JANUARY 20, 1977

DEVICE MAKERS CHASE ERASABLE-PROM TECHNOLOGY/72

Charge-coupled devices are trying new tricks/65

Cost-effective system design with microprocessors/102

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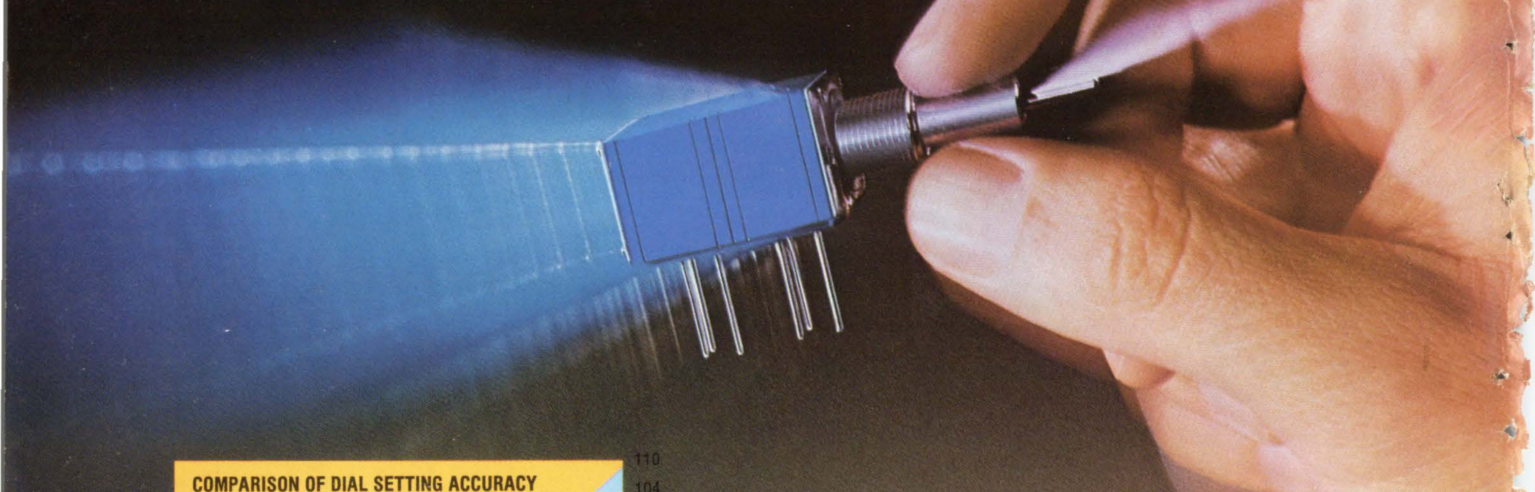

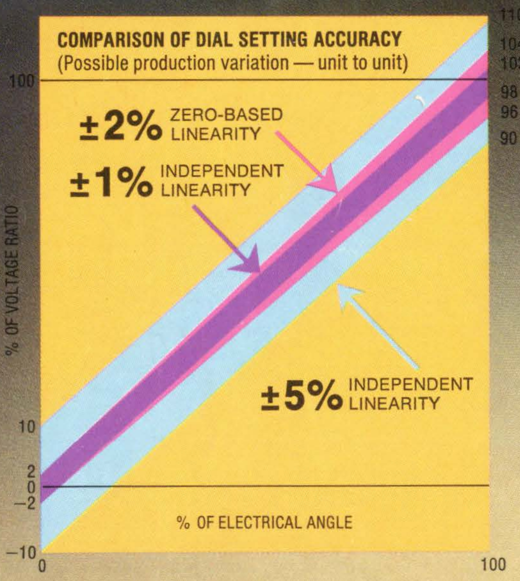

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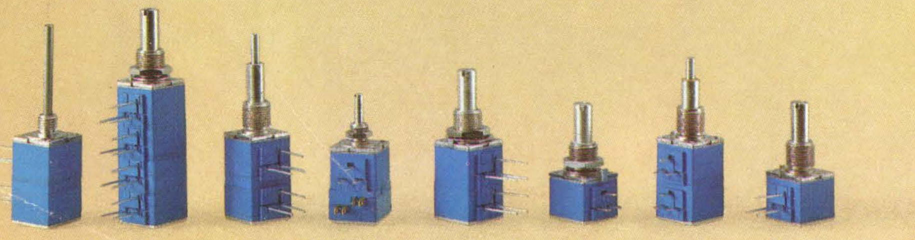

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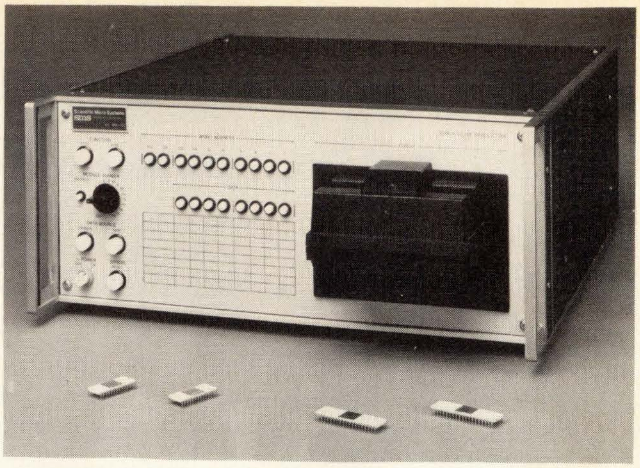

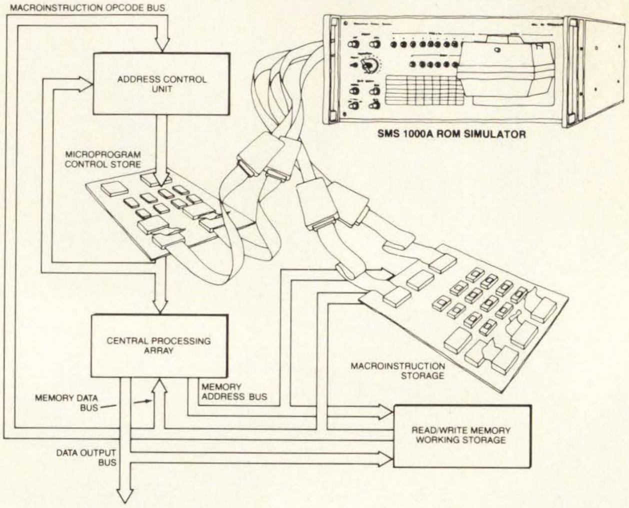

In the system shown, the ROM simulator simultaneously replaces the ROMS in both the microprogram and macroprogram store allowing the machine language code to be changed to find or patch a problem.

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Electronics

The International Magazine of Electronics Technology

Vol. 50, No. 2 • January 20, 1977

Highlights

Cover: Memory flood poses tough choices, 81
Memory chips pouring from semiconductor makers are turning up everywhere. They have become almost universal, introducing data storage's benefits to all electronics-equipment industries.

The driving force is wave upon wave of new technology. Dynamic random-access memories have picked up speed and quadrupled in density (p. 84); alterable read-only memories are making designs more flexible (p. 89), and the future certainly holds the 65-kilobit RAM, while charge-coupled and bubble devices may make an impact on bulk memories (p. 94).

Richard Rosenblum illustrated the cover.

Electronics may shine in gloomy Britain, 69
The advent of North Sea oil and a national export drive that will include the electronics industries spur many English executives' hopes for a good 1977. Best growth sectors likely will be semiconductors and medical electronics, closely followed by computers.

4 ways to get the most from microprocessors, 102
Inspiration is a big help in designing microprocessor systems, but a cost-effective application depends just as much on careful attention to programing, partitioning by speed requirements, adjunct-chip use, and arranging the processors in networks.

And in the next issue . . .
Integrated circuits invade power supplies; a special report . . . the high-reliability mirage in semiconductor devices . . . simple logic adds the dual delayed-sweep capability to oscilloscopes.

Electronics

Publisher's letter

The special report starting on page 81 is our second in two years on semiconductor memories. Our solid state editor, Larry Altman, impressed with the veritable flood of memories with new capabilities that are reaching the market, was struck with the resulting challenge for the engineer, who must pick the right device for his application. Thus, the focus of the article is on how to weigh the choices that the devices offer the engineer.

Altman is the right man to put together that kind of report. Covering the dynamic solid state field, he has a wide-ranging beat and a wide-ranging experience certainly fits him to the task. His output is prolific and so attuned to what's happening that little of the news and developments that he uncovers fails to make it into print.

The source of numerous special reports and hundreds of stories about semiconductor processes and devices in his eight years on *Electronics*, he has also put together three major books on semiconductor technology. The first is a compilation of information about microprocessors—what they can do, how they work and how they are made. The second, on large-scale integration, details processes as well as products. His latest, sort of a sequel to the first, again deals with microprocessors, but this time from the point of view of the designer who will use them as building blocks.

A graduate of Cornell, where he earned degrees in physics and in electrical engineering, he went on to Lehigh University. During his five years there, he both taught physics and picked up his master's degree. A NASA-funded plasma physics project at the Aberdeen Proving Grounds was followed by a stint with Sperry-Rand, where, among other things, he worked on the instrumentation for the reactor of the nuclear freighter Savannah. Along the way, too, he picked up some half a dozen patents.

With such a widely varied background—teacher, physicist, engineer, writer, editor—he brings a lot of valuable experience to his job of informing *Electronics'* readers about technological advances.

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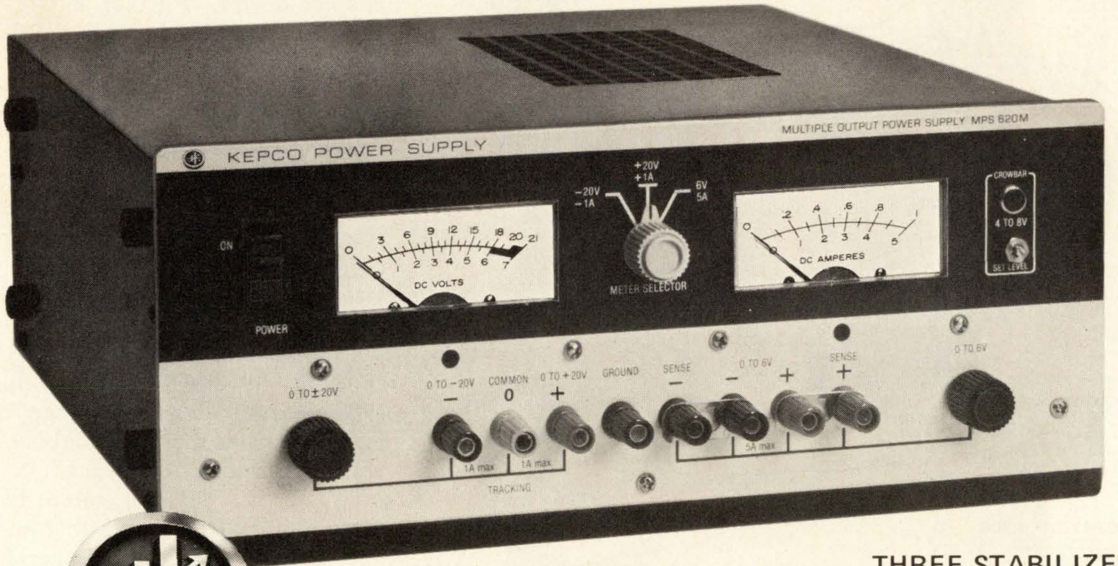

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Readers' comments

Philips device is a PCCD

To the Editor: An item in the Oct. 28 International newsletter ["CCD circuit wipes out video 'ghosts'," p. 63] reports that the recursive filter used "is based on a p-channel charge-coupled device." Further on you call this a "buried-channel, 128-bit CCD."

However, your inference that the Philips device was a p-channel buried-channel CCD is incorrect. It is an n-channel peristaltic charge-coupled device. This PCCD differs from buried-channel CCDs and from other types of charge-transfer devices in that it operates in a twin-channel mode. It is that operation that gives the PCCD performance superior to other charge-coupled types: larger dynamic range and higher transfer speed in combination with high transfer efficiency.

Leonard Esser
Philips Research Laboratories
Eindhoven, The Netherlands

Don't forget OCLI!

To the Editor: It was with interest that I read your Nov. 11 article, "Companies look for ways to raise solar-cell output," [p. 91]. Notably missing from your list was the Photoelectronics division of Optical Coating Laboratory Inc., with manufacturing facilities in the City of Industry, Calif.

Formerly known as Centralab Semiconductor, this organization has more than 20 years' experience in producing silicon solar cells. During this period, more than 10 million solar cells have been produced for both space and terrestrial applications.

Walter J. Lekki
Optical Coating Laboratory Inc.
Santa Rosa, Calif.

Correction

It's going to be a big bubble-memory data recorder that NASA is testing for space use [Jan. 6, p. 31], but not quite as big as the headline and first paragraph of our story said. For 102.4 *billion* bits, please read 102.4 *million* bits. Other references to memory size in the story are correct as they are printed.

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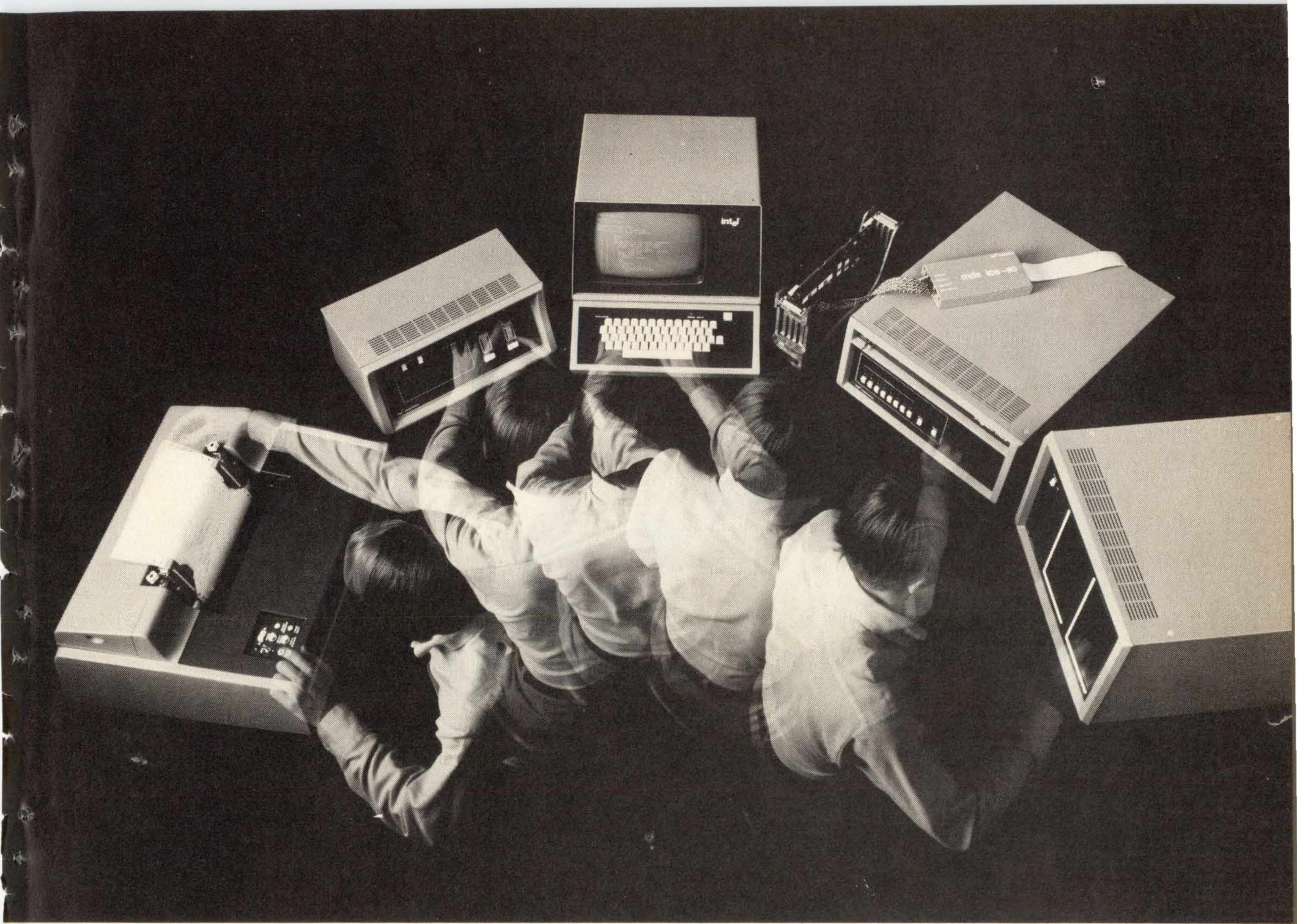
News update

■ The Army perceives a "critical need" for tactical artillery-locating radars, so the Electronics Command is going to skip the engineering development stage of its new AN/TPQ-37 radar system. In going right from competitive prototype to limited production, the command, at Fort Monmouth, N.J., has authorized production of 32 and given Hughes Aircraft Co. a contract for $27 million to further refine and make 10. They will be delivered in July 1978; the remaining 22 will be delivered later.

Hughes' Ground Systems group in Fullerton, Calif., and Sperry Rand Corp.'s Sperry division in Great Neck, N.Y., received about $12 million apiece to make one test model and support software [*Electronics,* Oct. 30, 1975, p. 71]. Hughes won the shoot-off to develop and produce the TPQ-37. In tests at Fort Sill, Okla., the radar "successfully demonstrated all major performance requirements, including a highly successful demonstration of its ability to work with Tacfire," the Army's new automated tactical fire-direction system, says Edward A. Miller, assistant secretary of the Army for R&D.

■ The Air Force wants to use a newly developed radar scan converter as part of the testbed for its proposed Director Fire Control System. The converter, called MDSC, for modular digital scan converter, uses a Hughes Aircraft Co. military computer. Scan converters are needed in today's aircraft because radars and electro-optical sensors must share a single TV screen in the cockpit, with the converter translating slow-scan radar signals to the fast rate of TV displays [*Electronics,* Feb. 5, 1976, p. 29]. Bidders for the Director system will be asked to use an MDSC in their test systems to be flight-tested aboard F-106A aircraft in 1978. The Air Force Avionics Laboratory at Wright-Patterson Air Force Base in Dayton, Ohio, is also pitching its MDSCs for retrofit to radars that use analog converters or direct-view storage tubes.



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Editorial

The impact of memory technology

The picture that emerges when one looks at today's semiconductor memories is an image of enormous vitality and growth. Ten years ago, of course, semiconductor memory really did not exist; today, there are scores of device types available from dozens of suppliers. The worldwide market will approach $1 billion by the end of this year. Clearly the semiconductor industry has done a phenomenal job in designing useful devices and promoting their implementation through the data processing industry.

Without in any way belittling that job, however, it should be pointed out that the role played by the major computer manufacturers has often been overlooked. Indeed, the major computer companies have had a profound impact on the architectural design and product definition of every successful memory device.

Take the 1103. Granddaddy of all semiconductor random-access memories, it is given credit for spawning today's memory industry. A joint effort between semiconductor house Intel and computer maker Honeywell produced the design, with system specialists from Honeywell playing a prominent role in determining the shape and performance of the device.

Perhaps even more important is the test and reliability information that computer manufacturers and other major users feed back to semiconductor manufacturers about the performance of their devices. Hewlett-Packard, for example, after detecting major flaws in early 4,096-bit RAM designs, worked closely with the suppliers in the first stages of production to eliminate the problems. In a real sense, then, the computer industry has underwritten memory component development and continues to do so.

Of course, this close association of suppliers and user is not altruistic. To remain competitive with giant computer maker IBM—which builds its own memories and shares with no one—independents of all sizes have come to rely on the semiconductor industry for their computer hardware technology. In many ways, semiconductor manufacturers operate as though they were the computer industry's in-house circuit builders.

This symbiotic relationship between component designers and equipment makers holds true elsewhere in the world, too. In Japan, for instance, the collaboration between memory designers and mainframe developers is beginning to pay off in some quite advanced devices. Given Japan's avowed goal of becoming a major force on the world's computer market, those devices and the ones to come will be the levers that just might open wide the market doors.

One thing is certain, though. While semiconductor houses and computer makers, for their separate reasons, must work together, the result of their cooperation is a truly awesome digital technology that is already vastly changing the designs of equipment—from television sets to cars, from medical gear to industrial hardware—outside the traditional data-processing industry. That extension of electronics into nontraditional markets is far and away the most significant impact of that technology.

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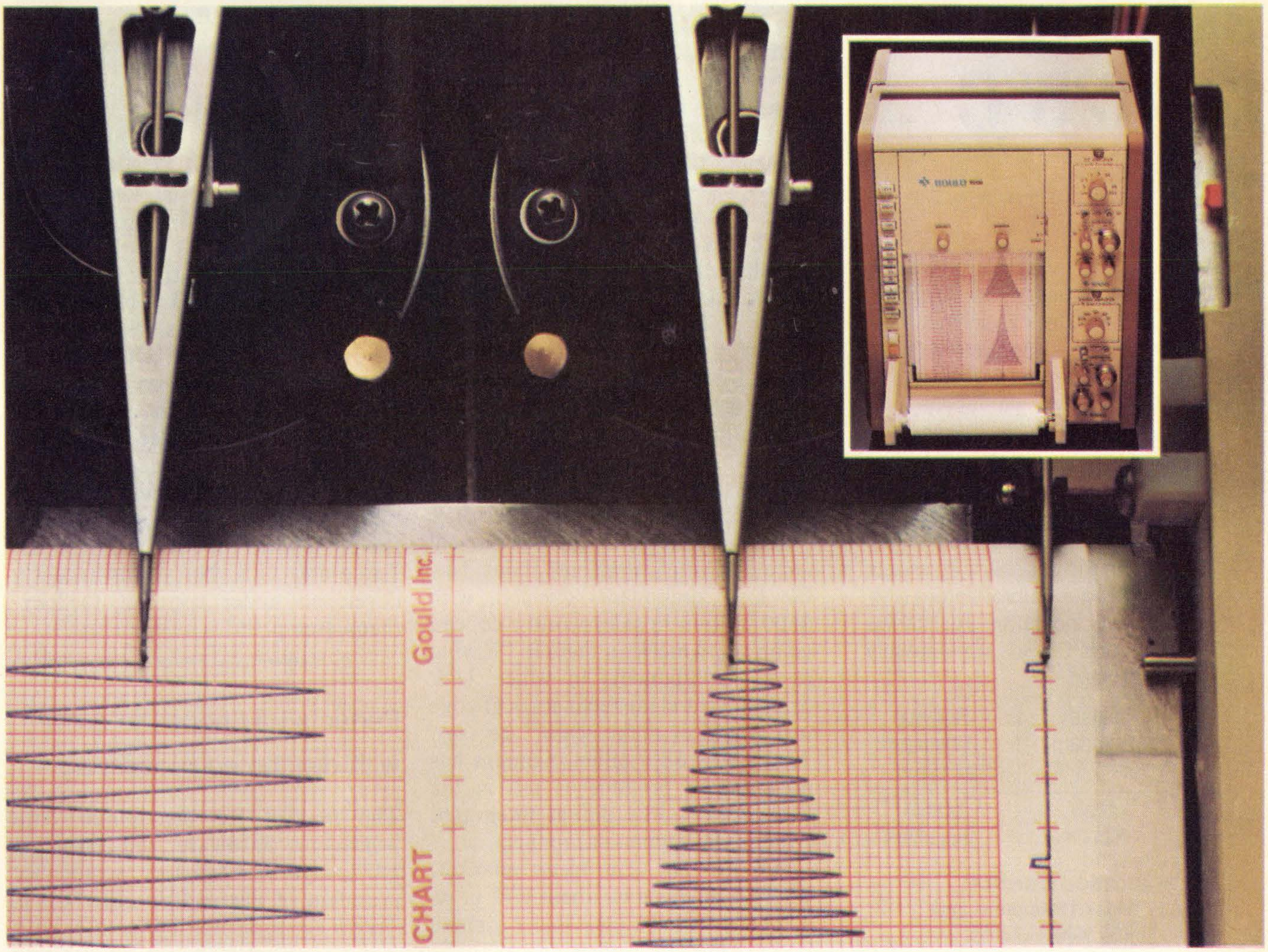

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"Find a niche in the market, and make a name for yourself by filling it with high-quality products." Though more easily said than done, this is the policy that Siemens AG has been following on the American market, says Erich Gelder, the newly appointed director of components sales for West Germany's giant manufacturer.

So far the strategy is paying off. In its fiscal year ending Sept. 30, Siemens sold about $30 million worth of components in the U.S. Its pot-shaped ferrite cores for coils, according to Gelder, have cornered about 30% of the U.S. market. For television and fm-radio tuning diodes its share is a full one third. The Munich-based firm is also doing "substantial business" in the U.S. with tantalum capacitors and zener diodes produced at its Scottsdale, Ariz., facilities.

Realist that he is, the 41-year-old Gelder has no illusions about how far his Components division, with $600 million in sales worldwide, can go on the American market. "Trying to sell components in which U.S. firms have a clear technological edge just wouldn't make sense," he says. That's why $8.8 billion Siemens has no plans to produce or sell in the U.S. devices like digital integrated circuits, let alone LSI products.

As for the European market, where Siemens does about 80% of its components business, Gelder aims to boost sales by following what he calls a "strategy of strength in specific fields." This entails concentrating on areas like optoelectronics, TV tuner elements, linear ICs, thyristors, and capacitors.

The gracious and amiable Gelder exhibits a rare combination of technical knowledge—he has written a number of text books on semiconductors—and savvy in spotting market opportunities, according to company sources. A graduate of the engineering school in Linz, Austria, Gelder came to West Germany in 1955, when he joined Siemens.

Possibility. Linear consumer ICs are high on Erich Gelder's sales list for the U.S.

Gelder believes that "although tough, the U.S. market offers much room for expanding sales of special items." One such item is film capacitors for which his company has developed a low-cost manufacturing process. There are also opportunities, he says, in linear ICs for consumer applications and in special military components. A 38-gigahertz traveling-wave tube for the U.S. Air Force and U.S. Navy was recently developed under contract to Raytheon [see p. 36].

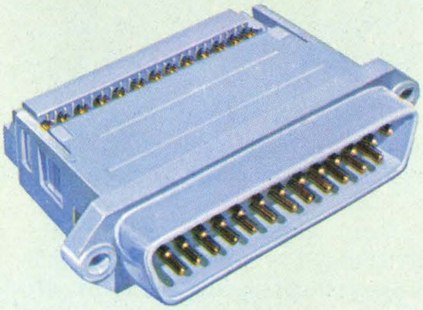
Pertec's Lay hopes to grow with distributed processing

The market for distributed data processing hardware will zoom in 1977, says B. Allen Lay, senior vice president of Pertec Computer Corp. "We'll see a dramatic increase, with many contracts for systems ranging from 10 to 50 terminal sites," he predicts.

Recently appointed to the post of general manager of Pertec's Business Systems division in Santa Ana, Calif., Lay cites two factors coming into play: "The cost of intelligence in network peripherals is down because microprocessors are so much cheaper, and both users and suppliers have learned to work with what is still a fairly new concept."

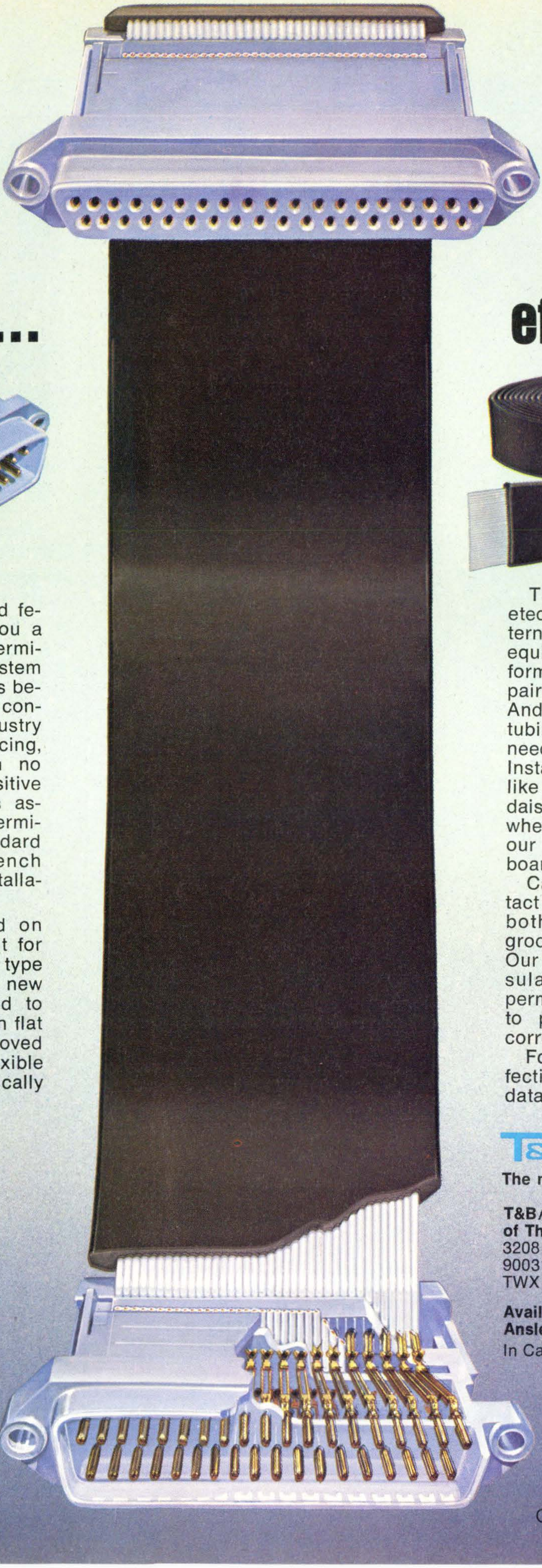
Until now, he points out, potential users have only been talking about needs, but committing themselves no

The Ansley "D" Connector...



Our new series of male and female "D" connectors offer you a cost effective external mass termination cable and connector system second to none. Its uniqueness begins with a one-piece "D" connector package that meets industry standards for size, pin spacing, and contact reliability. With no loose parts to match up, positive cable-to-contact alignment is assured. Conductors are mass terminated in seconds with our standard BLUE MACS™ hand or bench tools. The results? Faster installation, higher reliability.

Contact pins are spaced on .0545″ centers — a perfect fit for any standard inter-cabinet "D" type connector application. Our new "D" connectors are designed to mate with standard .050″ pitch flat cable as well as our new, improved jacketed cable — the only flexible flat cable engineered specifically for out-of-cabinet use.



a new meaning to cost effectiveness.

The Ansley BLUE MACS™ jacketed cable is U.L. listed for external interconnection of electronic equipment. Electrically, it outperforms standard jacketed twisted pairs in typical I/O applications. And there's no special zipper lock tubing required — reducing the need for an extra cable accessory. Installation is faster, easier. And like all Ansley connectors, you can daisy chain our "D" types anywhere in the cable — along with our DIP socket, card edge, or pc board connectors.

Cable alignment and high contact reliability is assured — because both cable and connector are grooved for absolute alignment. Our patented TULIP™ 4-point insulation-displacing contacts are permanently fixed and sealed-in to provide a reliable, gas-tight, corrosion-free mass termination.

For the full reliability/cost effectiveness story and technical data, call or write:

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The mass termination company.

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Available through authorized Ansley distributors

In Canada: T&B/Ansley, Ltd.
700 Thomas Ave.,
Industrial Park
Iberville, P.Q.

Circle 15 on reader service card

People

Opportunity. The competition for B. Allen Lay won't be head-on with the giants.

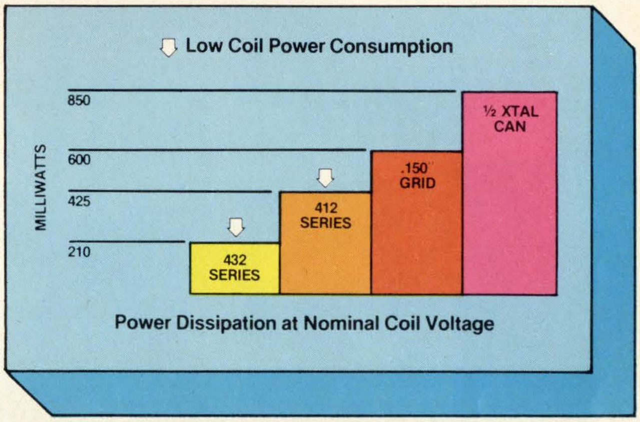
further, while equipment makers have pushed to come up with simple-to-use systems having the right software. Pertec is among the companies trying for the winning formula: its new XL-40 clustered terminal data-entry system is aimed squarely at distributed processing. Built around a stand-alone unit, it offers several interactive display terminal and keyboard configurations for a variety of processing tasks.

At Pertec, Lay is known as an especially hard-working executive, who routinely spends 12 to 16 hours a day on the job. For the past year his assignment was to oversee the acquisition of Computer Machinery Corp. [*Electronics*, Feb. 19, 1976, p. 14] and to integrate it into the company. Lay accomplished this nearly six months ahead of schedule and was rewarded with a promotion to head up the $50 million Business Systems division.

Overshadowing. The prospective growth rate for distributed processing excites Lay who sees it "dramatically overshadowing the computer industry as a whole for the next few years." This represents a nice opportunity for relatively small firms to compete "without running head-on against the giants" because, as he points out, rigid product line definitions have not yet developed. "It's really a brand new market where we're not faced with replacing main frame computers, but rather providing an added capability to a user."

TO-5 RELAY UPDATE:

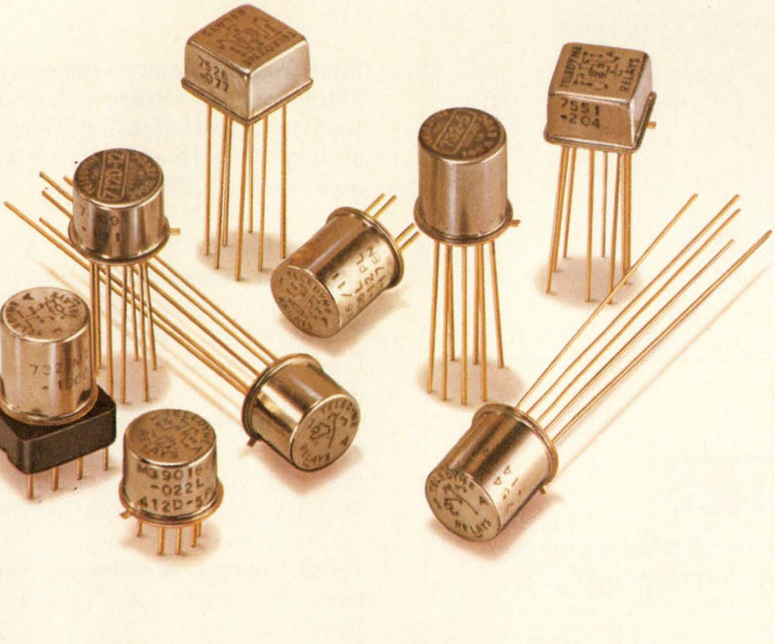
Solve your energy crisis with TO-5 relays



Subminiaturization and pc board compatibility — two obvious advantages of Teledyne TO-5 relays. But there's another outstanding advantage: low coil power consumption. This feature is best illustrated in the above graph which shows our TO-5 relay power savings compared to other miniature relays. The Teledyne 412 Series dissipates about 30% less power than the .150″ grid relay, and 50% less than the ½ crystal can. Our sensitive 432 Series is 65% less than the .150″ grid. And 75% less than the ½ crystal can.

This means you can save over 6 watts in a typical system using, let's say, ten TO-5 relays. In the end, you gain significant advantages in terms of thermal and power supply considerations that can help prevent an "energy crisis" in your system.

Our complete line of TO-5 relays includes military and commercial/industrial types, with virtually all military versions qualified to established reliability MIL specs. For complete data, contact Teledyne Relays — the people who pioneered the TO-5 relay.



- **Hybrid "T" Series**
  SPDT & DPDT types with internal transistor driver and suppression diode
- **"D" and "DD" Series**
  Military and commercial/industrial versions with internal suppression and steering diodes
- **Maglatch Series**
  SPDT, DPDT, and 4PST magnetic latching types
- **Centigrid® Series**
  World's smallest relay — only .225″ (5.72mm) high x .370″ (9.40mm) square
- **Hi-Rel Series**
  Screened versions for space flight applications (NASA qualified)
- **High Environment Series**
  Hi-temperature, Hi-shock, and Hi-vibration types

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Circle 17 on reader service card

Meetings

Wincon—Aerospace and Electronic Systems Winter Convention, IEEE, Sheraton-Universal Hotel, N. Hollywood, Calif., Feb. 7–9.

PC-77—Personal Communications Two-Way Radio Show, EIA, Las Vegas Convention Center, Las Vegas, Feb. 15–17.

ISSCC—International Solid State Circuits Conference, IEEE, Sheraton Hotel, Philadelphia, Feb. 16–18.

Optical Fiber Transmission Conference, IEEE, Williamsburg Lodge, Williamsburg, Va., Feb. 22–24.

Compcon Spring, IEEE, Jack Tar Hotel, San Francisco, Feb. 28–March 3.

1977 SAE International Automotive Engineering Congress and Exposition, Society of Automotive Engineers, Cobo Hall, Detroit, Feb. 28–March 4.

Nepcon '77 West—National Electronic Packaging and Production Conference, Industrial and Scientific Conference Management Inc. (Chicago), Anaheim Convention Center, Anaheim, Calif., March 1-3.

First Annual Joint Symposium on Ultrasound in Medicine, Ultrasonic Industry Association Inc. (New Rochelle, N.Y.) Hyatt-Regency Hotel, San Francisco, March 14.

Fourth Energy Technology Conference and Exposition, Government Institutes Inc. (Washington, D.C.), Sheraton-Park Hotel, Washington, D.C., March 14–16.

Symposium on Numerical and Asymptotic Techniques for Electromagnetics and Antennas, University of Arizona, Tucson, March 14–18.

Tenth Annual Simulation Symposium, IEEE, ACM, *et al.*, Tampa, Fla., March 16–18.

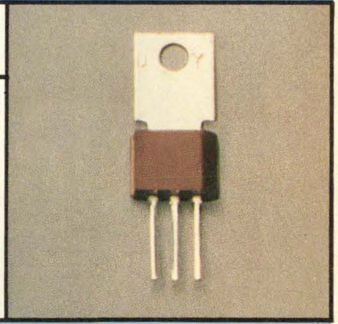
Southwest Printed Circuits and Microelectronics Exposition '77, Indus-

DARLINGTON POWER TRANSISTORS

The Designer's Choice from General Electric

NPN – HIGH GAIN – ½ AMPERE

GE TYPE	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	h_{FE} @ 5V, 200 mA MIN.	MAX.	COMMENTS
D40C1	6.25	30	10,000	60,000	• **Very High Gain** – 60k typical; High input impedance – 50k ohm typ; 1.2 watts P_T @ 25°C ambient.
D40C2	6.25	30	40,000	–	
D40C3	6.25	30	90,000	–	
D40C4	6.25	40	10,000	60,000	• **Applications:** IC Interface audio output, touch switch, oscillator, buffer, high power transistor driver, relay replacement.
D40C5	6.25	40	40,000	–	
D40C7	6.25	50	10,000	60,000	
D40C8	6.25	50	40,000	–	

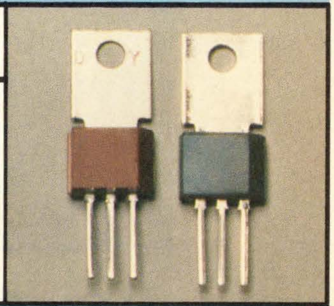


COMPLEMENTARY – 2 AMPERES

GE TYPE NPN	PNP	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	h_{FE} @ 5V, 200 mA MIN.
D40K1	–	10	30	10,000
–	D41K1	10	−30	10,000
D40K2	–	10	50	10,000
–	D41K2	10	−50	10,000
–	D41K3	10	−30	10,000
–	D41K4	10	−50	10,000

COMMENTS

Typical Applications:
- IC Interface
- Driver
- Regulator
- Touch Switch
- Lamp Driver
- Audio Output
- Relay Substitute
- Servo-Amplifier
- TO-202 Package

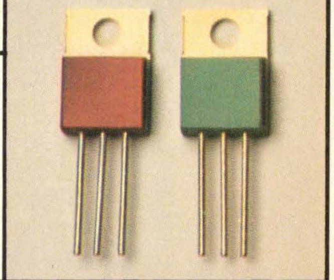


COMPLEMENTARY – 10 AMPERES

GE TYPE NPN	PNP	P_T $T_C = 25°C$ Max. (W)	V_{CEO} Min. (V)	h_{FE} @ 5V, 5 Amps MIN.
D44E1	–	50	40	1000
–	D45E1	50	−40	1000
D44E2	–	50	60	1000
–	D45E2	50	−60	1000
D44E3	–	50	80	1000
–	D45E3	50	−80	1000

COMMENTS

Typical Applications:
- IC Interface
- Relay and Solenoid Driver
- Regulator
- Inverter Power Supply Switch
- Audio Output
- Relay Substitute
- Oscillator
- Servo-Amplifier
- TO-220AB Package



We'd like to show you our DARLINGTON POWER TRANSISTORS; for free sample, identify GE type and write on company letterhead to: General Electric Company, Semiconductor Products Dept., Electronics Park, 7-49, Syracuse, New York 13201.

GENERAL ELECTRIC

Meetings

trial and Scientific Conference Management Inc. (Chicago), Market Hall, Dallas, March 16 – 17.

Vehicular Technology Conference, IEEE, Orlando Hyatt House Hotel, Orlando, Fla., March 16 – 18.

IECI '77: Industrial Applications of Microprocessors, IEEE, Sheraton Hotel, Philadelphia, March 21 – 23

Fourth Annual Computer Architecture Symposium, IEEE, Sheraton Silver Spring Motor Inn, Silver Spring, Md., March 23 – 25.

Data Processing Technology: 1977 – 1981, American Institute of Industrial Engineers (Santa Monica, Calif.), Americana Hotel, New York, March 23 – 25.

Data Communications Interface '77, Datamation magazine *et al.*, Georgia World Congress Center, Atlanta, March 28 – 30.

1977 International Semiconductor Power Converter Conference, IEEE, Walt Disney Contemporary Hotel, Orlando, Fla., March 28 – 31.

Tenth Annual Scanning Electron Microscopy Symposium, IIT Research Institute (Chicago), McCormick Inn, Chicago, March 29 – 30.

Salon International Des Composants Electroniques, Porte de Versailles, Paris, France, March 31 – April 6.

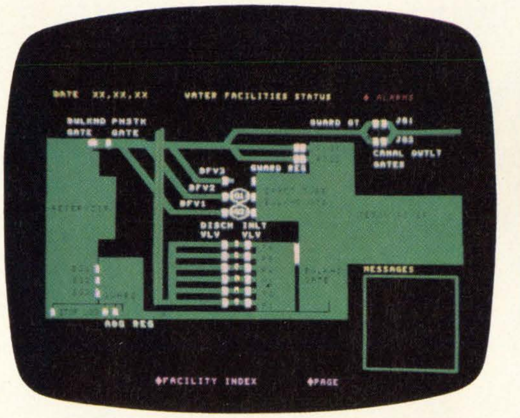
SVJAZ-77 International Telecommunications Exhibition, USSR Chamber of Commerce and Industry (U.S. contact: OK Machine and Tool Corp., Bronx, N.Y.), Sokolniki Park, Moscow, USSR, April 5 – 15.

Microcomputer '77 Conference and Exposition, IEEE, Lincoln Plaza Forum, Oklahoma City, Okla., April 6 – 8.

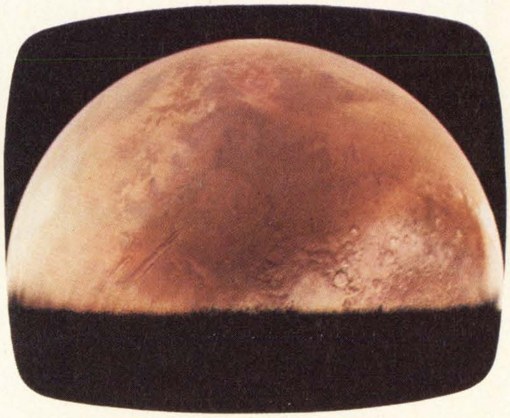
Fifteenth Annual International Reliability Physics Symposium, IEEE, Caesars Palace, Las Vegas, April 12 – 14.

What You Need Is What You Get.

Ramtek's new RM9000 modular graphics and imagery system gives you expandability, economy and flexibility.



Process Control: Water facilities plant.



Imaging: Viking I Orbiter.

Select The Performance You Need.

The RM9000's total modularity lets you select the exact performance you need to fill your particular application. You pay only for the performance you need. Nothing more. And that's like money in the bank.

Add On As You Have To.

As your needs change and grow, the RM9000's capability will grow right along with them. A comprehensive list of options such as expansion from black and white to grey scale or color—even a complete range of interactive peripherals and additional independent channels.

Microprocessor-Controlled Raster Scan.

The RM9000 is the first raster scan graphics and imagery system to be totally microprocessor controlled. That means you can implement a higher-order user language to minimize programming costs without a sacrifice in system throughput.

Functional. Reliable. Maintainable.

High reliability is the direct result of intensive testing of components and systems prior to shipment. Solid state components and printed circuit construction are used exclusively. Result? No special preventive maintenance measures are required. In fact, the RM9000 can be pre-programmed with self-diagnostic capability.

You Need To Know More.

To fully appreciate the RM9000's capability, you need more details. Call or write Ramtek Corporation, 585 N. Mary Ave., Sunnyvale, CA 94086. (408) 735-8400.

ramtek
Our Experience Shows

Here's what Mostek's 16K RAM

Technology: At 122×227 mils, the 4116 (with POLY II™ processing) has the smallest chip area in the industry—22%<Intel, 50%<TI.

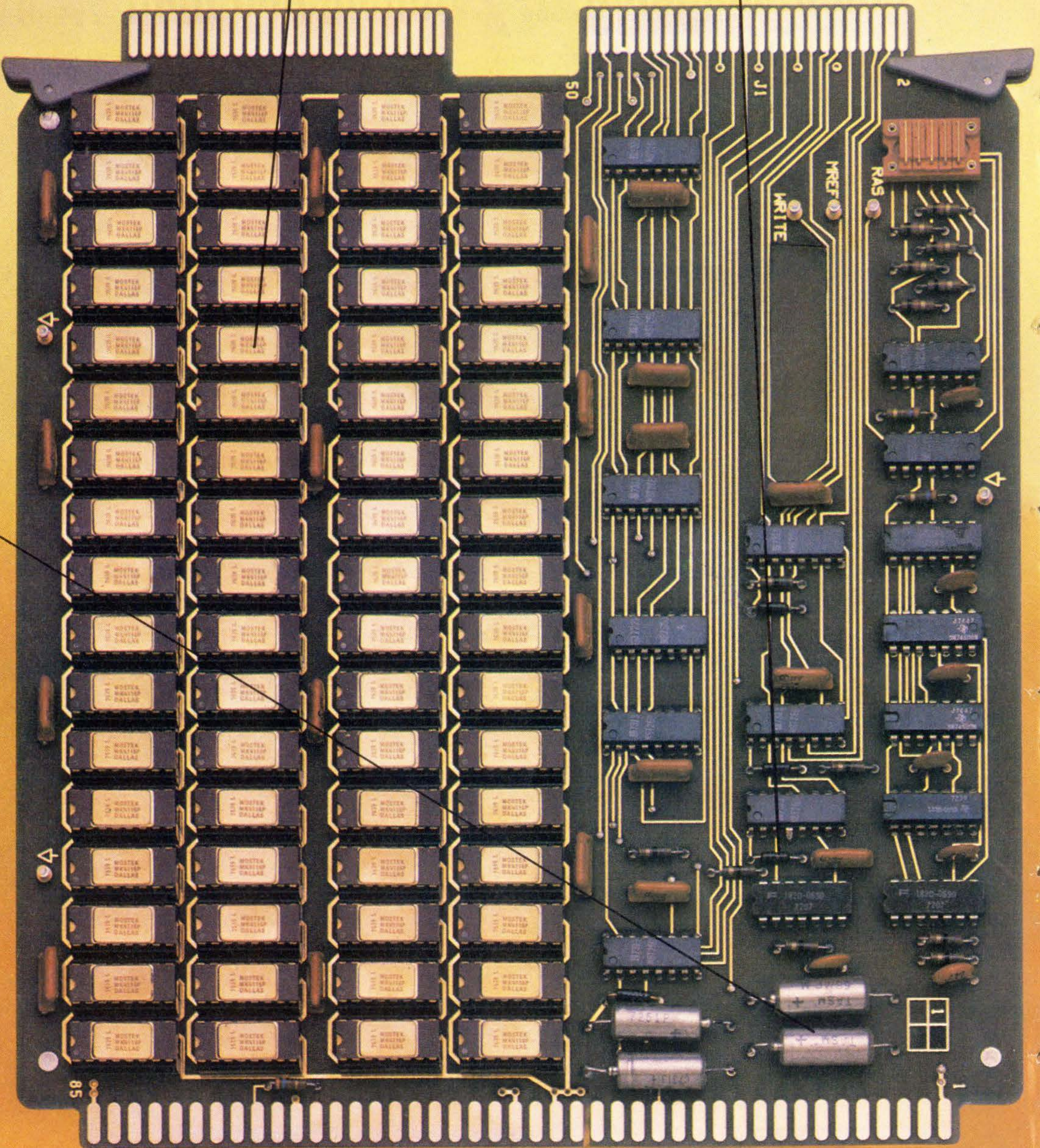
Speed: Mostek's 4116P-2 is the industry's highest performer at 150 ns access and 375 ns cycle time. The 4116P-3 has 200 ns access and 375 cycle time.

System Speed: Schottky-TTL compatibility for truly high performance systems.

Power: Max power ratings are 462 mW active and 20 mW standby.

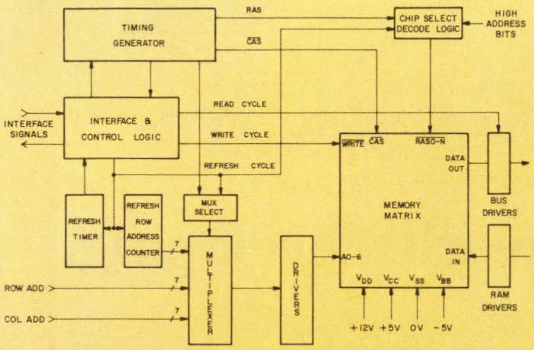
System Reliability: Mostek memories are recognized as the quality standard throughout the industry.

System Margins: Easy to use with ±10% tolerance on all power supplies (+12, ±5V). A Mostek exclusive.



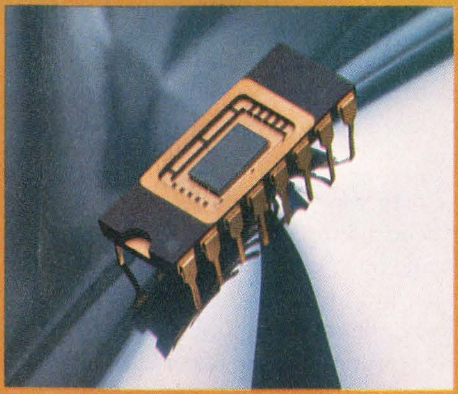
can do for your system.

Unlatched outputs for system flexibility.
The system implications of a product as advanced as the 16K RAM are significant. There are factors beyond the usual performance characteristics that will determine the efficiency and versatility of your system. Factors such as latched versus unlatched outputs. Mostek offers unlatched outputs for one reason—increased system flexibility.



Common I/O operation. If all write operations are executed in the "early write" mode, then D_{IN} can be connected directly to D_{OUT} for a common I/O data bus.

Full control of D_{OUT}. Mostek's approach means that D_{OUT} remains valid throughout the entire cycle—until the Column Address Strobe ($\overline{CAS}$) is taken to the inactive state. Also, with unlatched outputs the $\overline{RAS}/\overline{CAS}$ clock timing relationship is much more flexible.



Two methods of chip select. Since D_{OUT} is not latched, $\overline{CAS}$ is not required to turn off the outputs of unselected memory devices in a matrix. This means that both $\overline{CAS}$ and $\overline{RAS}$ can be decoded—allowing a two dimensional (X,Y) chip select array.

Extended page boundary. During page mode operation, Mostek's 4116 performs successive memory cycles at multiple column locations of the same row address. By decoding $\overline{CAS}$ as a page cycle select signal, the page boundary can be extended beyond the 128 column locations in a single chip.

Greater multiplexing margins with Mostek's 4116.

Another system benefit realized from Mostek's 4116 is the wide timing window allowed for multiplexing. This means that your system can operate at its full performance rating. With no timing loss.

The maximum $\overline{RAS}$ to $\overline{CAS}$ delay available for Mostek's 4116 is a full 50 ns for the 4116P-3 and 40 ns for the 4116P-2.

Mostek's 16K RAM is on the board.

The 4116 is in volume production and on distributor's shelves now—ready to be designed into your memory system. In addition, alternate sources are lining up behind Mostek's 4116. Eleven of the manufacturers planning to build 16K RAMs are designing for pin compatibility as well as functional compatibility with Mostek.

Our data sheet discusses all of the system advantages of the 4116—including operating flexibility and the advantages of page mode. Write for one today.

MOSTEK

1215 West Crosby Road
Carrollton, Texas 75006
(214) 242-0444

In Europe, contact:
MOSTEK GmbH
Telephone: (0711) 70196

MOSTEK ASIA
Telex 8514 8MKA HX

Circle 23 on reader service card

Bell to evaluate fiber-optic link this year in Chicago

The nation's two largest telephone companies are racing to evaluate fiber-optic communications systems in an operating environment [*Electronics*, July 22, 1976, p. 43]. John deButts, chairman of American Telephone & Telegraph Co., has announced that a one-and-a-half-mile system carrying voice, data, and video signals **will begin tests in Chicago by midyear.** General Telephone & Electronics says it will start evaluating a system carrying voice traffic next summer in southern California (see p. 36).

Bell Laboratories and AT&T, in cooperation with Illinois Bell and Western Electric Co., will test two underground repeaterless sections. One half-mile section will connect an office building in Chicago's Loop with an Illinois Bell central office; a one-mile section will connect this central office with another. A single Western Electric 24-fiber optical table ½ inch in diameter will be installed in standard telephone company ducts and manholes. A single pair of fibers will carry 576 simultaneous conversations or an equivalent mix of voice and data signals. Separate fiber pairs will carry Picturephone Meeting Service video signals. Light sources will be solid-state lasers and light-emitting diodes. The system evaluation should be completed next year.

RCA to sell portions of its Canadian business

RCA Corp. will cease **direct Canadian manufacturing and marketing of aerospace/communications equipment.** It is selling its facilities to Spar Aerospace Products Ltd. of Toronto for an undisclosed cash amount. Under an agreement to be signed Feb. 11, Spar will acquire the assets and assume the liabilities of the aerospace, government systems, and communications subdivisions of RCA (Canada) Ltd.'s Government and Commercial Systems division.

Spar is getting a business that specializes in the design and manufacture of spacecraft transponders, antennas and satellite earth stations, and other communications equipment such as terrestrial microwave systems. It will receive technical assistance from RCA's Astro-Electronics division in Princeton, N.J., and will lease space from RCA Ltd.

An RCA Corp. spokesman would not comment on the reasons for the sale of these businesses, **which provided $17 million in revenues last year.** The proposed sale is looked upon as part of a continuing program by RCA's new president and chief executive, Edgar H. Griffiths, to divest the company of electronics operations that are unprofitable or, as appears to be the case in this instance, only marginally profitable.

DOD speed-up seen on new F-15 missile . . .

One of Harold Brown's first program decisions as Secretary of Defense will be to decide **if the Pentagon should accelerate development of a new air-to-air missile** for the Air Force F-15 fighter. The new all-weather, radar-guided missile—already being designed under competitive contracts by General Dynamics Corp., Hughes Aircraft Co., and Northrop Corp.—would replace Raytheon Co.'s troubled AIM-7 Sparrow as the principal weapon of the new McDonnell Douglas fighter for the 1980s.

However, a Raytheon spokesman contends that the Sparrow is not in jeopardy. He says that both Raytheon and General Dynamics have contracts to come up with an advanced monopulse radar seeker for the missile. Also, outgoing Defense Secretary Rumsfeld recently told Congress that a follow-on wouldn't be ready until at least 1985.

. . . stopgap role weighed for U.K.'s Skyflash

It will be at least five years, though, before production can start on a new missile to succeed Sparrow—which reportedly lacks a multi-frequency radar target seeker and is thus susceptible to jamming—and Secretary Brown will be asked **to consider buying Britain's Skyflash missile to fill the gap.** However, Hughes denies reports that it proposes to modify the F-15's avionics to accommodate the Hawker Siddeley missile. But Raytheon might yet save its Sparrow business, say government sources, if it can modify its missile to accept the Skyflash seeker subsystem developed by Marconi Defense & Space Systems. Since Raytheon holds the U.S. license for production of the Marconi hardware and also serves as technical assistance subcontractor for Skyflash, that option is getting serious Pentagon consideration.

25,000 computers to be bought for home in '77

A substantial market that has developed in home and personal computers has a rosy growth potential, according to a study just completed by Venture Development Corp., a Wellesley, Mass., consulting firm. The $950 study, entitled "The Home Computer," **shows that nearly 25,000 computers will be purchased for home use this year,** and almost 23% of them will come from non-hobby companies such as Intel, National Semiconductor, TI, Intersil, and MOS Technology. Computer hobbyist shops will account for more than 60% of 1977 sales, and the market growth is forecast by Venture Development at an annual average rate of 32.7% from 1976 to 1981.

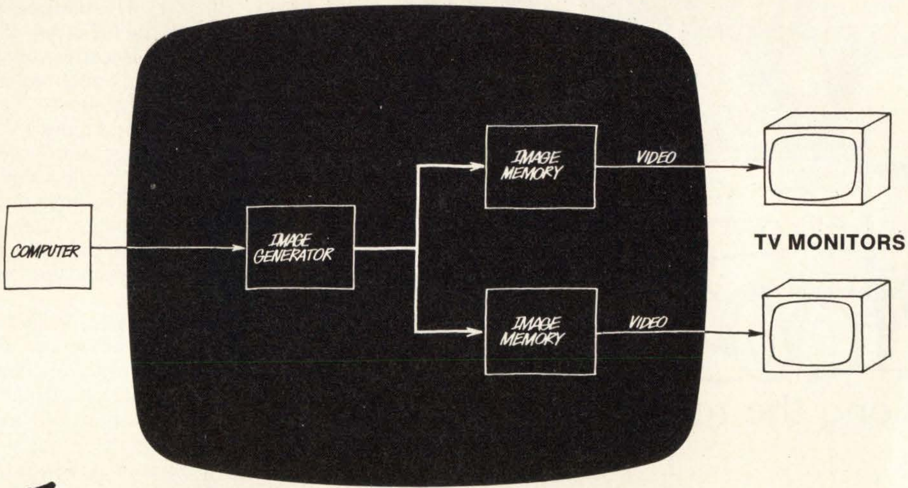
Demand for LCDs may push firm out of LED business

The demand for liquid-crystal displays may cause at least one company to quit the light-emitting-diode business. But it could take another 11 months for Integrated Display Systems Inc., the Montgomeryville, Pa., subsidiary of Solid State Scientific Inc. to make the move. Liquid-crystal production took about 10% of the firm's capacity in 1976, with the rest devoted to LED displays. Both types go into the cased and uncased modules supplied to several watch companies. But the LCD demand has been so great that Integrated Displays **doubled its capacity last year and will quadruple it this year.** It may begin offering these displays to outside watch/module manufacturers, says president Tom Saldi. "By the end of this year, we may be out of the LED display business," he says. "Our requirements for LCDs are so high—at least 10 times what they were in 1976—that we'll be concentrating on them."

Addenda

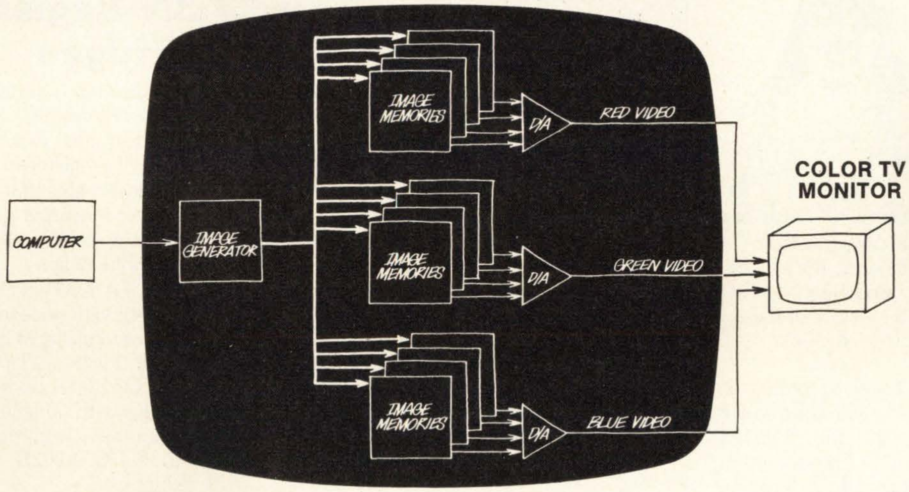
Nippon Electric Co. Ltd. plans to start a manufacturing facility in the U.S. The giant Japanese company, which specializes in telephone equipment, **is ready also to introduce a new all-electronic PBX system**. The NEAX-12, it is expandable in four-line increments from 24 to 120 lines and is microprocessor-controlled. . . . Following the success of its LM117, a 1.5-ampere, three-terminal adjustable positive voltage regulator, National Semiconductor Corp. soon will begin production of **an even more powerful version.** Called the LM150, it can handle more than 3 amperes over a 1.2-to-35-volt range, Also in the works are negative versions of both the LM117 and the LM150.

You've seen display systems like these... but not at these prices!



ISA BOOTH 407

2 channel B/W: $5,700



12 channel, 16 shades in each of 3 colors: $9,450

How about RGB color with half intensity blink, or high resolution B/W graphics, for only $6,450?

These aren't stripped down either. They're complete operating systems with a standard interface, and quantity discounts are available.

Those are just a few examples of how we've changed the graphic television display market. All of our systems work with standard TV monitors, and have these standard features:

- 3.0 μsec access to any point on the screen
- Hardware character generator with four character sizes
- Hardware vector generator
- Up or down scroll
- Non-destructive cursor
- Automatic location update
- Resolutions of 256 x 256, 256 x 512, or 512 x 512 (higher resolutions available).
- Selective erase of any rectangular area (of any size) on the screen.

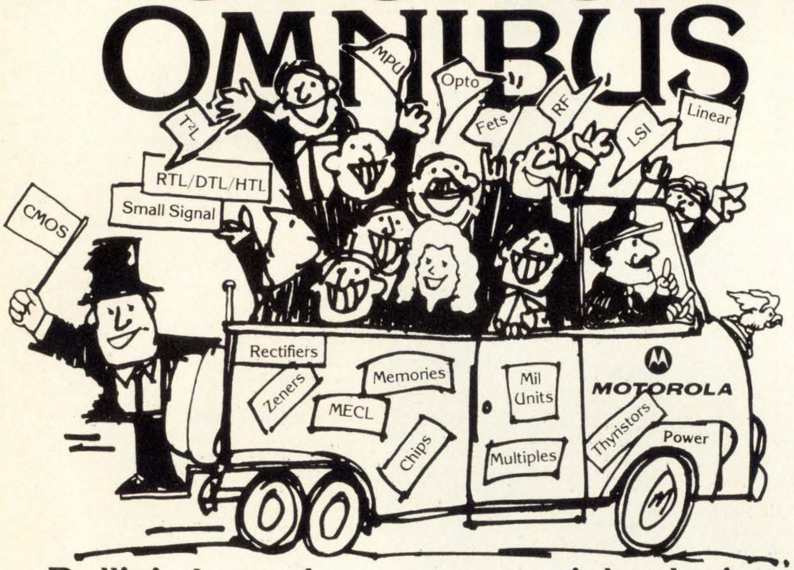
In addition, even those things that aren't standard aren't expensive. Special interfaces for most minicomputers, for example, are only $300 extra. Other options include: memory readback, video look-up tables with readback, keyboard, manual cursor controls, and more.

So, before you make any decisions about computer imaging systems, talk to us. We give you the big picture, but not the big price. For detailed specs, and/or a quotation, call or write.

GRINNELL SYSTEMS

2986 Scott Boulevard, Santa Clara, California 95050 (408) 988-2100

MOTOROLA OMNIBUS



Rollin' along the routes to right design

What a dummy . . .

Whoever said all solid-state varactor-tuned AM/FM receivers weren't practical?

Must have been a competitor. Motorola's got the smarts, the reputation, the technology and—for the first time in the industry—state-of-the-art *single* AM varactor diodes, the MVAM115/125!

Now you can bring to reality all those long-awaited, all-solid-state AM/FM receivers with the '115/125 plus our already existing FM varactors.

The '115/125 can be ordered in matched sets (±1.5% or 1 pF, whichever is greater) over the entire tuning range allowing flexibility for optimum circuit layout and performance.

The MVAM115 features 1- to 15-V tuning range, the '125 at 1- to 25-V range. Both offer state-of-the-art minimum capacitance ratio of 15 and 500 pF typical capacitance at 1 V.

More Motorola smarts include ion implant, ensuring guaranteed matching over the entire C-V curve and the most intelligent move of all—low price. Just $1.00 for the '115 and $1.10 for the '125, 100-up.

Get educated on the MVAM115/125. Send for data, design 'em in and then watch what people say about you.

What a genius!

MOSFET, JFET,

Motorola's got the most in FETs and here are 3 more series . . .

. . . just to prove the point. We didn't even have to come up with the 3N211, 12, 13 or the U308, 9, 10 or the J308, 9, 10 to prove the point. No, indeed.

While others lay claim to only one or two FET technologies, Motorola has four: JFETs, single-gate MOSFETs, dual-gate MOSFETs and DMOSFETs. Most are offered in plastic or metal packaging. For use in *all kinds* of industries, like communications and consumer and industrial.

The 3N211 series is a prime example of turning technology into household words in the consumer/communications field. That means popular performance at popular prices, friends.

This is a high-performance series for VHF/IF amplifiers/mixers with high Y_{fs} and characterized at 45 and 200 MHz. The '211 and '213 have high power gain of 33 dB typ @ 45 MHz and the '212 offers high 25 dB typ conversion gain.

The U- and J-series are two popular JFETs offering performance through 512 MHz and rated for communication receiver design. Both furnish high gain—11 dB typ @ 450 MHz and 16 dB typ @ 100 MHz, respectively—and low noise—3 and 1.5 dB typ at their rated frequencies.

Popular 100-up pricing for these household words is like this: 85¢ and 90¢ for the 3N-types . . . $1.35 to $1.55 for the U-series and 45¢ to 53¢ for the J-types.

Give us your call or your order for these or any other type of FET. We'll give you back satisfaction. For sure.

Target: One bulletproof 60-W, 470-MHz RF device

The way to shoot holes in any landmobile RF transistor is to give it 100% worst-case conditions like high line at 16 V with 50% over drive into a 20:1 VSWR.

Zap most of them and you've got zip. Not so with MRF648.

This off-the-shelf 60-W unit is rugged in the full sense of the word.

Because you get a device correctly tested under real-use conditions *exactly* like the above . . . conditions fatal to less armored types.

It's all fully verified by IR scan on our QC rifle range.

The units furnish Controlled Q* technology with computer-designed, internal matching networks maximizing bandwidth and ensuring easier circuit design.

Specs include 4.8 min dB gain and 60% efficiency with series-equivalent large-signal impedance parameters.

If you want more detailed reports we'll shoot our mouth off on the data sheet.

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Things that run long and hard . . .

Run better with 3N-Registered Bridges

You deserve a better bridge, right? You just found it.

For just two-bits† you can get a 3N-registered single-phase, full-wave bridge that withstands MIL and Motorola quality standards others surrender to unconditionally.

Like 1,000 HTRB at 600 V, 150°C ambient with no failures. Or 5,000 cycles of power cycling at 2.2 A (10% over rated current) with a ΔT_J of 100°C and no failures. Or 1,000 hours of high-temperature storage with no failures. Or solder heat, solderability and moisture resistance to MIL-S-19500/202B and /202D with no failures.

Like 1% AQL. And on. And on. And on. With no failures.

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Electrically the 3N246/253 series is a 1- and 2-A, 50- to 1,000-V family with 30-A and 60-A surge capability with the 2-A units operating to +165°C T_J.

Physically, their slimline cases save much board space.

Economically, their aggressive prices will give any bridge a run for its money.

Our volume production is running long and hard to give you what you deserve in a bridge—top quality at a low price.

And you can't beat that.

†1-A, 50-V unit; 25,000-up.

Switch bus routes with Schottky Three-State

MOTOROLA #1 LINEAR LEADER

Multiprocessor applications allow increased information throughput and greater flexibility than simpler MPU configurations.

With these systems, however, comes a requirement for switching bidirectional data to either of two or more ports. The MC6881/MC3449 switch performs bus routing.

A single 5-V supply is used and it's even possible to place all input/output nodes in high impedance state. Both driver and receiver are short-circuit protected.

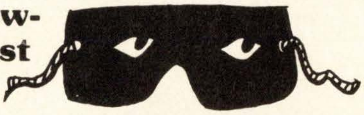
You can visualize the unit as three single-pole, double-throw switches with center OFF positions. Thus, data can be transferred to either of two selected ports or neither of them. And the direction of data flow is selectable with a logic controlled input.

The Schottky Three-State logic implementation guarantees the OFF-state nodes will present minimal loading to respective bus lines and logic inputs will not significantly load the bus.

Use it for shared memory and data bus multiplexing, too. It's MOS- and 74LS-compatible.

All aboard with MC6881/MC3449.

Low-cost



mask-programmable 2708 alternatives.

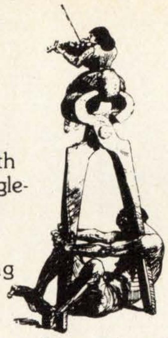
EPROMs are the greatest when that's what you really need. We recommend our MCM68708, being introduced this month. However, lots of people are going the whole hog with EPROMs where less expensive mask programmable ROMs will do every bit as well. You needn't ever be caught in that bind again. Motorola supplies four mask programmable alternatives, two 8Ks with the 2708 pin-outs and two 16Ks with nearly identical pin-outs.

The MCM65308 is a low-cost metal gate ROM for systems that already require three power supplies, and an access time that's actually much faster than the 350 ns printed on the data sheet. The other 8K is the silicon-gate MCM68308, a depletion load, high-performance ROM requiring only a single 5-V supply.

Put 16K of ROM where only 8K fit before with the metal-gate MCM68317 for lowest cost in systems already designed for three supplies, or the silicon-gate MCM68316E for single supply, extended temperature range applications.

All four ROMs are available with fast turnaround from authorized Motorola distributors and Motorola sales offices.

In a pinch with globtops?



Don't get burned or something fiddling with those expensive, single-sourced, TO-105 and TO-106 globtops.

Get pennypinching Motorola TO-92s and squeeze out:

1. **Another source**—Motorola volume eliminates sole-source strangulation.
2. **More milliwatts**—Motorola TO-92s stretch out to 625 mW.
3. **Expanded reliability**-Motorola chips run cooler, Motorola TO-92s are more hermetic.
4. **Cost contractions**—Motorola is the plastic transistor price leader. See? . . .

Motorola drop-in	Price 100-999 ¢
MPS3563-18	18
MPS3565-18	16
MPS3566-5	18
MPS3567-5	16
MPS3568-5	19
MPS3569-5	19
MPS3638A-5	21
MPS3640-18	19
MPS3646-18	18
MPS4248-18	16
MPS4249-18	19
MPS4250-18	22
MPS4258-18	23
MPS4275-18	18
MPS4355-5	26
MPS5133-18	13
MPS5134-18	14
MPS5135-5	13
MPS5138-18	13

Motorola knows you won't take getting pinched sitting down.

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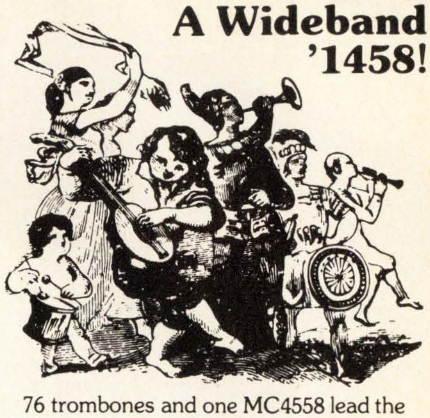
Strike Up A Wideband '1458!



76 trombones and one MC4558 lead the big parade to higher frequency performance in existing op amp designs!

This dual op amp plugs right into existing standard '1458 sockets with the same performance and then some: 2.5 MHz unity gain bandwidth . . . high common-mode input voltage range and the absence of latch-up . . . internal compensation . . . short-circuit protection . . . gain and phase match between amps . . . lowest power consumption—135 mW @ 125°C.

No external components are needed for frequency compensation.

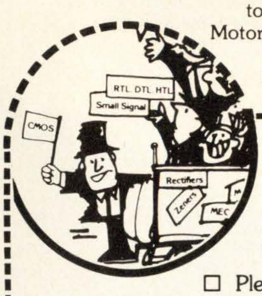
Besides providing over 3 times the bandwidth of the '1458, the '4558 is characterized for operation over the full MIL temperature range, −55° to +125°C. The MC4558C will operate from 0° to +70°C.

It's also available in the 8-pin ceramic package (U suffix).

Pricing is fantastically low for this performance:

Commercial	100-up $
MC4558CG (metal-can)	.95
MC4558CPI (mini-dip)	.80
MC4558CU (ceramic)	.90
Military	
MC4558G (metal-can)	2.20
MC4558U (mini-ceramic)	2.10

A final note. Motorola's fully orchestrated to turn out volumes . . . just give us the downbeat with an order.



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☐ Please have salesman call ( ) ______________

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Company ______________ Address ______________

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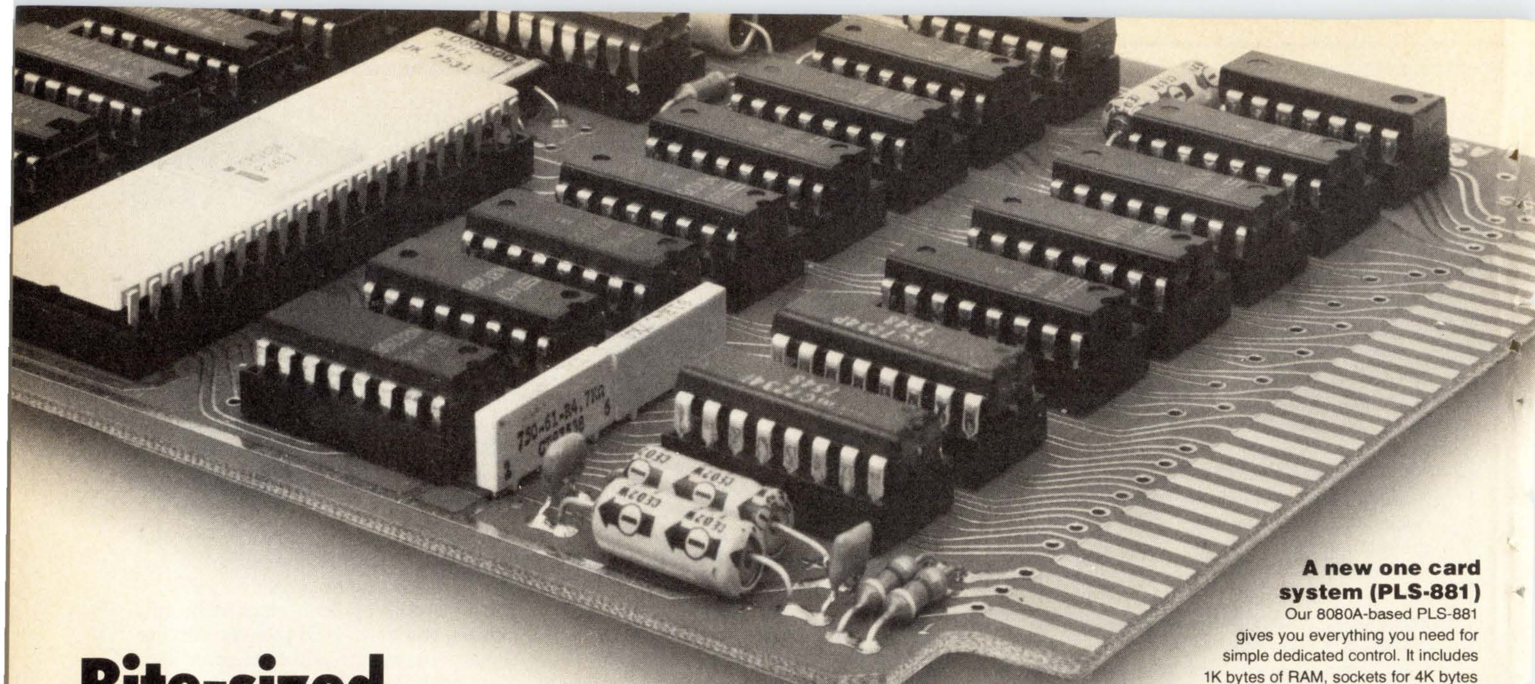
☐ 3N246/253 Bridges
☐ MC1458/4558 Op Amps
☐ MPS- Globtop Subs
☐ MVAM115/125 Tuning Diodes
☐ MC6881/3449 Bus Switch
☐ 3N211/U308/J308 FETs
☐ MCM65308/68308/68316E/65317 PROMs
☐ AN-766, "A Variable Frequency Control for 3Ø Induction Motors" Application Note.



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Our 8080A-based PLS-881 gives you everything you need for simple dedicated control. It includes 1K bytes of RAM, sockets for 4K bytes of ROM program memory, interrupt input, crystal clock, power-on and external reset, three 8-bit output ports, and two 8-bit input ports. It costs only $195 in 100 piece quantities.

Bite-sized 8080A systems make big boards hard to swallow.

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Buy 250 of any particular card and we throw in free its manufacturing and assembly plans and non-exclusive rights to manufacture it, allowing you to build your own hardware, relying on us as an established and dependable second source.

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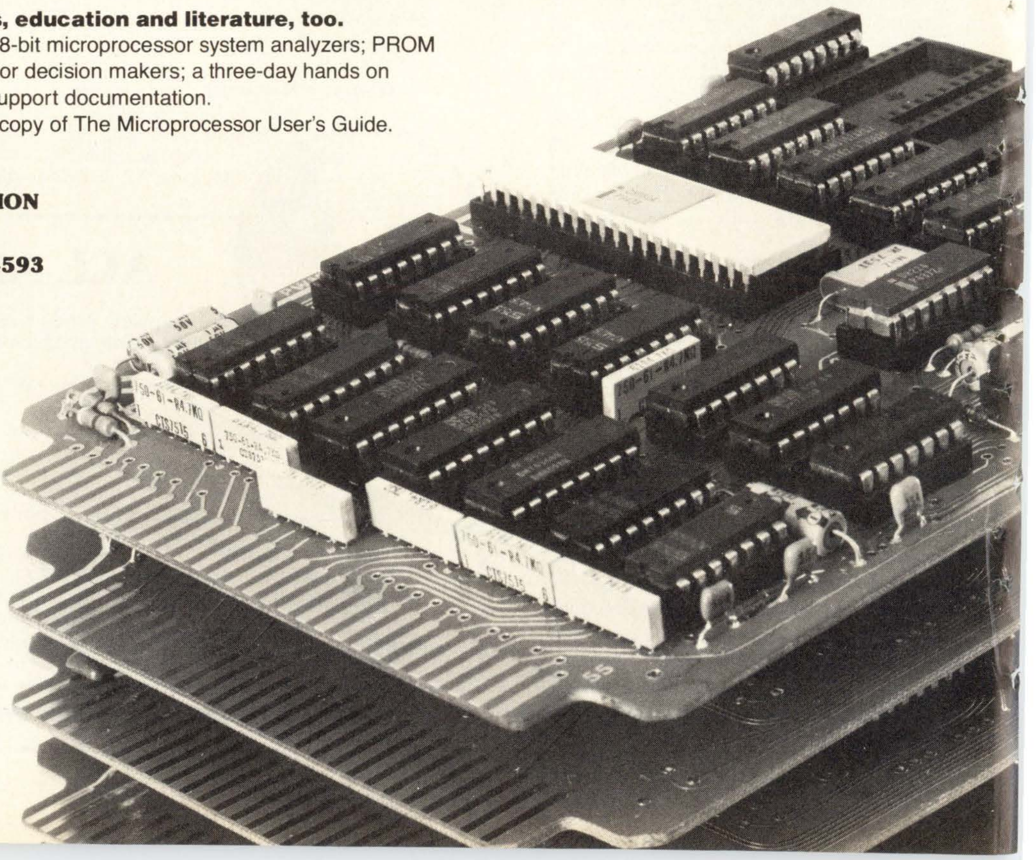


A new, expandable plug-in CPU card (8821)
Our "buffered bus" 8821 processor card implements the 8080A as a fully TTL buffered microprocessor. Add one I/O card and it becomes a complete two-card system. Or expand it to use full 8080A memory and I/O capability—it's compatible with all the Pro-Log ROM, RAM and I/O modules shown here plus many more. The 8821 costs only $190 in 100-piece quantities. We also have equivalent cards implementing the 6800 and 9002 microprocessors.

Circle 30 on reader service card

Motorola wins microprocessor contract from GM

Chip sets to be built around custom microcomputer family to handle auto needs; Delco to second-source the devices

In what may well be the largest single semiconductor buy in history, Motorola Semiconductor has been named principal supplier of microcomputer chips to General Motors Corp. According to officials at the nation's largest automaker, Motorola's metal-oxide-semiconductor large-scale-integrated circuits will be used over the next several years for antiskid braking, fuel management, engine control, instrument panel control and display, and, eventually, transmission control in all of GM's automobile lines.

By 1980 Motorola could be delivering annually anywhere from 2 million to 6 million sets of microcomputer devices, built around an 8-bit n-channel MOS family. Since each set could contain seven to nine chips worth $10 to $30 in semiconductor parts, annual sales to just the one customer could easily top $100 million.

In hotly contested bidding monitored through GM's Delco Electronics subsidiary in Kokomo, Ind., Motorola won out over leading microprocessor suppliers Intel Corp., Texas Instruments Inc., and National Semiconductor Corp. The 50 prototype systems it had supplied to Delco last August were the deciding factor.

Apart from them, however, sources close to the development indicate that central to the contract is Motorola's agreement to furnish Delco with all the LSI semiconductor design and processing technology needed to build the complex circuits. The aim is to make Delco at least potentially capable of supplying about half of the GM chip requirements, since it is likely to be the only second source for the parts. To this end, Delco is putting up a 25,000-square-foot MOS facility in Kokomo to fabricate and test wafers and chips for its microcomputer systems [*Electronics*, Aug. 19, p. 38].

Perhaps of prime importance in Motorola's selection was the considerable experience with the 6800 family GM has gained in its current Tripmaster program—a microcomputer-based dashboard-mounted information system that is being offered as an option in this year's Cadillac Seville. In fact, the standard parts being supplied for the Tripmaster will be used in early phases of the new program.

Delco engineers originally specified a full custom LSI approach

Motorola gains impetus from GM award

Buoyed by the big General Motors contract, Motorola is intensifying its program to extend its microcomputer capability. Observers of the semiconductor industry had noticed a letdown in the spirits of the company's MOS division soon after its move to Austin, Texas, about 18 months ago. With the GM buy, this gloom appears completely gone.

"It's an affirmation of our LSI capability," declares Colin Crook, the British-born, 35-year-old operations director for Motorola's microcomputers [*Electronics*, July 10, 1975, p. 14]. "We are now hiring in all phases of LSI design. We think the volume generated in the GM contract will accelerate our learning-curve experience, speed up our cost-reduction programs, and increase our ability to impact the standard-product market."

For that market, Motorola recently brought out the depletion-mode 6800D version of its 6800 microprocessor chip. It is this design that will be going in various forms to General Motors in the early stages. Motorola also plans as standard products for the semiconductor marketplace higher-performance versions of the 6800D, which will offer an up to 2.5-megahertz clock frequency (5-MHz cycles) on chips no larger than 19,000 square mils or 20% smaller than the older 6800 enhancement-mode designs.

Other standard 6800 products to come this year include a two-chip version intended for the low-end computer market. This will consist of the 6802 (central processor plus 128 bytes of random-access memory and clock) and the 6846 (read-only memory plus input/output plus timer). These two chips are completely compatible and interchangeable with all members of the 6800 family, including peripherals, memories, and I/O interfaces.

Meanwhile, Motorola is stepping up its 6800 peripheral capability. Coming in the second quarter are a program timer module, the 6840; an advanced data-link controller, the 6854, and a floppy-disk controller, the 6843. In the third quarter is planned a general-purpose interface adapter, the 68488; a direct-memory-access controller, the 6844; a cathode-ray-tube controller, the 6854, and a video-game chip.

known as the Delco custom microprocessor, or DCM. But in consultations with the semiconductor industry, they apparently came to realize that it was unreasonable to expect a supplier to furnish as many of the complex custom LSI parts in the time GM would need them. So they settled for standard 6800 chips plus two custom chips for the first stages of the contract and will phase in the custom chips for the DCM as they are designed and reach production—they hope in time for 1980.

"The first year we put a microcomputer in a car, there won't be 2 million of them, but Motorola will have a significant part of the volume," says Frank E. Jaumot Jr., director of research and engineering at Delco Electronics. Jaumot also doesn't rule out a future for Rockwell International's PAC (programmable automotive controller) microcomputer, now used for spark timing on Oldsmobile Toronados. Developed by sister division Delco-Remy, Anderson, Ind., it beat out an earlier Delco Electronics system designed for that chore. But now all GM divisions have agreed on the DCM with its Motorola-supplied parts as standard.

Austin plant. According to Colin Crook, operations director for Motorola's microcomputers, the company's facility in Austin, Texas, will supply the parts in a phased program: 2,000 chip sets to be delivered by May, 200,000 sets per year by the middle of 1978, and finally millions of sets per year after that.

Based on Motorola's new 6800 depletion-load technology [*Electronics*, April 15, p. 79], each of the first systems will consist of the 6800D microprocessor chip, a peripheral-interface-adapter chip, a 128-byte random-access memory (the 6810), and the 16,384-bit read-only memory (the 68316), all of them standard MOS LSI parts in the 6800 family. The two custom peripheral chips will implement Delco designs for handling specific input/output functions.

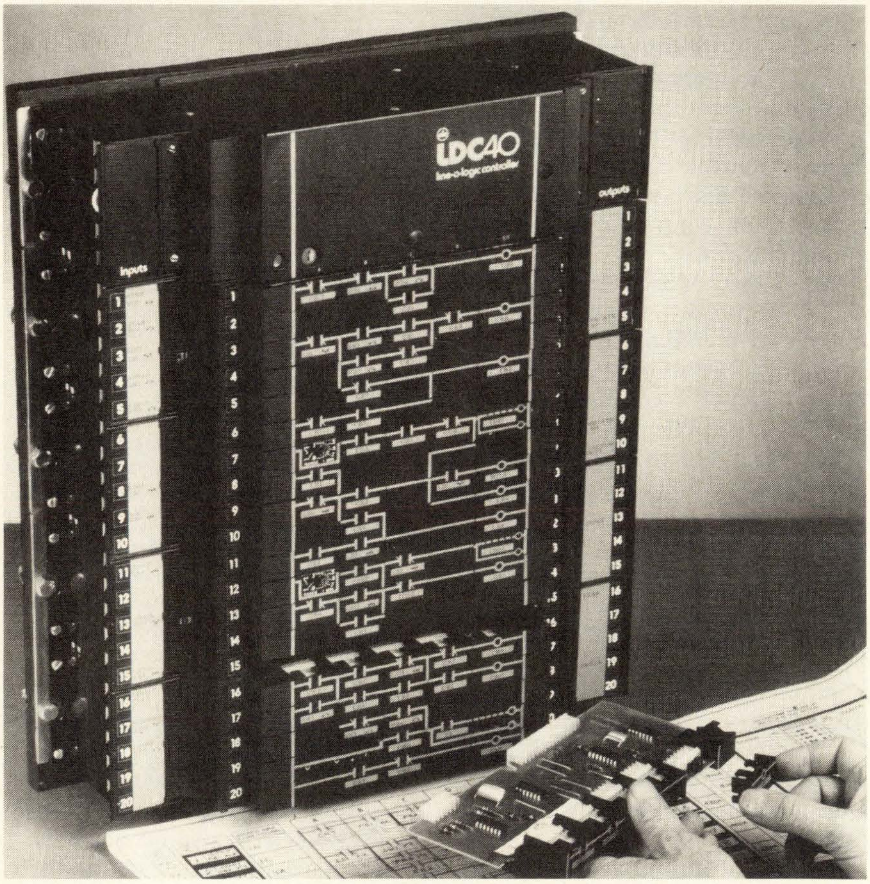
One of the reasons given for Delco's choice of Motorola is the performance of the semiconductor maker's chips. The 6800D will be specified at a 400-milliwatt power dissipation and a 1.5- to 2-megahertz clock rate (equivalent to 3- to 4-MHz cycle times in designs such as the Intel 8080). The parts will operate over the full automotive temperature range for ICs: $-40°$ to $+85°C$. Once the standard chip program progresses, Motorola will phase in the seven to nine LSI custom parts intended to provide even higher performance. □

Industrial

Plug-in modules make up controller while creating system-ladder diagram

It may start out by being plugged together on the system designer's desk, but the new industrial controller developed by Automatic Timing & Controls Co. winds up doing real control jobs out on the factory floor. The plug-ins are part of a kit of solid-state control modules that the $10 million division of American Manufacturing Co. hopes will allow it to make an impact in the relay-controller field. In addition to timers and counters, Automatic Timing manufactures electronic weighing and photoelectric devices.

"We're aiming for the 5-to-25-relay market where a programable controller would just be overkill," declares Ron Swanson, assistant sales manager at Automatic Timing, King of Prussia, Pa. "In systems having less than five relays, it's best



It's a snap. Control system plug-ins from Automatic Timing & Control can be put together on a designer's desk and carried out to the factory floor.

to stick to electromechanical devices, and for more than about 40 relays, programable controllers are practical."

Using the modules that make up what Swanson's company refers to as its LDC40 Line-O-Logic controller, a typical system with three inputs and three outputs would cost between $700 and $800 out on the factory floor. A spokesman at a large company already in the controls field admits that his equivalent solid-state card-type system "couldn't match the price tag" of the LDC40.

But price isn't the only attention-getter. "The modular approach has been around for some time, but never one that you program and put together on your desk," notes a spokesman at another controls manufacturer, Cutler-Hammer Inc.'s Logic Device and Systems division in Milwaukee.

To make the design chore as simple as possible, Automatic Timing has designed its modules as one-for-one analogs of the elements in the conventional relay-ladder diagrams cherished by relay-system designers. The ladder-diagram symbols are, in fact, drawn on the face of each 1 3/16-by-5/8-inch module (see photo).

Chassis base. Starting with a chassis measuring 14 by 15 inches, the designer merely plugs in cards containing the elements of the relay system that has been designed. Modules include relay coils, their associated normally closed and normally open contacts, counters, and analog or higher-accuracy digital timers, as well as "blank" modules containing only interconnection lines.

The basic chassis holds a matrix that is five modules wide and 15 modules high. However, this can be ganged to heights of 40 or more modules in groups of five or 10 at a time. Input and output modules and a power-supply module, which can drive up to 60 rows of modules, are also designed to be plugged into the chassis.

A three-input, three-output control system would contain about 50 modules in 10 rows, measure about 10 by 15 by 5 1/2 in., and weigh less than 28 pounds. An optional battery back-up supply and charger would add to the weight.

The system is also outfitted with an important troubleshooting aid. Each plug-in module, as well as the input and output modules, contains a light-emitting diode to indicate the status. Once the designer is satisfied the system performs its sequencing correctly, the system can be carried out to the factory floor and wired up to the inputs and outputs there. □

Military

Two contracts aim at integrated control, display panel for U.S. Army helicopters

Question: How do you cram avionics control panels stretching to a total height of 3 feet or more into the already crowded cockpit of an Army helicopter? Answer: Take advantage of microprocessors, add multiplexing, and create a time-shared control unit that displays everything on a panel only 10 1/8 inches high.

Two contracts. At least, this is what the U.S. Army Electronics Command at Fort Monmouth, N.J., hopes to do through its Integrated Avionics Control System, for which it has awarded two competitive $1.6-million engineering-development contracts. One award is to Grumman Aerospace Corp., Bethpage, N.Y., and the other to Rockwell International's Collins Avionics division in Cedar Rapids, Iowa. The two companies are developing what the program manager in the Army Avionics Laboratory, George Stech,

Muzak to send music by satellite?

Muzak Corp., the well-known supplier of background music in industrial and commercial buildings, and RCA Americom have successfully completed tests of a system for distributing programing via a satellite-based transmission scheme. But whether the system, which bypasses phone-line transmission, will actually enter production and be installed for Muzak customers around the country will depend mainly on the cost of the ground equipment, a factor that has not yet been determined.

The proposed system was to have used a 4-foot-diameter antenna, low-noise receiver, and down-converter, all assembled by All Systems [*Electronics*, Sept. 5, 1974, p. 36]. But the Moorestown, N.J., firm went out of business, and Muzak turned to Harris Corp.'s Electronic Systems division in Melbourne, Fla., for the system for which "we don't yet have accurate cost figures," says Muzak vice president Paul Warner.

All's projected costs of about $500 per receiver "was something we could live with," he says. "Right now, we don't know if it will be $500 or $5,000." Muzak expects cost data from Harris within two months and, if favorable, could begin production of the system within six to eight months, he says.

Use of the 4-foot dish antenna, he adds, would require a new ruling by the Federal Communications Commission, which only late last year approved the use of antennas 4.5 meters in diameter for receive-only earth stations [*Electronics*, Jan. 6, p. 33]. Previously, 10-m antennas were required for domestic satellite reception. "The FCC's initial reaction to the 4-foot antenna indicates there will be no problem getting approval," says Warner. "We're not asking for any frequency protection, since tests of the system indicate it's not bothered by terrestrial interference."

The test held Jan. 10 involved transmission of a musical program from the RCA Americom earth station at Vernon Valley, N.J., to an RCA geosynchronous satellite in orbit over the equator south of Los Angeles. It was received by the new antenna installed at Muzak's engineering headquarters in Westbury, N.Y.

asserts could become "the first application of the emerging technologies of microprocessors, multiplexing and integrated displays in the Army cockpit."

By October 1978, each company is to deliver eight models of an integrated system that will centralize the control of the operating frequencies and modes of up to 10 pieces of equipment with functions like vhf and uhf communications, navigation and friend-or-foe identification. The microprocessor-based central control unit, for handling data and interfacing, will be located in the helicopter's equipment bay. Only the display panel will be in the cockpit.

Just how the panel is to be fabricated—with light-emitting diodes or liquid-crystal displays, for example—is up to the contractors. A "ballpark" version being discussed has six lines of eight alphanumeric characters each.

In addition to the 10⅛-in.-high panel, a smaller one will be designed for any craft too crowded for a full-size panel for both pilot and co-pilot. This other panel will be only 4⅛ inches high and will display frequency and mode information for only the most essential equipment.

Busy pilot. The integrated system is needed not just to relieve the space problem, however. "The Army helicopter mission in the future is one where they're down flying combat missions just above the tree tops," notes John Songster, Collins' program manager. "The operator will need to have his head up and looking. He'll need pre-sets and microprocessors controlling certain functions, without his having to duck his head down to put his finger on some push button." The single control panel and the multiplexing scheme, in which signals are time-shared over the same set of wires, should help him.

Multiplexing was looked at for both the Grumman/Navy F-14 and McDonnell Douglas Corp./Air Force F-15 fighters, notes Grumman's program manager George Cotter. "But LSI and microprocessor technology weren't that far along at the time. They would have been too costly and bulky. Now the combination has reached the point where multiplexed data-control capability can be placed on a single printed-circuit card that meets the new military 1553A data-bus standard."

Three years away. The Army wants to award an initial production contract for 500 integrated control systems within three years. It also wants a production price no higher than $22,500 and has an option for 500 more units. All of that could add up to some $20 million for the production winner.

The Army's Stech says the system will be used first in the Advanced Attack Helicopter, for which Hughes Aircraft Co. recently won a $317.7 million development contract [*Electronics*, Dec. 23, p. 34]. "Eventually, we expect that most Army aircraft will use the IACS," he says.

Others too. It may also be aboard the Utility Tactical Transport Aircraft System, just awarded to United Technologies' Sikorsky Aircraft division, as well as on the improved CH-47 and Cobra AH-1. "There's talk that the program could go as high as $100 million, if the Army uses the system in as many aircraft as they indicate," says Grumman's Cotter. The Army alone has over 6,000 helicopters, he points out, and "the system is general enough in nature that it can be applied to almost any aircraft." □

Instrumentation

Scope takes on frequency domain

Norland Instruments Corp., which last year became the first instrument maker to design and build a programable, digital oscilloscope around a microprocessor, has come up with a pair of simple additions that vastly extend the scope's already considerable talents. Starting in March, every NI2001 shipped will be able to do frequency-domain analysis at no extra cost. The company will also introduce a $3,500 plug-in that adds enough processing capability to the mainframe so that it will, under control of the central microprocessor, do signal averaging.

Bright scope. Special-function plug-ins for Norland's NI2001 programable digital oscilloscope will be slid into the panel areas just above the keyboard.

Unlike other scopes with microprocessors, which use them merely for control and housekeeping chores, Norland's was designed so that its Intel Corp. 8080A also acquires signals, manipulates them, and displays the results in final form [*Electronics*, March 20, 1975, p. 140]. "We use a processor the way a computer manufacturer uses a processor," points out Fred A. Rose, president of the Fort Atkinson, Wisc., subsidiary of Cordis Corp. "The difference, as far as the user is concerned, is that the 2001 is an instrument, not a computer."

Frequency-domain analysis is use-

The TR 502 and TR 501 tracking generators are working partners for 7L13 and 7L12 spectrum analyzers.

Make **frequency response measurements** on rf devices with the TR 502 and 7L13. This combination of a constant level, calibrated rf source and high performance spectrum analyzer provides you with a wide dynamic range (110 dB) and narrow resolution bandwidth (30 Hz) ideal for crystal filter or cavity measurements.

For **selective frequency counter** applications use the TR 502's Aux. R.F. output to drive a frequency counter. Select and determine signal frequencies up to 1800 MHz with −128 dBm sensitivity at 30 Hz resolution bandwidth. When used with the DC 502 550 MHz Frequency Counter the spectrum display center frequency, indicated by a bright dot, is automatically counted.

In addition, the TR 502 and 7L13 form a **super-stable CW source.** The TR 502/7L13 system has 10 Hz stability in zero-span (non-swept) mode.

The TR 502 or TR 501 are powered with a TM 503 Power Module, leaving room for a DC 502 or other counter.

TR 502 Tracking Generator (recommended for use with 7L13)	$4650
TR 501 Tracking Generator (recommended for use with modified 7L12)	$3675
TM 503 Power Module Opt 7	$ 185
DC 502 Digital Counter Opt 7	$1195

See the TR 502 or TR 501 work in your application. Ask for a demonstration or more information. Write: Tektronix, Inc., Box 500A, Beaverton, Oregon 97077. In Europe, write: Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

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ful for looking at the relative magnitude of the frequency components of waveforms. With the 2001's new plug-in, a motor manufacturer can, for example, investigate input electrical power (voltage and current) and output mechanical power (torque and speed), together or separately. Given the Fourier capability, frequency components of the shaft versus amplitude can be displayed, for example, to detect vibrations due to variations in shaft speed, radial displacement of the shaft or frame, or external stimuli.

The interface between the time and frequency domain is, of course, the Fourier transform and its inverse. But instead of performing this with hardware, as other instrument companies have done, Norland will incorporate it into the 8080's program software. Earlier changes—such as the addition of log, trigonometric, and exponential functions, and a statistical package—have also been simple to accomplish with software expansions.

Not so limited. "Generally, though, the microprocessor has not been considered capable of doing Fourier transforms," says Glenn Batalden, the Norland project manager who refined the algorithm of the fast Fourier transform to fit Intel's 8080. "The way it's normally implemented could take 5 to 10 minutes on an 8-bit microprocessor." Batalden's scope uses 40 seconds to execute the FFT on a 1,024-point data array. That is not particularly fast, he points out, when compared to hardware FFT implementations that run in 30 to 100 milliseconds. But those are available only on systems dedicated to frequency-domain analysis and that cost upwards of $8,000. A software-driven FFT on a minicomputer takes about 20 seconds to carry out.

But Norland figures the 2001 is a valuable tool for the price. All that is added to the roughly $15,000 machine is a handful of new keycaps plus less than 2,048 8-bit bytes of programable read-only memory. They are enough to provide the FFT and its inverse and everything needed to make it useful, including power spectral density, conversion between polar and rectangular coordinates, complex multiplication and division, and the Hanning weighting and coherence functions.

Adding the Fourier package, including PROMs and keycaps, to the newer 8001A model in the field will cost customers $500. On the earlier 2001 scopes, the retrofit includes the "A" version's statistical, log, trig, and exponential functions as well, and will cost $1,250. □

GTE fiber links set for summer test

General Telephone & Electronics Corp. is now planning its field trial of a fiber-optic communications system for next summer. The system will consist of a 24-channel voice-grade link carrying traffic between telephone central offices. Actually, the trial of the complete system has been postponed about six months beyond the time the company last indicated it would be held. [*Electronics*, July 22, 1976, p. 43]. However, GTE says there is no one outstanding reason for the delay [see related story, p. 25].

The firm is looking at several possible sites in southern California, but none has yet been chosen. "The selected site will truly reflect the worst of all possible operating environments," says Lee Davenport, president of GTE Laboratories in Waltham, Mass., which is putting together the system. "We'll use repeaters and they'll be in manholes with water on the bottom. And we'll also try splicing in these environments."

Linesmen from the General Telephone Co. of California have already pulled cable supplied by General Cable Corp., Greenwich, Conn., through ducts and have made splices in the field. The cables are 1 kilometer long with attenuation of 5.5 decibels. According to General Cable vice president George Foot, the cables have been designed to be installed in ducts or buried underground using methods similar to those employed for conventional wire cable.

Microwaves

German TWT goes to U.S. military

Seldom does a non-American firm score on the tough U.S. military electronics market. But West Germany's Siemens AG has done so with a traveling-wave tube it developed for Raytheon Corp. The new TWT is the heart of a communications system that Raytheon, based in Lexington, Mass., is building for the U.S. Navy and Air Force for ship-to-shore and aircraft-to-ground communications via satellites.

What is special about the Siemens TWT is its combination of high frequency and power. Designated RW3010, the tube puts out a 1-kilowatt continuous wave at 38 gigahertz. "This frequency is probably the highest ever achieved in a 1-kilowatt [cw] TWT," says Jürgen Arnold, a sales engineer at Siemens' Components division in Munich.

The tube's 38-GHz is a big advantage, especially in communications from submarines. At that frequency the dimensions of the antenna reflector and the waveguides are so insignificant that these components can be made part of the submarine's periscope. Then, with only its periscope above water, a submerged boat will be able to transmit. The antenna reflector will automatically be kept oriented towards the satellite by a pilot signal from the satellite, a feature that is particularly useful in rough seas.

The RW3010's high frequency also spells improved noise immunity and, as Siemens points out, "a heretofore unattained level of protection against message interception" by hostile forces. This is because only a fraction of a percent of the bandwidth is needed at 38 GHz to give plenty of room for extensive coding. According to Arnold, the RW3010 is already undergoing tests that the U.S. Navy is conducting at two ground stations. The tube has not yet been tried out in submarines.

The TWT's high-frequency/power

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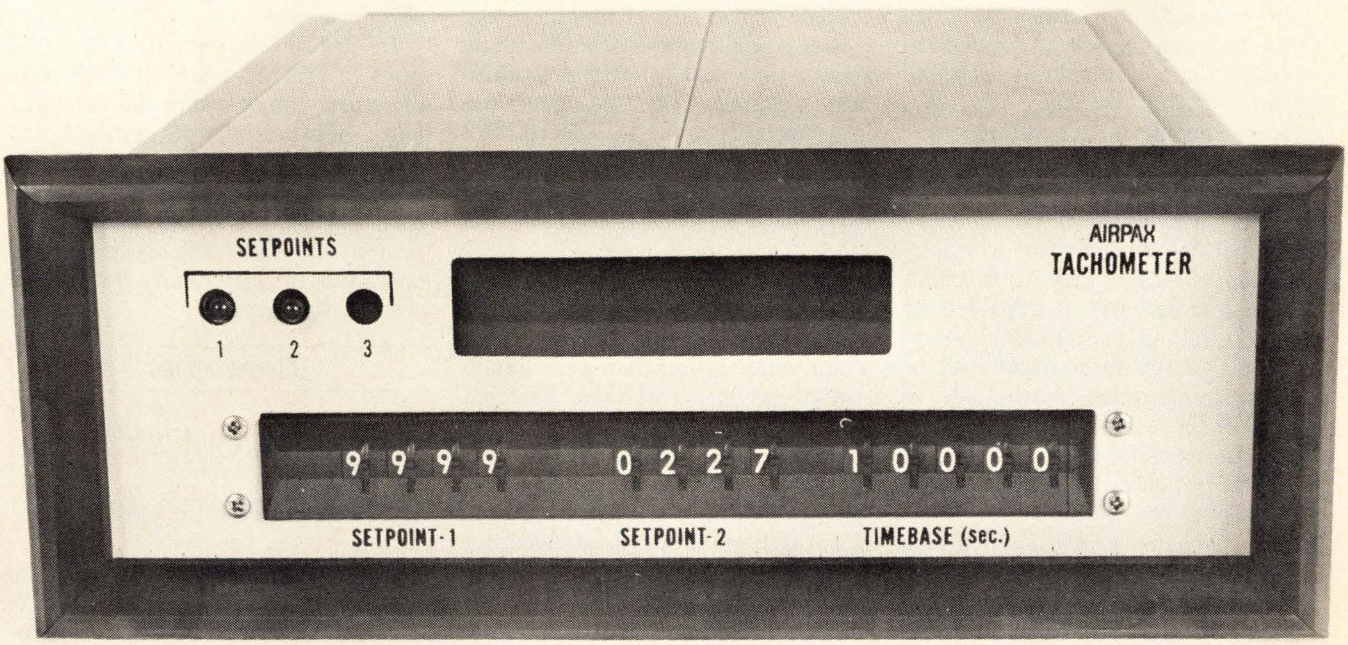

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performance called for a special tube design. The electron beam is produced by a cap-shaped cathode that can withstand a current density of 3 amperes per square centimeter. After it leaves the cathode, the beam is narrowed down to a cross-sectional area of 0.5 square millimeter. The beam's power density is then about 5 megawatts per square centimeter.

The focusing rings of the periodic-permanent-magnet TWT consists of samarium-cobalt material. Its three-section delay line is made up of coupled resonators. The tube is 53 cm (about 21 inches) long and weighs 5.6 kilograms (roughly 12.5 pounds).

Since the period of the frequency is independent of that of the magnetic focussing field, the electron beam can be accelerated again even after it has given off energy to the delay line. This gives a further gain in energy that, in turn, enhances the tube's efficiency. The overall gain of the coupled-cavity TWT is 43 decibels. Its efficiency of 35% is considered pretty high for a TWT with a single-stage collector. □

Communications

FCC gives AT&T go-ahead on Dataspeed, but asks that data charges be raised

As the new year began, American Telephone & Telegraph Co. received two favorable decisions from the Federal Communications Commission. They guarantee the telephone company a major role in offering digital data equipment and services interstate—that is, if they survive court appeals by competitors.

In one judgment, the FCC ruled that AT&T can market its Dataspeed 40/4 data communications terminal, despite claims by rival terminal makers that it is a computer and therefore a device AT&T is banned from offering. In the other ruling, the FCC made it a lot easier for AT&T and other common carriers to wholesale data processing and other private-line services. It amended its earlier thinking and decided not to require that separate subsidiaries be set up to do such marketing. In effect, then, carriers may sell the digital services through a myriad of extremely effective marketing arms—local phone companies.

But perhaps unwilling to give AT&T everything it wished for so early in the year, the FCC also ruled that AT&T must increase the rates charged for its Dataphone Digital Service that uses the Dataspeed 40/4 because they are "unreasonably low."

AT&T's competitors are not yet calling it quits, though. Jack Biddle, president of the Computer & Communications Industry Association, says his organization of data-equipment companies is appealing the Dataspeed 40/4 ruling to the U.S. Court of Appeals in the District of Columbia. IBM is also appealing the judgment separately.

"The CCIA, the Computer and Business Equipment Manufacturers Association, and International Business Machines Corp. are unanimous in agreeing that the Dataspeed 40/4 is in fact a computer device—not a communications terminal," Biddle says, "and as such is illegal under the FCC rules now in force."

Indeed, the FCC's own Common Carrier Bureau took the position last summer that the Dataspeed 40/4 is a computer, rather than a communications service. This time, however, the FCC argued it is wrong to conclude that "anything related to the data-processing service becomes data processing" just because of a close and growing interdependence between data processing and communications services.

CCIA's Biddle says that Dataspeed terminals—already being offered in some intrastate markets—and the ability of AT&T affiliates to market them directly will foreclose sales by other terminal makers. He cites the case of one CCIA member company, which "has some 600 terminals in place in telephone company installations." That, he says, "is quite a chunk of business, and it is going to be lost to Dataphone" hardware. Incidentally, the CCIA also contends that AT&T should be required to spin off Teletype Corp., a subsidiary of its manufacturing arm, Western Electric Co., if it wants to compete in the terminal-equipment market.

DDS pricing. But the FCC did no backtracking over AT&T's Digital Dataphone Service rates. In finding them "unjust and unreasonable," the agency upheld last year's contentions by two of its administrative law judges that the fees "gave the low-speed user an undue and unreasonable preference and were anti-competitive and predatory." AT&T initially proposed to offer DDS using the data-under-voice technology [*Electronics*, Apr. 4, 1974, p. 75]. DUV transmits a computer's digital bit stream over an unused portion of the microwave baseband at 4 to 6 gigahertz. It can provide private-line facilities for binary digital data transmission on a full duplex, synchronous basis.

In ordering AT&T to raise DDS rates to provide a 9.5% to 10% rate of return, the FCC said the company had "substantially overstated the market for DDS," with the result that income projections and demand forecasts "were overstated and unsubstantiated." The commission ordered new rates to reflect fully distributed costs of the service. □

Consumer

GI brings out raft of new video games

The games arcade will soon be moving into the home in full force. General Instrument Corp. introduced a raft of new video-game chips at last week's Winter Consumer Electronics Show in Chicago. Volleyball, tank warfare, and a road race can be made for the home tele-

vision set with the three families of games chips shown by GI's Microelectronics division in Hicksville, N.Y. They enable games makers to build 38 different contests—all either improvements or decidedly sharp departures over the basic ball and paddle, n-channel MOS types GI originally sold.

Essentially, the lastest additions fall into two categories: multigame dedicated chips, which mate with other add-on chips to increase the variety of games, and cartridge-programable chip sets, which use any or all of GI's lines of 16-, 8-, and 4-bit microprocessors.

The basic dedicated chips will be available in the first quarter, and the add-ons in the second half of this year.

Basic chips. All of the dedicated circuits are designed around a few basic chips. With them, game producers can build a tank-warfare game similar to the popular arcade version, volleyball, in which the ball must be angled vertically to clear the net, and a road race, as well as several other skill games adapted from arcades.

In upgrading the standard ball-and-paddle games such as tennis and hockey, GI has set standard features for the next generation of home products. These include on-screen scores, color-coded to each player, dual-axis paddle control, and, for squash, a ball that turns the color chosen by the player whose turn it is to hit it.

With the new Gimini multigame basic circuits, the games maker can choose among four chips, one with the six basic GI paddle-and-ball games, one with the six games plus new color-coding features, one with eight games, or one with the tank battle alone. With the Gimini add-on game circuits, the manufacturer can, with the right chip, add three variations of volleyball, a road race, a chase game called Barracade, or battle between a submarine and surface ships. An add-on in this group, which is available exclusively to one GI customer, provides "rate-motion" capability to the ball-and-paddle games so that players can

News briefs

Britain's ICL reorganizes U.S. arm

The United Kingdom-based computer maker, International Computers Ltd., has formed a new U.S. subsidiary, ICL Inc., to deepen its penetration of the North American market. The move comes in the wake of ICL's purchase of most of the business and assets of the Singer Co.'s Cogar Corp. subsidiary and certain assets of the now-defunct Singer Business Machines division. With the formation of ICL Inc., the former ICL (USA) subsidiary in New York has been disbanded. The new organization has a Marketing division in East Brunswick, N.J., and a Manufacturing division at the Cogar plant in Utica, N.Y., where ICL will produce the former Cogar 1500 intelligent terminal and Singer System 10 computer and point-of-sale terminals. Geoffrey Rowett, previously an ICL sales manager in the UK, is president of the new subsidiary.

FCC warns CB applicants—send no money

"Do not—repeat, DO NOT—send money. please." That extraordinary plea from Uncle Sam is being issued by the Federal Communications Commission to all its licensees, especially to citizens' band radio applicants. The FCC appeal stems from a recent court order invalidating the commission's fee structure for everything from CB and television broadcast licenses to telephone rate filing. [*Electronics*, Jan. 6, p. 36]. As a result, the FCC has suspended collection of all fees pending review of the court decision and establishment of a revised fee structure. Yet the commission says, "People are not getting the message. We are still getting checks with applications, particularly the $4 fee for CB licenses, and this is slowing down our whole process."

NASA picks Western Union over RCA to provide its TDRSS net

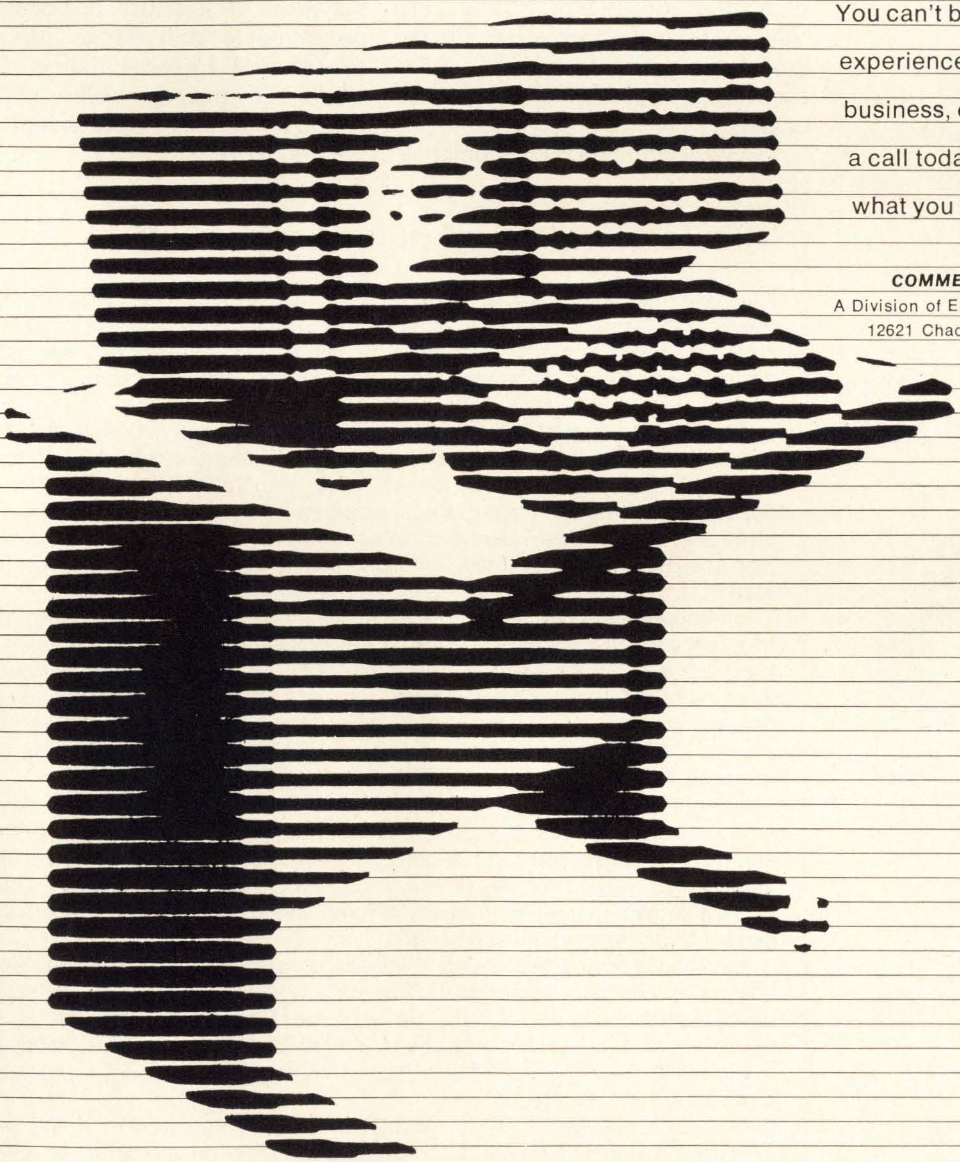
Western Union Space Communications Inc. has won a 10-year, $796 million contract from the National Aeronautics and Space Administration to provide a tracking-and-data-relay-satellite-system service. The new Western Union subsidiary won the award in competition with RCA Global Communications. The network, scheduled to begin operations in 1980, will use two operational satellites and one spare in synchronous orbit to link manned and unmanned spacecraft in earth orbit with a White Sands, N.M., ground terminal. Major subcontractors are Harris Electronic Systems division, Melbourne, Fla., and TRW Defense and Space Systems Group, Redondo Beach, Calif.

Pocket-sized TV bows with 2-inch screen

A $300 black-and-white television set that fits in a traveling businessperson's pocket was introduced this month by Sinclair Radionics in London and at the Chicago Consumer Electronics Show. The result of a 12-year effort, the 27-ounce Microvision features a 2-inch picture tube using low-power electrostatic deflection developed by West Germany's AEG-Telefunken. With the low power, the British calculator maker could then design most of the battery-powered receiver around five linear integrated circuits, two standard sound-deflection and amplifier-devices, and three custom-designed video intermediate-frequency detector and deflection circuits from an undisclosed United Kingdom supplier.

Ampex low-cost core memory aimed at 'access gap'

Ampex Corp., El Segundo, Calif., is aiming a low-cost core memory system holding as many as 4,096 kilobytes at fixed-head disk drives operating in the "access gap" between main memory and direct-access storage devices. Cost of the memory, called Megastore, is below 0.1 cent per bit, and access times are in the 1-to-10-microsecond range. The new system uses a two-wire organization rather than the three- and four-wire systems common in main memory cores today. Along with other simplifications in the circuitry, the two-wire setup allows the firm to put the price of the units in the access gap. First units being built are compatible with Data General's Nova and with Digital Equipment Corp.'s PDP-11 systems.



move the ball on the paddle, steal the ball, or impart speed and direction to shots.

Five-game chip. Also in this group is Square Off, a five-game chip. Players have 16 directions to move a vehicle or fire a missile, and there are fixed barriers and appropriate accompanying sounds. "The idea," explains Richard G. Norwood, general manager of the microelectonics division consumer-product line, "is to give the game maker maximum flexibility with minimum silicon—a large number of games without having to pay for detailed video-character definition." Thus, in Square Off, opponents in all the games are simple squares, rather than shapes resembling cars, guns, or tanks.

"What we're offering customers is the ability to come up with any number of additional games using these concepts, and then we will tailor-make their games so that everyone's products won't look alike," Norwood adds. But for companies that want to get into the higher-priced microprocessor-based competition, there are the Gimini programable basic circuits, most of which use GI's CP 1600 and PIC 1650 16-bit microprocessors and possibly one or two read-only memories. This group includes the Vegas series of three gambling games: blackjack, acey-ducey, and a slot machine. GI has also demonstrated programable skill games like Tic-tac-toe and Lunar Landing. However, the programables will be prepared for what individual customers desire. □

Tektronix develops pnp microwave transistor

As a rule, microwave bipolar transistors are npn devices. But Tektronix Inc., the Beaverton, Ore., instrument maker has developed a pnp device that it says will make it possible to build high-speed complementary-transistor switching circuits from fewer parts and with better performance than is possible with npn designs.

The new transistor can handle a maximum collector current of 250 milliamperes, with its collector-base breakdown voltage on the order of 90 to 100 volts. Cutoff frequency is between 1.5 and 2 gigahertz. The obvious application for transistors of this type would be in one or another of the firm's electronic instruments. However, the company declined to comment about this possibility, a spokesman maintaining that the "application is proprietary."

Ion implantation is the key to the unit's fabrication, says Tektronix. With this process, the doping of the thin layers needed for a successful pnp transistor can be precisely controlled. In particular, the device's base region must be thin and precisely doped to reduce the transit time of the minority carriers (holes) through this area. In addition, ion implantation permits precise control of such critical performance factors as punch-through and the collector-emitter voltage, which must be kept low.

The unit's collector region is formed by an epitaxially grown p-type layer on a p^+ doped substrate. A guard ring, an active base, and a base contact are then ion-implanted, and a conventional emitter diffusion follows. The metalization system for the device is dielectrically passivated gold, which provides a high mean time between failures and stable low-junction leakage current under reverse-bias conditions.

The ion-implanted guard ring is linearly graded and relatively shallow—only 0.75 to 0.9 micrometer deep. This configuration minimizes the collector-base capacitance, which must be very small for an application in an extremely fast measuring instrument, for example. In contrast, diffusion would result in an "abrupt" guard ring with deep side walls and appreciable collector-base capacitance.

At a bias voltage of 10 V, the collector-base capacitance of the pnp transistor is only 5 picofarads for a pulse rise time on the order of a few nanoseconds. What is more, for class-A amplifier operation, the device performs linearly at power levels up to 5 watts.

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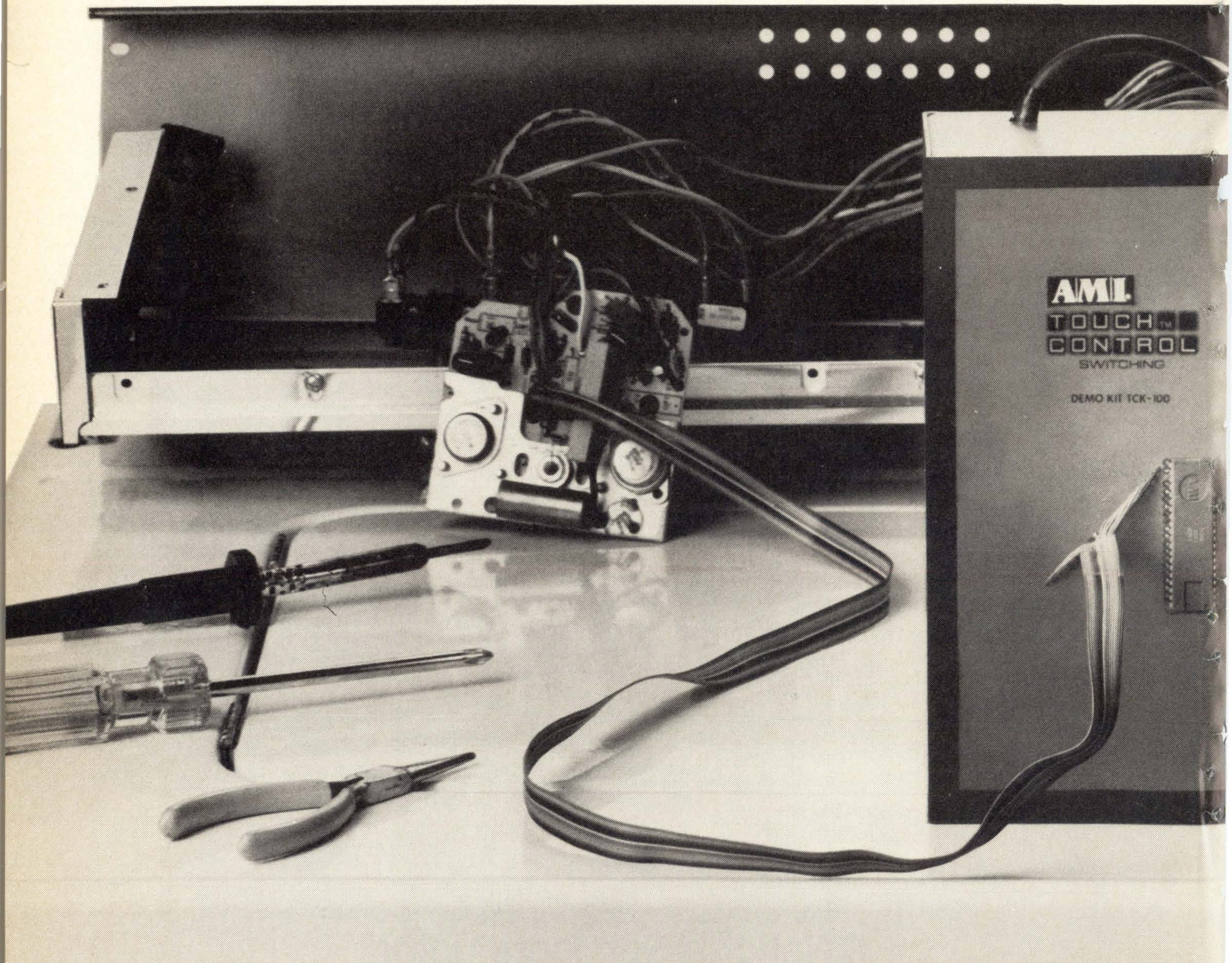

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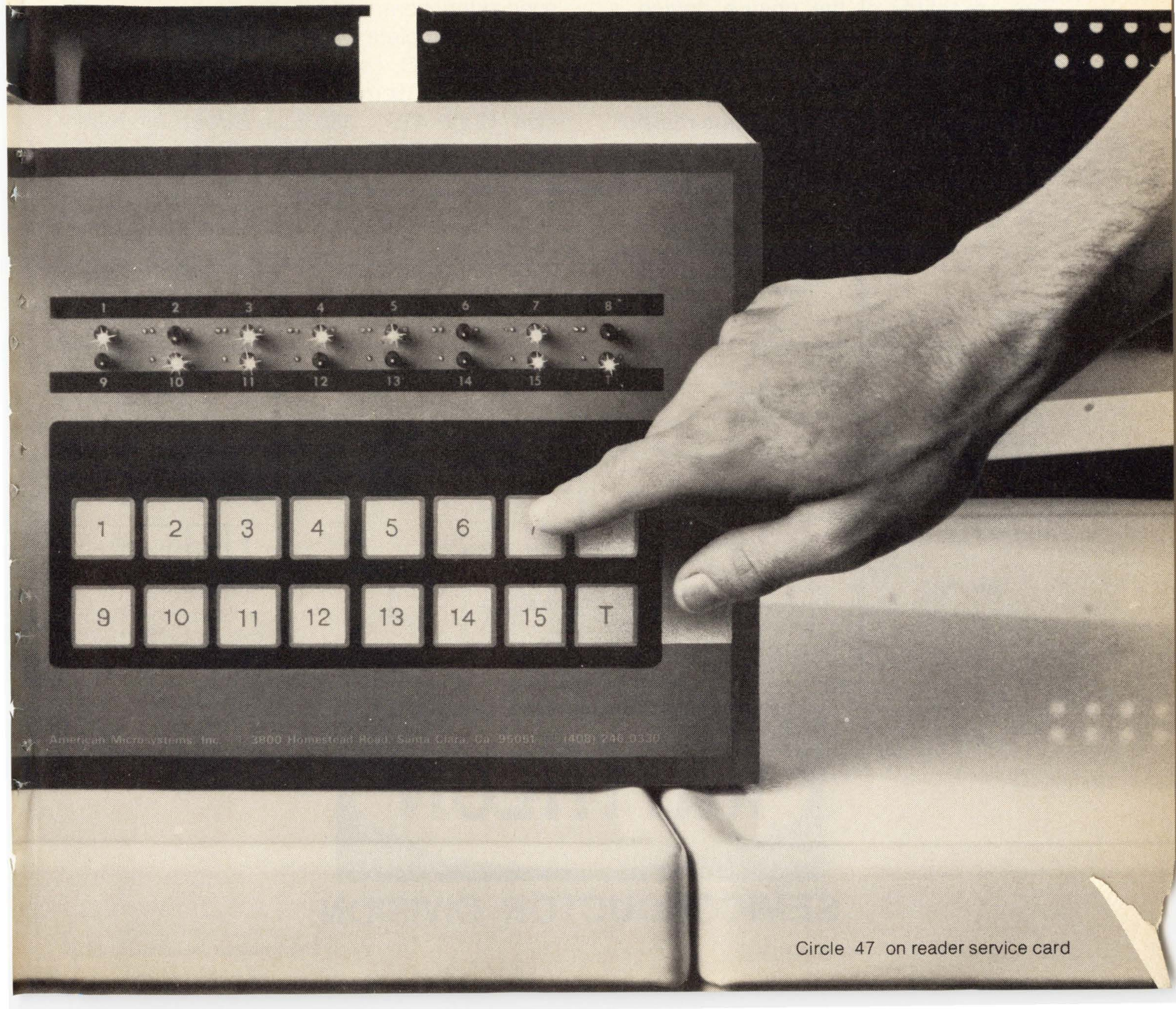

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Washington newsletter

Color TV imports to test Carter trade policies . . .

President Jimmy Carter's trade policies will get an early test from domestic makers of color-television receivers and parts, which have been joined by 11 of their unions to **push harder than ever for import quotas on receivers from Japan.** The coalition of manufacturers—GTE Sylvania Inc., Corning Glass Works, Owens-Illinois, Sprague Electric Co., and Wells-Gardner Electronics Corp.—and their unions calls itself Compact, the Committee to Preserve American Color Television [*Electronics*, Sept. 30, p. 36].

Compact wants the International Trade Commission to recommend that the President impose quotas on what it calls the tidal wave of imports—most from Japan—which totaled nearly 3 million receivers last year, a 40% share of the U.S. market, compared to 16% in 1975. President Carter will have 60 days to accept, modify, or reject any invocation of quotas under the escape clause of the Trade Act. If he rejects an ITC recommendation, Congress may override the rejection by a simple majority—a vote that the AFL-CIO indicates it will push for if necessary.

. . . as Zenith joins appeal to ITC by U.S. coalition

Compact's hopes for color television import quotas were buoyed when Zenith Radio Corp. unexpectedly reversed its earlier stance and **joined the coalition's plea for quotas.** But John J. Nevin, Zenith chairman and president, emphasizes that any such quotas should be ended when the commission can complete its investigation of Japanese-TV makers' alleged unfair and illegal practices. Still pending is a Zenith suit against Japanese producers that alleges government subsidization and other practices illegal under U.S. trade law.

Pentagon moves slowly on metric conversion programs

Already distressed with inflated weapons-system costs, the Department of Defense is discouraging conversion of existing weapons to the metric system, and it will push the use of metric units in new weapons **only "when there are nonsignificant technical or cost penalties."**

That is the substance of the Defense Department's new Directive 4120.18 published this month. The department says its "evolutionary pace" on metrication will be guided by industry's progress, which it hopes will be accelerated by the prospect of more joint production programs with other countries of the North Atlantic Treaty Organization. The U.S. is NATO's only member not yet using the metric scale.

Engineers to hear how FCC will register phones

How do you comply with the Federal Communications Commission's new rules for registering a telecommunications product for interconnection with the Bell System or other telephone companies? That question is to be answered Feb. 28 at Washington's Mayflower Hotel. The intensive one-day seminar, sponsored jointly by the Electronic Industries Association and the IEEE's Washington section, is scheduled **to give product planners, engineers, and their managers a working knowledge of Part 68 of the new FCC registration rules.** EIA, which says a "nominal" fee will be charged, is providing registration forms to applicants who write Jeannie Wisemiller at its hedquarters at 2001 Eye St., N.W., Washington, D. C. 20006, or call her at (202) 457-4937.

Washington commentary

R&D trends: DOD's developers shop the open market

Just as America begins a new political direction with the inauguration of President Jimmy Carter, it will also attempt a new technological thrust with the Federal budget for fiscal 1978. The irony of this is that the new budget's call for significant increases in Federal support of research and development is the product of the outgoing Administration of Gerald Ford, who sent his last budget to Congress just three days before leaving office. Even though the Carter Administration plans to ask Congress for changes in the Ford spending proposals throughout the year, it is the Ford budget that will serve as the fundamental document for new spending legislation.

When Ford science adviser H. Guyford Stever revealed that military R&D dollars in the new budget would increase about 15% from the $10.5 billion approved for fiscal 1977, he aroused strong interest in the Washington community of electronics contractors anxious to get support for new corporate R&D efforts. That anxiety, however, is causing some companies to overlook the larger changes in Federal R&D policies that these funding increases tend to obscure.

The turn to private enterprise

In the year just ended, the Pentagon and other agencies began turning more and more toward the use of products developed by private industry with its own funds as a means of establishing new Federal standards and upgrading Government systems, particularly electronic systems. The best example of this move came with the disclosure that the Navy and Army had selected Digital Equipment Corp.'s PDP-11 architecture as the basis for a new family of military computers for the 1980s [*Electronics*, Oct. 14, 1976, p. 77]. The report of that selection has now been confirmed by the Naval Research Laboratory, which takes credit for having "conceived and laid the groundwork for a new approach to military computer standardization."

The fact that private industry looks harder at—and generally gets better results from—R&D expenditures of its own money, rather than public funds, is not news to the scientific community, of course. Federal money produced some important studies that ultimately led to significant technological breakthroughs, but, in the end, the breakthroughs themselves were the product of private enterprise. Examples are readily found in such areas as semiconductors, data processing, telecommunications, and electro-optics.

This view is confirmed by former NASA executive William H. Pickering, who now serves as naval programs adviser to the National Academy of Sciences. "Predicting scientific or technological breakthroughs is a very unprofitable exercise," Pickering says. "Even predicting areas of importance can be hazardous. For example, it is not at all obvious that the quantum theory of semiconductors would have been considered an important field even five years before the invention of the transistor."

Comsat's example

Communications satellites provide another key measure of where private industry has proved more efficient than the Federal bureaucracy. The Navy must now lease ship-to-shore communications circuits from Communications Satellite Corp.'s operational Marisat system, while development of DOD's own Navstar Global Positioning System continues to flounder.

In telling a Navy symposium last fall that advancing electronics technologies will eventually lead to simple operation of complex devices, Pickering chose—perhaps inadvertently—to illustrate his point by citing two developments of private enterprise: the pocket calculator and the single-control color-television set. "Ten years ago," he said, "both of these would have been impossible, or would have cost a fortune. Now they are cheap, reliable, and can be operated by anyone with practically no training." Very few naval electronics systems can make that claim, despite vast R&D outlays.

Sperry Univac's Carl Hammer selected similar analogies to illustrate "the pervasive nature of electronic computers" in his appearance this month (Jan. 11) before the Aerospace Industries Association of America in Washington. "Who would have thought, 10 years ago, that makers of mechanical watches would be in a world crisis mode, or engineering students would crave anything but a 20-inch slide rule?" he asked.

President Jimmy Carter has yet to indicate his preferences for Federal support of R&D, but he would do well to heed the examples cited by Pickering, Hammer, and others when it comes to electronics technologies and to stress Federal support of development programs that can apply products of private research. **Ray Connolly**

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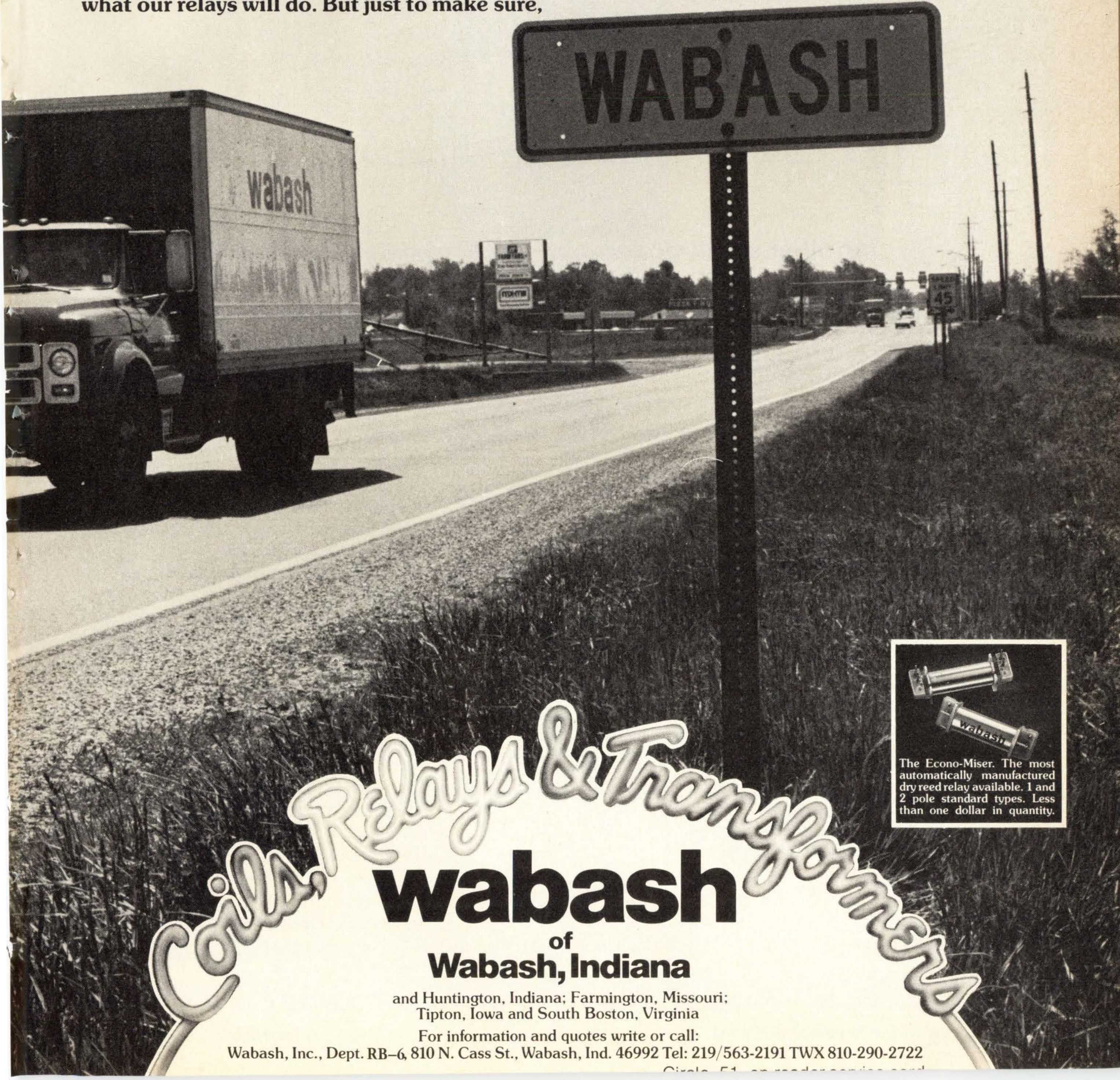

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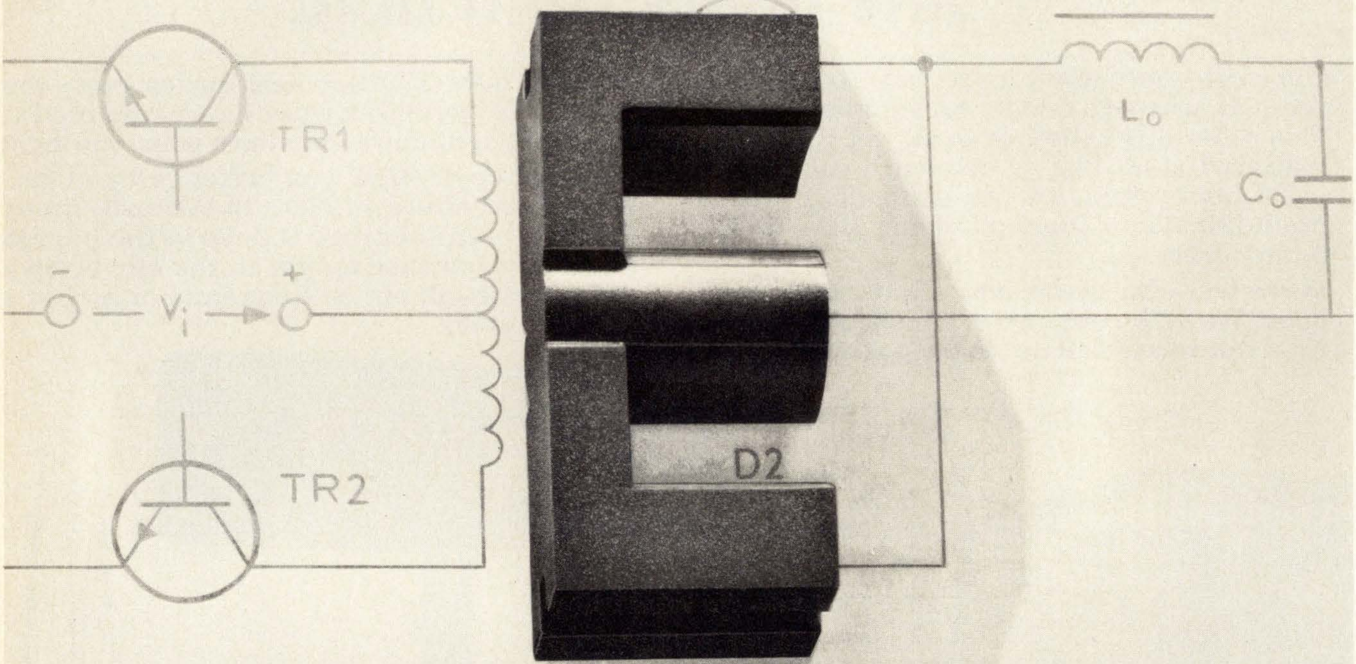

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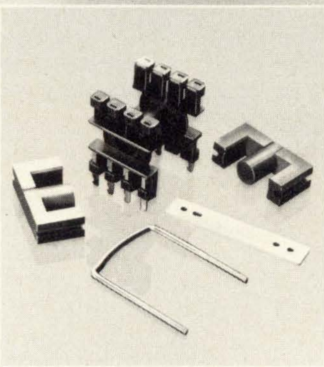

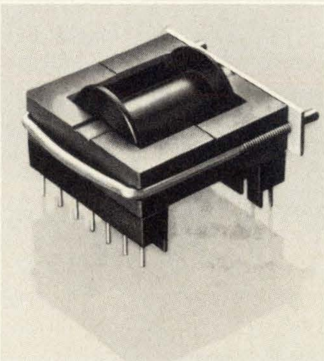

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ITU delegates seek early satellite channel allocations

Communications-agency officials from around the world hope to nail down channel allocations and slots in space for direct-broadcasting satellites for their countries by early February. The allocations, in the 12-gigahertz band, will come out of an International Telecommunication Union conference now under way in Geneva with representatives from 113 countries on hand. Although full-fledged direct-broadcasting satellites won't go on the air until the 1980s, **a lot of developing countries want channel assignments now** so they won't run up against overcrowding when they finally are ready to beam television programs from space into their territories.

Most West European countries want an allocation plan, too, to make sure they'll get a fair share of the channels in their region—up to five per country look feasible. Soviet Russia reportedly wants allocations fixed soon so outsiders can't flood Eastern Europe with "unauthorized" programs. **U.S. officials, on the other hand, went to the Geneva conference hoping they could persuade the majority of countries to hold off for a while.** Nonetheless, if a majority insists on a plan now, the U.S. almost certainly will participate.

Matsushita becomes fifth to market Japan Victor's VTR

Matsushita Electric Industrial Co. in April will become the fifth company to market the VHS home video-tape recorder developed by Victor Co. of Japan. The second company to manufacture the Victor product, Matsushita will continue to sell its own VX2000. Victor is making OEM units for Hitachi Ltd., Sharp Corp., and Mitsubishi Electric Corp.

The VHS offers two hours of playing time, twice as long as the Sony Betamax, the industry sales leader. Out of the expected fierce competition between the two systems, one could emerge as the industry standard. Although Matsushita's VX2000 is the cheapest unit on the market, it may fall by the wayside because cassette equipment is so much more popular.

Double pivots prevent errors in digital compass

By combining several electronic techniques, Marconi Research Laboratories has developed a rugged, lightweight digital compass it claims is ideal for pleasure boats, light aircraft, and vehicle-location systems. The instrument is designed with magnets attached to a digitally encoded compass card 3.75 centimeters in diameter that is suspended on a spindle.

To prevent the card from tilting during acceleration, thereby introducing error, the spindle is anchored by top and bottom pivots. The data, contained in patterns on 10 concentric circles on the circular card, is read by 10 fiber-optic sensors fed by light-emitting diodes to indicate changes in direction. After processing, the parallel digital words can be routed directly into a display or a computer. The UK firm claims accuracy to 0.35°.

Siemens pushes hearing-aid sales

West Germany's Siemens AG, a heavyweight in medical electronics, is expanding its hearing-aid marketing effort in France. The firm's French subsidiary, Siemens SA, has established a distribution company there to market hearing aids, audio meters, and audio systems to schools for the hard-of-hearing. **The new firm, Audipha Acoustique SARL, will also handle non-Siemens products.**

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Sanyo designs magnet inside magnetron for electronic cookers to be exported

In an offensive to capture more of the electronic-cooker market, especially in the U.S., Sanyo Electric Co. has developed a smaller and potentially cheaper magnetron than it has been buying to put in its products. Cooking efficiency is enhanced by designing the magnet inside the tube, rather than outside, especially to concentrate the energy inside and minimize flux leakage outside. Size of the cooker can be reduced because the tube is 20% smaller and 40% lighter than conventional versions for that purpose.

The initial magnetrons will be used in cookers to be exported. The cooker output is 600 watts—higher than in most Japanese products, but common in the U.S. The magnet's low temperature coefficient of flux change with temperature makes it desirable for Americans, who typically eat foods that must be cooked longer than the Japanese do, buy more cookers that also brown and steam the food, and use many more microcomputer-controlled electronic timers, which do not operate properly unless the cooker output is constant. In addition, the design virtually eliminates flux leakage inside the cabinet, which, if it were present, could interfere with nearby components that might be designed into the cooker.

Alloy. The two circular rod-shaped magnets, made of a proprietary alloy of iron, nickel, cobalt, and other materials, have a mere 0.18% coefficient of flux change per degree celsius—only about 10% the change that is characteristic of ferrite materials.

The alloy overcomes the disadvantage of the conventional pair of external ring-shape ferrite magnets, whose flux decreases as the temperature increases so that power output is reduced by 50 watts or so in 600-w tubes. This loss becomes more significant as temperature keeps rising when the magnetron is kept on continuously for long periods—typical of cookers that are equipped with browning and steaming cycles.

Design. One of the most difficult development tasks was to design the magnets so that they would provide a uniform field, even though one of the rods had to be formed as a thick-walled tube to allow space inside for filament leads. The materials also had to work inside the vacuum tube.

Although the magnetic material is more expensive than conventional ferrite, the magnetron takes up only 25% the volume of conventional tubes. What's more, the Sanyo tubes have iron envelopes that are cheaper than the copper ones of other magnetrons.

Forced air cools the tube, which

Around the world

System speeds aid to autobahn callers

Motorists stranded along West Germany's autobahns—those multilane freeways akin to interstate superhighways in the United States—can expect help to come much faster in the future if an electronic tone-signaling system is installed as planned. The project, financially supported by Bonn's Federal Transport Ministry, calls for equipping the 7,000 emergency telephones installed at 2-kilometer intervals along the autobahns with the automatic equipment. This system, developed by Munich-based Siemens AG, would enable personnel at a regional highway patrol station to pinpoint the telephone from which a call is received so that they could promptly dispatch a repair or rescue vehicle to the scene.

Each telephone would be assigned its own sequence of 12 signals produced by three tone generators on four frequencies. When the telephone is used, these signals would automatically be sent over the four-wire voice patch to the nearest station, where they would locate the phone on a light-emitting-diode display and in lights on a topographic monitoring board of the controlled region.

Trade winds blow profits for nautical gear

Brisk trade winds are blowing pleasure-boat makers through good years and taking marine-electronics companies along with them. That sunny forecast was underlined at this month's International Boat Show in London, where electronics companies were busy writing up sales of new hardware to intrepid yachtsmen. "Business was fantastic last year. This year will be as good if not better," exclaims Herbert Jones, sales-office manager for Electronic Laboratories Ltd., Poole, Dorset, maker of the widely selling Seafarer range of radars, autopilots, and echo sounders. Sales will rise about 20%, following "the best year ever," seconds Leonard A. Johnson, manager of the Grimsby Depot for the Sailor line of communications gear made by S.P. Radio A/S, Aalborg SV, Denmark. He explains that the business is almost recession-proof: if sales to owners of large yachts go down, those to small-boat fishermen will go up.

Intriguing uses of electronics technology also highlight the marketplace. Rigel Instruments Ltd., Petersfield, Hants., for example, has brought the microprocessor on board for its new $680 Astronavigation calculator, says chairman Paul Goudime. Based on an Intel 8080 chip set, the instrument enables the single-handed navigator to quickly find his position. A hand-held marine radar detector from Rutherford Ltd., Hayes, Middlesex, emits an audible tone to warn fog-bound small-boat sailors when big ships are bearing down on them.

has die-cast heat-radiating fins, rather than the usual stamped ones. Although more costly, the die castings save money by simplifying assembly.

At first, the magnetron is expected to cost the same as other tubes, but the price will probably drop as production quantities are increased. Sanyo will begin in April to produce 10,000 units a month in a new plant in western Japan with the same equipment used to develop this magnetron—the first electron tube the company has ever commercially produced. □

Great Britain

Inductive coil used to charge batteries and read out data from $170 dosimeter

Britain's Brandenburg Ltd. soon will announce a simple, durable electronic gamma-radiation dosimeter so small it fits in a suit pocket. The company, in Thornton Heath, Surrey, anticipates good sales for the $170 product as the world becomes increasingly worried about nuclear radiation from power plants and waste dumps.

Instead of being powered by replaceable batteries like most detectors, Brandenburg's sealed dosimeter is powered by silver-zinc batteries. They are recharged through a dual-purpose inductive coil that is also used by a base station to read out results for long-term plant analysis, says Ian Andrews, manager of the Nuclear department. What's more, the sealed construction ensures that the instrument cannot be contaminated nor damaged by someone changing batteries.

Sealed. The dosimeter, which weighs only a few ounces and is housed in a plain molded-plastic case of 19 by 50 by 120 millimeters, "can be carried around like a bleeper," says Phil Walters, marketing director. There are no external controls nor contacts, and the dosimeter cannot be turned off.

The instrument consists of a geiger tube, two digital up-counters, the inductive coil, and the storage cells, explains Harvey Jones, design engineer. Since the geiger tube's "output is independent of the nature of the radiation that comes in," he needed only one field-effect transistor to condition the signal for the two counters. The FET needs to handle only a fluctuating low output from the geiger tube.

Jones chose metal-oxide-semiconductor 16-bit up-counters because of their small size, simplicity, and low power consumption. The counters detect gamma radiation and trigger an audible alarm when contamination reaches a dangerous level. A second alarm alerts the wearer when he is exposed to an overdose and when the battery is low.

The counters, which tot up until they reach a preset limit, sound the audible alarm and then switch off the high-current geiger circuit. A round ferrite core of about 6 by 18 mm, with its two halves spaced about 6 mm apart, was chosen for the inductive coupling.

In a typical plant, the dosimeters could be used in conjunction with their typewriter-size base station placed near the exit. The station has one slot for interrogating the instrument's radiation level, which would be displayed by light-emitting diodes or printed out. At the end of a shift, the dosimeters would be inserted in other slots for charging. □

West Germany

Company upgrades hf transmitter

By developing a new way to implement the pulse-duration-modulation (PDM) technique, West Germany's AEG-Telefunken has improved the efficiency, increased the compactness, and largely standardized the component parts in a line of amplitude-modulated high-power radio transmitters. Developed at the company's Berlin laboratories, the family consists of three medium-frequency transmitters in the 100-kilowatt, 350-kw, and 600-kw ranges and three high-frequency transmitters in the 100-kw, 300-kw, and 500-kw classes. Compactness was also enhanced by using reduced-size transmitter tubes developed by France's Thomson-CSF that are cooled by a combination of water and vapor.

To be sure, the basic PDM technique, whereby the pulse duration of a rectangular wave is changed in accordance with the modulating audio frequency, has been employed in 100-kw mf transmitters built by American firms. But when it comes to transmitters with a higher power rating or wider frequency range, the basic technique is difficult to implement. To surmount obstacles to PDM, the researchers developed a method, called System Telefunken.

Drawbacks. Bodo Wysocki, head of transmitter-development activities, explains that in the basic PDM method, the modulating tube's cathode is at ground, but all electrodes of the rf-output tube are at high potential. Complex bypass circuitry is needed to put the high voltage, especially that of the cathode and screen grid, at ground. Not only is the required circuitry complex and expensive, but at high frequency, it could cause resonances.

To overcome these drawbacks, System Telefunken keeps the rf tube's cathode at ground potential, while the modulating tube is at a high potential. This arrangement simplifies the circuitry and makes it possible to operate PDM transmitters even at high power levels and with a continuously tunable wide frequency range.

Standardization. The technique also reduces the number of a-m tubes in a typical a-m transmitter from four or five to only three—one each in the modulator, the rf driver and the rf-output stage. The same type of tubes can be used in the modulator and output stages. □

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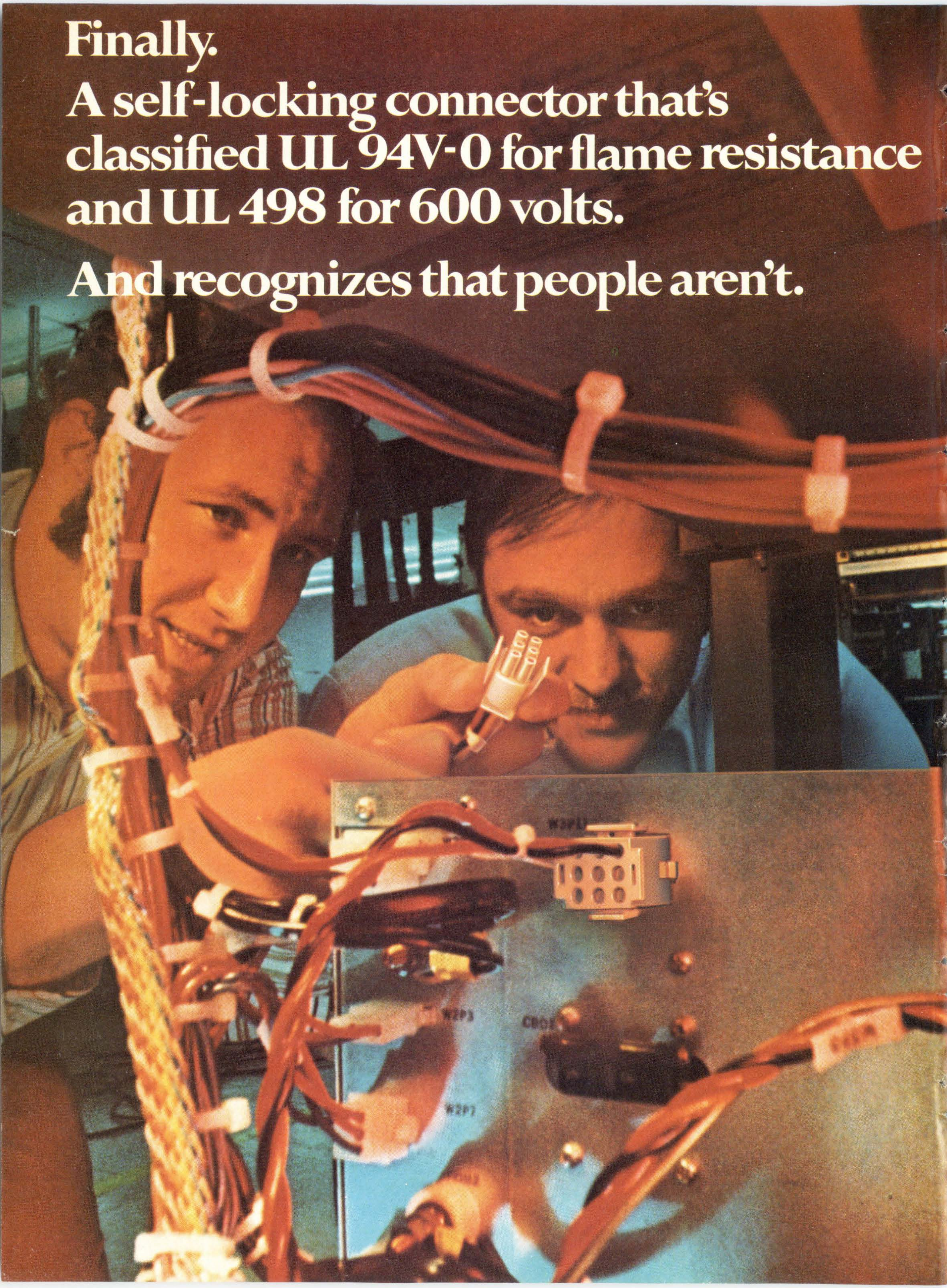
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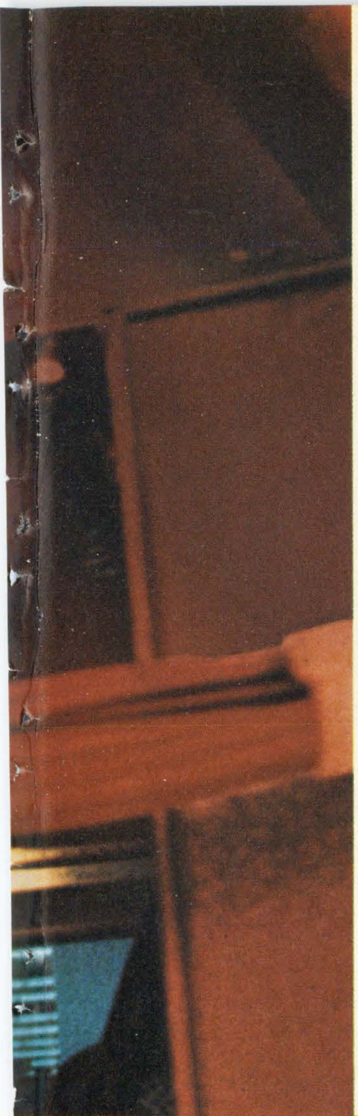

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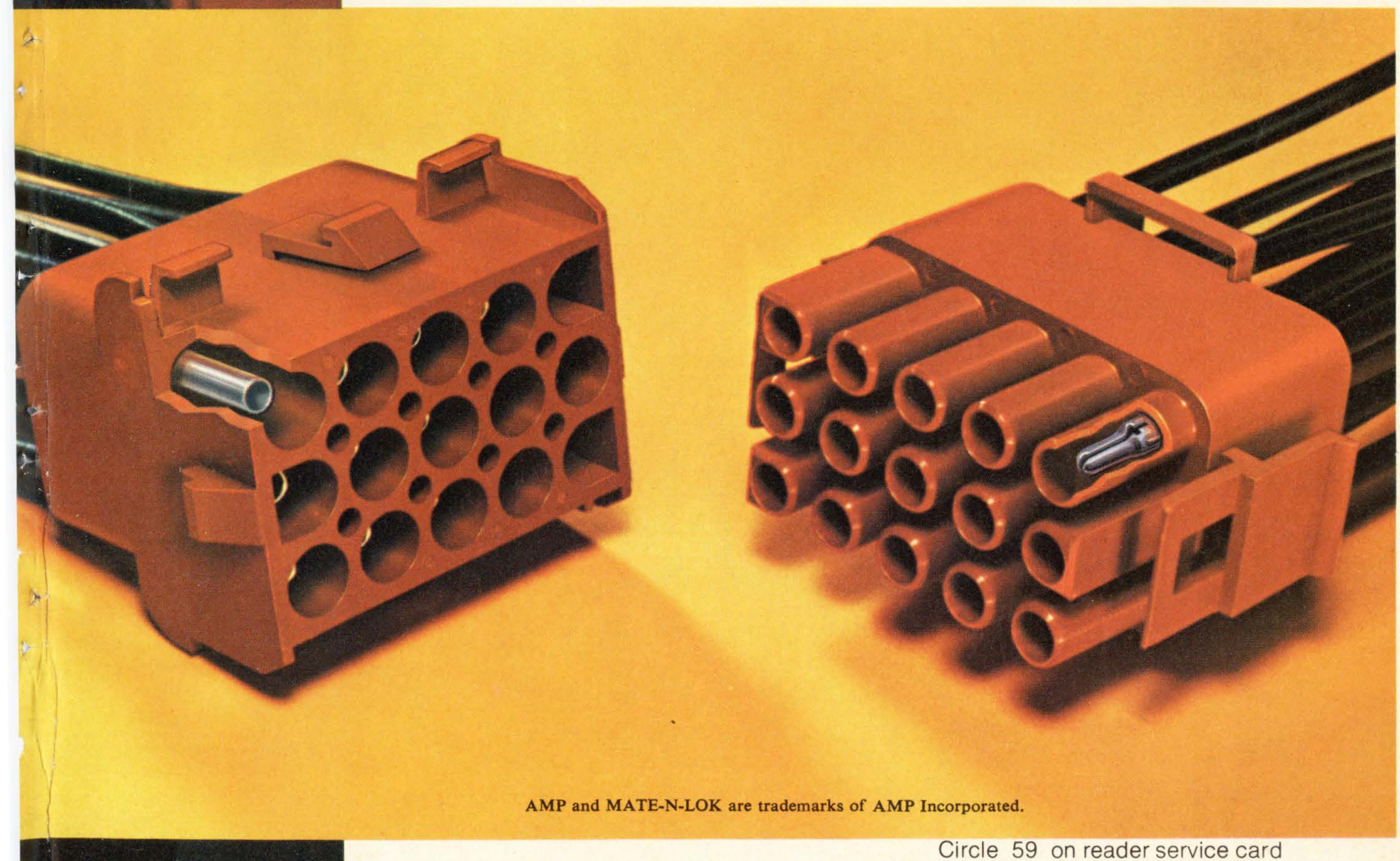

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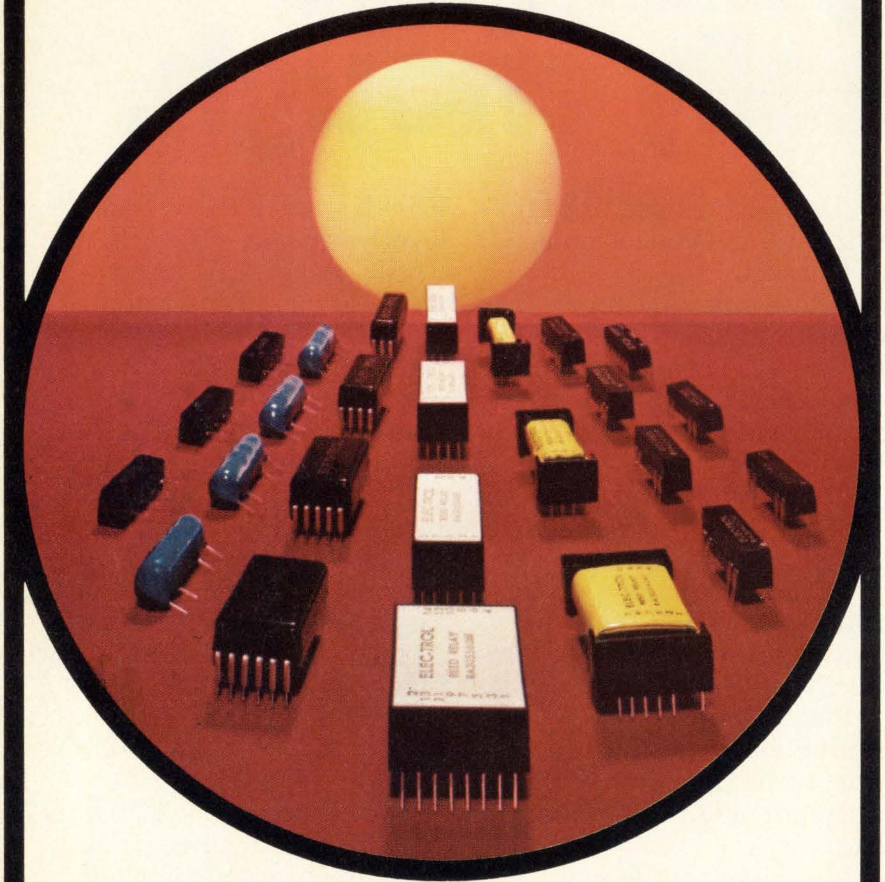

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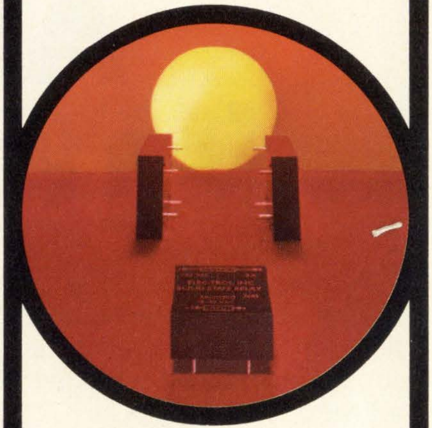

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CCDs show influence on design quietly

by Laurence Altman, Solid State Editor

Although much charge-coupled-device technology lies buried in semiconductor-device design or hidden in custom programs for today's large military systems, it is making a tremendous impact on solid-state design. That's the consensus of device and system specialists working with the seven-year-old LSI-circuit technique.

Ironically, the CCD impact cannot be judged by standard products—there are precious few of them. A few medium- and high-density CCD image sensors and cameras are available from RCA Corp. and Fairchild Semiconductor for special image applications, such as infrared detection and surveillance equipment, and a handful of CCD serial and block-accessible memories are being produced by Intel Corp. and Fairchild for prototype disk and tape replacements. Also, a number of simple integrated-circuit analog delay lines use the CCD or a similar bucket-brigade approach to implement a variable delay, but these are not widely used because in many cases established mechanical devices or with discrete components can do the job more cheaply.

Only when one looks beyond the standard-product industry does the full impact of the CCD technique become evident—and it is truly significant. Probably David Barbe, as senior scientist and contract manager for the Naval Research Laboratory's extensive CCD-support programs, is in the best position to evaluate the largely hidden but powerful impact of CCD design in relation to system performance.

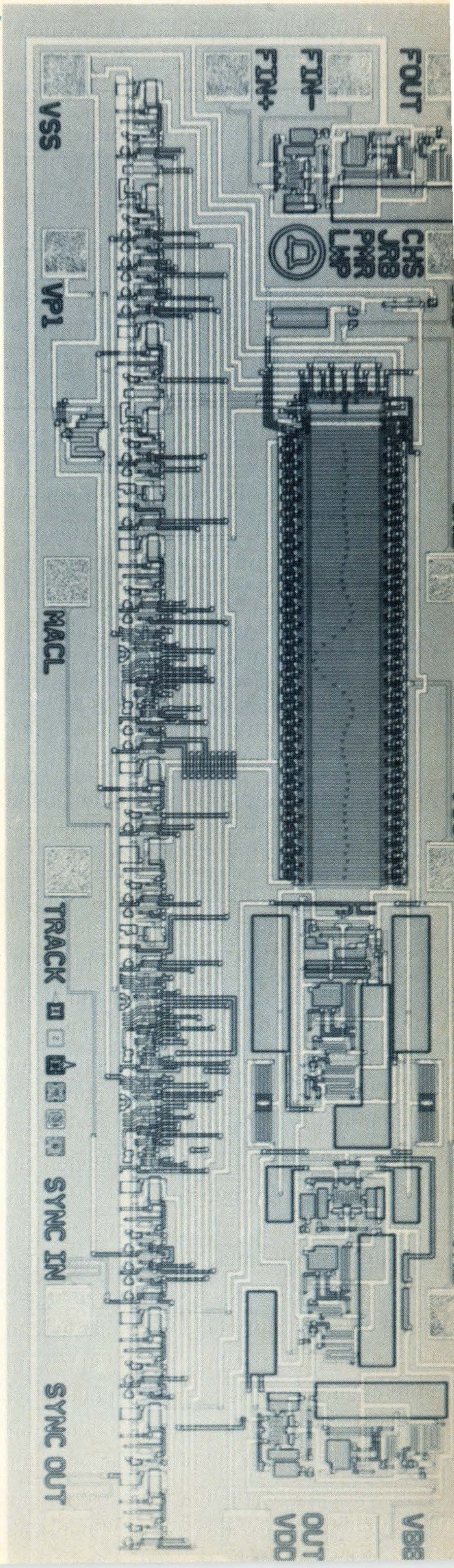
Military uses. "True, while CCDs have not made major new-product markets," explains Barbe, "the technology is the key to implementing powerful new system techniques, especially in military signal processing and secure communications. It's allowing us to do things we just couldn't do before." In infrared detection systems, for example, CCD imagers are key elements in surveillance, navigational, and weather systems because they are more sensitive in the IR range than imagers based on other technologies. In addition, CCD analog and digital transversal filters are now being used in prototype versions of new communications systems.

Besides taking the place of a whole bagful of analog signal-processing components, such new filters increase system flexibility. Lower-cost filters can now be adapted to a particular application without having to undergo expensive remasking costs.

"This is only the beginning," says Barbe. "I've talked to people who are designing in other communications areas, like radar, sonar, and voice communications. The charge-coupled device is an enormously important component for those types of communications."

Telecommunications potential. Besides military applications, the CCD's impact on commercial telecommunications will also be significant. Bell Laboratories' CCD supervisor, Mike Tompsett, who has worked from the start of the technique seven years ago with Bell Labs CCD inventors George Smith and Willard Boyle, believes CCDs have a strong potential for telecommunications hardware—integrated delay lines, filters, and memories—standard component blocks in the Bell System.

Tompsett, however, points out:



Getting through. CCD has a good deal of potential for telecommunications uses. Here is a filter from Bell Labs.

"At Bell, cost and reliability are crucial. Here, we differ somewhat from military requirements. We need relatively simple devices that must be rugged, extremely reliable, and very low-cost. Military signal processing, on the other hand, needs very complex devices—filters, and so on—that are more delicate and cost more to build.

"While they need performance, we're in a continuous cost-performance battle with very established techniques, and in many areas, we think CCDs will offer the best solution," he says.

Tompsett says that analog delay is a promising application for CCDs. "Compared to other methods, CCDs handle analog delay very elegantly," he says. "And there's a huge number of analog-delay applications in the system—applications that can be accomplished now and potentially.

"With CCDs, you can make fully integrated analog delay lines on one LSI chip and still end up with very high-quality devices—70-to-80-decibel signal-to-noise ratio, 60-to-70-dB distortion, and so on."

System integration. In the long run, Tompsett predicts, the CCDs will permit further integration of telecommunications systems on larger and larger LSI chips. "With CCDs, you can integrate a whole communications function onto one or a few LSI chips, whether it's digital or analog circuits. Since CCDs are built with standard n-MOS LSI processes, you can begin thinking about putting, on a single chip, complex CCD filters and analog circuits, together with standard n-MOS logic and memory to control them. We're working with our systems analysts or system partitioning for these types of applications," he says.

CCD for logic use. While other designers are following fairly straightforward approaches to CCD implementation, workers at TRW's Electronic Systems division are breaking new ground. In addition to building CCD chips for imaging, memory, and analog signal-processing, TRW Semiconductor design specialists are applying CCD-circuit techniques in the area of standard logic functions.

Their approach enables complex signal processing to be handled by digital methods of binary computation that are faster and lower-cost than more analog methods. TRW has already built 16- and 32-bit adders and multipliers with CCDs, as well as other standard binary and arithmetic operators.

Thomas Zimmerman, one of the program leaders, points to the advantages of CCD logic. "These logic circuits have much lower power dissipation and smaller size than other LSI methods," says he. "A 32-bit CCD adder requires only 21 square mils, while the equivalent function in n-MOS is over 30 mil^2. Moreover, a CCD adder dissipates well under 100 milliwatts, or 20 times less than equivalent n-MOS circuits.

Complexity. On complex CCD signal-processing chips, TRW could use CCD logic to shift, correlate, multiply and so on, as well as do standard computations like addition and subtraction. Moreover, the CCD chips can interface directly with a bipolar analog chip or go directly from logic to memory to a-to-d conversion. In short, one circuit technique can handle most signal-processing jobs.

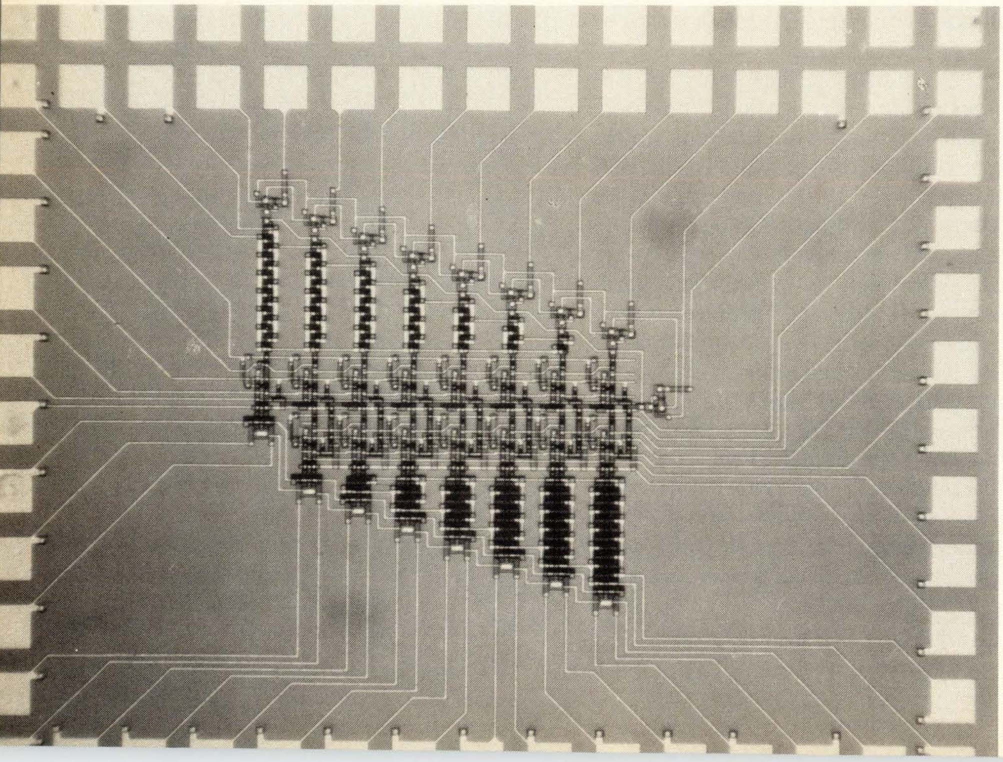
Zimmerman points out that CCD logic is not intended to perform the standard ripple or series logical processes, involving many feedback loops, that now commonly are utilized to perform today's computer algorithms.

For that reason, CCDs probably would not be useful in standard computer architectures, even though in many circumstances this LSI approach costs less than conventional n-channel MOS or transistor-transistor-logic methods. But for computer systems requiring a generous proportion of pipelining, it is almost perfect.

All things considered, the future of CCDs in large system designs is formidable. Equally impressive is the mushrooming influence of the devices on design techniques for dense RAM chips. While the CCD bulk-memory product line is beginning to emerge—65-kilobit chips are in the offing—charge-coupled storage, being developed for 65-kilobit RAMs, may in the end be more important to device design than the more visible bulk memories.

All the major semiconductor makers are using the CCD approach to squeeze the size of RAM cells below the 1 mil^2 needed for 65-kilobit devices. Texas Instruments Inc. and International Business Machines Corp. have shown their RAM cell structures using CCDs. And it is a safe bet that other CCD programs around the world are making similar progress. □

Thinking. CCD 8-by-8 adder from TRW, where CCD techniques are being applied to standard logic functions to get faster signal processing at lower cost.



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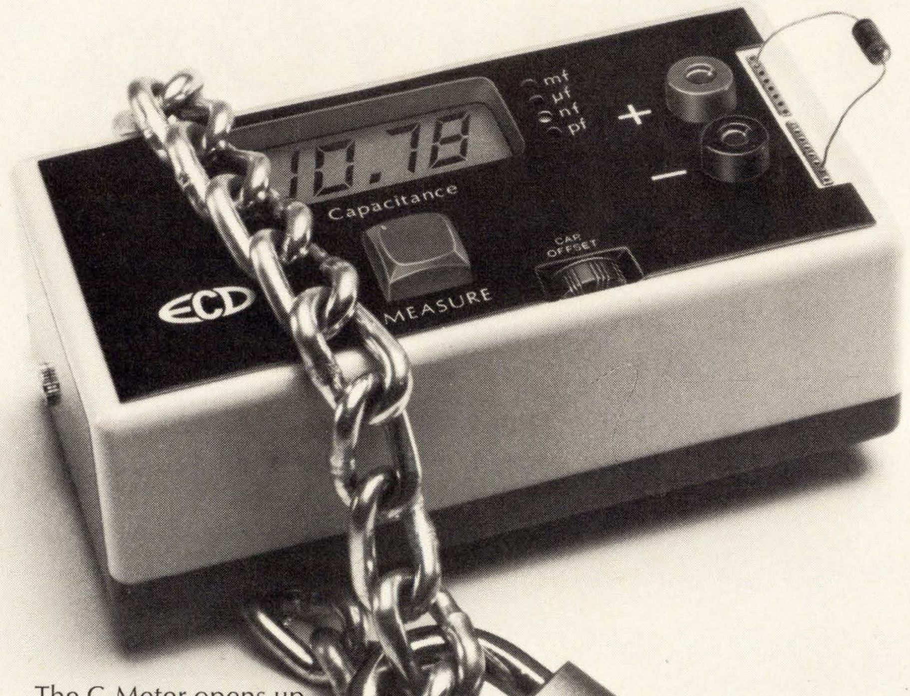

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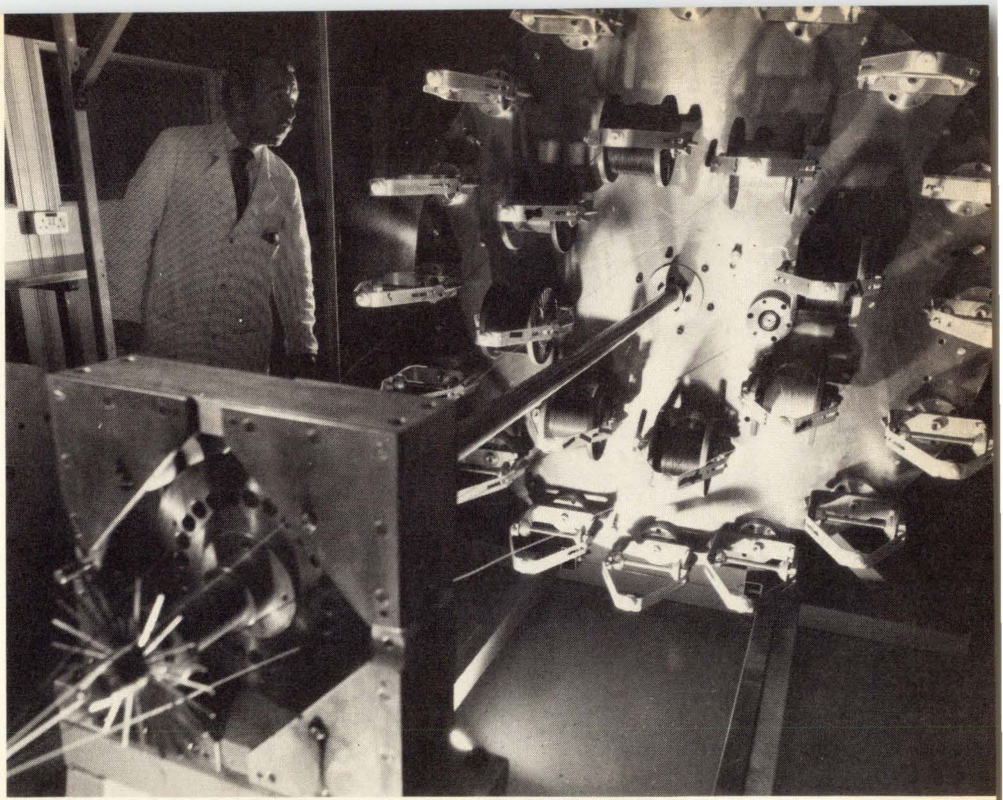
Light glimmers through British gloom

by William F. Arnold, London bureau manager



With a twist. Technician at Standard Telecommunication Laboratory watches cable equipment at work. Britain's telecommunications firms look for a generally good year.

Believe it or not, some British electronics executives and market analysts actually are rather optimistic about their nation's battered economy. For one thing, they expect the gross domestic product to rise about 2% in real terms—hardly top of the league, but very good for Britain in these hard times.

For another, as the treasured North Sea oil begins to lead the country toward a brief self-sufficiency in energy, it should help reduce the chronic deficit in the balance of payments this year and put it into surplus the next. And, though the pound sterling took a drubbing last year, it now underpins a competitive export drive in electronics and other industries.

"We're beginning to see the turning of the corner. The signs are there," declares Jack Akerman, managing director of Mullard Ltd., the large broad-based components subsidiary of giant Philips of the Netherlands. "In orders and advance orders, the book is stronger than any time in the past two to two and a half years," he says, citing such electronics sectors as consumer, mobile communications, industrial, and data processing. Akerman forecasts a 10% increase in business in real terms, conceding that the last year or so hasn't been that good.

Controversial. Such forecasting is controversial, however. No, the British market will be downright "flat," counter both Stephen Forte, managing director of General Instrument Microelectronics Ltd., and John F. Cryer, manager of linear integrated circuits for RCA Solid State-Europe. Texas Instruments Ltd.'s Stuart D. Kitchiner, marketing manager for integrated circuits, foresees industrial and computer markets as strong and the consumer sector not so good. On the other hand, Alan D. Hall, marketing director for ITT Semiconductors, thinks industrial electronics could decline.

Naturally, one's market picture could be colored by what one sells and to whom, but *Electronics'* 1977 market survey gives some ammunition to both sides. Totals for two major divisions of assembled equipment and components rise about 13% each, a healthy increase that could be nipped some by inflation, however. In percentage terms, the semiconductor and medical-electronics categories lead with 20%, followed by computers at almost 18% and communications at 14%. Conversely, the consumer sector effectively remains flat, reflecting still shaky consumer confidence.

The computer sector looks like the star in terms of volume and percentage increase. Up some $122 million over last year, it can anticipate particularly strong gains in sales of minicomputers and small and large computers, according to the survey. For example, International Computers Ltd., Britain's only mainframe maker, expects to meet its 15% compound-growth target this year, says marketing manager Peter Ellis. As ICL fills gaps in its New Range of large mainframes and minicomputers, it plans sizable sales to such traditional markets as chain stores and savings associations, while seeking new orders from savings banks and manufacturers. These markets are reflected in the figures for electronic office equipment and point-of-sale gear, up 18% and 21%, respectively.

Despite competitors' grumbles that ICL, partially government-owned, grabs too many government contracts, Ellis estimates that this sector "will not show as great an increase as before." Sperry Univac's Malachy L. McIntyre, planning director of the Europe-Asia-Africa division, comments that his company aims to take market share away from ICL and IBM, and says that manufacturers and financial institutions look attractive as potential customers.

In the marketplace, "there's a mini-versus-mainframe battle going on," observes Hewlett-Packard Ltd.'s Derek Smorthit, computer-systems sales manager. He, too, forecasts good growth in manufacturing, as well as distributed processing for warehouses, and plans to increase market share against main competitor Digital Equipment Corp.

Although the telecommunications sector may be buffeted by the projected British Post Office stretch-out of new semi-electronic exchanges, the overall total for the communications category brightens things a bit. Up about $119 million, the communications market is paced by notable gains in navigation aids (excluding radar), radio communications, except broadcast, and private telephone switching.

Consumer electronics may be the largest category, but it more closely reflects the overall economic mood by climbing a modest $66 million this year. As a barometer, sales of color-television sets probably will climb only slightly to about 1.7 million units, but that category represents $450 million this year. Some industry executives anticipate the beginning of a replacement market this year, however.

Industrial uncertainty. The industrial category mirrors an uncertain overall market outlook. Some think it might perk up, but perhaps the prevailing opinion is best expressed by Hewlett-Packard's David Metcalfe, instrument sales manager: "No real growth." *Electronics'* estimates confirm this by showing only a modest 9% rise, dominated by process-control systems.

A smaller but more diverse market is that of test and measuring equipment, although *Electronics'* estimates also show a slightly flat trend. But Metcalfe, surmising that this year more "smart" instruments will be on the market, thinks that the test equipment might show some real growth.

On the cheerier components side, the semiconductor category will rise some $52 million, almost matching the increase of the passive category, which still accounts for more than half the total market. As for microprocessors, the glamor boys of the industry, Fairchild's Robert N. Blair, general manager for northern Europe, states that "they will bulldoze ahead without question," adding that 16-k RAMS also are mushrooming." But ITT's Hall asserts, "There's more smoke than fire in that market—no OEM has built one into his products."

TI's Kitchiner concurs that the devices "are still in their infancy." *Electronics'* estimates show almost three times more sales this year—but only on a small slice of the total chip market.

This year, other suppliers should also join Texas Instruments in making decoders based on LSI devices for Teletext "video magazine" and Viewdata telephone-based "home video computer terminal" markets. ☐

BRITISH ELECTRONICS MARKETS FORECAST
(IN MILLIONS OF DOLLARS)

	1975	1976	1977
Total assembled equipment	**2,331**	**2,533**	**2,870**
Consumer electronics	790	791	857
Communications equipment	600	697	810
Computers and related hardware	643	720	842
Industrial electronics	148	158	172
Medical electronics	65	75	90
Test and measurement equipment	65	71	77
Power supplies	17	18	20
Total components	**820**	**918**	**1,048**
Passives	451	491	552
Semiconductors	198	236	288
Tubes	171	191	208

(Exchange rate: $1 = 60 pence)

Note: Estimates in this chart are consensus estimates of consumption of electronic equipment obtained from a survey made by *Electronics* magazine in September and October 1976. Domestic hardware is valued at factory sales prices and imports at landed costs.

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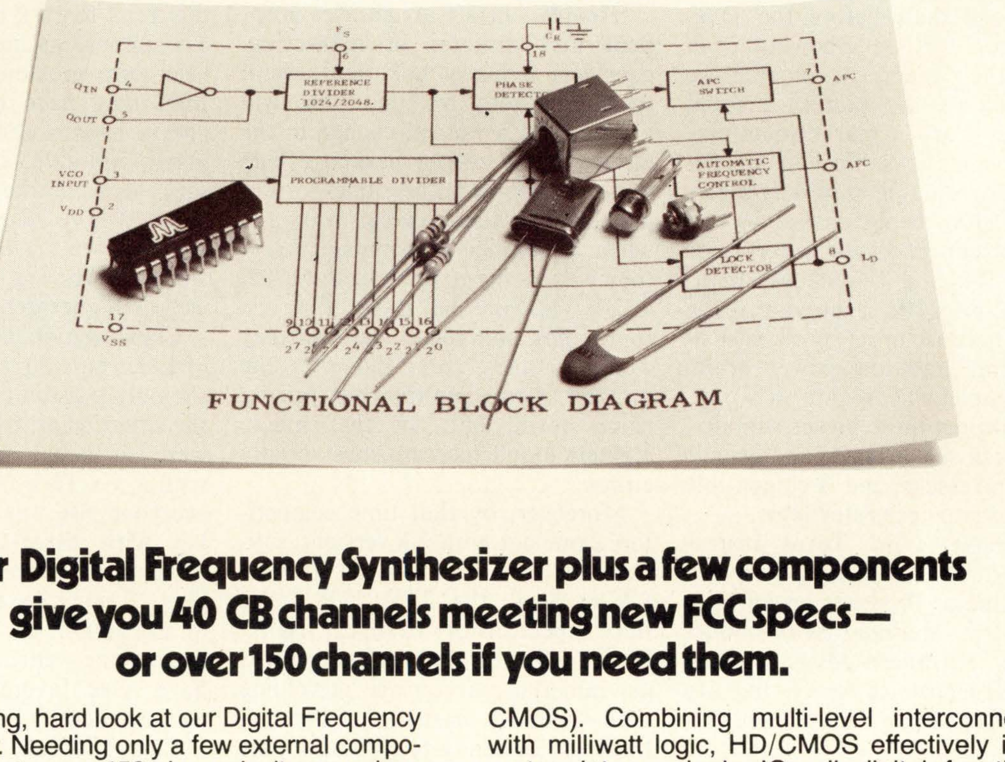

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Memories

Intel's 2708 draws a crowd

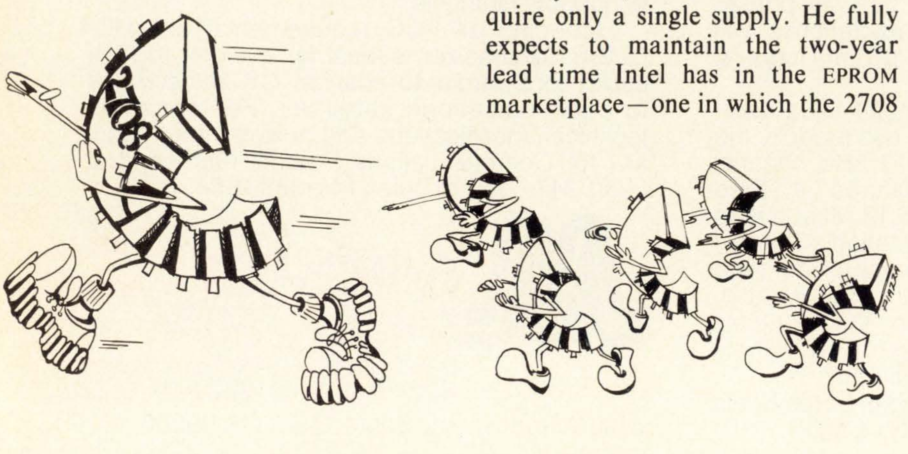
Competitors counter with rival 8-k UV-erasable PROMs even as 16-k versions are being prepared for market

by Bernard Cole, San Francisco bureau manager, and Larry Armstrong, Midwest bureau manager

Take a market estimated at $30 million, let one company dominate it with a device that is a key microprocessor prototyping element, and chances are that, before too long, competitors will be elbowing each other in their eagerness to catch the leader. That's the picture created with Intel Corp.'s market-dominating ultraviolet erasable and electrically reprogramable read-only memory, the 2708, being chased by the other top semiconductor makers.

While 2-k and 4-k PROMS exist, the 8,192-bit 2708 is proving to be valuable because of its speed, ease of programing, and low power drain. The n-channel silicon-gate MOS part, which requires three power supplies, can be accessed in 450 nanoseconds requires no clocks, and is compatible with transistor-transistor logic.

The chase is on. Texas Instruments Inc., Mostek Corp., Motorola Semiconductor Products group, Signetics Corp., National Semiconductor Corp., Advanced Micro Devices Inc., and Electronics Arrays Inc. are all pursuing the front-runner. Although Intel is keeping aware of what's going on behind it, the company professes to be unperturbed.



'Hoopla.' Jack Carsten, vice president and director of marketing, considers industry talk that several second sources for the 2708 will bring about a radical change in the nature of the EPROM market is "just a lot of hoopla. The same sort of hoopla was raised several years ago when a number of companies said they were going to produce the 1702, a 2-k EPROM," he says. "For one thing, only half those who said they would actually come out with the product. And when they did, pricing came down, but not that much. Volume didn't increase substantially either."

Moreover, by that time competitors came out with 2-k versions, says Carsten, Intel was offering its 4-k/8-k versions, the 2704/2708. "We fully expect history to repeat itself," he says. By the time its competitors get into the marketplace in volume with their 8-k parts, says Carsten, Intel will be ready to go with a part that will not only have twice the density—16,384 bits—but will require only a single supply. He fully expects to maintain the two-year lead time Intel has in the EPROM marketplace—one in which the 2708 constitutes 10% to 15% of Intel's annual memory sales, say industry sources.

Intel's Silicon Valley rivals view the trend to 16-k designs with single 5-V supplies as inevitable, but not a near-term problem. The threat that Intel may have both a single 5-V EPROM process and a 16-k part is not insurmountable, says Andrew Allison, MOS marketing manager at AMD, "We've all got a leg up on the process, we've all got parts, and we're all working on 5-V devices, as well as higher-density ones."

Counterpoint. Don Bell, president of Electronic Arrays, points out that the only possibility that might upset the situation a little would be if Intel were to begin volume production with a 5-V 16-k UV-erasable ROM as everyone else was entering the market with three-supply 8-k parts. "Even if they introduced it now," he says, "I don't see them with the part in any significant volume before the end of the year. Besides, they still have ASPs [average selling prices] against them."

Larry Jordan, EPROM marketing manager at National, says the 8080-type, three-supply microprocessor market will be viable for another two to three years. He expects the average price of 2708 types to drop by 50%, unit volume to about quadruple, and total dollar volume to peak at about double the present $20 million to $30 million a year before dropping off. By the time 5-V microcomputer systems such as the Zilog Corp. Z-80 and the 8085 go into volume production, he says, National will be ready with a 5-V EPROM and higher-density devices.

On the Texas front, TI and Mostek

have 16-k designs waiting in the wings, and officials of Motorola's MOS semiconductor operation in Austin do not expect larger EPROMS to have much of an impact this year. George Foote, Motorola memory planner, puts it this way: "There's such an incredible demand for 8-k EPROMS it will be another year or so before everything is sorted out."

TI's alternate. Texas Instruments, with its IMS2708 [*Electronics,* Jan. 6, p. 146] is probably the first alternate 2708 source. While TI's part is plug- and spec-compatible, it typically dissipates 450 milliwatts at 25°C—substantially less than Intel's 800 mw at 70°C. In addition, by the end of the month, TI will sample a second part, the 27L08, which dissipates 475 mw maximum at 0°C—roughly equal to 350 mw at 70°—considerably less than half the power of the Intel part.

TI plans to offer samples of its 16-k version in the second quarter. "It will be like the 2708, but twice as big," Hewkin says. The IMS2716 will probably be packaged in a 24-pin ceramic package and will require three power supplies.

Mostek, like TI, is working on a different 2708 design: "We're aiming our device to be as compatible with Intel's as possible," says Derrell Coker, applications engineer for the Carrollton, Texas, firm. "It looks identical at the pinout level, but we've lowered the power quite a bit." The company is now characterizing its part; samples will be available about March 1. The so-called MK 3708/2708 is TTL-compatible, and it will need less than 400 mw maximum from 0° to 70°C.

Also in Texas, Motorola is apparently copying the Intel design. Although the company has not formally announced its EPROM, it is sampling and gradually building production at its Austin, Texas, semiconductor facility. "The 68708 is identical in all respects to Intel's," claims George Foot, memory planner for Motorola Semiconductor. Foote estimates that 100,000 8-k EPROMS were shipped last year at an average selling price of $35 each. For 1977, he's estimating 500,000 units, but concedes that the average price eventually may drop to as low as $18 each. □

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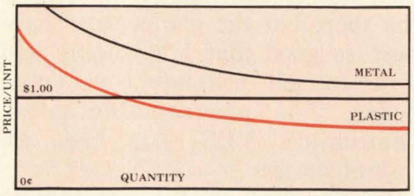

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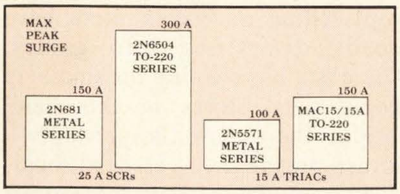

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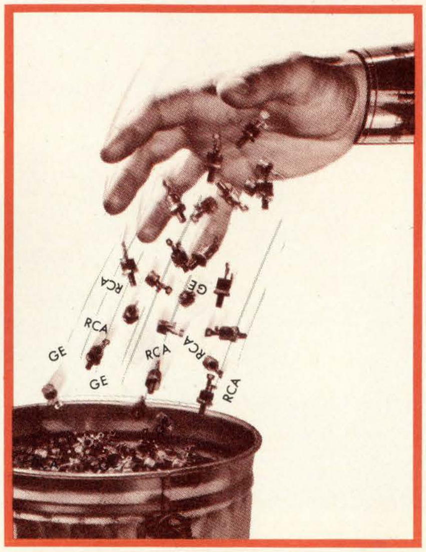

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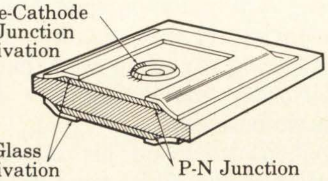

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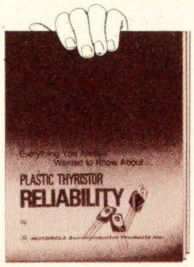

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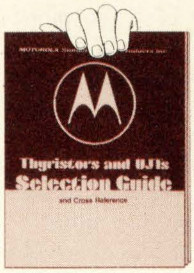

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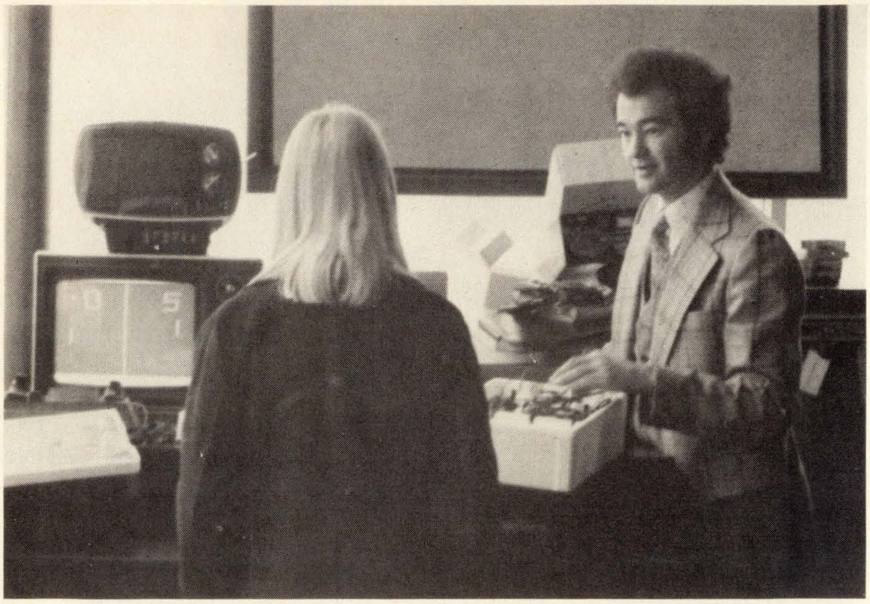

Gamesman. Philip M. Aiken talks to a customer in his Philadelphia video-game store. He expects to chalk up $1 million in sales in his first year in business.

Retailing is his game: EE turned store owner is striking gold

by Gerald M. Walker, Consumer Electronics Editor

A small band of pioneers is staking out claims in electronics retailing territories opened by the aggressive expansion of technology into consumer areas. One of those pioneers made quite a jump—from designing petroleum-industry process controls to selling video games, scientific calculators, and digital watches. And for Philip M. Aiken, giving up the drawing board for the showroom has proved to be a profitable move.

Last April he left his job at Mobil Research and Development Corp. in Princeton, N. J., to form Lectro-Media Ltd. in Philadelphia, a store specializing in the new darlings of discretionary spenders. Aiken also has a mail-order operation. In his first year, he expects to gross about $1 million.

Why should an engineer just a thesis short of a Ph.D. from Purdue get the urge to sell consumer electronics products? "These products have become more sophisticated, yet the traditional department stores and discount houses are not capable of evaluating them, much less demonstrating them," he says.

"We've had no trouble in taking business away from the traditional stores. The main problem has been convincing the manufacturers that a small specialty shop with national mail-order marketing can do a volume business."

Aiken developed his interest in consumer electronics more or less by accident. While designing refinery process-control systems for Mobil, he became an off-hours guru of scientific calculators, trying out and recommending models for other engineers at the R&D lab. When the first video games appeared early last year, he put together a kit using the General Instrument six-game chip, intending to put it on the mail-order market. But trying to sell a kit at a price competitive with finished products plus possible patent problems washed out his plan.

However, having learned the insides of video games and scientific calculators first-hand, Aiken recognized an opportunity to provide a special retail service.

"We are dealing with sophisticated products for sophisticated consumers who can appreciate the products," he says. "My original plan was to add microcomputers to the shop, but the games sales have been so good that I have only had time to sell computers via mail order. The programable game [Fairchild's VES] has been an instant success."

In addition to his engineering acumen, a key factor in his current success was moving to a store in Newmarket, an arts, crafts, and restaurant center in Philadelphia's most affluent residential area. In Aiken's glass-walled store, the games can be displayed easily. At night, he puts a bank of games on a projection television screen that adds dramatic appeal. Already cramped, Lectro-Media may move to larger quarters in the shopping center.

Becoming his own boss meant Aiken had to learn new skills. "The main lesson to learn in retailing, especially this business, is inventory control," he says.

"You can't afford to be caught with a large inventory of products when prices are falling every week. This was the case in calculators. So far, games prices have held."

"A problem with games in the current market is the arrogance of some of the small manufacturers, who are currently riding high. Programable games will change the situation in favor of the large manufacturers."

Naturally, he expects more and more competition. Some of the Byte Shops selling microcomputers have already diversified into games. "There is a big opening for small- to medium-sized stores in this field, provided they know the products—and are prepared to retail nationally," he remarks. "I have no regrets about leaving engineering.

"I don't think video games are a fad, at least not the programables. At first the important features were remote hand-held controllers and full color. Now the main feature is programability. The next step will probably be some kind of crossover from games to microcomputers." □

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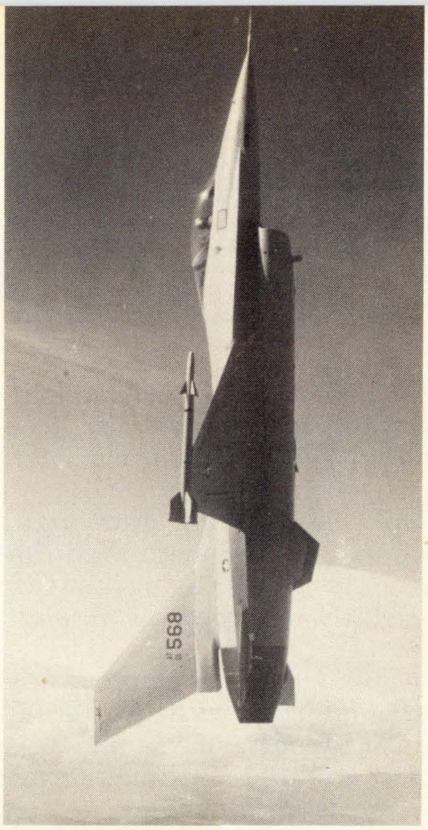
Wrapping up F-16 pacts

Agreements for $325 million worth of work under European offset deals to be signed by March

by James Smith, McGraw-Hill World News



European companies in line for avionics contracts for the General Dynamics F-16 fighter plane are breathing a bit easier these days. With most of the squabbling over what is being called the arms deal of the century behind them, the companies expect to have all the contracts for $325 million worth of electronics—not including the radar—signed by February's end. The work is being done under an offset agreement; that is, a percentage of the purchaser's cash outlay for finished planes is offset by subcontracts to that nation.

Involved are four nations—The Netherlands, Belgium, Norway, and Denmark—buying 348 of the lightweight fighters. The U.S. will purchase 650 aircraft containing, for the first time, equipment made overseas [*Electronics*, March 18, 1976, p. 75].

The final contracts—excluding the Westinghouse radar, which still is the subject of a great deal of controversy—will be signed two months later than planned. But General Dynamics officials in Brussels still expect to adhere to their original schedule of phasing in European electronics production with the airframe and engine of the F-16 program. The firm also expects to stay within the ceiling price of $6.09 million per plane.

Spreading the avionics work among the four European countries has caused several headaches and not a few delays. In Denmark, for example, contracts for more than half of the $100 million of offset electronics still have not been awarded. The delays have been caused by constraints built into the F-16 program. Among them:

- Requirements that European producers be cost-competitive with American firms.
- Insistence that suppliers of high-technology equipment have previous production experience.
- U.S. Government requirements that, for security, certain components be made in the U.S.

The major remaining problem is offset arrangements for the Westinghouse radar—which, if anything, have become more and more complicated and are not expected to be signed until May, five months late. Originally Belgian companies MBLE, Siemens, ACEC, and Bell Telephone Manufacturing Co., together with Philips' Dutch subsidiary Hollandse Signaalapparaten, expected to share more than $200 million in orders for radar components. But the low bid by Westinghouse in late 1975—one of the last contracts to be awarded—cut the figure in half.

Another stumbling block is that the Scandinavian countries have little available production capability for airframes and engines, so General Dynamics was forced to send much of the business to the Low Countries and channel a higher proportion of avionics to the Norwegians and Danes. As a result, it is proving very difficult to increase the electronics package for the Belgians and Dutch without shortchanging the Scandinavian countries.

Finally, General Dynamics is hoping that eventual sales of the F-16 to other countries, such as Iran, will sweeten the electronics kitty. European companies stand to share 15% on Third-World purchases—although the sharing between various industries still remains to be worked out. So far, the Belgians are not convinced by this possibility, fearing they may have trouble meeting cost-competitive requirements.

Contract negotiations for the offset were, at times, difficult and complicated. Typical of the arrangements that had to be made was one worked out between Lear Siegler Inc. of Santa Monica, Calif., and Danneborg of Denmark. After long negotiations, Lear Siegler is expected to subcontract components for the flight-control computer, in many ways the heart of the plane, to Danneborg. But the American firm will assemble and test the machine, giving it more production control and limiting Danneborg to work on parts that will keep it competitive. And the Danish company also need not purchase expensive test equipment for its F-16 work.

By contrast, Norway's Kongsberg Vapenfabrik will assemble, test, and deliver complete inertial navigation systems for the U.S. contractor, the Kearfott division of the Singer Co. in Little Falls, N.J. The Norwegian firm, however, will not make all the modules for the system. In this case, says General Dynamics, the intent is to transfer technology, taking into account the foreign firm's own commercial interests, experience, and cost-competitiveness. □

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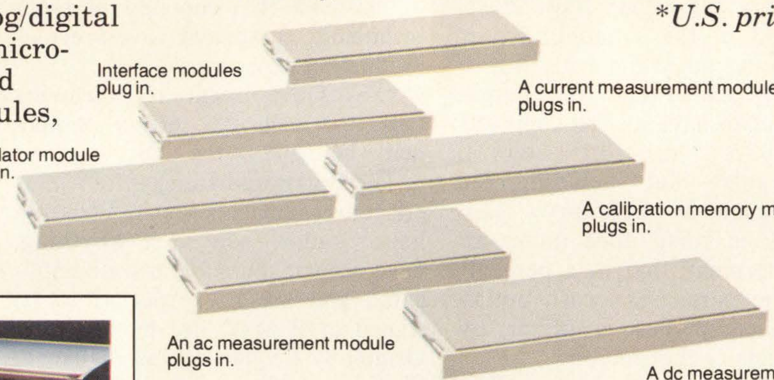


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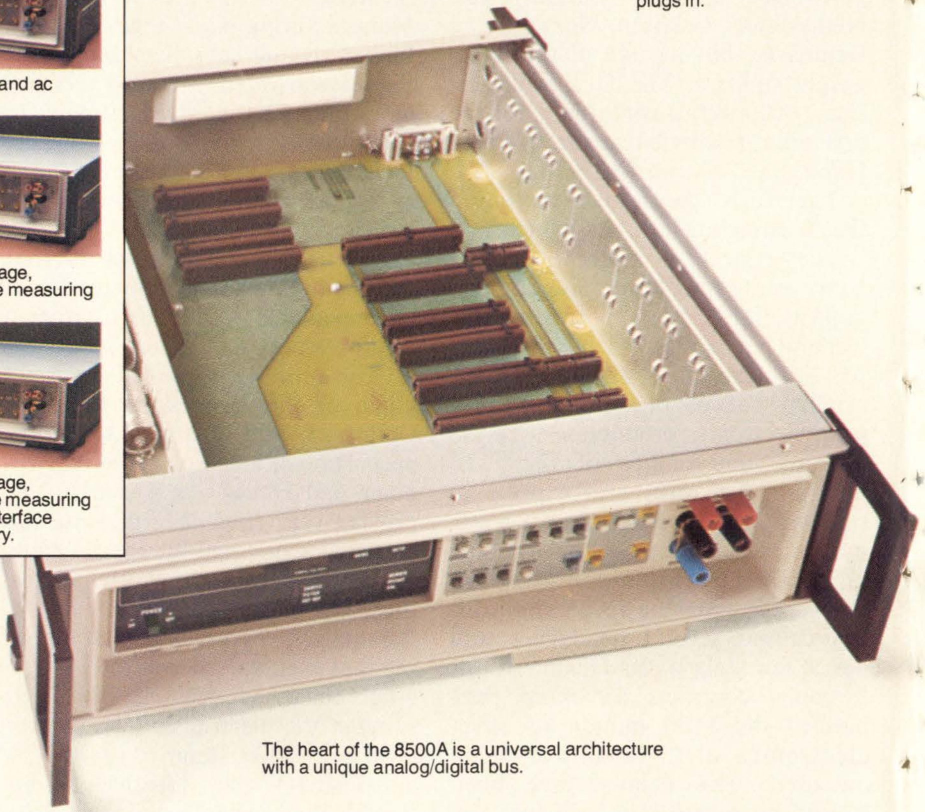
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SPECIAL REPORT: RAMs, p. 84; alterable ROMs, p. 89; the future, p. 94.

MEMORIES

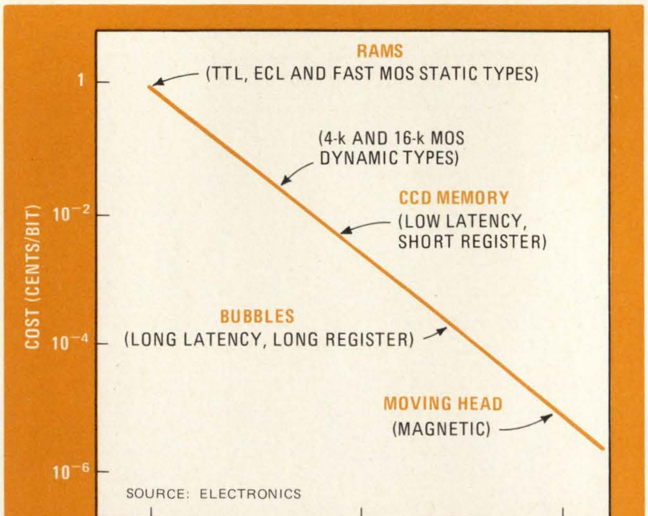
It's a user's paradise: cheaper RAMs, reprogramable ROMs, CCDs and bubbles coming along

by Laurence Altman, *Solid State Editor*

Memory chips are everywhere. Calculator manufacturers are putting them in programable calculators for storing arithmetic programs. TV makers are using them for storing channel frequencies in digital tuners. Instrument manufacturers are hooking them up to batteries in portable equipment, while makers of point-of-sale equipment are building them into on-line sales-counter units that continually update inventory information.

The flood is all-engulfing, now that the new memories are no longer limited to computers. They have become a universal design element that is introducing the benefits of data storage to all electronics-equipment industries.

The driving force is wave upon wave of new memory technology. New bipolar isolating methods have doubled the speed of TTL memories. Shallower and better-controlled ECL junctions have resulted in memories that can operate at an unprecedented 7-nanosecond access time. Double-level and depletion-load MOS techniques

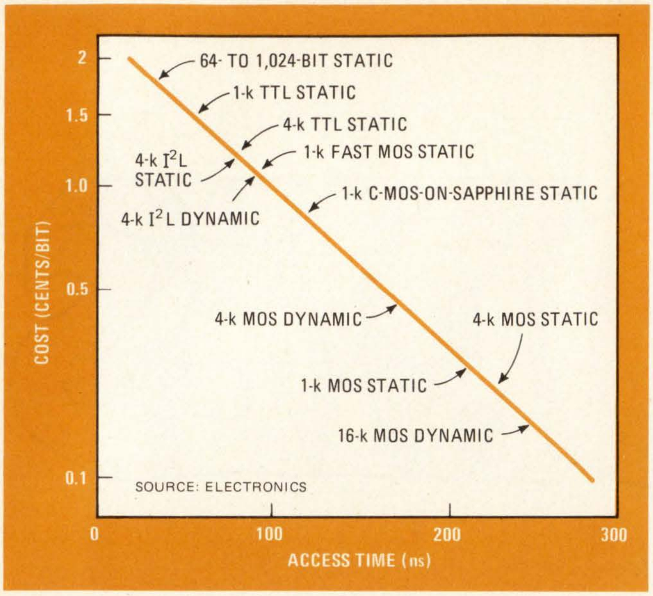


1. All-purpose performance. Semiconductor memories now span the requirements of all kinds of systems. RAMs meet high-speed mainframe and peripheral needs, CCDs cover the medium-speed serial memories, bubbles take on the low-end bulk memories.

TABLE 1: APPLICATIONS AND PERFORMANCE OF AVAILABLE MEMORY DEVICES

Application	Device types	Access time (ns)	Active power dissipation per chip (mW)	1977 cost (cents/bit)
Large mainframe	4-k n-MOS dynamic	150 – 350	450	0.15
	16-k n-MOS dynamic	200 – 350	500 – 700	0.08
Small mainframe microprocessor-based	4-k to 16-k n-MOS dynamic	150 – 350	450 – 700	0.15
	4-k I^2L dynamic	90	500	0.25
	4-k I^2L static	70 – 100	500	0.25
	4-k n-MOS static	150 – 550	350 – 500	0.20
	1-k SOS/C-MOS static (5 V)	150	4	1.5
Buffer, cache, etc.	256-bit ECL static	10 – 30	600 – 800	2.0
	1-k TTL static	40 – 100	600 – 800	1.5
	1-k n-MOS fast static	70	600 – 800	1.0
	4-k I^2L static	75 – 100	400	0.25
Peripheral	1-k n-MOS static	150 – 500	300	0.3
	4-k n-MOS static	150 – 550	350 – 500	0.2
	4-k I^2L static	90	500	0.25
	4-k n-MOS dynamic	150 – 350	450	0.15
	16-k n-MOS dynamic	200 – 350	500 – 750	0.08
	8-k EAROM	500	500	1.5
	8-k EPROM	400	450	1.5
Small storage (1 – 5 megabits)	CCD memory	100 μs		0.03
	disk	100 ms		0.01
Large storage (5 megabits plus)	bubbles	10.0 ms		
	disk	10.0 ms		0.01

SOURCE: ELECTRONICS



2. The crowded RAM spectrum. System designers can now choose among device types that range from 10-ns ECL RAMs costing 1 to 2 cents per bit to big 16-k dynamic RAMs that cost well below 0.1 cent per bit. Arrows indicate the middle-performance range.

are reducing power consumption to a mere 10 microwatts per bit and cell size to less than 1 square mil.

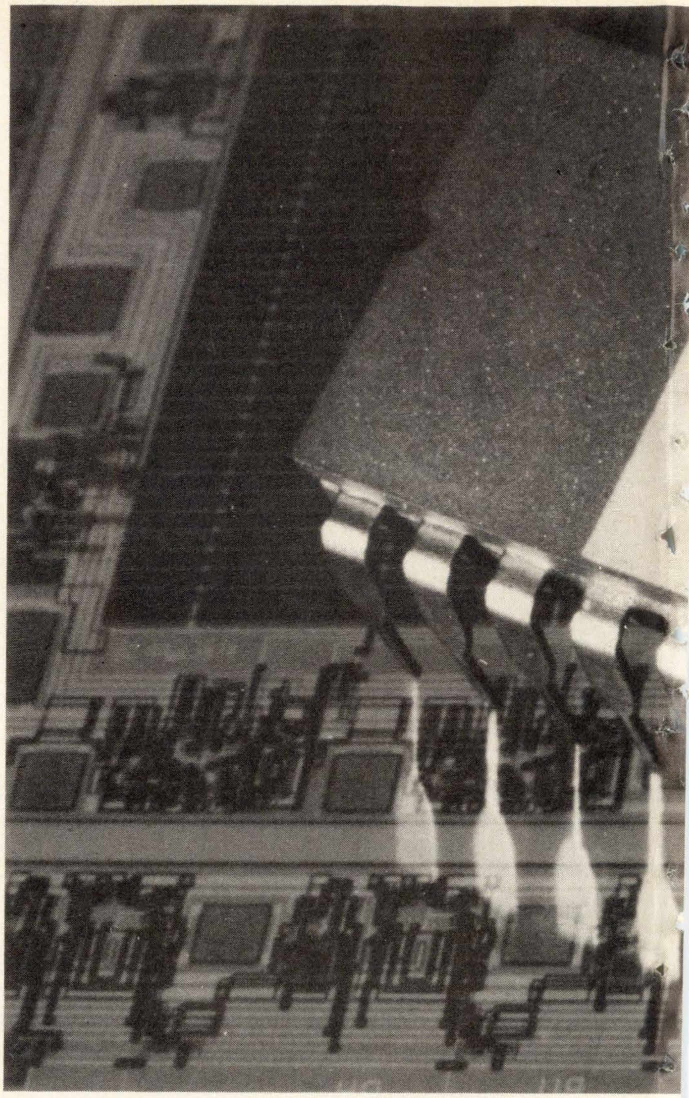
This increased packing density, along with the higher yields of improved manufacturing processes, is bringing bit costs down to where more equipment designers than ever can afford memory chips. Last year, 50 million semiconductor memories were used in equipment in the U.S. alone, and as many were used by designers in Europe and Asia. This year, an incredible 75 million memory chips will find a home in U.S.-based equipment, as the designers pick up on the new crop of lower-cost, higher-performance random-access and read-only memory chips, programable memories and logic arrays, shift registers, and bulk-memory storage devices.

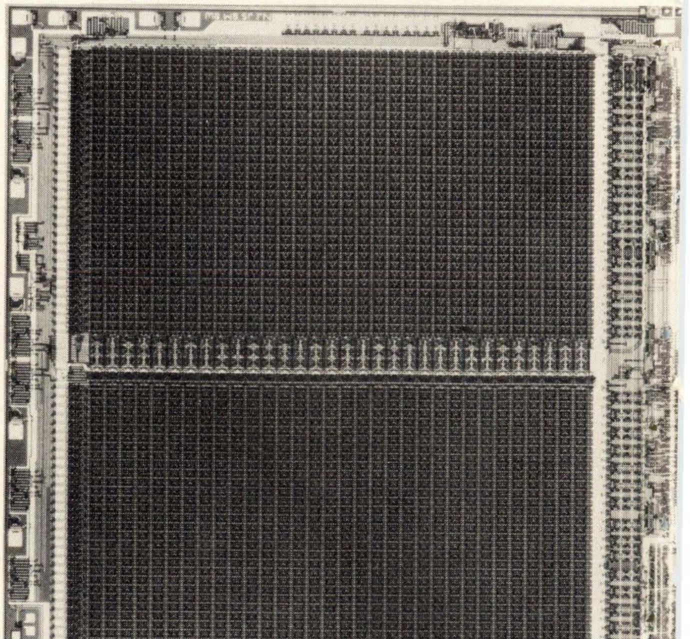
No holds barred—almost

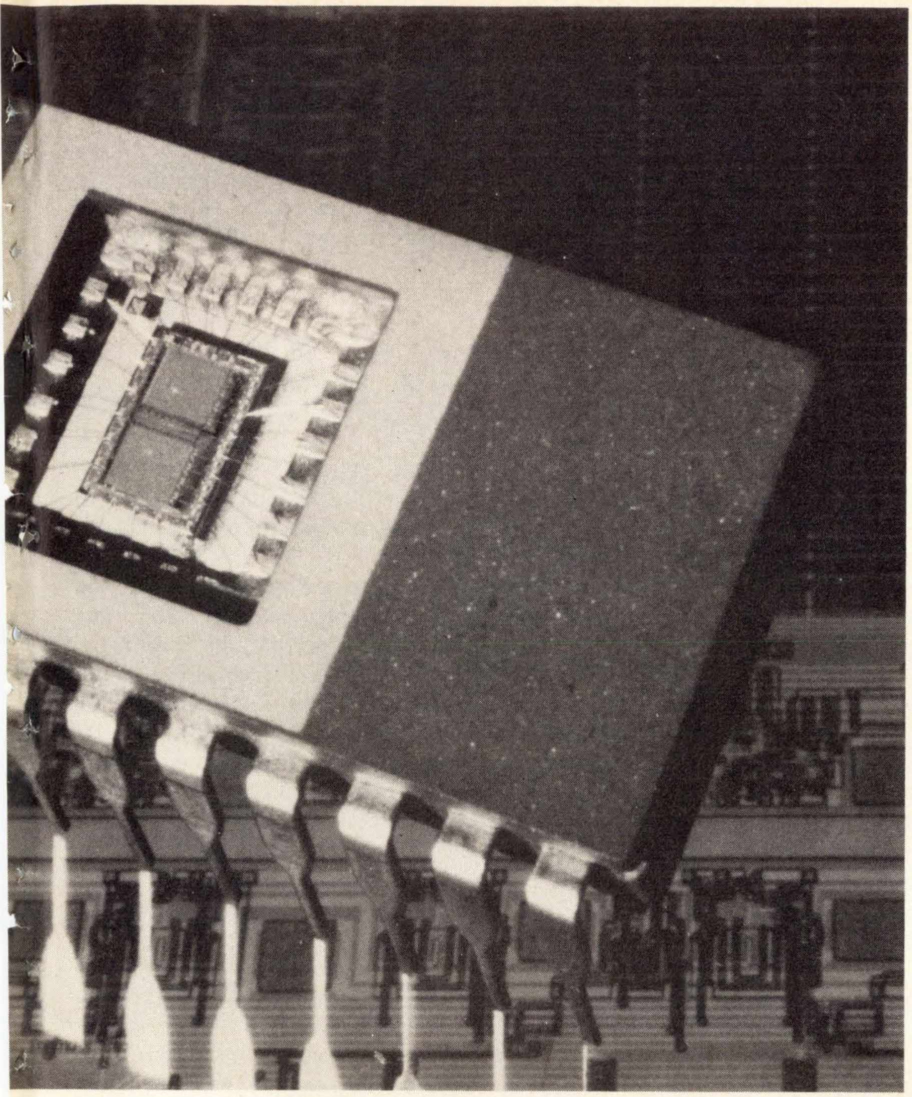
These semiconductor memory devices run very nearly the gamut of memory applications. Consider the cost-performance relationship of the chips available for use in read-write memory systems (Fig. 1).

Buffer and fast peripheral applications are well suited by the small fast RAMS, which range in access time from 30 to 90 ns and cost from about 0.15 to 1.5 cents per bit. Large mainframe and slower peripheral designs are the natural prey of the big, middling-fast 4,096-bit and 16,384-bit n-channel RAMS, which are accessible in 150 to 300 ns and cost the designer about 1 or 2 millicents per bit.

The still slower bulk- and auxiliary-storage systems can build on the new 16,384-bit and 65,536-bit charge-coupled-device and 100-kilobit bubble-block memories. CCDs run at anywhere from 1 millisecond to 1 microsecond and cost 10 to 30 millicents per bit, while bubble memories will have access times in milliseconds and cost well below 25 millicents per bit. Only the very slowest and lower-cost bulk-storage applications will for some time still be implemented with moveable-head

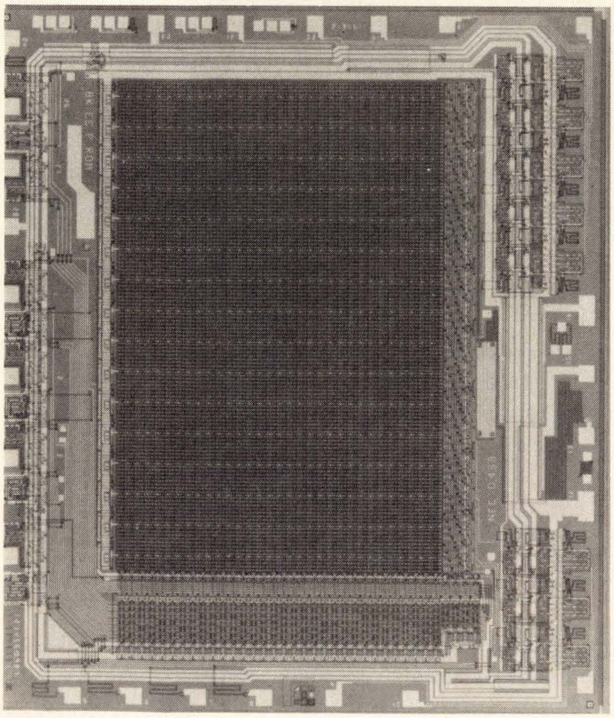






And across the street . . .

Memory devices besides the 16-k dynamic RAMs are making news. This 2708 8-k reprogramable ROM from Intel Corp. (left) is erased with ultraviolet light and has become a key element in microprocessor prototype design. Prices of this part, now in the $20 to $25 range, will drop sharply as other manufacturers enter production. Meanwhile Intel is readying a 16-k version. MOS static RAMs have also grown in bit density: devices like this 4,096-bit-by-1-bit device from AMD (lower left) are now reaching designers of peripheral and microcomputer systems. A dramatic breakthrough in alterable memories is NEC's μPD 458 8-k ROM (lower middle), which gives the designer still more flexibility by allowing him to reprogram his system electrically. Not least spectacular is RCA's 1-k static RAM (lower right) that is built with C-MOS-on-sapphire technology. With standby power dissipation of 0.1 microwatt and access times below 100 ns, the nonvolatile device is a natural for portable equipment and battery-backup systems.



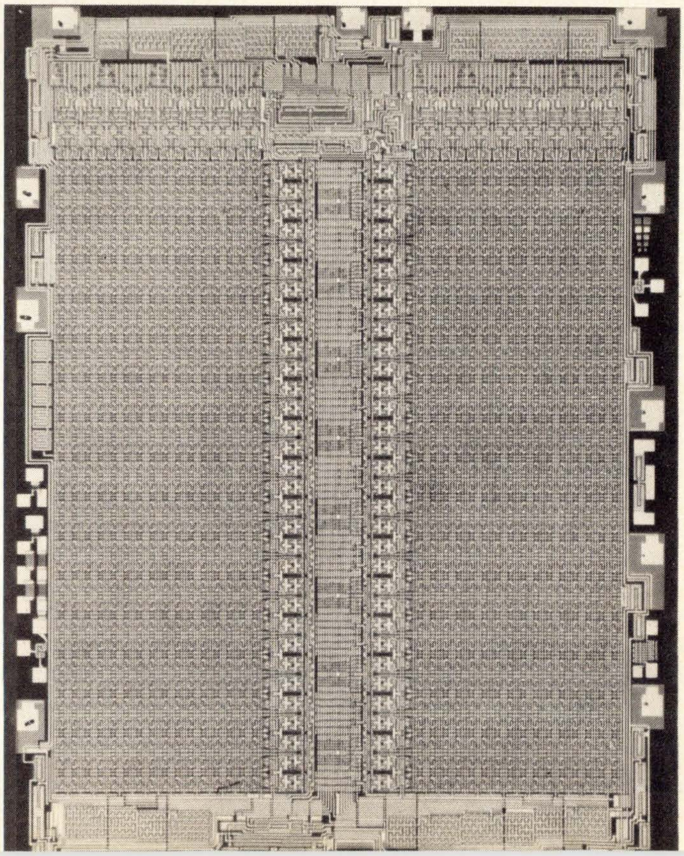


TABLE 2: UPCOMING RAMs FOR 100-NANOSECOND SYSTEMS

Parameter \ Type	Schottky I^2L static (S400)	I^2L static (LS400)	I^2L dynamic (93481)	Fast n-MOS static (2115)	C-MOS-on-sapphire static
Density (bits)	4,096	4,096	4,096	1,024	1,024
Access time (ns)	75	150	100	70	90
Cycle time (ns)	75	150	200	200	90
Power dissipation (mW)	500	165	400	450	2
Chip size (1,000 mil^2)	23	23	14	12	16
Package size (pin count)	18	18	16 (mux)	18	22

SOURCE: ELECTRONICS

magnetic devices and remain beyond the reach of semiconductor memories (Table 1).

But this abundance has its bewildering aspects. As device types proliferate and options multiply, so do the chances for confusion in choosing the best device for the job. This problem cannot be better illustrated than by contemplation of the variety of available random-access memories, which Fig. 2 shows in rough descending order of cost and performance.

The crowded RAM spectrum

At the top are the fastest bipolar static devices built with emitter-coupled logic. Supplied as 64- to 1,024-bit chips, they are furnished with ECL interface circuits that allow them to be controlled directly by subnanosecond ECL central processing units. They are used today in the big mainframe computer systems as specialized buffer and cache memories, which serve as scratch pads in complex interrupt-driven applications. Because ECL processing is complex, these parts are expensive, costing as much as 2 cents a bit. These RAMs also dissipate milliwatts of power per bit, so that a typical buffer memory system could well take a costly bite out of a computer-memory-system designer's power budget. But for the highest speeds, the designer has no choice: these are the fastest memories available.

Next are the transistor-transistor-logic devices, the 1,024-bit and new 4,096-bit static types that, while not as fast as the ECL types, nevertheless outperform most metal-oxide-semiconductor static parts. Typical access times of, say, 1-k 93415 types are now around 50 ns.

Consequently, buffer-memory designers can use these cheaper memories in place of the ECL types for many mid-range buffer systems. They save the designer power as well, dissipating no more than 600 mw per 1,024-bit array. Moreover, since they are built with low-power Schottky TTL, these parts can be driven directly with standard TTL and therefore relieve the system designer of the need to use any special circuit techniques in controlling them.

The ease of interfacing these static TTL designs results in very efficient memory systems, in which the peripheral and control logic on a storage card adds only 10 to 15 ns of delay to the memory chip's worst-case read access time. An array of 60-to-70-ns TTL RAMs can easily handle the 80-ns access time required at the back plane connector of a typical 8,192-word-by-16-bit storage card. (Some fast MOS statics cannot do nearly as well. Though competitive with bipolars in access times, they require high-level clocks and system interface circuits, which can slow down a memory system's throughput by as much as 50 ns.)

No such easy decisions are open to the designer of the 100-nanosecond mainframe or fast peripheral memory system either now or in the foreseeable future. Very shortly, at least four new device types will be vying for his attention (Table 2).

Which to choose?

There will be the new 75-ns and 150-ns 4-k static memories being built with integrated injection logic (Texas Instruments' S400 and LS400 types), a 100-ns I^2L dynamic device (Fairchild Semiconductor's 93481), and two very fast MOS static types—a static n-channel MOS design (Intel's 2115) with an access time of 70 ns and RCA's complementary-MOS-on-sapphire 1,024-bit type with a 90-ns access time.

These devices are just now entering production, and the designer information on them is sketchy. But some inferences can be drawn. In small peripheral designs, the static devices should have the edge since they do not require the clocks and timing circuits needed by the dynamic devices.

For large peripheral memories or small mainframes, on the other hand, the ability of the I^2L static device to operate with no overhead circuitry is less of an advantage, since this extra cost is distributed over a larger number of bits. Instead the lower chip cost and power dissipation of the I^2L dynamic device may well tip the balance in its favor.

In any case, the production experience that manufacturers will gain with these four new devices over the next several months will strongly influence the designer's choice, since production yield is so closely related to cost. The lowest cost potentially belongs to the I^2L dynamic device because of its small 15,000-mil^2 chip. (Fairchild puts it in the $10 range.) Also, its multiplexed 16-pin package is familiar, being commonly used in memory-system designs these days.

Finally, in the 150- to 300-ns memory application, the choice is less complex: the 4,096-bit and 16,384-bit MOS dynamic RAMs dominate the minicomputer and big mainframe systems, while the 1,024-bit and 4,096-bit static MOS devices are selected in most of the peripheral designs. This is traditional, the only complication being in the small microprocessor-based design. Whether a dynamic or static type will better suit such a design again depends largely on the size of the system and the ability of the microprocessor to handle the clocks and the refresh requirements.

Dynamic RAMs pick up speed, quadruple in density

In production for three years, the dynamic 4,096-bit random-access-memory chip has reached maturity as a technology. Nearly two dozen manufacturers supply a

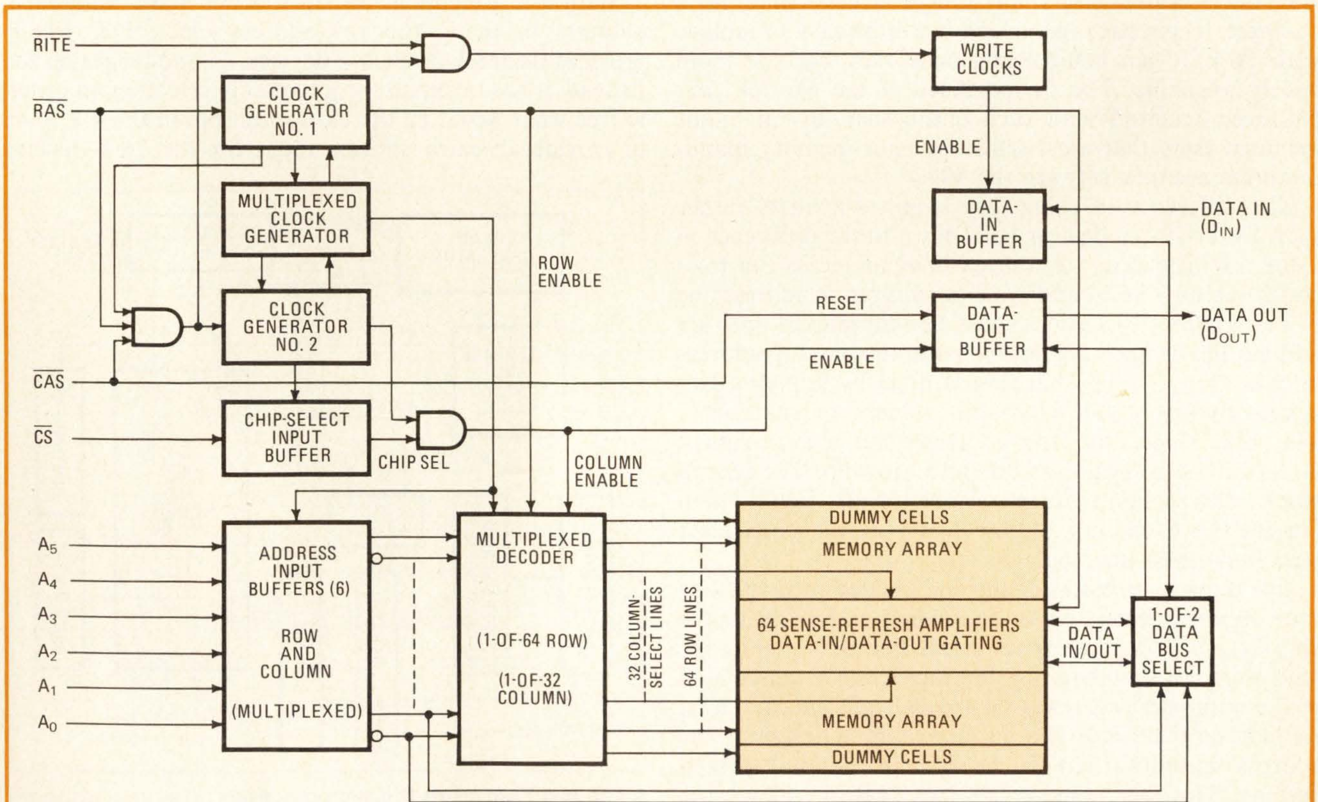
TABLE 3: 4,096-BIT RANDOM-ACCESS-MEMORY DEVICE TYPES											
Parameter \ RAM type	Fujitsu MB8215	Fujitsu MB8107	NEC D411D-3	Motorola 6605	Intel 2107B	TI 4060	National/AMS 7280/7270	Mostek MK4027	Mostek MD4096	Intel 2104	AMS 7005
Temperature range (°C)	0 – 70							0 – 70			
Package (pin count)	22							16			
Access time (ns)	100	200	150	200	200	200	200	200	250		
Read cycle time (ns)	220	400	380	360	400	400	400	325	375		
Write cycle time (ns)	200	400	380	490	400	400	400	325	375		
Read-modify-write cycle time (ns)	300	520	470	520	520	580	520	–	515		
Chip power dissipation (mW)	≈380	690	775	465	600	585	465	≈440	441	756	441
V_{DD} (%)	12 ± 5	12 ± 5						12 ± 10	12 ± 5		
V_{CC} (%)	7 ± 5	5 ± 5						5 ± 10	5 ± 5		
V_{BB} (%)	−5.2 ± 5	−5 ± 5						−5 ± 10	−5 ± 5		
Transistors per cell	4	1	3	3	11	1	1	1			
Chip size (1,000 mil²)	43	23.7	39.6	26.1	18.6	28.8	22.1	20.5	19.5	18.6	22.0
Number of masks	7	7	5	6	7	5	7	6	9	7	6

SOURCE: AMS

dozen different device types in 22-, 18- or 16-pin packages, the majority of them in a range of access times and power dissipations—150 to 300 nanoseconds and 350 milliwatts to 1 watt (Table 3).

Almost two thirds of the 4-k RAMs used to date are 22-pin types. These have become popular among designers of small memory systems because, like the 18-pin designs, they can be directly accessed over 12 separate address lines. Designers of large mainframe systems, on the other hand, generally prefer the smaller 16-pin package, despite its requirement that the 12 address signals be multiplexed onto six lines. In recompense for the more complex address system, users can cram about 60% more memory on each board.

Other differences affecting the choice of a 4-k RAM chip include chip size, power dissipation, availability and cost, and system life. Chip size over the long run profoundly affects system costs, since the smaller the chip, the less it will eventually cost to build and probably to buy. The Fujitsu 8215 4-k RAM, for example, has an access time of 100 ns that is three times faster than most others, but it requires four transistors for every cell and



3. The 16-k layout. All 16-k dynamic RAMs will be supplied in 16-pin packages, where 12 address bits are multiplexed onto six address lines. In this Mostek 4016 design, the six row-address bits are latched by a RAS signal, while a CAS signal latches the column-address bits.

fills up a chip measuring 43,000 square mils. That is twice the area of Mostek's or Intel's 16-pin devices. The enormousness of this chip and its inherently high production cost must surely have discouraged savvy system designers, since the 8215 has found few U.S. buyers.

Power dissipation is important to users. The relatively high dissipation of Intel's otherwise solid 2107B 22-pin design made it initially less attractive than Texas Instruments' similar but lower-power 22-pin component. After some production history, however, Intel reduced the figure to a respectable and more alluring 600 mw.

As always, availability and cost are crucial. Especially with a component as complex as a 4-k RAM, the supplier who gets his device into production first quickly gains the experience that enables him to supply the most reliable devices at the lowest cost. Sophisticated users always demand to see production schedules and yield and reliability data before they will commit themselves to a particular device.

Finally, even system life-time is a factor in 4-k RAM selection, since it will be easier to upgrade to 16,384-bit RAMs from some 4-k devices than from others.

Moving to higher speeds and smaller packages

The present trend in 4-k RAMs is to greater speed and density. In memory-system design, access time is practically everything. The processor cannot be executing an instruction while the memory is being addressed. Now that system designers have gained experience using the 4-k devices, they are demanding more and more speed.

First to recognize this preference was Mostek. Its new 4-k 4027 device offers an 150-ns access time in a compact 16-pin package, which it will be easy to replace with 16-k 16-pin components once they become more widely available. The performance of the Mostek part has been received with such enthusiasm by all major memory users that most semiconductor-memory manufacturers are now copying the 4027.

The difference in using fast 16-pin 4-k RAMs rather than 18- or 22-pin devices boils down to the difference in using six instead of 12 address lines to access the rows and columns. The 12 address bits required to address one of the 4,096-cell locations must be multiplexed onto six address inputs and then latched into the on-chip address latches (Fig. 3). The latching is done by applying two negative-going TTL-level (5-volt) clocks in succession. The first clock, the row-address-select (RAS) signal, latches the 6 row-address bits into the chip. The second clock, the column-address-select (CAS) signal then latches the 6 column-address bits plus the chip-select (CS) signal into the chip.

The internal circuitry of the 4027 is designed to allow the column information to be applied externally to the chip before it is actually required. Because of this, the hold time requirements for the input signals associated with column-address selection are also referenced to RAS, a condition that requires a bit more care in designing the address circuits than is needed in nonmultiplexed designs. However, this gated CAS feature allows the system designer to compensate for timing skews that may be encountered in the multiplexing operation. And since the chip-select signal is not required until CAS time, which is well into the memory cycle, its decoding time does not add to system access or cycle time.

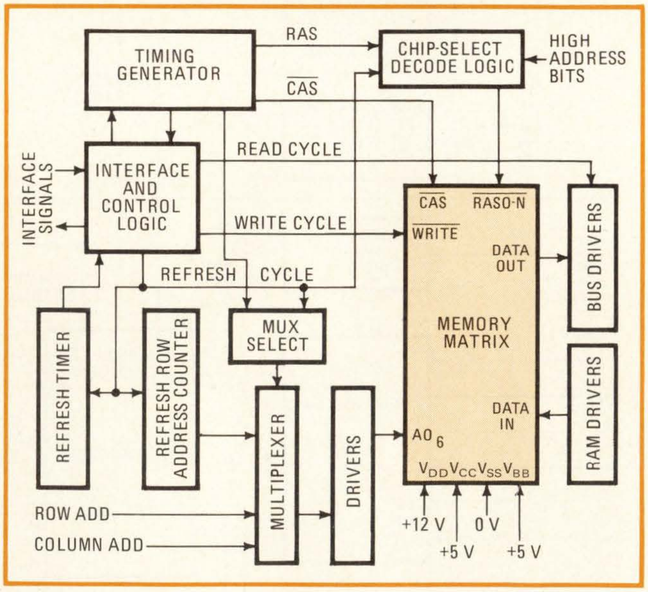
TABLE 4: AVAILABLE 16,384-BIT DYNAMIC RANDOM-ACCESS-MEMORY TYPES

Parameter / RAM type	Mostek 4116	Intel 2116	TI 4070	AMS 7116
Temperature range (°C)	0 – 70			
Package (pin count)	16			
Access time (ns)	250	250	350	250
Read cycle time (ns)	375	375	550	375
Write cycle time (ns)	375	375	550	375
Read-modify-write cycle time (ns)	515	515	–	515
Chip power dissipation (mW)	600	756		750
V_{DD} (%)	12 ± 5			
V_{CC} (%)	5 ± 5			
V_{BB} (%)	−5 ± 5			
Transistors per cell	1			
Chip size (1,000 mil^2)	28.8	33.8	45	33
Number of masks	7	7	5	6

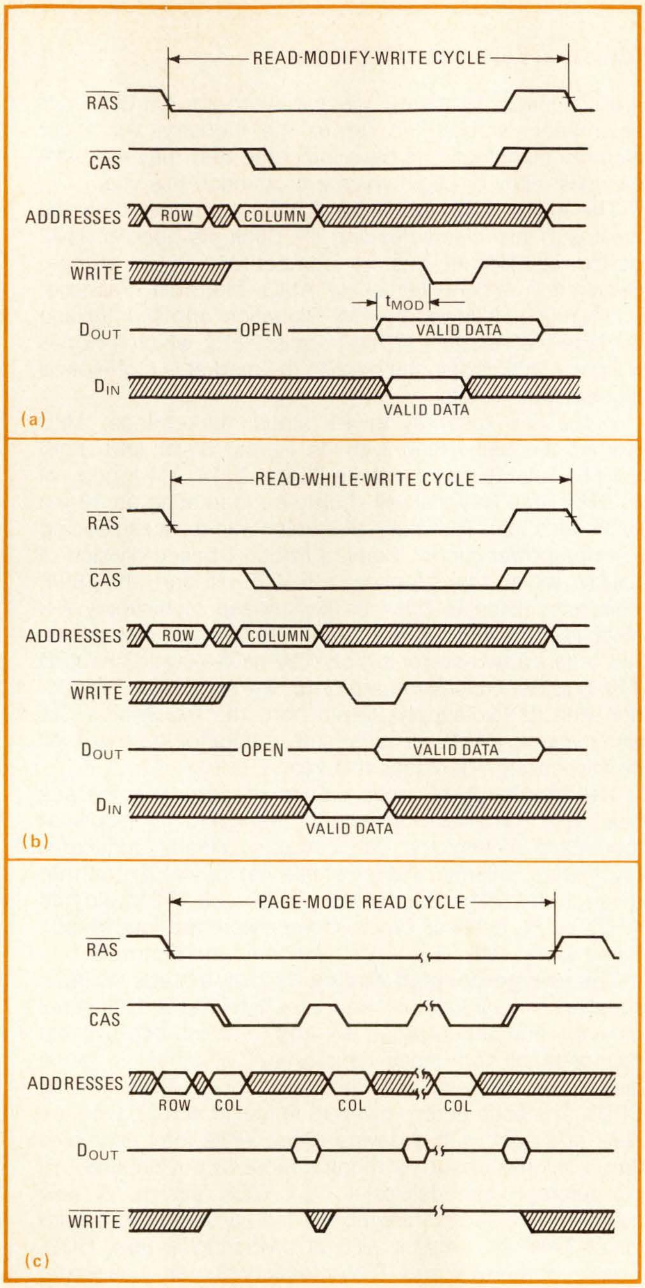
SOURCE: AMS

A system using 16-pin 4-k RAMs with this addressing scheme can fairly easily quadruple its bit density by changing over to 16-pin 16-k RAMs. The devices fit into the same sockets, and the system need adapt to only two interrelated changes: the 16-k RAM's unlatched output, which is the result of its need for an extra address input. (Multiplexing of course turns this single input into the additional 2 bits required to address 16,384 bits rather than 4,096 bits.)

With one exception, all 16-k RAMs have unlatched outputs. In them, the row-address-select line, which provides the latch in the 4-k devices, can no longer do so. Instead, it has taken on the job of chip selection, in order to free what would be the chip-select pin in the 4-k RAM to provide an extra address input for the 16-k device.



4. The 16-k RAM meets the microprocessor. Their ease of use will make 16-k RAMs popular in microcomputer-based systems, which typically also include interface decode and refresh logic, timing generator, and multiplex circuitry.



5. Talented. The 16-k RAMs can implement functions like read-modify-write (a), read-while-write (b), in which read and write cycles occur almost simultaneously at the same address, and page mode (c), in which multiple column locations are addressed per cycle.

Intel's 2116 16-k RAM alone is different, offering a latched or an unlatched output.

In the unlatched operation, the data output remains valid throughout the specified access time right up until the column-address-select line goes inactive. This easy availability of the output signal during the entire access time cycle will allow the 16-k RAM to be a universal memory for all sorts of system requirements. On the other hand, the system designer does give up some flexibility, because now he must be certain the device is not activated during a valid output condition.

Table 4 lists the available 16-k RAM device types. Since Intel's device can also be operated in the unlatched mode, a user for the first time can pick one of three available devices that are practically interchangeable, a condition that never existed with 4-k devices. At last, a system designer can get down to the business of designing sytems instead of wasting time evaluating the quirks of different device types.

Upgrading made simple

To design a system around 4-k devices for later easy upgrading with 16-k devices, the designer must remember that the 4-k chip-select input will later be used as the seventh multiplexed address input (A_6) of the 16-k device (Fig. 3). This fact changes the system design rules, making it preferable to use the row-address-select line instead of the chip-select one for device selection. That can be done by linking the RAS line only to selected 4-k/16-k devices while the column-address line is applied to all devices.

This arrangement is particularly useful in large systems, such as 65,536-word-by-16-bit memories with OR-tied outputs. As a matter of fact, the configuration is already in use in most 16-pin 4-k RAM system designs of greater than 4,096 words, since it needs much less power than when the chip-select pin has the job of device selection.

However, if a designer wants to keep the chip-select pin for device selection in his 4-k/16-k-RAM design, then the CS line should be distributed to all devices and terminated so that it will be able to serve as an address line later on. He can do that in the 4-k design by connecting the CS line to a signal driver. That forces it to a high level during column-address hold time and during refresh cycles, and to a low level during data cycles. Later, when he substitutes the 16-k for the 4-k in his upgraded design, the chip-select line will become the A_6 line and will be properly jumpered to an address driver.

The 16-k RAM in microcomputer systems

Because the 16-k RAM is so easy to use, it is fast becoming the favorite memory component for data storage in microprocessor-based systems. Figure 4 shows a block diagram for a typical 16-k-RAM memory system. The common elements of this system—which include interface logic, timing generator, decode logic, multiplex circuitry, refresh logic and buffers—can be built with approximately 12 to 20 standard TTL devices. A full 65,536-word-by-8-bit system, which is the maximum amount of memory addressable by most microprocessors, can be constructed on a single (double-sided) printed-circuit board in an area of less than 50 square inches.

The functions of most microprocessor-based memory systems are reasonably simple and straightforward, at least when compared to those of some minicomputers and large mainframes. Microprocessor memory modules are usually synchronous and initiate processor-requested read or write cycles upon command. Thus, refreshing a 16-k RAM in a microprocessor-based system is easily handled during the portion of an instruction cycle that does not require a memory access. The timing of a 16-k RAM can also be kept simple since most microprocessor systems do not require specialized memory operations,

Who is doing what in read-write memories

The endlessly available trade lists, which show every supplier of every device type, are often more confusing than illuminating, since they make no attempt at evaluation. There are well over a dozen suppliers of read-write memories—MOS dynamic and static RAMs, bipolar RAMs, alterable ROMs, and CCD and bubble block memories. Before selecting a particular manufacturer of a widely sourced device, wise users look not only at his price, but also at his production and reliability experience and the applications information he has available.

The 4,096-bit dynamic MOS RAM is the most widely used memory component today, and the largest suppliers of this device are the three manufacturers who got there first: Intel, TI, and Mostek Corp. Intel Corp. of Santa Clara, Calif., supplies both a 22-pin nonmultiplexed part, the 2107B, and a 150-ns multiplexed 2104 16-pin part. Texas Instruments Inc. of Dallas offers a 22-pin part, the 4060, and an 18-pin part, the 4050, and will soon be offering a 16-pin copy of Mostek's 150-ns 4027 device. Mostek Corp., Carrollton, Texas, which originated the 16-pin multiplexed device, continues to supply only that part but in two versions: the high-speed 4027 and the 300-ns 4096. These three vendors sell probably over 80% of all dynamic 4-k RAMs used today.

Strong alternate sources to these products also exist, as well as some lesser-known proprietary designs. Fairchild Semiconductor of Mountain View, Calif., will be offering both Mostek's 16-pin parts. Motorola Semiconductor in Phoenix already offers them both, besides its own 22-pin 6605A device. Advanced Micro Devices Inc., Sunnyvale, Calif., on the other hand, is an alternate source to TI's 18- and 22-pin devices, as are Signetics Corp., also in Sunnyvale, Electronic Arrays Inc. of Mountain View, Calif., and RCA's Solid State division, Somerville, N.J.

Meanwhile, National Semiconductor Corp., Santa Clara, Calif., has gone its own way with proprietary 18- and 22-pin devices, signing on neighbor American Microsystems Inc. as its principal domestic second source. AMS will also be furnishing a 16-pin multiplexed 7005 device.

Competition from abroad comes mostly from Japan. Very few Japanese devices have yet been used in U.S.-designed systems, but the number is likely to increase, especially in the next device generations as the Japanese gain U.S. marketing experience. NEC, Fujitsu, and Hitachi are the only ones at present selling 4-k RAMs in the U.S. Nippon Electric Co. has a 16- and a 22-pin device, the μPD 414 and 411, which are a lot like the Intel device. Fujitsu Ltd. has its 22-pin MB 8215 and MB 8107 devices, and Hitachi Ltd. is supplying a TI-like 22-pin part.

The 16-k dynamic RAM is in volume production at only three manufacturers, so here the players are easier to identify: Intel, with its 2116 device, TI with its 4070 device, and Mostek with its 4116 device. All are 16-pin multiplexed designs. While Intel is currently probably the leader in 16-k production, it is still too early to tell which suppliers will dominate the market, since only about 200,000 units have been supplied so far to the industry. All major memory manufacturers have indicated that they will have samples ready or begin volume production this year.

The static 1,024-bit MOS RAM is another crowded area, with Intel clearly leading the pack. Its popular 2102 device outsells its nearest competitors three to one. Bunched in second place are AMD, Motorola, Fairchild, and National, followed by AMI, Signetics, and TI. Intel also supplies the very fast (70-ns) static 2115, which it hopes will get a MOS foot in the door to the market in high-speed bipolar static RAMs.

In the new fast-moving 4-k static marketplace, AMD started the ball rolling with its 22-pin 9130 and 9140 devices, Intel followed with its 22-pin 2114, a 4-k copy of its 2102, and National will shortly be marketing an 18-pin 5255 4-k static. These are all 5-volt static devices needing just one power supply. Semi, a Phoenix-based division of EM&M, will also be supplying a 5-V 18-pin part, the 4804, while continuing to push its high-speed multisupply 4-k static line, the 4104-A, 4402, and 4200 series. Meanwhile, NEC offers a two-power-supply 100-ns 4-k static, the μPD 410, and General Instrument Corp. will soon be in production with its two-supply 22-pin part, the RA 3-4402. As with dynamic RAMs, all major semiconductor suppliers will be introducing 4-k statics this year.

The bipolar RAM, since bipolar processing is the key here, has Fairchild in the lead, thanks to its Isoplanar fabrication technology. The company clearly dominates the market, offering a dozen different device types that range from 256-bit ECL RAMs to 4,096-bit TTL static and 4,096-bit I^2L dynamic types. Competitors are Intersil Inc., Santa Clara, Calif., Signetics, National, and Motorola.

The charge-coupled device for bulk storage so far is supplied only by Fairchild and Intel. Intel has a 16-k serial memory, and Fairchild has 9-k and 16-k line-addressable memories, all very small-volume stuff. But the big move may come this year with the introduction of 65,536-bit CCDs. The edge here is given to Fairchild and TI, who are neck and neck with a device entry, while Intel estimates that it still has about six months more of development to go before it can deliver a 65-k CCD design. A new company in CCDs is Pneumonics Inc., a Santa Clara spin-off of TRW Inc., and it also is preparing a 65-k CCD. Finally, both RCA and TRW Semiconductor, Lawndale, Calif., have developed 65-k CCD chips for internal use but have not indicated whether they intend to make their parts commercially available.

The bubble memory is largely built and used in house. TI is producing a 91,000-bit bubble device for its own minicomputer storage systems; Rockwell International has developed a NASA-funded bubble-memory system, and Bell Laboratories, IBM Corp., and Honeywell Inc.'s Process Control division in Phoenix continue to build bubble-memory systems for in-house purposes.

such as read-modify-write or read-while-write cycles.

Most fortunate of all, the absence of an output latch on the 16-k RAM opens the way to a very important microprocessor interface concept—the common input/output data bus. Here, if common I/O operation is desired, the data input pin of the 16-k RAM can be directly connected to the data output pin on the pc board, all write operations then being executed in the early write mode (in other words, the write line goes low before the column-address-select line goes low).

A logical progression beyond the simple microprocessor systems leads to multiprocessor applications and minicomputers. In these applications, the 16-k RAM will have a much heavier impact than any previous semiconductor memory device, for unlike its predecessors it can carry out read-while-write and page-mode operations, not to mention read-modify-write cycles (Fig. 5).

Read-while-write is a well-known minicomputer-memory operation. In it, a read operation and a write operation begin at the same memory address within the same memory cycle, in effect occurring simultaneously (Fig. 5b). In more detail, the 16-k RAMs have been so designed that the bit stored in a particular cell can move out to the output of the device within the specified access time, just ahead of an input bit moving in behind it into the same cell within the same cycle. The deed is done by strobing the row and the column addresses into the device and then waiting a short time before giving the write command.

Rewriting

The read-while-write operation therefore takes less time than the more common read-modify-write cycle, in which a bit is read from a cell, then modified, and finally rewritten in its modified form into the same cell (Fig. 5a). This operation is usually part of some error-detection-and-correction scheme, whereas the read-while-write operation is used for high-speed shift-register or buffer applications.

The other minicomputer-memory type of operation that comes easily to 16-k RAMs is page mode (Fig. 5c). Page mode increases speed without increasing operating power by allowing successive memory operations to occur at multiple column locations of the same row address. A 16-k RAM with a normal access time of 250 ns would have a page-mode access time of 165 ns—a 30% speed increase.

Every type of memory operation can be performed in page mode: read, write, read-modify-write, and read-while-write. To lend it even more flexibility, the page boundary can be stretched beyond the 128 columns of a single 16-k RAM by decoding the column-address-select signal and using it as a page-cycle-select signal.

The big time

Mainframe applications of 16-k RAMs look like they will be even more varied than minicomputer applications. Mainframes usually need to have many types of storage scattered throughout the system, and the many advantages of 16-k RAMs should make them especially at home here.

Their density means that for the first time 16,384 bits of commercially available read-write memory can be packed onto less than 0.5 in.^{2} of pc board. Their performance enables them to cover a wide range of system speed requirements, since their access times range from 350 ns to under 150 ns or even less if page-mode operation is used. The flexibility of their various operating modes adapts the 16-k RAMs to use in everything from normal read-write storage to shift registers, buffers, and even first-in/first-out configurations. Especially encouraging are the wide system margins of this new generation of chip memories. The user can now begin to expect, as standard features, 10% tolerance on all power supplies, as well as direct compatibility with various types of high-speed logic families.

Alterable ROMs make designs more flexible

The hottest new area in memory is the alterable read-only memory—the nonvolatile memory device that a user can program and reprogram over and over again independently of the supplier. Adding another dimension of flexibility to system design, these alterable ROMs differ markedly from conventional factory-programed and even from field-programable types, neither of which can be programed more than once.

Factory-programed or mask ROMs, either bipolar or metal-oxide-semiconductor types, are programed by the manufacturer, who creates masks from a user-generated tape that contains the program. Masks are the least-cost solution to programing a ROM and are intended for large-volume production equipment. Rather more flexible, and certainly more expensive, are the field-programable ROMs called PROMs. These are bipolar devices that the user programs himself in the field. He constructs a program pattern of conducting and nonconducting cells with the aid of one of several commercially available programers, which provide the voltage that blows out a fusible link in selected ROM cells.

Because PROMs are field-programable, they have become extremely popular. Two thirds of the ROMs used today are field-programable. They are to be found especially in small-volume systems for which mask ROMs usually are not available from manufacturers. The only problem with them is that they are not reprogramable—a deficiency that is felt acutely by anyone prototyping a system or using equipment that requires periodic updates of its program.

Enter the alterable types. Here, a charge pattern representing the program is stored in selected gates of a MOS array (alterable ROMs are always MOS devices). The chips are programed by applying appropriate signals to package pins and cleared by applying an erasing signal to the same pins. In this way the device can be programed over and over again.

Three options

There are three types of alterable memories available today (Table 5). First came the ultraviolet-erasable PROMs, often called EPROMs. They were pioneered by Intel in 1970, using an ingenious floating-gate avalanche MOS process (Famos). These well-established products are erased by a dose of ultraviolet light. Applied to a window in the package, the light causes holes and carriers to recombine in the region just below the floating gate, clearing the stored charge.

The other two types are the electrically alterable PROMs widely known as EAROMs. Built either with a nitride storage medium (called MNOS) or with a two-gate modification of the floating-gate avalanche process, they may be programed like the UV-erasable PROMs but can be erased in circuit simply by applying an electrical pulse of about 30 volts to the programing pins.

It is important to be sure of the differences in opera-

TABLE 5: ERASABLE READ-ONLY MEMORIES (1,024 BITS AND UP)						
Developer	Type	Organization (bits)	Read access time (μs)	Programing time (s)	Erase method	Process
Intel Corp.	1702	256 x 8	0.5 – 1.0	30 – 100	ultraviolet	p-channel Si-gate
	2704	1,024 x 4	0.4 – 1.0	30 – 100		n-channel Si-gate
	2708	1,024 x 8	0.4 – 1.0	30 – 100		
	2716*	1,024 x 16	0.4 – 1.0	30 – 100		
Nitron	NC 7051	1,024 x 1	2 – 5	0.1 – 0.5	electrical	nitride
General Instrument Corp.	ER 2400	1,024 x 4	2	0.1 – 0.2		
	ER 3400*	1,024 x 4	2	0.01		
	ER 2800	8,192 x 1	2	0.1		
Nippon Electric Corp.	μPD 454	256 x 8	0.8 – 1	0.8 – 1.0	electrical	n-channel double-gate
	μPD 458	1,024 x 8	0.4 – 1	0.8 – 1.0		

*coming

SOURCE: ELECTRONICS

tion and performance of the three types of PROMs. They are not interchangeable, nor are they intended for quite the same applications.

The UV types, which are now available in 1,024-, 4,096-, and 8,192-bit varieties, are about as fast (500 ns) as plain MOS, ROMs or PROMs. They can therefore be used as alterable replacements for those memories in such applications as look-up tables, truth tables, fixed algorithms, and so on. Since they can be reprogramed, they allow the memory designer to change his program conveniently from time to time without ordering a new mask ROM or PROM.

More important is the use of UV PROMs as program memories for prototyping microprocessor systems. A system designer can use one to check out the integrity of his program and, once he has optimized the code, can either switch to a cheaper, conventional PROM or order a mask ROM for high-volume applications. A wide selection of ROMs and PROMs are compatible with UV PROMs.

Indeed, microprocessor designers are now using UV PROMs in ever-increasing numbers—over 1 million units were consumed last year for this purpose alone. And this year promises to render them more attractive, as a 16,384-bit UV-erasable PROM is about to be introduced by Intel. Unlike the other UV types, which require two or three power supplies, the new 16-k version will require a 5-volt supply only, making it usable with the new 5-V microprocessor systems.

The electrical switch

The drawback to the UV-erasable PROM is the use of ultraviolet light. It requires a relatively clumsy procedure that is not useful for applications needing fast real-time storage changes. For these, a user must turn to the electrical types, either nitride or modified Famos, which can be reprogramed at will right in the circuit with easily available electrical signals (30- to 40-V pulses).

The nitride types have read times of 2 to 5 microseconds, which is still too slow for most real-time program storage applications. But since they provide almost infinite store times, they are becoming popular as auxiliary memory in a host of new applications that require nonvolatile reprogramable storage—memory that does not lose its program when power is removed. In other words, the devices can be made to serve as slow nonvolatile RAMS.

For example, nitride memories will be used in digital odometers for vehicles, say applications specialists at Nitron, the Cupertino, Calif., division of McDonnell Douglas Corp. It and General Instrument Corp. are the principal commercial suppliers of nitride memories. In a digital odometer, the memory stores the mileage readouts and is updated every tenth of a mile. Clearly the nonvolatile nature of the electrically alterable ROM is key here, since the system must retain the stored data even when the car battery is dead and has stopped supplying it with power.

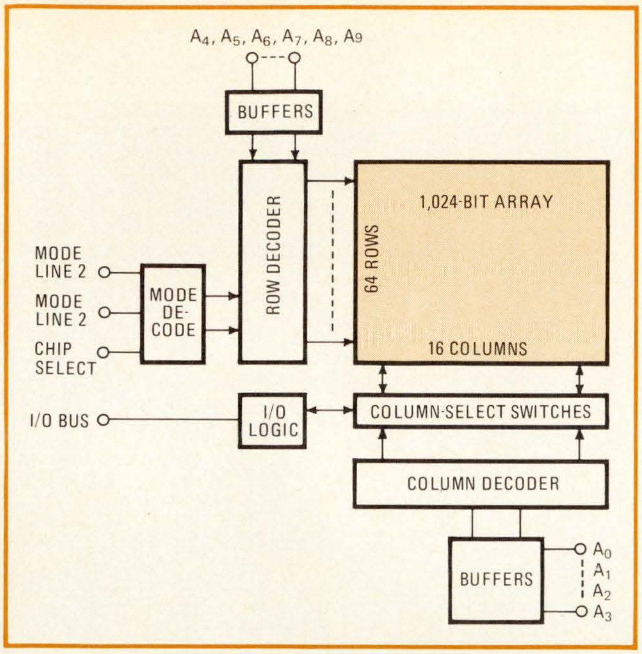
Nitride alterable ROMs are also being used in programable calculators, in digital television and fm radio tuners, in citizens' band radio tuning, in point-of-sale equipment for providing periodic inventory updating, in machine tool-controls that require power-down fail-safe memory to replace the old paper-tape systems, and so on.

A handy feature of the nitride alterable memory is that it may be either entirely or selectively erased. To erase it completely, the user applies voltage signals to all the address lines. To erase it selectively, or edit it, a more complex process is necessary.

Suppose a group of 16 bits is to be edited out of the 1,024 bits already stored in the Nitron NC 7051 device (Fig. 6), a fully decoded nonvolatile 1,024-bit memory with random access to each bit in the read mode. For simplicity's sake, suppose, too, that this group of 16 bits is one of the 64 rows in memory. Then the 6 most significant address bits (A_4 through A_9) select the 16 bits to be erased, and the 4 least significant address bits (A_0 through A_3) control the selection of column locations when the new data is written into the row.

When the number of bits in a row to be edited is fewer than 16, those bits that are not to be edited out are read out and stored in an external latch before the row is erased. After the erase cycle, they are rewritten back in, together with the edited bits. In the erase, block erase, and write modes, a programing voltage, V_p of -30 V, is applied to the programing terminal.

Though the nitride types are useful for many applica-



6. Erasable. The Nitron 7051 can be selectively erased electrically by letting, say, the first 6 most significant bits erase the data from one of its 64 rows, while the 4 least significant bits control the column locations for writing new data back into the row.

tions, perhaps the ultimate in erasability are the electrical types built with the MNOS avalanche process. They combine the speed of the UV types with the reprograming ease of the nitride types. Better yet, they do not use nitride for storage—a mechanism that suppliers of commercial semiconductor memory devices find almost impossible to build reliably. In fact, the nitride process was not developed by them, but by systems houses, such as NCR, Bell Laboratories, Honeywell, Nitron, and Westinghouse, which developed the process for specialized applications, usually with Government support.

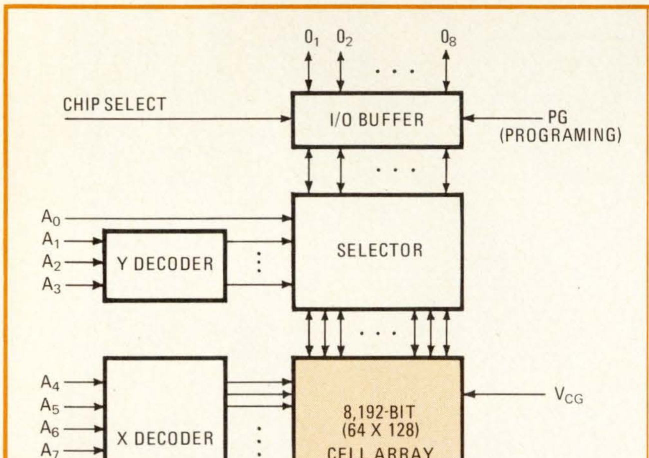
The commercial-memory suppliers, being more at home with standard MOS technology, are now adapting that technology to electrically alterable PROM structures, with results that are now beginning to be felt. Intel is known to be well advanced on an electrically alterable avalanche process, as are Texas Instruments, Mostek and others. But it is the Japanese Nippon Electric Corp. that is out in front.

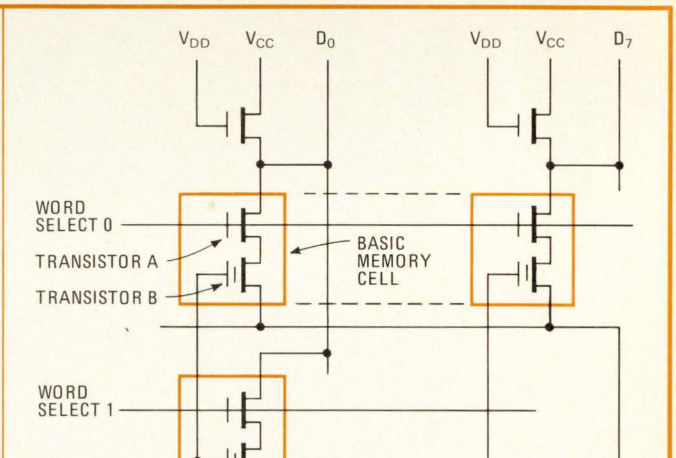
NEC's silicon-gate electrically alterable ROMs, in 2,048-bit and 8,192-bit sizes, are available in the U.S. and Europe, as well as in Japan. They have access times of 0.4 and 0.8 microsecond, respectively, and both are compatible in package and performance with a wide variety of standard ROMs and PROMs.

How they work

Consider the 8,192-cell array of NEC's μPD 458, with its X and Y decoders, selector, and input/output buffer (Fig. 7a). In programing the device the first step is to erase the previous contents of all memory cells by turning on the memory transistors of all the bits simultaneously. That is done from the V_{CL} terminal. Then writing in from the programing terminal (PG) turns off selected bits. The write-in is performed 1,024 times, once for each 8-bit word. The programed information is then read with programing voltages V_{CG}, V_{CL}, and V_{BB}.

Each μPD 458 cell (Fig. 7b) has two n-channel MOS transistors. Transistor A, an enhancement-mode device, responds to external addressing, while transistor B is the actual memory device. Once the device has been erased, the memory—all the B transistors—are in the conductive, or on, state, which corresponds to a positive charge on the floating gate. A write operation switches transistor B to the nonconductive, or off, state, which corresponds to a negative charge on the floating gate. The memories are usually shipped in the erased state. When



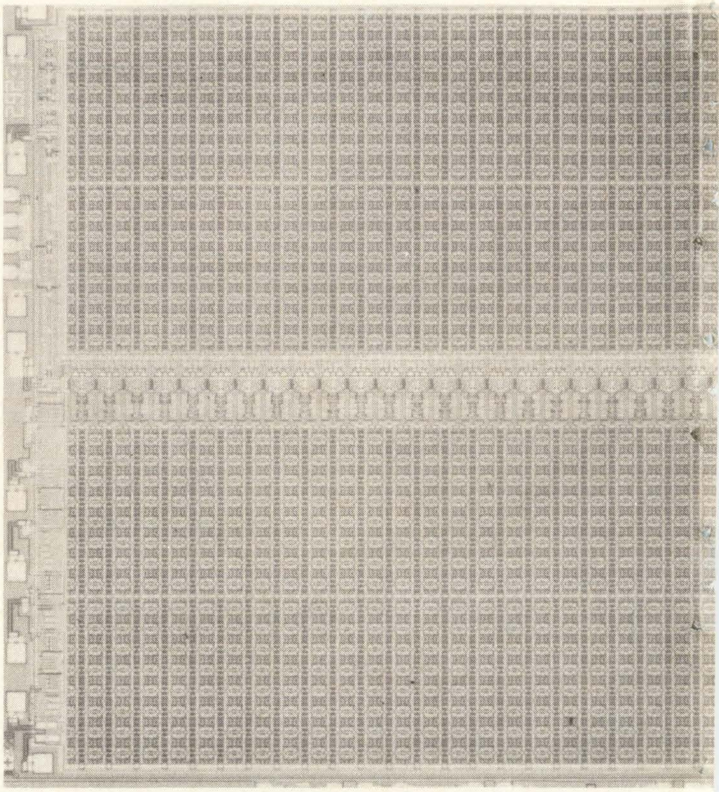


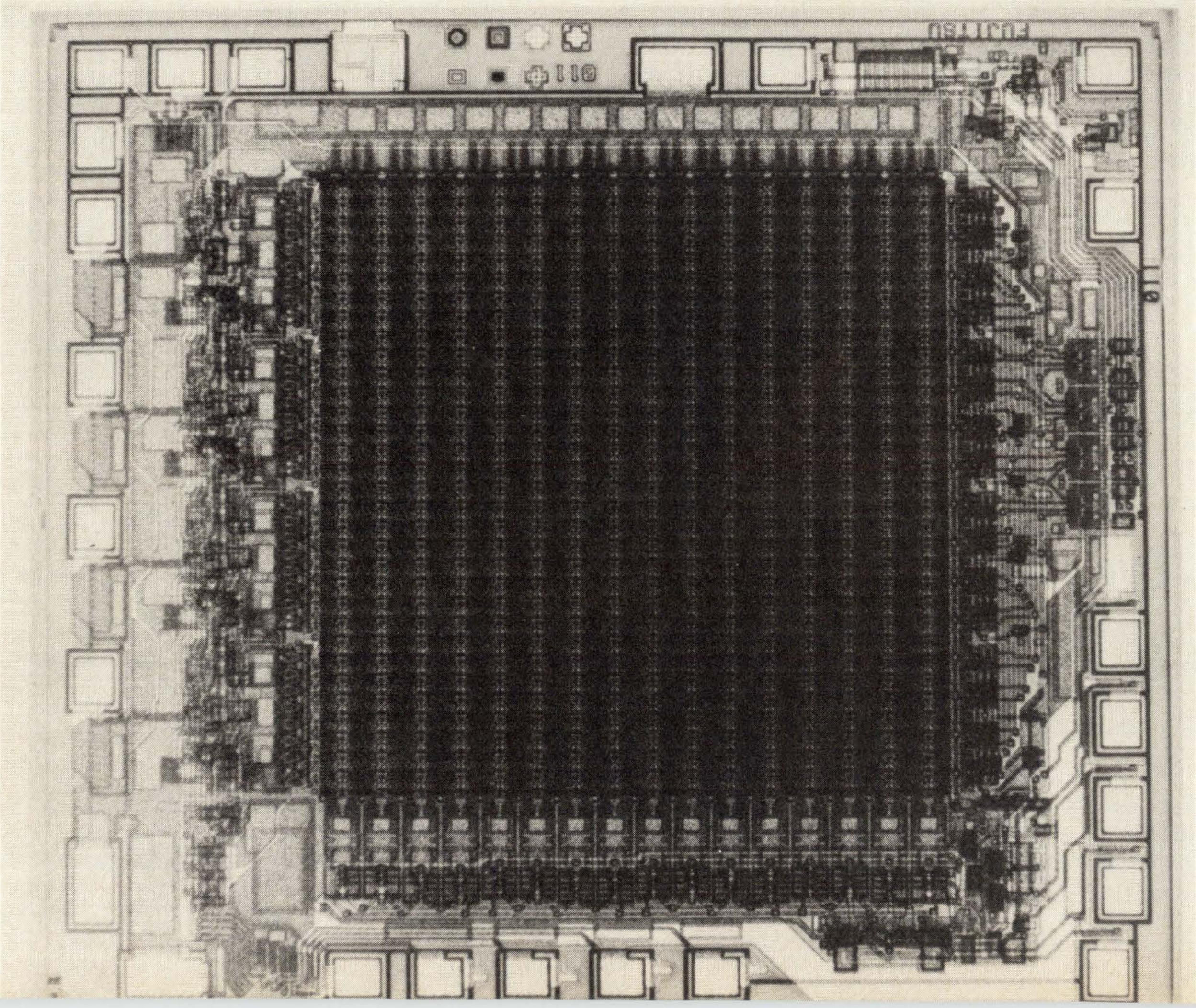
7. Simple as X Y. In NEC's μPD 458 electrically erasable ROM, the 8,192 bits are accessed with X and Y decoders (a), while selection is made with a selection block that is controlled by the chip select and I/O buffer. The basic memory cell (b) has two transistors.

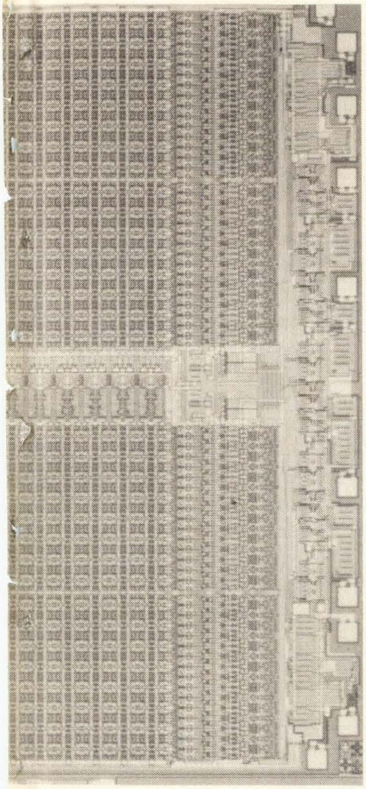
Memories of the East

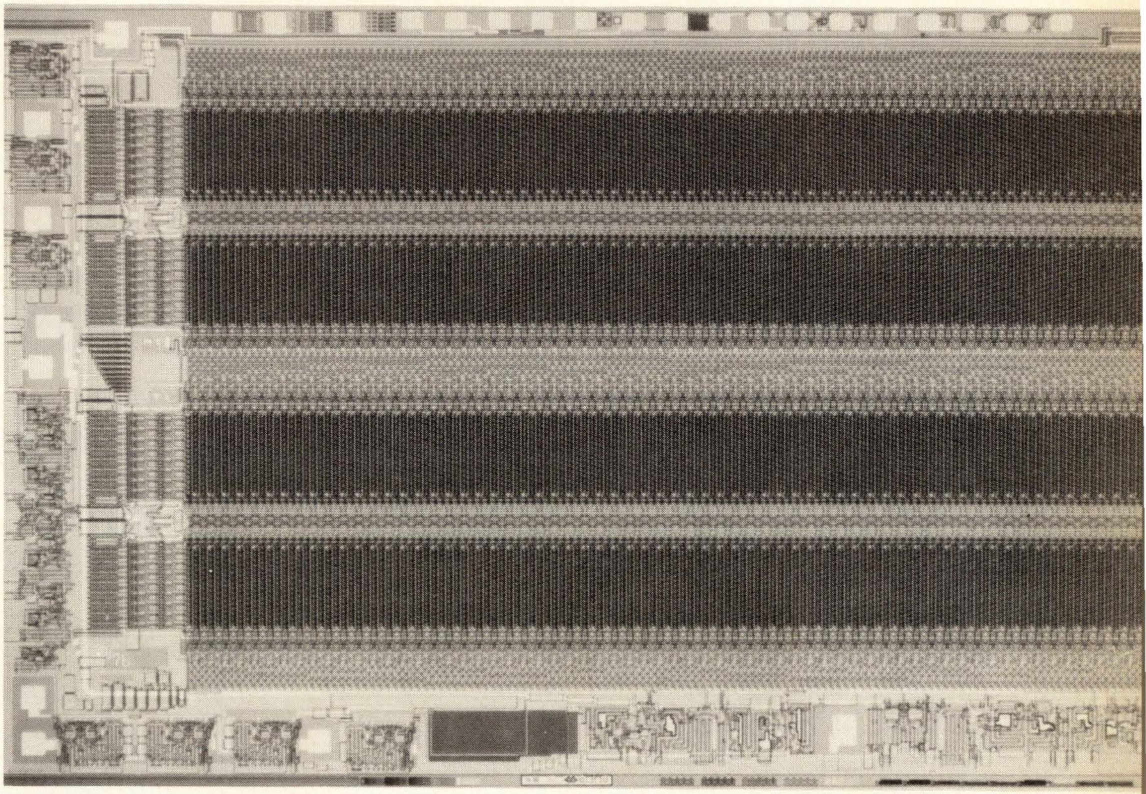
Awesome describes the potential memory capability of Japanese manufacturers of semiconductor components. There is a 4-k C-MOS static RAM from Toshiba (first right) that is four times as dense as equivalent U.S. manufacturers' C-MOS RAMs. There is the Mitsubishi 16-k dynamic RAM (second right) accessible in less than 150 ns—at least as fast as the best American device. There is a 7-ns (yes, 7 ns) ECL static RAM (below) from Fujitsu, plus a 65-k CCD memory from Toshiba (below middle) that equals the performance of any proposed American-made CCD memory. Hitachi has built a 2-million-bit bubble memory (below right) for prototype mass storage systems, while a 1-k ECL RAM (lower right) has the latest 2 micrometer-wide lines—half the width of other production devices.

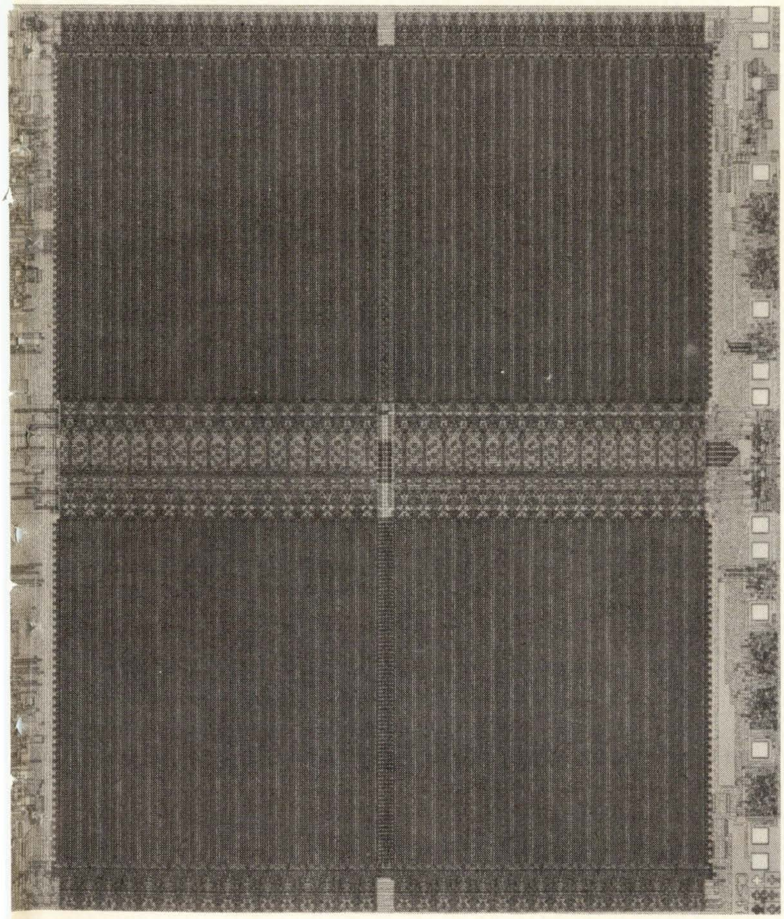
True, with the exception of the 16-k dynamic RAM, none of these devices will be generally available this year, and certainly similar prototype devices exist in U.S. and European semiconductor laboratories. Nevertheless, this display of advanced memory technology, together with the rapid advances Japanese designers are making in LSI logic, surely portends an increased visibility of proprietary Japanese digital LSI products in the U.S. marketplace. Backed by their government, Japanese semiconductor manufacturers clearly intend to make a major impact in the American computer and data-processing industry. To this end Japanese manufacturers have developed an increased American marketing expertise that will make products such as these ever more accessible to U.S. system designers. **Charles Cohen**

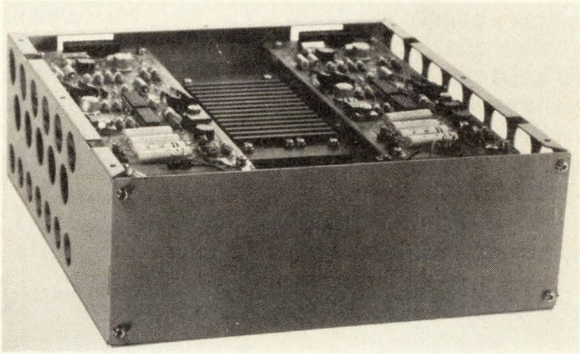


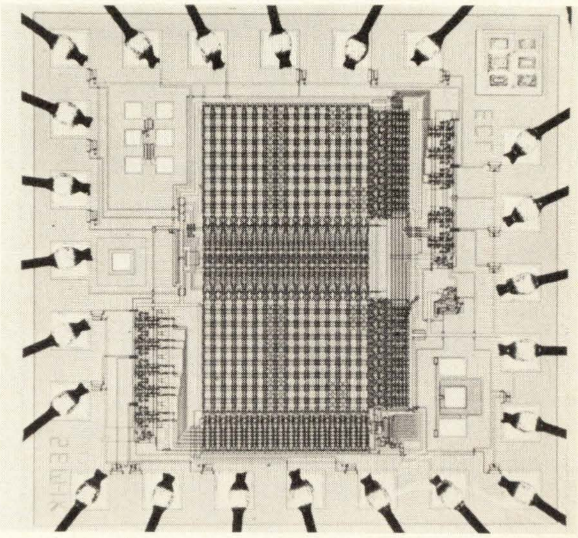












read, the data-out terminal is in the low, or 0, state for all 1,024 words—that is, transistor B of the cell is on.

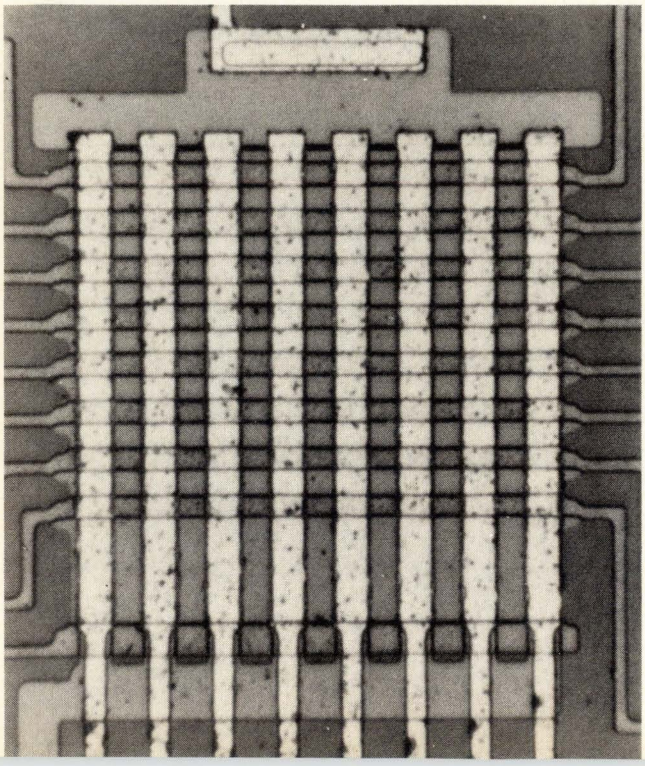
Altering the NEC devices is easier than altering UV types, even apart from the fact that voltages are easier to manipulate than ultraviolet light. For example, four voltages are required for writing in UV-erasable chips, while only two voltages are needed for that purpose in the μPD 454/8. Somewhat similarly, read times for the two different types of devices are comparable. But to achieve the same 450-ns access time, the 2708 UV types need three voltage sources, whereas the μPD 458 types with the same bit density need only two.

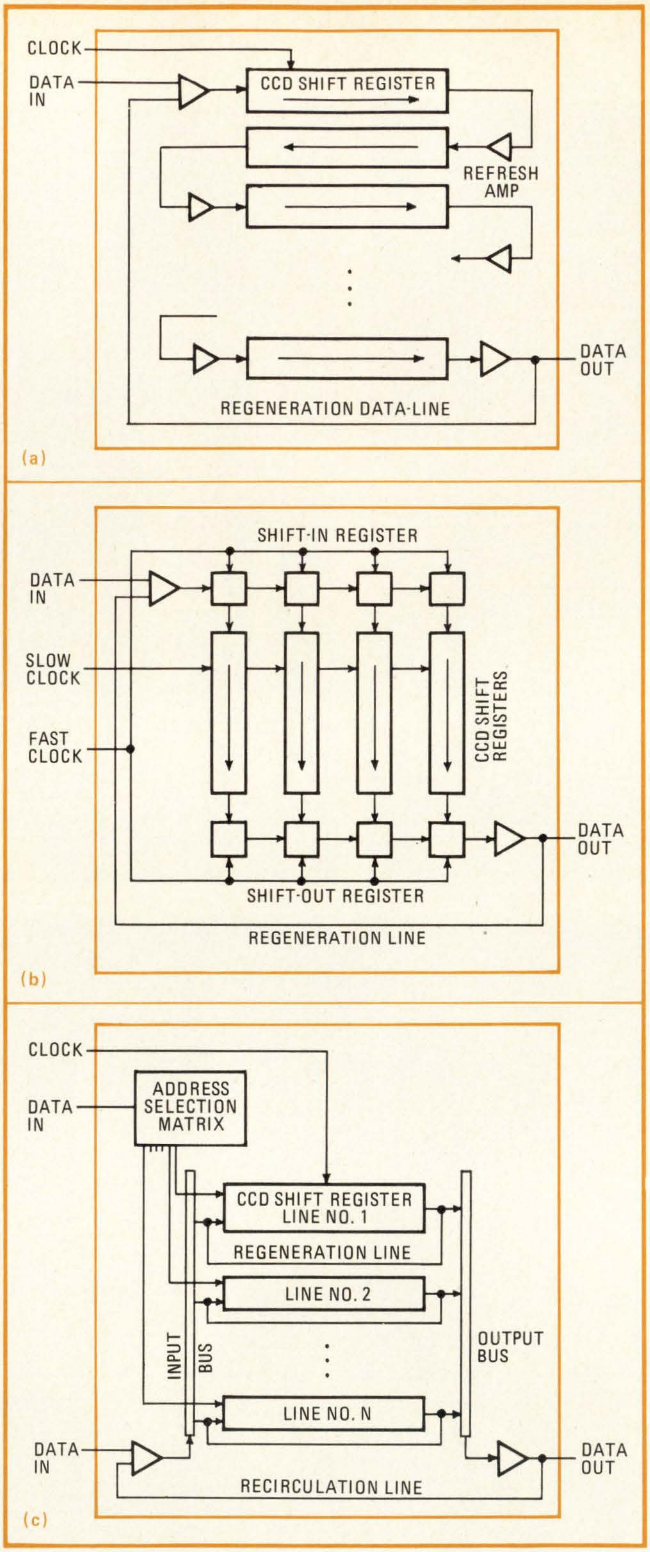
Beware, though, of trying to replace the UV-erasable types directly with the electrically erasable types. Like the 2,096-bit uv-1702A, the μPD 454 is packaged in a standard 24-pin ceramic dual in-line package, but its pin locations are not compatible with the 1702A's. The 8,192-bit μPD 458 and 2708 are, however, plug-compatible, even though the first is a 28-pin part and the second a 24-pin part. Compatibility is achieved because the μPD 458 pinout pattern has 24 of its pin locations matching those of the 2708. To accommodate it, the user has only to add four more pins to his board layout.

The 65-k RAM looms large, but CCDs and bubbles are 'iffy'

While the array of memory devices now available to a system designer is already awesome, that technology is by no means standing still. Proof of that are the new devices from Japan pictured on pages 92 and 93. Indeed performance should continue to double each year as devices incorporate new design techniques, such as V-notch MOS (V-MOS), double-diffused gates (D-MOS), charge coupling, and improved injection logic.

What then can memory-system designers expect in the way of new memory chips in the next three years?





9. The three faces of CCDs. The synchronous approach (a) to CCD memory chip organization is fast but uses most power; serial-parallel-serial organization (b) is slow but low-power, while the line-addressable RAM (c) is fastest and consumes medium power.

8. No transistors. Memory cells, based on CCD storage sites under conductor intersections, yield cells that occupy 0.16 square mil—much less than the 1 square mil required by one-transistor cells. Typical 30,000-mil^2 chip would easily hold 65,536 bits.

TABLE 6: CCD MEMORY ORGANIZATIONS			
Characteristic	Serpentine	Serial-parallel-serial	Line-addressable RAM
Capacity (bits)	16,384	16,384	16,384
Organization	256 x 16 x 4	4,096 x 4	128 x 32 x 4
Access time, (at 5 MHz)	51.2 μs	819.2 μs	25.6 μs
Power dissipation (mW)	400	150	250
Temperature range (°C)	0 – 85	0 – 70	0 – 55
Relative chip area	1.0	0.9	1.1
Clock drive requirements (pF)	1,000 1,000	1,000 40	100 15
Relative cost	1.0	0.8	1.1

In dynamic random-access memories, surely someone will be offering a 65,536-bit device by 1980, since it is already in advanced development at semiconductor laboratories. In production, such a device will bring the RAM bit cost down to the 50-millicent level, an incredible feat when five years ago a 1,024-bit RAM cost $25.

Glimpses of how the device will be built (by TI, Intel, IBM, and others) indicate that the single-transistor-cell structures of today's 16-k RAMs will probably be replaced by some form of charge coupling, with the RAM cell comprising a charge-coupled capacitor controlled by a MOS gate [*Electronics*, Dec. 9, 1976, p. 38]. The result will be a dynamic RAM cell no larger than a single MOS gate, or about 100 square micrometers in area (Fig. 8).

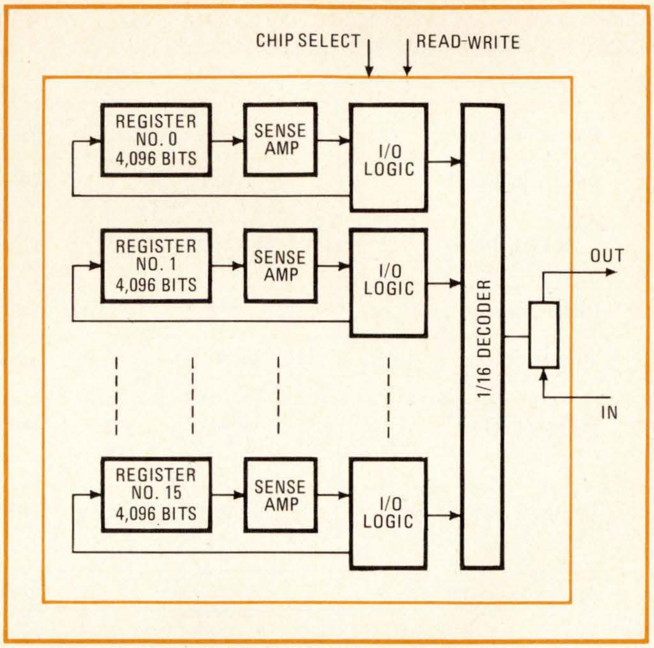
In static RAMs, the same quadrupling of density should result, allowing 16-k static MOS RAMs to offer 100- to-200-ns access times for peripheral-system designs. Smaller MOS statics will also pick up speed: within the next few years 1-k and 4-k static RAMs can be expected to achieve access times well below 50 ns, intensifying still further the battle between MOS and bipolar devices for the high-speed buffer-memory system.

Of course, progress in bipolar memory components has by no means ceased. As manufacturers acquire ever more production experience with injection logic and with tighter forms of emitter-coupled and transistor-transistor logic, system designers can look forward to 16-k I^2L RAMS with access times well under 100 ns and 1- and 4-k TTL designs with speeds down below 10 ns.

Then there are the rapidly developing electrically alterable nonvolatile memories. Certainly 8,192-bit and 16-k types with access times down to 200 and 300 ns, as well as 1- to 4-k nonvolatile RAMs with similar speeds, should become widely available for the growing numbers of applications that need permanent storage capability.

A matter of cost

A clouded area, however, is bulk memory, where semiconductor methods run into stiff cost competition from movable-head magnetic-memory technology. With the emphasis on very high density and very low cost, semiconductor-memory manufacturers are counting on charge-coupled devices to bring them into the 10-to-30-millicent-per-bit-range and bubble devices to bring them under 1 millicent, prices that will make their systems competitive.



10. The 65-k CCD. Fairchild's 65-k CCD memory will probably be organized in 16 registers of 4,096 bits each. Four addresses will decode the 16 blocks to the I/O pins. While one block is being accessed, the other 15 will recirculate and refresh themselves.

To focus first on CCDs, 9-k and 16-k devices have actually been around for over a year, but they have not generated much enthusiasm among designers of large memory systems, mostly because the devices have been too small and too expensive. Many indeed, believe that the next generation of 65-k devices may well decide whether CCDs have a future as a memory technology.

In terms of performance, CCD memory fills a need—it fits into the gap between other semiconductor and magnetic media (Fig. 1). Chip organization is important here, and there are three ways to organize a CCD memory chip: synchronous, serial-parallel-serial, and line-addressable RAM (Fig. 9). A synchronous organization, where the data simply moves from cell to cell in a long snake-like fashion, is the easiest to build and fast. But as Table 6 shows, it also dissipates the most power.

Available CCD memories therefore are either serial-parallel-serial types (Fairchild's 9-k CCD 450 and Intel's 16-k 2416) or line-addressable RAMs (Fairchild's 16-k 460). In the serial-parallel-serial organization, parallel lines of data move simultaneously to a row-end detector, shortening access time. But it is more complex to build and dissipates more power, since many cells are operating at the same time. Finally, the line-accessible organization, in which each line of data is accessed at random, is fastest and dissipates respectably low power.

The real issue, however, is not performance but cost, and that means density. From the layout design rules of chips announced during last year, Fairchild CCD memory designer Mark Guidry estimates that the CCD cell usually occupies 60% to 70% of the area of a one-

TABLE 7: BUBBLE-MEMORY PROSPECTS			
Characteristics	1976	1978	After 1980
Bubble size (μm)	4 – 6	2 – 3	< 1
Density (bits/in.^{2})	10^6	10^7	> 10^8
Speed: data rate (MHz) access time (ms)	 0.1 – 0.25 10	 1 1	 > 1 < 1
Module capacity (bits)	10^6	10^8	10^9 – 10^{10}
Storage medium	garnet	garnet	garnet amorphous film
Lithography	optical	optical, conformable printing	optical, conformable printing electron beam X-ray
Device configurations	T-bar	gapless T-bar	gapless T-bar contiguous disk bubble lattice
Application examples	POS system calculator	space-flight recorder main memory extension	large file data base
Competition	CCD, FET	CCD BEAMOS fixed-head disks and drums	CCD BEAMOS moving-head disks

SOURCE: **IBM**

transistor MOS RAM cell. (It can fit in 50%, but seldom manages to do so because of charge detection limits.) Lower overhead requirements for CCD memory than for MOS RAMs also improve its density. In fact, the percentage of CCD digital-memory area to total die area runs between 40% and 50%, while other chip memories typically run from 30% to 40%. These figures alone suggest that the cost per bit for CCD memory should be half that of MOS RAM.

Besides the geometric considerations, the yield factors at work could further lower the CCD cost. For large low-cost systems, the serial-parallel-serial organization offers significant advantages. It allows register size to be greatly increased without increasing the number of transfers between input and output, so that many internal refresh amplifiers can be eliminated. It reduces power, since the internal parallel registers are clocked at a low frequency. It does away with nonuniformity in dark current, which is now averaged over all the bits in a register. As a result, yields for CCD memories can be significantly higher than for MOS RAM designs.

Nevertheless, CCD memory designs to date have been less cost-oriented than performance-oriented, with average latencies (access times) of under 100 microseconds. It is to be hoped that the new 65-k designs will address the cost issue at least as seriously as performance. These designs should require only 30% more area than 16-k MOS RAMs and can be expected to achieve at least a third of their bit price.

What will a 65-k CCD memory look like? According to Guidry, it will probably be organized either as 16 registers of 4,096 bits or as 32 blocks of 2,048 bits decoded to a single input and output (Fig. 10). Given this organization, four addresses will be required to decode the 16 blocks to the input and output pins. While one block is being accessed, the remaining 15 will recirculate and refresh themselves synchronously with the accessed register.

Last of all, what are the prospects for bubble memories? Prototype bubble systems are already entering limited production for system evaluation, but many feel their general use is still at least three years away.

What is slowing bubbles

Cost again is the cause of the delay. Since bubble memories are slow, with access times measured in milliseconds, they must be cheap enough to compete with the lowest level of magnetic-core technology, which costs well under 1 millicent per bit. That level is beyond today's bubble chips, with their densities in the 100,000-bit range and their cost about 30 millicents per bit.

Still, progress is being made in reducing the size of bubble cells as well as in making them faster. Table 7 shows estimates made by researchers at International Business Machines Corp. of the performance and characteristics of bubble technology, both as it stands now and as it likely will be after 1980. As bubble sizes drop below 1 micrometer and bit densities move above 100 million bits per square inch, system designers will be able to fit up to 10^{10} bubble bits into a single module. □

Further reading

Here are eight feature articles, published in Electronics last year, that go into more detail about various aspects of semiconductor memories.

"Memories score new highs in speed and density," Feb. 19, p. 105.
"Enter the 16,384-bit RAM," Feb. 19, p. 116.
"Advances in designs and processes yield surprising MOS performance," April 1, p. 73.
"4-k static RAMs give fast access," May 13, p. 137.
"Dynamic I²L random-access memories compete with MOS designs," Aug. 19, p. 99.
"Check list for 4-k RAMs flags potential problems in memory design," Sept. 2, p. 103.
"Predicting the real costs of semiconductor-memory systems," Nov. 25, p. 117.
"An electrically alterable ROM—and it doesn't use nitride," Dec. 9, p. 101.

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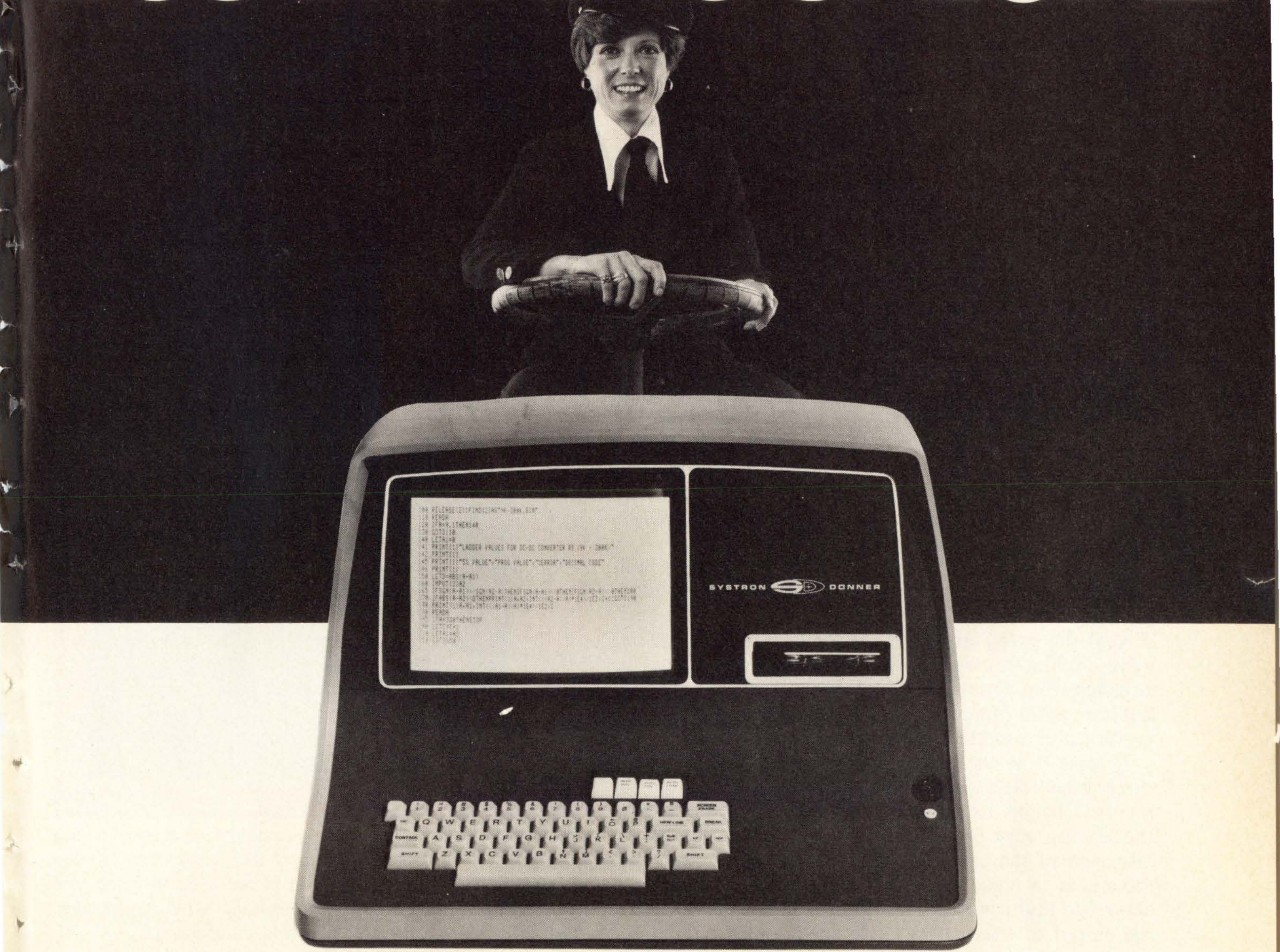

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Circle 97 on reader service card

Fast-starting gated oscillator yields clean tone burst

by Walter C. Marshall
National Oceanic and Atmospheric Administration, Seattle, Wash.

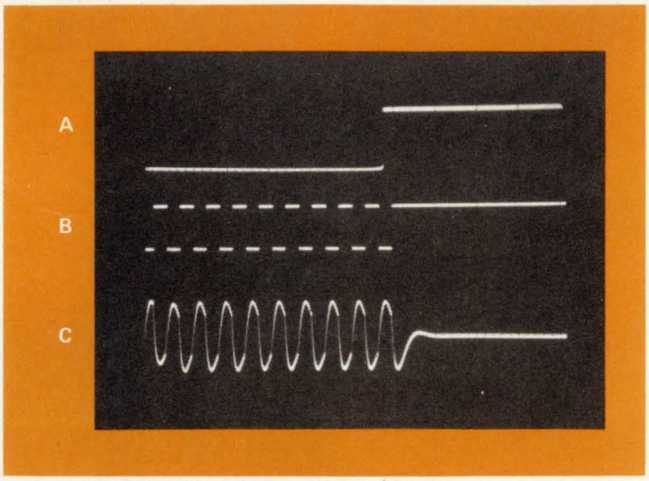
Synchronization pulses required for analyzing recorded data are usually frequency-multiplexed on one channel of a laboratory-type tape recorder. To ensure a high degree of accuracy in the data analysis, the gated tones must exhibit precise start-up and high monotonicity. This gated oscillator, which turns on with the leading edge of the gate pulse, always passes an integral number of cycles. And because the last cycle is never truncated, the oscillator produces no higher-frequency harmonics that could interfere with other decoders.

The complete gated oscillator, shown in Fig. 1, is built with only one complementary-metal-oxide-semiconductor integrated circuit, a 4011 quad two-input NAND gate. Two of the gates, labeled B and C, form the RC square-wave oscillator, which has a frequency that can be adjusted from about 4 to 25 kilohertz by varying the 10-kilohm potentiometer. The remaining two NANDs perform the discrete gating function.

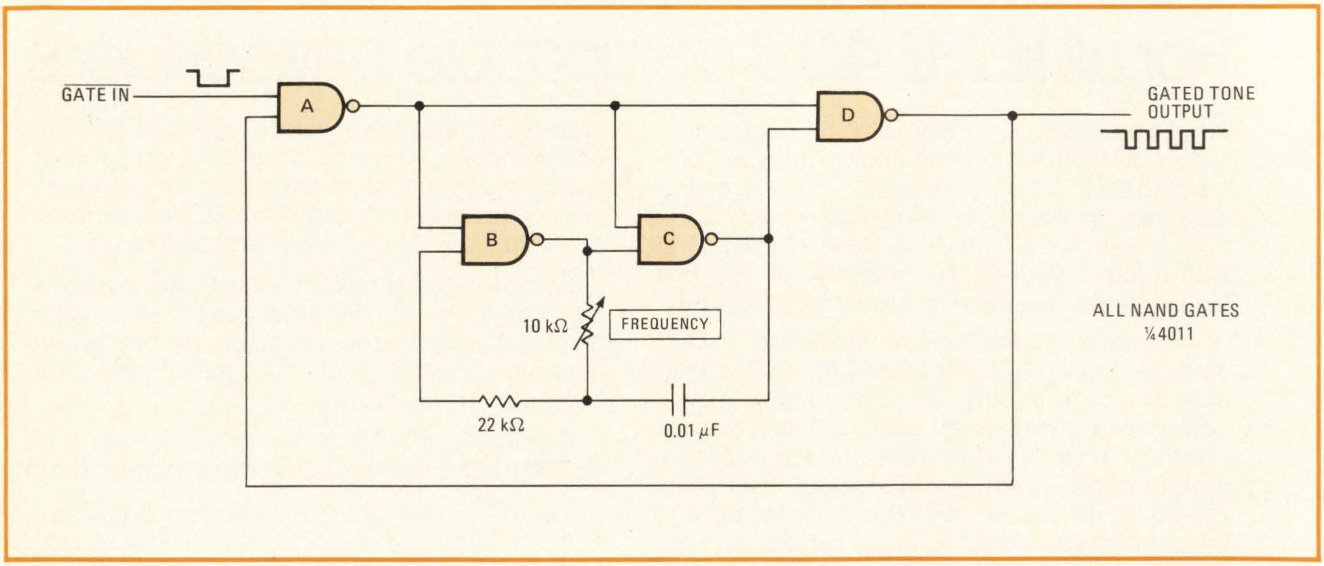
A logic 0 at the input to NAND gate A enables the three other NANDs, and thus the signal at the output of NAND D begins its voltage transition concurrently with the leading edge of the gating pulse. Truncation of the last cycle of the output signal is prevented by returning the signal to input NAND A. If the gating pulse should cease (go high) when the output of D is at a low level, the output of NAND A is unchanged, and the oscillator continues until a cycle is completed. Once the output of NAND D returns high at the end of a cycle, gate A turns off and the tone burst is cleanly terminated.

An oscilloscope photograph of the signals is shown in Fig. 2. Waveform A is the gating pulse, and B is the gated output. At the cessation of the gating pulse (positive transition), the oscillation of the output signal continues until the cycle is completed.

Waveform C is the gated output after it has been passed through a two-pole active bandpass filter to remove higher-frequency components. This tone is then mixed with other synchronization tones and applied to the tape-recorder input. □



2. No truncation. Scope photo shows trailing edge of synchronizing signals. Waveform A is the closing of the gating pulse (positive transition), and B shows completion of last cycle in gated tone output, despite closing of gate. Waveform C is the filtered burst, stripped of higher-frequency components for recording.



1. Clean tone burst. One-chip circuit generates tone burst of an integral number of cycles when gated by a negative-going input signal. Basic RC square-wave oscillator built around NAND gates B and C is adapted from RCA applications note ICAN-6267.

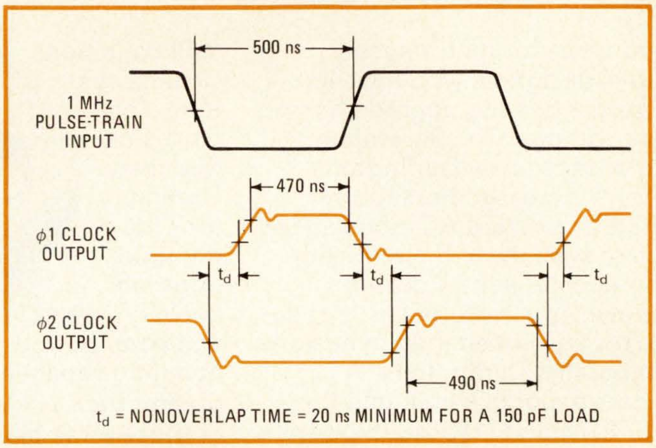
Two-phase clock features nonoverlapping outputs

by Neil Heckt
The Boeing Co., Seattle, Wash.

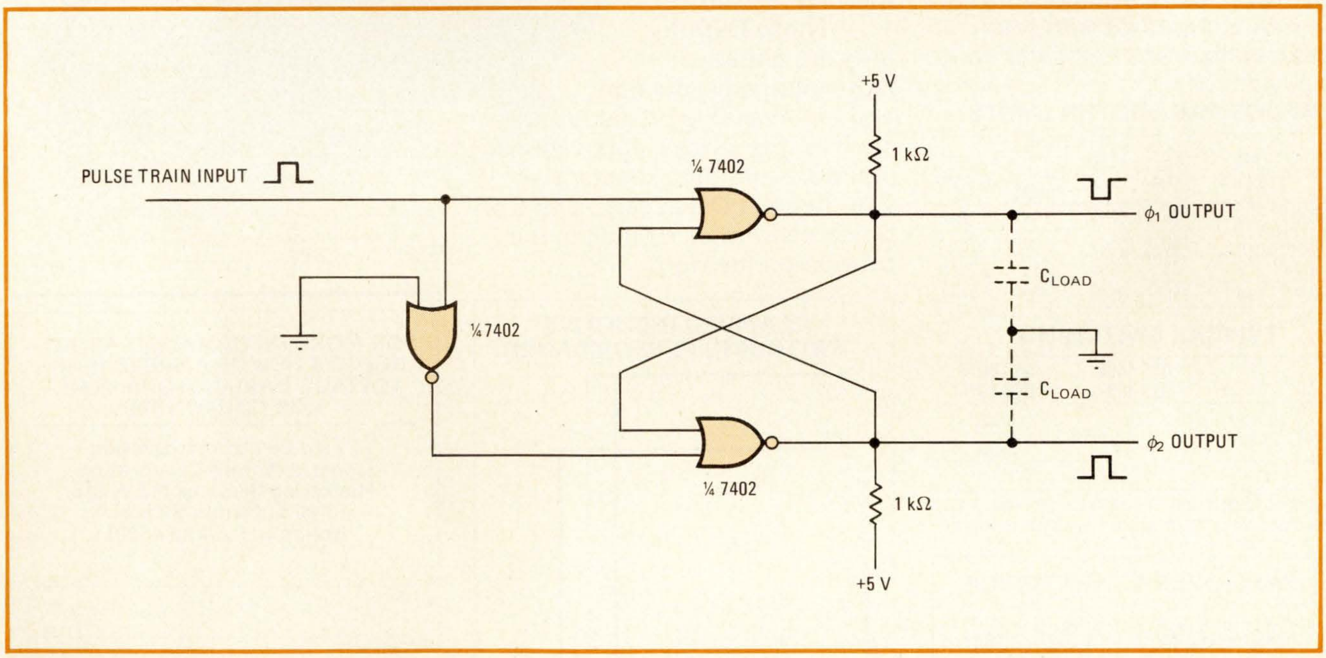
A reliable, two-phase clock signal with nonoverlapping outputs—the kind that is an absolute must for the Motorola 6800 and other microprocessing units—can easily be derived from a pulse train input. This design avoids overlap by exploiting the propagation delays inherent in transistor-transistor logic, and it uses only one integrated circuit.

As shown in the schematic of Fig. 1, a pair of two-input NOR gates in the 7402 chip are wired as an R-S flip-flop to provide the split-phase outputs. The propagation delay of the gates depends on their capacitive loading; it is typically 10 nanoseconds with a 15-picofarad load, increasing to 20 ns with a 150-pF load. As specified in the Motorola 6800 applications manual, the clock inputs of the central processing unit are capacitive, with maximum values of 160 pF but typically 110 pF.

With a 1-megahertz, 50%-duty-cycle input pulse train, this circuit produces a ϕ_1 output 470 ns in duration, a ϕ_2 output 490 ns in duration, and 20 ns of nonoverlap, as shown in Fig. 2. The duration of the nonoverlap is independent of the input duty cycle. □



2. No overlap. With a 1-MHz, 50%-duty-cycle input signal, the ϕ_1 and ϕ_2 outputs have durations of 470 ns and 490 ns, respectively. The nonoverlap, which is dependent upon the propagation delay of the gates, is a function of load capacitance and varies from about 10 ns with a 15-pF load to 20 ns with a 150-pF load.



1. Phase splitter. Simple circuit derives two out-of-phase signals from oscillator input, with outputs suitable for clocking 6800 and other microprocessors that have strict timing requirements. Nonoverlapping of outputs is constant, regardless of input duty cycle.

Diodes fix levels for composite-video generator

by Robert H. Lacy
Applied Automation Inc., Bartlesville, Okla.

A composite video waveform, suitable for driving cathode-ray-tube monitors with RS170 video-input specifications, can be generated with a circuit that uses diodes to set the luminance and synchronization voltage levels. Schottky barrier diodes in the circuit provide fast, clean pulses free of overshoot and ringing, with rise and fall times of about 12 nanoseconds.

As shown in the composite video waveform example of

Fig. 1, the circuit fixes four discrete voltage levels—sync, blanking, black, and white. Since the design is intended for displaying digital alphanumeric data on the CRT, only the two extremes of the gray scale are supplied—black and white. However, the peak level of the video signal could be clamped to 2.5 volts, for example, to provide a gray output as well.

If the display of raster lines on the screen is not desired, control of the blanking level may be omitted; however, in a high-contrast CRT, for example, the lines should remain visible, as they counteract reflections off the CRT glass. Thus blanking is needed to eliminate the retraace that appears at higher brightness settings.

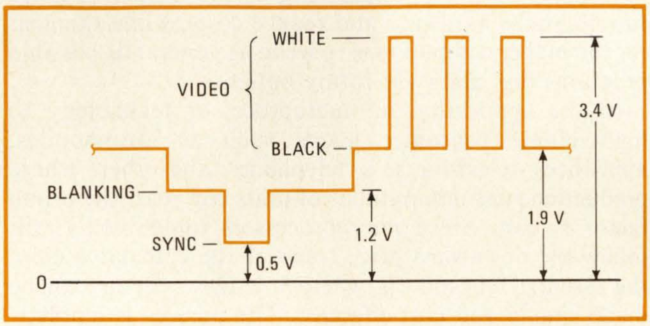
The schematic is shown in Fig. 2. The three inputs—sync, blanking, and video—are transistor-transistor-logic-compatible. Schottky-TTL inverters buffer the inputs for fast rise and fall times.

The most positive voltage, producing a white luminance level from a logic-1 video input, is established at approximately 3.4 volts by the R_1-R_2 voltage divider. The black level, corresponding to a logic-0 video input, is obtained from the 1.9-V total forward voltage drop of the two junction diodes and just one Schottky diode. The blanking and sync levels are determined by the other diode combinations, as shown in the figure.

The reverse-recovery time of the three-diode string in the video input is very fast, thanks to the Schottky diode characteristics. The rise time of the video pulses is determined mainly by the time constant of R_1 with the stray capacitance, indicated here by C_{stray}.

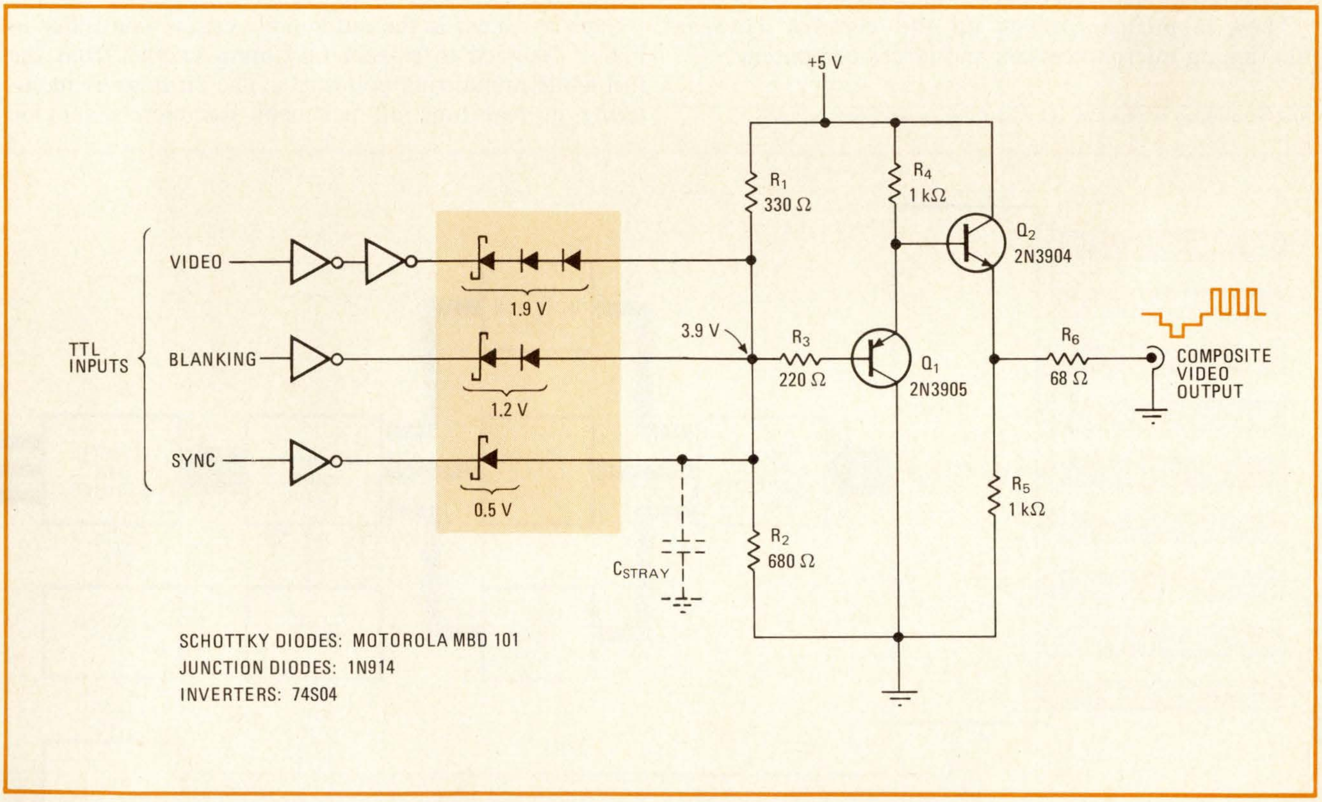
With such quick rise and fall times, the circuit is more than adequate for CRT displays of 80 characters per row. If only 40 characters per row are required, conventional silicon switching diodes such as the 1N914 may be substituted for the Schottky devices, though with a sacrifice in edge definition.

A series-complementary emitter-follower pair, made up of transistors Q_1, Q_2, and associated resistors R_3 through R_5, provides a high-impedance buffer for driving coaxial-cable lines. The 68-ohm resistor in series with the output increases the output impedance of the Q_2 follower, preventing oscillation in the event an untermi-nated cable is connected. □



1. Composite video waveform. Four voltages shown are compatible with CRT monitors having RS170 specifications. Waveform is typical of digital input to CRT, with only white and black displayed.

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.



2. Video voltage-level generator. Voltage drops across diodes determine luminance and sync levels of the composite video waveform from TTL input signals. Blanking input is needed to eliminate retrace, if raster lines are brought up. Q_1 and Q_2 followers buffer the signal for driving a standard 75-Ω coaxial line, and output is short-circuit-proof.

Four design principles get the most out of microprocessor systems

Careful attention to programing, partitioning by speed, adjunct-chip use, and networking produce more cost-effective applications

by David H. Chung, *Fairchild Camera and Instrument Corp., Mountain View, Calif.* *

☐ Imagination was the magic ingredient in the creation of the microprocessor. Now, with the architecture standardizing, imagination is even more crucial in the optimal exploitation of these devices. Often a well-thought-out microprocessor application is many times more cost-effective than a brute-force solution.

Imagination can get a big boost from careful attention to certain key aspects of design. An analysis of some outstanding applications suggests that there are four fundamental approaches to the creative utilization of the microprocessor:

- Minimizing total hardware by clever programing.
- Partitioning the system by speed requirements.
- Using adjunct medium- or large-scale-integrated circuit chips astutely.
- Arranging microprocessors in networks.

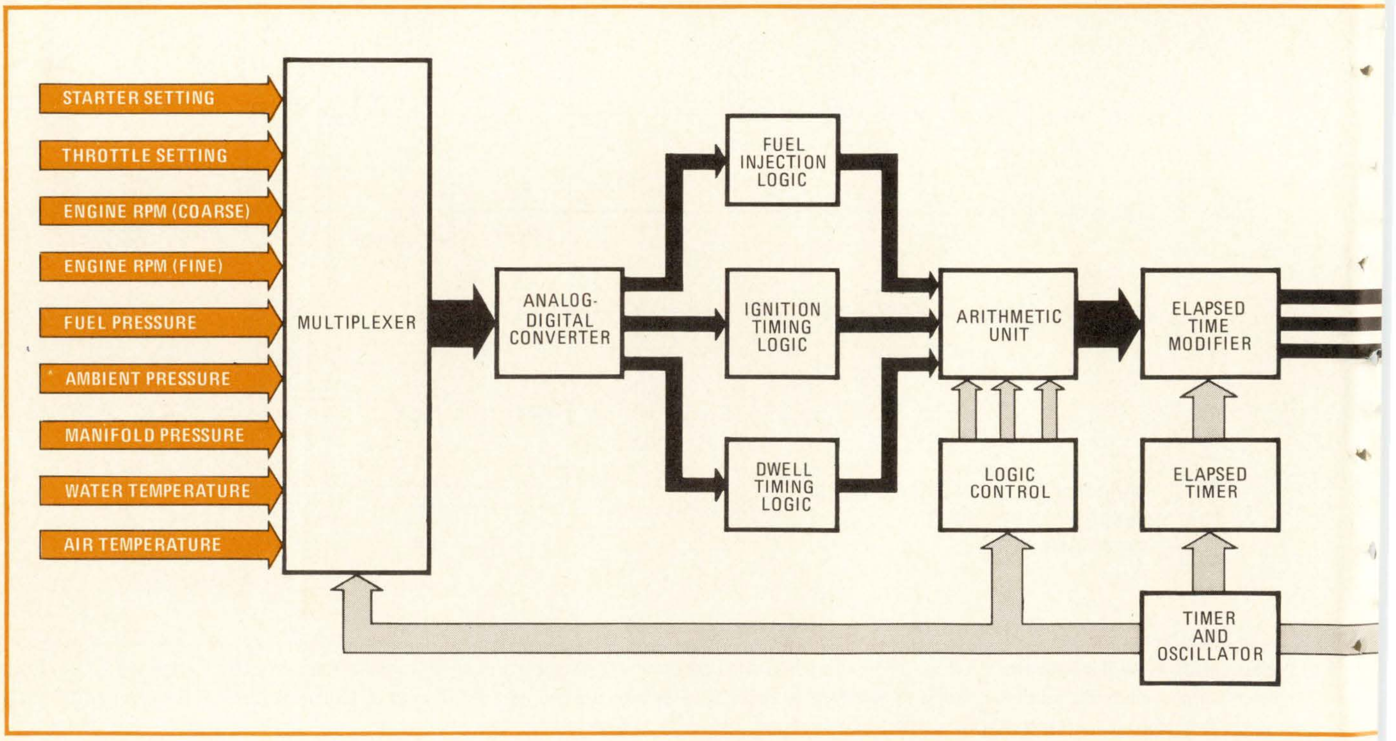
These approaches point up the contrast between programing microprocessors and larger computers: specialized software programing of the dedicated chips can minimize hardware and reduce costs, while the goal for the bigger computers is to write as general as possible programs that allow for future options.

*Now vice president of Umtech Inc., Sunnyvale, Calif., of which he is cofounder.

In the application of microprocessor technology to high-volume consumer goods such as automobiles, appliances, television sets, telephones, and others where production runs into millions of units per year, the prime factor is cost. Since microprocessors undoubtedly will follow the downward price trend of the calculator chip, the essential question is whether entire systems can be made simple and cost-effective. The answer is emphatically yes, provided that programs are efficiently written to capitalize on all the features of the processor.

Clever programing

Such a system is the automobile-engine controller in Fig. 1 designed to extract maximum energy from the fuel while minimizing pollutants. The strategy is monitoring in real time all pertinent parameters (engine



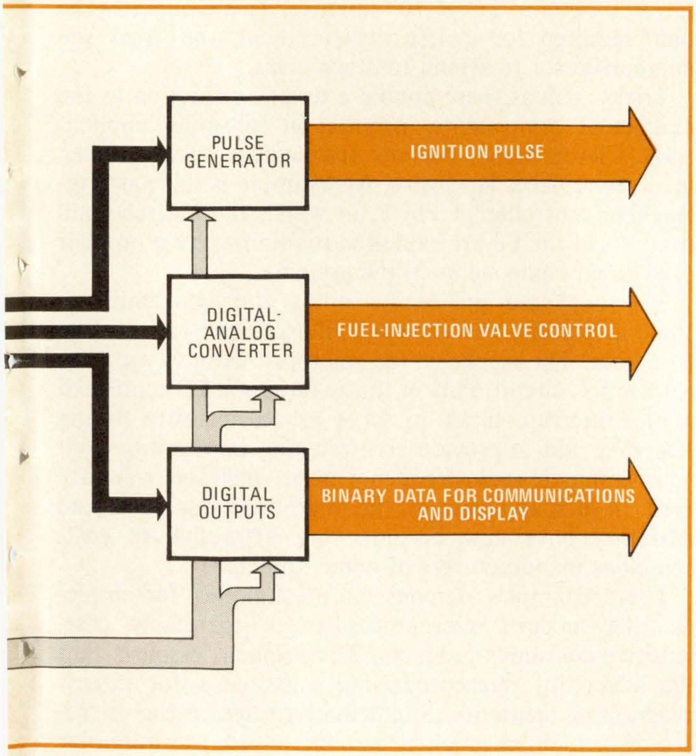
pressures, temperatures, speed, etc.) in order to arrive at the optimum gasoline-air mixture and precise instant of ignition. This process must be repeated at least 100 times a second.

The controller first multiplexes the analog inputs to permit sharing of an analog-to-digital converter. The digitized inputs go to the algorithmic portions for real-time solutions. One of these sections is for fuel injection, another for ignition timing, and the third for optimum spark energy (dwell time). All three blocks share the use of a single arithmetic unit.

These activities are coordinated by the logic control section and sent to the elapsed-time modifier, which provides the correct real-time distribution of the control functions. An elapsed timer supports the modifications. Lastly, the signals are converted to forms suitable for the driven devices: a pulse of precise timing and width is required for engine ignition; an analog signal of proper amplitude must be generated for fuel-injection control, and several digital lines for communications and display must be available.

If this concept is realized by a brute-force approach, the result could be a 200-chip system, hardly meeting the cost objective of a mass-consumer product. Use of a first-generation 4-bit microprocessor might reduce the count to the still-unacceptable level of 100, while a second generation unit can get the count down to 20. But, with a little ingenuity, a controller using the F8 microprocessor can be a four-chip system (Fig. 2). The two-chip F8 microcomputer system includes random-access memory, read-only memory, timer, interrupt hardware, and input/output ports, in addition to the traditional central processing unit.

To achieve minimum cost, the processor chips must assume analog-to-digital conversion, all computation, timing tasks, and digital-to-analog conversion. The microprocessor can perform the computation effortlessly, and a major savings in a-d and d-a circuits can be realized if pulse width is used as the intermediate analog signal at the inputs and the outputs. The most difficult task is keeping the timing under control.



Many functions must be timed simultaneously. The microprocessor must maintain elapsed time, perform a complete input/output cycle in less than 10 milliseconds, monitor the engine rotation, sample the analog input pulse widths, and generate the correct ignition time and spark pulse width. Perhaps the most stringent timing requirement is measuring the pulse widths of the analog inputs—in particular, the 200-microsecond engine pressure pulse—to an accuracy of ± 1 μs. This is a formidable task for any processor with a timer resolution of 15.5 μs and a tightest counting loop no better than 17 μs.

To accomplish all these functions, the microprocessor's role as a real-time controller must be enhanced. Several methods of enhancement have been devised, which provide valuable insight into next-generation processors.

Enhancing real-time control

First, a "timed binary-search" algorithm has been developed, which quickly resolves the high-speed pulse width in much the same manner as a sampling oscilloscope resolves a very fast waveform. In a standard sampling technique, the processor would sample the waveform every 17 μs, adding a time skew of precisely 2 μs with each "look," in the form of a NO-OP instruction. The information for a complete picture of the waveform would then be given after about a hundred samples.

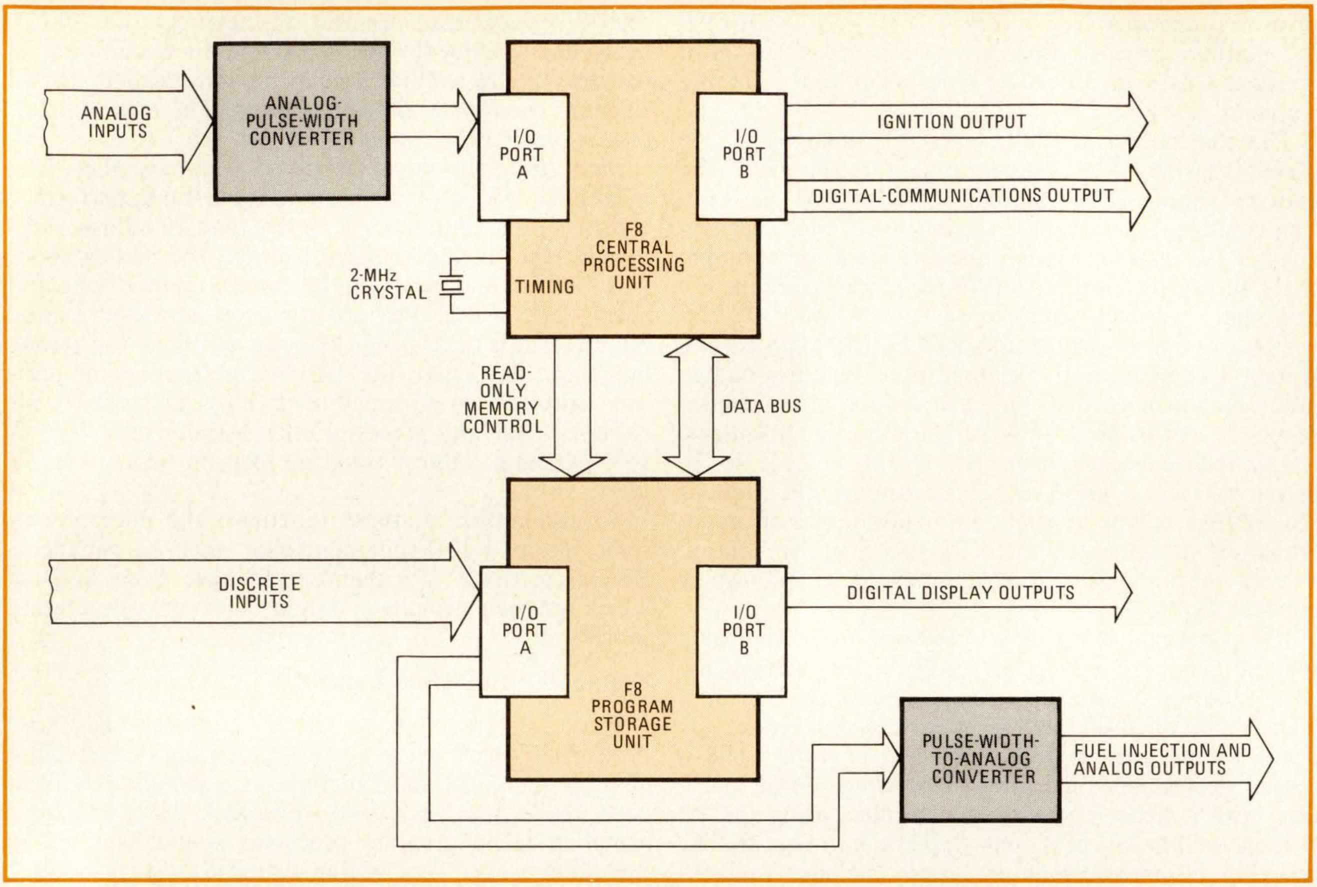
This process is greatly speeded by using a standard binary search technique, in which the skew is added in binary multiples of 2 μs—17 + 8 μs, then 17 + 4 μs, and so on—resolving the pulse width to ±1 μs after just a few looks.

Second, a method has been devised for greatly improving the accuracy of the interrupt, which can occur randomly during any instruction. This method of registering the instant of interrupt improves timing accuracy by a factor of almost 10. The interrupt routine is able to determine exactly the variable time delay between the instant the interrupt occurs (during an instruction that must be completed) and the time it is activated. It is the precision of the time skew that determines the overall timer resolution.

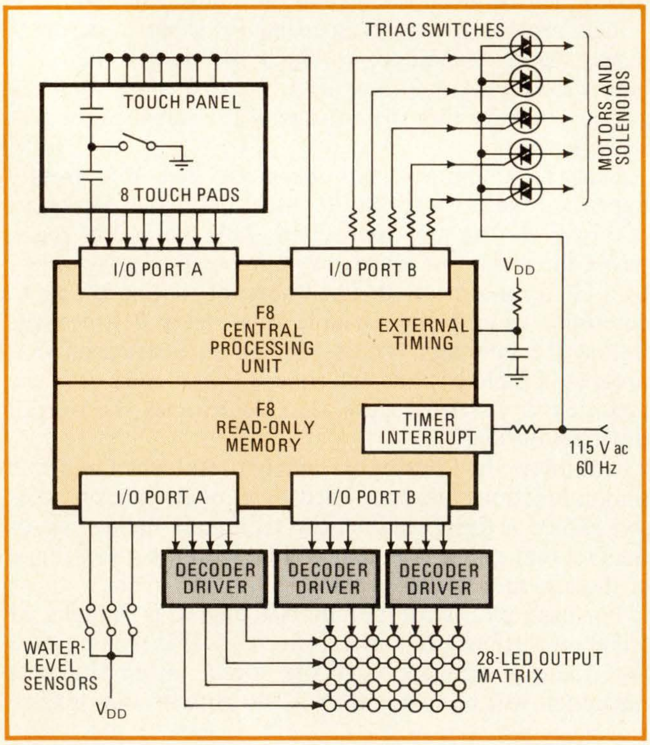
A third method proves extremely useful when multiple timing functions are controlled by a single microprocessor. Called a time window, the technique makes use of the fact that a measurement will be within a given range of the last such measurement.

For example, if the automobile engine is running at 5,000 revolutions per minute, mechanical inertia ensures that there is no possibility the speed within the next revolution will be faster than 5,500 rpm or slower than

1. Automotive controller. The large number of input and output variables, as well as the complicated sequencing of real-time events, detail what seems to be a microprocessor system with extensive hardware, if not a difficult programing task for a minicomputer.



2. Four chips. With clever programing, one example of which is using pulse widths as intermediate analog signals at inputs and outputs to avoid expensive analog-to-digital conversion, the engine controller is implemented with only a four-chip microprocessor set.



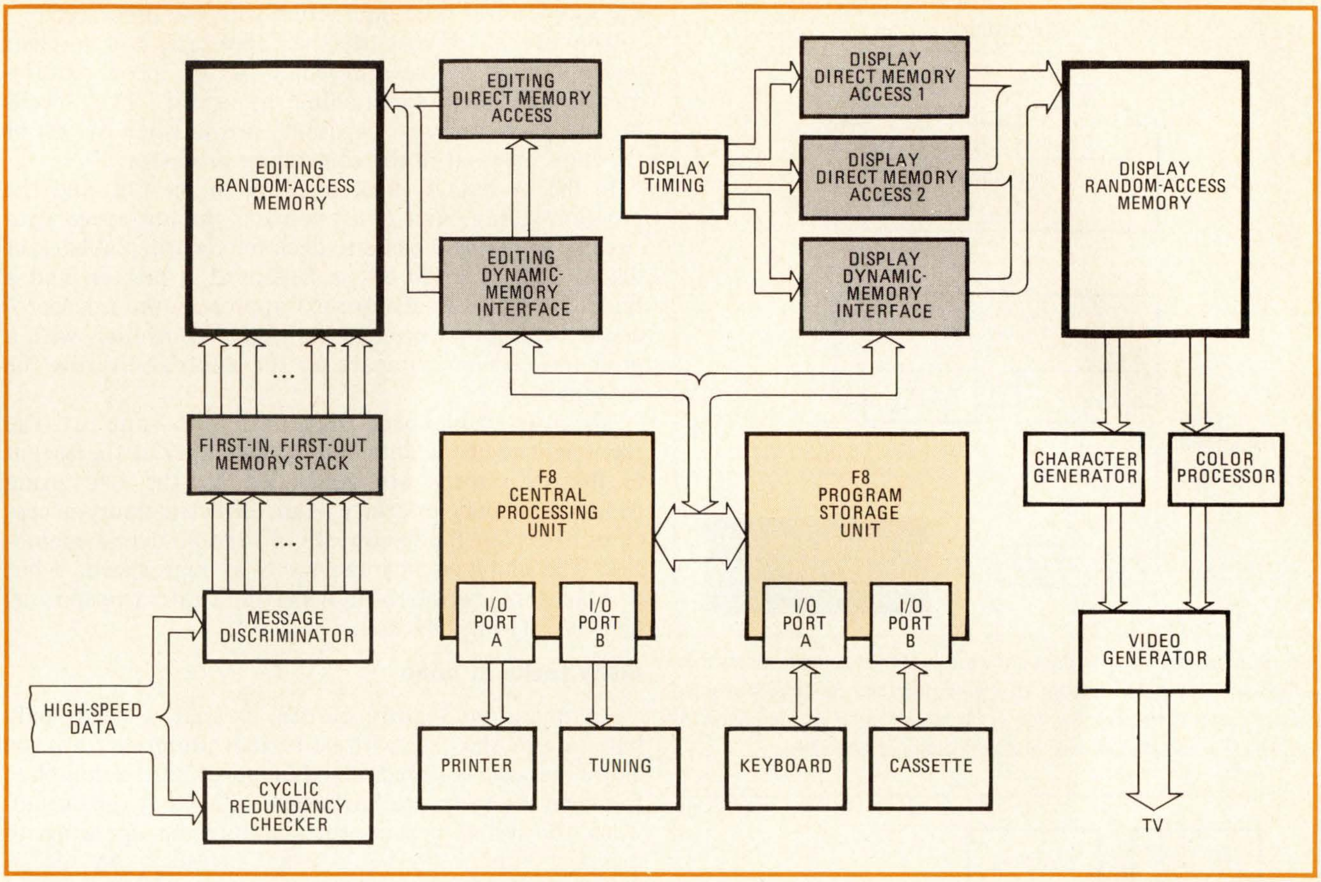
3. White goods. For the microprocessor to break into the home appliance field, hardware must be reduced to a bare minimum. Exploiting the bidirectional input/output ports of the F8 microprocessor slashes the chip count to two.

4,500 rpm. The processor can monitor engine speed quickly through a time window having a width at most 10% greater than the period of the last revolution, or $1.1 \times 1/5000 = 2.2 \times 10^{-4}$ minutes. This eliminates the time required for coarse measurement and frees the microprocessor to attend to other tasks.

Tricks such as these enable a drastic reduction in the number of components, essential in consumer applications. Clever design permits tremendous savings when software replaces hardware. An example is the washing-machine controller in Fig 3, in which the bidirectional I/O ports of the F8 are exploited to minimize the number of external components in the system.

The touch-pad and sensor inputs, the light-emitting-diode indicators, and the controlling outputs all use the port lines. The clock for the microprocessor is an inexpensive RC circuit. Part of the ac line signal is connected to the interrupt input to serve as an accurate timing reference and to provide zero-crossing information that helps eliminate radio-frequency noise when the triacs are fired. In such applications, the microprocessor's cost and flexibility have now become very attractive to cost-conscious manufacturers of home appliances.

These examples demonstrate techniques for implementing modern microprocessors in extremely cost-sensitive consumer products. The implicit lesson is that the advent of microprocessing units calls for a new programing mentality: to efficiently program the microprocessor to do as much as possible in order to minimize



4. High-speed control. Microprocessors can handle high-speed data streams, as in this TV data system, when direct-memory-access and dynamic-memory-interface chips, under control of the CPU employ random-access memories as high-speed, 8-bit parallel shift registers.

the total hardware that is used in the system.

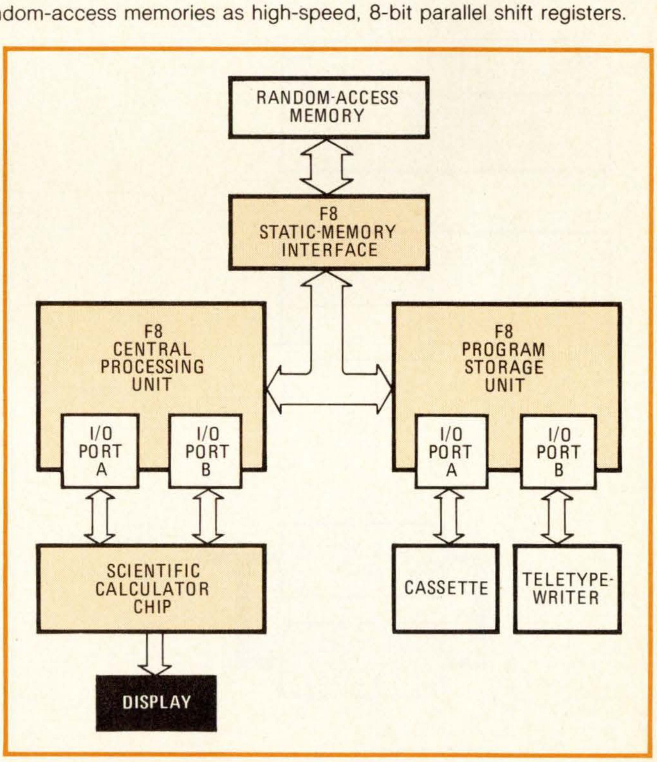
It is popularly believed that metal-oxide-semiconductor microprocessors cannot handle high-speed data streams—rates from 9,600 bits per second to 10 megabits/s. But if the different speed requirements are separately controlled by software, a microprocessor-based system can handle just such data streams.

Partitioning by speed

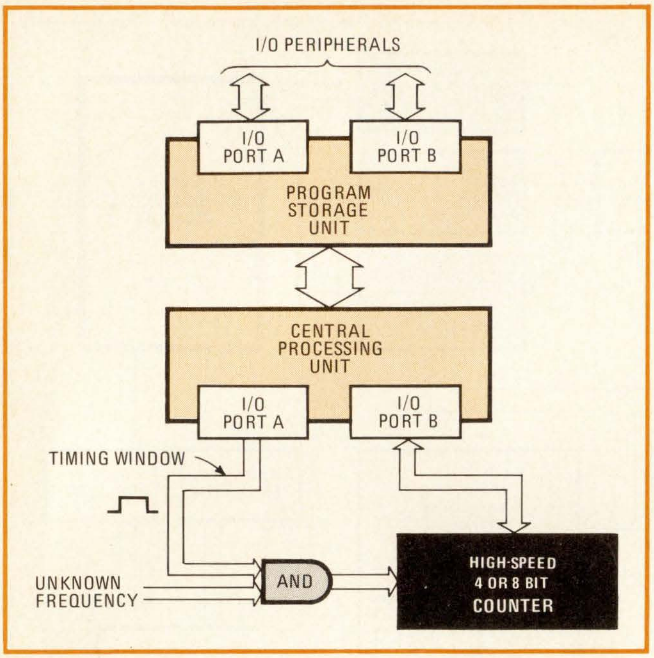
Figure 4 shows a TV-based data system that permits a subscriber to select a number of real-time news items to be displayed on his set—stock transactions, sports results, weather, etc. Some data is transmitted over the telephone line at a rate of less than 9,600 b/s, but most of it is carried by an ordinary TV transmitter or cable-TV system at 5 to 10 megahertz.

With a little help, a single microprocessor is capable of intercepting the correct messages from the very fast data stream, checking the data integrity on the fly, editing it, and displaying it in color on a home TV set. The processor coordinates these principal functions and executes printer- and cassette-control and tuning.

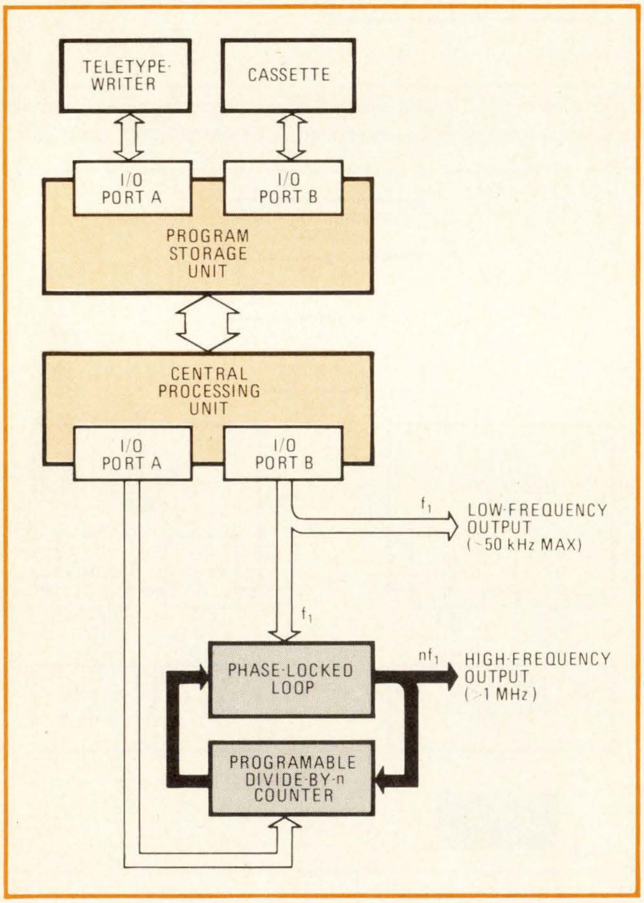
It is essential to recognize that a modern microprocessor chip set is capable of handling two different types of I/O data streams with quite different characteristics. It can control low-speed (up to 10 kilohertz) data streams requiring bit-by-bit manipulation by the central-processing unit. It can control high-speed (up to 10 MHz) data streams requiring proper timing and buffering but



5. Simple Basic compiler. A minimum-hardware system for compilation and execution of Basic language programs uses only three microprocessor chips—the central processing unit, program storage unit, and static-memory interface—and a scientific calculator chip, which can drive a light-emitting diode display.



6. Fast counter. The powerful software of a microprocessor permits a high-speed bipolar counter of only a few bits to quickly resolve closely spaced frequencies for applications such as detection of frequency-modulated signals and multichannel decoding.



7. Wide-range synthesizer. Although the microprocessor can synthesize frequencies only up to 50 kilohertz, using a phase-locked loop with a programable divider under software control permits generation of frequencies up to several megahertz.

no complex real-time interaction with the processor.

The key to a cost-effective application is a clear understanding of the different types of speed requirements, and then partitioning by speed. The speeds beyond microprocessor capability are satisfied by MSI or LSI chips external to the controlling processor.

In the TV data system, software in the CPU and the program storage unit (PSU) controls the low-speed data stream, including a cassette deck for record/playback of digital data at 1,800 b/s, a keyboard, a printer, and a tuner. By using a software-I/O approach, the microprocessor becomes a universal peripheral controller, with a profound economic impact on the affordability for the consumer.

The two high-speed data streams—one at the receiving end of the data system, the other at the output to the TV screen—are controlled by the CPU using dynamic-memory-interface and direct-memory-access chips to exploit the bandwidth of random-access memories. The chips employ the RAMs as high-speed, 8-bit, parallel shift registers, allowing data-rate transfers as high as 1.33 megabytes/s.

Many tasks at once

An important feature of DMA is that it needs only initiation by the CPU, with no further attention until the entire message is stored at the input, or until a complete frame on the TV screen has been displayed at the output. Thus, the system permits the simultaneous operation of message input to the editing memory, TV-screen refreshing from the display memory, and computation. In addition, the CPU has access to all three memories (editing, display, and the ROM in the PSU) and is able to coordinate input and output data with the instructions programed in the PSU. These features greatly reduce system cost while maintaining flexibility.

Since the microprocessor is not capable of complex interaction with high-speed data streams, the strategy is to build simple adjunct circuits. For example, the function in Fig. 4 called message discrimination must constantly monitor the input data stream to determine if a message is part of the selected subject. If the selection is, say, stock quotations, the discrimination function allows only this message to enter the editing memory.

Discrimination is readily realized by a shift register loaded by the CPU whenever a new subject is selected. The shift register's contents (the code for the selected message) are compared with the header of the incoming message to determine whether it should be entered in the editing memory or ignored, thus permitting message checking on the fly and greatly relieving the software burden.

This example shows how a clear insight into speed requirements leads to cost-effective microprocessor-based solutions to many high-speed problems. The standard processor chip set and RAMs can satisfy most of those requirements. In some cases, an optimal configuration of *ad hoc* hardware must be added, typically in applications such as floppy-disk and magnetic-tape controllers, communications-concentration demultiplexers, and video games.

Enhancing the microprocessor can be extended from use of a simple shift register to a number of MSI or LSI chips that perform discrete functions in a cost-effective manner. Figure 5 shows a system capable of compiling and executing Basic language instructions implemented with only three F8 microprocessor chips and a scientific calculator chip.

Basic statements are entered via the teletypewriter into the PSU. The CPU performs the syntactical verification and object-code compilation and stores the program in RAM. The power of the calculator chip, slaved by the CPU whenever a numerical computation is required, affords the system great performance at very low cost.

Besides providing multiple-precision scientific calculations, the modern scientific calculator chip includes several storage and manipulative commands that aid the microprocessor in compilation and execution. With minimum hardware, this system has excellent I/O capabilities—it interfaces to both a TTY and magnetic cassette deck, and, if necessary, the calculator chip can drive a LED display.

Using adjunct chips

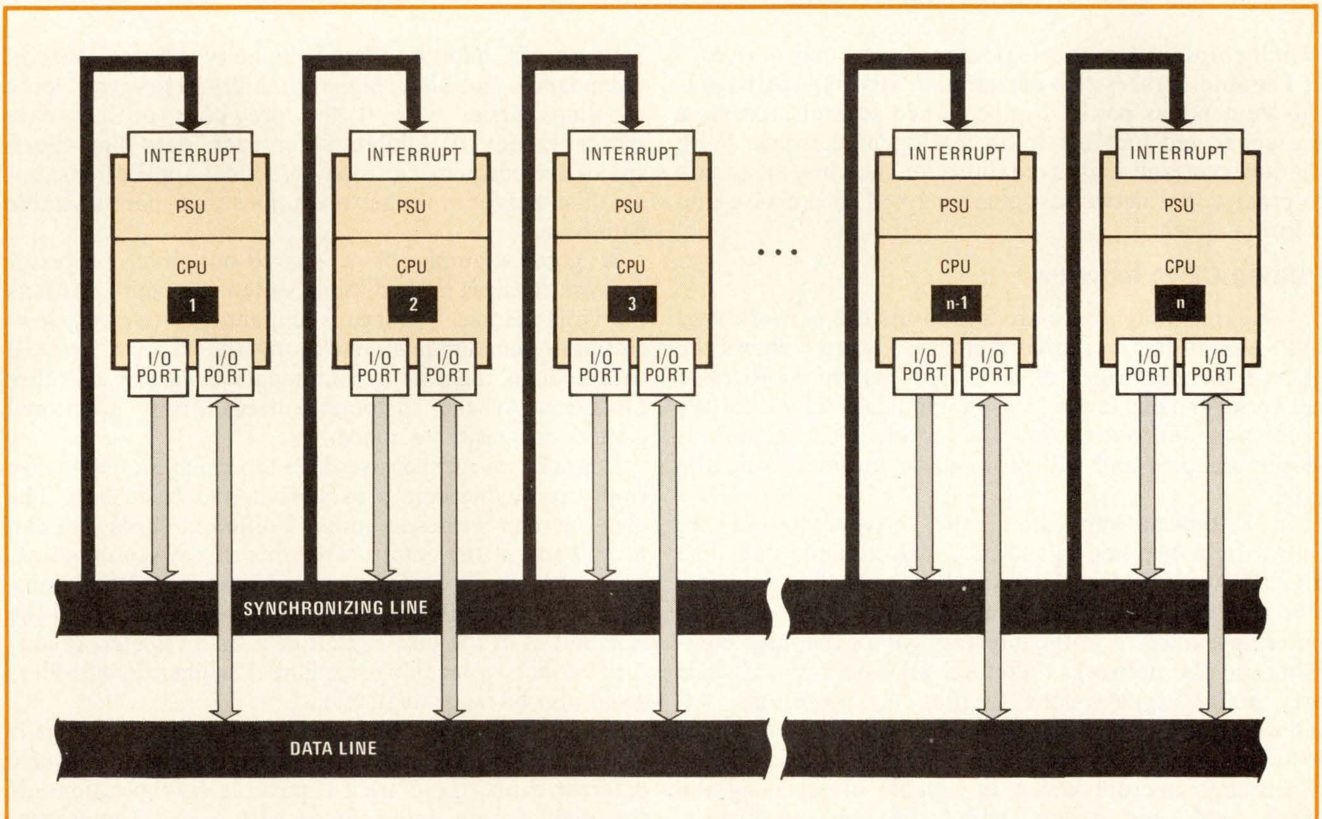
Augmenting a two-chip microprocessor system with a fast bipolar modulo counter of only a few bits enables high-resolution measurement of unknown frequencies (Fig. 6). Such a system is useful in applications like multichannel TV remote-control systems, detection of digitally-coded frequency-modulated signals, or any decoding operation where there are many closely-spaced frequencies to be resolved.

The microprocessor generates various timing windows that permit the unknown frequency to advance the counter. At close of each window, the CPU interrogates the contents of the counter and, depending upon the frequency and the required resolution, adaptively generates a recursive set of timing windows to impinge on the unknown frequency. Again, the use of a binary search will greatly accelerate the resolving process.

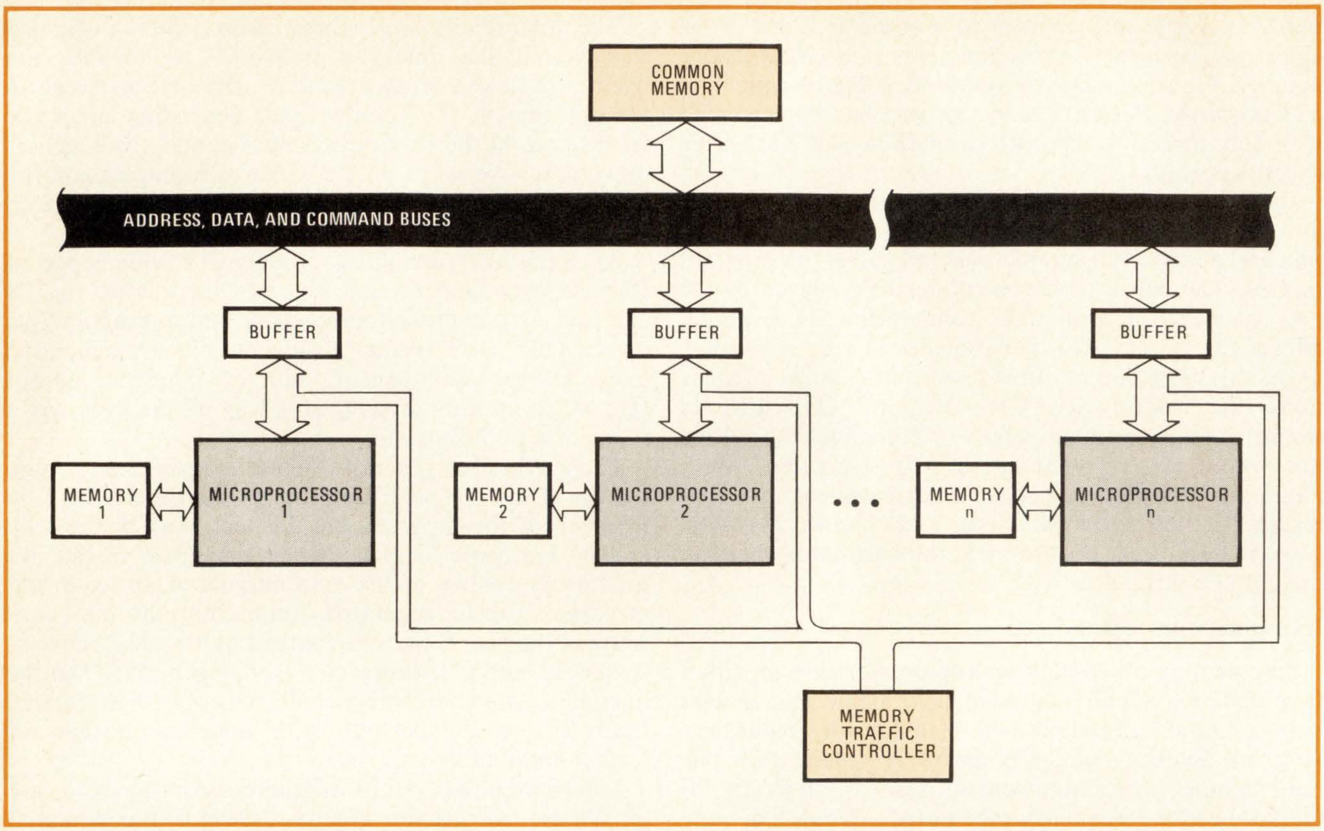
A synthesizer capable of producing a wide range of frequencies is built around four principal chips: the F8 CPU and PSU, a phase-locked loop, and a programable divider (Fig. 7). The square-wave outputs are generated under software loop control. The low-frequency output (f_l), which appears directly at a port on the CPU, has a range of 0 to 50 kHz.

The synthesizer generates higher frequencies through the use of the PLL, which multiplies frequencies both by insertion of the programable divider ($\div$n) in the loop and by harmonic locking. When these two modes are used under control of the CPU, outputs of up to several megahertz can be generated, limited only by the bandwidth of the PLL. If the CPU controls a DMA chip, the low-frequency output could reach a few megahertz. Then the microprocessor conceivably could control PLLs assembled from discrete components with upper limitations of several hundred megahertz.

Enhancing the power of microprocessors by clever use of MSI or LSI circuits greatly broadens the potential market for microprocessors. Other chips that serve as useful adjuncts include timers, first-in/first-out stacks,



8. Shared-bus network. Connecting microprocessors together through a shared communications bus affords the most loosely coupled and probably the most useful form of network arrangement. Each microprocessor has its own memory and functions independently, but can communicate with others over the data line when flagged through an interrupt routine via the synchronizing line.



9. Shared-memory network. For multitask operations that share a sizeable data base, arranging a network of microprocessors to share data of global interest is most practical. Each microprocessor is autonomous—its primary memory enables it to execute programs independent of the others. A traffic-controller resolves conflicts in accessing the common memory.

watch chips, arithmetic/logic units, and other devices.

The microprocessor's outstanding attribute perhaps is the tremendous power attained when several processors are connected together in an intelligent network. With the low cost and high availability of the chips, it is safe to predict that network engineering will soon evolve into a formal science.

Putting CPUs together

Fundamentally, there are two forms the network may take: shared bus or shared memory. Figure 8 shows the general configuration of a shared-bus microprocessor network. The bus serves as a communication line, but the processors can operate on their own. This network is loosely coupled and will prove to be the more versatile type.

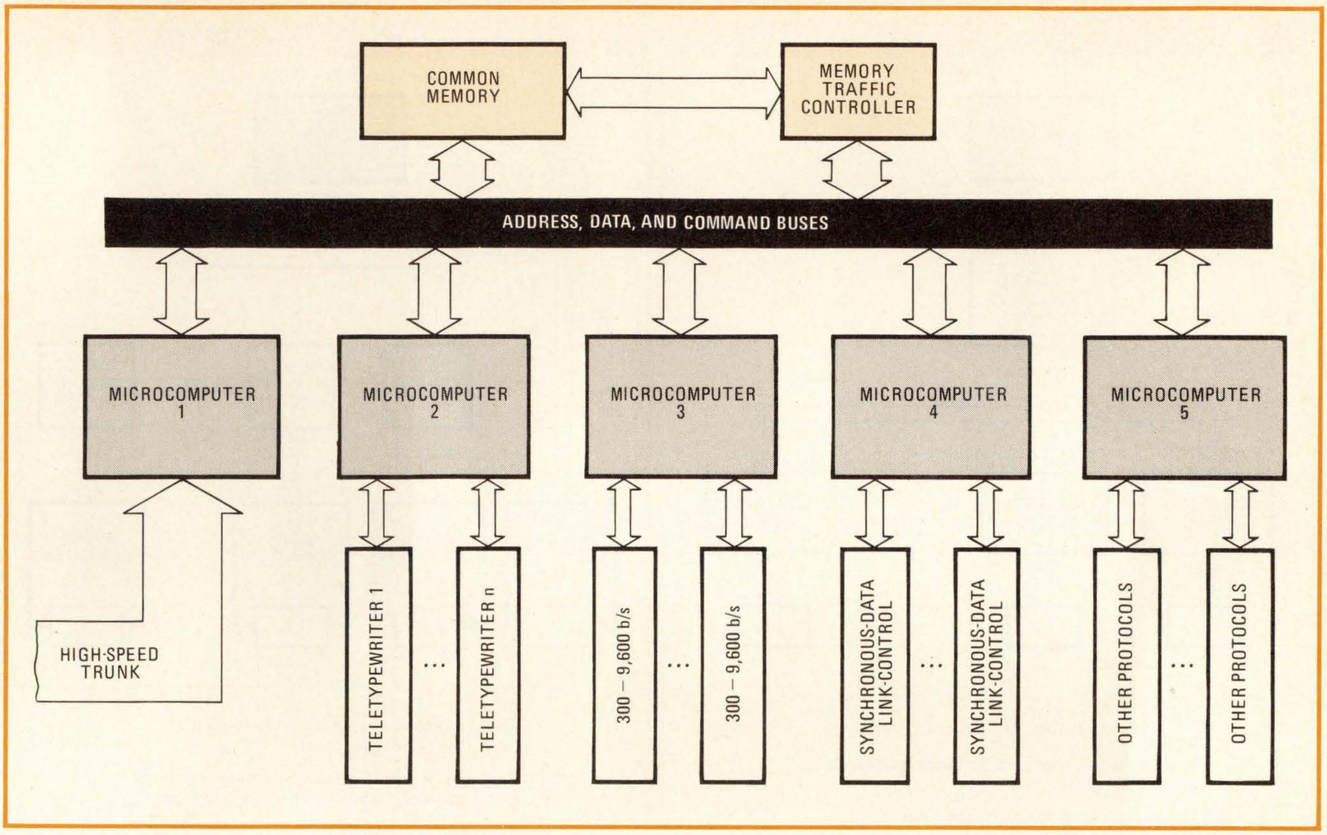
In a typical application, the microprocessors are linked by a two-line bus—one a bidirectional data line and the other a synchronizing line to strobe the data. The sync line, controlled by the transmitting microcomputer, is connected to the interrupts of all the microcomputers in the network; therefore, all data transmissions are totally asynchronous to the CPU operations. All uninterested computers may disable their interrupt lines to avoid program disruption, save for a message protocol. Since each microprocessor is capable of receiving the check fields and understanding the message format, reliable message transmission and reception is assured.

The hardware simplicity and modularity afforded by the two-line bus permits easy expansion of this type of network. In addition, bus simplicity allows low-cost redundancy and thus high reliability. However, loose coupling carries with it the drawback of low data speeds—about 10 kilobits/s for each data line. Such speeds are adequate for many practical applications, but are ill-suited for multitask operations that share a sizable data base.

A good example of a shared-bus microprocessor network involves an ambitious system concept known as the Trojan Horse. The idea is to manufacture a very low-cost basic function in an enclosure (the "Trojan Horse") with enough room to accommodate a variety of other functions. As the customer's needs grow, additional circuits can easily be added.

Consider an inexpensive desk-top calculator with five empty printed-circuit card slots in the basic box. The manufacturer wishes to build 12 different cards that can fit into any of the empty card slots in any combination. The cards could provide various computing functions, such as engineering and accounting, or could extend the capabilities of the unit to that of a cash register, credit-card verifier, or teaching machine. Peripheral controllers could also be made available.

While this product is a marketing man's dream, it is an engineering nightmare. With five slots and twelve different cards, there are 13^5 possible configurations. If the product were implemented with a single microprocessor, the problems with software, field engineering, and documentation—to name only a few—would have been insurmountable.



10. Reduced line cost. A communications concentrator/demultiplexer combines many low-speed communications links into a high-speed trunk for transmission, then demultiplexes to recover the original protocols at the receiving end. If a shared-memory microprocessor is used, the throughput is n times greater than the previous multiline system, where n is the number of microprocessors in the network.

The shared-bus concept can make the product viable: every card must contain an autonomous microcomputer system. When the basic calculator receives a job request from the user, it sends out a message via the two-line communication bus. The intended computer will acknowledge the message and carry out the command. If the intended card is not in the system, the calculator will note the lack of response and will notify the user. This highly modular system allows easy field maintenance and is applicable to human-oriented systems, such as point-of-sale terminals and dedicated calculators.

Scanning with software

Another striking application of the shared-bus network involves the replacement of an expensive sensor system with the computing power of a microprocessor network. Present airborne-communication systems employ a very costly scanning antenna controlled by an equally expensive computer. The design specifications of the antenna are extremely demanding, yet it must scan the horizon as commanded by the computer in a slow, closed-loop mechanical system.

If this system is supplanted by a large number of low-cost stationary antennas, each with a dedicated microprocessor and all sharing a communication bus, a lower-cost system with enhanced capabilities results. Reliability is increased many times since there are no moving parts, and the system is necessarily much faster.

Multitask operations with sizable amounts of data are best implemented by the second type of microprocessor network, the shared-memory setup (Fig. 9). Since each constituent microcomputer has its own primary memory, it can execute its program without having to wait for the others. The data of global interest can be written into or read from the common memory, permitting efficient data exchange between any two members. Wiring through the common buses (address, data, and command) is in daisy-chain fashion. A memory traffic controller resolves any conflict that might arise from simultaneous requests for use of the common memory.

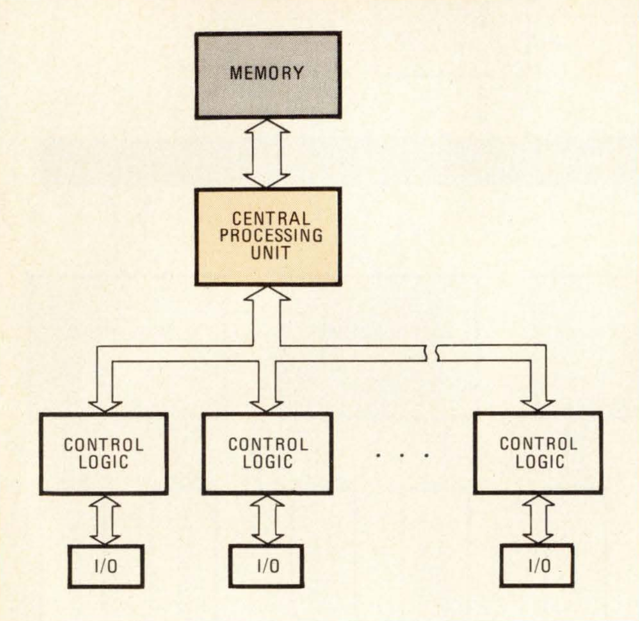
An orderly method of communication between any two microprocessors in the network can be instituted by an algorithm establishing a mailbox. Certain memory locations are used as a dedicated command depository (hence "mailbox") between any two specific microprocessors. They occupy very little memory space, because only pointers are needed to complete a dialogue.

Short-distance star

The number of lines required for the address, data, and command buses ranges from 30 to 50. Since most memory signals are time-critical, this type of network is unsuitable for distribution over long distances. However, for handling large amounts of high-speed data, such a setup should be considerably cheaper or far more cost-effective than a single-processor system. The table on the next page compares the two types.

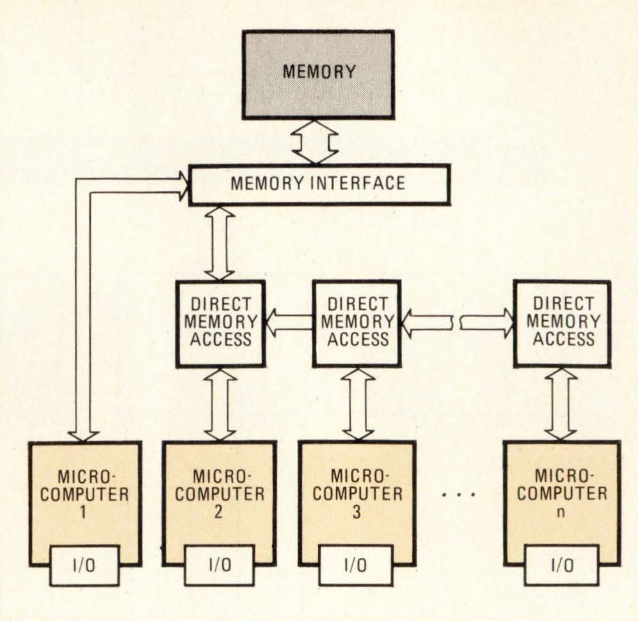
One example of a shared-memory network application is a small business computing system, such as a key-to-diskette. Microprocessors were first implemented as low-

SINGLE MICROPROCESSOR SYSTEM



1. Difficult to expand the system in hardware
2. Difficult to extend the software to include more functions
3. Memory access through single port
4. Expensive minimal system
5. Different control logic for each subsystem
6. Difficult to integrate and debug
7. Demands high rate of interrupt response
8. Costly (many different parts)
9. No modularity
10. Incompatible with low-cost MOS technology

SHARED-MEMORY MICROPROCESSOR NETWORK



1. Easy to expand the system in hardware (using the same basic chips)
2. Easy to extend the software because it considers each additional subsystem a storage register
3. Two ports per memory
4. Low-cost minimal system
5. Same parts in each subsystem
6. Easy to integrate and debug
7. Does not require high rate of interrupt response
8. Cost-effective by using fewer of the same parts
9. Total modularity in hardware and software
10. Compatible with low-cost, highly reproducible MOS technology

cost substitutes for minicomputers, and the results of using a single microprocessor to coordinate all hardwired I/Os were disastrous. However, the F8 microprocessor is structured as an I/O controller, and as such lends itself well to a shared-memory network when DMA chips are employed. The I/O devices in this type of system typically include a cathode-ray tube, diskette, printer, magnetic tape, keyboard, and modem.

Concentrating low speed to high speed

A communications concentrator/demultiplexer using a shared-memory microprocessor network is shown in Fig. 10. The goal was to reduce the line cost by concentrating many low-speed communications links into a single high-speed trunk at the sending end and recovering the original protocols at the receiving end.

The microcomputers share a global memory, and, in this system, the tasks are clearly partitioned. Again, all microcomputers are autonomous, and hence are operating simultaneously irrespective of the others. The throughput of the network is amplified by a factor of n, the number of microprocessors used.

Microcomputer 1 is the coordinating microcomputer of the network. It controls the high-speed trunk, carrying on a continuing dialogue with the other microcomputers through the mailbox procedure and administrating the use of the common memory to all other microcomputers through the memory traffic-controller.

The other microcomputers have assigned jobs—for example, microcomputer 2 handles all the TTY signals, translating them into the protocol of the high-speed trunk on sending and back into the TTY protocol for receiving. In addition, it must perform a host of routine tasks, including data integrity assurance, retransmission, code conversion—all the functions expected of a concentrator. Microcomputers 3 through 5 must perform these tasks for the different communications protocols.

The network's inherent modularity permits functions to be added and deleted easily. For important transmissions, the setup can include a redundant microcomputer to double-check results and act as a standby. But its key advantage is the low cost, attributable to two savings: the low cost of standard microprocessor chips and the modular software. □

Input capacitance feedback improves neutralization

by Martin V. Thomas
Boston University Medical Center

The conventional method of neutralizing input capacitance of an amplifier with positive feedback can be improved by using the amplifier's actual input capacitance as the feedback element. This may be done with a circuit that uses a floating power supply.

The benefits are not only a greater reduction in effective input capacitance, but also a reduced feedback requirement. In turn, since positive capacitive feedback essentially increases the high-frequency gain of an amplifier, less of it means lower amplifier noise and a reduced tendency toward oscillation.

Neutralization is particularly needed for measuring signals from high-impedance sources. For example, with a source resistance of 10 megohms and an amplifier input capacitance of 5 picofarads, a signal bandwidth of only 3 kilohertz is permissible. With this circuit, however, up to 10 pF of source capacitance can be neutralized to an effective value of less than 1 pF when the source resistance is 10 megohms. If the source capacitance is negligible, the amplifier's effective input capacitance can be further reduced to 0.5 pF or less.

Using feedback to neutralize capacitance yields a reduction, in general, to:

$$C_{eff} = 2(C_T/2\pi f_{bw}R_s)^{1/2}$$

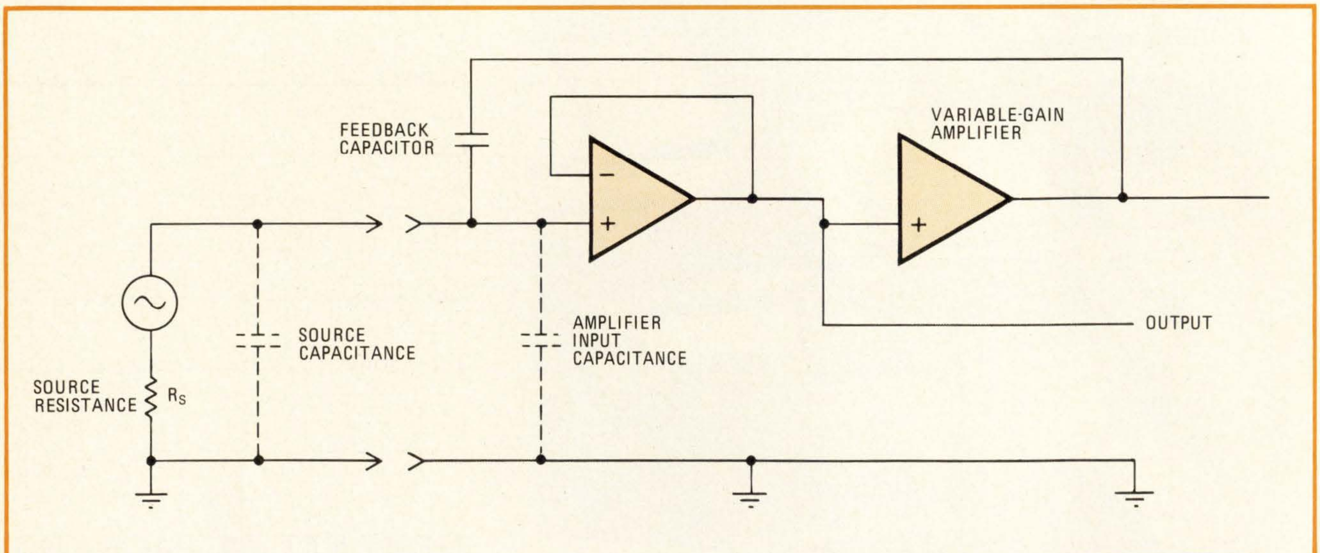
where R_s is the source resistance, f_{bw} is the amplifier's −3dB bandwidth, and C_T is the total capacitance.

In the conventional neutralization method C_T would include three components: source, amplifier input, and feedback capacitance as illustrated in Fig. 1. Using the improved method, however, eliminates the feedback component (since it is actually the amplifier's input capacitance) and results in a lower C_T, and thus a lower C_{eff}. A hidden advantage, as already noted, is that less feedback than in the conventional method is required, which lends itself to circuit stability and decreased noise.

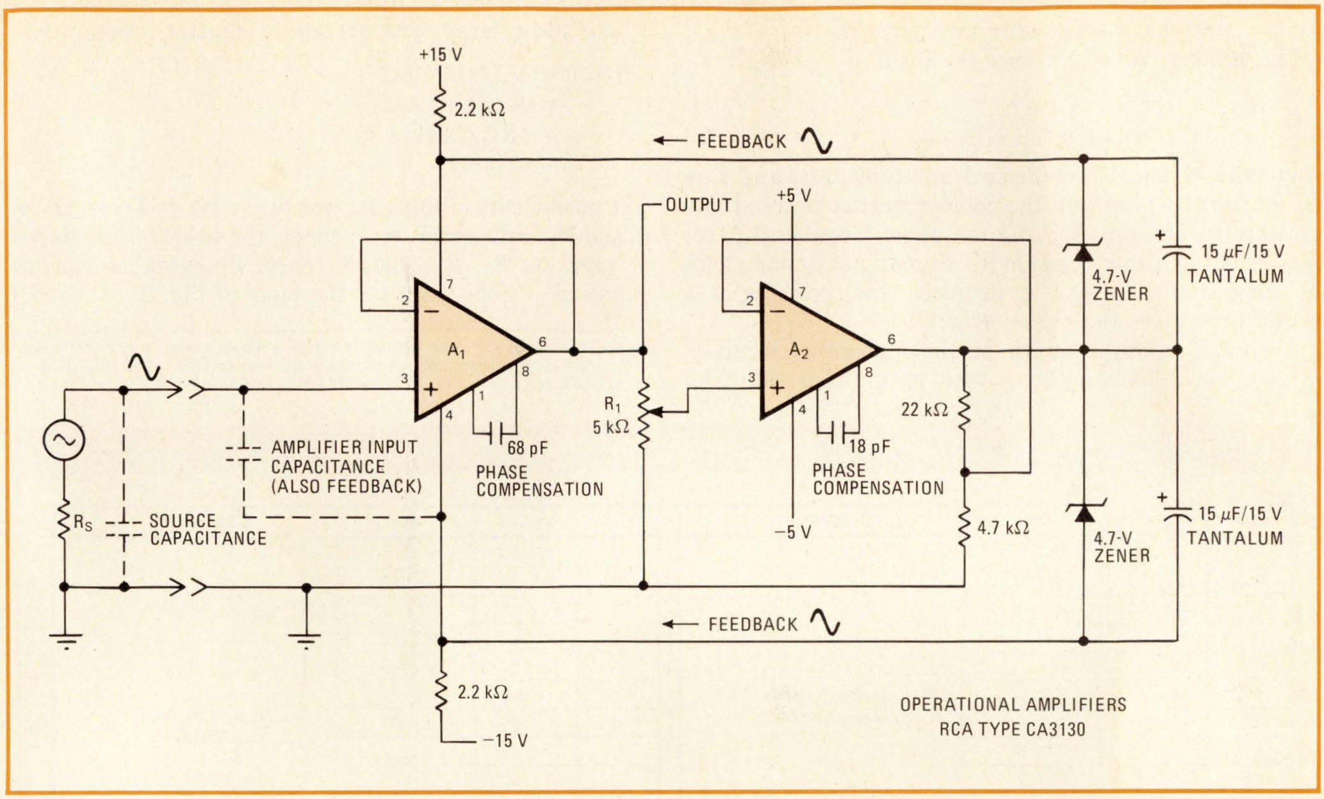
Figure 2 shows there is no discrete feedback capacitor in the input amplifier (A_1) circuit. The bipolar power supply for the input amplifier is floated with respect to ground, and the compensation (feedback) signal is actually superimposed on the supply-voltage lines by amplifier A_2. It can be seen then, that the power supply for A_1, while maintaining a total differential dc voltage of 9.4 volts (from the two 4.7-V zener diodes at the output) actually is shifting with respect to A_1's noninverting input (pin 3), in phase with the ac input signal. Thus the feedback capacitor is actually the input capacitance of A_1 as shown by the phantom capacitor.

If no compensation for external capacitance is required, gain-adjust pot R_1 may be omitted and A_2 reconfigured as a unity-gain voltage follower. If so, A_2's 18-pF phase-compensation capacitor should be increased to about 47 pF. As it is shown in the schematic, A_2's gain is 22 kilohms/4.7 kilohms or about 4.7.

If the circuit is used as the input to an instrument, integrated circuit A_1 should be located physically as close to the source as possible. If the device has a probe input, it is a good idea to install A_1 and its 68-pF phase-compensation capacitor within the probe, while the rest of the circuit can be in the instrument proper. □



1. Capacitance neutralization. The basic configuration for input-capacitance neutralizing feeds back an in-phase component from the output through a compensating capacitor. C_{eff} is then a fraction of the sum of the source, amplifier-input, and feedback capacitances.



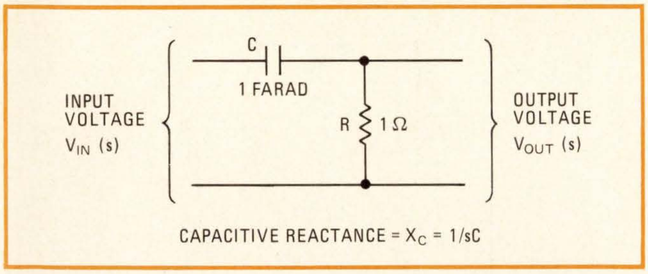
2. Improving the design. Use of the amplifier input capacitance as the feedback element reduces effective input capacitance significantly and requires less feedback. The CA3031 operational amplifiers were chosen for large bandwidth and high input impedance. To avoid overdriving A_1, power supply for A_2 is limited to ±5 V, which may be derived from the ±15-V supply with zener diodes.

Calculator notes

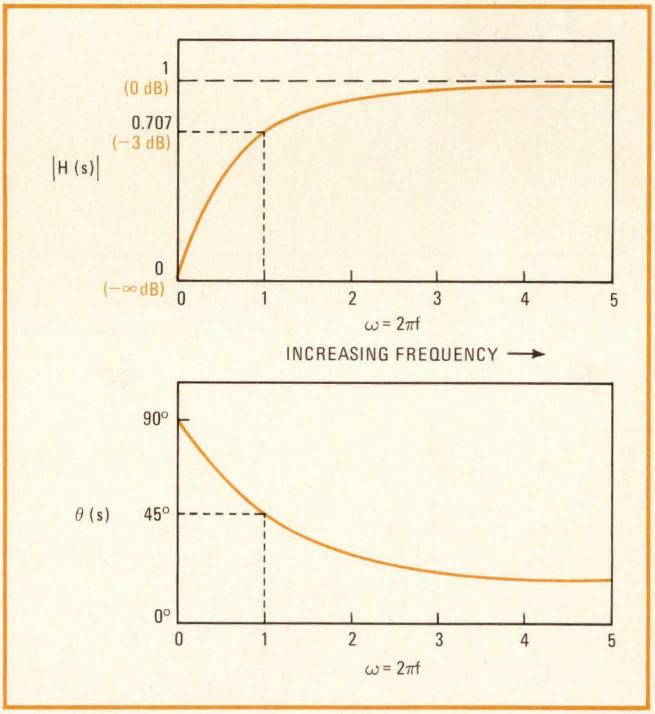
HP-25 program yields values of network transfer functions

by Robert R. Boyd
Aeronutronic Ford Corp., Newport Beach, Calif.

Reducing networks to generalized transfer functions is a straightforward means of circuit analysis. The program on p. 114 calculates in cascade magnitude and phase-angle values of transfer functions up to the third order for any given input frequency, enabling the user to rapidly plot



1. High-pass filter. The transfer function of this simple high-pass filter is s/(s + 1), which is better understood if the circuit is treated as an ac voltage divider. The generalized use of s, where $s = \sigma + j\omega$, is useful in complicated transient analysis; for simple analysis it can be reduced to $j\omega$, where $\omega = 2\pi f$.



2. Family of plots. The simple HP-25 program permits rapid plotting of magnitude and phase characteristics of networks. Upper graph is the magnitude of the high-pass filter voltage transfer function, asymptotic to unity; lower graph is the phase shift of the network, which approaches zero as frequency increases.

the transfer characteristics of any network.

The transfer functions take the form:

$$H(s) = \frac{N_2s^2 + N_1s + N_0}{D_3s^3 + D_2s^2 + D_1s + D_0}$$

where the N and D coefficients are constants, and $s = j\omega$. To run the program, the coefficients are entered into registers R_0 through R_6, and the given frequency ω_x (or $2\pi f_x$) is entered into register R_7. Pressing R/S once yields the magnitude, $|H(j\omega_x)|$ in decibels, and pressing it a second time gives the phase, $\theta(j\omega_x)$.

A typical example might be the high-pass circuit of Fig. 1, shown for simplicity with normalized values of 1 ohm and 1 farad. The network's transfer function is:

$$\begin{aligned} H(s) &= V_{out}(s)/V_{in}(s) \\ &= R/(R+1/sC) \\ &= sRC/(sRC+1) \\ &= s/(s+1) \end{aligned}$$

The coefficients in this case are $N_2 = N_0 = D_3 = D_2 = 0$, and $N_1 = D_1 = D_0 = 1$; hence, the value of 1 is stored in registers R_1, R_5, and R_6 only. Plugging in various values of ω yields data for the plots of Fig. 2. □

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

HP-25 PROGRAM TO CALCULATE MAGNITUDE AND PHASE OF TRANSFER FUNCTIONS

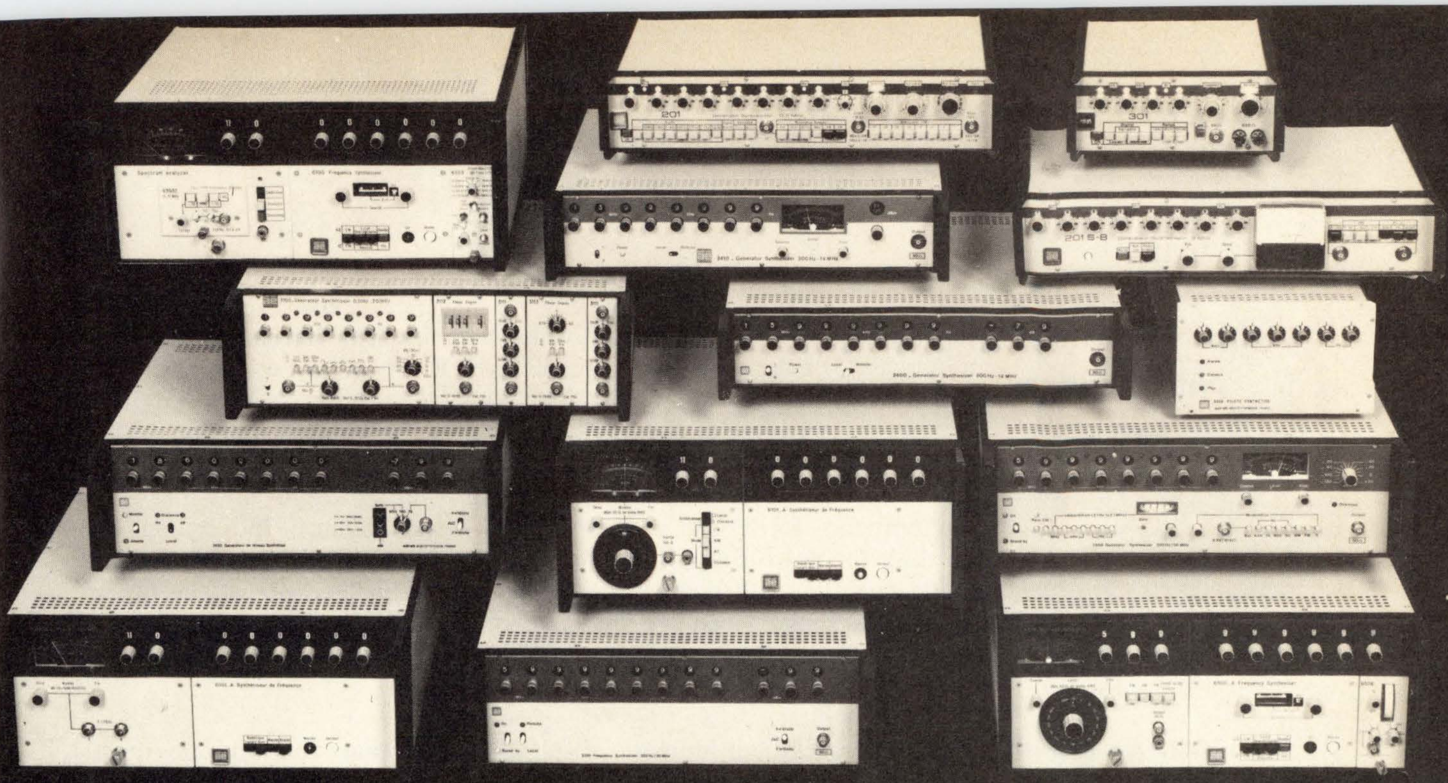
LOC	CODES	KEY	COMMENTS
01	24 05	RCL 5	
02	24 03	RCL 3	
03	24 07	RCL 7	
04	15 02	g x²	
05	61	×	
06	41	−	calculation of denominator
07	61	×	
08	24 06	RCL 6	
09	24 07	RCL 7	
10	15 02	g x²	
11	24 04	RCL 4	
12	61	×	
13	41	−	
14	15 09	g→P	convert to polar coordinates
15	21	x⇄y	
16	24 07	RCL 7	
17	21	x⇄y	
18	23 07	STO 7	
19	22	R↓	
20	31	ENTER↑	
21	31	ENTER↑	
22	24 01	RCL 1	
23	61	×	
24	21	x⇄y	

LOC	CODES	KEY	COMMENTS
25	15 02	g x²	
26	24 00	RCL 0	calculation of numerator
27	61	×	
28	24 02	RCL 2	
29	21	x⇄y	
30	41	−	
31	15 09	g→P	convert to polar coordinates
32	21	x⇄y	
33	22	R↓	calculate magnitude of H
34	21	x⇄y	
35	71	÷	
36	14 08	f log	
37	02	2	convert |H| to decibels
38	00	0	
39	61	×	
40	74	R/S	
41	22	R↓	
42	22	R↓	calculate θ
43	24 07	RCL 7	
44	41	−	
45	74	R/S	
46	23 07	STO 7	input new frequency
47	13 01	GTO 01	

INSTRUCTIONS

1. Key in program.
2. Store coefficients:
   - $[N_2]$ STO 0
   - $[N_1]$ STO 1
   - $[N_0]$ STO 2
   - $[D_3]$ STO 3
   - $[D_2]$ STO 4
   - $[D_1]$ STO 5
   - $[D_0]$ STO 6
3. Store initial frequency:
   - $[\omega_0]$ STO 7 $(\omega = 2\pi f)$
4. Run program:
   - R/S yields $|H(j\omega_0)|$ in dB
   - R/S again yields $\theta(j\omega_0)$
5. Key in any frequency:
   - $[\omega_x]$ then R/S, etc.

REGISTERS	
R_0	N_2
R_1	N_1
R_2	N_0
R_3	D_3
R_4	D_2
R_5	D_1
R_6	D_0
R_7	ω and temporary storage



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Adret makes it easy. Frequency generators are our only business and you'll find more synthesizers in our new catalog than anywhere else. You're sure to find an Adret synthesizer that meets your needs at a very competitive price.

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You get the most for your instrument dollar.

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Engineer's newsletter

Light-level sensor puts a bridge between two LEDs

Here's a neat way to build a sensitive light-level sensor that indicates either an increase or a decrease from a preset level. Put two light-emitting diodes back to back across a balanced bridge, says Calvin Graf of San Antonio, Texas, and make one of the legs of the bridge a photocell. This photocell and a 1-kilohm resistor form the high end of the bridge, which is connected to a 3-to-12-v source, while a 1-kilohm resistor and a 1-megohm potentiometer form the grounded side. Next, balance the bridge by adjusting the pot for a null (neither LED lit). Now, **if the amount of light hitting the photocell changes, unbalancing the bridge, one or the other LED will turn on,** depending on whether the light level has increased or decreased.

Off-the-shelf 7-segment-to-BCD conversion

Those seven-segment numeric display outputs that you find on most analog-to-digital converter chips meant for digital meters—what if you need to convert them into binary-coded-decimal signals for a computer application? One way is to reprogram the chip's outputs with a programable read-only memory [*Electronics*, Dec. 23, p. 88], but Lawrence W. Johnson of HP Labs in Palo Alto, Calif., feels he has a better way.

"Use the one commercially available device IC, National Semiconductor's DM86L25, that's designed to do the job," he says. The part not only does the seven-segment-to-BCD conversion, but **"its bells and whistles include two output enables, the ability to accept either positive or negative logic, and the ability to recognize four letters, the minus sign, and a blank,"** according to Johnson. He adds that he suspects the chip of having a mask-programed ROM on it (we checked, he's right), so the problem boils down to whether you want to "zap your own or buy one readymade."

Better gold bonds for hybrids

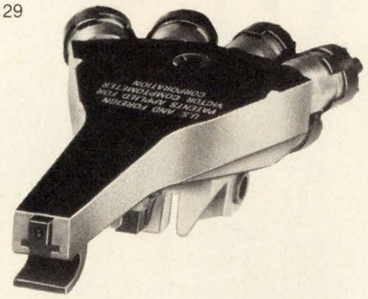
It's common practice in packaging hybrids for high-rel applications to bond the chip's aluminum leads to gold substrate pads. But that solution to substrate corrosion causes another problem—failure of the wire bond at high temperatures. Designers find that wire bonds to standard gold pads fail after 1,000 hours at 150°C. The answer could be a new gold conductor composition, DuPont's 9910, which **maintains its average bond strength of 6 grams even after the temperature stress** defined above. In fact, DuPont engineers have found that failures during the tests were in the aluminum wire itself and not in their new precious material.

What other EEs are earning

If you're trying to get a handle on how your salary matches up to that of other EEs and other engineering specialties—and who isn't—a couple of the publications just out from the Engineers' Joint Council could help. Due this month is a 92-page report, called "Professional Income of Engineers 1976," priced at $8. It's the result of the 12th biannual survey conducted by the Engineering Manpower Commission. Also available is "Engineers' Salaries—Special Industry Report 1976," a detailed 172-pager costing $60 and covering engineers in industry, broken down by supervisory status, degree level, and other characteristics. For order information contact EJC, Dept. PM, 345 E. 45th St., New York, N.Y. 10017. **Laurence Altman**

Victor's high-speed matrix printer can fit into your systems design.

129



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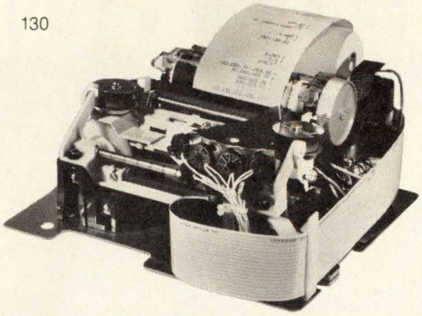

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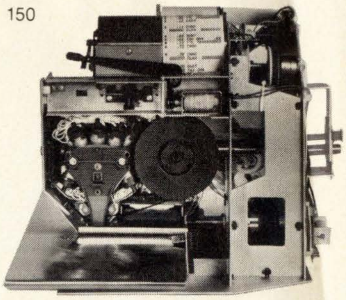
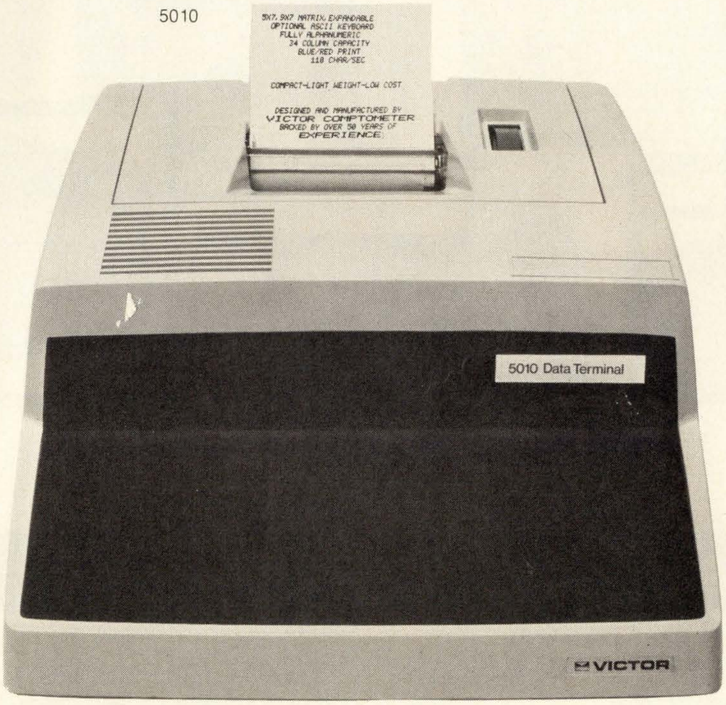


5010



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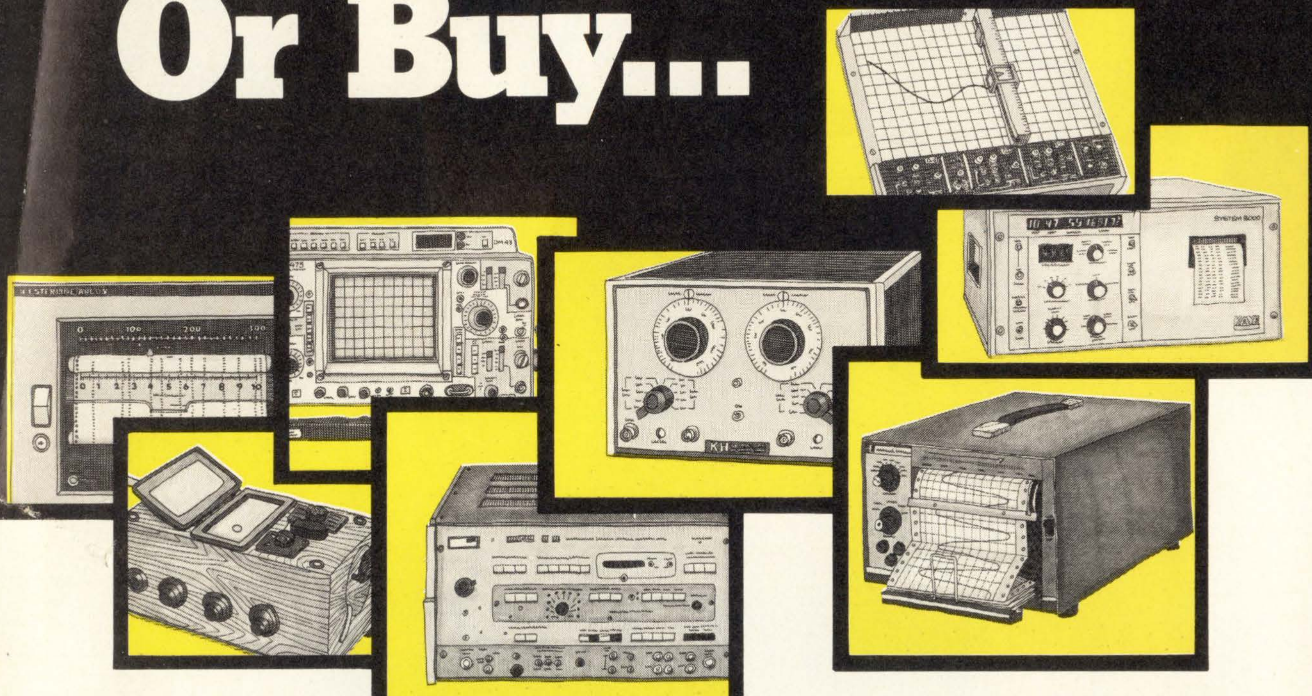

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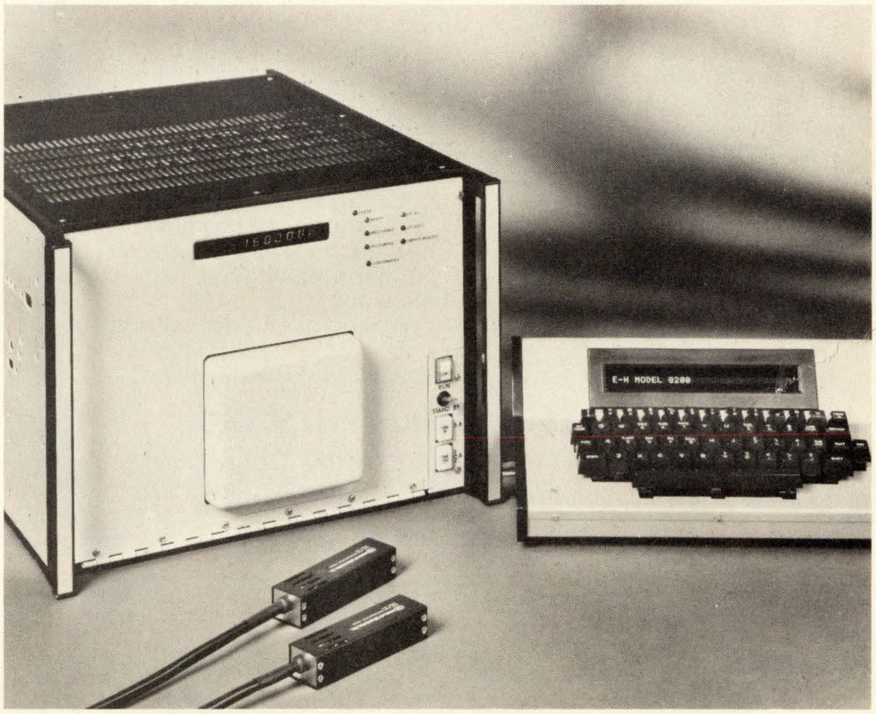
Modular design shrinks test system

Microprocessor controls multimeter, counter, and digitizer plug-ins that replace a rack full of instruments used for automatic testing

Since automatic test systems must measure a wide variety of parameters, as well as convert signals from synchros and other transducers into usable form, they usually require a rack full of instruments. These can be difficult to interconnect or reconfigure, and E-H Laboratories has therefore developed an integrated, modular measurement system, the 8200, that is compact and microprocessor-controlled for flexibility of application.

Housed in a single $12\frac{1}{4}$-inch rack-mountable cabinet, the 8200 integrated measurement system (IMS) is a general-purpose tester containing modular subassemblies that make measurements under the control of a 6800-type microprocessor. The 6800 allows the execution of complex test sequences and can provide for the analysis of test results. It runs the programs generated by the operator and entered through a keyboard or an IEEE-488 interface into a programable memory. This memory stores programs for accomplishing a series of tests or a single test.



Testing is done on 26 input lines. Four of these are designed for high-frequency and ac inputs, and four for low-level dc measurements. Low-frequency testing may be performed on any of these eight inputs. The remaining 18 lines are routed directly to three spare instrument slots in the system.

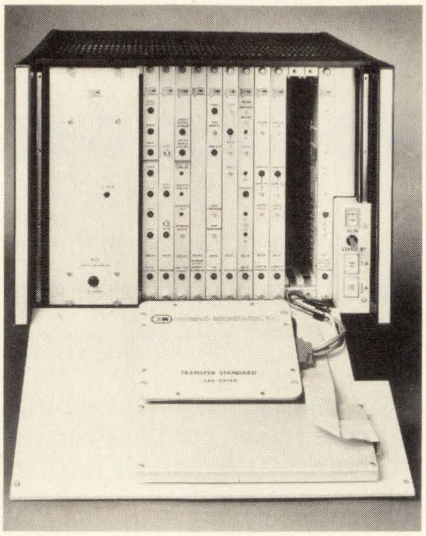
The 8200 can be triggered to begin a measurement sequence with an external trigger signal or with the input waveform itself. In the latter mode, the incoming signal on the selected line is used to derive a trigger signal. Then it is delayed by a fixed interval of about 50 nanoseconds to allow for the delays and settling times necessary before an accurate measurement can be made.

Once the system has been programed to make a series of measurements, the input waveform is sampled and stored in digital form by one of two circuits: a high-speed digitizer, which takes up to 1,024 samples per waveform at 100 to 200,000 samples per second or more, or a slow-speed sampler, which takes 1,024 samples per waveform at a rate of 100 to 40,000 samples per second. Each sampler/digitizer has two input channels.

Frequency, time interval, period, and total count measurements on the waveform are made by a time converter and counter that has a resolution of 9 digits and a frequency range from dc to 100 megahertz. Measurements of the time interval between two points on a single or two successive waveforms can be made over a two-channel comparator that can be programed to detect either a positive or a negative slope. Each channel is also programable to detect either the first or the second transition after the comparator is enabled.

A digital multimeter measures dc voltage and current, ac voltage, and resistance. The $5\frac{1}{2}$-digit instrument is similar to Dana Laboratories' model 5900, but comes in a modular package that takes up three slots in the 8200 mainframe.

Another system plug-in is a converter that accepts synchro or resolv-



er inputs and furnishes digitized data for external processing. The principal component of the synchro-to-digital converter is a Data Device Corp. SDC-501-3 converter module.

The 8200 is also capable of testing itself through a front-panel-mounted transfer standard. The standard can be removed from the system and taken to a calibration lab for testing while the rest of the system remains in operation.

Tests performed in the self-test mode include dc and ac voltage checks on the digital multimeter, 40-increment a-d conversion tests on the samplers, and frequency checks on the counter's master clock. An internal switching matrix accepts data from the self-test circuit and external sources and distributes it, under control of the microprocessor, to the appropriate measuring device.

Depending on which instruments are included, the model 8200 is priced between $35,000 and $40,000. The system can be expanded through an additional chassis that doubles its capacity. The microprocessor can address enough input/output spaces to handle the additional load.

The read-only and random-access memories provided on the 8200 controller card can also be expanded to handle longer or more complex test programs or data manipulation.

E-H Research Laboratories Inc., 515 Eleventh St., Oakland, Calif. 94607. Phone Earl M. Olsen at (415) 834-3030 [338]

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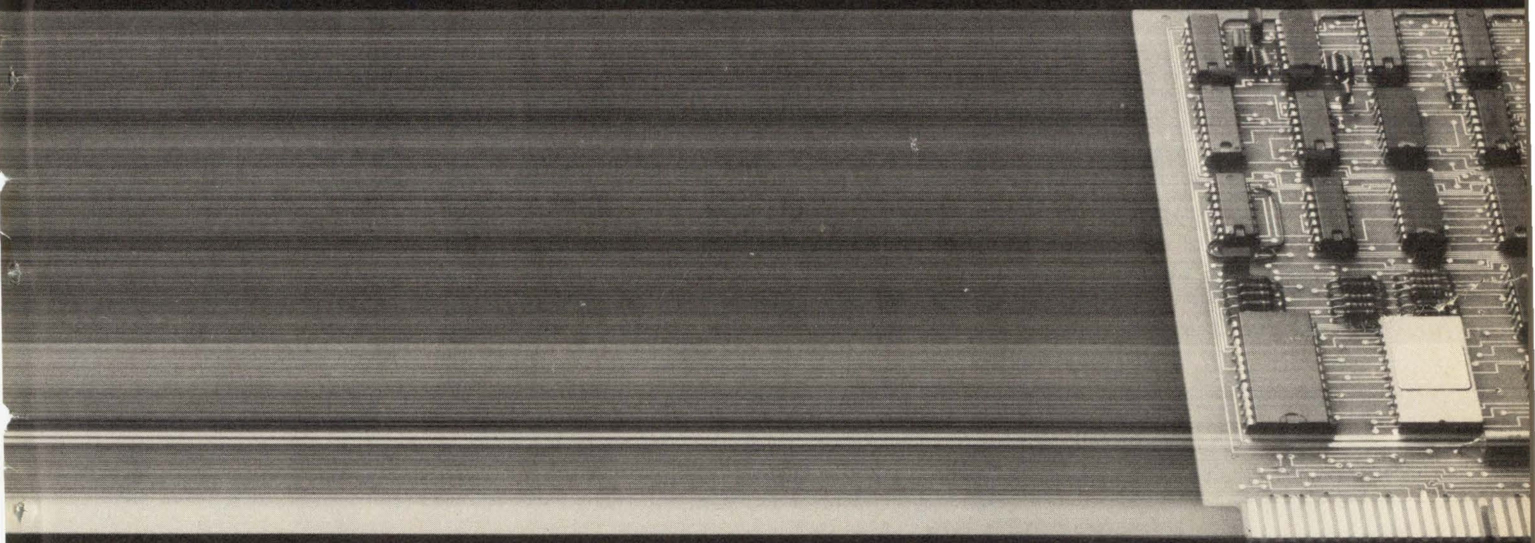

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Circle 121 on reader service card

Optical coupler includes regulator

When used as line receiver, photo-isolator shunts excess input current; shielded photodetector inside provides high common-mode rejection

by Lucinda Mattera, Components Editor

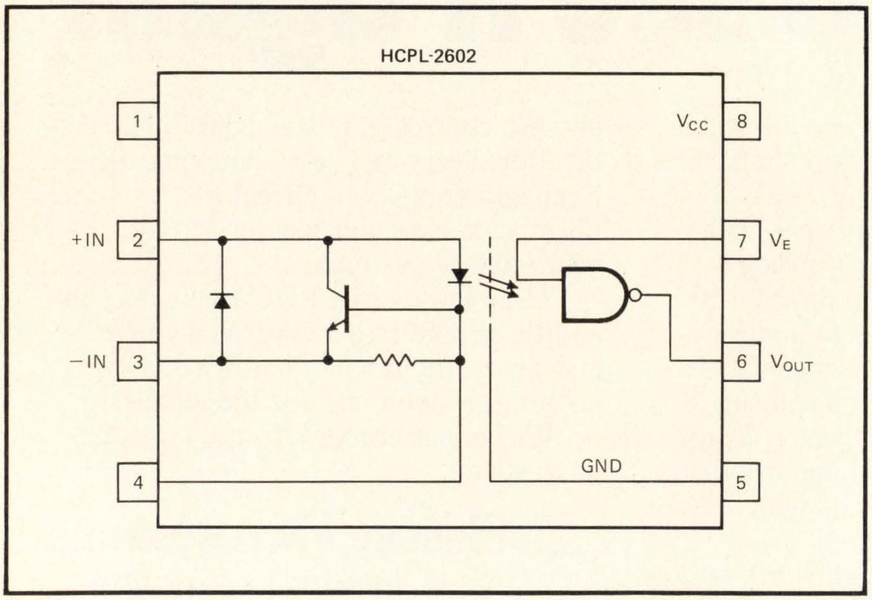
The largest single use, by far, of high-speed optical couplers is as line receivers (or transmitters) of digital data. These "logic-gate couplers" provide isolation from transients and ground loops, but extra circuitry is needed to terminate the line properly.

However, the Optoelectronics division of Hewlett-Packard Components is now offering a coupler that includes its own input-current regulator to simplify line termination when the device is used as a line receiver. The internal regulator clamps the line voltage and regulates the current of the coupler's light-emitting diode so that line reflections do not interfere with system performance.

Excess current is caused by variable drive conditions, such as variations in line length, differences between line drivers, and fluctuations in power-supply voltage. But in the HP device, the internal regulator shunts this excess current, permitting line current to be increased so as to improve the immunity of the system to differential-mode noise and also to boost the rate at which data is transmitted.

For most applications, the transmission line can be connected directly to the input terminals of the new HCPL-2602 coupler without the need for additional series or shunt resistors. Typically, the internal input regulator permits an LED current of 8.5 milliamperes to flow before it starts to shunt excess current. According to the firm, the 2602 can be used as a line receiver in high-noise environments that conventional line receivers often cannot tolerate, frequently permitting a twisted-pair transmission line to be substituted for more expensive coaxial cable.

An open-collector Schottky-clamped transistor serves as the output of the coupler's photodetector stage. Additionally, the photodetector is protected by an internal shield that keeps common-mode rejection high, with little or no degradation of operating speed. In fact, the 2602 provides a guaranteed common-mode transient immunity of 1,000 volts/microsecond, which is equivalent to rejecting a 1-megahertz sinusoid of 300 V peak to peak, the company points out.



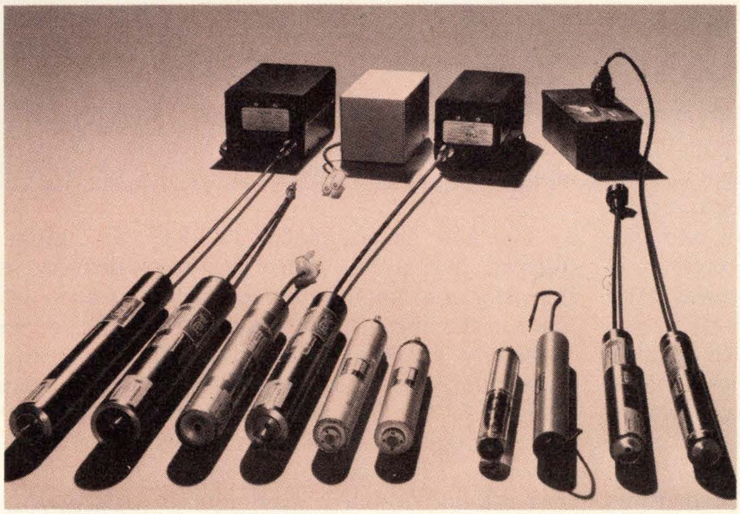
The coupler provides an insulation voltage of 3,000 V between input and output stages and can handle input currents (either forward or reverse) up to 60 milliamperes. The unit interfaces easily with digital logic circuits, and its dc specifications are guaranteed from 0°C to 70°C. An input current of 5 mA will sink an eight-gate fanout (transistor-transistor logic) at the output with a typical propagation delay of only 45 nanoseconds from input to output.

For an input current of 7.5 mA and a 350-ohm 15-picofarad load, propagation delay time is 45 ns typical (75 ns maximum) for either a high or low output level. The device's maximum low-level input current is 250 microamperes, while its minimum high-level input current is 5 mA. At 1 MHz, the unit exhibits an input capacitance of 90 pF maximum. Leakage current between input and output is 1 μA at most, as input-to-output resistance is a high 10^{12} ohms.

The HCPL-2602 is priced at $9.30 each for 1 to 99, $7.30 for 100 to 999, and $6.65 in quantities of 1,000. Delivery is from stock.

Hewlett-Packard Components, Optoelectronics Div., 640 Page Mill Rd., Palo Alto, Calif. 94304. Phone (415)493-1212 [339]

Why design engineers are making RedLine™ their hot line.



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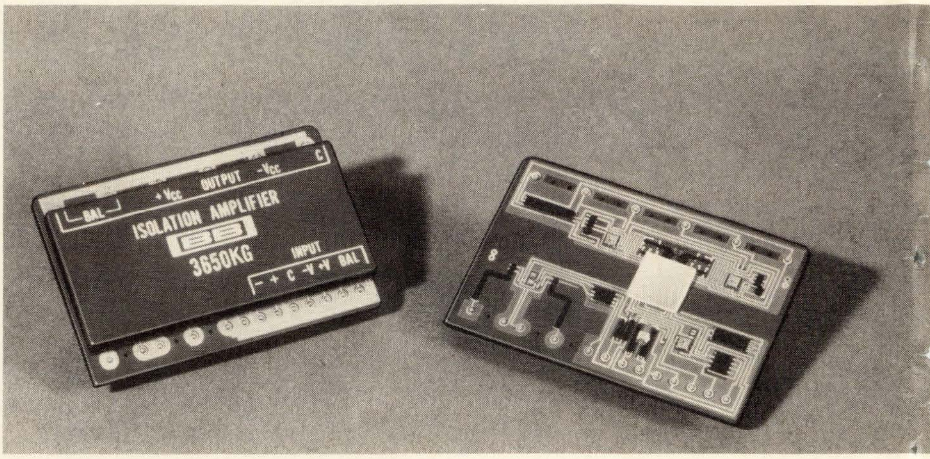
Subassemblies

Amplifier specs get a boost

Burr-Brown improves isolation-type hybrid units, adds a model to the line



Isolation amplifiers are popping up all over the place in applications that range from medical electronics to industrial process control and data acquisition. Recognizing their growing importance, Burr-Brown is upgrading the performance of its line of hybrid optically coupled isolation amplifiers and adding a new member to the family—one that provides good linearity, as well as tight input-offset-voltage characteristics.

First introduced about a year ago, the series 3650 and 3652 isolation amplifiers are thick-film hybrid circuits that employ optoelectronic semiconductors to isolate input and output stages. (In contrast, other commercially available isolation amplifiers are modular devices employing transformer coupling.) The 3650 models have bipolar inputs, while the 3652 models use field-effect transistors up front.

Prices are slightly higher for the upgraded line, but several key performance parameters have been improved considerably. For example, isolation voltage, which was 1,500 V, is now 2,000 V minimum, and bandwidth has increased from 10 kilohertz to 15 kHz. Similarly, gain nonlinearity is tighter for all the models, and input-offset-voltage drift is lower for all but one unit.

Additionally, the power-supply voltage range has been extended for all models—it now spans ±8 to ±18 V for both input and output stages. What's more, the temperature range over which the units remain functional is broader, extending from −40°C to +100°C, and leakage current (at 240 V and 60 Hz) has been cut in half to just 0.25 microampere maximum.

The new device, model 3650KG (shown in photo), offers the best linearity and input-offset performance in the line. Its gain nonlinearity is merely ±0.02% typical, ±0.05% maximum, while gain stability is ±0.005%/°C. The unit holds input offset voltage to ±5 millivolts maximum (at 25°C) and offset drift to just ±5 microvolts/°C maximum. In quantities of 1 to 24, it sells for $69, dropping to $47.50 in lots of 100.

For the economy unit, model 3650HG, input offset voltage is still ±5 mV, and offset drift remains ±25 μV/°C. However, gain nonlinearity is now ±0.05% typical, ±0.2% maximum. The 3650HG is priced at $43 singly, or $26.50 each for 100.

For the model 3650JG, input offset voltage stays at ±1 mV, but offset drift is reduced to ±15 μV/°C. Gain nonlinearity for this unit drops to ±0.03% typical, ±0.1% maximum. It carries a single-unit price tag of $56, $36 in 100-unit lots.

Input offset drift for the FET-input models is down to ±50 μV/°C for the 3652HG, ±25 μV/°C for the 3652JG. At 25°C, these units have an input offset voltage of ±5 mV and ±2 mV, respectively. Gain nonlinearity is ±0.05% for both models typically, and ±0.2% maximum for the 3652HG, ±0.1% maximum for the 3652JG. In quantities of 1 to 24, the 3652HG sells for $58 ($37 in hundreds) and the 3652JG for $69 ($45 in hundreds).

All the amplifiers come in a ceramic package measuring 1.75 inches long by 0.9-in. wide by 0.22-in. high. For small quantities, delivery is from stock; for large orders, it takes four to six weeks after receipt of order.

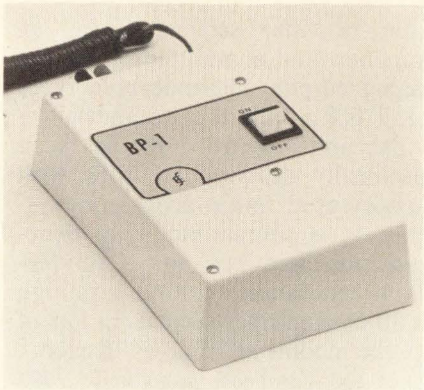
Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85734. Phone (602) 294-1431 [381]

Battery-pack power supply is compact and transient-free

An uninterruptible dc power supply that produces up to 1 ampere at +5 volts and 100 milliamperes at a voltage that can be adjusted between −9 and −12 V contains a sealed lead-acid battery for operation during failures of the ac line. Measuring approximately 8 by 6 by 2.5 inches, the model BP-2 keeps its output free of surges and transients whenever the ac input is interrupted or is reapplied.

Offered in benchtop and open-frame versions, the BP-2 is regulated to within 1% on its fixed output and 5% on its adjustable output. The open-frame version of the power supply includes a TTL-compatible output that is activated when the line fails. It also permits access directly to the 9.1-V dc battery. The battery, which has a capacity of 2.5 ampere-hours, can withstand up to 1,000 full charge-discharge cycles.

In small quantities, the open-frame version of the BP-2 sells for $165, while the benchtop version is priced at $175. A companion unit, the BP-1, which includes only the fixed output, sells for $140 in its



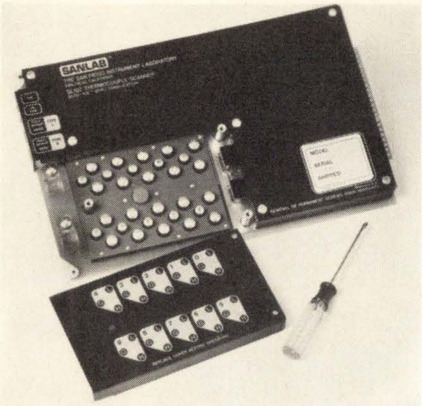
open-frame configuration and $150 in its benchtop form.

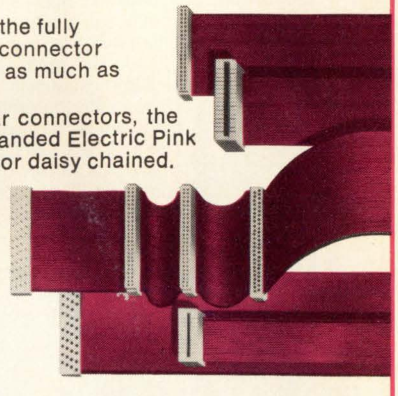
Useful in a variety of applications, the uninterruptible supplies are especially recommended for volatile semiconductor memory systems. They can also increase an experimenter's peace of mind in an experiment that has to be left running overnight or over a weekend.

Sunrise Electronics, 228 North El Molino, Pasadena, Calif. 91101. Phone Anna Erickson at (213) 963-8775 [384]

Unit connects thermocouples with a-d converter

Containing everything needed to connect 10 thermocouples with an analog-to-digital converter, the model SL102 thermocouple acquisition module receives inputs from grounded, ungrounded, or mixed thermocouples and conditions the signals for conversion to digital form. The unit contains a reed scanner with low thermal voltages, a reference junction, a 60-hertz active





Circle 126 on reader service card

filter, a filter settling timer, an amplifier, and a multiplexer for the analog output. Thermocouple types J,K,T,E,R,S, and B are standard.

The unit's control logic has been specifically designed to work with bus-oriented microprocessor systems. It is compatible with diode-transistor-logic, TTL, and C-MOS levels. It can handle scan rates as high as 30 channels per second. In lots of 10, the module sells for $495 each.

San Diego Instrument Laboratory, 7969 Engineer Rd., San Diego, Calif. 92111. Phone (714) 292-0646 [388]

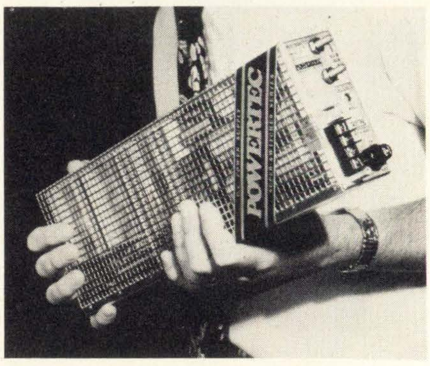
Supply switches at 40 kHz to pack 250 W into 166 in.^{3}

By combining a space-saving mechanical configuration with a 40-kilohertz switching rate, the designers of Powertec's 9E series of power supplies have managed to put a convection-cooled 250-watt supply into a package that measures only 2.25 by 4.94 by 15.0 inches and weighs only 6.19 pounds. The input voltage range for the series is 115/230 volt ac +10%/−20%, with a 20-millisecond hold-up time.

Ripple and noise are 50 millivolts peak-to-peak; regulation is within 2 mv for a 30% line change or 0.2% for a full load change, and recovery time to within 0.1% is less than 400 microseconds for a 50% load change.

The series includes supplies with voltage outputs of 2, 5, 12, 15, and 24 v dc. They sell for $395 each.

Powertec Inc., 9168 De Soto Ave., Chatsworth, Calif. 91311. Phone (213) 882-0004 [385]



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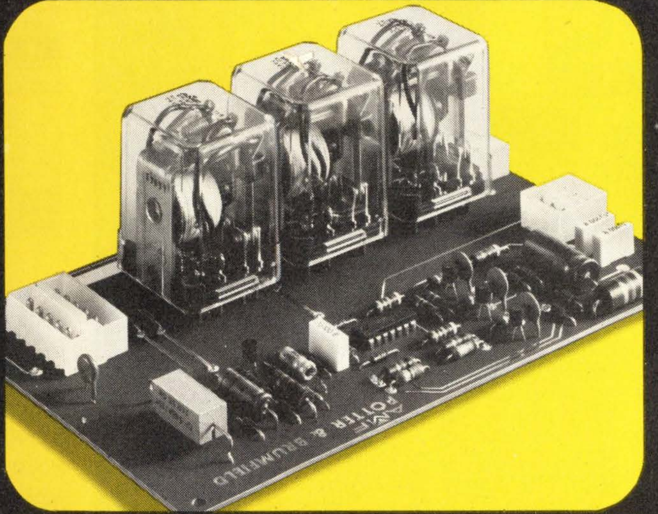

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Data handling

Hand terminals' uses broadened

Four models widen choices in computer interaction and in display modes

Four new models significantly expand the applications and capabilities of Termiflex Corp.'s hand-held terminals beyond those of the company's first unit, the HT/2. Three of the new terminals—the HT/3, /4, and /5—are low-cost units for applications not requiring the versatility or display-buffer capacity of the $1,775 HT/2. The fourth, the HT/8, quadruples the display capability—from the 20 characters of the HT/2 to 80 characters. With any of the terminals, an engineer can control a microcomputer system and can enter, through the keyboard, all 128 ASCII characters.

The HT/3 displays a single line of 12 alphanumeric characters and sells for $795 in unit quantities. If a larger display is desired, the HT/4, at $1,195, has 24 characters in two lines. Both units operate at 1,200 bauds, have even parity, display the 64-character ASCII code set, and operate in a full-duplex mode.

The HT/5, selling for $495, is designed for applications where it is necessary to display only the status of certain functions. It has an annunciator display or 12 labeled lights that the computer system can turn on, turn off, or blink to communicate with the operator. The operator communicates with the system by using the terminal keyboard.

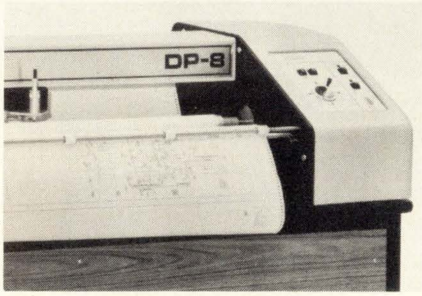
The HT/8, at $3,995, offers an 80-character display and makes online control or testing available for a multitude of applications where a large quantity of data is required. Both the HT/2 and HT/8 operate at 10, 15, 30, or 120 characters per second in full- or half-duplex mode.

All terminals in the line provide two-way, bit-serial, asynchronous communications of ASCII codes, and all are RS-232-C-compatible.

Termiflex Corp., 17 Airport Rd., Nashua, N.H. 03060. Phone (603) 889-3883. [361]

A yard-wide plotter draws up to 4.5 in./s

A one-pen digital plotter suitable for printed-circuit board artwork, weather maps, geophysical plotting, and medical applications, can operate at pen speeds up to 4.5 inches per second. Measuring 36 inches wide, the DP-8S has nine switch-selectable



step sizes ranging from 0.00125 to 0.01 inch. In addition to handling 36-in. paper, the DP-8S can accommodate 12-inch paper for A- and B-size drawings. The plotter sells for $8,400.

Houston Instrument, One Houston Square, 8500 Cameron Rd., Austin, Texas 78753. Phone (512) 837-2820 [364]

Computer graphics terminal includes full refresh

The Megraphic 6014 computer graphics terminal is an interactive unit that includes full refresh capability. Consisting of a Data General

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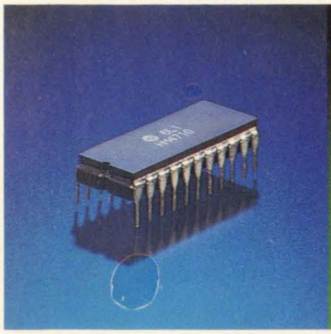
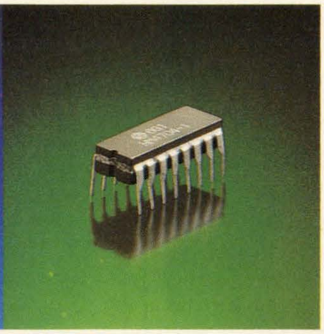


HM4710

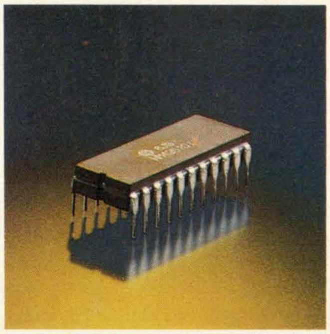
High speed 22pin 4K Dynamic RAM
Access Time
ECL Output 100ns max HM4710
TTL Output 130ns max HM4711-1



HM4704-1

High Speed 16pin 4K Dynamic RAM
Access Time
TTL Output 200ns max HM4704-1

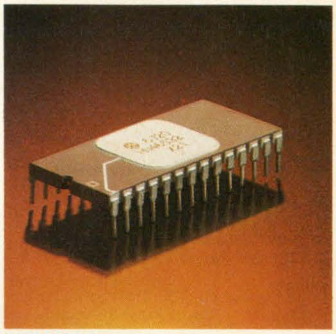
1K STATIC (C MOS)



HM435101V

Wide supply voltage margin
(Vcc=5V±10%)
All input and output are
TTL compatible
Access Time
650ns max HM435101V

MOS ROM



HN46532

32K bits MOS ROM (4kW x 8b)
Access Time
650ns HN46532

DYNAMIC RAMs

Type	Process	Organization (word x bit)	Access Time (max)	Package	Replacement
HM4704-1	NMOS	4096 x 1	200ns	16DIP	Mostek MK 4027
HM4704-2	NMOS	4096 x 1	250ns	16DIP	
HM4710	NMOS	4096 x 1	100ns	22DIP	
HM4711-1	NMOS	4096 x 1	130ns	22DIP	
HM4711-2	NMOS	4096 x 1	150ns	22DIP	
HM4711-3	NMOS	4096 x 1	200ns	22DIP	Intel 2107B

MOS ROMs

Type	Process	Organization (word x bit)	Access Time (max)	Package	Replacement
HN35600P	PMOS/Mask	256 x 8	930ns	16DIP	Intel 4001
HN35800P	PMOS/Mask	1024 x 8	930ns	28DIP	Intel 4308
HN351702A	PMOS/E.P	256 x 8	1000ns	24DIP	Intel 1702A
HN46532	NMOS/Mask	4096 x 8	650ns	28DIP	
HN46830A	NMOS/Mask	1024 x 8	575ns	24DIP	Moto MCM46830A
HN462708	NMOS/E.P	1024 x 8	450ns	24DIP	Intel 2708

STATIC RAMs

Type	Process	Organization (word x bit)	Access Time (max)	Package	Replacement
HM435101	CMOS	256 x 4	650ns	22DIP	Intel 5101L
HM435101V	CMOS	256 x 4	650ns	22DIP	
HM435101-1	CMOS	256 x 4	450ns	22DIP	Intel 5101L-1
HM452102-3	NMOS	1024 x 4	350ns	16DIP	Intel 2102A
HM452102-4	NMOS	1024 x 4	450ns	16DIP	Intel 2102A-4
HM46810A	NMOS	128 x 8	450ns	24DIP	Moto MCM6810A

BIPOLAR RAMs

Type	Family	Organization (word x bit)	Access Time (max)	Package	Replacement
HM2110	TTL	1024 x 1	35ns	16DIP	F.C 10415A
HM2110-1	TTL	1024 x 1	25ns	16DIP	
HM2510	ECL	1024 x 1	70ns	16DIP	F.C 93415
HM2510-1	ECL	1024 x 1	45ns	16DIP	F.C 93415A

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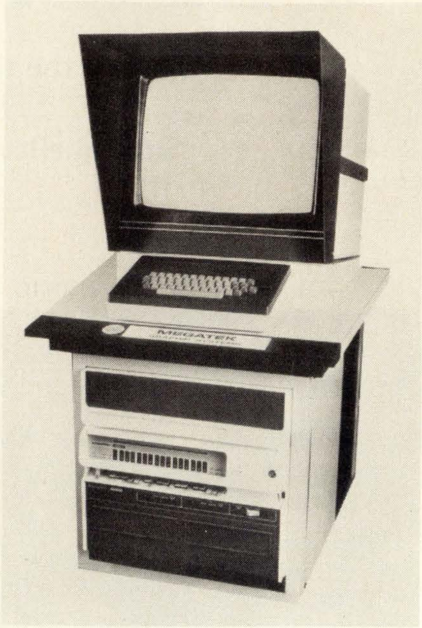
New products



Nova 3 minicomputer with 8,192 16-bit words of memory, a 17-inch cathode-ray-tube monitor, a keyboard with a joystick, a graphics processor, an emulator for the Tektronix 4014, cabinetry, and a software package, the terminal sells for approximately $16,000. Because it contains the Nova 3, the Megraphic 6014 can operate as a stand-alone facility besides as a remote terminal for a larger machine. The terminal's software package gives it the capability to update the host computer directly from the CRT screen, to simulate dynamic motion without flicker, to selectively erase, scale, clip, rotate, translate, blink, stretch, and zoom in on an image.

Aimed at what Megatek estimates are the 10,000 users of Tektronix 4014 terminals who require more capability, the 6014 has a delivery time of 30 to 60 days.

Megatek Corp., 1055 Shafter St., San Diego, Calif. 92106. Phone (714) 224-2721 [363]

Diskette drive controller does housekeeping chores

The model 1070 diskette drive controller includes an 8080 microprocessor to perform all of the housekeeping functions usually left to the CPU. Able to interface with most major microcomputers, the controller includes software for all file-management functions including IBM 3740 formatting and initializing. In data-transfer functions, controller commands include seek, write, read, delete, and initialize. Two error-checking bytes are added to write data and checked when the data is read with each transfer.

A complete diskette drive subsystem includes the model 1070 controller, an interface, cabling, and one or more diskette drives. A subsystem with a single model 70 drive sells for $1,195, while a subsystem with a model 270 dual drive is priced at $1,495. Delivery time is 30 to 60 days.

PerSci Inc., 4087 Glencoe Ave., Marina Del Rey, Calif. 90291. Phone Herb Wait at (213) 821-5545 [366]

Floppy diskette drive has 370-ms average seek time

With a track-to-track access time of 30 milliseconds, a random average seek time of 370 ms, and a large-quantity price of about $300, the model 82 Micro-Floppy diskette drive is well suited for use in word-processing systems, microcomputers, small terminals, and portable computers. The unit has a basic capacity of 109.4 kilobytes on 35 tracks. However, a variety of capacity-increasing features—adding tracks, double-density recording, using both sides of the disk, and various combinations of these techniques—can increase the capacity to 498.8 kilobytes.

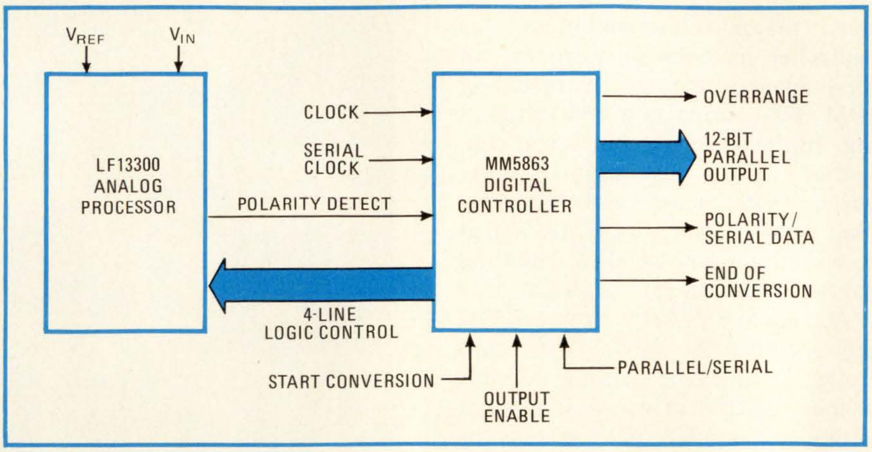
The model 82 measures only 3.25 by 5.75 by 7.95 inches, weighs 3.5 pounds, and works with a 5.25-inch diskette. The diskettes can be hard-sectored with 10 sectors per track, or an IBM-type soft-sectored format (18 sectors per track, 128 bytes per sector) can be employed. Rotational speed of the Micro-Floppy diskette is 300 revolutions per minute. Evaluation units should be available this month.

Wangco Inc., 5404 Jandy Pl., Los Angeles, Calif. 90066. Phone (213) 390-8081 [367]

Semiconductors

Chip set builds 12-bit converter

A-d unit's analog processor uses bi-FET technology; controller is MOS device



In the last six months, developments in monolithic integrating analog-to-digital converters have been snowballing. These devices are now offering higher resolutions, tighter accuracies, and greater chip complexity. Latest to arrive, from National Semiconductor Corp., is a pair of monolithic building blocks for realizing a 12-bit (plus sign) integrating a-d converter.

One chip, designated the LF13300, is the analog processor, which National is fabricating with its bi-FET technology. The other chip, the MM5863, is the digital controller—it is a p-channel metal-oxide-semiconductor device.

According to James Solomon, manager of linear design at National, the LF13300 contains essentially two types of elements—bipolar operational amplifiers with p-channel junction-field-effect-transistor input stages and JFET analog switches with bipolar drivers. Ion implantation of the JFET structures onto the same 8,000-square-mil chip as the bipolar devices, he says, makes it possible to maintain low constant on-resistances even with variations in analog input voltage. As a result, the bi-FET LF13300 does not suffer from latch-up problems or static-charge blowout, problems often encountered by users of similar complementary-MOS converter parts, according to Solomon.

Combining JFET front ends and bipolar back ends in various combinations, says Solomon, permits all the essential elements for an integrating- or ramp-type analog processor to be fabricated on a single chip. The device includes a high-impedance unity-gain buffer stage, a comparator/amplifier stage, an integrator, and a nine-element analog switching stage. Housed in an 18-pin dual in-line package, the LF13300 dissipates 570 milliwatts. It operates over a power-supply range of ±5 to ±18 volts and has an input analog range of ±11 V (for a supply voltage of ±15 V).

The MM5863 is the companion digital controller for the LF13300. David Whetstone, converter products marketing manager, says this 110-by-110-mil digital building block provides all the necessary control functions plus such features as auto-zeroing, polarity and overrange indication, as well as continuous conversion. Moreover, its 12-bit-plus-sign parallel and serial outputs are tri-state, and on-chip output latches are included to simplify data-bus interfacing. Contained in a 28-pin dual in-line package, the MM5863 requires power supplies of 5 V and −15 V and can operate at clock frequencies that are as high as 500 kilohertz.

Together, says Solomon, the LF13300 and the MM5863 are capable of conversion times in the 30-to-40-millisecond range at a 250-kHz clock frequency, making the pair ideal for industrial data-acquisition systems employing microcomputers. The two-chip a-d, says Whetstone, has a nonlinearity of ±½ least significant bit maximum and ⅛ LSB typical. Gain-error drift is ±1 part per million per degree celsius, and the zero-reading drift is specified as ±0.5 ppm/°C.

Prices on commercial versions in quantities of 100 and up are $6.65 each for the LF13300 and $6.25 each for the MM5863. National is also introducing an eight-channel multiplexer made with the company's bi-FET technology. This device, the LF13508, is priced at $6.40. For the output end of a data-acquisition system, the company is offering two 8-bit monolithic d-a converters, the LMDAC-08 ($5 and up) and the LM1048 ($3.80 and up). Both are second-source versions of devices made by Precision Monolithics and Motorola.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051 [411]

IC converts voltage to frequency and vice versa

Capable of operating from a single supply voltage of 4 to 18 volts, the model A-8402 is a monolithic converter that can convert frequency to voltage or voltage to frequency with an accuracy of 11 bits. The unit operates on analog voltages from 0 to 10 V and on pulse trains with repetition rates from 0 to 100 kilohertz. Key specifications are a maximum nonlinearity of 0.05% at 10 kHz, a maximum gain temperature coefficient of 200 ppm/°C, and a digital output compatible with DTL, TTL, and C-MOS circuitry. Normally rated for operation from 0°C to 70°C, the A-8402 is also offered in an extended-temperature-range version, the A-8402 ET1, that operates

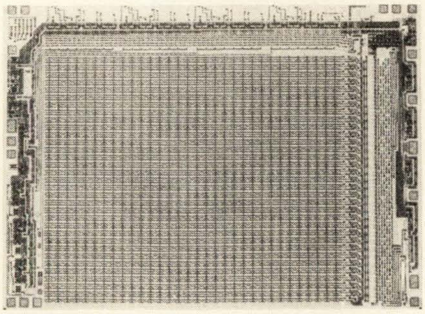
from −25°C to a high of 100°C.

Housed in a 14-pin ceramic dual in-line package, the A-8402 sells for $6.50 each in hundreds. Delivery is from stock to four weeks.

Intech/FMI Inc., 282 Brokaw Rd., Santa Clara, Calif. 95050. Phone (408) 244-0500 [416]

8,192-bit PROM has 100-ns access time

A field-programable fusible-link read-only memory, the 82S184/5 is a bipolar device with a maximum address access time of 100 nanoseconds and a typical power dissipation of 50 microwatts per bit. Organized as 2,048 words of 4 bits each, the PROM is offered with either open-collector (82S184) or three-state



(82S185) outputs. Both devices sell for $31 each in hundreds.

Signetics, 811 East Arques Ave., Sunnyvale, Calif. 94086. Phone (408) 739-7700 [420]

Ion-implanted silicon diodes replace germanium devices

Three families of ion-implanted silicon diodes with forward voltage drops from 225 millivolts to 450 mv are expected to replace germanium diodes in a variety of applications. Designated the HSA/46, HSB/46, and HSC/46, the devices not only have voltage drops up to 50% lower than germanium units, they also retain the thermal stability associated with silicon components.

The HSA/46 family, which is rated from 200 milliamperes to 600 mA, has a maximum drop of 225 mV at 1 mA, a forward recovery time of 0.5 nanosecond, and a reverse recovery time of 3 ns. The HSB/46 family is similar except that the maximum forward voltage is 325 mV. The HSC/46 family, which ranges from 400 mA to 700 mA, has a maximum drop of 450 mV, a forward recovery time of 1 ns, and a reverse recovery time of 9 ns.

All three families of diodes can dissipate a maximum of 500 milliwatts and are available with peak reverse voltage ratings up to 100 volts. Prices range from 98 cents to $3 each in hundreds.

Solid State Devices Inc., 14830 Valley View Ave., La Mirada, Calif. 90638. Phone (213) 921-9660 [417]

C-MOS switches approach speed of JFET devices

The DG300 series of C-MOS analog switches typically turn off in 70 nanoseconds (150 ns maximum) and turn on in 110 ns (250 ns maximum). While thus approaching the speed of multichip JFET devices, the monolithic C-MOS switches retain the low-power and high-voltage advantages of C-MOS technology. They can switch and isolate 30-volt signals, and, depending upon the specific model, dissipate a few hundred microwatts or a few milliwatts of power.

The series consists of eight switches, two each of the following configurations: dual single-pole single-throw, single-pole double-throw, dual double-pole single throw, and dual single-pole double-throw. Four of the switches are compatible with low-voltage C-MOS logic levels and open-collector TTL or DTL. The other four switches are specifically designed to work with higher-voltage C-MOS circuitry.

Supplied in 14-pin dual in-line packages, the series is offered in three temperature grades: commercial (0 to 70°C), industrial (−20 to 85°C), and military (−55 to 125°C). Prices, in hundred-up quantities, range from $3.25 to $16.50 each.

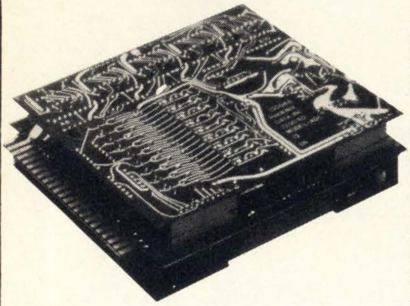
Siliconix, 2201 Laurelwood Rd., Santa Clara, Calif. 95054. Phone Jim Graham at (408) 246-8006 [419]

Power Darlingtons have fall times as low as 90 ns

Motorola has added four high-speed npn power Darlingtons to its Switchmode series of products. Two of them, the MJ10006 and MJ10007, have fall times of 90 nanoseconds and storage times of 780 ns. These times are typical for a device switching an inductive load of 180 microhenries, clamped at its rated $V_{CEX(sus)}$, and having a case temperature of 100°C. The two other units—the MJ10004 and MJ10005—have typical fall and storage times of 100 ns and 850 ns, respectively. To keep the turn-off times low, reversed diodes are connected in parallel with the input base-emitter junctions. The transistors also contain reverse diodes across their collector-emitter junctions.

All four devices are glass-passivated for enhanced reliability, and are rated for operation at junction temperatures from −65°C to 200°C. The two slower units have maximum collector-current ratings of 20 amperes, while the faster Darlingtons are rated at 10 A. Values of $V_{CEX(sus)}$ range from 400 V to 450 V, while minimum h_{FE} is 50 for the slower units and 40 for the faster. In quantities of 100 to 999, the prices of the new Darlingtons range from $4.50 each to $9.50. Volume quantities are available now.

Technical Information Center, Motorola Semiconductor Products Inc., P.O. Box 20294, Phoenix, Ariz. 85036. Phone Low Frequency Power Marketing at (602) 244-4284 [414]



Microprocessors

16-bit unit made by I^{2}L process

Rugged, low-power device from TI aims at military, industrial environments

Among principal applications for the big 16-bit microprocessor chips are military and industrial systems, where high speed and other electrical characteristics are in demand. That's why Texas Instruments is marketing an I^{2}L version of its 9900 microprocessor.

This ruggedized version, called the SBP9900, not only offers the same cycle time and large interrupt-capability as its MOS counterpart, but it offers special electrical advantages and operates in severe-temperature and low-power environments. The new unit extends the 990/9900 family of software-compatible microprocessors and minicomputers into these areas.

Fabricated with TI's integrated-injection-logic process, the SBP9900 was developed in parallel with the n-channel MOS TMS9900. The firm started making both devices last spring, but has delayed announcing the I^{2}L version until it could satisfy its internal requirements.

The firm has been using the full-temperature-range SBP9900 for a variety of military and industrial applications, such as for the navigational processor in airborne and manpack receivers for the Pentagon's Navstar/Global Positioning System [*Electronics*, May 27, p. 46].

The part is now being shipped from stock to external customers, and the firm is aiming squarely at military and industrial applications, says Richard L. Horton, product manager for the company's Digital Circuits division, Houston. "At least initially, the SBP9900 will be built and marketed only in the temperature range of −55°C to +125°C," he says.

Although prices have not been established, Horton indicates that the customary premium for full-temperature devices will be charged, tagging the I^{2}L part somewhere from three to five times the price of its MOS counterpart, which is now selling for about $70.58 in 10-piece lots.

"The learning curves, however, suggest that the I^{2}L device will decline in price faster than the MOS one," he says. He hints of the possibility that the company will offer a commercial version of the I^{2}L part later this year.

The microprocessor shares the architecture and instruction set of the rest of the company's 990 minicomputer family. It uses existing software, including prototyping systems, assemblers, and compilers.

The SBP9900 has a 3-megahertz clock rate and 500-milliampere injector current. The device dissipates 500 milliwatts. A multiply, for example, requires 17.33 microseconds at the 3-MHz clock rate. But the use of I^{2}L gives the new processor two decades of user-selectable speed-power variation. If the injector current is set at 1 ampere, the clock can range from dc to just over 4 MHz. If current is fixed at 10 mA, power dissipation will be 6.4 milliwatts and the clock can run up to 125 kilohertz.

The device can be operated from a single dc power source—either a conventional current source or a voltage source and series resistor. In low-power applications, a single C- or D-size battery will run the microprocessor. In addition, since I^{2}L is static, a penlight battery backup will keep the logic alive.

Fully static logic has other implications, as well. "There are no critical clock phases or timing limitations on the device," Horton points out. "It doesn't require any special clock drivers or buffers, for instance. The clock inputs are fully TTL-compatible." Because the device is static, it's easier to troubleshoot than MOS units. The user can step through or stop instructions in mid-execution to debug a program. The 16-bit microprocessor is housed in a 64-pin

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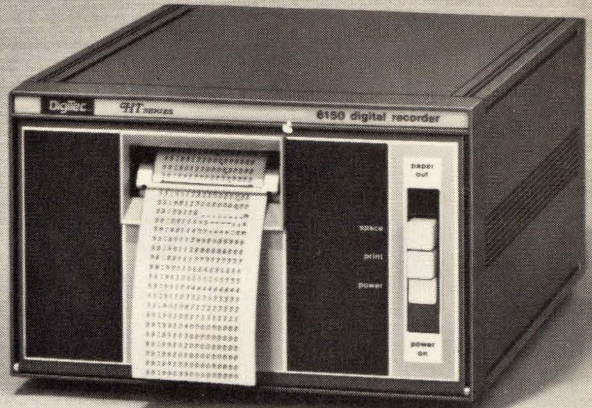

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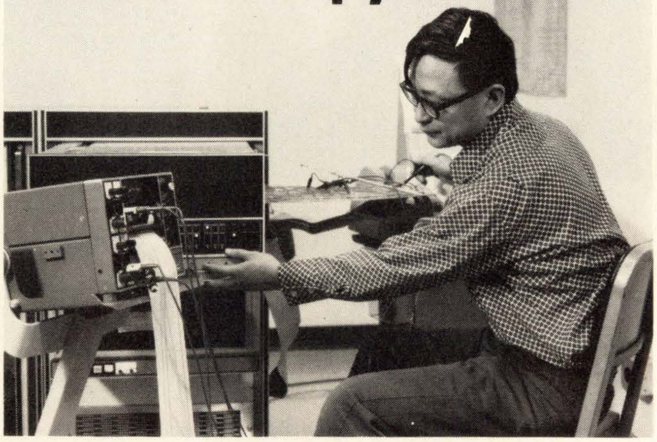

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(713) 494-5115 [342]

Microprocessor controller manages microinstructions

The latest member of Motorola's M10800 MECL processor family is an LSI circuit that manages the block of microinstructions stored in a processor's control memory. The bipolar device, designated the MC10801, responds to a set of 16 jump and branch instructions.

Five 4-bit input/output ports are available on the chip to shuttle control memory address information. Eight 4-bit master-slave registers hold the current microprogram address, cycle as an index counter for repeats, store operation codes and flag conditions, and nest subroutines in a four-by-four last-in/first-out stack.

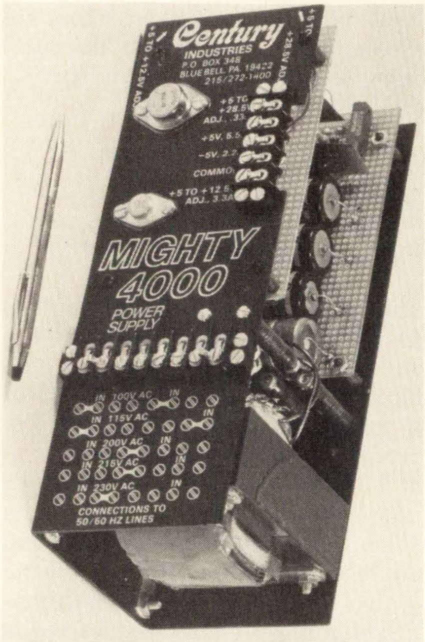
While designed for the M10800 family, the MC10800 is also useful as the microprogram controller in a MECL 10,000 system. Compatible with all MECL 10,000 circuits, the unit requires −5.2- and −2-v supplies, operates over the range from −30°C to 85°C, and is housed in a quad in-line package. The price is $50 each in quantities of 100 to 999.

Technical Information Center, Motorola Semiconductor Products Inc., P.O. Box 20294, Phoenix, Ariz. 85036. Phone bipolar marketing at (602) 962-2151 [344]

Quad supply includes PROM-zapping output

Designed to provide all the power required by a microcomputer system such as a Texas Instruments Inc. TMS-9900 or a Zilog Z-80 with 64 kilobytes of random-access memory, the model 4000 quad power supply includes an adjustable output for the on-board programing of programable read-only memories. This out-

New products



put provides up to 0.33 ampere at a voltage variable from 12 to 28 V dc. The supply's three other outputs are: 5 V at 5.5 A, −5 V at 2.2 A, and an adjustable 5 to 12 V at 3.3 A. These figures are for free air at ambient temperatures up to 40°C.

The model 4000 sells for $134 each in small quantities, and it is also offered as a kit for $109 each.

Century Industries, Bridgeport Industrial Park, 4th and Coates Streets, Bridgeport, Pa. 19405. Phone Emil C. Rotar at (215) 272-1400 [343]

12-bit computer works with PDP-8/E software

Like its predecessor, the PCM-12, the new PCM-12A is a 12-bit microcomputer designed around the Intersil IM6100 microprocessor. And like its predecessor, the 12A is fully compatible with the software developed by Digital Equipment Corp. for its PDP-8/E minicomputer.

What set the new machine apart from the earlier one are a floppy-disk mass-storage capability, a built-in crystal-controlled baud-rate generator, an improved signal-distribution system, and an absolute loader that will directly bootstrap a binary-format tape into any field of memory at the press of a front-panel switch.

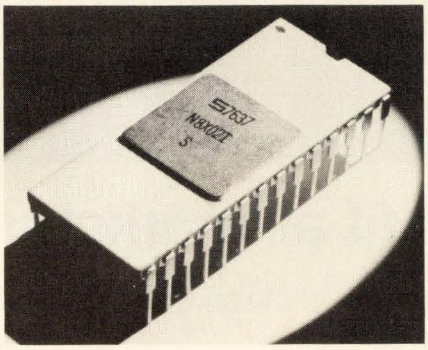
The PCM-12A is available both wired and in kit form. A kit containing a CPU, a control panel, 1 kilobyte of static random-access memory, a cabinet, and a power supply sells for $799.

Pacific Cyber/Metrix Inc., 180 Thorup Lane, San Ramon, Calif. 94583. Phone (415) 837-5400 [345]

Control-store sequencer replaces random logic

The 8X02 is a low-power Schottky LSI device whose basic function is to control the fetch sequence of microinstructions in high-performance microprogramed systems. The control-store sequencer, which replaces the random logic formerly needed to perform this function, is capable of addressing up to 1,024 words of a microprogram and is expandable to any microprogram size by conventional paging techniques.

Cited as advantages of the 8X02 over similar units are its 1-kiloword addressing capability, its subroutine nesting capability, and its four-way stack register file. The sequencer's



control instructions include increment, test and skip, and conditional branch to subroutine.

Able to operate from a single 5-volt supply, the 8X02 has a cycle time of 80 nanoseconds. The price of the control-store sequencer, in hundreds, is about $19.45 each. Delivery is from stock.

Signetics, 811 East Arques Ave., Sunnyvale, Calif. 94086. Phone (408) 739-7700 [347]

How to get high

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HIGH CURRENT

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Signetics' high technology products fit all markets.

We have a lot of things to talk about. From our broad line of analog products available to fill consumer, data processing, instrumentation and communication requirements—including new products, exclusive products, interface products, industrial products, military products, you name it. Right down to our special applications assistance which includes detailed literature and our experienced engineering staff that's always on-call to help you on a one-to-one basis.

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High voltage. Just for example, there's the Signetics NE541 Class AB monolithic power driver that offers an operation up to 80 volts, low standby current, and a wide power bandwidth. Perfect for driving large audio output stages and similar applications. Signetics has many other analog products rated at high voltages to meet your latest requirements.

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yes	yes				yes				
		yes	yes			yes			
	yes			yes	yes			yes	
yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

and memory function faster with low signal levels. Signetics sense amps, dual comparators and other products turn on and off faster. Perfect for data recording and communication applications.

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811 E. Arques Ave., Sunnyvale, Ca. 94086

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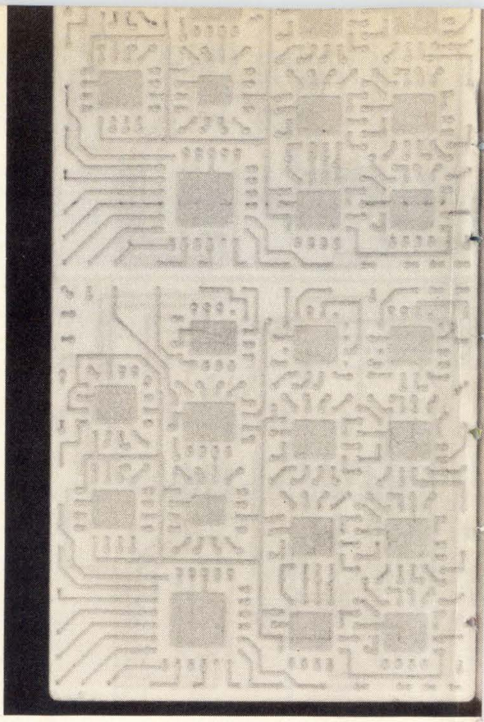
Materials

Inks for hybrids match alumina

Conductors and dielectrics simplify thick-film multilayer construction



To successfully fabricate multilayer thick-film hybrids, selection of materials is critical because the dielectric and metalization must be treated as interacting components. For that reason Du Pont has specifically designed two new conductor/dielectric systems for using either air-fired or nitrogen-fired materials to make complex multilayer hybrids.

In the first system (shown in photo), dielectric 9950, air-fired at 900° to 925°C, teams with Du Pont's gold conductor composition 9791 or a newer conductor, 9910. Resistors may be screened on top of the dielectric with the company's Birox 1400-series compositions.

The thermal coefficient of expansion for the new dielectric closely matches that of 96% alumina substrates so that "bowing" is minimized in large pieces. In fact, after eight dielectric layers were fired at 900°C, the change in camber across a 2-inch substrate measured less than 0.5 mil, no more than that of a five-conductive-layer structure.

The dielectric constant of composition 9950 is 9 to 12, high enough to minimize capacitance between crossing signal lines. The high thermal conductivity allows for power dissipation in large arrays of integrated-circuit chips. The conductor/dielectric system can yield a resolution of 8 to 12 mils between layers of the metallic interconnects (vias).

For nitrogen-fired multilayer thick-film hybrids, another easily solderable conductor/dielectric system, composed of copper-conductor composition 9923 and dielectric 9949, has a resistivity of less than 1.5 milliohms per square. On alumina substrates and dielectric 9949, the copper ink exhibits high initial adhesion of 4 to 5 pounds and retains adhesion of 3 to 4 pounds after aging at 150°C.

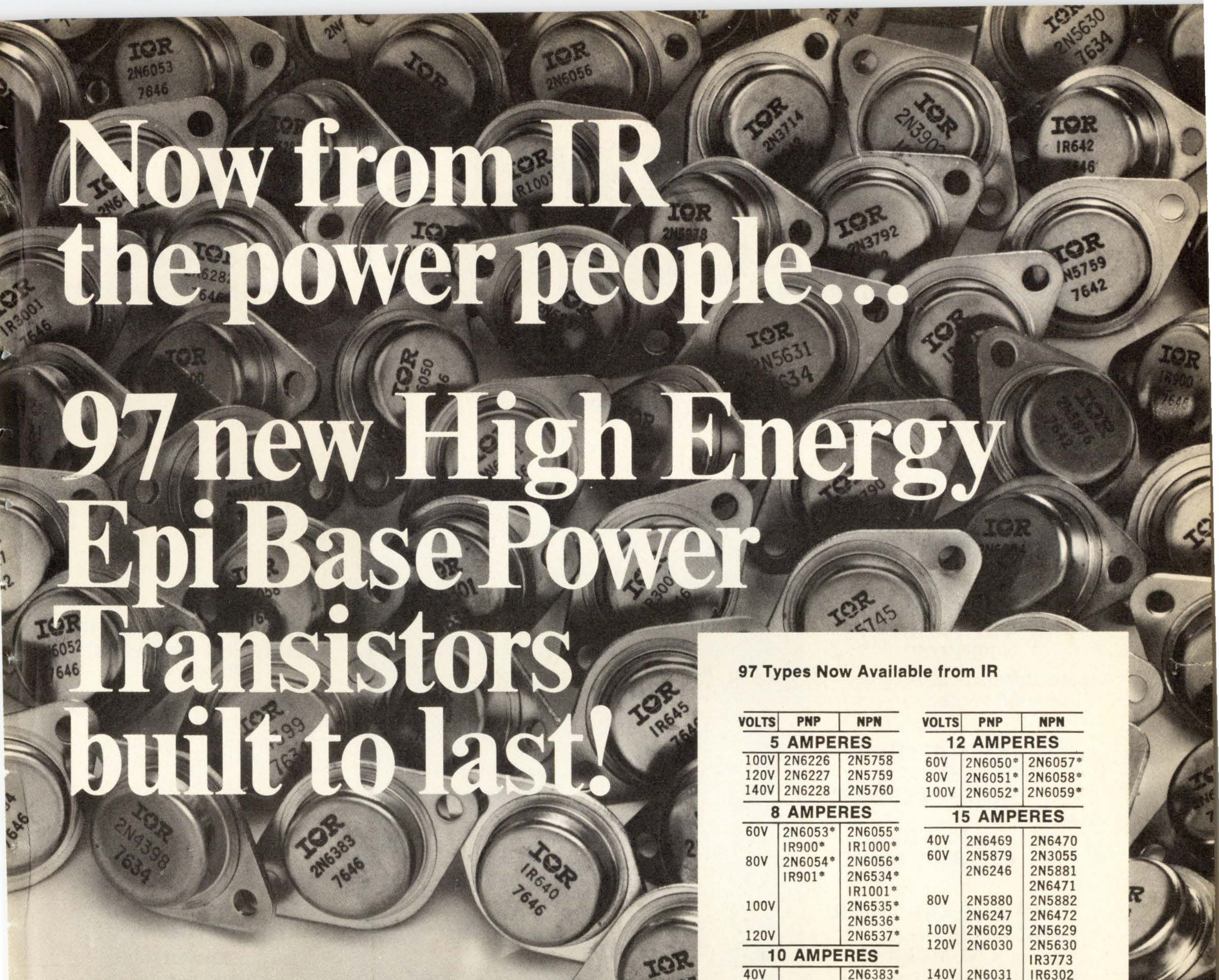
Composition 9949 has a dielectric constant of less than 8 and—like its air-fired complement, dielectric 9950—its thermal expansion is matched to alumina substrates to minimize bowing of large substrates. The new material has a dissipation factor of less than 0.5, breakdown voltage of 600 to 800 volts and insulation resistance of 7×10^{12} ohms.

The copper conductor has good printing characteristics, allowing for 7-mil lines and spaces, and it fires at 900°C in commercial nitrogen-atmosphere furnaces. Multiple firings, required in multilayer interconnects, do not alter the resistivity or adhesion properties of the copper. [341]

Du Pont Co., Wilmington, Del. 19898. Phone (302) 774-2358. [341]

Heat-transfer grease resists fluid-filler separation

A silicone heat-transfer compound designed to improve the thermal contact between heat-generating devices and their heat sinks retains its greaselike character even after six months of aging at 200°C. In contrast, some similar materials dry out and harden after only three months at that temperature. Heavily



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Delivery is off-the-shelf. Contact your nearest IR Salesman or Distributor for prices, spec sheets and samples, or write to International Rectifier, 233 Kansas St., El Segundo, CA 90245. Telephone (213) 322-3331.

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8 AMPERES		
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	IR900*	IR1000*
80V	2N6054*	2N6056*
	IR901*	2N6534*
		IR1001*
100V		2N6535*
		2N6536*
120V		2N6537*
10 AMPERES		
40V		2N6383*
60V	2N3789	2N3713
	2N5791	2N5715
	2N5875	2N5877
	IR2500*	2N6384*
	IR645*	IR1010*
		IR1020*
		IR3000*
		IR640*
80V	2N3790	2N3714
	2N3792	2N3716
	2N5876	2N5878
	IR2501*	2N6385*
	IR646*	IR3001*
		IR641*
100V	2N6229	2N5632*
	2N6248	IR642*
	IR647*	
120V	2N6230	2N5633
140V	2N6231	2N5634

*Darlington

VOLTS	PNP	NPN
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80V	2N6051*	2N6058*
100V	2N6052*	2N6059*
15 AMPERES		
40V	2N6469	2N6470
60V	2N5879	2N3055
	2N6246	2N5881
		2N6471
80V	2N5880	2N5882
	2N6247	2N6472
100V	2N6029	2N5629
120V	2N6030	2N5630
		IR3773
140V	2N6031	IR6302
		2N5631
20 AMPERES		
60V	2N5745	IR3772
	2N6285*	2N6282*
80V	2N6286*	2N5303
		2N6283*
100V	2N6287*	2N6284*
25 AMPERES		
60V	2N5883	2N5885
80V	2N5884	2N5886
30 AMPERES		
40V	2N4398	IR3771
		2N5301
60V	2N4399	2N5302
90V	IR4502	IR802

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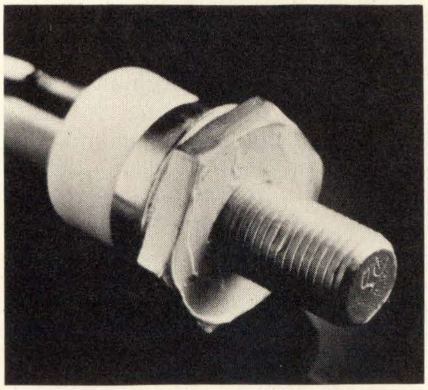
New products



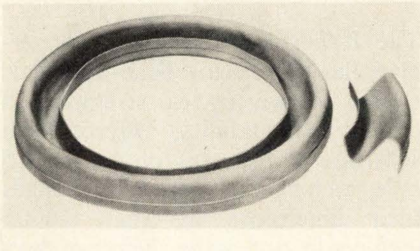
filled with heat-conductive metal oxides, Dow Corning 342 has a much lower tendency toward fluid-filler separation than previous heat-sink compounds.

Because the material can be easily pumped, either manual or automatic applicators can apply it to the base or mounting studs of transistors, diodes, and silicon controlled rectifiers. It is available in 4-ounce tubes, 12-oz cartridges, and 20- and 100-pound pails.

Dow Corning, Midland, Mich. Phone (517) 496-4468 [476]

Knitted wire adds strength to conductive elastomer

By adding layers of knitted wire to its Xecon conductive elastomer, Metex Corp. has produced a reinforced



material with greatly improved flexure strength and longer life. Called Armored Xecon, the material provides more than 60 decibels of shielding from 14 kilohertz to 10 gigahertz. It can be molded in a variety of shapes and sizes with one or more layers of knitted wire. Both the knitted-wire alloy and mesh size as well as the silvered-particle-filled silicone elastomer can be varied to

New products

meet customer requirements. Because it was developed to meet stringent military requirements, Armored Xecon is expected to easily meet most industrial and commercial specifications.

Metex Corp., 970 New Durham Rd., Edison, N.J. 08817. Phone Peter G. Novak at (201) 287-0800 [477]

Flexible epoxy retains high resistivity when hot

Polycal No. 112 is a two-part epoxy compound for encapsulating and potting conductors, cables, and junctions in applications in which movement and flexing are expected. The flexible material has extremely high resistivity even at elevated temperatures. At 300°F, the resistivity is 10^{14} ohm-centimeters.

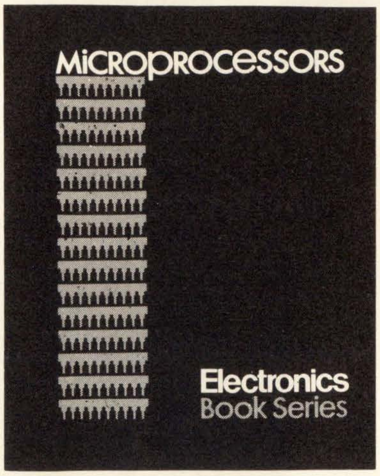
The epoxy is recommended as a substitute for polyurethanes when superior insulating properties are needed. A castable elastomer, it can also be used to impregnate fiber or cloth. Polycal No. 112 is available in pints, quarts, gallons, five-gallon pails, and 55-gallon drums.

Polycal Research Corp., P.O. Box 4624, Irvine, Calif. 92716 [480]

Flexible circuit materials are strong and stable

The R/flex 2400 series of copper-clad flexible circuit base materials exhibit noteworthy tear strength and dimensional stability. Offered with substrate thicknesses of 4 and 7.5 mils, etching the materials changes their dimensions less than 0.0005 inch per in. and aging them two days at 125°C, less than 0.0016 in./in. Initiating and propagating tear strengths for the 7.5-mil composite are 8 to 9 pounds and 0.8 to 1.0 lb, respectively. The two tear strengths of the 4-mil version are about 50% as great as those of the thicker material.

The R/flex materials, clad on one or both sides with 1- or 2-ounce electrolytic copper foil, are available



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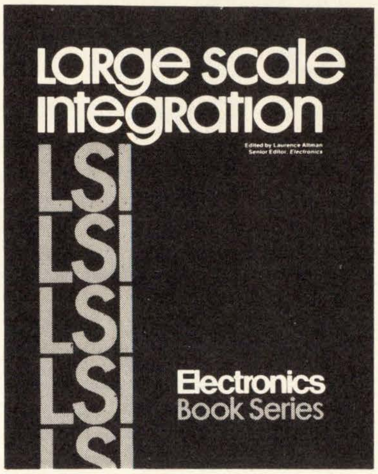

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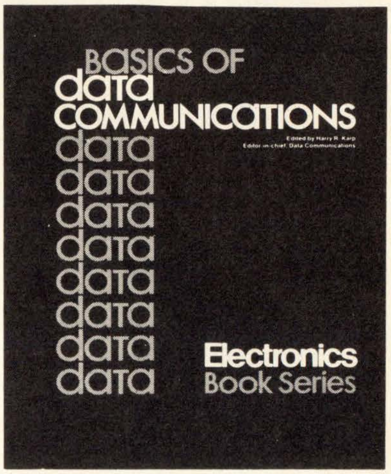

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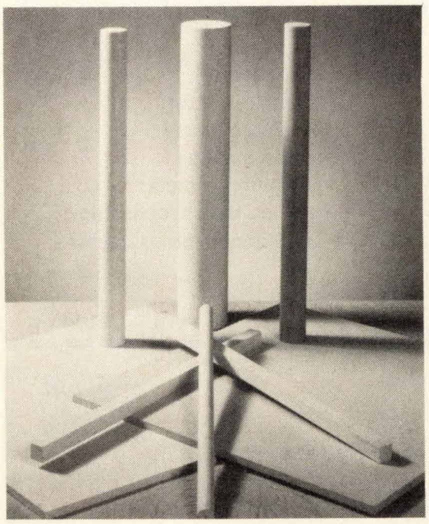
Rogers Corp., Rogers, Conn. 06263. Phone Frank McGarry at (203) 774-9605 [479]

Rigid microwave foam has dielectric constant of 1.46

Eccostock GT-22 is a dielectric syntactic foam for microwave transmission-line and antenna applications. The light-weight (22 pounds per cubic foot) material has a dielectric constant of 1.46 and a loss tangent of 0.006. It has good dimensional stability, will not cold-flow,



and can be machined with automatic screw machines. Water absorption is less than 1% after 16 hours immersion at 1,500 psi. A 1-inch-thick sheet of Eccostock GT-22 1 foot square is priced at $65. Although the company is working on materials with dielectric constants as low as 1.2, these compositions are not yet available.

Emerson and Cuming Inc., Canton, Mass. 02021. Phone (617) 828-3300 [478]

New literature

Voltage regulators. A comprehensive 202-page handbook that describes the theory and practical application of integrated-circuit voltage regulators can be ordered from Motorola Semiconductor Products Inc., Literature Distribution Center BB100, P.O. Box 20924, Phoenix, Ariz. 85036. Among the topics covered by the handbook are transistor selection, heatsinking, basic regulator theory, reliability considerations, and troubleshooting. The handbook also includes recommended circuit configurations and design examples. The single-copy price of the Voltage Regulator Handbook is $2.50. Circle reader service number 421.

Radiation testing. A 26-page publication entitled "Guidelines for Radiation Effects Testing" provides the reader with the information and procedures necessary to perform radiation tests on electronic components, circuits, and subassemblies. The document includes suggestions for facility selection, dosimetry techniques, and instrumentation selection. Copies are available from IRT Corp., Box 80817, San Diego, Calif. 92138 [422]

Semiconductors. The line of hybrid and discrete semiconductor devices made by TRW RF Semiconductors is described in a 12-page catalog that can be obtained by writing to the company at 14520 Aviation Blvd., Lawndale, Calif. 90260. The catalog includes devices that operate from 1 megahertz to 4 gigahertz, and handle power levels from microwatts to kilowatts. [423]

Direct-acting recorders. A 56-page comprehensive catalog from General Electric describes the company's line of direct-acting strip-chart recorders used for measuring voltage, current, power, reactive power, frequency, and power factor. Included in the catalog (No. GEP-352B) are applications guidelines, model descriptions, specifications, dimensions, external wiring diagrams, and prices. Copies are offered by the General Electric Co., One River Rd., Schenectady, N.Y. 12345 [424]

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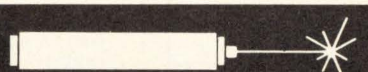

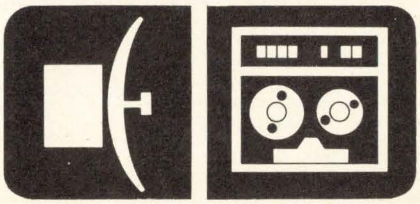

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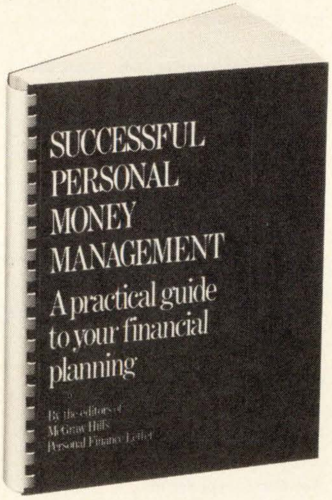

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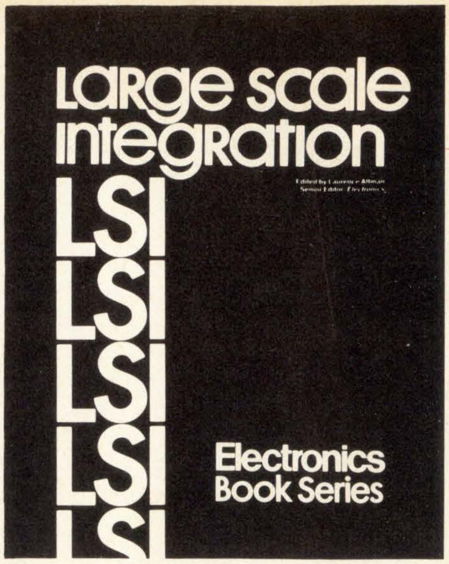

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