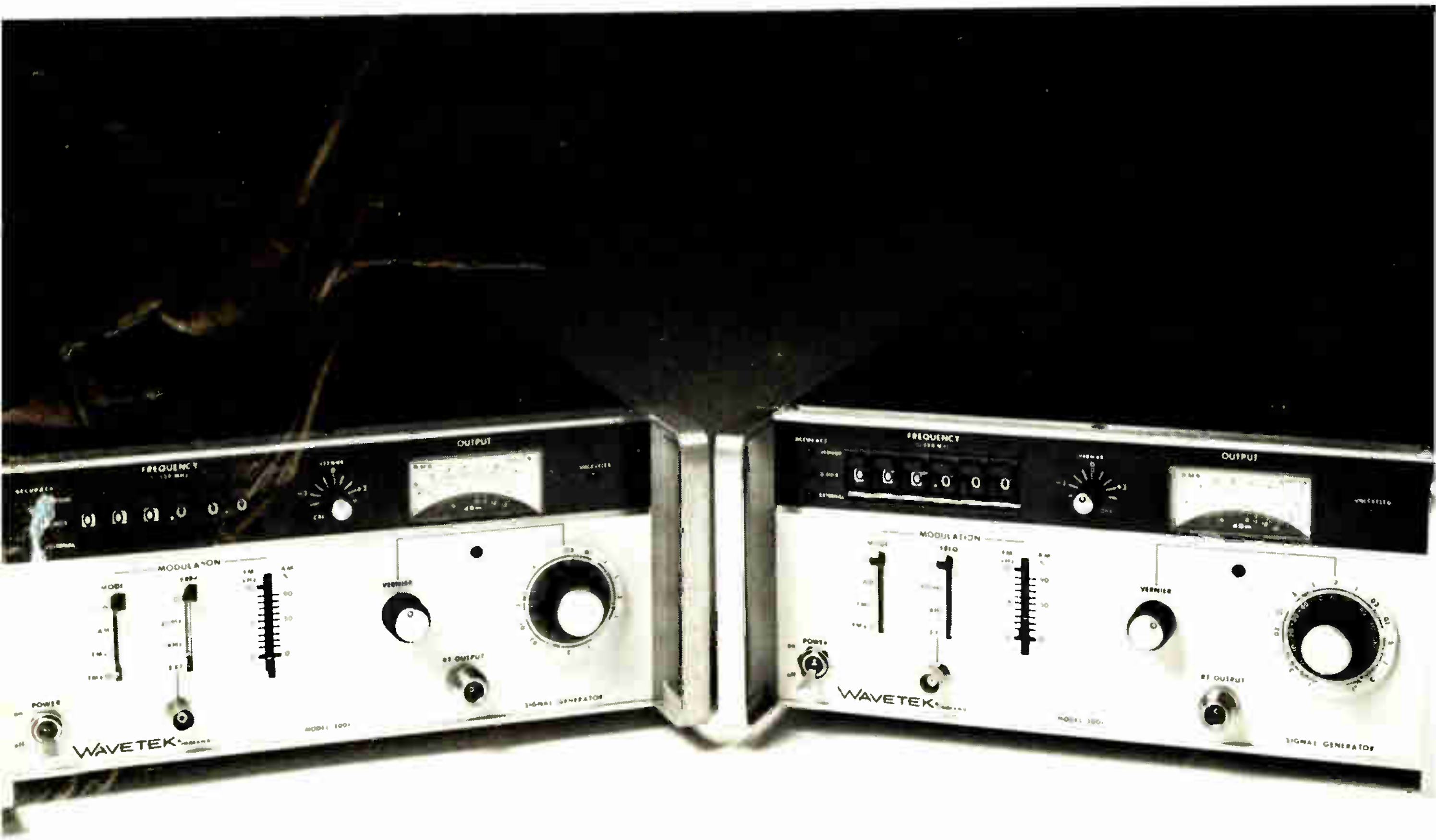

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Demands of LSI are turning chip makers towards automation, production innovations

by Jerry Lyman, *Packaging & Production Editor*

☐ The fight for a competitive edge in the semiconductor industry is taking place as much on the production line as in the design-and-development laboratory. Spurred by the explosion of applications brought on by the LSI revolution, the semi houses are making huge investments in automatic equipment in order to expand capacity and upgrade yield. What's more, increased circuit densities and higher performance are straining the limits of conventional production technology, so that integrated-circuit makers must adopt new procedures to keep up.

To meet the demands of large-scale integration, IC makers must make bigger chips and put more on them, while increasing throughput and yield. These rules tend to work against one another, because the number of defects on a wafer goes up as it gets bigger or as more components are crowded on.

As well as bigger wafers, smaller geometries are an answer. But traditional production methods are rapidly reaching their limits in both directions.

While there are significant improvements under way in the chip-layout and wafer-production processes outlined in Fig. 1, the most radical advances are taking place in the process that turns a raw wafer into finished IC chips. There are four major changes occurring in the loop that makes up steps 14 through 20 of Fig. 1:

- The beginning of microprocessor-controlled conveyor-belt operation of the lithographic steps.
- Replacement of contact pattern printing by projection printing and even more advanced methods.
- Substitution of plasma dry etching for acid wet etching when removing protective layers.
- Automation by minicomputer and microprocessor of the diffusion process and related activities.

Even the prosaic steps of probe testing and scribing and

Wafers get bigger and bigger

Today production lines of most U. S. semiconductor houses are in transition from 3-inch to 4-in. wafers. Already however, many of the firms are looking down the line at the 5-in. wafer.

For instance, General Instrument Corp. uses mainly 3-in. wafers but is beginning production with 4-in. ones. The transition has been relatively smooth, since 85% to 90% of the firm's 3-in. wafer processing equipment was purchased with convertibility to 4-in. production in mind. The firm's new plant in Chandler, Ariz., will have a basic 4-in. line that will be convertible to 5-in. wafers.

Texas Instruments Inc., Fairchild Semiconductor, and Plessey Semiconductors Ltd. are other IC firms setting up 4-in. lines convertible to 5-in. wafers. But the majority of the IC firms are content to be conservative and stop at 4-in. wafers for now.

Why are the IC companies going over to the larger wafers? "There are basically two reasons," says David Peterman of TI's semiconductor research-and-development laboratories. "One is to increase the equipment capacity for a given space and number of people, and the other is simply to get more output per person per hour. In short, productivity is the motivating force."

Marshall Wilder, manager of the 4-in. wafer line at Advanced Micro Devices Inc., Sunnyvale, Calif., puts it another way "A 4-in. wafer has 1.8 times the dice of a 3-in. unit and the labor cost is the same—making the dice from a 4-in. wafer cheaper."

However as many IC firms' process people point out, there are two disadvantages of larger wafers. First, wafer lithography becomes more critical with increased size. Second, breakage of a 4-in. or 5-in. wafer of complex large-scale integration can be an extremely costly loss. These two factors, plus the equipment limitations, will probably slow the general move into 5-in. wafers.

As the wafers get larger, equipment makers will either have to retrofit or completely redesign their machines. Practically all the critical machinery for IC processing can handle 4-in. wafers. But there is no projection aligner, for instance, that can expose a 4-in. wafer, and many planned 4-in. facilities will use projection lithography.

For 5-in. wafers, there are even more holes in the vital lineup of equipment. Henry Styskal president of Teledyne TAC points out, "Equipment makers can only afford to keep one jump ahead of the IC industry. We designed our 4-in. probers when IC people were making 3-in. wafers. We can't afford to go ahead too far on our own until we are sure the entire industry is changing its wafer size."

breaking are becoming semiautomated and automated under microprocessor control.

Turning 3- and 4-inch silicon wafers into semiconductor chips begins with a coat of silicon dioxide that protects the wafer from unwanted processing effects. Then wafers undergo lithography to print circuit patterns onto them. They are coated with a photoresist that acts as a selective mask for or against etching (for a fuller explanation of the technical terms, see "An integrated-circuit processing glossary," p. 87). The wafers are baked to harden the resist, then aligned to a photomask and exposed to ultraviolet light to print the mask patterns on. After the patterns are developed, the wafer undergoes etching and diffusion. The entire process can be repeated a number of times to build different circuits on the dice.

Moving wafers

These lithographic steps take place in a work area that has come to be known as the yellow room, from the use of yellow lights that do not affect UV-sensitive photoresists. At first, yellow-room workers moved the wafers from one step to another with tweezers or vacuum pickups. But these inherently slow modes of transportation result in wafer contamination, damage, and breakage. Today, most yellow rooms are composed of modular stations, each with independent analog or digital control. The wafers are in cassettes, which feed into the modules' conveyor belts or tracks. The wafers move serially through a module where part of the printing process takes place and feed into an output cassette. After about 25 wafers have been processed, a worker carries the output cassette to the next station.

Although the cassette-to-cassette flow reduces contamination, damage, and breakage, it has deficiencies—some of them carried over from the earlier methods. One is a lack of uniformity in the processing caused by worker control of the process parameters. Another is the time and labor it takes to transfer the cassettes from one station to another. Also, the individual process modules take up a lot of floor space.

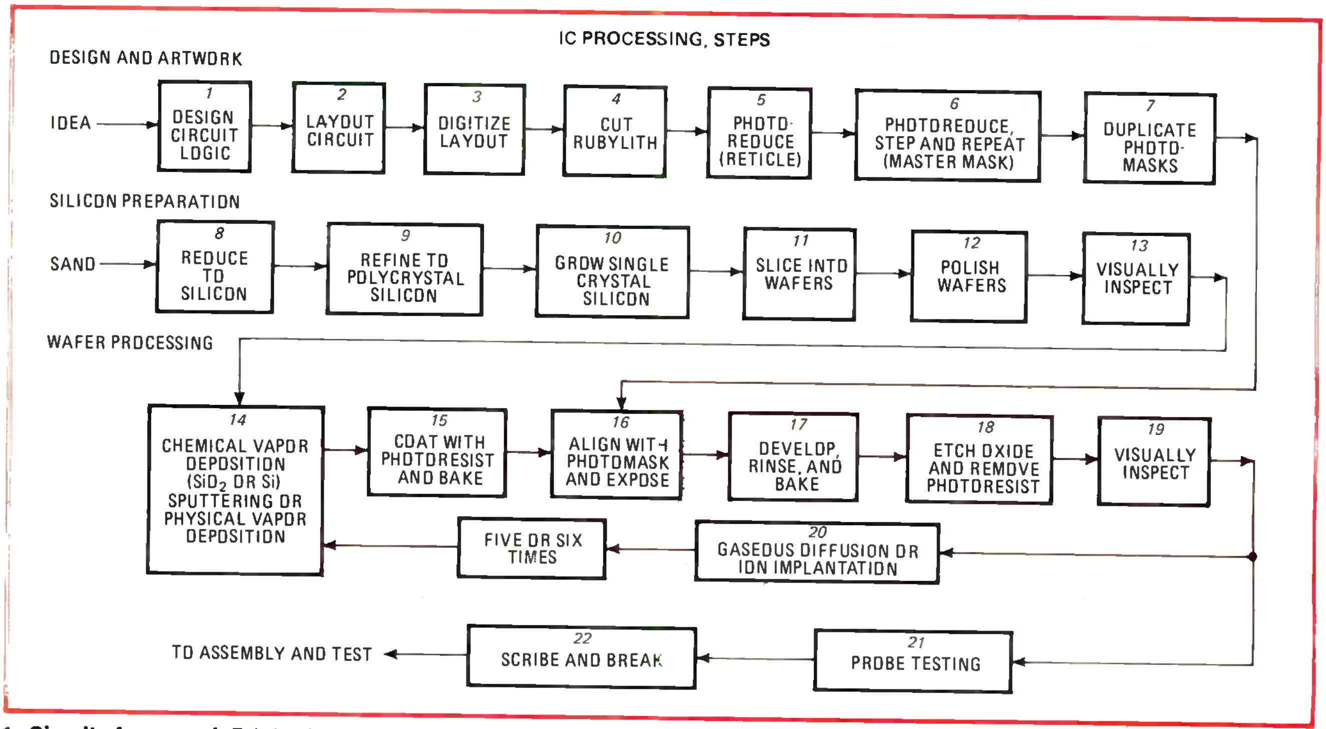
So equipment manufacturers have developed a new type of wafer-processing equipment for the yellow room. Using an in-line approach, the modules are mechanically linked with wafer transports. Moreover, a central microprocessor or a hard-wired digital device controls all process variables. The equipment is more compact than the separate modular stations. This compactness makes possible as many as four processing tracks where only one track of the older equipment fits. The equipment is designed for 3-, 4-, and even 5-in. wafers.

Now there are only single input and output cassettes for the worker to handle. The wafer wends its way through the various connected modules on an air track or on fully mechanized tracks. The tracks may branch, switch, and even make a complete U turn.

Down the tracks

Four California companies are supplying in-line equipment: the Sunnyvale division of GCA Corp., Kasper Instruments Inc., and Macronetics, both also in Sunnyvale, and the Cobilt division of Computervision Corp. in Santa Clara. GCA uses an air transport, which works on the principle shown in Fig. 2. Macronetics' wafer transport (Fig. 3) uses pneumatically driven Teflon supports to gently move the wafers through the modules. The Kasper and Cobilt systems move the wafers from module to module on belt drives.

A typical GCA Wafertrack system (Fig. 4) links spinners, ovens, scrubbers, and developers under micropro-



1. Circuits from sand. Fabricating a wafer of ICs involves many techniques: circuit design, photoreduction, photolithography, wet and dry chemistry, materials handling, metal deposition, and gaseous diffusion. Last steps in the process are inspection and electrical probing.

cessor control. These modules (which may be used independently) are linked by a standard communications bus. Modules from other companies, such as semiautomatic or automatic mask aligners or probers, can be interfaced to this control bus.

Many tasks

The processor monitors the status of each module more than 10 times a minute. It also monitors and displays process parameters, controls the wafer transport, computes batch statistics, and generates alarms. In addition, it can control peripheral devices and can communicate with larger management computers, a feature that will expedite full-scale computer control of several Wafertrack lines (Fig. 5).

In general, a microprocessor-controlled in-line system has much finer control of process variables than does the independent-module setup. There is better application of photoresist and better control of baking temperatures, for example. The tight tolerances maintained on process variables can raise wafer yield at least 5% over the cassette-to-cassette approach, according to William Loveless, vice president of marketing for GCA.

An in-line system can do one batch of wafers to one microprocessor program and the next batch to another. Use of the modules also has a degree of flexibility. For example, a two-track system can temporarily split into three tracks to make use of three ovens. Also, one operator often can run two or three independent lines.

Eventually, in-line systems will change the yellow room to a fully automatic operation. Both Macronetics and GCA have proposed automated photomasking systems composed of one or two identical three-track lines. While each track would operate independently, a central microprocessor or minicomputer would control the entire system. GCA's Loveless says that systems incorporating many of the automated steps have already been ordered by some IC firms.

Even greater automation is found in a Kasper Instruments' double-track system that is available now. This processing line takes a wafer through a cycle of scrub, bake, spin, bake, align and print, develop, and bake. It has a fully automatic contact mask aligner, unlike the proposed Macronetics and GCA systems, which would require operators in place at each semiautomatic projection aligner.

Many IC makers are using the components of in-line systems in the stand-alone mode, with each module's resident memory programmed to set repeatable, consistent process parameters. Advanced Micro Devices Corp., Sunnyvale, Calif., operates a Wafertrack in a cassette-to-cassette mode. However, the modules for spinning and baking are in-line, and they are controlled by a single microprocessor.

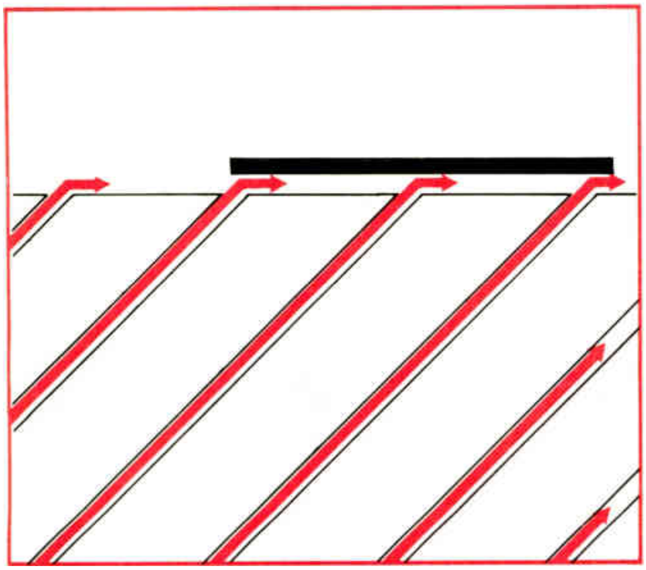
While it is possible to move easily from the independent to the in-line mode with the components of these new systems, IC firms are approaching in-line production with caution. "I don't believe in a fully automatic yellow-room concept," says Robert Fink, director of industrial engineering at General Instrument Corp., Hicksville, N. Y. "I will automate a coat-bake section, and I like the idea of a scrub-bake controlled by a microprocessor. But I don't want my automation chain too long, because then I'll run into down-time problems."

Different approaches

Different circumstances call for different automation approaches, says David Peterman of Texas Instruments Inc.'s semiconductor research and development laboratories in Dallas. Volume production is suited for a highly automated line, he says, while a high-technology product that may require periodic process changes is more suited to the semiautomated approach.

Peterman sees the in-line approach attaining higher yields and throughputs, but he agrees with GI's Fink that one breakdown could stop an entire line. He also points out that the in-line process is relatively inflexible, in that special new machines cannot be added once the production line has been set up.

With product lines all of complex large-scale-integrated ICs, Intel Corp., Santa Clara, Calif., is committed to the cassette-to-cassette approach. Its production lines must be capable of quick changes for new products or modifications of existing parts. "In-line's lack of flexibility has stopped us from full automation," says Willard Kauffman, director of component production. "Intel won't go in-line until this type of equipment is fully proved out and reliable."



2. Jet transport. In GCA's Wafertrac, an air transport system gives gentle touchless wafer handling. The mechanism provides a rolling vortex of air that surrounds, moves, and supports the wafer.

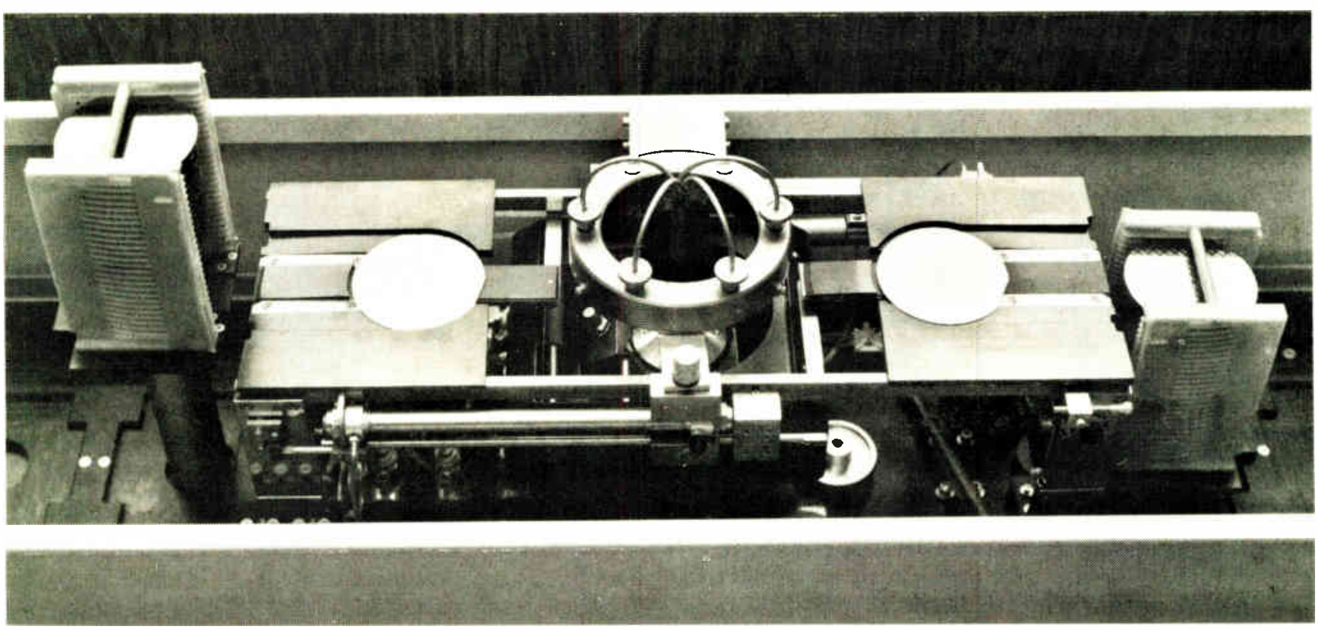
Unfamiliarity also slows the move to full automation, points out David Turcotte, Motorola Semiconductor Group's manager of n-channel MOS wafer fabrication in Austin, Texas. "We end up going through a 1½-to-2-year learning curve on almost any new piece of equipment we buy. There is a general reluctance to put new equipment in a manufacturing area until this learning process is over." All in all, fully automated yellow rooms are probably at least two years away.

Projection printing

Perhaps the greatest changes in wafer processing are taking place in the pattern-printing step. The well-established contact printing is being replaced by projection printing, and coming up fast are such new techniques as exposure of the pattern onto the wafer with electron beams.

In contact printing (Fig. 6), an emulsion or hard-surfaced pattern mask is aligned with reference points on a resist-coated wafer, then pressed directly to the wafer and exposed to UV light. Projection printing uses a complex refractive or reflective lens system to project the mask's image onto the wafer. Because mask and wafer do not touch, it has two obvious advantages over the contact procedure: extended mask life and elimination of damage or contamination to the wafer.

Most contact printing uses high-quality emulsion masks that cost between $5 and $10. These masks must be discarded after about 15 exposures. A hard-surfaced (chrome) mask, which costs about $25, can last for perhaps 150 contact printings—but it must be cleaned and inspected after every 15 exposures, so its actual cost is almost $50. With projection printing, the chrome masks can be used for at least a year before being discarded.



3. Untouched by human hands. Pneumatically driven teflon supports transport wafers in Macronetic's in-line wafer-processing equipment. Wafers move from the left cassette to the transport, through a scrubber, to the right transport, and back to a cassette.

The leading supplier of projection-printing equipment, Perkin-Elmer Corp., Norwalk, Conn., says that one of its customers, operating around the clock, reports mask savings of about $200,000 a year for each projection system. Other suppliers of the projection equipment are Canon Inc., Tokyo, and Kasper Instruments, with Cobilt reportedly aiming to make its first gear available by year's end.

Substantial increases in device yields are an equally important selling point for projection printing. The procedure uses chrome master masks ordinarily used to contact-print production masks. Since these masters are the nearest thing to a perfect mask, imperfections are held down. Projection printing also eliminates yield losses from such factors as stripping of mask emulsion onto the wafer, sticking of the photoresist to the emulsion, and pressing onto the emulsion of epitaxial spikes, silicon pieces, and dust particles (which then print onto succeeding wafers).

Raising yield

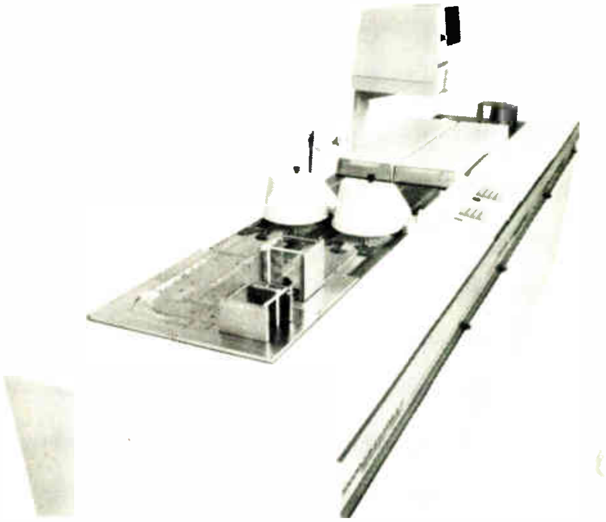
Typically, projection printing is applied to such LSI devices as memories, microprocessors, and calculators. These chips are large dice with low yields, so even small yield increases offer big savings. The graph of Fig. 7 shows estimated yield vs die area for a typical contact procedure and a typical projection procedure. In addition, Perkin-Elmer data indicates that projection equipment can give as much as 50% yield improvement.

The table summarizes the theoretical advantages of replacing contact printing with printing for an n-channel metal-oxide-semiconductor 4,096-bit random-access memory. Taken from a report by Perkin-Elmer and consultants Ruddel Associates of Sunnyvale, Calif., it shows that for this complex IC, projection printing results in a higher wafer yield along with lower mask expenses.

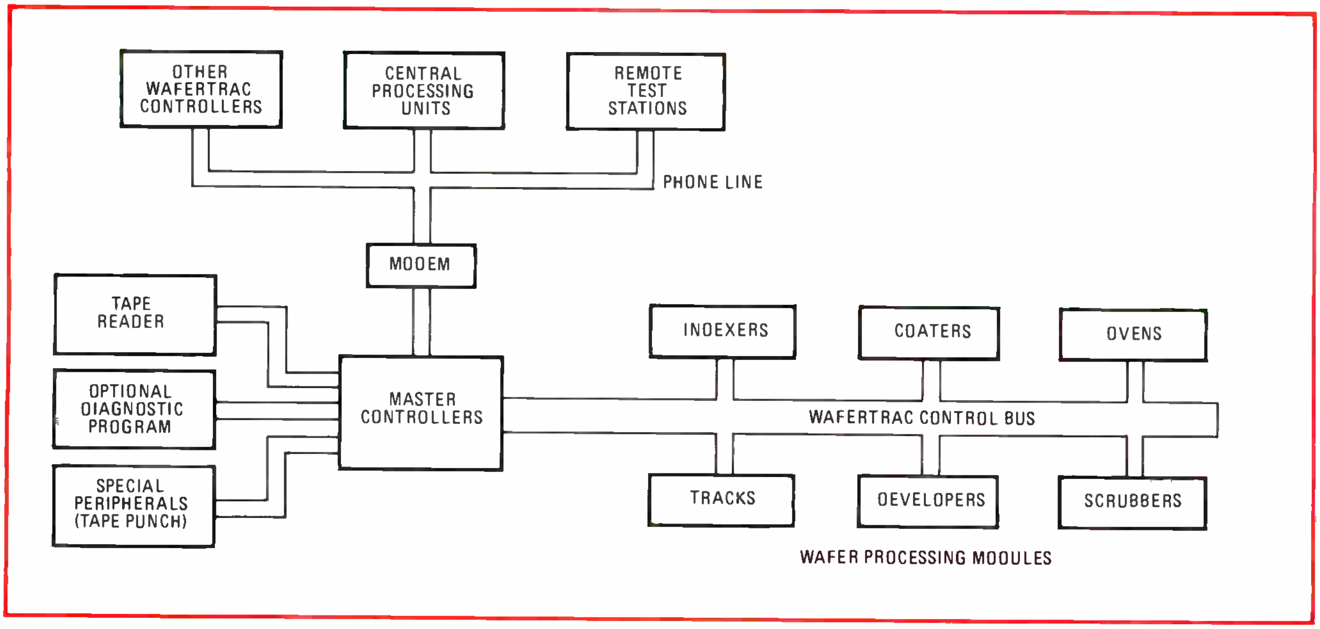
The projection procedure does, of course, have some disadvantages. For one thing, current printers cost well over $100,000, compared to $17,000 to $20,000 for a good semiautomatic contact printer. Moreover, there are fully automatic contact printers, but none yet for projection printing.

No commercially available projection printer can expose the entire surface of a 4-in. wafer—a shortcoming that makes them poor candidates for future production lines with even bigger wafers. As well as better coverage, IC houses want simpler maintenance of the complex optics of the equipment and less sensitivity to temperature change.

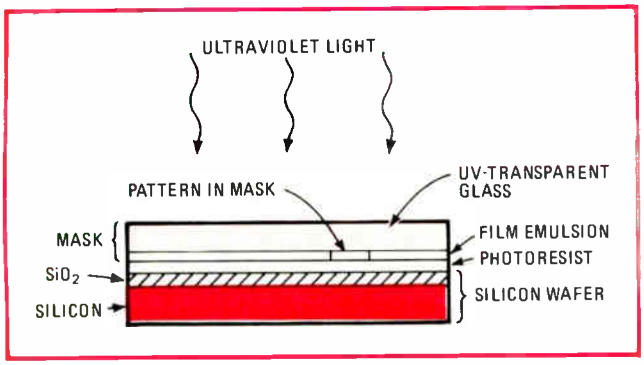
Nevertheless, semiconductor makers are using projection equipment. Jim Day, manager of mask-making engineering for National Semiconductor Corp., Santa Clara, Calif., says his company uses projection for very



4. Wafer railroad. This GCA Wafertrac in-line system takes cassettes of wafers through a microprocessor-controlled sequence of scrubbing, baking, spinning, and developing. It needs only a single person to load and unload the input and output wafer carriers.



5. Dial-a-wafer. The Wafertrac system can be linked over a standard communication bus to other process modules and peripherals. With a modem, the system's microprocessor can communicate over phone lines with a master computer, other Wafertracs, or a remote test station.



6. In contact. Contact printing of IC patterns consists of shining UV light through a chrome or film-emulsion mask that is pressed directly against a resist-coated wafer. Despite the method's deficiencies, it is still the dominant method of IC lithography.

complex large-area devices, especially those sensitive to surface damage. National uses semiautomatic equipment to expose 5-micrometer geometries. "With projection, we are getting between one and two years' mask life, and wafer yields are substantially higher," he says.

Day sees two reasons for the increased yield. Alignment registration from layer to layer is tighter—in a contact printer, alignment has a gap that causes a shift when the wafer and mask actually touch. Mask stability is assured, simplifying the finding of process problems.

The widely used Perkin-Elmer machines are 1:1 projection systems built around a reflecting optic system. The latest version, the model 140 (Fig. 8), has a high-performance condenser for shorter exposure times. It can expose 90% of a 4-in. wafer and can be loaded with a cassette of wafers. Earlier models must be hand-loaded. All the Perkin-Elmer machines can expose lines and spaces 2 μm wide with an alignment to 1 μm.

Industry sources report that Cobilt is developing a 1:1 machine that will automatically align wafers as large as 5 in. The machine reportedly will be interfaceable with either cassette-to-cassette or in-line equipment.

Stepping down

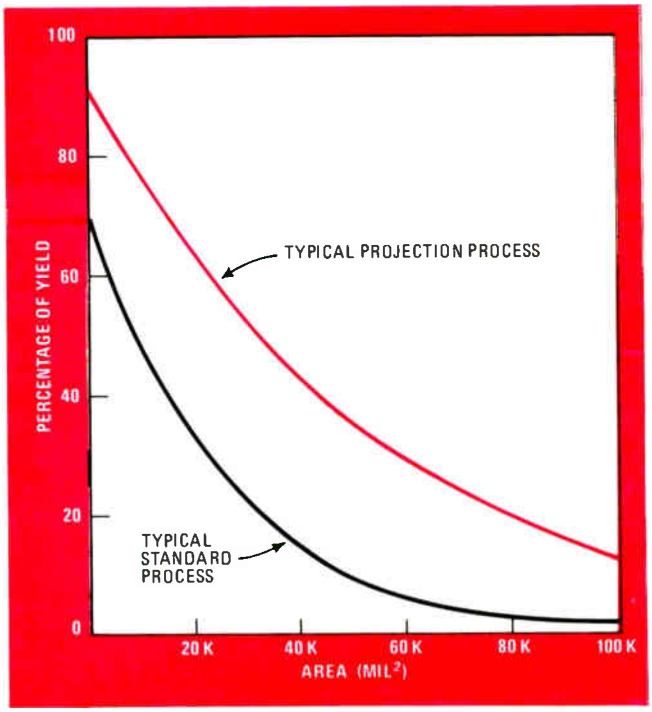
Besides the 1:1 equipment, there are systems available that project a reticle on to a wafer with a 4:1 to 5:1 ratio. Moving the reticle with a step-and-repeat mechanism exposes the entire wafer surface and gives significantly finer resolutions. Such a machine is the Canon 4:1 FPA-141 (Fig. 9) that costs $150,000 and can print 0.89-μm lines in a positive resist and 1-μm lines in a negative resist. Alignment accuracy is ±0.125 μm, and throughput is 30 wafers an hour. Maximum wafer size is 3 in.

The Dutch firm, Philips Gloeilampenfabrieken, has

TABLE: THEORETICAL ADVANTAGES OF PROJECTION LITHOGRAPHY FOR N-MOS RAM

	Contact	Projection	Difference
Rework rate	12%	6%	6%
Finished wafers/year	81,432	87,672	6,240
Finished dice/year	3,909,000	6,312,000	2,403,000
Annual mask cost	$332,000	≈$15,000	≈$317,000
Product manufacturing cost	$4.17	$3.55	$0.62*

*Without adjustment in direct overhead rate for savings in masks.



7. Big chips. As chip area increases, probe yield goes down. For a usable yield on LSI wafers, many IC firms are switching from contact lithography to projection alignment and printing.

developed a 5:1 projection machine with 2-μm line resolution but with automatic alignment accurate to 0.1 μm [*Electronics*, May 12, p. 32]. Maximum wafer size is 4 in.

In the U.S., GCA's Burlington, Mass., division and Ultratech Corp., Santa Clara, Calif. are developing reduction projection systems. Improved versions of such systems with 1-μm line resolution, automatic alignment, and 4-to-5-in. wafer capability could rival the existing examples of the electron-beam pattern-exposure systems—while doing the job at less cost and with higher throughputs, says Warren Moore, project marketing manager of Kasper Instruments. He predicts such machines before the end of 1977.

Electron-beam lithography

Optical projection methods just about reach their resolution limit around 1 μm. For geometries smaller than this, IC makers must look to either direct electron-beam exposure or X-ray exposure through a contact mask manufactured with an electron beam.

In the direct-exposure method, an electron beam under computer control exposes patterns onto a wafer or mask coated with an electron-sensitive resist. The computer determines the pattern [*Electronics*, May 12, p. 89]. The technology can hardly be said to have emerged from the laboratory. IBM's East Fishkill, N.Y., laboratory has produced wafers at the rate of 22 2¼-in. units an hour, and Japan's Cooperative Laboratory has a system [*Electronics*, June 9, p. 33] with about the same throughput for 3-in. wafers. Those U.S. semiconductor firms that have an electron-beam capability are concentrating on making high-resolution, low-defect masks for use with optical projection systems. In Europe, firms like France's Sescosem division of Thomson-CSF, Germany's

An integrated-circuit processing glossary

Alignment: a technique in the fabrication process by which a series of six to eight masks are successively registered to build up the various layers of a monolithic device. Each mask pattern must be accurately referenced to or aligned to all preceding mask patterns.
Boat: a wafer holder used in a diffusion furnace.
Cassette: an open metal or plastic carrier used on IC production lines for moving groups of wafers.
Die: a portion of a wafer bearing an individual IC, which is eventually cut or broken from the wafer.
Diffusion: a high-temperature process involving the movement of controlled densities of n-type or p-type impurity atoms into the solid silicon slice in order to change its electrical properties.
Emulsion: a suspension of finely divided photosensitive chemicals in a viscous medium, used in semiconductor processing for coating glass masks.
Etching: a process using either acids or a gas plasma to remove unwanted material from the surface of a wafer.
Mask: a chrome or glass plate having the transparent circuit patterns of a single layer of a wafer. Masks are used in the defining of patterns on the surface of a resist-covered wafer.
Master mask: a chrome mask of a complete wafer's multiple images. It is used either in projection printing on a wafer or to contact-print additional masks.
Photoresist: a material that selectively allows etching of a wafer when photographically exposed. With a **negative resist,** the resist film beneath the clear area of a photomask undergoes physical and chemical changes that render it insoluble in a developing solution. In a **positive resist,** the same areas after exposure are soluble in the developing solution, so they disappear, permitting development of the exposed pattern underneath.
Plasma etching: an etching process using a cloud of ionized gas as the etchant.
Probing: a testing technique that uses finely tipped probes to make electrical connections to a sample chip.
Reticle: a glass-emulsion or chrome plate having an enlarged image of a single IC pattern. The reticle is usually stepped and repeated across a chrome plate to form the master mask.
Step and repeat: a method of positioning multiples of the same pattern on a mask or wafer.
Stripping: a process using either acids or plasma to remove the resist coating of a wafer after the exposure, development, and etching steps.
Yield: the number of usable IC dice coming off a production line divided by the total number of dice going in. Yield tends to be reduced at every step in the manufacturing process by wafer breakage, contamination, mask defects, and processing variations.

Siemens AG, and Holland's Elcoma division of Philips have purchased or are building electron-beam equipment for mask making. Sescosem's equipment was developed by Masktechnique, also part of Thomson-CSF, to make the 10:1 reticles that are required in the fabrication of master masks.

The leader

Texas Instruments Inc. most probably leads the other semi houses in electron-beam technology and application. The Dallas-based firm is using its EBM11s for mask making, machine development, and experimental direct wafer exposure. "By 1978, all masks for new designs will be electron-beam produced," says Turner Hasty, manager of semiconductor research and engineering laboratories for the company. "By 1980, sample quantities of ICs directly exposed by electron beams will be available."

Most U.S. IC firms are considering buying the machines of Etec Corp., Hayward, Calif.; Varian Associates' Extrion division, Gloucester, Mass., and Cambridge Instruments Ltd., Melbourne, Royston, North Hertford, Great Britain. Also, GCA Burlington has started development of an electron-beam system.

The machines available all can expose patterns on either masks or wafers, but their limited throughput makes them cost-effective only for mask making. Etec's $1,600,000 MEBES and Extrion's $1,000,000 EBMG-20, both improved versions of Bell Telephone Laboratories Inc.'s EBES, are intended for mask making. They can expose patterns on masks for 5-in. wafers in about an hour.

Extrion recently sold its first system to mask maker Ultratech, while Etec has already delivered MEBES units to Fairchild Camera and Instrument Corp. and two other IC makers. In about a year or so, about a dozen MEBES will be in the field, predicts Nelson Yew, technical director of Etec.

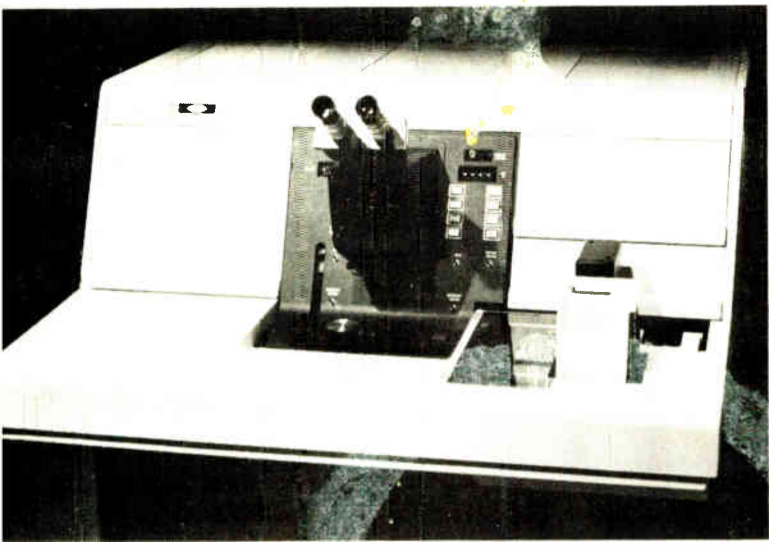
Fairchild has already used its machine to make a master mask for a 65,536-bit charge-coupled-device memory. The Mountain View, Calif., firm bought the expensive system because of "the low mask-defect rate and quick turnaround time," says Donald Brettner, vice president of manufacturing. "Also, it can be used for larger chip sizes than can optical pattern generators, which are limited to a chip size of 400 square mils."

A major impetus for development of electron-beam machines is their effortless handling of a big problem with bigger wafers. All lithographic systems require an optically flat wafer; yet the larger the wafer, the more vulnerable to distortion it is. For instance, the high-temperature processing steps can distort a 3-in. wafer to the extent of several micrometers by growth or shrinkage along its planar surface or by bowing. For LSI devices with 1-to-2-μm geometry, any one-step masking process will register properly over only a small percentage of the total wafer area.

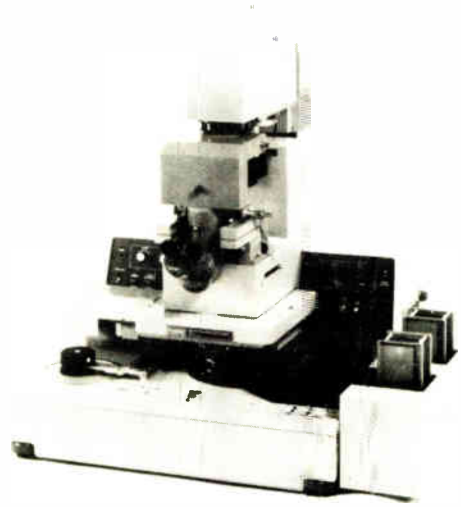
Since the beam of electrons is infinitely and minutely adjustable, exposure can be tailored to the shape of the wafer. No rival production technology can do this. However, wide-scale use of electron beams awaits the development of machines with throughputs of at least 30 wafers an hour.

X-ray lithography

Another lithography possibility is X-ray exposure of a wafer in contact with a mask produced by electron beams. It is a simple and inexpensive approach, although



8. Projection aligner. Perkin-Elmer's Micralign model 140 direct-projection mask aligner can expose 90% of a 4-inch wafer and is equipped with automatic wafer loading. Older versions of this unit are used for much of the current projection lithography.



9. Reduction projection. Canon's FPA-141 step and repeats a 4:1 mask image onto a resist-covered silicon wafer. The unit can print 0.89-μm lines in positive resists and 1-μm lines in negative resists.

the masks are costly and alignment is difficult with a 3-μm-thick mask which no commercial mask aligner is equipped to handle. Also early systems had excessively long exposure times—20 wafers a day.

General Instrument Corp. is working with the Massachusetts Institute of Technology to develop a system of X-ray lithography. Submicrometer lines have routinely been exposed on prototype ICs, the firm says.

An early example of a GI system uses gold-on-Mylar photomasks in contact with wafers coated with a special positive photoresist. X-ray exposure is from a source generated by a 20-kiloelectronvolt electron beam of 1.5 kilowatts. A modified Cobilt contact aligner is used to align successive mask levels. Exposure times are less than an hour, comparable to those of commercial electron-beam machines.

Plasma processing

After lithography comes a step equally critical for yield: removing the photoresist and etching off the protective layers of silicon dioxide or silicon nitride (which prevents unwanted passivation). Almost from the beginning of the IC industry, the standard method of stripping and etching has been with sulphuric, hydrochloric, or phosphoric acids, which have given the procedure its name of wet etching. Now IC firms are switching almost completely to a dry procedure that is called plasma etching.

A plasma essentially is a volume of ionized gas atoms capable of supporting a current. Some fraction of the atoms are ionized; positive and negative ions are present in roughly equal numbers. The plasma contains a substantial group of free radicals—electrically neutral atoms that can form chemical bonds. The free radicals react with the photoresists and the protective layers for an etching effect.

Figure 10 is a simplified representation of a plasma etching system. The plasma is generated in a gas contained in a cylindrical reactor by energy supplied by a radio-frequency generator. Free radicals (CF_3 and F) reach a wafer also in the reactor. The radicals react with the wafer's surface layer of SiO_2 to produce SiF_4 and oxygen.

There are a number of reasons for the turn to plasma etching. Its reagent gases, such as freon, oxygen, and argon, are safer to handle and are less expensive than wet etching's corrosive chemicals, which also produce dangerous fumes and wastes. It provides finer resolution, sharper etching, and less undercutting of that part of the protective layers that is to remain.

Plasma etching makes possible sequential etching and stripping operations on the same machine. Most important, it raises yields because of its inherent cleanliness, few process steps, and elimination of wafer handling.

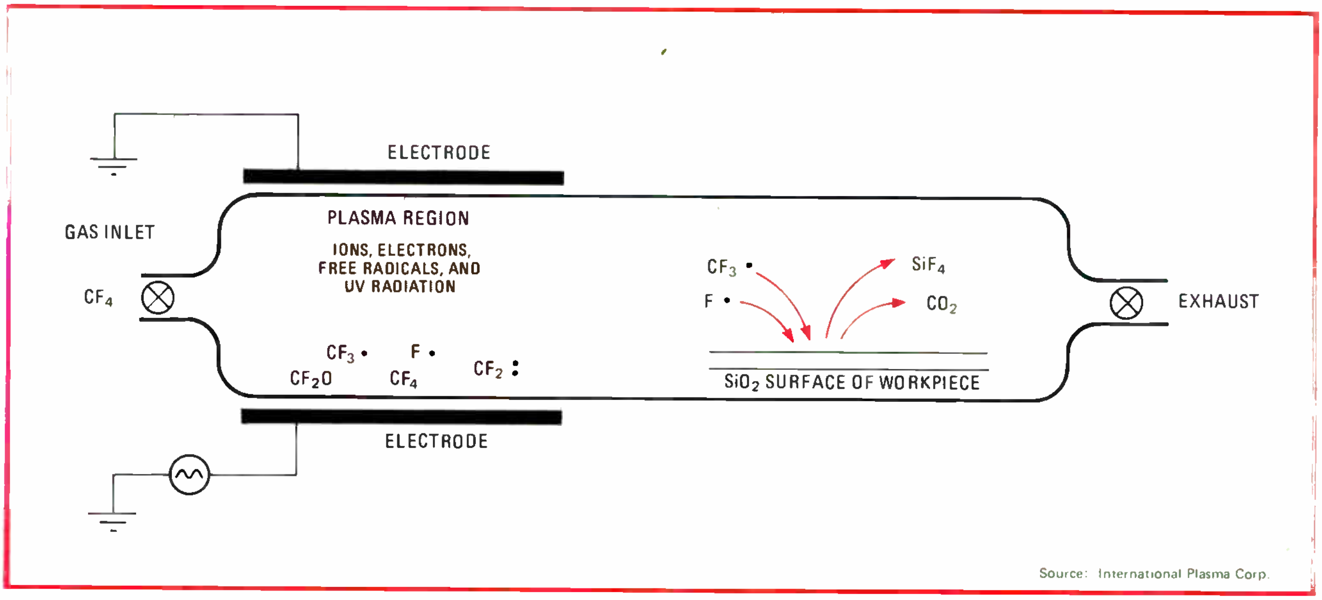
The flow chart of Fig. 11 illustrates the steps in etching a silicon-nitride layer on a wafer with the plasma process. Wet processes require an added layer of silicon dioxide on top of the nitride layer to make the resist adhere, and they need six or seven rinse and dry steps.

Plasma throughput

One serious drawback that must be solved before the plasma procedure takes over completely from the wet process is the relatively slow throughput of 40 to 50 wafers an hour. The semiconducter makers want a rate of 150 wafers an hour.

Another problem is unwanted etching of the underlying silicon substrate when the protective layers are etched. Varying gas pressure and rf power makes it possible to create free radicals that will favor the silicon-dioxide/-nitride layers. The principle is found in plasma etchers from LFE Corp., Waltham, Mass., and DW Industries, Sunnyvale, Calif.

The cylindrical reactors that have been used present problems also. The plasmas they produce cannot etch aluminum, which is the interconnection material evaporated onto the wafer in one of the final processing steps. Thus this layer has had to be chemically etched. The



10. Plasma. In a plasma reactor during an etching process, plasma is generated in the space between two electrodes. The wafer to be processed lies outside the plasma region, but free radicals survive to reach the wafer and react chemically with the silicon dioxide.

nonuniform nature of these plasma fields leads to uneven etching, which can cause across-wafer variations and wafer-to-wafer variations in the same run. Differences in temperature between runs can cause run-to-run variations. These three etching variations can cumulatively make a difference of 10% to 20% in the depth of the material etched.

The solution to these etching problems appears to lie with a new type of reactor, the parallel-plate machine. The cylindrical reactor generates plasma remote from the wafer to be etched, while the parallel-plate models generate it directly over the wafer. This location permits the relatively unstable free radicals to spend more of their lifetime on the wafer. Among other benefits, this permits the etching of aluminum.

Minimizing plasma variations

The uniform plasma field produced by these reactors minimizes most of the across-wafer and wafer-to-wafer variations. The parallel plates can be water-cooled to keep wafer temperatures constant, thus minimizing many run-to-run variations and eliminating a preheat operation necessary in the cylindrical reactor.

All the major U. S. makers of plasma-etch machines are working on parallel-plate models. Two such machines [*Electronics*, June 9, p. 42], from DW Industries and International Plasma Corp. Hayward Calif., can etch into aluminum at the rate of 2,000 angstroms a minute. The DW machine can process 35 3-in. wafers at a time, while the International Plasma machine can do 10 3-in. wafers at a time.

A third new machine from Applied Materials Inc., Santa Clara, Calif. is used for low-temperature plasma deposition of silicon-nitride films for device passivation (Fig. 12). Tegal Corp., Richmond, Calif., also has a new parallel-plate reactor for depositing silicon nitride on a processed wafer to act as a moisture-inhibiting passivation layer.

Parallel-plate reactors still are relatively small machines, but much larger models are on the way. They will be able to handle bigger wafers and to interface with cassettes or with in-line production systems.

Ion-beam milling

Another dry-etch method to which IC manufacturers may turn is ion-beam milling. In this technique, a collimated beam of ions is focused onto a resist-covered wafer in a vacuum chamber. The beam selectively mills out unmasked material by displacing ions of the wafer. Unlike plasma etching, milling will etch any material, including garnet and nickel iron. Therefore it has been extensively used with magnetic-bubble memories, which are built on substrates of these materials.

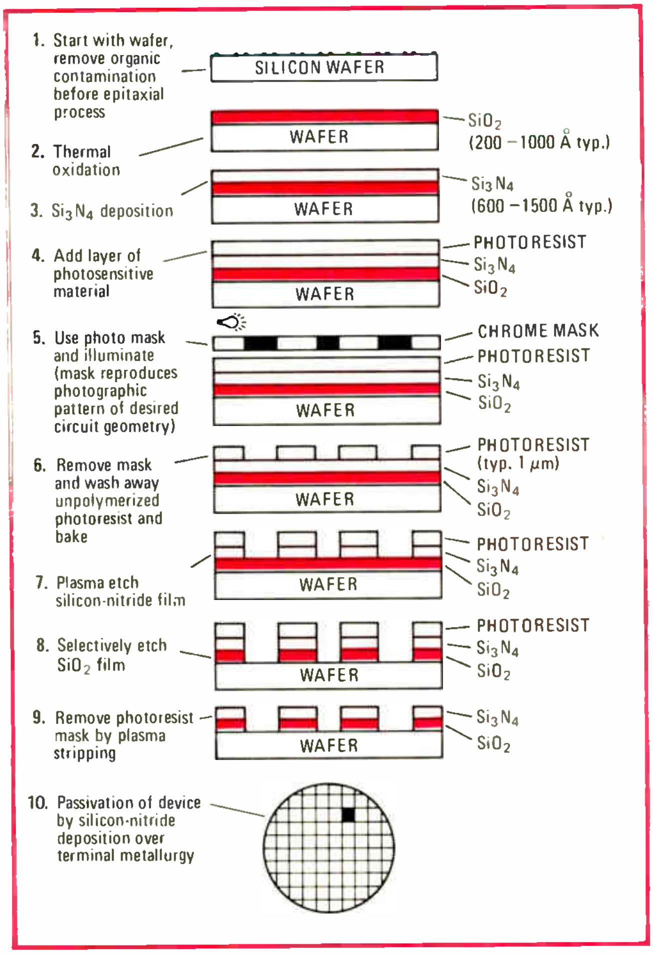
Right now, ion milling machines from Veeco Instruments Inc., Plainview, N. Y., and Technics, Alexandria, Va., are mostly confined to laboratory use, since their wafer holder is a plate only 3 to 5 in. in diameter. However, a new Veeco system has a wafer holder 10 in. in diameter that can hold 38 2-in. or 14 3-in. wafers. This unit could move ion-beam milling out of the lab, especially if bubble memories take off.

Automated diffusion

Among the various procedures wafers undergo after the yellow room, the most common and most important is diffusion of impurities onto the wafer to provide the semiconductor properties. To raise product yields and cut operation costs, considerable automation of this procedure is taking place.

In the diffusion process, a batch of wafers is placed in a furnace and subjected to specified conditions of temperature and gas flow for a set period of time. A typical cycle is plotted in Fig. 13. To get uniform results, each load of wafers must experience the same environmental conditions for the same length of time. The critical process parameters are time, temperature, and gas composition.

The original control approach was simple analog elec-



11. Plasma processes. A typical process for a silicon wafer shows that plasma processes may be applied for wafer cleaning, oxide etching, resist stripping, and silicon-nitride deposition (passivation).

tromechanical systems, many of which are still in place. However, this semiautomatic instrumentation does not give the required uniformity, so the minicomputer approach in Fig. 14 has been tried successfully.

One minicomputer can control as many as 64 of the tubes in which diffusion takes place. As well as accurately monitoring and controlling time, temperature, and gas flow, the computer can control insertion into the furnace of the boat (the fixture holding the wafer), can provide more than one mix of parameters, and can record data for easier alarm monitoring and compilation of product history.

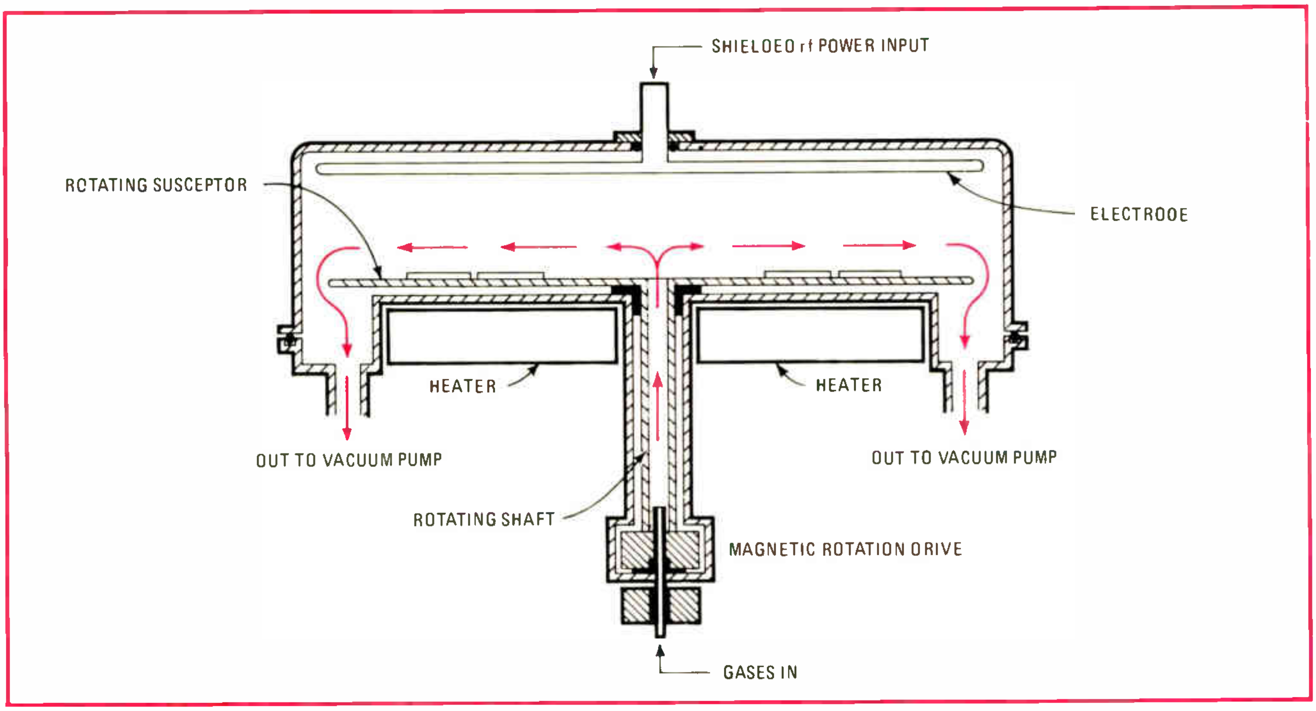
The advent of the microprocessor made it possible to have the equivalent of minicomputer control at less than the price of some of the older semiautomatic electromechanical units. It also is leading to a solution for excessive down time when the minicomputer or multiplexer fails, putting all the tubes out of business.

Using the microprocessor

Single microprocessors control eight-tube diffusion furnaces built by Thermco Products Corp., Orange, Calif., and Sola Basic Industries Inc.'s Tempress Microelectronics division, Los Gatos, Calif. Thermco's furnace control is built around National Semiconductor's IMP-16C/400, while Tempress uses an Intel 8080.

Both furnaces are hybrid systems. The microprocessor controls the time sequences, but the temperature and gas-flow controllers are analog. However, the microprocessor does control the set points (desired temperature and gas flow) through digital-to-analog converters. If the microprocessor fails, either of these furnaces may be run manually with each tube's analog controller.

To overcome the down-time problem, Bruce Industrial Controls Inc., North Billerica, Mass., has developed a



12. Parallel plate. A new type of reactor using parallel-plate construction, rather than the older barrel method, is appearing for both etching and deposition. Applied Materials uses the parallel-plate reactor, shown in cross section, in its Plasma 1 silicon-nitride deposition unit.

furnace with a microprocessor assigned to each tube. Again, the tubes have analog controllers for temperature and gas flow.

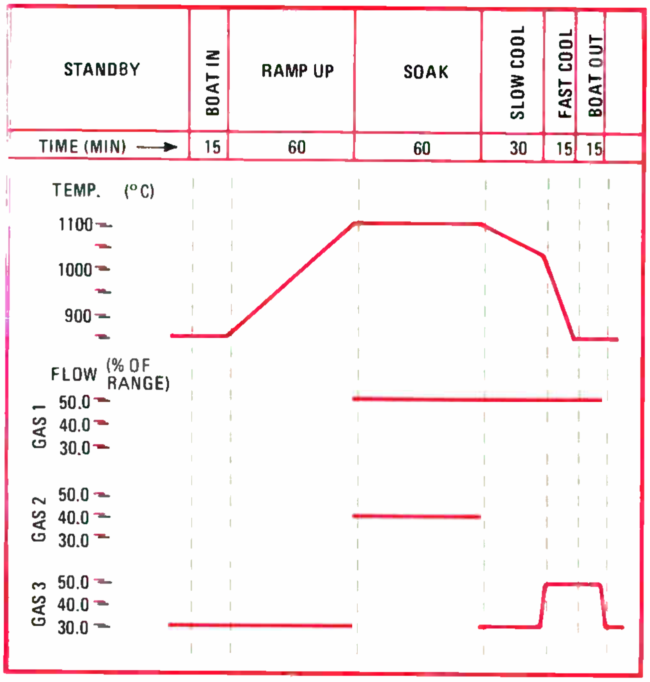
Since each MOS Technology Inc. 6502 is dedicated to only one tube, its failure affects only that tube, which can be operated in a manual backup mode. As well as performing the functions performed by the Thermco and Tempress furnace controls, the Bruce unit scans analog outputs, comparing them against values in memory and identifying discrepancies. It also can link with digital peripherals and has provision for expansion to direct digital control of gas flow and temperature.

This versatility does have an obvious drawback. At least for the time being, the processor-per-tube approach is more expensive than the time-shared processor method.

Direct digital control

Even more precise than the hybrid fully automatic approach is direct digital control of all three critical parameters. It gives freedom from the long-term drift, overshooting, and low resolution of analog controllers and has the computing capacity to provide more control functions at a substantial reduction in initial cost. Such an eight-tube diffusion furnace has been available for the past 3½ years from Thermco.

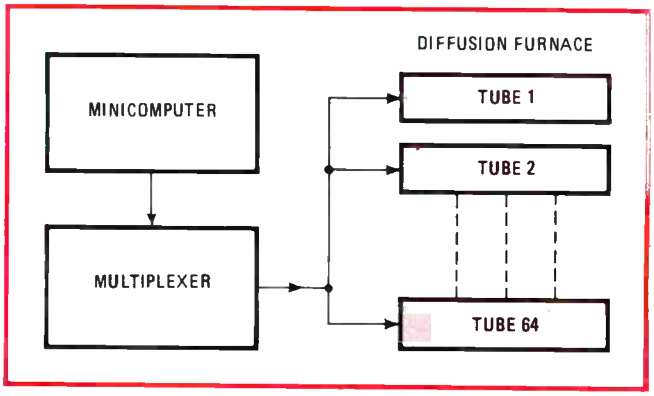
"We went to DDC primarily for very tight control of temperature gas flow and boat speed," says Dick Dunn, marketing manager of Thermco. "In this type of system, we are not limited by the performance of analog controllers. Now we can calibrate an entire system—every one of the eight tubes is exactly alike. With analog controllers, recovery rates from tube to tube aren't necessarily identical. With DDC, all tubes have identical recovery rates and identical reactions."



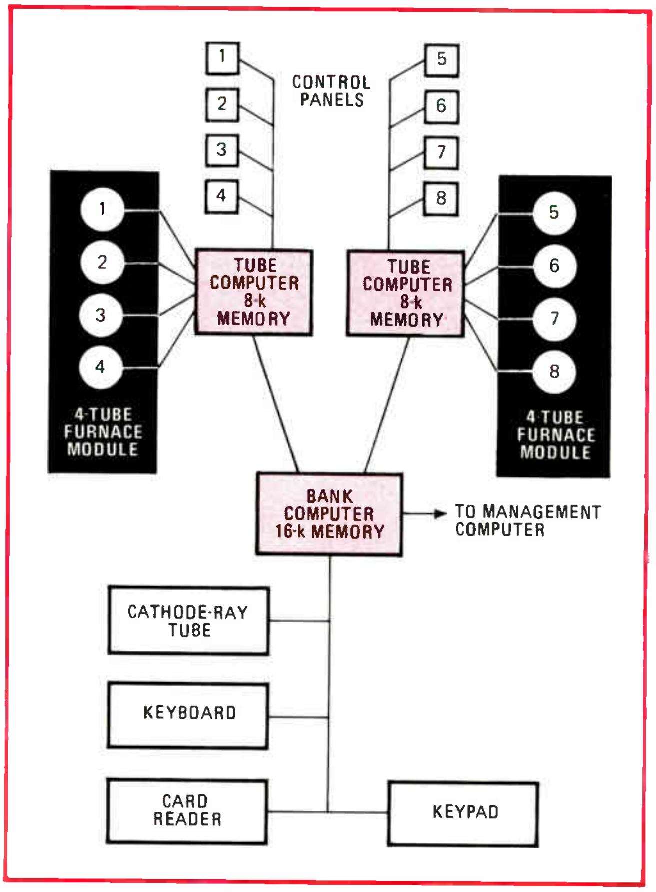
13. Diffusion. Time, temperature, and gas flow are controlled in the diffusion process. Note that temperature vs time functions use ramps rather than step functions to maintain process control.

Thermco's system (Fig. 15) uses three Computer Automation Inc. LSI 2/20 minicomputers: two to maintain direct digital control over two modules of four tubes each, and one to interface with the user and to serve a supervisory role over the two tube computers.

The Thermco setup does have one disadvantage. Failure of a tube computer disables the four tubes it controls, and there is no analog backup. However, the



14. Minicomputer control. One of the first approaches to automating multiple diffusion tubes was to let a minicomputer with a multiplexer act as the master controller. However, failure of either of these components disables all the diffusion tubes.



15. Direct control. Thermco's direct digital control system for an 8-tube diffusion furnace uses three LSI 2/20 minicomputers—one bank computer and two tube computers. Each tube computer controls four diffusion tubes and eliminates all analog controllers. The bank computer supervises the other two computers.

17. Microprocessor control. The Electroglas Model 1038 reflects the improvements that IC firms wanted in probers. It is microprocessor-controlled and has a cassette-to-cassette mechanical interface and Z-axis compensation for wafer warpage.

minicomputers have proved extremely reliable in use, Dunn maintains.

The next step is to introduce microprocessors. Bruce Industrial Controls has already demonstrated in a developmental model that it can adapt its processor-per-tube approach to direct digital control, and Thermco says that its next generation will use microprocessors.

After a wafer takes five to eight trips through the wafer-processing steps, it emerges for its first electrical tests at a probe station interfaced with a large automatic device tester. It is placed on a special staging plate and aligned with the tester. Then tungsten-tipped probes on a card fixed to a ring are placed in contact with each die's input/output pads.

Probing the future

Most IC producers are committed to probers that are manually loaded and semiautomatically aligned. An operator makes an initial alignment, and then the machine probes rows of dice sequentially.

This semiautomatic probing does increase yield by reducing operator error, but IC makers would prefer a cassette-to-cassette or in-line feed to the prober to further reduce damage. In fact, they would prefer to eliminate the operator, or at least to to reduce staffing to one person supervising as many as five machines. Such automation calls for microprocessor control of the aligning and probing steps.

Above all, prober users want Z-axis control. This feature is needed to compensate for the surface warpage of large processed wafers—which can be as much as 5 mils. With warped wafers, the prober can either damage dice or fail to contact them. Some semiconductor houses find that dice at the edge of wafers are rejected needlessly because of this effect.

The solution is Z-axis control, which senses the height of the wafer at each die and compensating by moving the wafer platform up or down. This feature is available on probers that are being field-tested: the Cobilt CP-4400, the Tac PR-100 from Teledyne Inc.'s Teledyne TAC division, Woburn, Mass., and the model 1038 from Electroglas Inc., Santa Clara, Calif.

In the Teledyne and Electroglas units, Z-axis sensing and compensation takes place with each die. The Cobilt prober maps wafer topography with capacitive sensors and then applies to each die a Z correction generated by an algorithm in an on-board microprocessor.

Only the CP-4400 has fully automatic wafer alignment, but Electroglas expects to have this important feature fairly soon. All three machines have cassette-to-cassette interfaces for wafer handling, and the Electroglas machine can be interfaced with GCA's in-line Wafertrac.

The 1038 (Fig. 16) uses a Motorola 6800 to store 10 separate test programs that can be loaded by a teletypewriter or an RS-232 communications interface. Coordinates of bad chips can be stored in the 6800's memory to help in discarding unusable dice. Cobilt also uses a microprocessor, but the Teledyne unit has hardwired logic for its programming. All three units can be controlled by an external computer.

Automation may eventually bring about a complete hands-off operation, all the way from sand to packaged chip. The manufacturers of the production equipment feel that advance will come soon, but IC firms are more conservative.

Certainly the yellow room's steps and the probing stations are approaching full conveyor-belt automation. But it is a fairly safe guess that it will take some years before the etching diffusion, ion implantation, and metalization procedures catch up, which leaves many steps still to be automated. □

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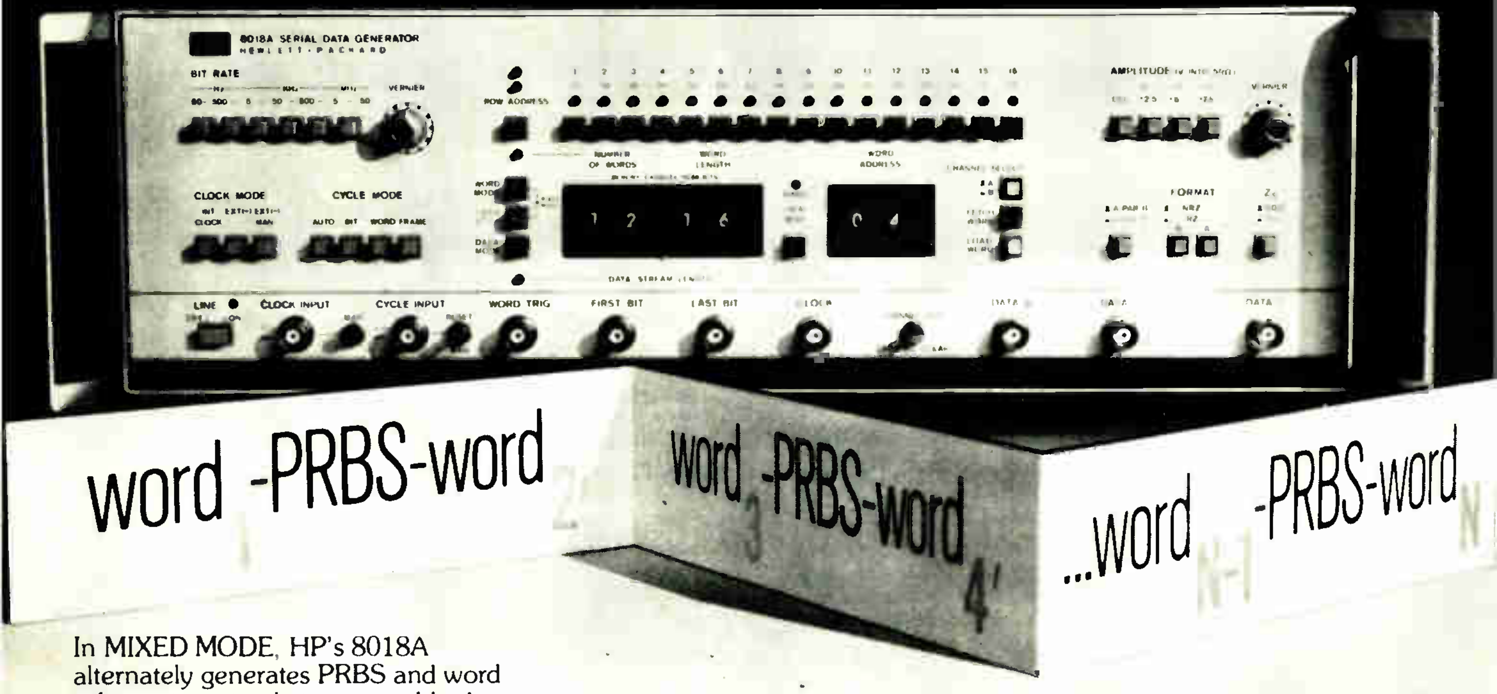

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Part 2: EEs feel impact of microprocessors

Poll, interviews say engineering education often lacks relevance

by Gerald M. Walker, *Senior Editor*

☐ What gives electronics engineers the greatest satisfaction on the job? Apparently, it's being creative—solving a problem, coming up with a successful design that is put into production and on the market. But the means available for solving design problems and the nature of the problems themselves change with each major advance in technology.

Today, it is the understanding and use of the microprocessor that is occupying a growing number of EEs in just about every sector of the electronics industries, as well as in enterprises previously untouched by electronics technology. Like the transistor and the integrated circuit before it, the microprocessor has forced engineers to seek additional education. In this case, however, many have had to learn about software to fully appreciate the microprocessor's capabilities. The expansion of their knowledge has in turn caused most EEs to think in terms of systems, to use functional modules rather than individual components, and to exercise their imaginations far more than was required a decade ago.

To find out how pervasive the effect of the microprocessor has been on EEs, *Electronics* included questions about its impact in a survey of readers conducted by the McGraw-Hill Research department. To augment the survey, *Electronics* also conducted interviews with EEs across the country for their views on the topics covered in the questionnaire. Their comments follow the survey results closely.

Microprocessors change the game

Not surprisingly, almost three quarters of the respondents, 72.9%, said that the introduction of advanced semiconductor technology has directly affected the way they do their job or the way their company's products are designed (Table 1). Almost the same percentage of respondents also believes that the application of large-scale integration and microprocessors will significantly alter their engineering

Career series: *With this issue,* Electronics *continues a three-part series of articles about electronics engineering as a career. Part 1 [July 7, p. 87] reviewed results of a survey of readers concerning attitudes toward their career, its satisfactions and frustrations. Part 2, in this issue, covers another vital section of the survey: the impact of microprocessors on the way* EEs *do their job. It includes comments culled from interviews with engineers around the country. Part 3, in the next issue, will conclude the series with personal statements by* EEs *on future career trends, both professional and technical.*

"The big change with microprocessors is in the hardware-software interaction. Firmware is becoming more and more important. What used to be done strictly with hardware now uses a microprocessor. To do the job, people are going to get involved in software."

Paul Severino, *Data Translation*

career. Within the electronic-systems and -equipment group, the highest percentage, 78.5%, was from electronics engineers for computer companies, as might be expected. But even 60.6% of those from consumer products manufacturers have felt the impact of large-scale integration and microprocessors.

Those who consider that the microprocessor has altered their job were impressed by the magnitude of the change, while those who have had little to do with the microprocessor tended to downgrade its significance. Thus comments such as "unlimited potential," "impact will be large," "will have to specialize to learn programming," and "advances always alter our lives" were common. A typical comment by those unaffected was "just another new component."

Although some older EEs complain that they are left out of assignments involving the application of new technologies in favor of younger engineers and therefore find it all the more difficult to keep up, results of the survey do not support that contention. The percentage of middle-aged EEs who reported that microprocessors have directly affected their job or their company's products is almost the same as the percentages of those in all the other age groups. But on the question of altering the course of their careers only the 50-and-over EEs show an appreciable difference—a lower percentage—from the under-30 group (Table 2).

Also, there is no major difference between engineers with advanced degrees and those with only a BS in the impact of semiconductor technology on their jobs. Of the former, 77.6% said microprocessors have directly affected their job, whereas 70.5% of the latter said their jobs were affected.

Continuing education—is it?

Some 58% of the respondents said they have had to learn about microprocessor applications and software for their job assignments (Table 3). Once again, there was no major variation by age or degree. There was, however, a fairly wide variation in the breakdown by company products. For example, 70.9% of EEs for computer and data-processing firms have had to learn about microprocessor applications, while less than half of the consumer products engineers have had to do so. In the subassemblies and components group, 74.1% of respondents from hardware and materials companies have had to learn microprocessor applications, compared with 50% from components producers. Among engineers for industrial and other users of electronics, 55.2% stated that they have had to learn microprocessor applications for their job assignments.

As for how they do it, a whopping majority—97.9%—

TABLE 1: HAS INTRODUCTION OF MICROPROCESSORS DIRECTLY AFFECTED THE WAY YOU DO YOUR JOB OR THE WAY YOUR COMPANY'S PRODUCTS ARE DESIGNED? (PERCENTAGES)

		Electronic systems / equipment									Subassemblies / components				Other manufacturers		
	Survey total	Total	Computer processing	Communications	Navigation and guidance	Aircraft, space, and undersea	Test and measurement	Consumer products	Industrial controls	Medical electronics	Total	Subassemblies	Components	Hardware and materials	Total	Industrial equipment	Miscellaneous
Yes	72.9	75.3	86.2	74.7	77.1	68.7	84.3	66.0	75.5	73.0	73.9	69.7	76.8	66.7	61.0	65.3	58.0
No	24.2	21.7	11.5	21.4	18.6	26.2	13.6	29.8	21.9	23.8	22.7	28.8	20.5	18.5	34.4	29.2	38.6
Don't know	1.8	1.9	2.3	2.6	1.7	3.0	2.1	3.2	2.0	1.6	1.7	—	1.8	11.1	3.2	2.8	3.4
No response	1.2	1.0	—	1.3	2.5	2.1	—	1.1	0.7	1.6	1.7	1.5	0.9	3.7	1.3	2.8	—

> **“The industry will grow faster and the engineer will be even more vulnerable to being cast aside. There will be pressure on the designer to keep his company in the forefront, because if the company cannot keep up with changing technology, it will cost the EE his job.”**
>
> Edward Rodriguez, *Theta-J Relays*

said that they use technical magazines and journals to keep up with the introduction of new technology (Table 4). College and company training courses were also mentioned by 61.9% of the respondents.

Although semiconductor technology has forced many EEs to keep up to date, some respondents doubt that engineering schools can keep up. Just under half, 49.7%, think that schools are capable of staying abreast of the latest technologies, 27.4% think not, and most of the remainder do not know. Among the comments concerning engineering schools were "hard to get qualified teachers for new material," "schools have time for basic theory only," "the field is moving too fast," and "textbooks are not coming out as fast as new design developments."

One of the most revealing results regarding an engineering education is that, asked whether they find their schoolwork relevant to the work they are now doing, only 44% of the respondents said yes. Almost 7% gave a definite no, and less than half, 47.7%, find their school studies partly relevant.

The responses to this question were broken down by career satisfaction, highest degree obtained, and age, with interesting results (Table 5). For instance, over half of the very satisfied, 54.4%, said their schooling is relevant to their job assignment. By contrast, two thirds of those dissatisfied with their careers are in jobs either not relevant or only partly relevant to their engineering schoolwork. EEs with advanced degrees are benefitting somewhat more from their school courses than are holders of bachelor degrees—49.4% to 41.3%, respectively—in terms of relevance.

The breakdown by age groups produced an unexpected finding. More than half of the EEs 50 years old and over said their schooling is relevant to their present work, but only 44.2% of the most recent graduates (those under 30) and even fewer of those in their thirties, just 38.3%, feel that way.

The breakdown by company products also turned up interesting differences (Table 6). Within the firms that make up the electronic-systems and -equipment group, over half the engineers for navigation and guidance systems makers find their education relevant to their work, compared with only 39.5% of those involved in computers.

A relatively new discipline, medical electronics, had 49.2% in assignments relevant to their school studies. Yet for the well-established test and measurement equipment group, fewer, 44.3%, said their school courses were relevant to their present work. Within the subassemblies and components group, the figures are 50.9% and 40.7%, respectively, for EEs in components and those in hardware and materials. (The latter had the highest percentage of "not-relevant" responses, as well.)

TABLE 2: DO YOU BELIEVE THAT APPLICATION OF LARGE-SCALE INTEGRATION AND MICROPROCESSORS WILL ALTER YOUR ENGINEERING CAREER SIGNIFICANTLY? (PERCENTAGES)

	Total	Highest degree		Age			
		BS	Advanced degree	Under 30	30–39	40–49	50 and over
Yes	71.7	72.8	71.4	74.4	74.7	70.4	61.5
No	21.0	20.6	21.4	17.6	17.9	23.1	32.4
Don't know	5.9	5.7	5.6	7.1	6.2	5.4	3.9
No response	1.4	0.9	1.7	1.0	1.1	1.1	2.2

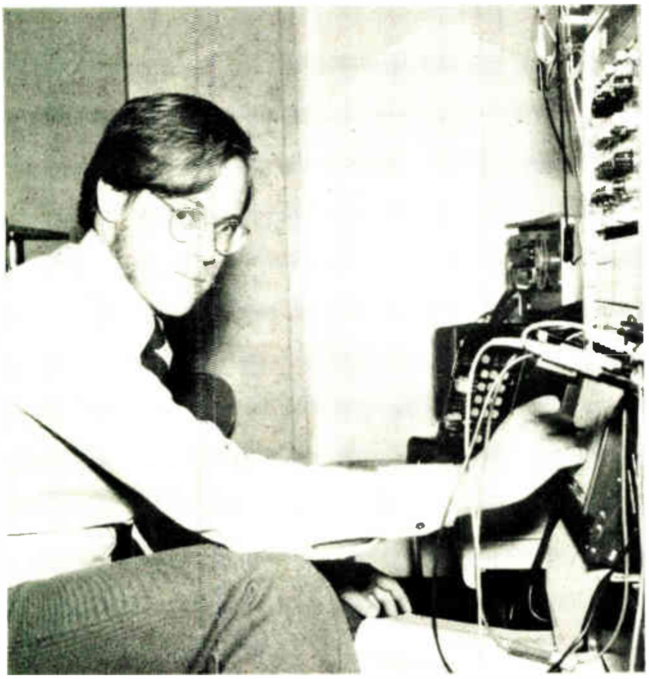
EEs comment on the career

The *Electronics* survey provides a fresh look at electronics engineering as a career and the views of EEs as they approach the 1980s. To flesh out the statistics of the *Electronics* survey, engineers across the country were interviewed at length. Their comments add a valuable perspective, bringing to life some of the results of the poll. The interviews emphasize the impact of the microprocessor, although not everyone agrees on how electronics engineers should handle the changes.

For instance, from a major supplier of microprocessors, Intel Corp., Santa Clara, Calif., executive vice president Andrew S. Grove states, "The spectrum of jobs is shifting. Sophisticated logic and computer functions will be available in the same package, and the engineer will need to know what to do with those blocks." Grove believes that by 1980 four fifths of the EEs will be working with design blocks and the other fifth will be building those blocks. There will be a strong interdisciplinary bent. In other words, Grove predicts, "the EE of the 1980s has to be a digital Renais-

"Engineering schools are out of touch with the real world. I came out with no gut feeling for a device, what characteristics to expect and how to analyze it in nonideal performance situations. My most valuable experience was a part-time job unrelated to my studies."

Mark Halverson, *Litton Industries*



sance man" to handle the variety of tasks.

Les Vadasz, Intel's vice president of engineering, agrees with Grove that engineers in the 1980s will have to have much broader knowledge than did engineers in the 1950s. He thinks they will need a good cross section of knowledge—not just of systems but of devices—as the traditional boundaries disappear. "If the EE of the next generation understands only devices or only systems, he's at a disadvantage," Vadasz explains, "because with the microprocessor you're essentially relating the total system capability back to the device."

Paul J. Severino, director of engineering for computer products and a partner in Data Translation Inc., Natick, Mass., adds, "The big change with microprocessors is in the hardware-software interaction. Firmware is becoming more and more important. What used to be done strictly with hardware now uses a microprocessor. To do the whole job, people are going to get involved in software, and that's going to require a change in education."

Edward T. Rodriguez, chairman and technical director of Theta-J Relays Inc., Bedford, Mass., believes that microprocessors will mean professional life or death for EEs. He sees an industry in the next 10 years in which every EE will have to be computer-oriented and will be under great pressure to keep up with new trends in technology. "The industry will grow faster and the engineer will be even more vulnerable to being cast aside. There will be pressure on a product designer to keep his company in the forefront of the art, because if the company cannot keep up with changing technology, it will cost the EE his job and the company its market position. If an engineer doesn't come up with new answers, he may have no place to work."

Reactions to engineering education mixed

While the microprocessor is changing the way EEs view their jobs, as well as the way they work, unchanged is the question of whether engineering schools adequately prepare engineers for today's demands. Questioning of the educational system goes back to the transistor and has continued through the development of integrated circuits right up to the era of large-scale integration.

Speaking for many recent graduates, one BSEE of the 1970s, Mark Halverson, judges his training as "in general not all that great." Now a rising senior systems engineer with three and a half years on the job at the Guidance and Control Systems division of Litton Industries, Woodland Hills, Calif., Halverson voices a charge often leveled against engineering schools: "They're out of touch with the real

TABLE 3: HAVE YOU HAD TO LEARN ABOUT MICROPROCESSOR APPLICATIONS AND MICROPROCESSOR SOFTWARE FOR YOUR JOB ASSIGNMENTS? (PERCENTAGES)

		Electronic systems / equipment									Subassemblies / components				Other manufacturers		
	Survey total	Total	Computer processing	Communications	Navigation and guidance	Aircraft, space, and undersea	Test and measurement	Consumer products	Industrial controls	Medical electronics	Total	Subassemblies	Components	Hardware and materials	Total	Industrial equipment	Miscellaneous
Yes	58.4	60.8	70.9	55.5	60.2	54.1	67.1	46.8	68.9	60.3	54.0	62.1	50.0	74.1	55.2	58.3	53.4
No	39.6	37.8	26.8	43.2	36.4	43.3	32.1	50.0	29.8	36.5	43.8	37.9	47.3	22.2	42.2	38.9	44.3
No response	1.9	1.4	2.3	1.3	3.4	2.6	0.7	3.2	1.3	3.2	2.3	–	2.7	3.7	2.6	2.8	2.3

"Schools and industry have to do some soul-searching about how better to prepare students for a fast-changing industry. But the universities can't keep up with new technologies. The emphasis should be on how the person uses materials to solve problems."

Andrew Varadi, *National Semiconductor*

world." Specifically, he believes, "the curriculum was weak in the applied aspects of the field," which was reflected in poor laboratory courses and training in statistical analyses of devices.

The teaching of theory was fine, in Halverson's view, but the courses failed to relate it to practical applications. "I came out with no gut feeling for a device, what characteristics to expect, and how to analyze its performance in non-ideal situations. My most valuable experience in school, in fact, was a part-time job in the university's radiation lab, which was unrelated to my studies, but was actual engineering work experience."

His biggest surprise when he went to work for Litton was the amount of independence permitted on the job. "They gave you the problem to solve, and it was up to you. The situation is professional and rewarding."

Because large-scale-integrated devices and microprocessors are absorbing more and more systems functions, significant changes in the education of engineers entering the semiconductor sector will be necessary, according to Andrew Varadi, director of memory components operations at National Semiconductor Corp., Santa Clara, Calif. The industry needs people with specific abilities, but also with a broad overview, says Varadi. "The schools are not preparing people with the background. It takes about two years before a college graduate is contributing to the bottom line of a company." Schools and industry, he continues, have to do some "soul-searching about how better to prepare students for a fast-changing industry. But the universities can't keep up with the new technologies."

TABLE 4: HOW DO YOU KEEP UP WITH THE INTRODUCTION OF NEW TECHNOLOGY ? (PERCENTAGES)

	Total	Highest degree		Age			
		BS	Advanced degree	Under 30	30–39	40–49	50 and over
Technical magazines and journals	97.9	98.6	97.0	98.4	97.5	97.8	98.3
Company training courses	30.5	31.8	29.5	32.7	27.7	35.4	28.5
College courses	31.4	30.5	31.4	40.4	32.6	25.3	22.3
Home study	4.1	3.6	4.5	3.8	4.7	4.7	1.7
Books, library	4.4	3.6	5.1	2.9	5.5	2.9	6.1
Experimentation, self-assigned projects	2.3	3.2	0.9	2.6	2.8	0.7	2.8
Vendor product data	3.5	3.4	3.6	2.9	3.4	4.3	3.4
Miscellaneous and correspondence school courses	1.8	1.6	1.7	0.6	1.7	2.9	2.8
Seminars	5.0	4.2	7.3	3.2	5.3	7.2	3.9
Interchange with knowledgeable associates	3.1	2.3	5.1	3.2	2.6	4.3	2.8
Other methods	1.0	0.9	1.1	1.0	0.6	1.8	1.1
See no need to keep up	0.4	0.3	0.6	0.3	0.6	–	0.6
No response	0.7	0.6	0.4	0.3	0.4	0.7	1.7

Varadi underlines the importance of courses that stress problem solving. "Some test problems are reduced to yes and no answers and regurgitating what was taught in class. Instead, the emphasis should be on how the person uses materials to solve problems."

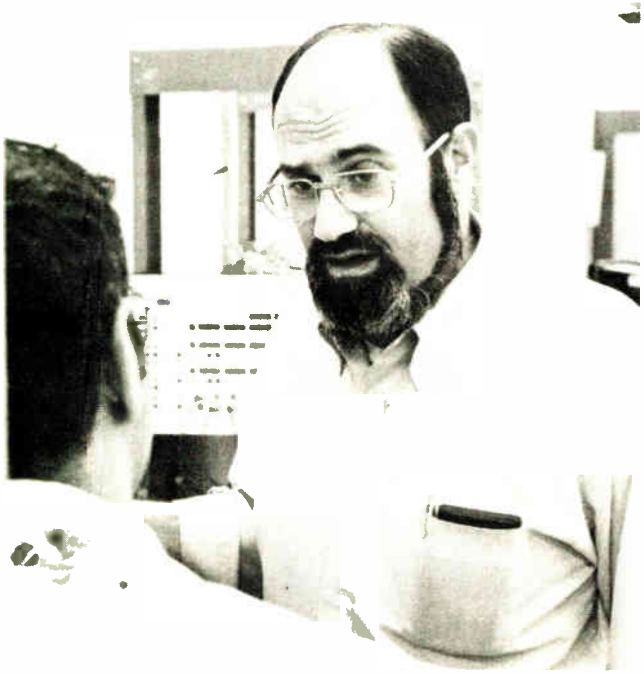
Many academics, however, do not agree with these complaints. They point out that there is and always has been a fairly wide gap between the good, up-to-date engineering schools and the mediocre ones, for which the complaints may be true. In addition, they argue, the purpose of engineering training is to teach the basic, unchanging principles of engineering even at the risk of appearing to be out of step with current technology.

Speaking for one of the prestigous schools, John G. Linvill, chairman of the department of electrical engineering at Stanford University, Palo Alto, Calif., says that electronics engineering students at Stanford are getting the kind of education they need to enter the rapidly changing electronics industries. However, he admits that Stanford may be unique in its proximity to the Silicon Valley semiconductor complex, as well as to other electronics equipment firms, including Hewlett-Packard.

Linvill notes that Stanford has a cooperative program with semiconductor companies involving the use of closed-circuit television transmitted from the company plants to the school's classrooms. "That made the university and

"I'd like to see the IEEE take a more active part in promoting our health and welfare. The AMA and the ABA do a good job, whereas the IEEE doesn't do anything. Working engineers might take a bigger hand in the IEEE, but it takes time that they devote to their jobs."

Paul Groner, *Varian Data Machines*



industry in this area really grow together."

According to Linvill, there will be fewer Ph.D.s as the electronics industries begin to de-emphasize basic research in favor of product applications. As a result, he expects that more and more EEs will find a master's degree adequate.

How useful is an MBA?

For some time now, a number of engineers have pursued a graduate degree in business administration rather than in engineering, assuming that such a degree would help them shift to management. However, a recent study of such engineers raises questions about whether the decision to pursue management studies is well-advised or part of a well-planned effort for career advancement. Peter Pleshko of IBM Systems Communications division, Kingston, N. Y., himself an EE with an MBA, queried 45 engineers who were MBA candidates. Pleshko found that most had not discussed their decision with their manager before enrolling in the MBA program.

In a talk at the recent Electro77 conference, Pleshko pointed out that although the reasons given by the group for getting an MBA were both job advancement and job enrichment, the degree seems to provide more enrichment than advancement. "It is not clear that employee graduate education in this area brings any direct benefit," he stated. "Little data exist which describe the benefits of the MBA for scientific and engineering personnel." Pleshko believes that, since companies usually foot all or part of the tuition for advanced degrees, management should take more interest in advising MBA candidates from engineering departments on the potential career value, if any, of such studies.

Professionalism: go it alone or unite?

Engineering as a profession has usually been enhanced by EEs operating individually—as a result of either a technical breakthrough or an important promotion. Only in the last five to six years has there been thought given to what engineers can gain for themselves by uniting. During this period, for example the Institute of Electrical and Electronics Engineers has turned some of its attention and dues dollars from supplying technical information to advancing electronics engineering as a profession. How effective the IEEE has been in this pursuit is still a matter of debate, but it is symptomatic of a change in engineers' traditional attitudes of self-reliance.

Indeed, the *Electronics* survey reviewed in Part 1 of this series found that 70.3% of the respondents want their companies to take a direct part in advancing engineers' careers. Moreover, a large majority of those belonging to the IEEE, 72.4%, support the institute's efforts to improve the professional status of EEs. However, a majority of the respondents are not even members of the IEEE. Less than a third, 29.4%, think that the Federal Government should sponsor training programs to help EEs cope with layoffs. And unchanged is the negative response toward forming an EEs' union. Thus, although there has been growing concern for a united effort to achieve certain professional goals, it appears that in some ways EEs still prefer to go it alone.

Addressing the conflict between individual versus group effort, Paul Groner, manager of circuit design at Varian Data Machines, Irvine, Calif., a subsidiary of Varian Associates, points to a list of needs that only a national organiza-

TABLE 5: DO YOU FIND YOUR ENGINEERING SCHOOLING RELEVANT TO THE WORK YOU ARE NOW DOING?
(PERCENTAGES, BY CAREER SATISFACTION, HIGHEST DEGREE OBTAINED, AND AGE)

	Total	Satisfaction with engineering career			Highest degree		Age			
		Very satisfied	Moderately satisfied	Dissatisfied	BS	Advanced degree	Under 30	30 – 39	40 – 49	50 and over
Yes	44.0	54.4	41.1	31.3	41.3	49.4	44.2	38.3	48.0	54.2
No	6.7	4.2	6.6	11.8	8.0	4.9	7.7	6.0	7.2	6.1
Partly	47.7	40.0	50.5	55.9	49.7	44.9	47.4	53.4	43.7	37.4
No response	1.6	1.4	1.8	1.0	1.0	0.9	0.6	2.3	1.1	2.2

"The microprocessor is forcing logic designers to become more aware of software, to become computer designers. Overall, the microprocessor will expand the opportunities for EEs because electronics engineers will be the prime motivators behind using these things."

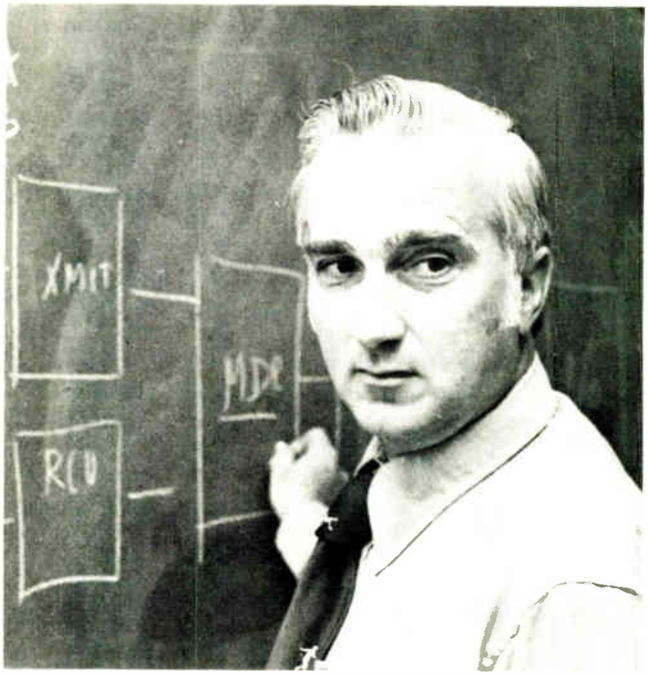
Christopher Witt, *Grumman Aerospace*

tion can tackle. Among the goals, he includes tax benefits for salaried professionals, sabbatical leaves, and portable pensions. "I'd like to see the IEEE take a more active part in promoting our health and welfare," he says.

But Groner would not like the institute to turn into a union. "A union is a mixed blessing: on the one hand abhorrent to an engineer, but on the other a good thing. The American Medical Association and the American Bar Association do a good job, whereas the IEEE doesn't do anything. Then again, no engineer wants to get to the point where a shop steward tells hims not to pick up a soldering iron. Working engineers might take a bigger hand in the IEEE, but it takes time that they would rather devote to their jobs."

Another EE who feels no need for a union is Christopher Witt, manager of systems engineering at Grumman Aerospace Corp., Bethpage, N. Y. A member of the IEEE and, as a licensed professional engineer in the State of New York, of the National Society of Professional Engineers, Witt says, "I consider these two organizations to be more than adequate representation." Nonetheless, Witt would like to see the institute work to advance EEs professionally. He mentions pensions and age discrimination. Equally important, he adds, "I would like to see a more powerful lobby, one that understands the industry and is a source of information to legislators. It's a must."

But if anything is going to be done for engineers, it is going to have to be done by the engineers themselves, says Faith Lee, an engineer at RCA Corp.'s Solid State division in Somerville, N. J. "Because of the tremendous competitive situation in the United States, companies generally can't afford to do anything about the engineer who does not have a pension, who doesn't have decent working conditions, or who is being discriminated against. If an engineer wants to see something done about these issues, then the engineer will have to get off his or her duff," she asserts. "The



average employed engineer will have to take over the IEEE. They'll have to start voting, running for office, and in other ways make their desires clearly known, or they'll be no better off."

Coming down on the side of individual effort, Diana Hendry, section head for memory software at National Semiconductor, says, "If I hadn't put forth the extra effort on my own to gain the extra background, I wouldn't be where I am today." However, she adds that, once an engineer demonstrates eagerness to move up, a company should help. (National reimburses employees for job-related outside education in which they get a B or better). "It's

TABLE 6: DO YOU FIND YOUR ENGINEERING SCHOOLING RELEVANT TO THE WORK YOU ARE NOW DOING?
(PERCENTAGES, BY TYPE OF COMPANY)

		Electronic systems / equipment									Subassemblies / components				Other manufacturers		
	Survey total	Total	Computer processing	Communications	Navigation and guidance	Aircraft, space, and undersea	Test and measurement	Consumer products	Industrial controls	Medical electronics	Total	Subassemblies	Components	Hardware and materials	Total	Industrial equipment	Miscellaneous
Yes	44.0	43.9	39.5	46.7	51.7	47.6	44.3	46.8	41.1	49.2	48.3	47.0	50.9	40.7	47.4	47.2	45.5
No	6.7	6.6	7.7	6.1	5.9	5.2	5.0	9.6	7.3	9.5	6.8	6.1	5.4	18.5	3.9	2.8	5.7
Partly	47.7	47.8	52.1	45.4	41.5	46.8	47.9	41.5	49.0	38.1	43.8	47.0	42.0	37.0	48.1	48.6	48.9
No response	1.6	1.8	0.8	1.7	0.8	0.4	2.9	2.1	2.6	3.2	1.1	–	1.8	3.7	0.6	1.4	–

"If I hadn't put forth the extra effort on my own to gain the extra background, I wouldn't be where I am today. But once an engineer demonstrates eagerness to move up, a company should help, because it's tough going to school and working at the same time."

Diana Hendry, *National Semiconductor*

tough going to school and working," she admits. "You see people doing homework during their lunch break."

To Paul Severino of Data Translation, because the EE is tied to demand over which he has no control, he is the one who gets hurt when demand drops, not the employer. The solution, he thinks, would be to limit the number of EEs, starting by making it tougher to get into graduate schools. "If the supply were regulated, then the employer would have to be concerned more with how he treats his people. Put the onus on the other side instead of leaving the engineer open to being chopped down in midcareer." Severino maintains that "the whole idea of a career is to be able to grow. If the profession were controlled, engineers would have to do that."

He also thinks that corporate salary structures are unfair. "There's no reason why the top engineering guy shouldn't make as much money as the top sales guy. The sales response is that their jobs are riskier, but I disagree. The engineer puts his career on the line every time he designs a product. In a technical company, products come from the designers. If I'm going to work, I don't want someone else to reap the benefits—and that's what happens to engineers."

"Many people get out of school, see an open road, and assume they'll arrive at their destination," observes Edward Rodriguez of Theta-J Relays. "What they don't realize is that the road changes along the way. Every engineer with half a brain should look at his first seven years after graduation as training. He should pick the brains of everyone he works for so that if anything happens, if he loses his job, at least he's made good use of his time."

Further, says Rodriguez, "if an engineer wants to make money, he should know that he's not going to do it in a big company. Large companies don't train people, they just keep moving them up and then ask why they're not doing a good job."

In dealing with changing technology and enhancing the profession, it is likely that the combination of individual effort and group activism will continue as EEs enter the 1980s. Part 3 of this series, which will appear in the next issue, expands this analysis of electronics engineering as a career by presenting the views of several engineers who have thought very seriously about where electronics engineering is headed. □

Motivating engineers

Today's electronics engineers are often frustrated, dissatisfied, and alienated by the bureaucratic controls and excessive focus on organizational efficiency of traditional management methods. That is the conclusion of M. K. Badawy of Cleveland State University, who has conducted research on motivating engineers.

To overcome these problems, he suggests these rules, based on his study of working engineers:

- Treat engineers as professionals. They should be given the information and tools to do their job and the opportunity to review, appraise, and judge their own performance.
- Enhance the managerial competency of engineering managers. Do not promote the technically competent to management jobs simply for their technical know-how. Identify potential engineering managers early and develop their potential. Include management training in the engineering educational system.
- Establish the right climate. Companies should design a more decentralized and less formal organizational structure, with a variety of opportunities for communication, interaction, and participation.
- Improve career planning for older engineers. Diversity in assignments is a vital ingredient in maintaining a productive and satisfying career for older professionals. Pushing technical personnel into new fields will broaden their interests and have a significant effect on their motivation and productivity.

Badawy points out that, while it is the responsibility of the engineering manager to create the conditions that will motivate engineers, it is the responsibility of the individual engineer to take advantage of the situation and promote his personal as well as the organization's goals—in other words, what's good for the individual may be good for the company.

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Nonmaskable interrupt saves processor register contents

by Ivars P. Breikss
Honeywell Inc., Test Instruments Division, Denver, Colo.

Linking a battery-powered random-access memory to the nonmaskable interrupt input available on many microprocessors will save the contents of the memory registers in a microprocessor system during power loss. The NMI input is used to initiate a software routine that, when alerted to a power loss by such means as a power-line relay, stores the contents of the registers in the RAM and then disables the RAM's inputs. These registers require such protection of their status if the microprocessor is to continue execution of the program at the point at which it left off when power failure occurred.

The data-save circuit may be implemented as shown in the figure, using two 5101 complementary-metal-oxide-semiconductor RAMs in conjunction with the 6800/6820 combination of microprocessor and peripheral interface adapter. Since each RAM is organized as a 256-word-by-4-bit array, this 8-bit system requires two of them, configured as a 256-word-by-8-bit device. A set-reset flip-flop, built by cross-connecting two C-MOS two-input NAND gates, controls the data-enable port of the RAMs. The flip-flop and the RAMs are powered by a 4.5-volt battery if the main power is lost.

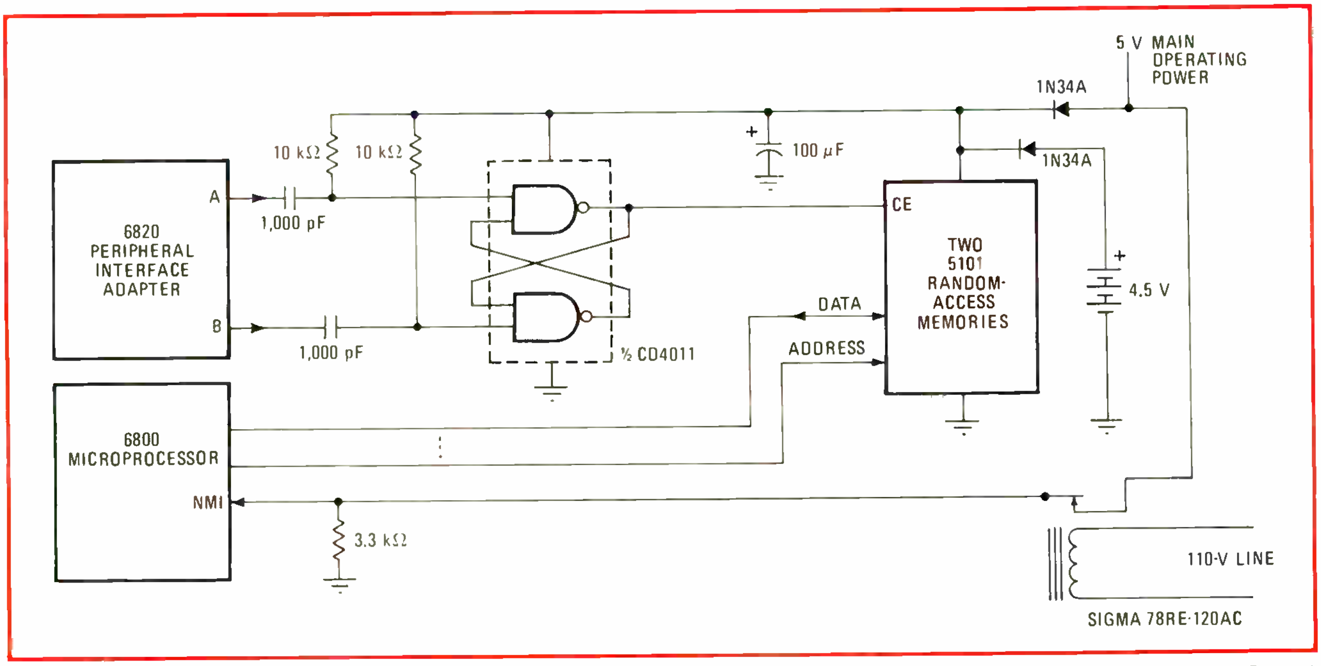
During system startup, a pulsed logic 1 signal is generated at the A output of the PIA through software control. The negative-going edge of this pulse sets the flip-flop and drives the control-enable lead (CE) of the RAMs. This allows desired system parameters, which may have taken hours to determine initially, to be stored in the RAM for protection from power failure.

During a power-down cycle, the address and data lines of the RAM will usually assume random logic states for several milliseconds. This condition is likely to destroy or modify the contents of the RAM unless a logic 0 is applied to the CE input at least a few microseconds before the main power is lost.

A loss of line voltage causes the relay to open; once the operating voltage drops below 4.5 V the battery immediately assumes the power-delivery chores to the RAM and flip-flop. Loss of voltage to the microprocessor and PIA occurs approximately 25 ms later; a pulse must be delivered to the CE port of the RAM before that time.

Relay dropout initiates the NMI sequence. The NMI input, which was at 5 V, drops rapidly. The negative-going transition terminates normal program execution and initiates the interrupt sequence. During this time, an output pulse is generated at port B or the PIA. Its negative edge clears the flip-flop, disabling the RAM by removing its CE signal. This occurs before operating power collapses; thus the RAM's content is not upset. Capacitive coupling between the PIA and the flip-flop is employed to prevent false triggering which may occur during power loss.

This circuit is exceptionally reliable and consumes little power. A small 4.5-V battery will store 256 8-bit words for more than a year if necessary. □



To the rescue. Should power to microprocessor or PIA fail, data in their registers is stored in battery-powered RAMs for protection. Control-enable line of RAMs is enabled during normal operation, disabled on power-down to prevent modification of RAM contents.

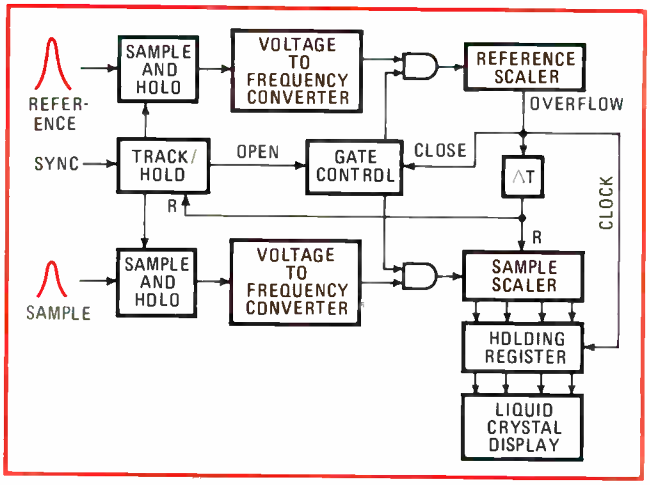
Digital normalizer derives ratio of two analog signals

by James H. McQuaid
University of California, Lawrence Livermore Laboratory, Livermore, Calif.

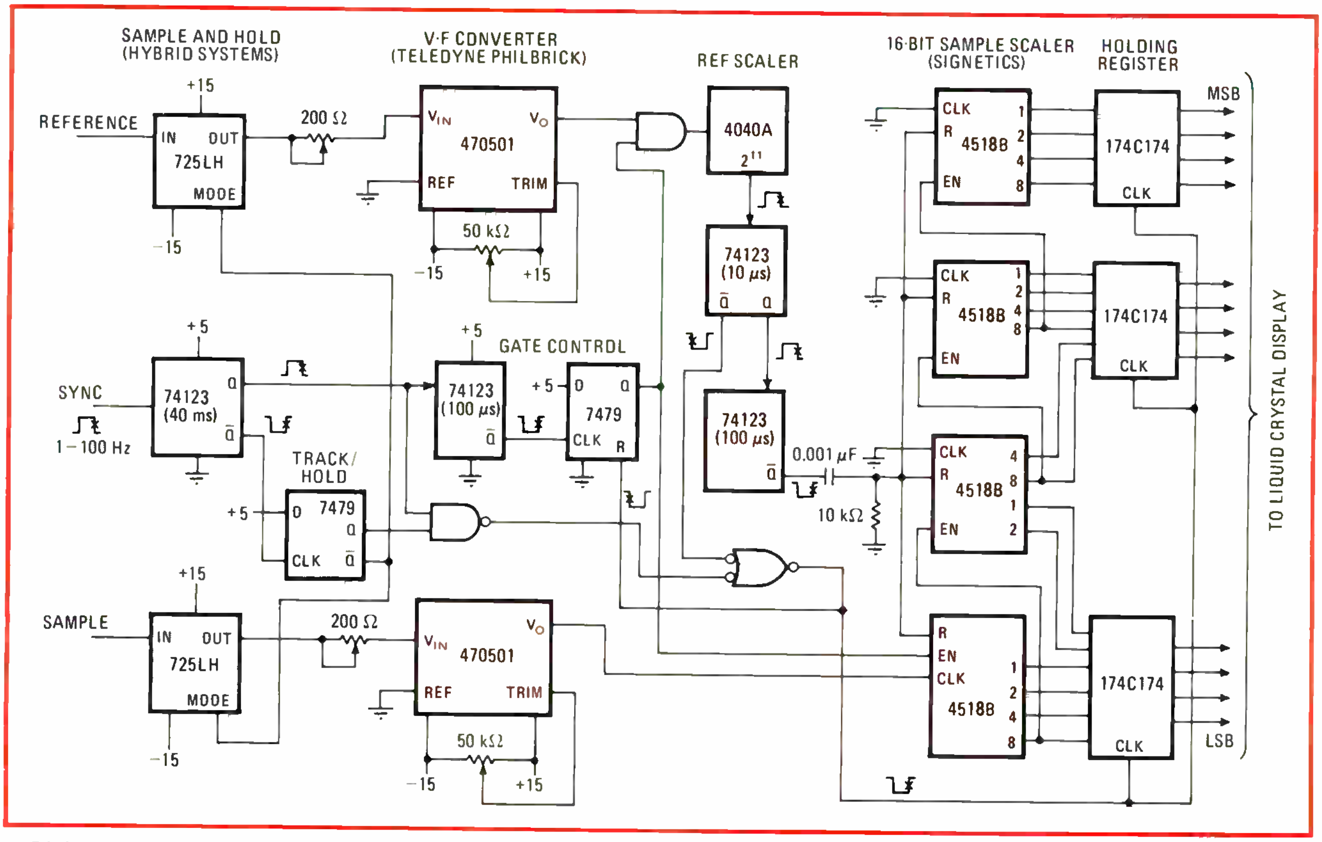
The absolute value of a voltage or current at a circuit point is frequently less important than the ratio of that quantity to a reference. This circuit compares two analog signals by using a high-accuracy digital technique for normalizing the reference voltage, thus simplifying circuitry and avoiding the use of analog dividers or microprocessors. It is invaluable in many light-chopping applications, such as lasers, where the measurement of light intensity at a specific frequency must take into account total source-intensity variations. It is also useful in atmospheric physics when measuring the concentration of a specific gas in a mixture by infrared techniques in which the intensity of the beam is subject to drift.

As shown in the block diagram (Fig. 1), the reference and sample signals are each introduced to a sample-and-hold circuit. Peak-detection circuitry in this device, in conjunction with track-and-hold logic, which controls the sample rate, produces a voltage output that is presented to their respective voltage-to-frequency converters. Each converter's output is a pulse train with a frequency directly proportional to the input voltage.

The track-and-hold logic and associated gating circuits simultaneously initialize both scalar circuits and allow the output pulse train of both converters to be counted. When the count in the reference scaler exceeds its capacity, an overflow pulse is generated that closes the gating circuit; at this time, the contents of the sample scaler are clocked into the holding register and then sent to the display. The contents of the reference scaler are regarded as a unit voltage, and the reference scaler



1. Ratio meter. Voltage comparison of analog sample to time-dependent reference uses analog-to-digital converters. Voltages are converted to frequency and counted. Reference count normalized to unity serves as gating signal to count number in sample counter. Output of circuit yields ratio of sample to reference voltage.



2. Digital normalization. Circuit detects relationship of analog sample amplitude to reference voltage by digital means. Several one-shots are used to obtain proper timing and gating. Circuit uses C-MOS devices where possible to reduce power consumption.

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controls the gating time to the sample scaler. Thus the contents of the holding register will normally be some fraction of the unity-set voltage. The sample scaler and sampling circuits are then reset, ready to process the next sample.

As shown in Fig. 2, the sample-and-hold devices are Hybrid Systems 725LH devices, which are accurate to within 0.01% and have a droop rate of 15 millivolts per second using their internal holding capacitor. The sync input used to control the sampling period is a 5-volt, 1-to-100-hertz pulsed voltage. The converters are Teledyne Philbrick 470501 devices with an upper limiting frequency of about 1 megahertz. This frequency is produced at an input of 10 V, and the device's voltage-frequency characteristic is linear to 0.005%. The converter may be easily calibrated with its 50-kilohm trimmer potentiometer and the 200-ohm rheostat at the output of the 725LH device.

The 4040 reference scaler is a 12-bit binary counter. After reaching its counting capacity (1,024) during a given sampling period, it clocks the contents of the Signetics 4518B into the 174C174 C-MOS holding register while resetting the gating circuits. The sample scaler capacity (16 bits) and the large reference scaler capacity (12 bits) ensure a high counting accuracy, typically to within 0.1%. In addition, the larger capacity of the sample scaler allows the signal amplitude to exceed the reference amplitude while the correct ratio is still displayed.

The ΔT function in the block diagram is a small but important part of the circuit. It is implemented as shown in Fig. 2 with a number of one shots to achieve correct timing and edge triggering for data transfer. The digitizing time for the circuit shown is 4 milliseconds. Greater speed (with less accuracy) can be easily achieved by reducing the number of bits in the reference scaler. For instance, a digitizing time of 250 microseconds may be achieved with an 8-bit reference scaler. □

Differentiator and latch form synchronous one-shot

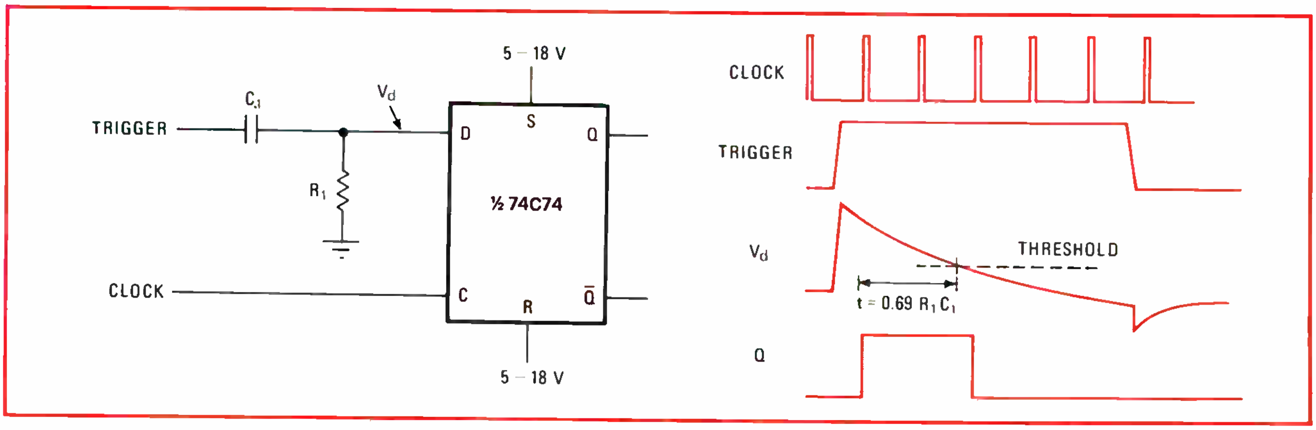
by Chacko C. Neroth
Amdahl Corp., Sunnyvale, Calif.

Many logic circuits require all operations to be synchronized with the system clock, including the firing of monostable multivibrators, even though the input signals to the one-shot are time-independent. However, a synchronous one-shot may be implemented using a D flip-flop and a differentiator network. In essence, the circuit substitutes a differentiator at the D input for a timing network in the one-shot in order to provide either immediate or time-delayed synchronous operation upon the arrival of a suitable trigger.

As shown in the figure, a positive-going input signal is applied to the D input of the 74C74 complementary-metal-oxide-semiconductor device through the resistance-capacitance network R_1C_1. The state of the flip-flop, which depends on the logic level at the D input during a clock pulse at the C input, assumes a 1 value at the arrival of the first clock. The output remains high until the voltage across the resistor has decayed below the 1 threshold of the D input (because of capacitor discharge), and the next clock occurs at the C input. Thus, assuming the clock period is high compared with the R_1C_1 period, the approximate pulse width, or on time, of the flip-flop is equal to 0.69 R_1C_1; the exact width of the pulse is an integral number of clock periods during which the D input is high.

The logic threshold of the C-MOS device at the D input is almost proportional to the supply voltage; therefore the pulse width output is relatively insensitive to supply voltage variations. For best results, the resistance-capacitance network should be selected to ensure that a decay in voltage across the resistor reaches the threshold level at the D input halfway between clock periods. Operation with negative-edge triggers is possible if R_1 is connected to the positive supply line instead of ground. □

Designer's casebook is a regular feature in *Electronics*. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.



Monostable controller. Synchronous multivibrator is formed by differentiator and flip-flop, permitting initialization of clocked system by asynchronous data. Pulse width of multivibrator is determined by time constant of differentiator and clock rate.

Fast emulator debugs 8085-based microcomputers in real time

New module even checks contents of intelligent peripheral chips and monitors activity at other critical circuit locations

by Michael Yaotung Yen,
Intel Corp., Santa Clara, Calif.

☐ Spurred on by the frantic pace of semiconductor technology, microprocessors are faster than ever, and peripheral chips are so smart that some of them are more complex even than the processors they serve. To keep up with these advances, the Intellec Microcomputer Development System has been updated with the ICE-85 in-circuit emulator.

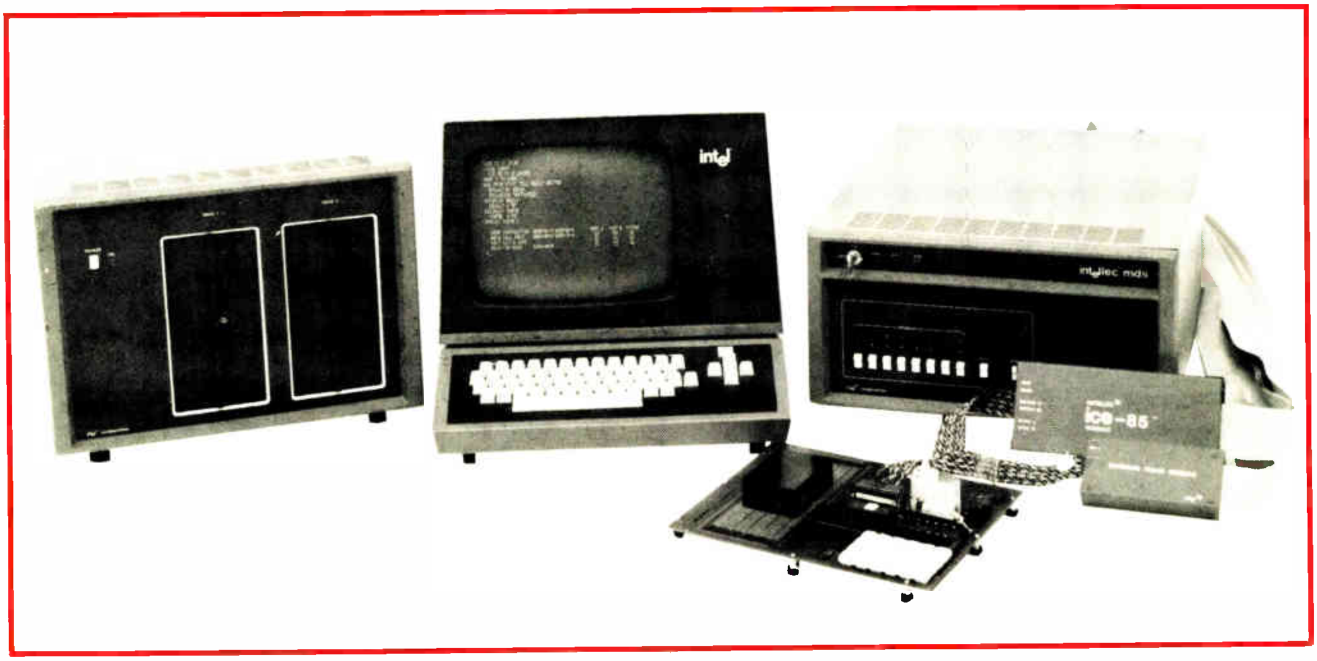
In-circuit emulation in effect extends the debugging capabilities of a software development system to the prototype microcomputer system (see "The ICE module reviewed," p. 110). By enabling the hardware and the software to be developed concurrently, the first generation of such development systems improved significantly on earlier methods of prototyping microcomputers. But the high speed of new microprocessors like the 8085 and the complexity of prototyping with smart peripheral chips required redesign of the plug-in ICE module, and the first of this second generation (pictured below) now allows much more rapid development of systems based on the 8085 microprocessor.

A series of hardware and software innovations provides the second-generation ICE-85 module with the following capabilities:

- Real-time emulation of the operation of the high-speed 8085 processor.
- User-tailored in-system diagnostics for use on peripheral chips.
- Significantly increased logic-analysis capability compared with previous ICE modules.
- Enhanced symbolic debugging.
- Display of the contents of the trace buffer in assembler mnemonics.

The problem of speed

One of the most important features of an ICE is real-time emulation of the processor, which allows the prototype system to operate at its full speed when using ICE. As the speed of microprocessors increases, this feature becomes difficult to achieve, primarily because of delays



in the signal cable. Previous emulators, typified by the ICE-80 developed for the 8080A, can operate only up to about a 2-megahertz clock rate, whereas the ICE-85 emulation module can run at the 8085's 3-MHz rate or even at higher speeds.

The first-generation ICE is shown in Fig. 1. The ICE cable plugs into the microprocessor socket in the user's prototype system, and there is about 6 feet of cable between it and the emulating microprocessor chip. Because of the length of this cable, the associated signal propagation delays to and from the emulating processor must be compensated for by a faster central processing unit in the emulated hardware. The ICE-80 module uses this technique to accomplish real-time emulation. However, in the case of high-speed processors such as the 3-MHz 8085, the propagation delays in the connecting cable are so significant that they can no longer be compensated for simply by installing a faster processing unit.

Close to the action

The ICE-85 module solves this problem by locating the emulating microprocessor chip on the plug at the end of the ICE cable, rather than inside the development system (Fig. 2), and it also has a significant portion of the emulator circuitry in a nearby cable box built into the cable assembly (Fig. 3). Thus, time-critical signals to and from the prototype memory and peripheral circuits reach the microprocessor chip without traveling through any cable. Only those signals requiring data multiplexing will incur a 1-foot cable delay to the cable box. However, since no real-time emulation signals travel on the 5-foot cable and buffer, these critical delays are essentially eliminated.

Mounting the microprocessor on the plug provides another important feature. The clock crystal circuitry of the 8085 processor chip is sensitive to an external capacitive load, and cable connections should be avoided. Since the processor chip is mounted on the cable plug, no cable connection is necessary to these crystal pins, and thus the ICE-85 module can operate from the crystal in the prototype system, which aids in checking out that circuitry. Also in the cable plug assembly is some simple multiplexing circuitry that directs data flows between the microprocessor chip, the prototype system, and the ICE cable box.

Peripheral chips are becoming highly integrated and also now require ICE-like diagnostic tools. Although an ICE could be developed for each peripheral chip, such a move is rather impractical. An ICE is a sophisticated product, and procurement of multiple development systems to house multiple ICE modules would be expensive. Also, synchronization of the multiple ICEs would be a difficult task, and controlling several modules from separate Intellec consoles would be confusing to a good many designers.

Another problem is the protocol that is used by peripheral chips to communicate with the central processor and which may require multiple input/output or memory accesses or both. With earlier ICE designs, a designer had no convenient way of executing the protocols for interrogating and changing the internal status of peripheral chips. The ICE-85 module, however, extends its diagnostic capabilities beyond the 8085 processor chip to include coverage of the peripheral chips, allowing total system diagnostics.

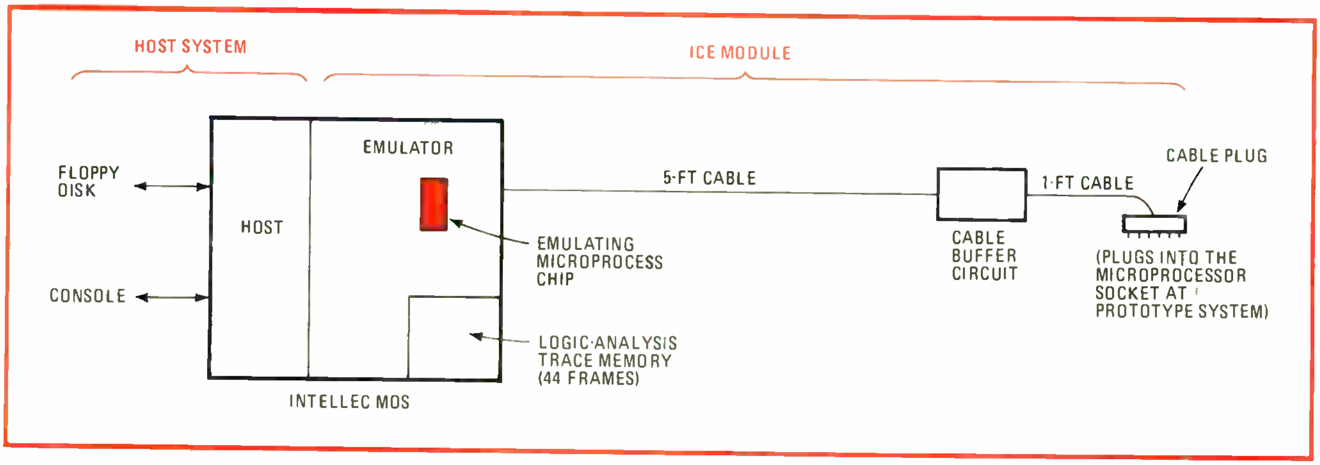
Handling the peripherals

First, ICE-85 software provides a "user macrocommand" capability to cover the processor routine required to change the peripheral chip's operation mode, change the chip's data-output ports, read the chip's status, or read the chip's data-input ports. The user defines this command routine and furthermore can assign it a symbolic macroname. Under this name, the macrocommand will be accepted at the ICE console and then executed in a manner transparent to the execution of the user development program.

This concept of symbolic control of peripheral chips can be further expanded. Since one macroroutine may be defined by a designer to access other macroroutines, it is enough to enter one simple high-level macrocommand at the console to display the contents of one or more peripheral chips.

A designer thus can type a simple macrocommand and cause ICE to interrogate and display the status of the

1. First generation. The ICE-80 module, for development of systems based on the 8080 microprocessor, has the emulating microprocessor inside the Intellec mainframe and linked to the prototype by 6 feet of cable. But cable delays limit emulation speed.



The ICE module reviewed

An in-circuit emulator creates a complete microcomputer development system by operating in conjunction with a host system generally used for software development. The ICE module connects to the user's prototype, extending the host system's capabilities to the hardware prototyping and software-hardware integration of the microcomputer. With ICE, the prototype can be debugged through the development system while it is trying out developmental programs that may reside either in the host system memory or in program memory on the prototype board.

The operation of the prototype's microprocessor is emulated by a similar microprocessor in the emulator. The module's support circuitry and software add diagnostic capabilities that would be impractical or impossible to add to the prototype itself. With an ICE module installed, the designer can run his developmental program in real time on the prototype.

An ICE generally operates in three modes: interrogation, run emulation, and single-step.

The interrogation mode occurs whenever user code is not being executed. In this mode, the user can investigate the results of the last operation and prepare the prototype system for a new operation by:

- Displaying or altering the internal registers, program counter, and stack pointer of the microprocessor and the memory locations or input/output ports of the prototype microcomputer system.
- Specifying an emulation breakpoint for a number of different conditions, such as memory read, memory write, instruction fetch, or I/O operation at a selected address, or any access to a user-defined nonexistent memory space, and examining the condition that causes a break in emulation at that point.
- Displaying the trace data that a high-speed trace memory has stored for a number of instruction cycles.
- Displaying the execution time measurement.

The run emulation mode executes the user's program and traces and compares information about each instruction. When a break condition is encountered or a time-out condition is met, emulation stops, and ICE returns to the interrogation mode.

The single-step mode runs the user's program and traces and compares information, but does so one cycle at a time. The emulated processor no longer runs at full speed; however, the emulator can gather much more detailed information about the program flow in this mode.

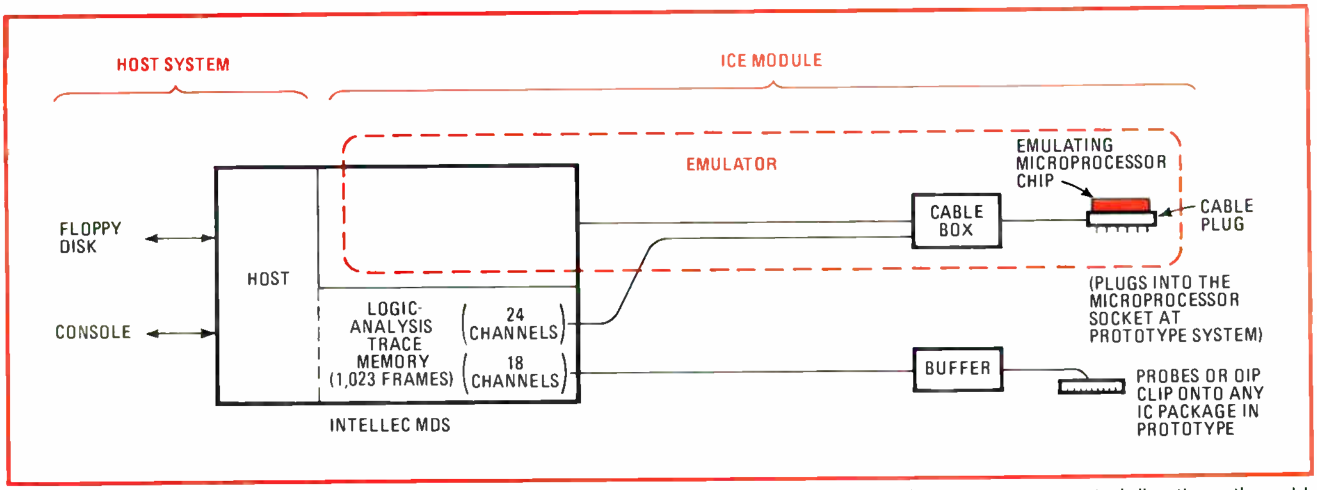
In-circuit emulation also allows the user to assign the development system resources to his prototype system. That is, he can use the random-access memory and I/O capabilities resident in the development system as though they were local memory and I/O in his prototype system. This feature allows the user to run his program in his prototype system, even before his prototype memory is built. In addition, it saves development time spent in temporary programming of a programmable ROM.

The host development system uses ICE software to load the object code of the user's program from an external mass-storage medium, such as a floppy disk, into either the development system memory or the user's prototype system RAM. The code is executed, debugged, and then returned to the development system's mass-storage device for later debugging sessions, PROM programming, or generation of ROM bit-patterns.

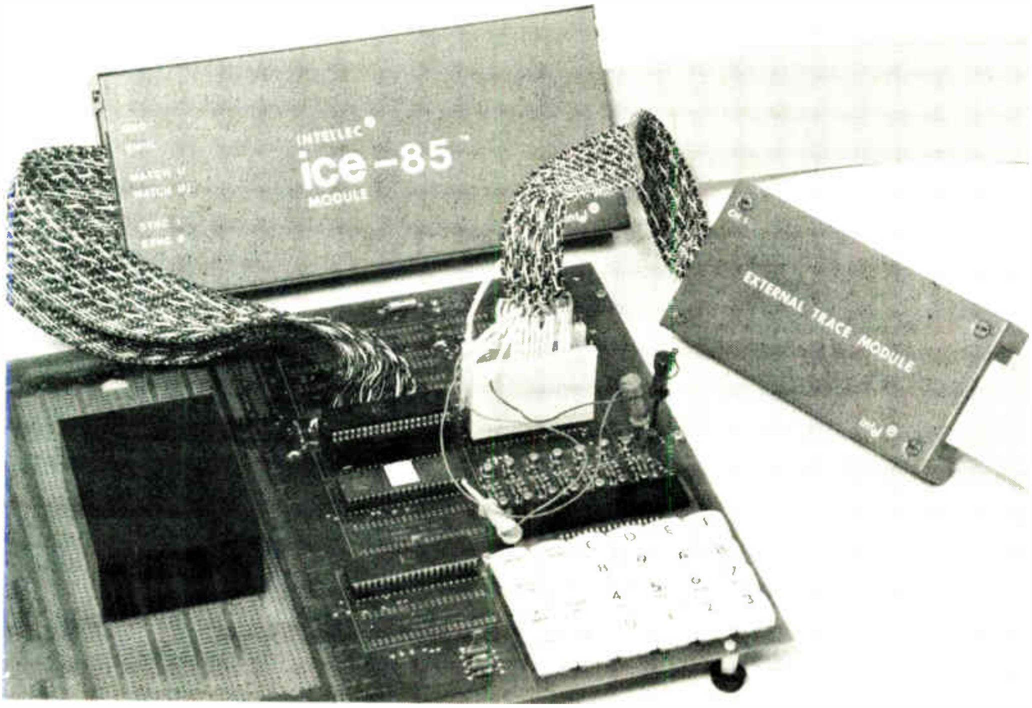
The memory emulation and program load/save capabilities allow the user to start running and debugging his prototype at the earliest stage of the hardware development cycle. As a result, design errors are quickly located and corrected, both hardware and software are debugged concurrently on the same prototype system, and the task of integrating hardware and software as a complete system is thus simplified.

The emulator also does extensive self-diagnostics. During a run emulation, it checks for the absence of clocks, and it verifies data written to user memory (by reading it back after writing). Errors detected will cause a disruption in the operation, followed by the output of the corresponding error message to the user.

Although ICE offers many valuable features, the physical connection from ICE to the user prototype system remains very simple—one cable plug to the microprocessor socket in the prototype system. No temporary jumpers, trace cuts, or circuit modifications are required to run the prototype system with ICE. This simple interface connection serves as a significant attraction to the design engineer looking for a highly efficient as well as convenient developmental debugging tool.



2. The ICE-85 module. The in-circuit emulator for the 8085 microprocessor has the emulating microprocessor mounted directly on the cable plug, which is inserted in the prototype. This eliminates signal delays in the cable. A DIP clip holds 18 leads for extra debugging capability.



3. Plug in. The ICE-85 module has its emulating microprocessor mounted on the cable plug, and 18 trace probes can pick up other signals directly from the prototype circuitry.

entire prototype system, giving information on the:
- Current instruction address.
- Current instruction.
- Data transferred during the instruction cycle.
- Current operation mode of all peripheral chips.
- Current contents of internal registers on all peripheral chips.

Further, when ICE is operated in a single-step mode, the designer can see how the peripheral chips change their internal status at the execution of each instruction. In this manner, he can quickly verify the peripheral control routines in his program.

In addition to its on-line trace memory for logic-state analysis of the 8085, ICE-85 also has an external trace module with 18 probes. The data captured by the probes synchronously with the clock can be used to break emulation under conditions specified by the user. These probes may either be used individually or be connected to a dual in-line package clip, which can be moved around the system to clip onto any integrated-circuit package. This feature allows ICE to monitor those signals that are of interest but not accessible through the user program alone.

As an example of the ICE-85 module's peripheral control, consider the 8253 programmable-interval-timer chip, one of the peripheral chips that may be used with the 8085 microprocessor. It consists of three independent, general-purpose, multimode 16-bit timers. Writing a control word to the chip selects one of the three timers in the chip and selects one of the six possible modes in which the timer may operate. After a control word is written to select an operation mode, a consecutive two-byte write operation specifies the initial count of the 16-bit timer. In such cases, the designer will want to know if the initial count is correctly set and will want to verify and reference the timer operation during his program's execution.

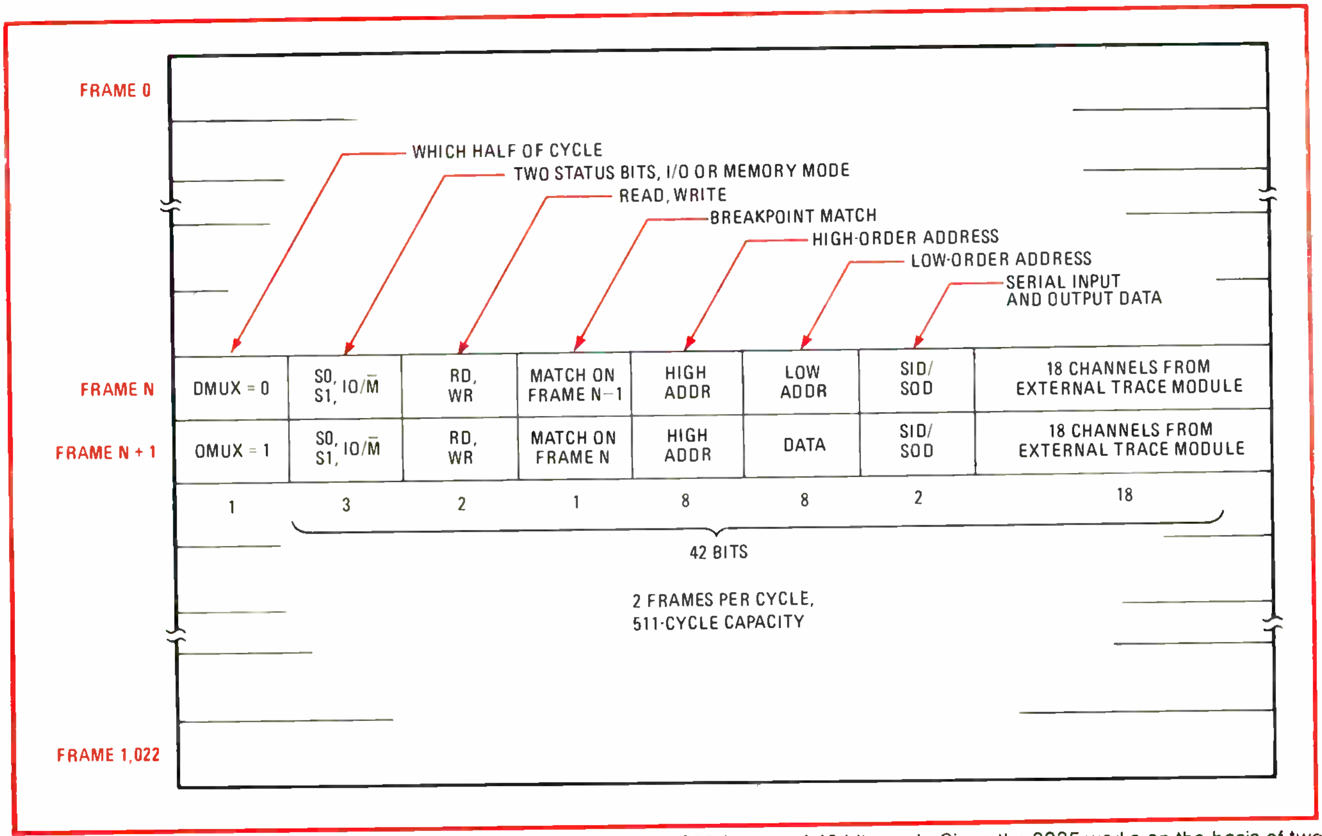
With the ICE-85 software, the design engineer can define macroroutines to control the timer. For example, he may symbolically initialize the timer, with a simple macrocommand, such as ":WTIMER0 32168". ICE then executes the macroroutine called WTIMER0, which initializes the 16-bit content of timer zero in the peripheral chip to be 32,168. He then directs the ICE to execute a segment of the development program until it encounters a breakpoint. At that point he may interrogate the current contents of timer zero by the simple command: "RTIMER0," which reads and displays the current content of the timer.

It should be noted that since the execution of peripheral routines is transparent to the execution of the user developmental program, the user program can resume execution after a break as if these routines were not inserted. Also note that control of the peripheral activity includes the transistor-transistor-logic circuits surrounding the processor in addition to the complex peripheral chips. Thus, the designer can obtain a total picture of his system's operation.

Logic analysis

The ICE-85 module combines in-circuit emulation with an enhanced logic state analysis. The earlier ICE-80 module has an on-line trace memory of 44 32-bit words. Figure 4 shows ICE-85's 1,024-word on-line trace memory, where each word, or frame, is 42 bits, or channels, wide.

Of the 42 channels of memory, 24 channels are assigned to the 8085 processor signals (such as 8 bits for



4. Trace memory. For logic analysis, the ICE-85 trace memory holds 1,023 frames of 42 bits each. Since the 8085 works on the basis of two frames per cycle, with low-order addresses and data multiplexed in alternate frames, the memory can store up to 511 machine cycles.

high-order addresses, 8 bits for either data or low-order addresses, and 1 bit for each of various functions such as status, read, and write and for serial data input and output) while the remaining 18 channels sample data from the external trace probes. The user can specify the grouping and formatting of trace data displays. This feature gives an in-depth and total picture of how an 8085-based prototype system operates.

In addition, there are two 42-bit breakpoint registers, plus two 42-bit clock qualifier registers that set up conditions for ending and advancing a trace operation. In the breakpoint and qualifier registers, each bit can be set, from the console, as either 0, 1, or "don't care." Thus, with 42 bits, a wide variety of conditions from the 8085 program and any other chip in the prototype can be used to perform breakpointing and tracing.

Symbolic debugging and mnemonics

Symbolic debugging was introduced in the ICE-80 software package, and it is also incorporated in an enhanced form in ICE-85 software. It allows the user to make symbolic references to the instruction and data addresses in his program. As the following example indicates, this feature greatly facilitates the use of relocatable object modules of code by the user during the program development cycle. Users need not be concerned about address changes during each reassembly and corresponding linkage of code modules. They need only reference symbolic labels initially attached to instructions in programming source code.

On the basis of the processor's address and data signals captured in trace memory, ICE-85 converts the operation codes of the executed instructions back to assembler mnemonics for display. This feature allows the designer to verify the actual instructions, in comparison with the assembly listing of his program.

To illustrate these points, the symbolic labels in the ICE commands make it easy to reference the instruction addresses in a development program. Without this feature, the designer would have to keep continual track of absolute addresses of subroutines as they change during the design process when new instructions are inserted. For example, a single command statement "GO FROM .LABEL1 TILL .LABEL2 EXECUTED" will cause the ICE to do all the following tasks:

- Set the program counter of the microprocessor to the absolute address symbolically labeled as LABEL1.
- Set a hardware breakpoint register to be the absolute address symbolically denoted as LABEL2.
- Run the processor in real time.

When the instruction at LABEL2 is executed, ICE will stop the processor, display a breakpoint message to the user, and return to the interrogation mode.

To sum up, the ICE-85 module can quickly debug systems built around the 8085 microprocessor. In the world of increasing peripheral-chip complexity, it reaches into the user's entire prototype system, providing active control and interrogation of the internal registers of the peripheral chips. Finally, with the 18 external probes, it allows monitoring and breakpointing capabilities to be extended to the IC external pin signals observed in the user's prototype system. □

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The right gyrator trims the fat off active filters

Replacing inductors with gyrators creates almost perfect filters

by Thomas H. Lynch, *Bunker-Ramo Corp., Electronic Systems Division, Westlake, Calif.*

☐ Analog filters exhibiting nearly ideal performance can be built around a gyrator—if the right configuration of this active circuit is used. In effect, the gyrator makes a capacitance behave like an inductor, freeing the filter of the problems plaguing conventional inductors, like large size, low Q, winding capacitance, nonlinearity, and magnetic susceptibility.

Yet most designers look upon the gyrator as an idealistic circuit with a "peculiar" behavior that puts it out of touch with practical applications. This attitude completely ignores its power. Unlike other active-filter circuits, the gyrator permits the designer to take advantage of the large body of data and techniques already developed for passive LC filters. He can start with a passive prototype circuit and then replace each inductor with a gyrator, substantially reducing filter size and weight for frequencies up to about 50 kilohertz.

Fortunately, too, there is one gyrator realization that works superbly. Not all of them do—in the past, different versions have suffered from drawbacks like instability, poor control of loss, sensitivity to component matching, and even excessive complexity. But the preferred version is simple and stable and simulates a high-quality inductor, permitting very high-performance filters to be realized. In addition, this gyrator, unlike other active-filter circuits, preserves the most significant advantage of coupled LC networks—their inherently low sensitivity to changes in component values (see "The strength of LC filters," p. 116).

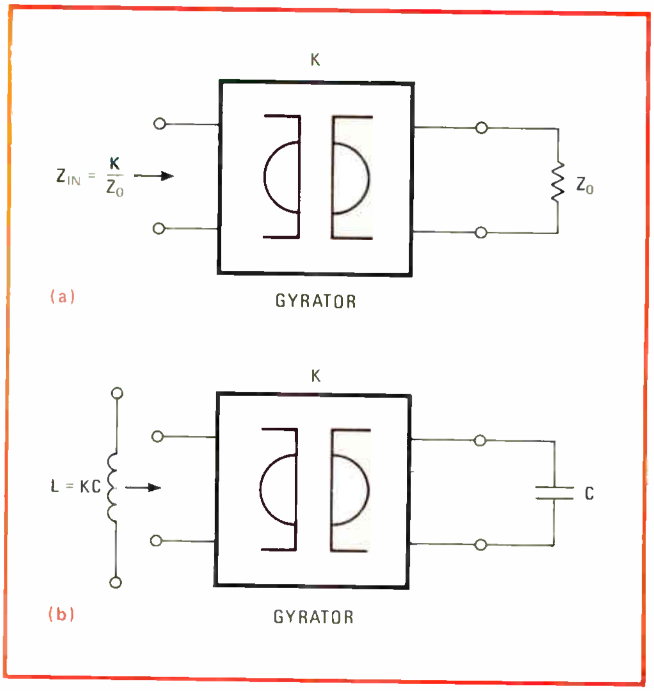
Understanding the gyrator

Basically, the gyrator is a lossless two-port circuit (Fig. 1a) that inverts a load impedance. When used with a high-Q capacitor (Fig. 1b), it simulates the virtual characteristics of a high-Q inductor. The preferred realization for the gyrator requires only two amplifiers and five impedances, as shown in Fig. 2 for both the general impedance representation (a) and the practical RC implementation (b). In the latter case, the circuit simulates an inductor having a value of KC, where K is a constant determined by the resistors:

$$K = R_1R_3R_5/R_2$$

At first glance, this gyrator's need for two amplifiers may seem a disadvantage. However, consider the major drawback of most single-amplifier resonators. They generally require an amplifier having a gain in excess of Q^2; and those that do not usually are extremely sensitive to passive-element variations. On the other hand, the gyrator does not require a high-gain amplifier—in fact, stable Qs of better than 1,000 may be obtained with only 40 decibels of gain. Furthermore, unlike other active-filter circuits, the gyrator is remarkably insensitive to any amplifier parameter, so it may be built with garden-variety devices, even quad chips, as long as they are unity-gain-stable amplifiers.

Additionally, with the gyrator, amplifier phase shift enhances Q, rather than diminishing it as in other active-



1. Ideally. Coupled LC filters simulated with gyrators have characteristics approaching the ideal. In effect, the gyrator is a lossless two-port circuit (a) that inverts a load impedance. With a capacitive load impedance, the circuit (b) simulates a high-quality inductor.

The strength of LC filters

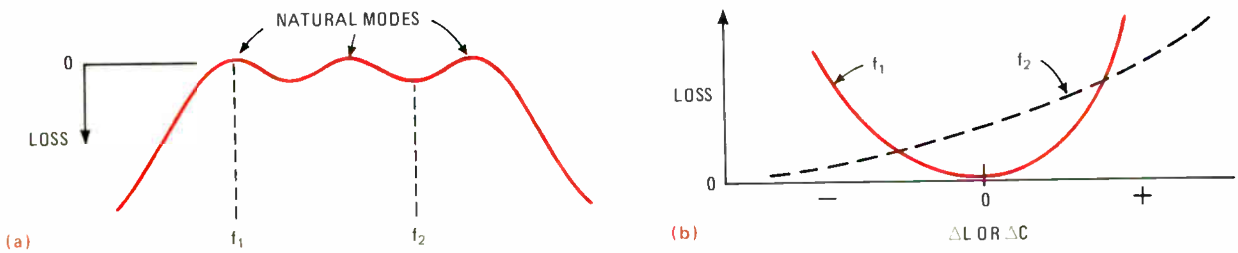
In theory, coupled LC filters have the lowest sensitivity to component variations. These doubly terminated reactive two-ports produce a frequency response by reflecting power back to the source in the stopbands. In the passband, power transfer is maximum at natural modes (a) determined by the filter's transfer function.

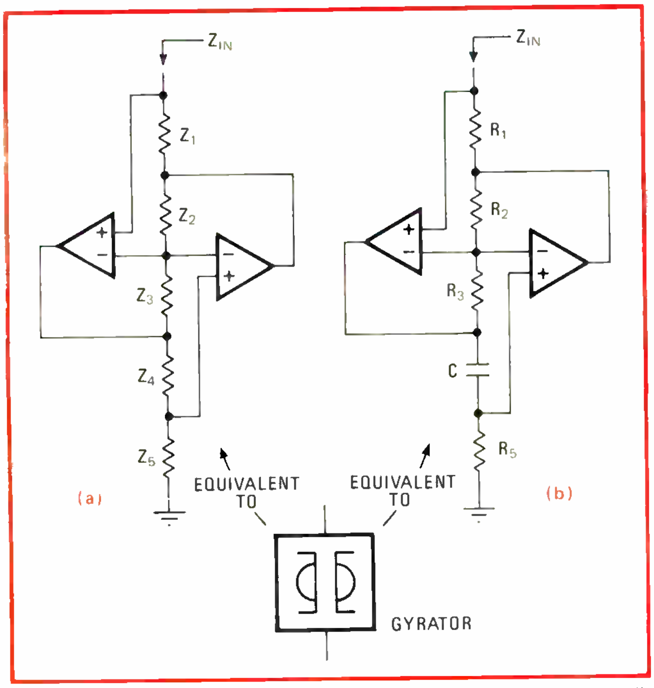
In the real world, a change in any inductor or capacitor making up the filter can only cause a loss in the load power—down from the maximum. This power loss at one of the natural modes (f_1) increases monotonically (b), while at frequencies other than the natural modes, such as f_2, a small loss exists because of the ripple caused by reflected power. At any point within the passband, then, the change in loss has a well-behaved and slowly varying characteristic that follows the changes of any inductor or capacitor in the network.

Since no one inductor or capacitor determines a natural mode, a change in any single inductance or capacitance can only partially affect the shift in a natural-mode frequency. It follows that coupled LC filters are inherently insensitive to changes in component values. Similarly, if all of the inductors in the filter are replaced by gyrators, this insensitivity to component variations does not change, since the gyrator is an active circuit and adds no dissipative elements to the filter.

Other active-filter circuits, however, like the biquad and state-variable or universal active filters, are developed from the state equations describing a second-order transfer function. Since these circuits duplicate the properties of a second-order (one complex pole pair) LC filter, their component sensitivity is still the same as for coupled second-order networks. On the other hand, extension to higher orders requires factorization of the transfer function into biquadratic (second-order plus lower-order) factors, each of which specifies a separate Q and natural-mode frequency. The desired transfer function is then realized by cascading biquadratic stages. Since these stages are uncoupled, changes can easily occur in the amplitude or frequency of the simulated modes, making the high-order filters built this way sensitive to component variations.

An alternative is the design approach called leap-frog. It implements the state equations of the prototype LC filter directly, using integrators and summing amplifiers. But though the resulting filter does have about the same low sensitivity as the equivalent coupled LC network, the final circuit can become very complex for high-order functions.





2. Realistically. Preferred gyrator realization (a) requires two amplifiers and five impedances. In practical RC implementation (b), impedance Z_4 is a capacitor, and the other impedances are resistors. The gyrator may also be represented by the special symbol shown here.

filter circuits. At the ideal phase shift of 90°, the Q of the simulated inductor is approximately equal to that of the capacitor being used. If the phase shift is greater than 90°—which is usually the case—the Q becomes even higher.

Needless to say, the inductor the gyrator simulates is not perfect—the gyrator can be no better than the resistors and capacitors with which it is built. Of the two, resistors are less worrisome, for tin-oxide, metal-film, and thin-film types all perform acceptably. Capacitors, on the other hand, are the weakest link in the gyrator circuit, and there are usually two or more of them per complex pole pair. They impose the first limitation—maximum Q—in any realization, and their capacitance may change a lot with temperature. The table reviews the important characteristics of a variety of capacitor types. Generally, NPO ceramic devices are least affected by temperature, whereas polypropylene units achieve the highest Q.

Creating a floating gyrator

One seeming limitation of the gyrator is that it is grounded at one end. But the floating inductor often needed in a filter can be simulated successfully—for example, by connecting two grounded gyrators. However, this does not necessarily mean that an extra gyrator is required for every floating inductor in a passive LC filter. Figure 3a shows two gyrators sharing the bottom resistor, R_5, at opposite ends, so as to simulate a single floating inductor. This resistor is described in the gyration constant:

$$L = \frac{R_1 R_3 R_5}{R_2} C$$

The equation may be rewritten as:

$$L = \frac{R_1 R_3 C}{R_2} R_5$$

which says that the simulated inductance is directly proportional to the value of R_5. Therefore, if R_5 in fact becomes a loaded port for the gyrator, the simulated inductance will depend on the value of resistance connected to that port.

A cursory examination of the preferred gyrator realization (in Fig. 2b) will reveal a corollary to the above relationship. Between the top of R_1 (the input port) and the bottom of C, a voltage null exists because of the amplifiers' input connections. Therefore, the port to which R_5 is connected has the same voltage as the input port (although the currents are not the same, otherwise an apparent inductance could not exist). As a result, the input impedance, Z_{IN}, is also proportional to resistor R_5. This resistor could even be a network of resistors to describe the topological connections, of, say, a T or pi network of inductors, as indicated in Fig. 3b.

Designing another floating gyrator

Indirectly, a floating inductor may be achieved in another way—one that opens up other possibilities for converting a passive LC filter to its active equivalent. When a second capacitor is added to the gyrator and one resistor removed, the circuit becomes a functionally dependent negative resistor (FDNR)—an element that appears to be a negative resistance that decreases in value with frequency.

Consider the transfer function for the basic impedance converter of Fig. 2a:

$$Z_{IN} = (Z_1 Z_3 Z_5)/(Z_2 Z_4)$$

If Z_1 and Z_3 are capacitors and the other impedances are resistors, then:

$$Z_1 = Z_3 = 1/sC$$

where $s = j\omega$. The input impedance can then be written as:

$$Z_{IN} = \text{FDNR} = \frac{1}{s^2}\frac{R_5}{C^2 R_2 R_4} = -\frac{1}{\omega^2}\frac{R_5}{C^2 R_2 R_4}$$

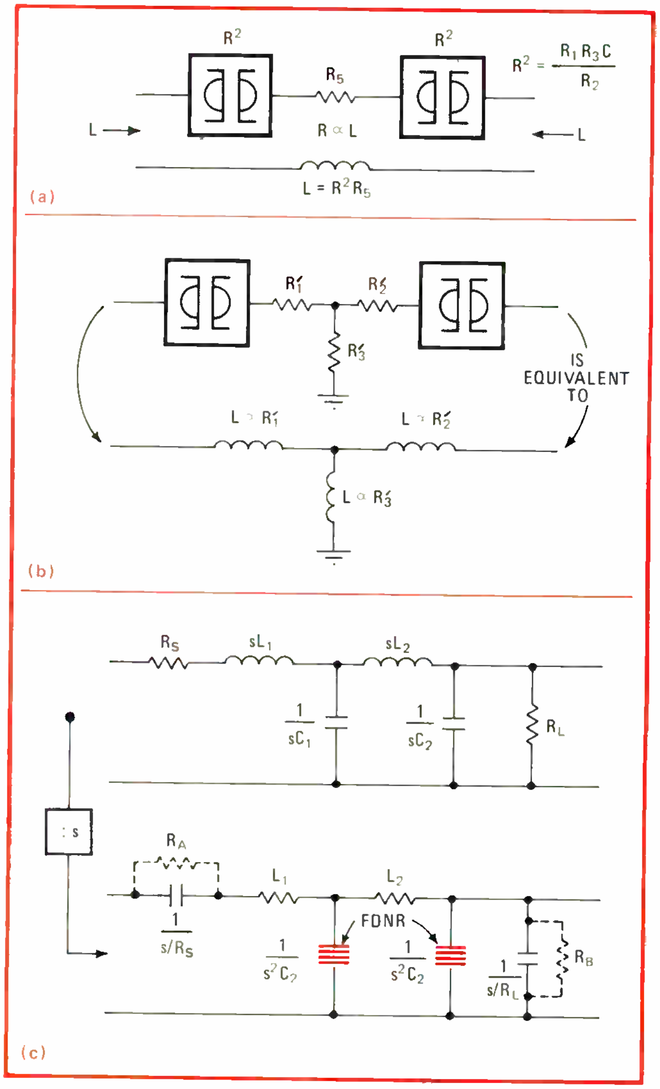
This element may be used to solve the problem of simulating floating inductors in low-pass filters. The technique is simple—just divide all elements by s, which is the complex variable, and then replace the $1/s^2$ terms with an FDNR, as shown in Fig. 3c. The floating inductors become resistors having a value of L. Resistor R_A and resistor R_B simply provide bias and response for the circuit at dc.

Although the gyrator is not the easiest circuit to understand, designing with it is really not that hard. Suppose the requirement is for a double-tuned bandpass

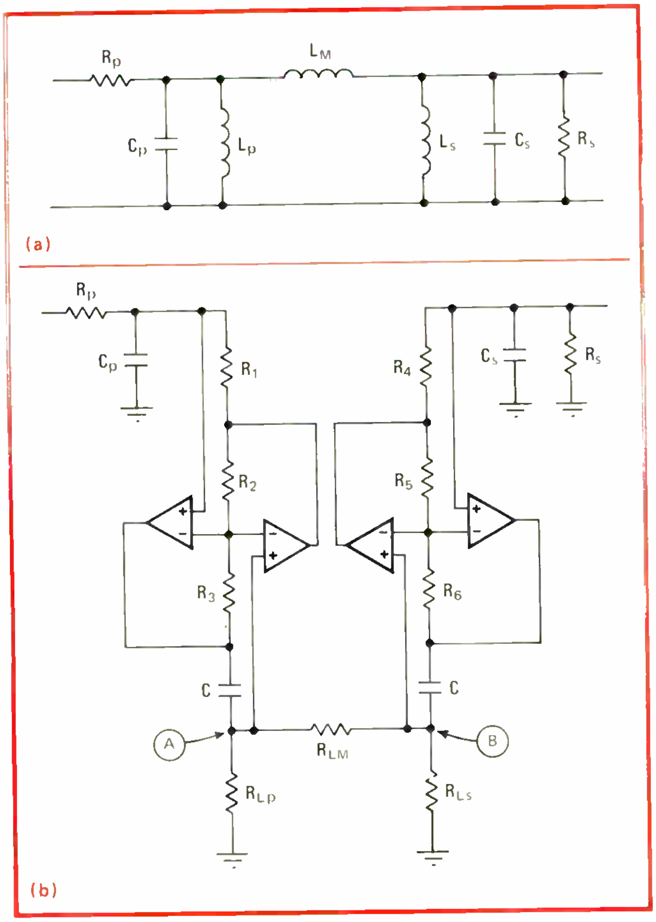
CAPACITOR CHARACTERISTICS

Type	Q (at 1 kHz)	Temperature coefficient (ppm/°C)	Temperature range (°C)
Mica	600	1 to +70	−55 to +125
Polystyrene	2,000	−150 ±50	−55 to +85
NPO ceramic	1,500	±30	−55 to +125
Polypropylene	3,000	−115	−55 to +125
Glass	1,500	+140 ±25	−55 to +125
Polycarbonate**	500	≈ 50*	−40 to +100
Mylar**	100	large	−55 to +85
Polyester**	100	−160*	−40 to +100
Porcelain	2,500	±25	−55 to +125

*0°C to 50°C **Q and C nonlinear functions of frequency and function



3. Floating. Lower terminal of basic gyrator (Fig. 2b) is grounded. To float the circuit, two gyrators may share the same resistor (a), or a network of resistors (b). Floating inductors may also be simulated (c) with functionally dependent negative resistors (FDNRs).



4. Bandpass filter. Double-tuned bandpass filter of (a) may be built with two gyrators, as in (b). Sharing resistor R_{LM}, the grounded gyrators simulate the pi network of inductors in the passive version. All of the amplifiers may be general-purpose devices.

filter, like the one drawn in Fig. 4a. The procedure is straightforward. First compile the design data required:

e_r, the desired passband ripple, expressed in peak-to-peak decibels;

f_o, the center frequency in hertz;

f_r, the ripple bandwidth in Hz;

C, the capacitance value for both C_p and C_s in farads;

r, the termination ratio of R_p/R_s.

Next, calculate these variables:

$$A = (10^{e_r/20})^{-1}$$

$$q = \left[\frac{2(1-A^2)^{1/2} + r + (1/r)}{2 - 2(1-A^2)^{1/2}}\right]^{1/2}$$

$$Q' = f_0/f_r$$
$$\alpha = 2(1-A^2)^{1/2}$$
$$X = [\alpha(1+q^2)]^{1/2}$$
$$Q = Q'X$$

$$X' = \left\{\frac{\alpha}{2}(1+q^2)\left[1 + \frac{[\alpha^2 + 4(10^{e_r/20}-1)]^{1/2}}{\alpha^2}\right]\right\}^{1/2}$$

Then compute the design results:

$$R_s = \frac{Q}{\omega_0 C r^{1/2}}$$

$$R_p = R_s r$$

$$L_M = \frac{R_s r^{1/2}}{\omega_0 q}$$

$$L_p = L_s = \frac{L_M}{\omega_0^2 C L_M - 1}$$

$$G_0 = \frac{1}{r^{1/2}}\left[\frac{q}{1+q^2}\right]$$

where G_0 is the midband gain.

$$BW(3\ dB) = \frac{X'}{X} f_r$$

where BW(3 dB) is the 3-dB bandwidth.

Building a double-tuned filter

Two gyrators replace the pi network of inductors, as shown in Fig. 4b. Now assign the same capacitance value for C as that chosen for C_p and C_s. The amplifiers may be a quad-type 4136, since choosing such a device ensures a good match between the amplifiers for optimum gyrator performance. Next, determine the gyrator resistances from:

$$L_p = (R_1 R_3 R_{Lp} C)/R_2$$

It is good practice to maintain the resistances at about the same value, so assume:

$$R_1 = R_2 = R_3 = R_{Lp} = R$$

Then:

$$R^2 = L_p/C$$

The value of R should be large enough to minimize amplifier loading and slightly smaller than the amplifier differential input impedance. For convenience, choose the closest standard value for R and let:

$$R = R_1 = R_2 = R_3$$

Then compute:

$$R_{Lp} = L_p/CR$$

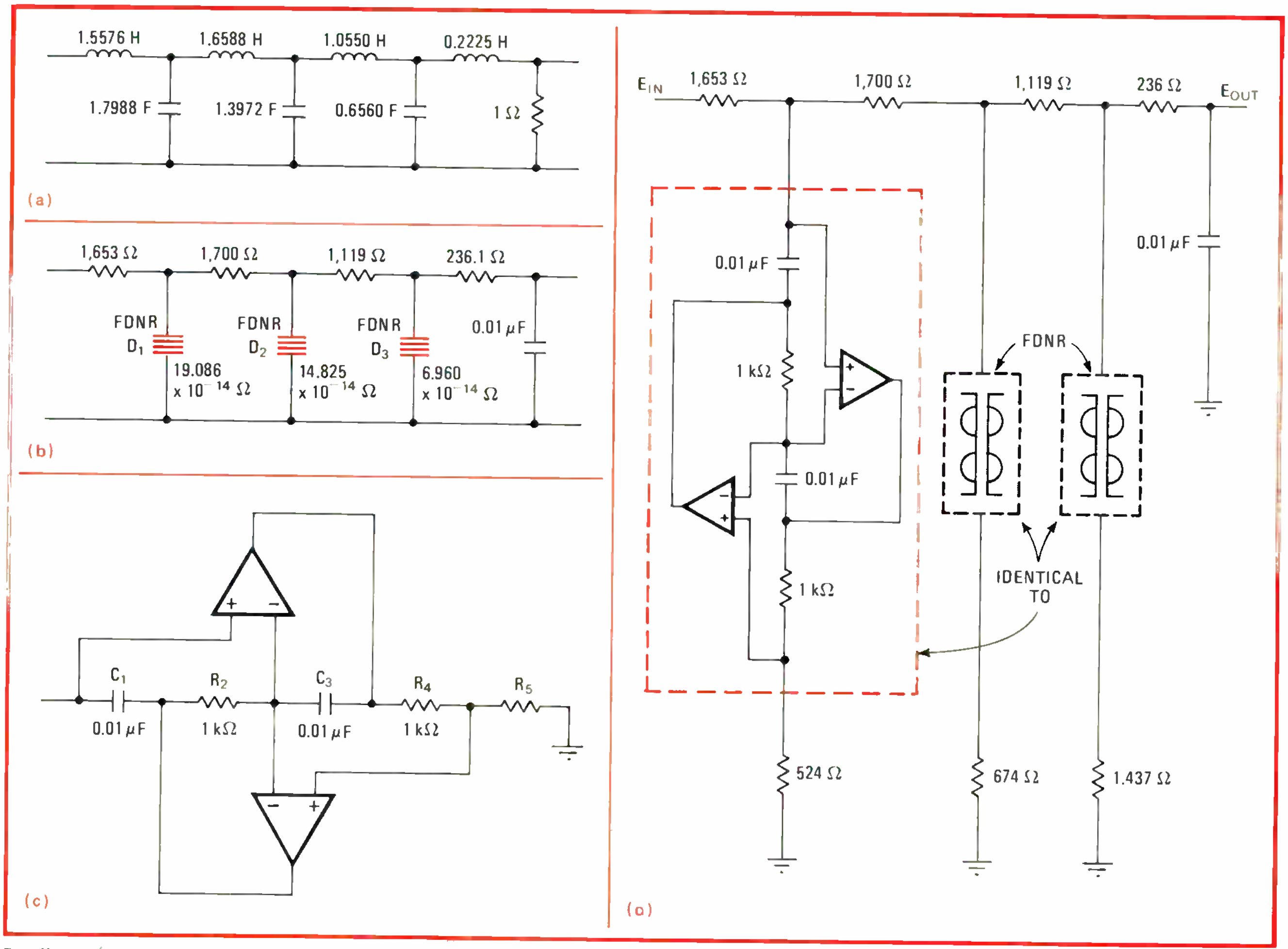
Again select a nearby standard value for R_{Lp} and scale R_{LM}:

$$R_{LM}/R_{Lp} = L_M/L_p$$

This ratio must be maintained, since it determines the coupling in the circuit. All of the component values are now known. The tolerances for C may be ±5% and ±1% for R, although the tolerances for $R_{1\text{-}6}$ could be looser as long as the devices' environmental characteristics are acceptable.

Tuning the filter

Tuning is simple. Overall Q has already been determined by the value of R_{LM}. Using point A as the output, the primary (left-hand) gyrator is set by shorting point B to ground and adjusting R_1 or R_2 to achieve resonance at the center frequency. Reducing R_1 (by shunting it) will decrease L_p, raising the resonant frequency. The reverse holds for R_2. Tune for 0° phase shift relative to the



5. Aliasing filter. Number of floating inductors in low-pass aliasing filter (a) makes implementation with grounded gyrators difficult. Instead, FDNRs may be used (b), each of which requires two capacitors (c). The final circuit (d) employs only three of these FDNRs.

source. Next, disconnect point B from ground, and tune R_4 or R_5 for 90° phase shift (at the center frequency) at the output, or point A, which is equivalent. (Tuning with a Lissajous circle can provide accuracy to better than 2°.)

A second example demonstrates how to design with FDNRs. The requirement is for a low-pass aliasing filter—a seventh-order Butterworth circuit having a 1-dB corner at 15 kilohertz.

Using functionally dependent negative resistors

A prototype circuit (Fig. 5a) is first obtained from one of the standard tables in existing literature. Here, the number of floating inductors prevents easy implementation with the grounded gyrators, and the best approach is to use their close relative—the FDNR.

To convert the LC prototype circuit to an FDNR realization, first normalize the corner frequency to 1 radian per second. Next scale the circuit for frequency by dividing the inductors and capacitors by $2\pi(15\text{ kHz})$, and then scale the impedances for a convenient capacitor value, say 0.01 microfarad or $1/(0.01 \times 10^{-6})$ ohms, in which case multiply the inductances by 10^8 and divide the capacitances by 10^8. Finally, dividing all of the network impedances by the complex variable, s, results in the FDNR realization of Fig. 5b.

Each FDNR is actually the basic gyrator configuration, but with two capacitors (Fig. 5c) instead of just one. In this example, all of the resistors, except R_5, are set equal to 1 kilohm, and the two capacitors to 0.01 microfarad each. Then R_5 may be computed from:

$$R_5 = (R_2R_4C_1C_3)/D$$

where D is the impedance value of the FDNR. Therefore, for D_1, R_5 = 524 ohms: for D_2, R_5 = 674 ohms, and for D_3, R_5 = 1.437 kilohms.

Figure 5d shows the final circuit, in which all seven capacitors have the same value, an essential point in low-cost design. The circuit may be built with 1% resistors having values closest to those computed and with NPO ceramic capacitors screened to tolerances of ±1%. Again, garden-variety amplifiers, like the 4136 quad, perform well enough for the purpose. □

Bibliography
L. T. Bruton, "Nonideal Performance of Two-Amplifier Positive Impedance Converters," IEEE Trans. Circuit Theory, Vol. CT-17, No. 4, pp. 541–549, November 1970.
G. C. Temes and S. K. Mitra, "Modern Filter Theory and Design," John Wiley & Sons, New York, 1973.
A. Antoniou and K. S. Naidu, "Modeling of a Gyrator Circuit," IEEE Trans. Circuit Theory, Vol. CT-20, No. 5, pp. 533–540, September 1973.
A. S. Sedra and J. L. Espinoza, "Sensitivity and Frequency Limitations of Biquadratic Active Filters," IEEE Trans. Circuits and Systems, Vol. CAS-22, No. 2, pp. 122–130, February 1975.
A. Antoniou and K. S. Naidu, "A Compensation Technique for a Gyrator and Its Use in the Design of a Channel-Bank Filter," IEEE Trans. Circuits and Systems, Vol. CAS-22, No. 4, pp. 316–323, April 1975.

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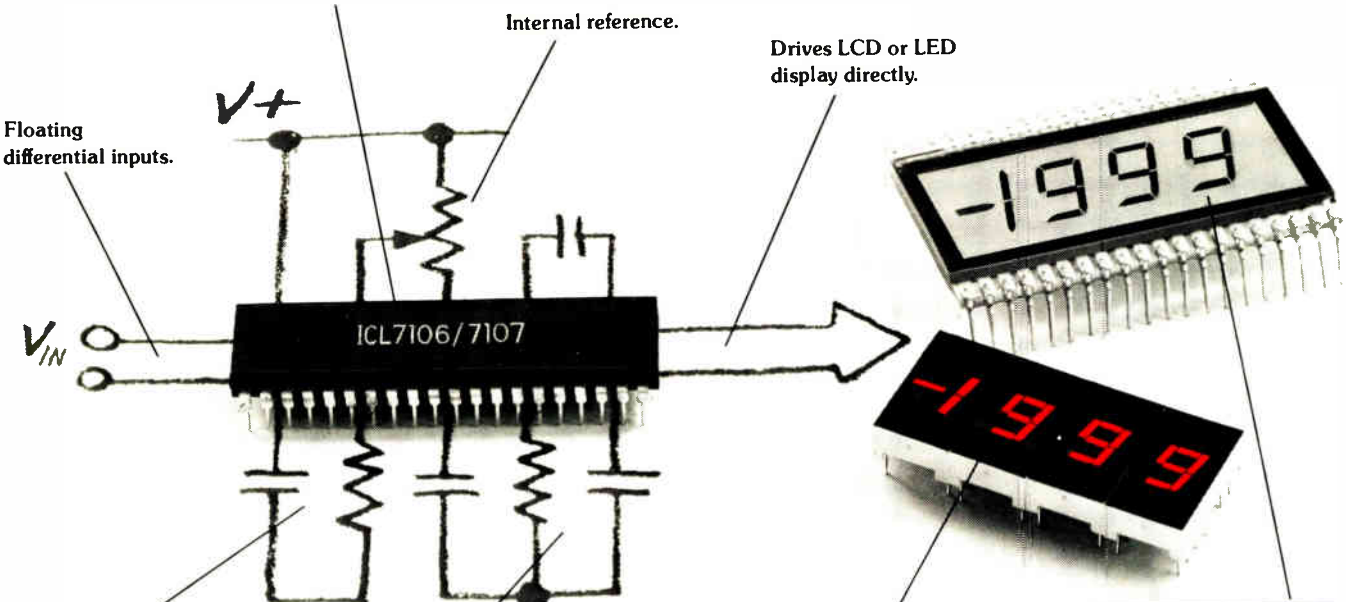

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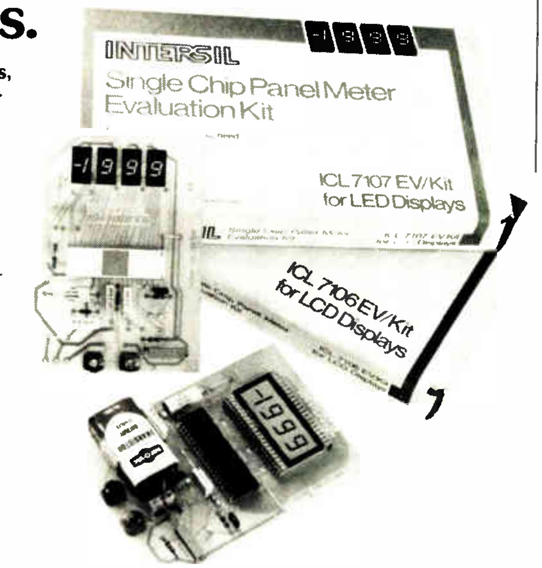

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Circle 121 on reader service card

Fixed-voltage regulator pair forms bipolar power supply

by S. K. Wong
Torrance, Calif.

Two fixed-voltage regulators and suitable feedback circuitry can form a bipolar power supply that combines the excellent voltage regulation, trackability, and high current capacity of the three-terminal integrated-circuit voltage regulator with the voltage adjustability of more expensive supplies. This unit provides bipolar voltage from 8 to 20 volts at 1 ampere. The trackability, defined for an adjustable power supply as the voltage difference remaining between the bipolar ports at the desired output voltage, is 1%. Regulation for both line and load is about 100 millivolts.

Many IC bipolar regulators are available, but they provide only 100 milliamperes or so and their output voltages are essentially nonadjustable. Other popular regulators provide high current (up to 3 A) but are fixed-voltage devices. Although IC bipolar regulators can be modified with high-power transistors to boost the output current capability, and separate positive and negative voltage regulators can be connected directly to meet special voltage and power requirements, both designs still lack both adjustability and trackability. These features are often needed in many applications.

Figure 1 shows the regulated supply that employs two popular three-terminal regulators and a three-transistor feedback circuit. A 115-v, 60-hertz alternating current input is transformed to approximately 40 v across its center-tapped winding, and is rectified and filtered to generate ±27 v to the input of the respective regulators. The positive voltage output is:

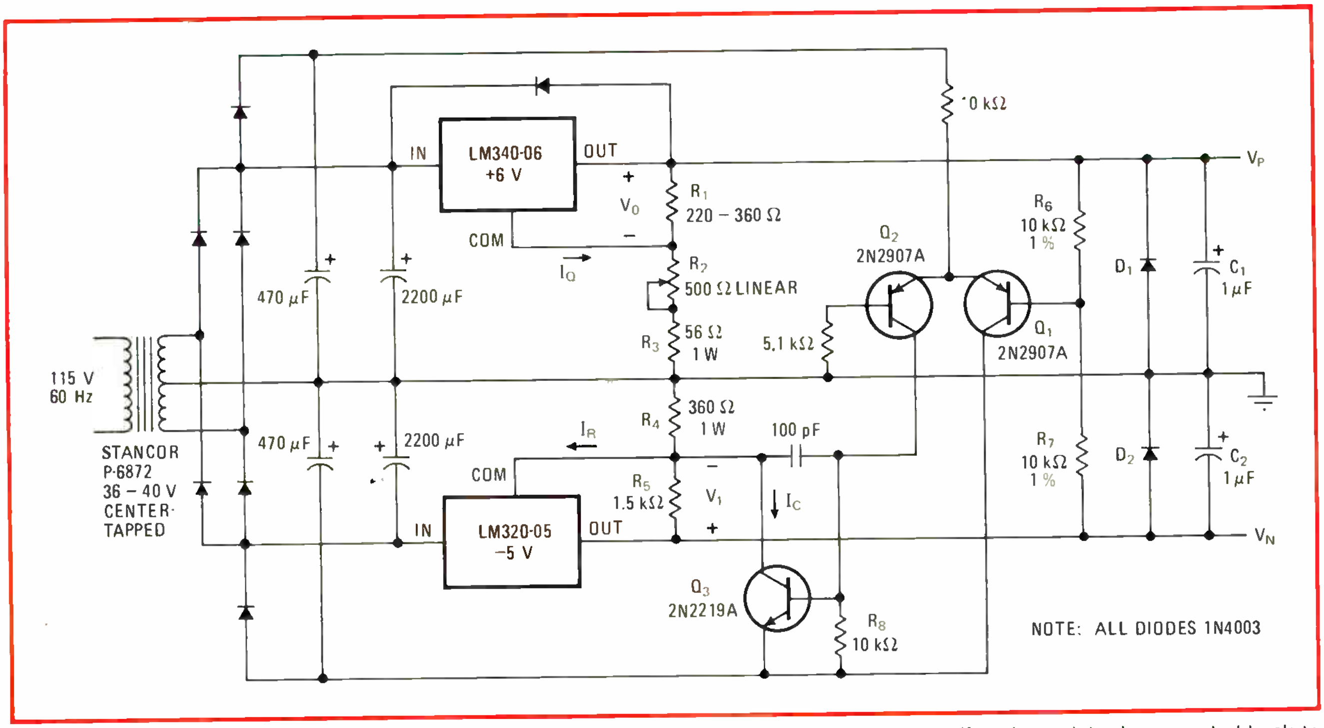
$$V_p = [1+(R_2+R_3)/R_1]\, V_o + (R_2+R_3) I_Q$$

where V_o may nominally range from 5.75 to 6.25 v for the fixed-voltage LM340-06 device and I_Q is the quiescent regulator current, which is 10 milliamperes maximum and is fairly independent of input voltage and load current. Adjustment of R_2 will change the output voltage, and accordingly, the negative voltage output V_N. The negative output is:

$$V_N = (1+R_4/R_5)V_I + R_4(I_C+I_R)$$

where I_R is the quiescent regulator current, I_C is the collector current of transistor Q_3, and V_I is the output voltage of the negative regulator.

The LM320-05, which is a −5-v regulator, and transistors Q_1 through Q_3 form a slaved configuration. A differential amplifier composed of transistors Q_1 and Q_2 monitors the difference in magnitude between V_P and V_N through a precision voltage divider R_6 and R_7 and compares it to a zero reference. Normally, the voltage at this junction is zero, because $V_P = -V_N$. Any error voltage is amplified to cause a change in the collector



Bipolar-tracking power supply. Adjustable voltage output is obtained with fixed-voltage regulators if each regulator is connected back to back through current-varied networks. Circuit retains regulation properties, has high current capability, excellent trackability.

current of Q_3, which in turn changes the voltage across R_4 and consequently V_N.

The high output current that can be produced by the supply generates several points where power dissipation is great. Components must be selected to ensure that those levels can be adequately handled. The maximum current through Q_3 is 78 mA. The maximum power consumption is about 500 mw. The 2N2219A transistor is used for this application. Both regulators should be mounted on suitable heat sinks. Resistor R_3 prevents excessive current through R_2 when its value is low.

Heavy common-mode loads may cause difficulty in the operation of the feedback network during start-up unless diodes D_1 and D_2 are used to clamp the circuit outputs. C_1 and C_2 are tantalum capacitors for improved transient response. □

Time-shared DVM displays two inputs simultaneously

by Barry Harvey
Siliconix Inc., Santa Clara, Calif.

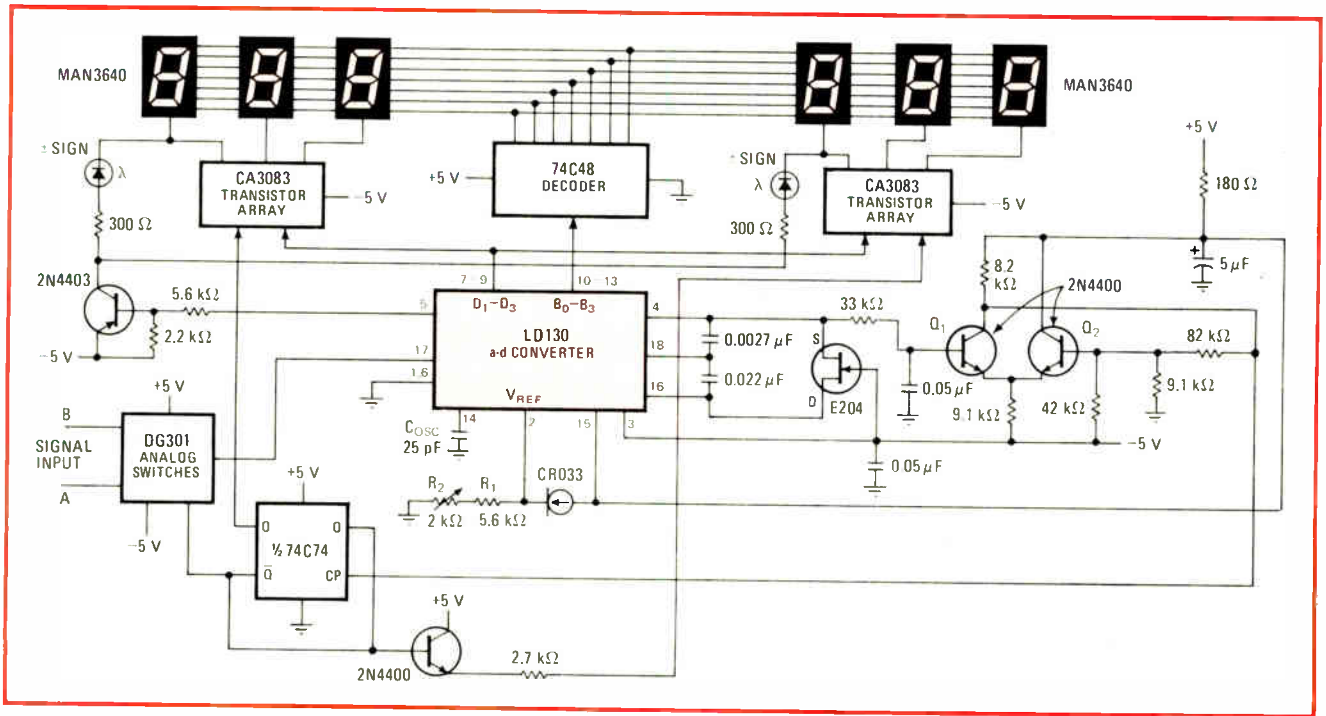
Two voltages can be measured and displayed simultaneously with one voltmeter if the voltmeter is built around a time-sharing circuit containing a fast-sampling analog-to-digital converter. The converter is united with an input-signal multiplexing network, and the system elicits a normally flicker-free response from a light-emitting-diode display, while saving the cost of the additional voltmeter and other parts that would be needed for two separate measuring units.

As implied by the figure, this circuit accomplishes two major tasks; it controls the rates at which analog signals and two banks of LEDs are sampled, and it determines the strobe rate of each LED in the banks.

The LD130 ±3-digit a-d converter was selected for its relatively fast sampling speed of up to 60 samples per second. The sampling rate of this complementary-metal-oxide-semiconductor device is controlled by external capacitor C_{osc} in conjunction with the internal oscillator circuitry of the device. Its output drives transistor pair Q_1 and Q_2, which in turn drive the sampling and multiplexing circuits through the 74C74 D flip-flop. The output of the flip-flop switches 30 times per second; the analog input signals are multiplexed at this rate through the DG301 analog switch, and one of two banks of LEDs is selected through the CA3083 transistor array. Each bank contains three MAN3640 displays.

The LD130 periodically samples each signal input and converts it into a digital output. Each display and its segments are driven through a strobe sequence; $D_1 - D_3$ determine which digit in each bank is enabled, lines $B_0 - B_3$ of the converter supply binary-coded-decimal information to the seven segments of each LED through the 74C48 decoder/driver, and the 74C74 determines which bank is chosen. The strobe rate for the LEDs is 384 times per sampling period.

Although the measurements are performed 30 times per second per channel, fast enough so that flickering would not usually be detectable, flutter of the least significant digit may occur when the LD130 is sampling



Two voltmeters in one. If the input signals can be sampled at rates of 60 times per second or greater, they can be measured, then observed simultaneously at acceptable flicker rates. Key to circuit operation is use of fast-sampling analog-to-digital converter.

the input signals, because of the ±1-count effect inherent in counter operation. However, in applications where the output is observed only occasionally, it will not bother the eye, and in any case, a full three-digit reading is discernible.

To calibrate the converter, a reference of approximately 2 volts is required at the V_{ref} terminal, and this is easily furnished by the 330-microampere constant-current diode CR033 and resistors R_1 and R_2. R_2 is adjusted to null the output for no-signal conditions. □

D-a converter controls programmable power source

by C. Viswanath
Indian Institute of Science, Bangalore, India

The output of an integrated-circuit regulator can be digitally controlled to generate any number of voltages for use in testing components or equipment. A digital-to-analog converter transforms the digital value into a current, and the current is converted to a linearly proportional voltage.

As shown in the figure, the Analog Devices' MDA-10Z-110 converter generates an output current of 0 to 2 milliamperes with a resolution determined by its 10-bit digital input. This current is transformed to an output voltage of 0 to 6 volts by the following 741 operational amplifier. The 723 is adjustable over a wide voltage range (7–37 volts), and for use as a 2-to-22-v regulator it requires a linear controlling voltage.

The 2N4351 field-effect transistor operates as a voltage-controlled resistor to produce voltage V_{REF}, which is essentially equal to the voltage across resistor R_6 and is linearly proportional to the digital input to the d-a converter.

The 723 was designed so that its output voltage is equal to an input voltage times a factor determined by gain-controlling resistors placed in a feedback loop. Thus, its characteristic equation may be expressed by:

$$V_o = KV_{REF}$$

where K is equal to $1 + R_1/R_2$.

The 723 yields a load regulation of 0.02% and a line voltage regulation of 0.01% at output currents of up to 150 milliamperes. This excellent performance is made possible by the error-control amplifier in the 723, which compares V_{REF} to the scaled-down voltage derived by the resistor feedback network R_1 and R_2. Resistor R_{sc} is used in a current-limiting capacity. A value of R_{sc} = 30 ohms will limit the output current to 20 milliamperes; a value of R_{sc} = 4 ohms limits the output current to its rated maximum of 150 milliamperes. External transistor circuitry can be added to easily extend the load current capacity. □

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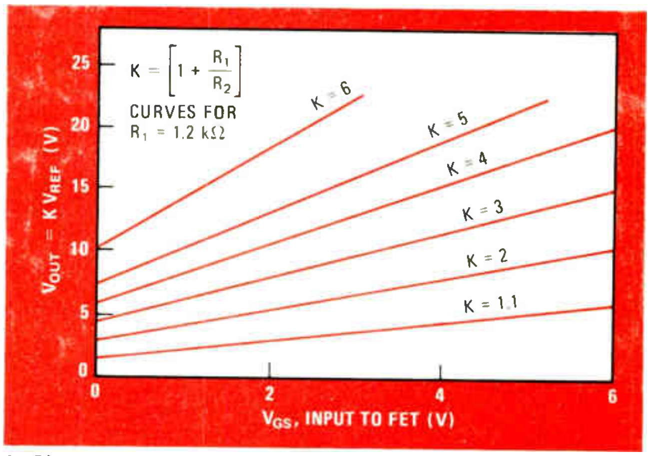
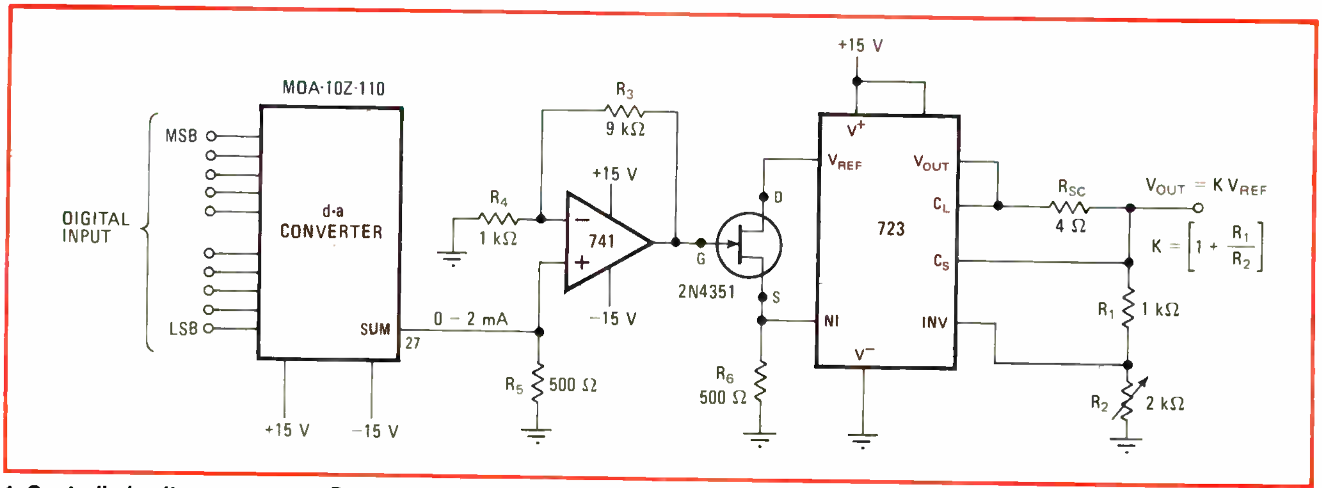


2. Characteristic equation. Relationship of scale factor K to V_{out}, V_{GS} is linear as shown by curves. Scale factor is controlled by resistor feedback network at regulator output. FET, used as voltage-controlled resistor, assures output voltage is proportional to K.



1. Controlled voltage generator. Digital-to-analog converter determines output voltage of regulator when FET is used as a voltage-variable resistor. If digital source is computer, specified voltages may be generated for automatic testing of components.

Engineer's newsletter

Electron-beam wafers are closer than you may think

It's a mistake to believe that the use of electron beams to write circuit patterns directly on wafers is still years away from the production stage, for it already looks like a viable alternative to photolithography. In-house-designed prototype electron-beam fabricating stations now in operation at semiconductor laboratories in the U. S. and abroad can complete a one-mask pass on a fully populated 4-inch wafer in as little as 8 minutes—tantalizingly close to the 6 minutes per mask that specialists agree will make electron-beam wafer fabrication a production feasibility.

But even at the present throughput rate, ICs fabricated with electron beams can be cheaper than those made twice or three times as fast with photolithographic methods. That's because the wafer can contain from 4 to 16 times more bits or gates, so that simply by transferring the 8-minute electron-beam machines to production, semiconductor manufacturers will **immediately halve or quarter their chip fabrication costs.** And that's too much of an advantage for them to hold back for very long.

Detecting failures of seven-segment displays

An incorrect reading off a malfunctioning seven-segment display is all too easy to come by, so a good many countries reject equipment containing such a display unless it incorporates a failure-check system. For gas-discharge seven-segment displays, Philips in the Netherlands has come up with a simple failure-check circuit that can easily be put together from just a few components. Upon request, the Dutch company will supply a low-cost kit containing two bipolar display drivers, a complementary-MOS gate, a number of resistors, an alarm device, and—of course—instructions on how to build the circuit. For details, write to: Michael Crawley, Philips Gloeilampenfabrieken, Elcoma division, Building BAE-2, Eindhoven, the Netherlands.

Sticky tape reels up unpackaged chips

As a rule, unpackaged integrated circuits for use in hybrids come in waffle-like carriers that do not permit the chips to be handled automatically. But there is a better way—it's called Di-Tape, and both IBM Corp. and Delco have been using it for some time. With Di-Tape, chips may be stored on reels of tape that readily lend themselves to automated techniques. Available from Teledyne Tac of Woburn, Mass., the polyester tape has punched-through sprocket and die-cavity holds, plus a thin strip of adhesive, laminated to its under side, to create a sticky floor in the cavities for holding the chips in place. The latest version of the tape has **a window slit in the adhesive floor to ease chip removal**—and for MOS chips, the underside of the tape is metalized.

Learn to evaluate the dynamic response of X-Y recorders

X-Y recorders are commonly believed limited to low-frequency applications ranging from dc to several hertz, yet **some models may be useful at the higher frequencies associated with direct-writing oscillograph recorders.** It all depends on the recorder's dynamic response, which is determined by its acceleration and slewing speed, companion specifications that are often difficult to relate for a specific application. To find out how, write to Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif., 94304, asking for "X-Y Recorder Dynamic Performance," a four-page application note, No. 214-2.

Lucinda Mattera

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Description	Basic 76	Basic 77	Jumbo 77	Economy 76	High speed counter*	12 bit A/D converter	Expanded 76
ROM (x8)	640	1344	2048	640	640	640	1024
RAM (x4)	48	96	128	48	48	48	48
Total I/O lines	31	31	31	22	39	37	31
Cond. Interrupt	2	2	2	1	2	2	2
Parallel Input	8	8	8	4	8	8	8
Bidirectional Parallel	8	8	8	8	8	8	8
Discrete	10	10	10	9	10	10	10
Serial	3	3	3	–	3	3	3
In-line package	42 pin quad	42 pin quad	42 pin quad	28 pin dual	52 pin quad	52 pin quad	42 pin quad
Availability	Now	Now	Now	2Q 77	2Q/77	3Q 77	16 wk ARO

Power supply is 15v except low voltage version of Basic 76 available 3Q 77.
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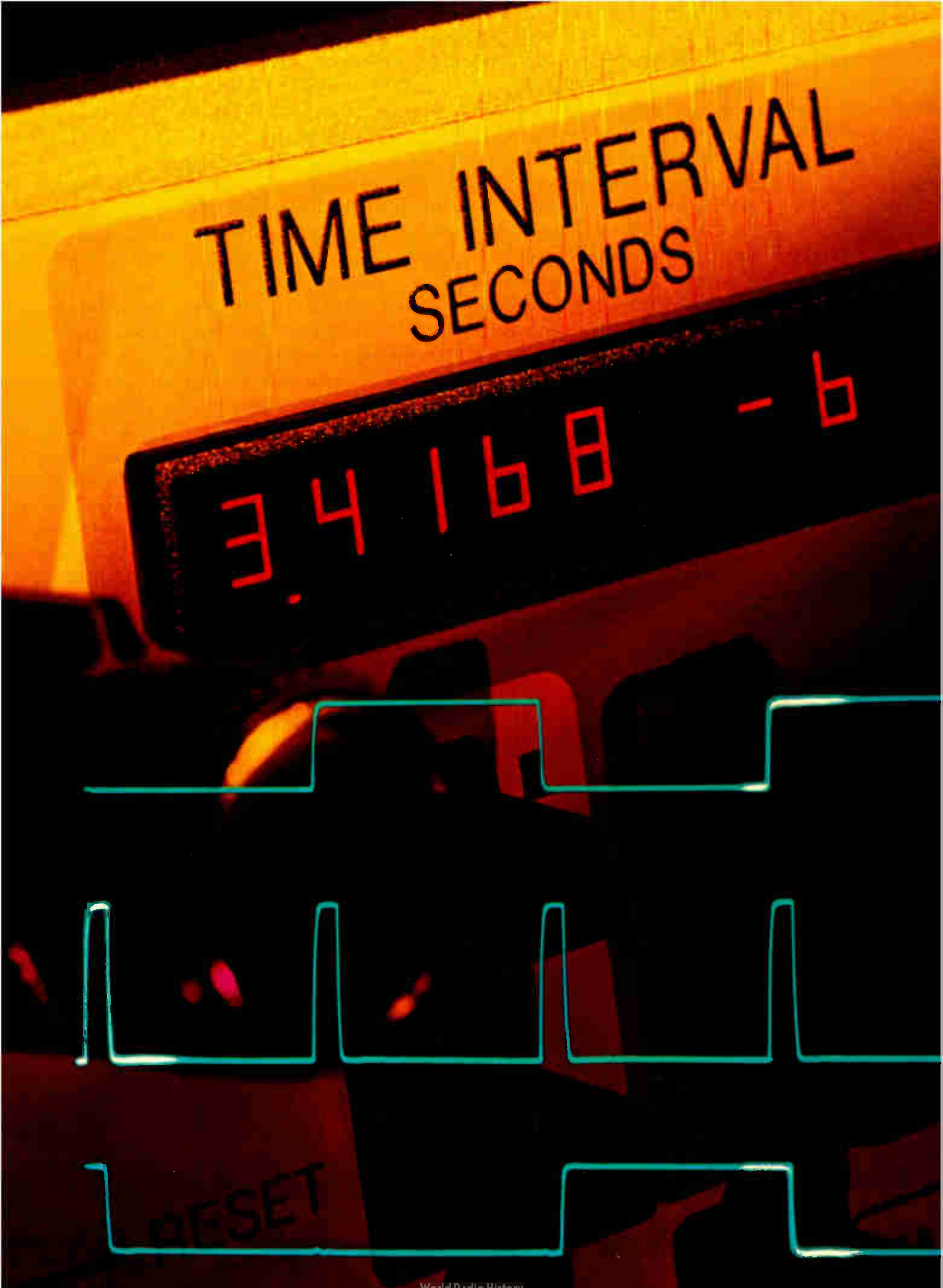
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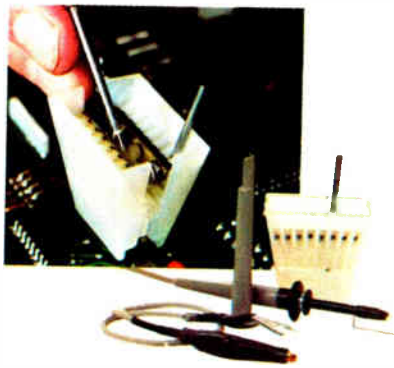

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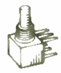

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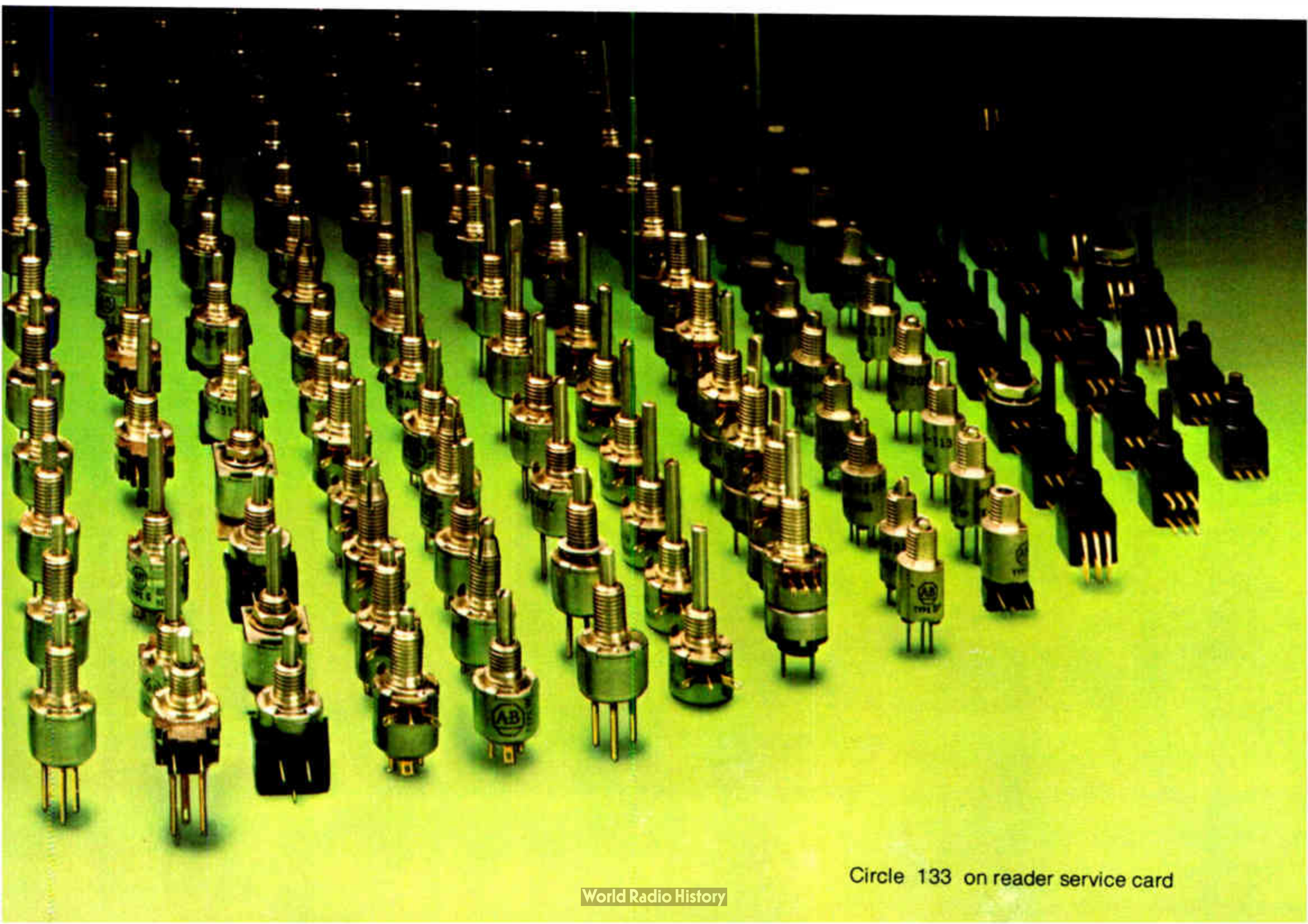


Circle 133 on reader service card

Price cuts, IC compatibility entice more users to solid-state relays

by Larry Armstrong, *Midwest bureau manager*

☐ For the first time in their 10 years of existence, optically isolated solid-state relays look ready for the big time. The newest no-frills models have a broader appeal than do the familiar feature-loaded premium designs, packages are shrinking to fit in better with integrated circuits, and prices are tumbling.

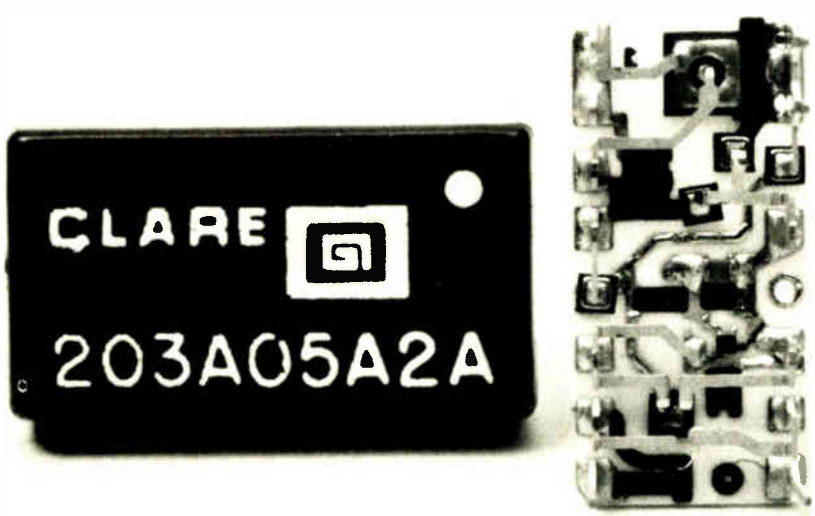
In hopes of a market boom, several makers are turning to thick-film hybrid techniques (Fig. 1), which lend themselves better to low-cost mass production than the traditional component-laden printed-circuit boards. Some also look forward to the spread of the microprocessor, particularly into industrial process control, and have begun packaging solid-state relays specially as input/output modules that convert an ac or dc voltage to a logic-compatible signal and vice versa.

But what has popularized the relays most is their falling price, touched off by the advent two years ago of the photocell-coupled relay. Pioneered by Sigma Instruments Inc. and Theta-J Relays Inc., the low-cost photocell-based devices have put heavy price pressures on their silicon-photodetector counterparts, which often require additional circuitry to trigger the output semiconductor device.

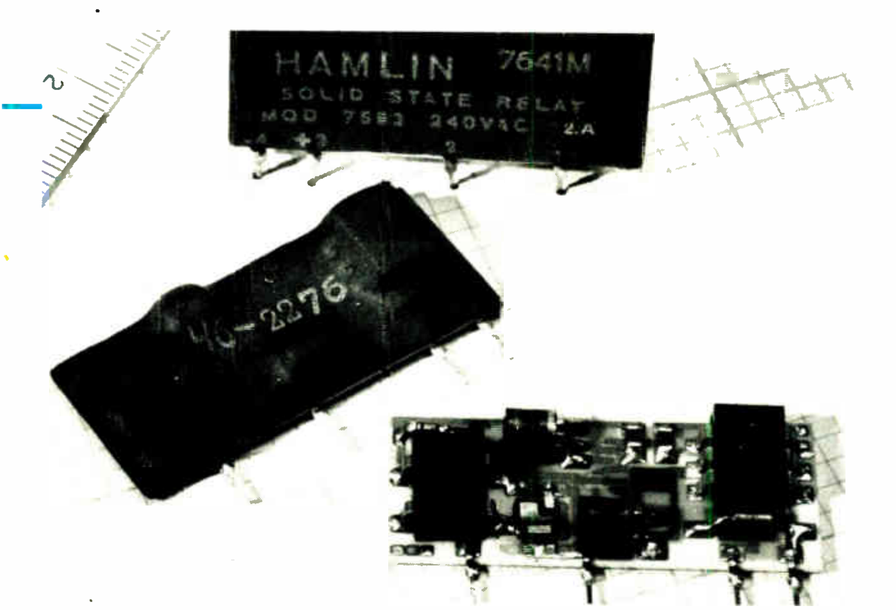
The result of the intense price competition has been a solid-state relay market that in terms of units shipped is growing at about 20% per year but in dollar terms has remained level, at $20 million for the last several years. About $14 million is now optocoupled "all solid-state" models; the remainder is mostly reed-coupled, or "hybrid," solid-state relays.

The photocell types manage to eliminate more than just the full-wave bridge generally used to interface a photodetector with an output thyristor. They also drop the conventional solid-state relay's output snubber—an RC network needed when working into inductive loads—and the newer models are dropping the input zero-voltage crossover network into the bargain.

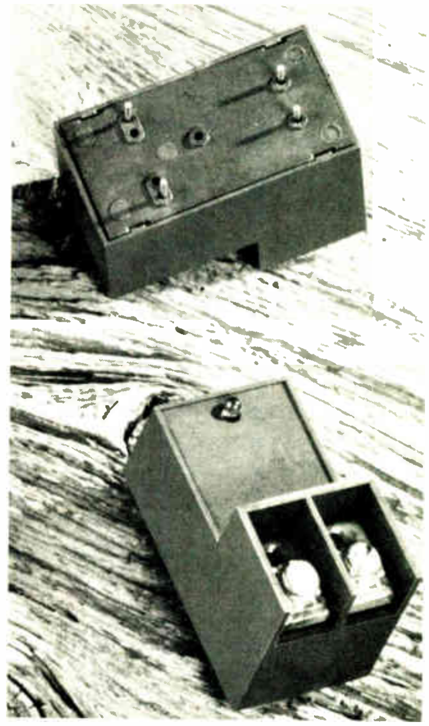
Zero-crossover circuitry delays the relay's firing in order to apply the load at or near the zero-voltage point of the ac line, thus reducing the



1. Thick film catching on. Relay manufacturers like C. P. Clare are looking to thick-film hybrid technology to meet low-cost goals in high-volume markets.



2. Single in-line. To build this low-cost relay, Hamlin assembles pretested packaged components on a substrate containing screened resistors and conductors.



3. For microprocessors. Solid-state input/output modules from Electronic Relays translate high-level ac or dc voltages into logic-compatible signals or *vice versa*.

radio-frequency interference that can cause false triggering. Sigma claims that the reduction is not often needed, as the equipment in which the relay is located is most likely shielded from rfi. "And we have studies to show that any solid-state relay reduces rfi by a factor of between 4 and 20 versus electromechanical relays, with their inherent bounce and arcing problems," says Robert E. Cullen, marketing services manager for the Braintree, Mass., firm. Sigma also questions whether the additional rfi protection bought by a zero-crossover network is worth the additional expense.

Further, "there are 3 to 5 milliamperes of leakage [in the off state] with a zero-voltage firing network, where our units have leakage of only 1 microampere—the leakage of the triac," Cullen adds. "That's particularly important in medical applications where a person may be in contact with the load."

Sigma's 226 series devices are built around only four components: a light-emitting diode and its current-limiting resistor, an output triac, and a photocell—in effect a light-sensitive resistor that controls the triac's gate current. The photocell is particularly innovative, Cullen believes, because it is a light-sensitive cadmium-sulfide material that is screened onto the same substrate on which the triac chip is mounted. The circuit's simplicity and ease of assembly are reflected in Sigma's prices: $4.83 each in lots of 100 and $3.85 each for 1,000-piece lots, for a unit that will switch 1.5 amperes at up to 140 volts root mean square. Input control is either 4.3 to 10 v or 10.3 to 16 v dc, and the firm has a 280-v ac output model. Input-to-output isolation is 2,500 v, higher than the industry's standard 1,500 v.

But the firm that has competitors grumbling about price cutting is Theta-J Relays Inc., Bedford, Mass., which has the broadest line of low-cost ac and dc relays available [*Electronics*, Aug. 5, 1976, p. 120]. Theta-J, like Sigma, specializes in easily assembled, four-component relays using cadmium-sulfide photocells. But it does not mount the triac on the same substrate, because it wants thermal isolation between the two. Nor is it copying the Sigma approach; Edward T. Rodriguez, Theta-J's chairman and technical director, has been granted a patent on his photocell technology.

The company recently extended its J-Tab series ac relay from current-carrying capabilities of 5, 10, and 15 A [*Electronics*, Nov. 11, 1976, p. 129] to 25 and 40 A by slightly modifying the package, beefing up the leads, and adding a second tab. "Also," Rodriguez adds, "we found that by making these modifications, we could second-source Sigma Instruments [226 series], so we took advantage of that, too." The devices are available in 90- to 140-v dc and 90- to 280-v ac versions, with nominal input control signals of 5, 12, or 125 v.

A few of Theta-J's more recent entries are designed to be mounted on pc boards, following a noticeable trend in solid-state relays. But nothing illustrates that trend better than five new series of relays that Gordos/Grigsby-Barton Inc. put into production in February. All the products use similar circuitry and sport identical specifications but are housed in five different packages. "All are zero-voltage turn-on types," says Paul E. Bachman, sales manager for the Rogers, Ark., Gordos subsidiary, "but we've had to design five package types in order to second-source the most popular pc-mounted solid-state relays on the market today."

The pull of printed circuits. Depending on the package, the Grigsby-Barton line features 0.5-, 1-, 1.5-, 3-, and 5-A switching at 25°C; at least two different current-switching capabilities are available in all package styles, and one package can handle all five. Control inputs are 5, 12, 24, and sometimes anywhere from 3 to 30 v dc. The firm can provide up to 3,750-v isolation in some packages, although 1,500 v is standard. Snubber networks are optional, as are internal metal-oxide varistors, which further suppress load transients. In lots of 1,000 pieces, the 3-A pc version is priced at $5.57, with a 5-v dc control input range and output snubber network.

The Crydom division of International Rectifier Corp., El Segundo, Calif., has also recognized the move toward pc-board relays. Last fall, it introduced its Challenger series 3, a 0.4-inch-high (by-0.8-by-1.2-in.) device rated at 2 A at 40°C. The series 3 deviated from the boxy, chassis-mountable package that its competitors call the "hockey puck" and have almost universally copied.

The more recent Crydom chassis-mountable Challenger series 2 is smaller, measuring 0.85 by 1.75 by 0.6 in. and will switch up to 8 A at 40°C with appropriate heat sinking. Like the pc-board mounting series 3, both 120- and 240-v ac models are available, and input signal voltage ranges from 3.5 to 8 v dc.

Specsmanship. The three California firms that control most of the solid-state relay market—Teledyne, Crydom, and Opto 22, probably in that order—are currently engaged in a healthy game of specsmanship that is being felt by other relay manufacturers as well. Upset by the bad name solid-state relays were getting because of failures caused by improper use, Opto 22 of Huntington Beach, Calif., by its own account kicked off the move to more comprehensive data sheets by publishing dissipation curves and thermal-resistance data. Teledyne says it has always provided enough power-dissipation data for the equipment designer to work with, but Crydom's just-published bulletins show plotted thermal characteristics, maximum surge current, and intermittent duty-cycle ratings. Particularly important, it says, are the thermal curves, which graphically display allowable load current, ambient temperature, required heat sink, allowable package-base temperature, and resultant power dissipation.

There are also signs of a move away from stuffing pc boards with discrete components and toward thick-film hybridization, which requires high-volume production to give it a cost advantage. "Discretes, I think, have had their day," says Anthony Bishop, solid-state product manager at Teledyne Relays, Hawthorne, Calif. In Bishop's view, this is especially true for the military market. Earlier this year, the firm introduced its model 683, a thick-film, optocoupled relay enclosed in a metal hermetic dual in-line package and aimed at military and aerospace users. But it is also planning a similarly built version for the commercial temperature range, and Bishop says that it may be an alternate source for Clare's thick-film 203 series.

Hybrids at hand. C. P. Clare & Co., a Chicago subsidiary of General Instrument Corp., pioneered the use of thick film in solid-state relays with this series, first introduced at the 1973 National Computer Conference. That device, slow in winning acceptance, is now being upgraded from its original 0.75-A rating to handle a full 1.5 A at 45°C with minimal heat sinking—nothing but a conductive rubber pad affixed to the bottom of the relay.

The new version will come in the same oversize DIP package as its predecessor—0.88 by 0.5 in.—but the package footprint will conform to that used by integrated circuits, points out Rick L. Prieto, Clare's product planning manager. This allows the use of standard extruded-aluminum IC heat sinks to take the package above 45°C operation. Other specs are the same as the earlier part: input control voltage starts at 4 v and can go above 6.5 v with an external current-limiting resistor. The device will handle loads from 6.3 to 240 v ac, with a dielectric withstanding voltage of 2,000 v.

Clare has not changed the price of the 203. It is still $7.20 each in lots of 1,000 and slightly under $10 each for 100 parts. "We'll have four to six catalog variations of the 203 within a year," Prieto adds, including parts without the zero-crossing feature, alternate pinouts to match the footprints of competitors' products, and two dc-output versions that will handle 400 mA at up to 250 v dc without heat sinking.

While Clare and Teledyne are using chips on their substrates, Hamlin Inc. has taken a similar thick-film approach, but it uses conventionally packaged and lead-frame-mounted discretes on an alumina substrate that also carries the screened conductive and resistive patterns. The Lake Mills, Wis., firm figures that it can pare yield losses by using pretested components that in addition need not be wire-bonded during assembly.

The new Hamlin relay [*Electronics*, April 14, p. 155] is also offered in one of the solid-state relay industry's first single in-line packages (Fig. 2). "It's less than a half cubic inch in volume, but more importantly, it takes up only a half square inch of board space," says W. Forbes Barton, solid-state relay product manager for Hamlin. Still, the ac device will switch a full 2 A at 25°C, and the firm plans a version with an integral heat sink on the back of the substrate that will give the relay a 4-A rating.

At only $4.95 in 1,000-piece lots, the 7850 series zero-crossing relay does require a snubber network across the output triac when the relay is working into inductive loads. "And we're working on another version without the triac," Barton adds. Customers, of course, will have to add their own output power semiconductor, but "the device will allow them a broad current-switching flexibility with only a single front end in the inventory," he points out.

Making up to microprocessors. But recognizing that the big future demand for solid-state relays fits hand in glove with the increasing industrial use of microprocessors, several relay manufacturers have started configuring their products into panel-mounted versions called input/output converters or in-

4. More I/O devices. Midtex will shortly be offering an extensive line of input/output microprocessor-interface modules comprising both analog and digital models.

put/output modules. Available in both ac and dc models, the input versions of these modules convert an ac or dc voltage to a logic signal, whereas the output versions convert a logic signal to an ac or dc voltage.

Teledyne has had much of this I/O market to itself since it introduced its 671 series some three years ago; in addition, it has packaged the same circuits into pc-mountable 1.5-by-2.0-by-0.5-in. boxes as its 675 series. "They close a switch on the output, so we've always considered them relays," says Teledyne's Anthony Bishop, "but the rest of the world hasn't." Well, the rest of the world appears to be catching on.

"The market for these I/O packages will be bigger than the solid-state relay market is now," predicts Joseph E. Pascente, president of Electronic Relays Inc., Niles, Ill. His firm is on the verge of bringing out a line of I/O modules that match the Teledyne three-pin footprint but take up about half the space, he says. Like Teledyne's, the modules (Fig. 3) are simply optocoupled ac and dc solid-state relays in a panel-mountable package that includes a light-emitting diode to indicate the presence of an input or output signal.

The specs of the first four modules in Electronic Relays's 71 series approximate Teledyne's specs, but instead of using a heat sink inside the package, ERI brings the tab of the internal thyristor out to one of the module's screw terminals and relies on the gauge of the hookup wire for heat sinking. The ac output type will handle 2.75 A at up to 280 V ac and works over an input voltage range of 3 to 7 V dc, while the dc output module can switch 2.75 A at 55 V dc over a 4-to-10-V dc control input. The ac input device operates from 95 to 132 V ac, the dc input device from 10 to 32 V dc. Prices are higher than for solid-state relays in more conventional packages.

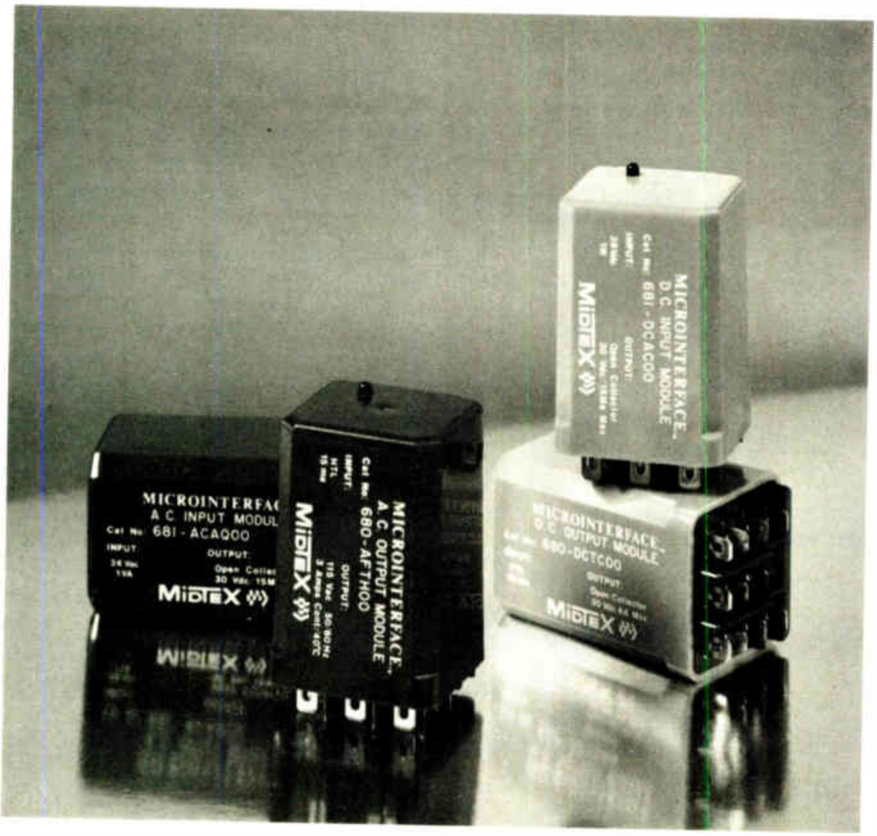
But perhaps the broadest effort in I/O modules will be seen from Midtex Inc. in the next few months. The North Mankato, Minn., firm has already tooled 24 of its projected line of 36 Microinterface analog and digital modules. Twenty are digital, including such functions as thermistor and thermocouple set-point input modules, and 10 are merely ac- and dc-optocoupled solid-state relays. They are all housed in the same physical enclosure (Fig. 4) as Midtex's 157 series three-pole double-throw electromechanical relay, 1.5 in. square and 2.2 in. high, with 3/16-in. quick-disconnect/plug-in terminals and a red indicator light on the top of the housing.

"We think the big growth in the solid-state relay business will occur because of the microprocessor," says Robert K. Else, president, "and we're aiming these products at the interface to microprocessor systems." Typical applications include machine tools, process controls, elevator controls, and—since the Midtex parts are available in normally closed versions as well as the conventional normally open—energy management and security systems, where it is important that the system continue to operate even when the processor does not.

Input modules all feature a transistor-transistor-logic-compatible open-collector output circuit rated up to 30 V dc and include nominal input levels of 24 V ac, 117 V ac, 28 V dc, and 130 V dc. Ac output modules switch 3 A at 117 V ac, with input control voltages of either 7 or 18 V dc nominal, and are available with or without snubber networks and zero-crossover switching. Dc output modules can handle 130 V dc at the same input control voltages. Prices are competitive. An ac output device, to give one example, with zero cross-over and snubber, sells for $9.10 each in lots of 1,000.

To enhance the life of the triac, Midtex puts filters on the front end in addition to a snubber network at the output triac. This filter technique, which uses resistors, capacitors, and an inductor in a pi network, provides complete immunity from any transients that may exist on the power line or be generated when the module is unplugged under power. In the device's specs, the additional filter shows up as improved transient-withstanding capability. In the device's price, it is a 15% premium.

Theta-J, too, has made tentative moves into the I/O module end of the solid-state relay market with a line of miniature high-voltage-to-TTL photocell-isolated converters. Designated the HL series, the firm's input modules are packaged in a half-inch-high 16-pin DIP and provide outputs that will switch 5- or 12-V logic levels at 25-mA currents. □



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Line receivers for IBM 360/370 I/O applications.

The SN75125 and SN75127 are monolithic seven-channel line receivers in a 16-pin package that meet the IBM 360/370 I/O specification. Special low-power design and Schottky-clamped transistors allow for low supply-current requirements while maintaining fast switching speeds and high-current TTL outputs. Both operate from a single 5V power supply. The SN75127 has standard V_{CC} positioning.

The SN75128 and SN75129 are eight-channel line receivers with many of the features of the 125 and 127 plus common strobes for each group of four receivers. The SN75128 has an active-high strobe while the SN75129 has an active-low strobe.

RS-422 dual differential drivers.

The SN55/75158 and SN75159 are dual differential line drivers designed to meet EIA Standard RS-422. They require only a single 5V power supply and offer balanced-line operations, TTL and DTL input compatibility, short-circuit protection and high output impedance in the power-off condition. Typical propagation delay times are 16 ns. Input clamp diodes provide transient voltage protection.

The SN75159 offers all of the features of the SN75158 driver plus 3-state outputs for bus-organized systems.

Dual line receivers.

To the SN55/75140 Series are added the 141, 142 and 143 dual single-ended line receivers with TTL-compatible strobes and outputs. Each features single 5V supply requirements, ±100 mV sensitivity, reference voltage adjustable from 1.5 to 3.5V for maximum noise immunity, and a high input impedance for data-bus applications.

Like the existing SN55/75140, the new 141 offers a common reference pin and common strobe but adds an input-protected diode for the power-off mode. The 142 and 143 line receivers have individual reference pins, individual strobes and an internal 2.5V reference available. The 143 receiver has a diode-protected input stage.

General-purpose line drivers with 3-state outputs.

The DS78/8831 and DS78/8832 can be used as either single-ended or dual differential drivers. They operate on a single 5V power supply and are ideal for party-line applications. All offer very low output impedance with high drive capability, also 40-mA sink and source capability. Typical propagation delay times are 15 ns. The drivers are differentiated by the output clamp diode to V_{CC} on DS78/8831.

Single-ended transceiver.

The SN75136, a functional pin-for-pin replacement for the Signetics N8T26, is a quad transceiver using Schottky-clamped transistors and a single 5V power supply. Both the driver and transceiver have 3-state outputs for data-bus operations. PNP inputs minimize input loading (200 μA max.).

Differential transceivers.

The SN75118 and SN75119 are single differential transceivers similar to TI's SN75116 and SN75117 with the added feature of 3-state receiver outputs. Both devices operate from a single 5V power supply.

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Chip converter settles in 2 μs

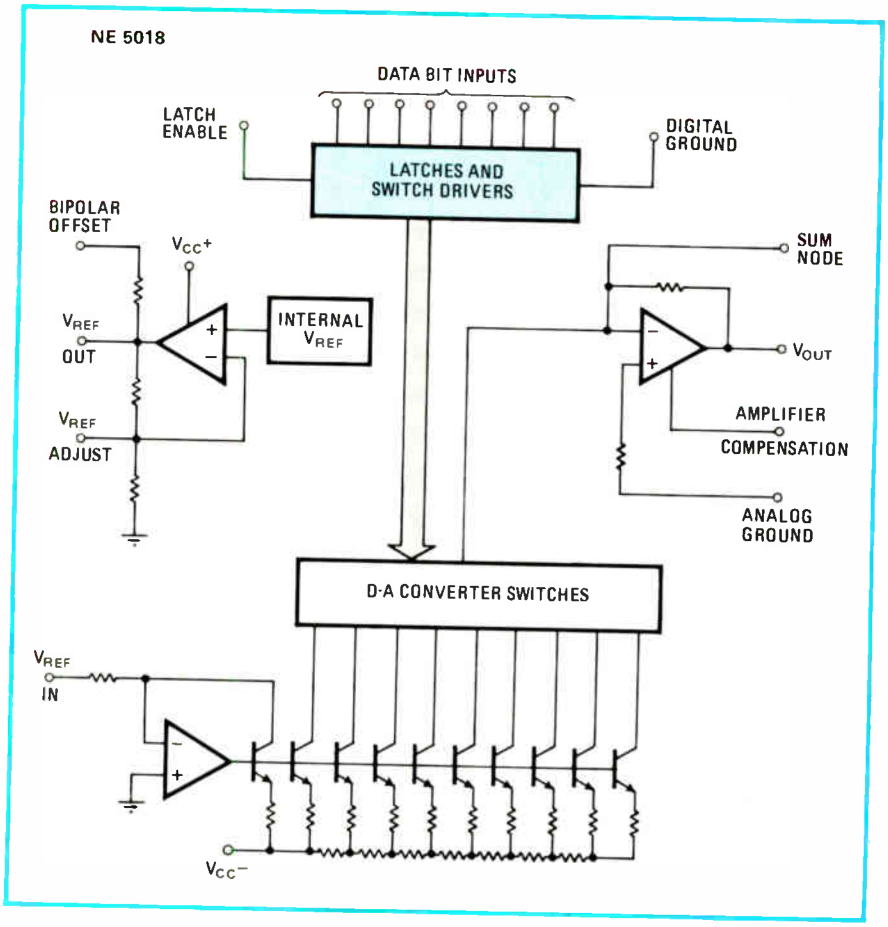
Self-contained 8-bit d-a unit, first in a series of large-scale linears, includes input latches for microprocessor compatibility

by Bernard Cole, San Francisco bureau manager

Using a slightly modified version of its standard process for bipolar operational amplifiers, Signetics Corp. has moved into production with the first device in an upcoming series of what the company calls "large-scale linears." The new chip is the first monolithic 8-bit digital-to-analog converter to be both self-contained and microprocesor-compatible, and it is fast, having a settling time of only 2 microseconds.

Most 8-bit d-a chips require an external output amplifier and sometimes even an external voltage reference. Also, until now, none has included the input latches needed in a microprocessor-based system to capture and hold the digital data long enough to be acted upon by the converter without tying up the microprocessor.

With the new NE5018, Signetics engineers have squeezed—on a 24,000-square-mil chip—a stable reference, a high-speed amplifier, a d-a converter made up of an R-2 ladder of current sources and digital switches, and an 8-bit input latch. "For only $7 to $8," says Derek Bell, data converter marketing manager, "a system designer can replace three to six components costing a total of $11 to $12 with a single NE5018."



Compatible with microprocessor systems that have data buses of 8 bits or wider, the NE5018 has data-input latches controlled by a latch-enable pin. The data and latch-enable inputs are ultralow-loading types for easy interfacing with all logic systems.

With a 200-to-400-nanosecond latch-enable pulse width, the latches appear transparent when the enable input is in the low state. When it goes high, the input data present at the moment of transition is latched and retained until the enable input again goes low.

The chip combines a stable voltage reference (5 volts nominal) with a high-slew-rate buffer amplifier. The voltage reference may be externally trimmed with a potentiometer for easy adjustment of full scale, while maintaining a low temperature coefficient. The output buffer may be offset, says Bell, so as to provide bipolar as well as unipolar operation.

Monotonic to 8 bits, the NE5018 is accurate to within ±½ least significant bit. Requiring power supplies of ±18 v and −18 v for optimum performance, the NE5018 incorporates short-circuit protection on-chip for both the amplifier and the voltage reference. Power dissipation is 800 milliwatts.

In quantities of 100, the NE5018 is available off the shelf for $7.95 each.

Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086 [338]

Digital I/O boards work with LSI-11

Family of four half-quad cards provides flexible interfacing with TTL levels, contact closures, and loads of up to 300 mA

by Michael J. Riezenman, New Products Editor

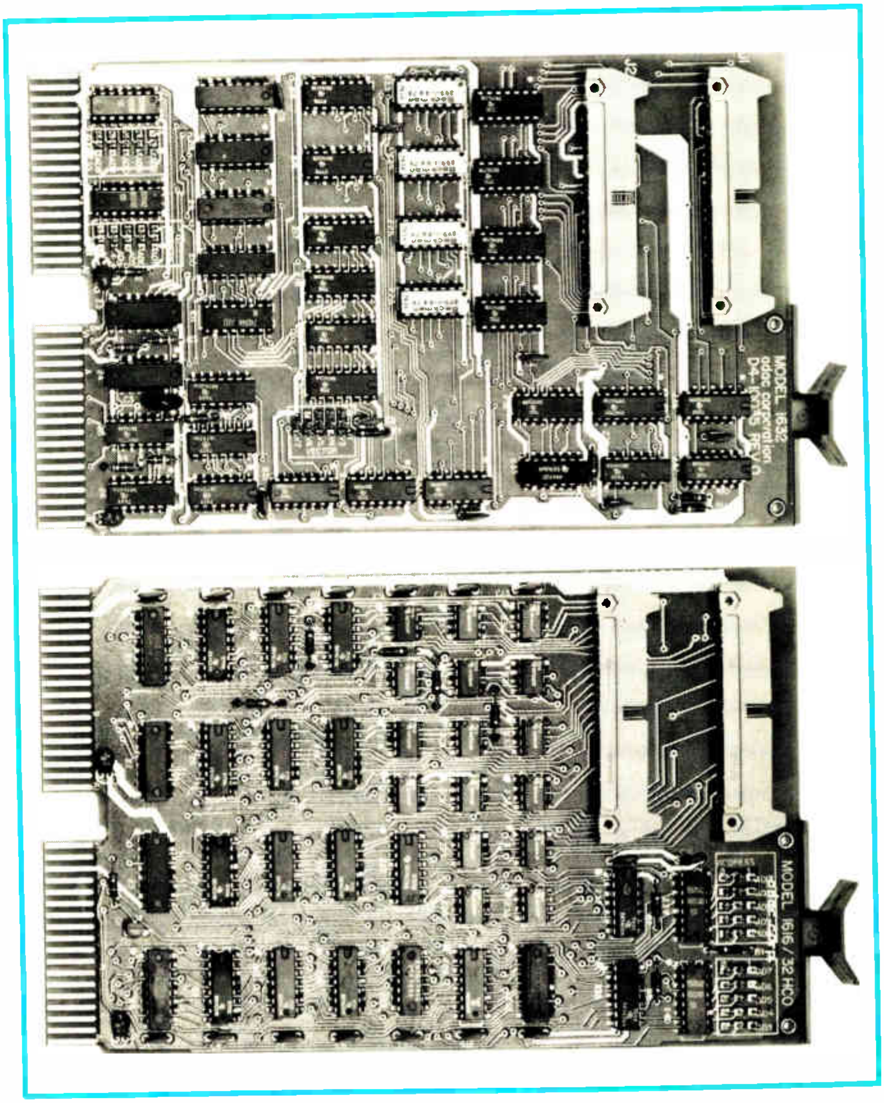
Following its success in designing analog input/output boards for some of the more popular minicomputers and microcomputers, Adac Corp., Woburn, Mass., has developed a series of four digital I/O cards for the Digital Equipment Corp. LSI-11 microcomputer. Contained on what DEC calls a half-quad card, which measures 8.5 by 5 inches, each of the new boards is noteworthy for a high degree of flexibility.

The model 1632 parallel I/O card, for example, is a unit with 32 lines that can be used in groups of eight, as either inputs or outputs. The transistor-transistor-logic-compatible system contains a 16-bit status register and operates either under program control or program interrupt. The status register contains two interrupt-enable bits, two flag registers, and four uncommitted read/write registers that can be used to provide control signals external to the board. The register addresses can be configured, by means of jumpers, to correspond to any address in the DEC field of peripheral addresses, according to Adac.

Control signals are provided in the I/O connectors to signal that new data is ready when either of the two output latches is updated. Two data-transferred pulses indicate that the data formerly present on the input lines has been transferred to the bus. In addition, two initializing pulses reset external devices. In quantities of one to four pieces, the model 1632 sells for $195.

For detecting contact closures, Adac has developed the 1616-CCI—a 16-line card that is supplied with a header and cable to carry individual input lines to the board. Each of its input lines is filtered and sets a flip-flop when a contact closure to ground occurs. A common reset line resets all of the flip-flops when the data is read onto the bus of the microcomputer.

The 1616-CCI interfaces with the LSI-11 in either the program-control



Interfaces. Two of the cards in Adac's digital I/O family demonstrate that 32 channels can be accommodated on a half-quad card. At the top is the 1632 parallel I/O card, and on the bottom is the 1632-HCO high-current lamp driver, which provides 32 outputs.

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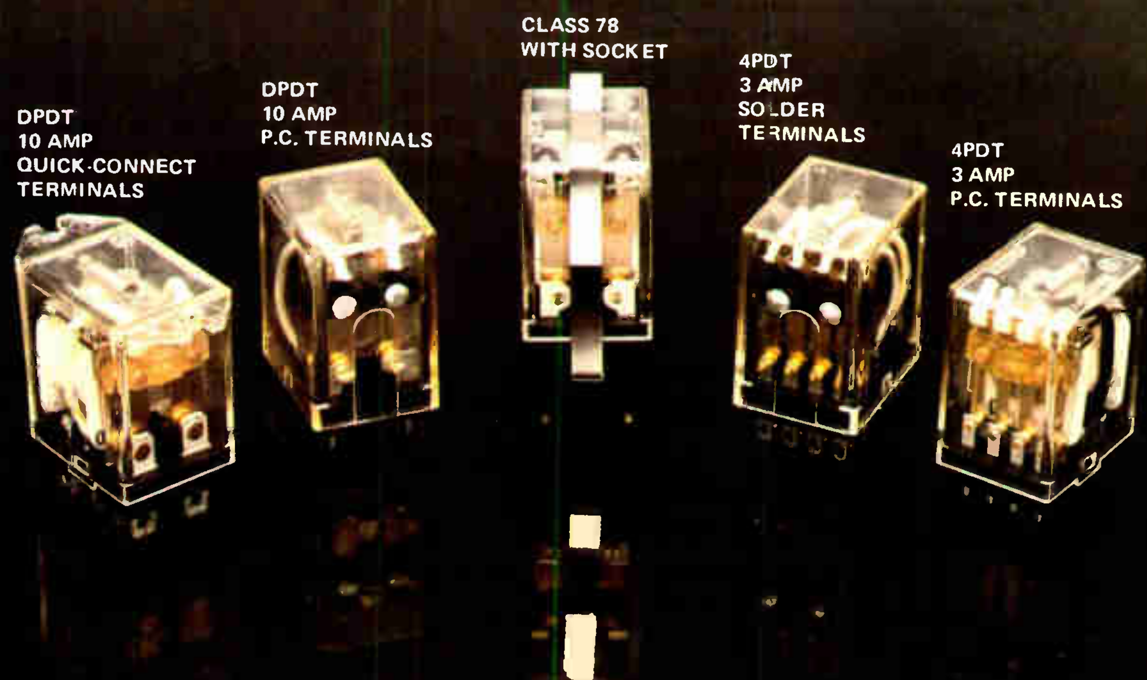
Barriered contacts available on some versions for opposite polarity switching. All relays are available with either solder, or P.C. terminals. The 4PDT version is also available with bifurcated contacts. A full range of sockets are also available. This includes screw terminals, solder and printed circuit types.

For complete information and specifications, WRITE FOR OUR CLASS 78 BULLETIN. Magnecraft Electric Company, 5575 N. Lynch Avenue, Chicago, Illinois 60630.



Magnecraft
ELECTRIC COMPANY

Circle 141 on reader service card

New products

Microprocessors

Computer is built around the 6800

Portable system can control instruments or perform data-reduction tasks

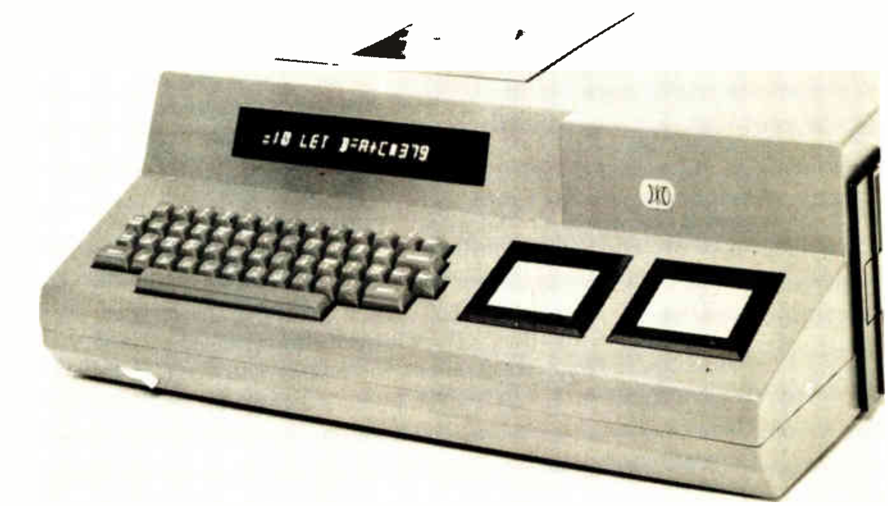
A fully self-contained microcomputer, based on the Motorola 6800 microprocessor family, has been developed by Digital Electronics Corp. for such applications as instrumentation control, data acquisition and reduction, and transaction logging. Designated the DE68DT microcomputer, this fully integrated system contains a keyboard, a 20-column alphanumeric display, a 40-column impact printer, single or dual minicassette tape drives, and a miniature floppy disk. RS232-C ports for optional printers or modems, a numeric keypad, and a nine-slot card cage all fit into the case with the 6800 central processing unit and power supplies. Read-only memory expansion to 65 kilobytes and 16-kilobyte programmable ROM cards are available for easy installation.

Software available includes assembler, Basic, and Fortran IV, as well as a 6-kilobyte ROM/PROM operating system called Debug, one of the most powerful debugging tools yet developed for 6800-based systems, the company says.

The DE68DT is also useful in such applications as microprocessor software development and microprocessor education. It can be used, too, for small-business accounting with the addition of appropriate software. A dual floppy-disk drive or other user peripherals may be coupled easily to the input/output bus to provide customization to fit any user requirement.

The extensive Debug command set includes: memory examine and change, search, move memory block, various tape and disk commands, multiple breakpoints with loop counters, register examine and modify, single-step, trace, various printer commands, and hexadecimal calculator functions. A mnemonic translator permits software debugging in assembly language. Entry/display, search, and print modes are selectable, offering assembly mnemonics and hexadecimal or ASCII characters.

Two versions of the DE68DT are available. The standard DE68DT is a desk-top unit that weighs less than 30 pounds, depending on options. Dimensions are 22¼ inches wide by 17½ in. deep by 7½ in. high. The DE68C is a compact unit without integral miniature floppy disk, but



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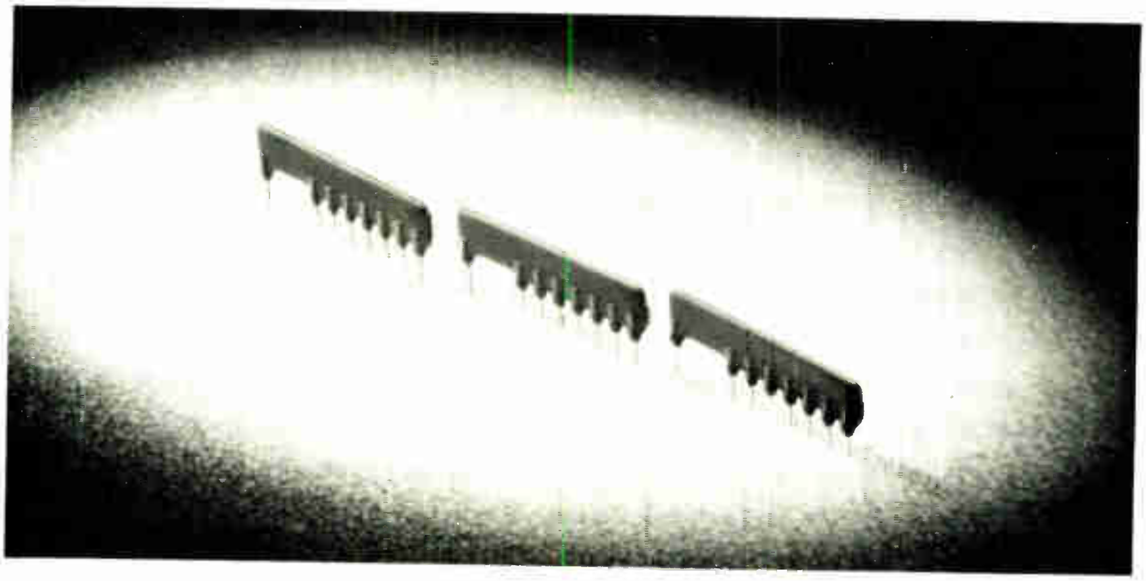

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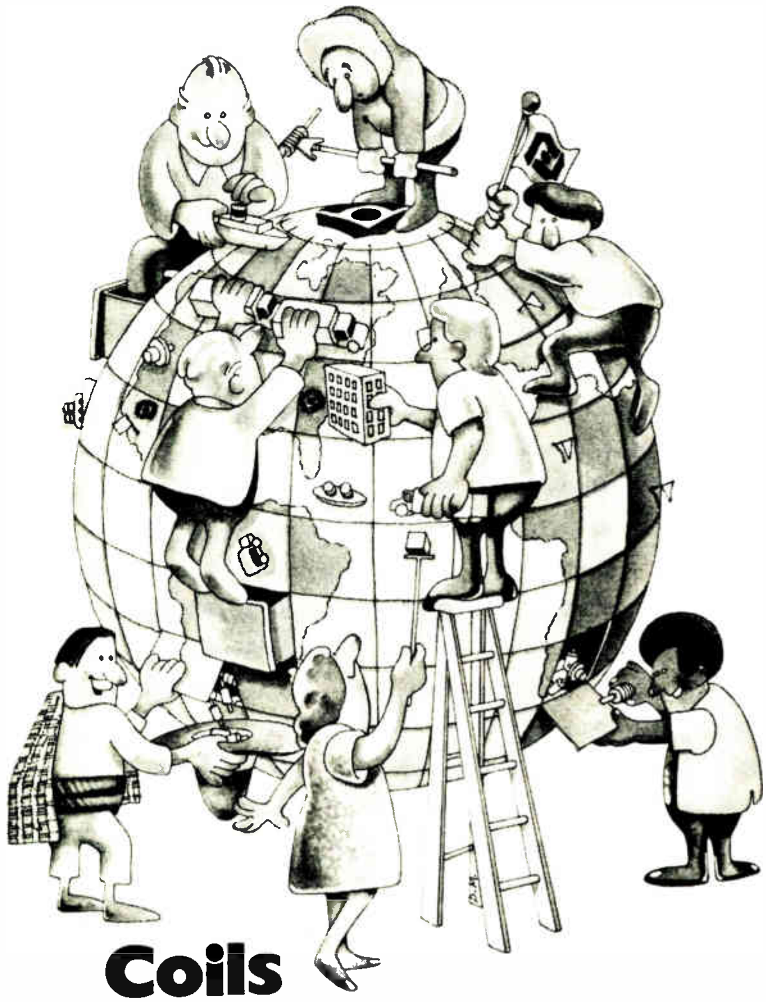
Circle 145 on reader service card



otherwise similar to the DT. Its weight is under 25 lb., and it measures 19½ in. wide by 20 in. deep by 5½ in. high. Both units are fully portable. The microcomputers are priced from $2,200. Delivery time is normally 30 days from receipt of order. Quantity discounts and leasing programs are available.

Digital Electronics Corp., 415 Peterson St., Oakland, Calif. 94601 [401]

Math board boosts computer system speed

For the first time, equipment manufacturers will be able to use low-cost, microprocessor-based computer systems, such as Intel Corp.'s SBC 80 family, in applications requiring high-speed, high-precision arithmetic computations. Making this possible is the Schottky bipolar SBC 310 mathematics unit developed by Intel.

The new unit enables SBC 80 computers to perform mathematical operations an order of magnitude faster than has previously been possible with microprocessor software. Major applications will include process-control systems where speed is critical, such as flow-type processes, instrumentation systems requiring high-speed data reduction and logging, off-line and on-line numerical controls, and aircraft navigation.

Besides high speed, the SBC 310 adds a new dimension to the SBC 80 family's processing and control capabilities. It is a parallel processor implemented with Intel's powerful series 3000 bipolar microcomputer set. A microprogram, stored in the unit's nonvolatile memory, implements 14 new instructions. These include 32-bit floating-point arithmetic, 16-bit and 32-bit fixed-point integer arithmetic, compare and test operations relative to zero or to floating-point constants, and float-to-fix or fix-to-float conversions.

The unit operates as a concurrent processor; that is, the SBC 80 computers can continue executing their main programs while the math board processes arithmetic data in parallel. It carries out simple commands transmitted via the standard SBC 80 bus.

Intel's Multibus allows as many as 16 SBC 80 computers to share a single SBC 310 math board. As a result, the math unit can be used in complex applications such as multiprocessors, as well as in distributed processing and in stand-alone computer systems.

The SBC 310 is designed to operate as an intelligent slave on the SBC 80 system bus. Memory-mapped input/output addressing is used; in other words, the SBC 310 board is addressed like memory, and data generated by the unit can be manipulated like data accessed in memory. Also, the board can operate in an interrupt-driven or polled mode, like the I/O ports on SBC 80 computer boards.

To communicate with the math board, the SBC 80 computer controlling the bus uses standard 8080 microcomputer memory instructions. Each math function is selected by a simple operation code. Data to be processed is entered into registers on the SBC 310 as a memory-write operation. Results are obtained by a read operation. Between the two accesses, the unit executes the command concurrently with the main SBC 80 computer program.

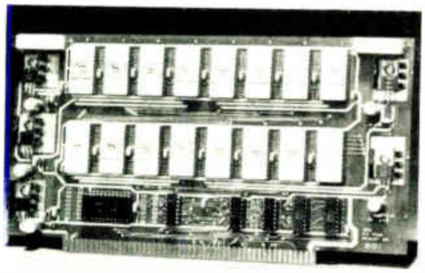
The SBC 310 is immediately available at the single-unit price of $595 and can also be ordered in volume at discount prices. A printed-circuit board assembly measuring 6.75 by 12 inches, it interfaces directly with the SBC 80 system bus and operates on a single 5-volt power supply.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [402]

S-100 memory board holds 16 8-k erasable PROMs

Designed to plug into microcomputers that use the popular S-100 bus, a memory-board kit holds as many as 16 model 2708 erasable programmable read-only memories. If the board is not fully loaded with

New products

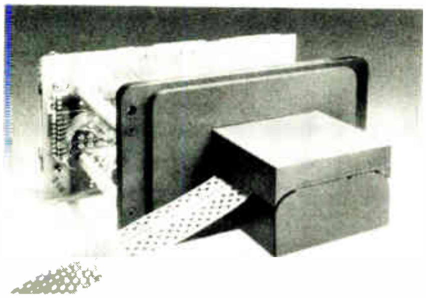


the 8,192-bit memories, the unused sections can be disabled so that a read/write memory can be accommodated within their address space. The board also has provision for a wait state so that it can run in a Z-80 system. Supplied with a full set of integrated-circuit sockets, but without the PROMS, the kit has a small-quantity price of $85. Delivery is from stock.

Ibex, 1010 Morse Ave., Suite 5, Sunnyvale, Calif. 94086. Phone (408) 739-3770 [403]

Punched-tape reader runs at 150 characters per second

Designed for use in microcomputer development systems and PROM programmers, the model 2001-2 reader reads any standard punched paper tape at 150 characters per second. The transistor-transistor-logic disc-compatible unit contains a read head that minimizes errors caused by



skewed or otherwise imperfect tape. The head, which is made of a highly wear-resistant material, will not accumulate static charges—another way in which it tends to lower the reader's error rate.

EECO, 1441 East Chestnut, Santa Ana, Calif. 92701. Phone "Tape Readers" at (714) 835-6000 [405]

Subassemblies

Eight isolators share oscillator

Multichannel isolation amplifiers designed for industrial, medical systems

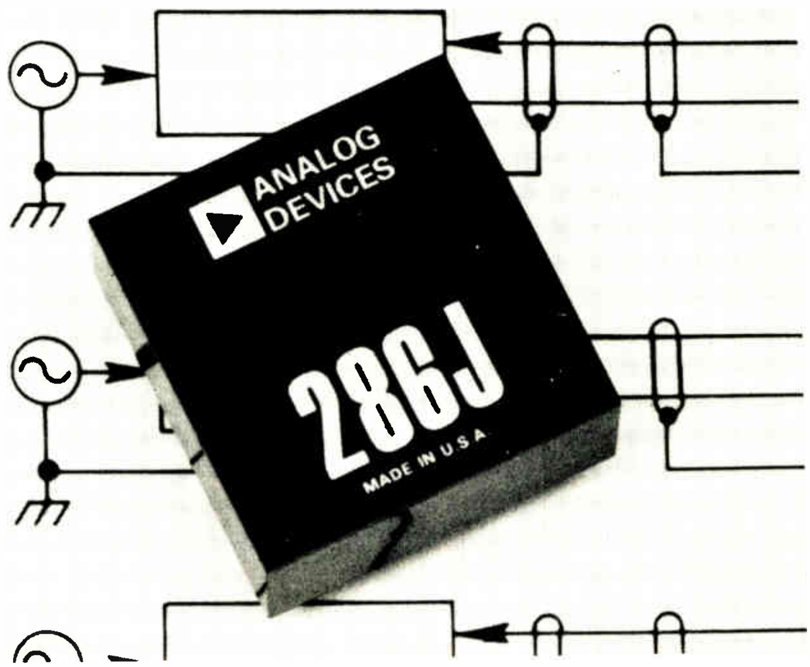
Following up the success achieved by their model 284J single-channel isolation amplifier [*Electronics*, Oct. 28, 1976, p. 144], engineers at Analog Devices Inc. have developed a multichannel unit with even better performance. The new one, called the 286J, is intended for multichannel ground-loop elimination and high-voltage protection in industrial and medical applications.

James Maxwell, marketing manager for analog modules, says that by employing an inexpensive external oscillator, users can make the 286J work in data-acquisition systems handling 1,000 channels or more. The external oscillator consists of an integrated circuit, a capacitor, and two resistors, and it costs about $2, Maxwell says. The oscillator's common frequency can be shared by up to eight 286J units in order to provide the multichannel capability.

The 286J itself has an attractive price—$37 each in hundreds and $59 each in quantities of one to nine—which Maxwell believes will open new industrial applcations especially. The module delivers an isolated output of ±15 volts dc at ±15 milliamperes minimum and fits in the same package as the 284J, measuring 1.5 by 1.5 by 0.62 inches. It also has the same guarded floating front end, including the internal power supply.

The new module can withstand common-mode voltages of 2,500 v continuously or a maximum 10-millisecond pulse of ±6,500 v peak. At ±10 v minimum, it betters the dynamic range of the 284J by 5 v, and its nonlinearity of no more than ±0.05% is well ahead of the earlier model's ±0.03%. Maxwell stresses, though, that the 284J is still the company's recommendation to customers who have single-channel applications.

Like its predecessor, the 286J has a transformer-isolated design that exceeds the patient-safety requirements of Underwriters Laboratories' (UL) Standard 544. Gain is resistor-programmable from 1 to 100, guar-



anteed common-mode rejection is 110 decibels minimum at 60 hertz, and gain stability is specified at 0.001% per 1,000 hours, or 0.01%/°C.

Small quantities are available from stock; delivery time for production quantities is 3 to 4 weeks.

Analog Devices Inc., Route One Industrial Park, P. O. Box 280, Norwood, Mass. 02060. Phone James Maxwell at (617) 329-4700 [381]

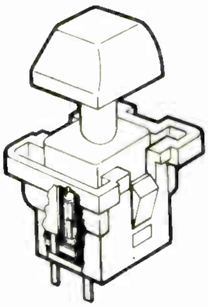
D-a converter has 14-bit monotonicity from 0 to 70°C

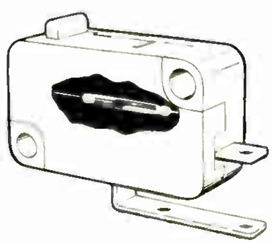
Although it sells for only $175 in small quantities ($135 each for 100 to 249), the MN3310 digital-to-analog converter combines high speed and high linearity over a broad temperature range. The 16-bit converter will settle to within half a least significant bit for a 10-volt step, in no more than 35 microseconds. Its maximum nonlinearity is 0.003% of full scale over the temperature range from 0°C to 70°C. And it is guaranteed monotonic to within 14 bits over that same temperature range.

Applications for the new device include high-accuracy instrumentation, precision control systems, and high-performance function generation. The compact unit is housed in a 24-pin hermetic dual in-line package and has a maximum no-load power consumption of 420 milliwatts. Supply requirements are ±15 v dc.

The hybrid circuit is a complete converter, containing both a reference supply and an output operational amplifier. Active laser trimming allows it to meet all of its specifications without any external adjustments. However, for increased flexibility, gain and offset adjustments are provided.

The converter's transistor-transistor-logic-compatible digital inputs are coded in straight binary. Its output has a typical impedance of 0.25 ohm. Maximum output voltage is 10 volts and maximum load current is 5 milliamperes. Samples of the MN3310 are available for prototyping now. Production quanti-





ties would have a delivery time of six to 10 weeks.

Micro Networks Corp., 324 Clark St., Worcester, Mass. 01606. Phone John F. Munn at (617) 852-5400 [382]

LED display interfaces directly with computers

An intelligent alphanumeric light-emitting-diode display offers full buffering, a built-in ASCII decoder, multiplexer, memory, and light-emitting-diode drivers. The device is thus able to interface with microcomputers and other logic circuits exactly as a random-access memory does. Any character position may be accessed independently and asynchronously. Characters remain lit until a new one is entered.

The DL-1416 display generates all 64 ASCII characters 0.16 inch high. It is actuated entirely by TTL levels and requires only a single 5-volt supply. Each module displays four characters and is so designed that any number of modules may be butted end-to-end to create long displays with equal spacing between all characters. The modules measure 1 by 1.2 inches.

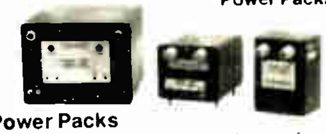
In quantities of 1,000, price is \$5.50 per character (\$22 per four-character module). Delivery is from stock.

Litronix, 19000 Homestead Road, Cupertino, Calif. 95014. Phone (408) 257-7910 [384]

Compact 12-bit d-a converter includes an input buffer

Designed to help engineers solve the interfacing problem with minicomputers and microcomputers, the DAC-HK12B series of 12-bit digital-to-analog converters includes a 12-bit input storage register. A control input determines the state of the d-a converter, having it either store or transfer the input data.

The thin-film hybrid device incorporates a zener reference circuit, a reference-control circuit, three quad current switches, a fast output



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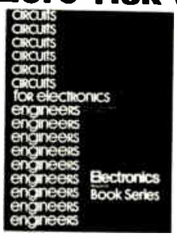

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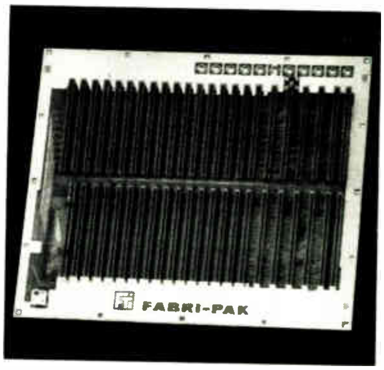

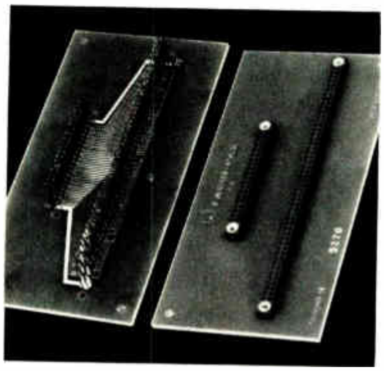

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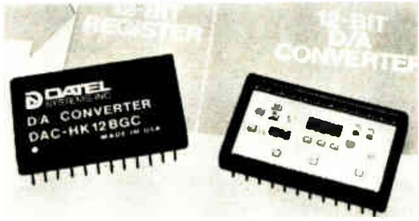


amplifier, and the input register. The quad current switches, combined with a laser-trimmed nichrome resistor network, give the converter its differential linearity temperature coefficient of 2 ppm/°C.

Five output voltage ranges can be achieved by simple external pin connection: 0 to +5 v, 0 to +10 v, ±2.5 v, ±5 v, and ±10 v. Output settling time is 3 microseconds to within half a least significant bit for a 10-volt change. Pricing on the DAC-HK12B, in quantities of 1 to 24, ranges from $99 to $179 each depending upon packaging and temperature range.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021 [385]

Synchro-digital converters accept both 60 and 400 Hz

A series of transformer-isolated synchro-to-digital converters accepts both 60- and 400-hertz inputs with no need for any external components. Housed in standard modules, the new converters are offered with resolutions of 12, 14, and 16 bits. Called the 632, 634, and 636, respectively, the units accept either three-wire synchro plus reference or resolver plus reference inputs.

The 12-bit model 632, which measures 2.6 by 2.6 by 0.82 inches, sells for $249 each for small quantities. The higher-performance devices are housed in modules that measure 2.6 by 3.1 by 0.82 in. The 634 sells for $495, and the 636 is priced at $595. All three units weigh less than 8 ounces. They are all also available from stock to six weeks.

Natel Engineering Co., 8954 Mason Ave., Canoga Park, Calif. 91306. Phone (213) 882-9620 [386]

Data handling

Acquisition unit runs at 250 kHz

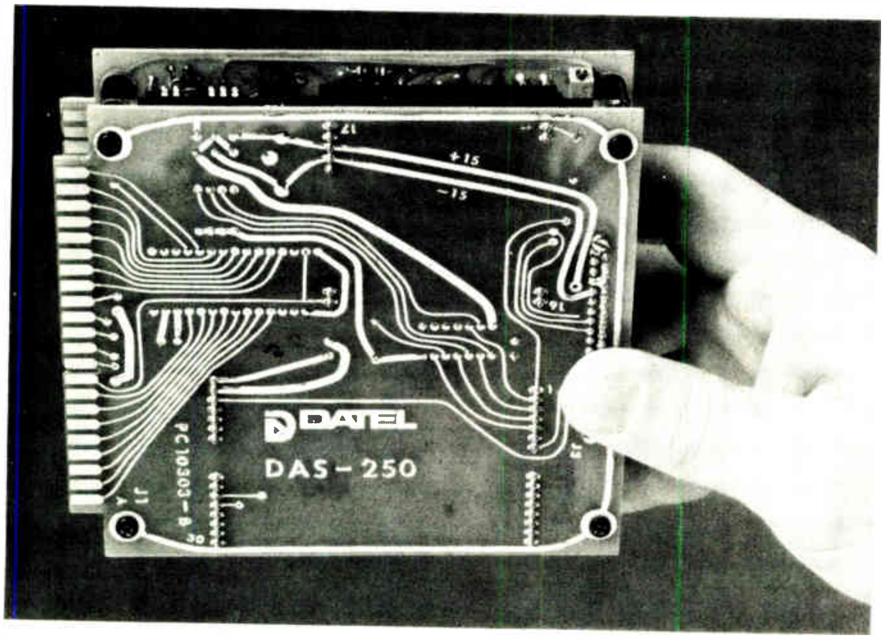
Subsystem offers 12-bit resolution and handles 16 single-ended channels

Data-acquisition subsystems that operate at high speed often sacrifice data-conversion resolution. Not so with the model DAS-250, says Datel Systems Inc.'s Lawrence Copeland, product marketing manager for computer peripheral products. He claims the new subsystem does 250,000 samples per second (250-kilohertz throughput) and still delivers full 12-bit resolution. The nearest competitive unit offers 100-kHz throughput, he says, and many others near that speed have only 8-bit resolution.

The DAS-250 combines several of Datel's high-speed data-acquisition modules into a subsystem that handles 16 single-ended data channels. It is two 4.25-by-5-inch printed circuit boards joined by 1-in.-high standoffs. Two of the components that contribute to its high speed, Copeland says, are the 12-bit analog-to-digital converter with 2-microsecond performance and the fast-settling sample-and-hold amplifier that has a 20-nanosecond aperture time and a 350-ns settling time.

Another feature that contributes to the subsystem's speed is the use of three quad latches at the output of the a-d converter. For operation with mini- and microcomputers, this is an attractive feature, says Copeland, because the output data does not have to be held in the converter until the computer asks for it. The output data can be gated out to the latches in 4-bit groups so that the buses of 4-, 8-, 12-, and 16-bit computers may be used. In this manner, the a-d converter can immediately start another conversion without waiting for an earlier output to be fetched. Furthermore, those outputs are three-state for easy use with open-collector or three-state computer buses.

The DAS-250 also includes an internal 16-channel address counter and analog multiplexer, which is incremented with each a-d conversion for automatic sequential multichannel scanning. But the counter may be used in a random-select mode. In this case, it is a jammed register loaded with a 4-bit address from an external processor. Copeland points out that this capability is important to users who have a mix of inputs. For example, signals from slow transducers such as thermocouples can be sampled on a random basis, but high-activity channels can also be sampled more often under program control.



The subsystem has an overall accuracy of (±0.025% of measured value ±1 least significant bit). Input impedance is 100 megohms, and the single-ended input ranges are 0 to +10 volts or −5 v to +5 v.

Copeland looks for the subsystem to be used in analog instrumentation for fast-changing physical events such as shock or impulse studies and fast chemical reactions. Unit price is $595, and delivery time is 4 to 6 weeks.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02121. Phone Lawrence Copeland at (617) 828-8000 [361]

Intelligent cable obviates need for interface logic

A general-purpose intelligent cable developed by General Automation gives users a low-priced method for interfacing many byte-wide devices to any minicomputer in the company's LSI series. It is designed to interface directly with most low-to-medium-speed devices, eliminating the need for the user to develop special interface logic. The cable's word width is selectable in 8-bit increments up to 32 bits.

Data is stored in a 32-bit buffer, controlled by what Computer Automation calls a Picoprocessor. This is a fast, miniature digital processor that is microprogrammed to provide protocol sequencing and status and error checking with all modes of input/output programming. Imbedded in a 12.5-foot intelligent cable, the Picoprocessor can be mounted to any flat surface by screws or by an adhesive fastener.

With the cable, which sells for $300, data is transferred by using two-wire strobed or handshake protocols. Other intelligent cables are available for interfacing with card readers, line printers, paper-tape readers and punches, modems, magnetic tapes, alphanumeric displays, cathode-ray tubes, and teletypewriters.

Computer Automation, 18651 Von Karman, Irvine, Calif. 92713 [363]

Unit cleans and tests computer tape

The SLT-80 is a fully automatic cleaner-tester for computer tape that removes accumulated dirt, dust, and oxide debris that adhere to the tape and cause signal dropouts and read/write errors. It also reports the exact condition of the tape, computer correlated at subcritical, nominal, or hypercritical levels.

To use the machine, the operator places reels (with autoload bands in place) on the self-seating hub and presses one button. The system automatically opens the band, threads the tape, cleans, tests, and stacks it back onto the reel. The full cycle takes 3.75 minutes.

Three models are available for testing nine-channel formats at 1,600 bits per inch, 6,250 bits per inch, or both densities in combination. The machines sell for $12,100 and have an average delivery time of 30 days.

Kybe Corp., 132 Calvary St., Waltham, Mass. 02154. Phone Richard Hurley at (617) 899-0012 [367]

CRT-display interface shares memory with PDP-8

Designed as a shared-memory interface between a PDP-8 minicomputer and a cathode-ray-tube display, the Viuram-8 (video interface unit random-access memory) plugs directly into the computer's Omnibus and gives the computer program direct access to the display. This means the full capability of the computer can be used to format and update the display, says Computer Technology, the company that developed the Viuram-8.

Use of the CRT interface also eliminates the conventional bit-serial, character-serial asynchronous line between the CRT and the computer, the company points out. In the Viuram approach, the CRT memory and all the video-generation circuitry fit on a single board that plugs directly into the minicomputer's backplane. In this configuration, the host computer itself provides the intelligence for the CRT display.

The Viuram-8 sells for $765 in quantities of 10 to 24. An optional keyboard interface is priced at $70. Delivery time is three weeks. A Viuram also is available for use with the LSI-11 computer.

Computer Technology, 6043 Lawton Ave., Oakland, Calif. 94618. Phone (415) 451-7145 [366]

16-channel data logger requires little power

Using standard Philips cassettes as the storage medium, a low-power, 16-channel data logger will accept up to 16 channels of analog data at a 0-to-10-volt level, convert the data to digital form, format the bits into the proper-size words and files, and write the bits on cassette tape in ANSI-acceptable, phase-encoded recordings with a density of 800 bits per inch. Designated the model 2821, the logger uses about 100 milliamperes when recording. It goes into an automatic standby mode in which it draws less than 50 microamperes when there is no data to be recorded.

The 2821 has a data rate of 50 bits per second and can store up to 1 million bits on a standard 300-foot cassette. The formatting is done while the logger is writing the data.

The 2821 is suited for remote recording of environmental data or long-term unattended field measurements. Measuring 10 inches wide by 6 in. high by 11 in. deep, it weighs 5 pounds. Standard operation is at 110 or 220 volts. The logger sells for $2,030 and has a delivery time of three weeks after receipt of order.

Memodyne Corp., 385 Elliot St., Newton Upper Falls, Mass. 02164. Phone Kevin M. Corbett at (617) 527-6600 [364]

Semiconductors

MOS chips drive displays

P-channel circuits designed for use with larger liquid-crystal readouts

With liquid-crystal displays gaining popularity, several device makers have developed monolithic circuits that replace arrays of discrete parts for driving small (typically 0.4-inch) field-effect LCDs. Such displays are used, for example, in portable instruments, panel meters, and calculators. Designed for compatibility with complementary-metal-oxide-semiconductor and transistor-transistor-logic systems, the circuits generally operate in the 5-to-15-volt range and thus cannot drive the much larger (up to 8-inch) message-board type of dynamic-scattering LCDs, which need upwards of 30 v in most applications.

Now, LSI Computer Systems Inc. of Melville, N. Y., offers two alternatives for equipment manufacturers who have had to use discretes or often costly custom integrated circuits to drive the larger LCDs. Two new p-channel MOS chips, the LS7100 and LS7110, are designed for driving dynamic-scattering LCDs and are available off the shelf in large quantities. "They make the large, dynamic-scattering LCDs even more attractive for use in message boards, large signs, wall clocks, and automobile and aircraft instrument panels," among other applications, says LSI Computer Systems president Attila Tetik.

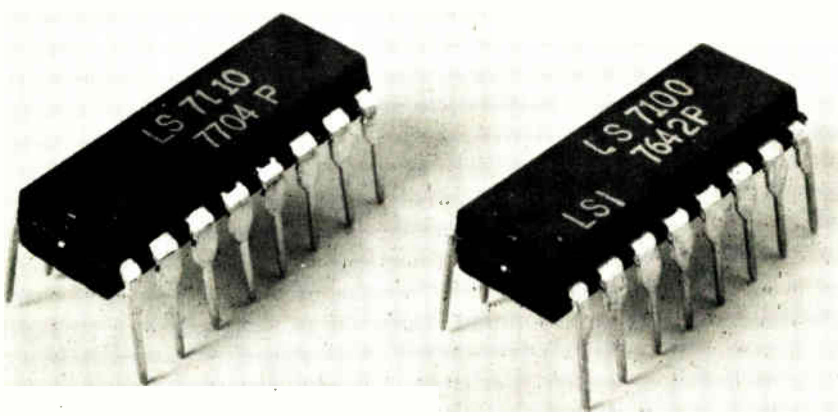
The LS7100 is a combination latch, binary-coded-to-seven-segment decoder, and driver that operates at 5 to 80 v. The LS7110 is a combination binary-addressable, latched, eight-channel multiplexer, demultiplexer, and driver operating at 5 to 70 v. Both chips, says Tetik, "can transmit up to a maximum of 60 v without distortion," from the common input to the outputs. All the inputs are both TTL- and C-MOS-compatible, and both chips are housed in 16-pin dual in-line ceramic packages. They consume less than 400 microamperes at 50 to 60 v, with leakage to the LCD less than 50 millivolts.

The LSI 7100 has the same pin configuration as Motorola's MC14543 and RCA's CD4056, C-MOS-compatible parts that, with their 5-to-15-v operating range, "are useful for driving field-effect LCDs, but not the large, dynamic-scattering type," Tetik says. What is more, he adds, the LS7100 "is price-competitive." In lots of 1, 1,000 and 100,000, it sells for $2.62, $1.19, and $0.66, respectively, the company says.

Perhaps equally important, when compared with discretes, the LS7100 "requires a minimal amount of circuitry to interface with a 120-v ac line and drive a liquid-crystal or gas-discharge display," Tetik says. For example, to drive an LCD, the LS7100 needs a bridge rectifier consisting of four diodes, one capacitor for the bridge and another for high-frequency noise suppression, one zener diode for the chip voltage and a second to control the amplitude of the LCD's driving voltage, five resistors, and two diodes for clipping the sine wave. The device's repertoire includes the digits from zero to nine, as well as –, L, U, P, A, and H.

Conceived initially to be an LCD driver for alphanumerics, "the LS7110 turned out to be a general-purpose multiplexer-demultiplexer--driver. Its application isn't limited to displays. It can also be used as a switching matrix—such as in telephone cross-bar-type applications—or to gather and dispatch information, as well as in communications and process-control applications," among others, Tetik adds.

More importantly, he continues, "the LS7110 can perform all these functions at very high voltage levels. It readily interfaces with 28-v or 50-v signals commonly used in laboratory or telephone work." Previously, telephone companies have used electromechanical switches for cross-bar applications, and others have used individual field-effect-transistor switches or miniature relays to switch high-voltage analog signals. "Now we have a vehicle," says Tetik, "that, presented in different formats, can integrate a large number of these functions." The LS7110 lists for $3, $1.39 and $0.77 when it is ordered in lots of 1, 1,000 and 100,000, respectively.



The LS7110 has eight analog switches with a common source brought in to act as an analog ground. There also are eight channel outputs. The switches are controlled by eight parallel independent logic latches, which means that the user can have any number of combina-

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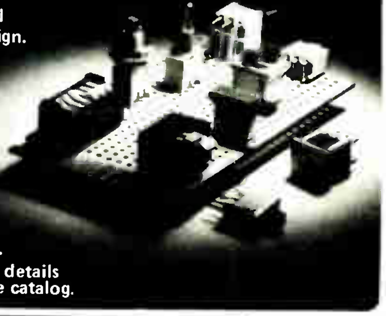

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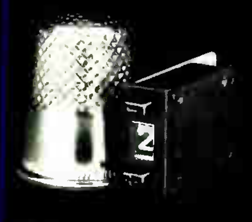

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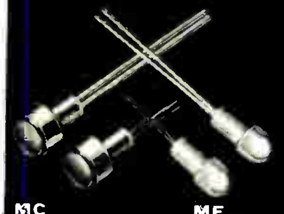

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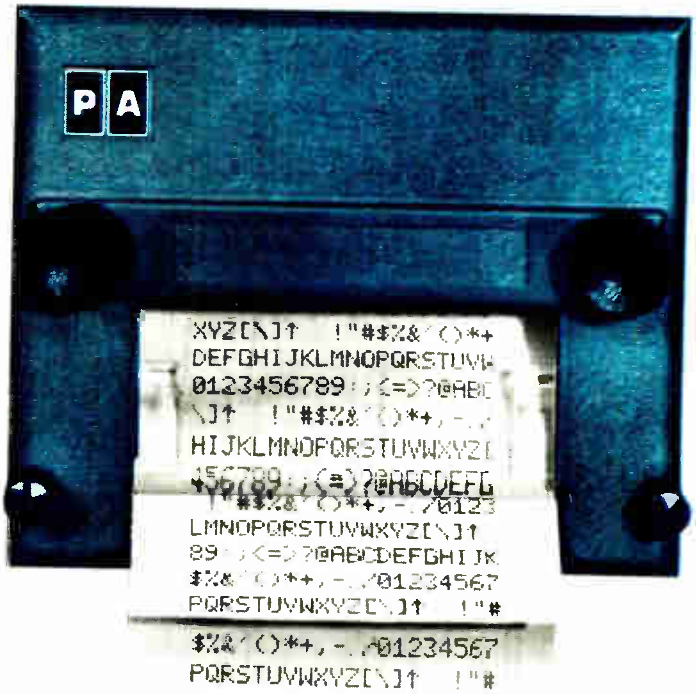

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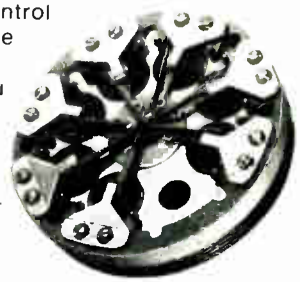

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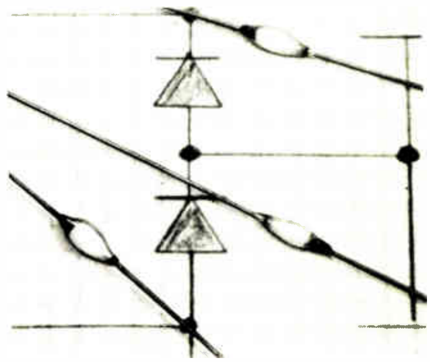
tions at one time that is required. The latches are strobed and addressed by a 3-bit binary address, with a single data line to load in a 1 or a 0 and open or close the respective switches. Both chips have open drain outputs so that when a switch is open, the output is floating and the segment is turned off, with the device's internal impedance discharging the output. The inputs have internal pull-down resistors so they may be left floating for logic 0.

LSI Computer Systems Inc., 1235 Walt Whitman Road, Melville, N. Y., 11746 [411]

High-voltage rectifiers recover in 250 nanoseconds

A series of fast-recovery, glass-passivated rectifiers offers peak-reverse-voltage ratings to 16 kilovolts with a maximum reverse recovery time of 250 nanoseconds. Designated the S093-4044 series, the rectifiers have a maximum average half-wave current of 10 milliamperes. The maximum forward-voltage drop is 12 volts for units from 4 kv to 8 kv and



24 v for the rectifiers with PRV ratings from 10 kv to 16 kv.

Usable in air, in Freon, and in oil baths, the hermetic devices are designed to meet a wide variety of military, industrial, and consumer requirements. Units in the series are priced from 49 cents each to $1.98 each, in unit quantity, depending upon PRV. Delivery of the rectifiers is from stock.

Solid State Devices Inc., 14830 Valley View Ave., La Mirada, Calif. 90638. Phone (213) 921-9660 [413]

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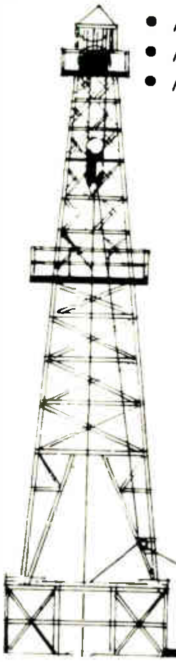

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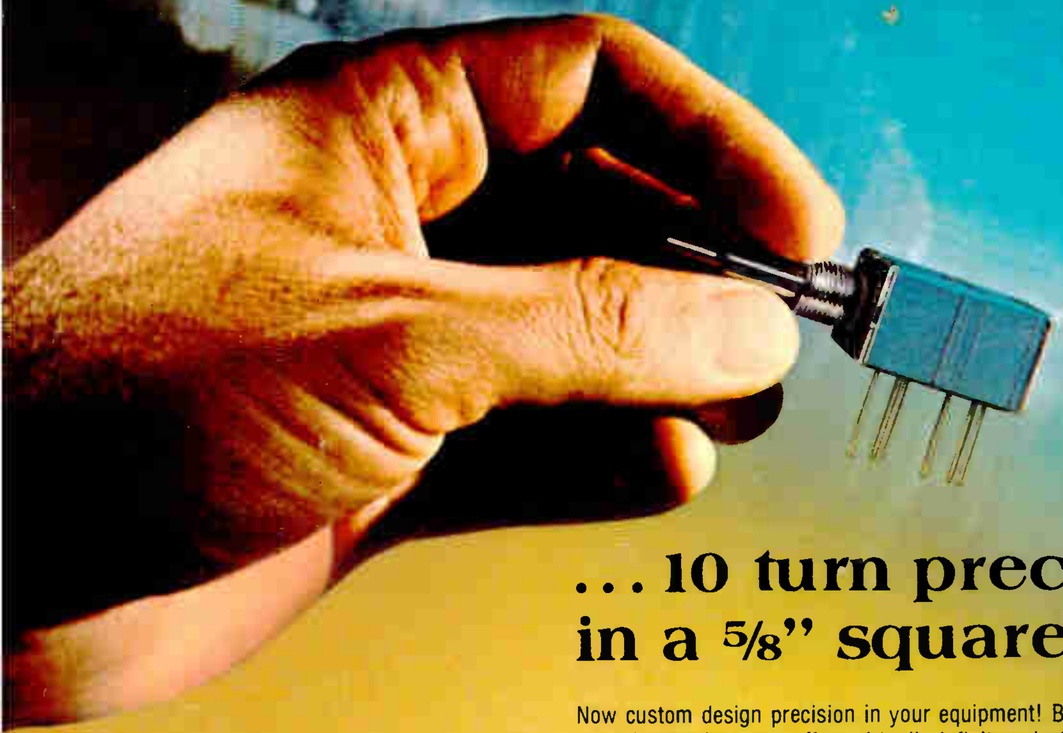
Circle 901 on reader service card

The First Modular Precision Pot...



... 10 turn precision, in a 5/8" square package.

Now custom design precision in your equipment! Bourns modular line of 10-turn wire-wound potentiometers offers virtually infinite selection of standard options, with specs that are unequaled in any other line of modular controls, potentiometers and switches.

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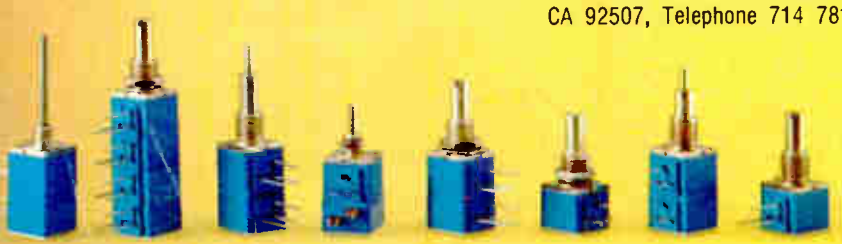

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