JANUARY 3, 1980

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Error correction comes to microcomputer memory boards/ 168

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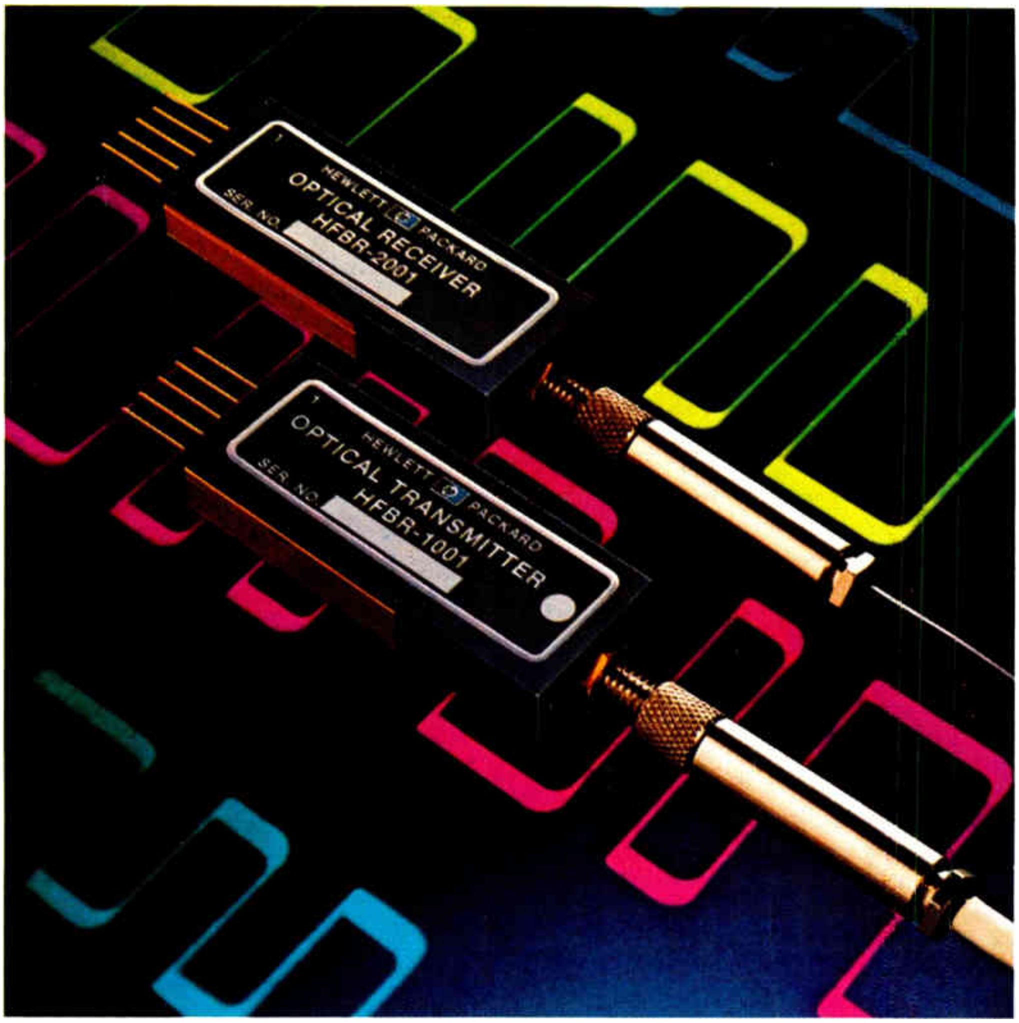

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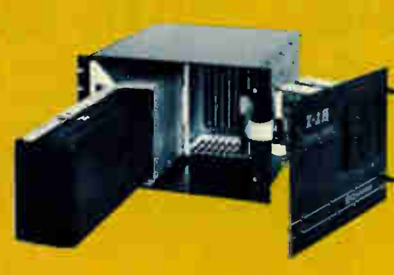

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Electronics

The International Magazine of Electronics Technology

Vol. 53, No. 1 • January 3, 1980

Highlights

Cover: Electronics markets look hardy, 125

That recession talked about for so long still looms, but the electronics markets should be relatively immune when it comes. However, growth for U. S., Western European, and Japanese electronic equipment consumption will slow to 10.2% this year, down from 14.1%, according to *Electronics*' annual markets forecast.

In a reversal of last year's pattern, Japan should lead with an expected growth rate of 11.3% (p. 143). Next is the U. S., at 10.3% (p. 126). Lagging somewhat behind will be Europe, at 9.6% (p. 138).

Cover is by Art Director Fred Sklenar.

VHSIC set to roll, 81

The military's $210 million six-year program for the development of very high-speed integrated circuits has broken loose of the House Armed Services Committee. The first nine contracts, worth $10 million to $12 million, will be awarded this month, out of a total of $30.4 million for fiscal 1980.

LCD makes multiplexing easy, 151

Improved material and packaging borrowed from integrated-circuit manufacturing make it possible to multiplex a 40-character liquid-crystal display simply and economically. What's more, the compact display interfaces easily with a microprocessor.

Hamming up memory boards, 168

The reliability of microcomputer systems is a growing concern, and error detection and correction can do much in memory to improve it. A Multibus-compatible series of 8- and 16-bit memory boards uses a modified version of the Hamming code to correct 1-bit errors and detect 2-bit ones.

. . . and in the next issue

Testing partial memories . . . a structured assembly language for microprocessors . . . a second-generation low-power Schottky family.

Electronics

Publisher's letter

The New Year's celebrations are hardly over and the pundits are hard at work trying out labels for the 1970s. Some have already looked at the effects of the energy crisis triggered by the Organization of Petroleum Exporting Countries and tabbed it the sagging seventies.

After the soaring sixties, the 1970s do indeed look flaccid. But the same glib labels that observers following the national economy may tag on the 1970s do not necessarily apply to the electronics industries. For the most part, they have operated in their own waters—influenced by the economic ebb tides, but not left high and dry.

Proof of this ability to keep ahead of the worst of the economic ills is demonstrated in the markets forecast that appears in this issue (p. 125). Even though the economies of the United States, Western Europe, and Japan have slowed in the face of high energy costs and inflation, the electronics markets have continued to log very healthy growth. As the threat of recession has intensified, electronics companies seem to have become more confident that they can skip along, more or less immune to a general recession.

Yes, the growth rate will slow this year as the long-anticipated recession finally settles over the economy. But a better than 10% increase in a general economic downturn is not so bad. The annual *Electronics* survey that is the basis of our markets forecast indicates that much momentum has built up in the last few years. It's almost as though the industry is too busy to take notice of a recession.

Leading the parade is the booming data-processing and office equipment sector. Its impact is considerable—not only is the market in integrated circuits rocketing upward, but test instruments, too, are riding the coattails of the computer boom.

Therefore, the 1970s were anything but sagging for most sectors of the electronics industries. Even the consumer portion, which is weak this year, hit new peaks during the decade. Look, for example, at the plethora of new consumer products that are commonplace today thanks to the proliferation of low-cost ICs. At the beginning of the decade few expected to have speech-synthesis products in the hands of consumers. Indeed, these newer products will soon outpoint the traditional television and hi-fi audio equipment sales.

Ten years ago *Electronics* dubbed the 1970s the digital era and predicted a decade of rapid growth for the computer industry. In 1970, *Electronics* pegged the computer and related equipment total at \$5.3 billion. This year this market should be worth \$30.2 billion, according to *Electronics*' survey (p. 136).

Given these results, it's awfully difficult to be pessimistic about the next 10 years. There are growth opportunities in every market segment, limited only, it seems, by the capital to invest in the opportunities and the availability of skilled people to carry out the expansion.

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Meetings

Second Design and Finishing of Printed Wiring and Hybrid Circuits Symposium, American Electroplaters' Society (1201 Louisiana Ave., Winter Park, Fla. 32789), San Francisco Hilton, Jan. 15–17.

TV Mex, the TV Microelectronics and Microprocessing Exhibition, and IDEA, the International Domestic Electrical Appliances Exhibition, Montbuild Ltd. (11 Manchester Sq., London W1M 5AB, England), National Exhibition Centre, Birmingham, England, Jan. 15–17.

VHSIC—A New Era in Electronics, American Institute of Aeronautics and Astronautics (Box 91295, Dept. VHSIC, Los Angeles, Calif. 90009), Hyatt Regency, Cambridge, Mass., Jan. 21–22.

Advanced Semiconductor Equipment Exposition, Associated Ad-Ventures Inc. (Suite V, 4546 El Camino Real, Los Altos, Calif. 94022), Convention Center, San Jose, Calif., Jan. 22–24.

Annual Reliability and Maintainability Symposium, American Society of Mechanical Engineers, IEEE *et al.* (for information, contact N. Kutner, Burroughs Corp., Burroughs Pl.–5F48, Detroit, Mich. 48232), San Francisco Hilton, Jan. 22–24.

Embedded Computer Systems Acquisition Management, American Institute of Industrial Engineers Seminars (P. O. Box 3727, Santa Monica, Calif. 90403), International Inn, Washington, D. C., Jan. 22–24.

Third Annual SEMI Information Services Seminar, Semiconductor Equipment and Materials Institute (625 Ellis St., Suite 212, Mountain View, Calif. 94043), Marriott Hotel, Newport Beach, Calif., Jan. 27–30.

Software Quality Assurance and Configuration Management Seminar, The American Institute of Aeronautics and Aeronautics (P. O. Box 91295, Los Angeles, Calif. 90009) *et al.*, Colonnade Hotel, Boston, Mass., Jan. 28–29, and International Inn, Washington, D. C., Feb. 21–22.

Communication Networks '80, The Conference Co. (60 Austin St., Newton, Mass. 02160), Sheraton Washington, Washington, D. C., Jan. 28–30.

Fifth Topical Meeting, Integrated and Guided Wave Optics, Optic Society of America (200 L St. N. W., Washington, D. C. 20036) and IEEE, Hyatt–Lake Tahoe, Incline Village, Nev., Jan. 28–30.

The Automated Office, American Institute of Industrial Engineers, (P. O. Box 3727, Santa Monica, Calif. 90403), Statler Hilton Hotel, New York, Jan. 28–30, and Twin Bridges Marriott Hotel, Washington, D. C., Feb. 11–13.

11th International Symposium for Mini and Microcomputers, International Society for Mini and Microcomputers (P. O. Box 2481, Anaheim, Calif. 92804), Asilomar Conference Grounds, Pacific Grove, Calif., Jan. 30–Feb. 1.

Export Administration Act of 1979, Law & Business Inc. (757 Third Ave., New York, N. Y. 10017), Mark Hopkins Hotel, San Francisco, Jan. 31–Feb. 1.

Annual Television Conference, Society of Motion Picture and Television Engineers (862 Scarsdale Ave., Scarsdale, N. Y. 10583), Sheraton Centre Hotel, Toronto, Feb. 1–2.

Los Angeles Technical Symposium, Society of Photo-Optical Engineers (P. O. Box 10, Bellingham, Wash. 98255), Sheraton-Universal Hotel, North Hollywood, Calif., Feb 4–7.

Eighth Semiannual Conference on Federal ADP Procurement: New Departures, American Institute of Industrial Engineers (P. O. Box 3727, Santa Monica, Calif. 90403), Shoreham Americana Hotel, Washington, D. C., Feb. 4–6.

Third International Business Computing, Word Processing and Information Management Exhibition and Conference (Info '80), BED Exhib-

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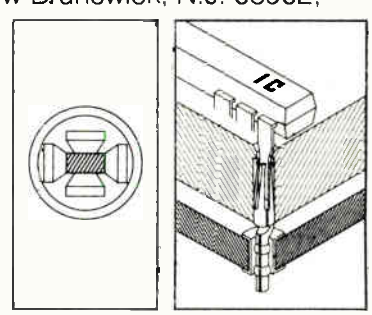

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Meetings

itors Ltd. (Bridge House, Restmor Way, Wallington, Surrey SM6 7BZ, England), Cunard International Hotel, London, Feb. 12–15.

Southwestern Tool and Manufacturing Engineering Conference and Exposition, Society of Manufacturing Engineers (P. O. Box 930, Dearborn, Mich. 48128) and National Tool, Die, and Precision Machining Association, Albert Thomas Convention Center, Houston, Texas, Feb. 19–21.

Alternate Energy Sources of the 1980s Conference, IEEE, Town and Country Hotel, San Diego, Calif., Feb. 20–22.

Word/Text Processing, American Institute of Industrial Engineers, (P. O. Box 3727, Santa Monica, Calif. 90403), Ambassador West Hotel, Chicago, Feb. 20–22.

Diamond Jubilee Exhibition, Society of Automotive Engineers (400 Commonwealth Dr., Warrendale, Pa. 15096), Cobo Hall, Detroit, Feb. 25–28.

Conference on Industrial Investment Opportunities in Morocco, Moroccan Industrial Development Office (821 U. N. Plaza, Suite TM-606, New York, N. Y. 10017), Rabat, Morocco, Feb. 25–29.

Short courses

Lasers and Applications, Feb. 5–7 and May 20–22, Ramada Inn Rosslyn, Arlington, Va. Write to Society for Optical and Quantum Electronics, P. O. Box 245, McLean, Va. 22101.

Modular Software Design, Feb. 6–8, George Washington University, Washington, D. C. Write to Continuing Education Program, GWU, Washington, D. C. 20052.

Fundamentals of High-Resolution Lithography, Feb. 11, and **IC Technologies for the 80s,** Feb. 12, Cabana Hyatt Hotel, Palo Alto, Calif. Write to U. of Calif. Extension, 2223 Fulton St., Berkeley, Calif. 94720

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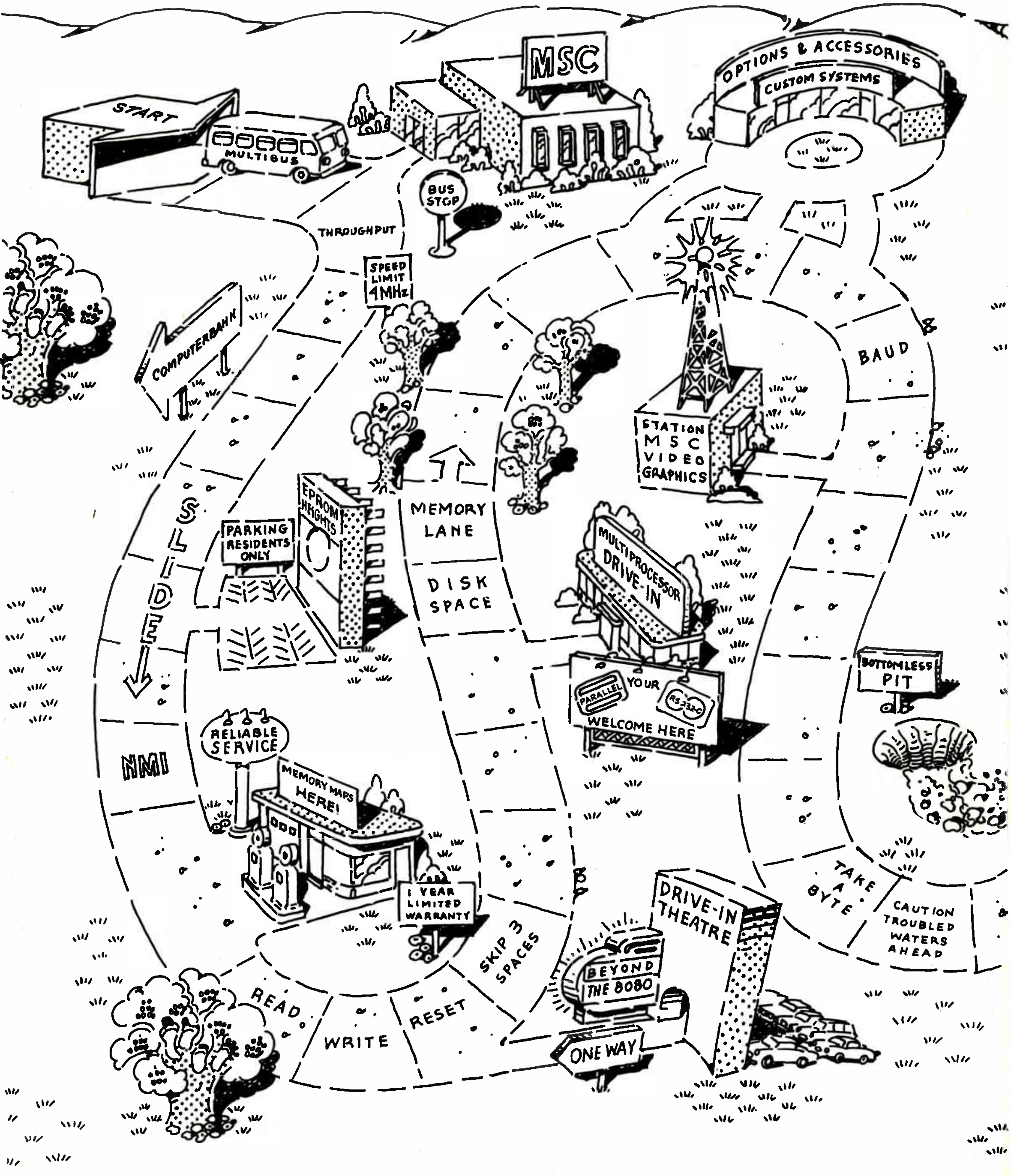

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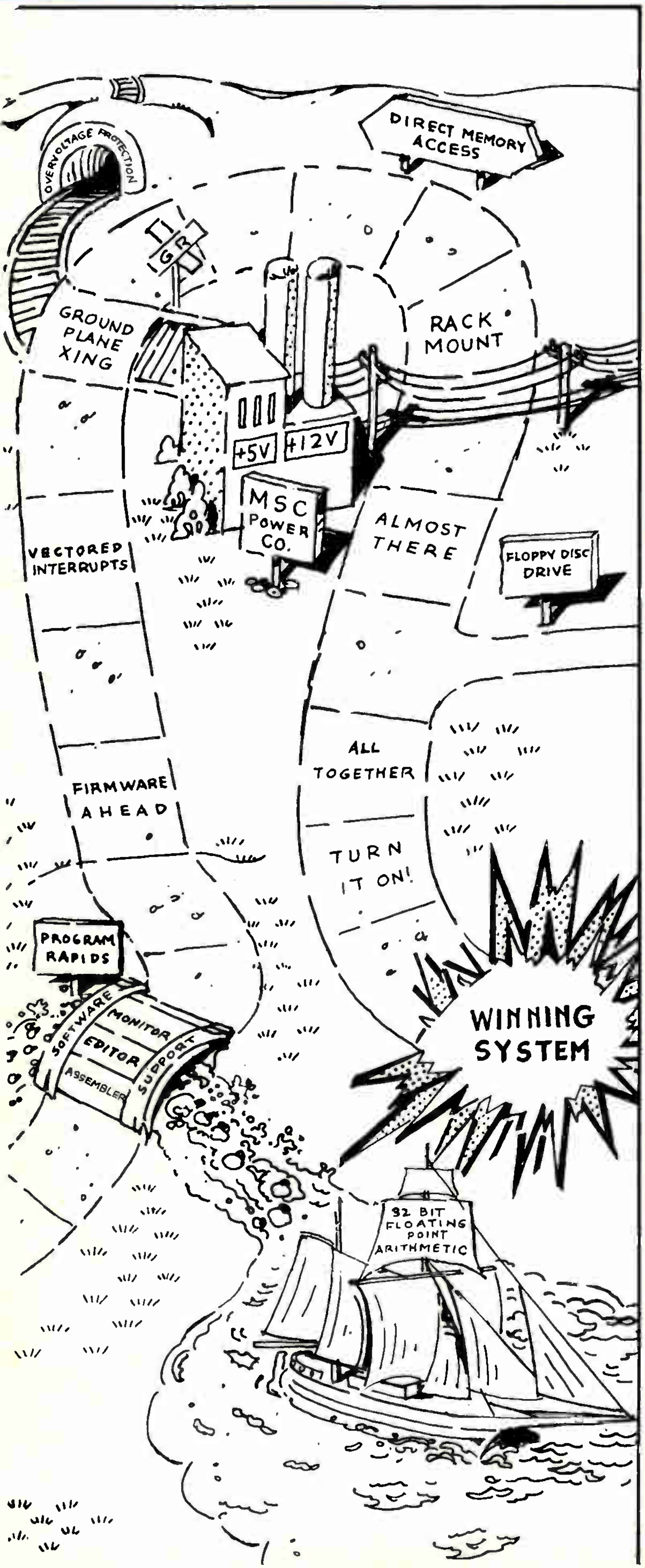

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Circle 146 on reader service card

News update

■ Skylab, the 85-ton United States experimental satellite, caused worldwide anticipation, consternation, and something of a frenzy just before it came crashing back to earth in Australia last summer. Now Hermes, a communications satellite, has also ended its useful life, though scientists say that, unlike Skylab, it will never fall because of its considerably higher orbit.

Hermes was Canada's eighth such satellite. It was launched just about four years ago, on Jan. 17, 1976, and was the first domestic communications satellite to operate in the 14-(up link)-to-12-(down link)-gigahertz band. This meant that earth stations smaller than ever before could be used to transmit and receive audio, video, and data signals.

Regarded as the forerunner of the direct-to-home broadcast satellite, Hermes lived almost twice as long as the two years that were expected, and it performed well throughout the third and fourth years. Its final act was to carry out some rain attenuation tests requested by the Australian government. But, says Canadian Minister of Communications David MacDonald, contact has now finally been lost.

Hermes' faithful 200-watt traveling-wave tube was supplied by Litton Industries and worked until the bird's final day. TWTs, despite recent developments in solid-state technology, continue to be the amplifiers of choice in satellites because they offer high amplification factors, broad bandwidth, and, as was the case with that carried aboard Hermes, long life expectancy.

Hermes now presumably joins the growing collection of other satellites, parts of satellites, and other Space Age detritus. This is much to the distress of the people who want to put other birds into orbit, only to find so much of the preferred parking areas cluttered with floating leftovers. In fact, one aide of the National Aeronautics and Space Administration says, "if we don't change the way we do business in space, a broad belt of debris from collisions will form." [*Electronics*, June 21, p. 96]. **-Harvey J. Hindin**

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People

Lepselter sees more doubling of IC complexity each year

With so many semiconductor manufacturers lamenting anticipated difficulties in producing very large-scale integrated circuits, it is refreshing to hear from an optimist. One such person is Martin P. Lepselter, director of the Advanced LSI Development Laboratory at Bell Laboratories in Murray Hill, N. J.

Lepselter is the 1979 winner of the Jack A. Morton Award of the Institute of Electrical and Electronics Engineers for his invention of beam-lead IC technology and for his work on IC metallurgy, including the development of platinum silicide. While beam-lead technology has seen some use for challenging packaging problems, refractory silicides such as PtSi are being increasingly hailed as one way to lower the resistance of VLSI interconnections.

Though some chip makers feel that Gordon Moore's "law" will be violated in the near future, Lepselter disagrees. Moore's law holds that IC device complexity doubles approximately every year; but even Moore himself, president of Intel Corp., feels the slope of the curve will soon level off to become less dramatic. However, "we will keep Moore's curves on line," insists Lepselter. "We can keep going with double the devices every year."

He is a big booster of n-channel MOS technology, believing it "can be pushed to 0.25-micrometer channel lengths," he states. Lepselter, a mechanical engineering graduate of City College of New York, also has faith in silicon despite the growing interest in gallium arsenide for higher speeds—no wonder, for he holds 45 patents in silicon device technology. "Silicon will be just as fast," he predicts. "When you go below 1-micrometer line widths, you are not limited by mobility; RC time constants become dominant."

To keep Moore's law in line, Lepselter has been instrumental in the development of a complete high-resolution X-ray lithographic system at the labs. It can resolve 0.5-μm geometries and it has a quick turnaround time: "It has the potential to do 6-inch wafers in a couple of minutes and this exposure time can be improved by a factor of four with tricks," he says. He boldly adds that "0.5-μm will be the commercial technology of 1981."

Booster. Bell Labs' Lepselter believes that LSI complexity curve will continue to climb.

Chapman completes transition from marketer to top position

It is rare for a company's top financial officer to shift into its marketing department, and even more rarely is such a transition successful. But apparently William E. Chapman has succeeded, for the former treasurer and marketing vice president at Litronix Inc., a subsidiary of West Germany's Siemens AG, is now executive vice president and chief operating officer of the Cupertino, Calif., optoelectronics producer.

A 1960 graduate of Vanderbilt University with a bachelor's degree in business administration, Chapman spent his first 14 years in industry with Westinghouse Electric Corp.'s financial sector before joining Litronix as its treasurer in December 1974. Several months after Siemens' acquisition in October 1977 of the then-financially troubled Litronix, Chapman assumed the top marketing spot because, as he puts it, "we needed to have some bottom-line orientation in our marketing function."

People

At the top. Litronix' Chapman started as treasurer, is now chief operating officer.

Now that Litronix is back in the black—it turned a profit in the fiscal year ended Sept. 30, 1979, according to Chapman—the 41-year-old official intends to direct Litronix in addressing three big needs—improved quality, greater productivity, and enhanced profits. One reason for this is the Japanese. Although not yet a big factor in the U. S. optoelectronics market, Chapman says, "The Japanese will be here. We have to start now to be in a position to counter them, and better them, by being innovative in responding to the market's needs and getting our productivity and quality up."

Although his ultimate goal is improved profitability for Litronix, Chapman says, "It is a time-consuming process, and it is not done in one or two quarters." Rather, he believes Litronix needs to look at basics and, like European companies, "look at things from a more long-term viewpoint."

One of the biggest challenges facing Chapman is to come up with a recipe to maximize resources for Litronix' growth. Two of the areas that contributed to the firm's growth in 1979 and enabled it to gain market share, and which Litronix will concentrate on, are intelligent displays and opto-isolators. "These two areas look very strong for the next five years, especially for different types of products." Not to be overlooked, he continues, are the standard light-emitting-diode lamp business—"especially good right now"—and specialty products such as multicolor and flashing lamps.

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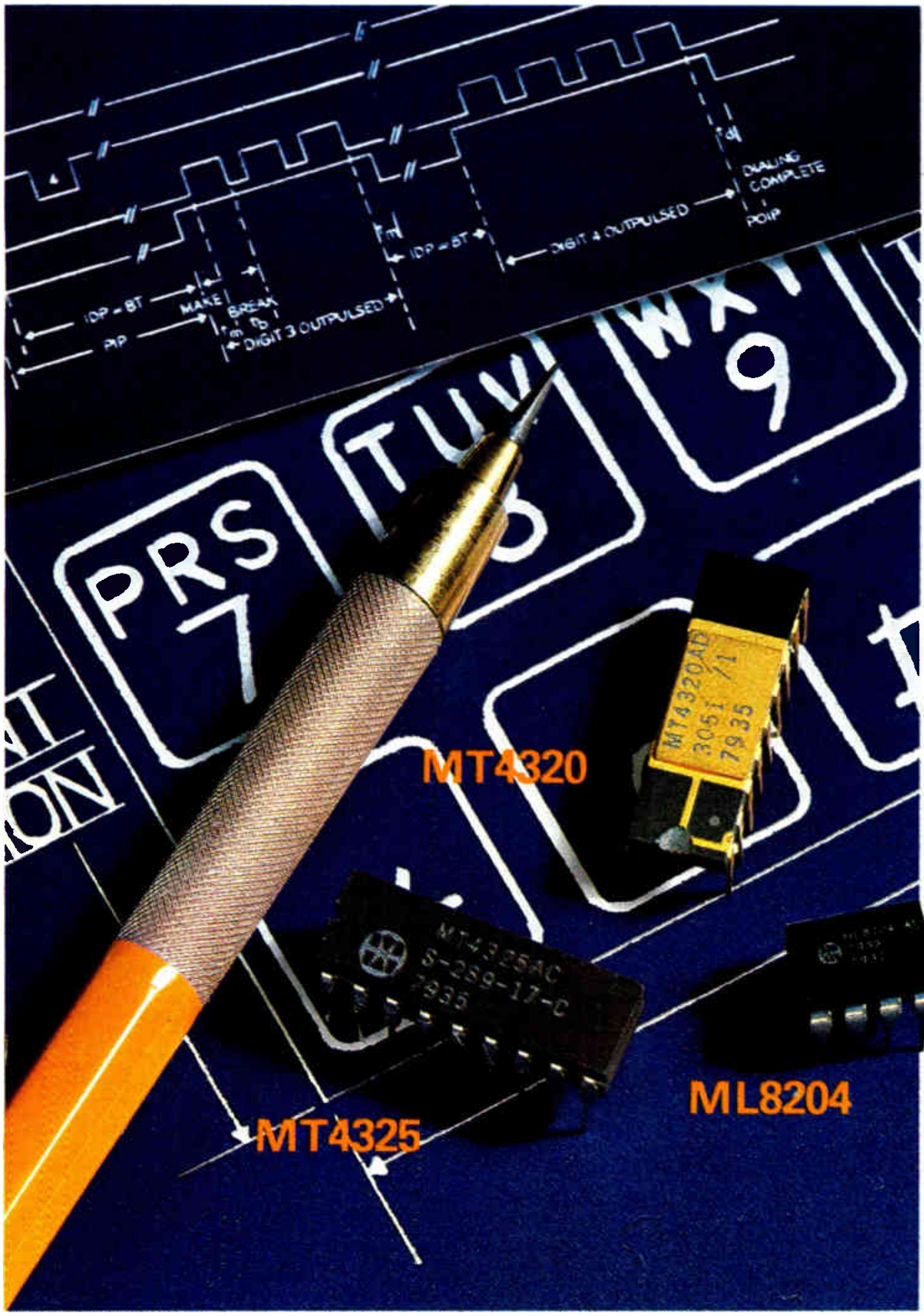

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Our designers at Mitel Semiconductor know the telephone. That's because they work side by side with Mitel Telecom engineers. The application of our semiconductor technology to the telephone has produced the most efficiently integrated phone components in the world.

The MT4320 Pulse Dialer

The MT4320 allows the rotary dial to be directly replaced by a push button pad. This pin for pin equivalent to the industry standard DF320 has an operating voltage range of 2 to 7 volts, 250μW operating power dissipation, and a stand-by current consumption of less than 1μA. The MT4320 stores up to 20 digits, has last number redial, pin selectable line break/make ratio and pin selectable impulsing rate of 10, 16 or 20 PPS.

The MT4325 Programmable Dialer

The MT4325 has all of the features of the 4320. In addition it has an audible key tone and access programming for automatic dialing pause in redial mode.

The ML8204 Tone Ringer

This replacement for the telephone bell, with a minimum of external components, provides a pleasant warbling sound, and interfaces to the telephone line. The ML8204 has low power consumption, an on-chip regulator, positive switch-on and is packaged in an 8 pin minidip.

MITEL SEMICONDUCTOR, we've got the goods for you.

MITEL SEMICONDUCTOR

United States: 1735 Jefferson Davis Highway, Suite 1009, Arlington, Virginia, U.S.A. 22202. Telephone (703) 243-1600
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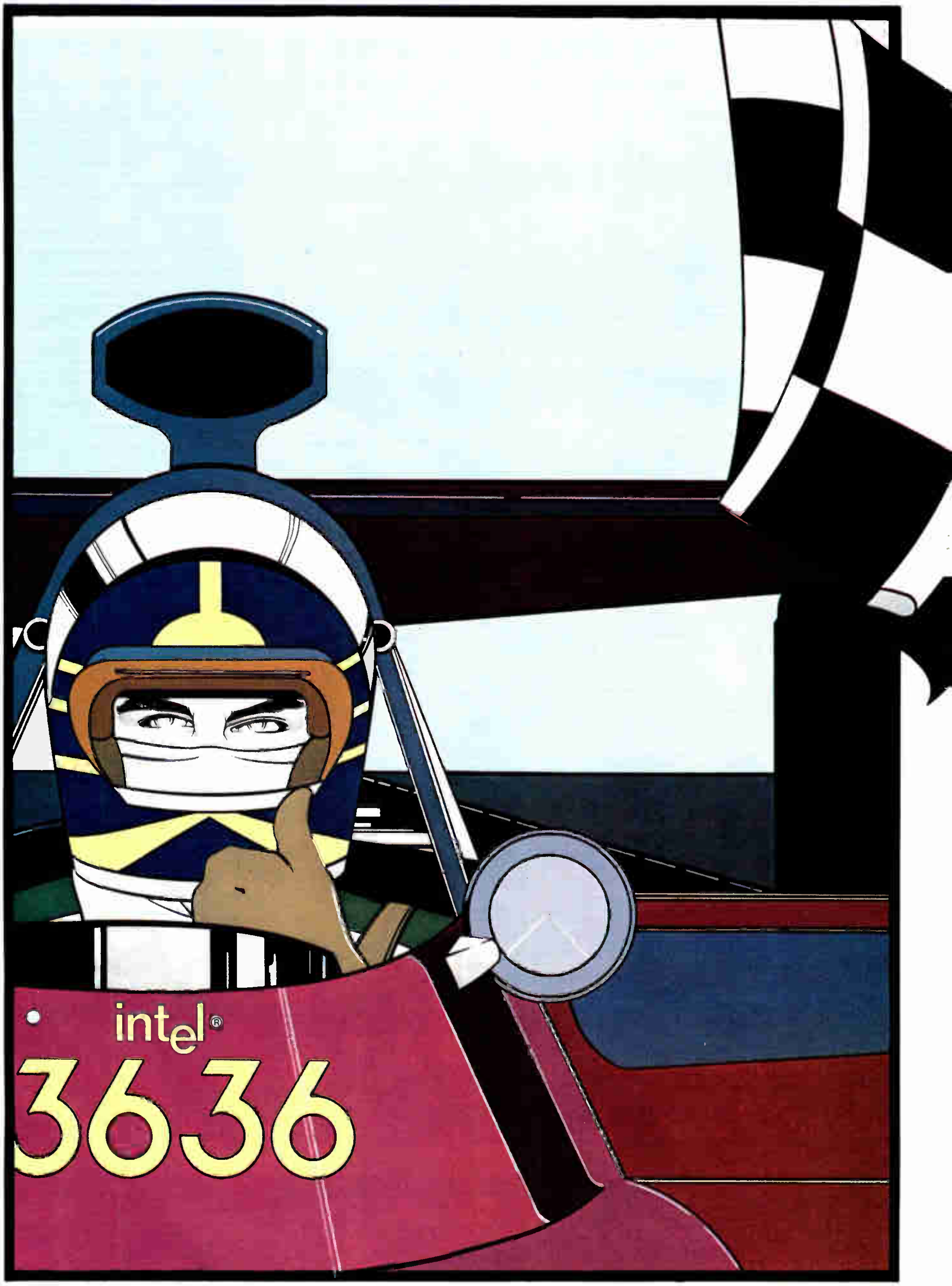
18 Airport Blvd., Bromont, Quebec, Canada J0E 1L0. Telephone (514) 534-2321, Telex: 05-267474.

Europe: Hamilton Road, Slough, Berkshire, England SL1 4QY. Telephone 0753-36137, 0753-36138, Telex: 847730
Fredericiagade 16, Suite 309, 1310 Copenhagen K, Denmark. Telephone (01) 119302, Home (02) 484083, Telex: 27246

Asia: TST P.O. Box 98577, Kowloon, Hong Kong. Telex: 64235-Mitel HX

Circle 17 on reader service card


intel®
3636

16K Speed Champ

Intel's new 3636 bipolar PROM breaks the 16K speed barrier with 65ns access. It's a victory for bit slice designs.

Streamlined performance is the whole point of today's advanced bit slice computers. High speed. High density. High reliability. Now Intel delivers the 16K 3636, manufactured with our new Stacked Fuse Bipolar* process to produce the highest performance microprogram memory yet.

Design for speed and comfort

Our 2Kx8-bit 3636 gives you four times the density of 4K bipolar PROMs with no speed penalty. The 3636's maximum access of 65ns makes it the ideal memory for fast, high density bit slice designs, as well as look-up table and other program store applications.

Using the 3636 instead of 4K PROMs lets you reduce component count and microprogram board requirements up to 75%. By designing program store on the CPU board, you can even save up to a full board slot for I/O or other functions.

For designs requiring extended temperature ranges, our 80ns military device, the M3636, is ideal.

No matter what your application, you're certain to reduce power requirements. Power consumption per bit for the 3636 is only one fourth that of most 4K bipolar PROMs and only half that of most 8Ks.

Whether you're replacing 4K or 8K bipolar devices, the 3636 makes it simple. It's packaged in the industry standard 24-pin DIP, so you won't have to redesign in order to upgrade.

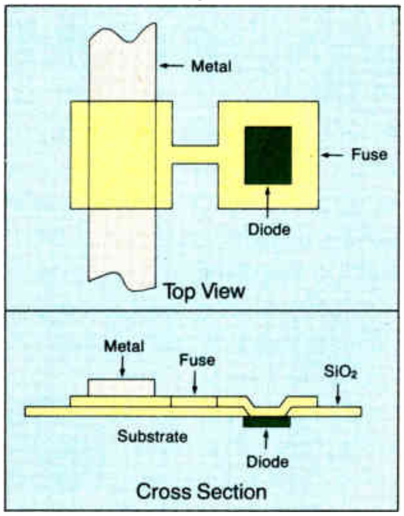
And you can program the 3636 in seconds using Intel's UPP103 or any standard PROM programmer.

Our formula: Stacked Fuse Bipolar

The most efficient way to improve speed characteristics of bipolar PROM's is to reduce die size. Very simply, smaller geometries reduce capacitance, thus speeding access time.

Intel achieved the 3636's high speed and dramatically smaller die size with a new "stacked" bipolar process. Stacked Fuse Bipolar combines Intel's expertise in Large Scale Integration with dual layer metalization and polysilicon fuses. (See diagram.) The result is the highest density and performance ever in a 16K bipolar PROM.

Stacked Polysilicon Fuse



Intel's new Stacked Fuse Bipolar process allows a 30% reduction in the 16K cell size. This dramatic density improvement yields faster access speeds than ever before possible. The illustration shows the "stacking" of our polysilicon fuse over the diode instead of placing them side by side as in older designs.

Intel's 3636 Bipolar PROMs			
	3636-1	3636	M3636
Maximum Access Time (ns)	65	80	80
Typical Power Per Bit (mW)	0.05	0.05	0.05

Intel's 3636 also means high reliability. We've already proven the producibility and dependability of Stacked Fuse technology with our 3625A 4K bipolar PROM. Hundreds of thousands of these components are already in operation, including military versions for hi-rel applications. In addition, millions of device-hours of tests with zero fuse failures confirm Stacked Fuse Bipolar's reliability. Further details on Intel's bipolar PROM reliability are found in our Summary Evaluation Report, RE1, available on request.

Get on the fast track today

Our high performance 3636 is available now. To order, or for complete data and reliability information, contact your local distributor or Intel sales office. Or write Intel Corporation, Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051. Or call (408) 987-8080.

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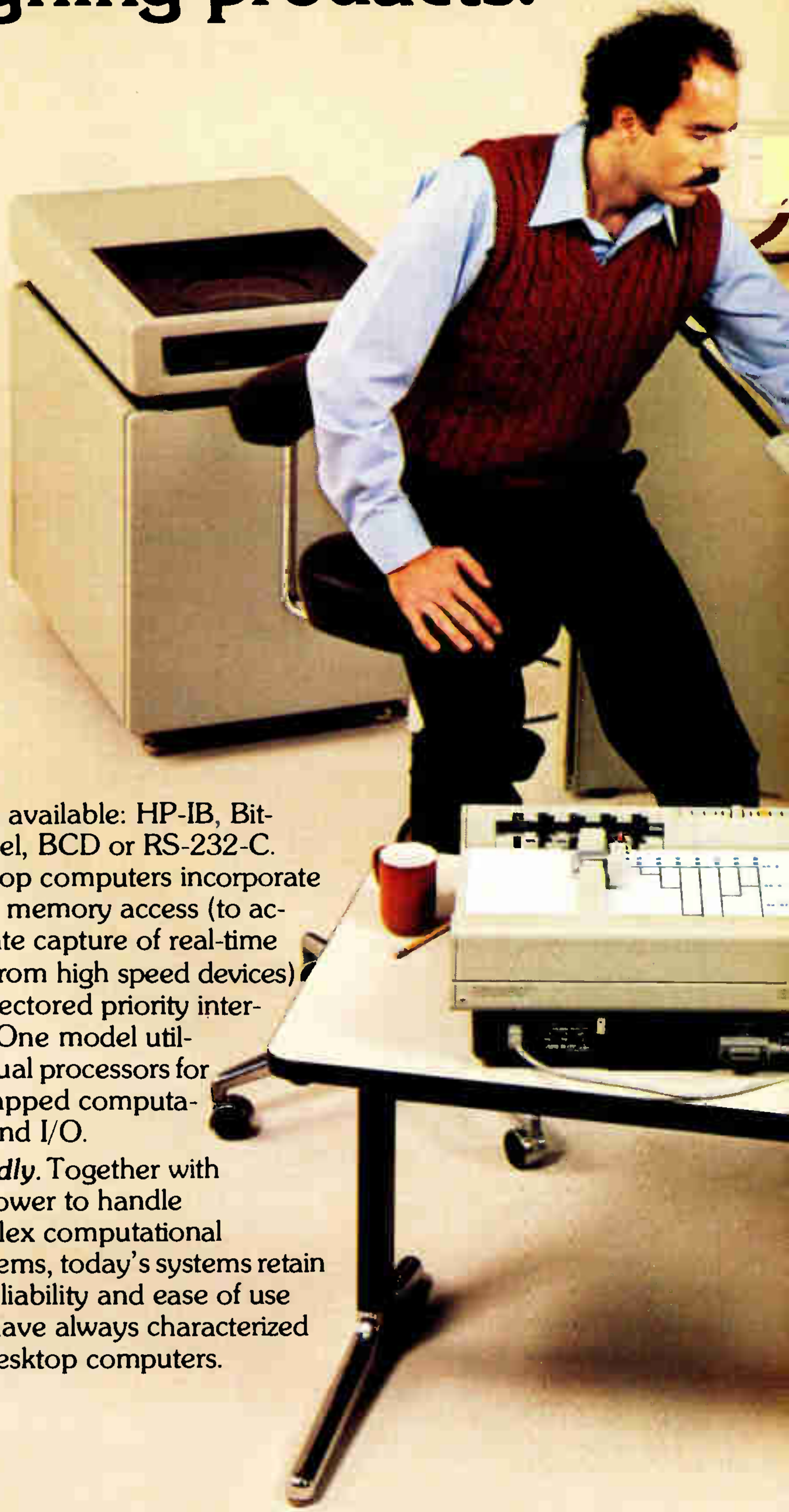
Europe: Intel International, Brussels, Belgium. Japan: Intel Japan, Tokyo. United States and Canadian distributors: Arrow Electronics, Alliance, Almac/Stroum, Component Specialties, Cramer, Hamilton/Avnet, Harvey, Industrial Components, Pioneer, Wyle/Elmar, Wyle/Liberty, L.A. Varah and Zentronics.

*Stacked Fuse Bipolar is a patented process of Intel Corporation.

Circle 19 on reader service card

"Engineers find computer systems powerful designing products."

Why?



Computation Power. Today's Hewlett-Packard desktop systems put big computer power under your personal control. You solve problems with up to 449K bytes of user-addressable read/write memory, all available for your programs and data. Built-in operating systems incorporate HP Enhanced BASIC, a powerful super-set of ANSI Standard BASIC. Coupled with optional assembly language, HP Enhanced BASIC gives you optimum performance for time-critical operations. Extensive libraries of HP software help turn weeks of setup and development time into days.

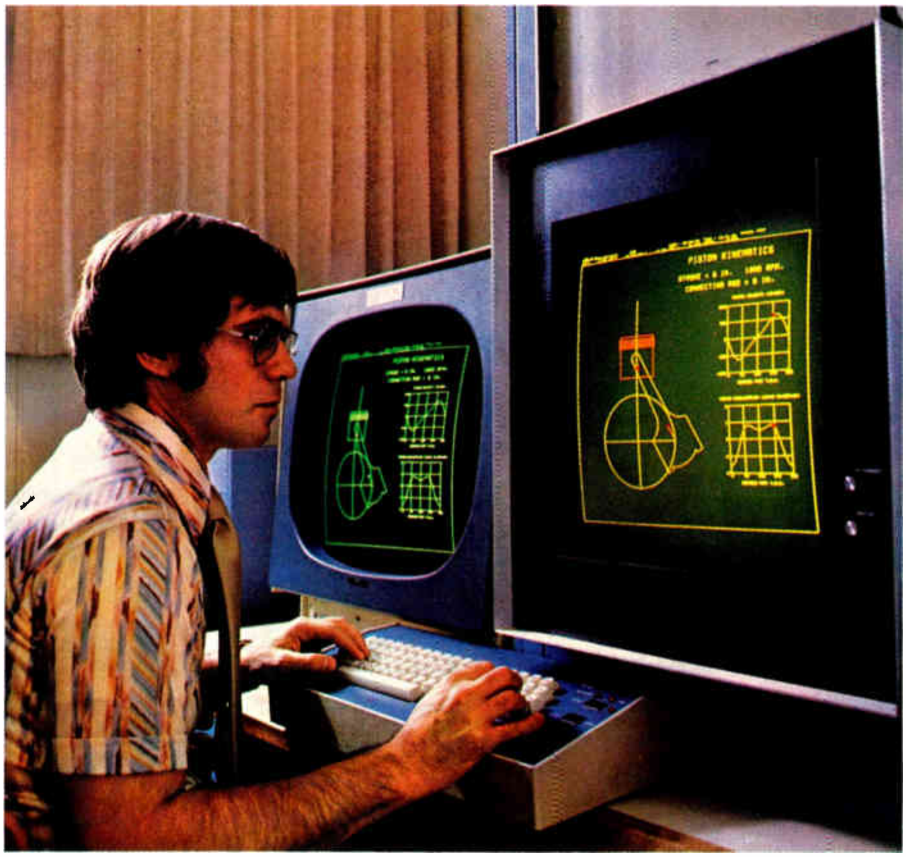
Powerfully Integrated. Each system is a functionally integrated work station, from the keyboard and CRT display to the built-in processors and quiet printer. It provides everything you need to manipulate data, check interim results, perform side computations, explore variations and produce alphanumeric and graphic hard copies of your solutions.

Systems Capability. Your system can be augmented with a broad range of HP peripherals or front-end measurement instruments. Interconnection is as easy as selecting interfacing cards and cables from one of four protocols available: HP-IB, Bit-Parallel, BCD or RS-232-C. Desktop computers incorporate direct memory access (to accelerate capture of real-time data from high speed devices) and vectored priority interrupt. One model utilizes dual processors for overlapped computation and I/O.

Friendly. Together with the power to handle complex computational problems, today's systems retain the reliability and ease of use that have always characterized HP desktop computers.

Control Data: Committed to

Control Data people, systems and services are helping manufacturers prepare for the '80's.



Exemplifying what state-of-the-art CAD technology can do for manufacturers, Chrysler Corporation Chief Engineer Robert Brauburger reports dramatic gains in the speed and efficiency of their design process. Above: a Chrysler engineer uses a color graphics terminal to analyze piston performance. Below: the control room at Chrysler's Technical Computing Center, where an operator monitors four interconnected Control Data® CYBER 170 systems.

American manufacturers are challenged by spiraling inflation and increasing competition. They must keep pace with productivity gains abroad to maintain market share and protect the jobs of their employees.

In the U.S., the annual growth in productivity over the last ten years has been half of what it was over the previous two decades. Many manufacturers are turning to computer-based technology to reverse this trend.

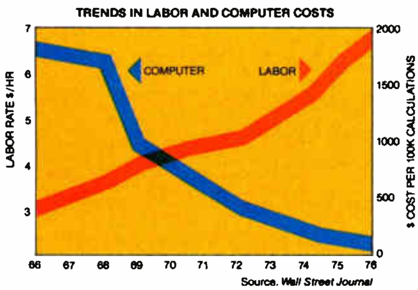
Over half the FORTUNE 500 are using our products and services.

Large scale Control Data computers are recognized for their outstanding ability to perform complex scientific and engineering computations rapidly and with great accuracy. Our systems are installed in major manufacturing companies around the world. And Control Data's recently announced CYBER 170 Series 700 continues in this tradition by offering increased performance at reduced cost.

Control Data also offers manufacturers a wide range of data services through some of the world's foremost data processing networks.

Through our CYBERNET® Services we provide the benefits derived from processing on Control Data computer systems, along with sophisticated application programs

the Manufacturing Industry



for structural, mechanical and electronic design and analysis.

Through our Service Bureau Company, we provide a whole range of services for business planning, analysis and control, plus a complete interactive system for material requirements planning, production control and management information.

In addition, many companies are training their personnel with our PLATO® computer-based educational service.

A new automated design and drafting system

One of the most important ways Control Data is helping manufacturers make better use of human resources is through computer-aided design (CAD).

Recently, we announced AD-2000,* an automated design and drafting system which speeds the design process by eliminating many of the tedious, time-consuming tasks previously performed by hand. AD-2000 offers practical and up-to-date design and drafting capabilities while providing a link to numerical control and other computer-aided manufacturing (CAM) functions.

Coming from Control Data—a fully integrated CAD/CAM system

The critical link between CAD and CAM is the effective control and flow of data among respective systems. Control Data has the products and expertise to allow the interface of design, analysis and manufacturing applications.

And when our new CAD/CAM technology is available, manufacturers will be able to go from a design on a CRT screen to a finished part—all with greater productivity and better use of resources than offered by the present technology.

Control Data is committed to helping industry bridge the gap between the old and new technologies. Through our Manufacturing Consulting Services organization we are helping manufacturers plan and implement their CAD/CAM strategies through training, consultation and technical assistance. And through Commercial Credit Company, an important part of Control Data, we provide manufacturers with a whole range of financial services, including capital equipment financing.

Boeing, a long time user of Control Data computers, recently installed two CYBER 175's in a CAD/CAM center to assist in the design of its new generation of passenger aircraft.

Systems. Services. Solutions. Measures of Control Data's commitment to the manufacturing industry.

For further information, write:
Control Data Corporation,
Manufacturing Industry
Marketing, HQW09F, Box 0
Minneapolis, MN 55440.

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Developed by Manufacturing and Consulting Services, Inc., Costa Mesa, CA.

Editorial

Let's skip this recession

We're optimistic—there, we've said it and we're glad. Like just about everybody else in the electronics industries, we got tired of waiting for the recession last year that Wall Street and various economists told us over and over was coming.

Okay, it's 1980, and we're still waiting. Right now, our gut feeling is that the electronics industries are going to plow right through the year. The figures for this year's markets forecast show that there will be a slowing of growth and some genuine soft spots.

But look at all the hot spots. There are just too many under-capacity items, even in the supposedly weak consumer sector, to start damping the production fires. As for unemployment—have you tried to hire an experienced engineer lately? Have you tried to hire anybody lately?

Inventories, too, appear to be in line. For some semiconductor products, there are no inventories—it's all being rushed into use. At the front lines, distributors are seeing signs of caution, but again, nothing resembling a major slowdown in ordering.

It's time to shrug off the recession mentality, fire Chicken Little, and get on with keeping the electronics business as healthy as ever. We think the markets will do better than the 10%-plus forecast by the survey respondents. We think the industrialized nations are learning to live with the Organization of Petroleum Exporting Countries. In addition, demand for electronics products—from components to computer systems—is expanding within the constraints of the general economy.

Finally, it's an election year and that often does wonders for the economy.

Electro, Wescon, Midcon—and now, Southcon

As another sign that recession warnings may be wrong, the electronic industries are about to get another convention—Southcon. Like Electro, Midcon, and Wescon, the new event will alternate between large cities in the same region, in this case Atlanta and Orlando, Fla. Southcon will make its debut Jan. 13–15, 1981, in Atlanta.

But the question is, does the electronics community need another show? At least on the face of it, it would seem not. After all, not only do we hear about an imminent recession, but there is the not-too-distant memory of shows that have come and gone, sunk by underwhelming support. However, in the instance of Southcon, that does not appear to be the case.

First of all, what shows like this one indicate is that fast-moving electronics—now part of the mainstream of consumer, industrial, and commercial technology—is in need of better communications, and regional conventions serve that need best. Also, the Southeastern part of the country is one of the fastest-growing high-technology sectors in the nation.

Finally, electronics conventions are thriving, as borne out by the unanimously positive responses from exhibitors at last year's Midcon in Chicago about the quality of exhibit attendees. Many of those exhibitors indicated that the attendees were more serious and of a more professional caliber.

There's one positive omen about the Southeast that may bode well for 1981's Southcon. The application of electronics technology to industries not in the traditional sectors served by electronics is very high in that area of the U. S. Many members of these nonelectronic companies will certainly benefit from a major convention that expands their horizons, and Southcon could possibly be that event. It would be pleasant to think so.

Looking for these important advantages in microprocessor I/Os?

Think Crydom Series 4.

Integrated barrier type terminals meet all established safety requirements . . . accept two #12 wires.

Output modules incorporate internal transient protection in DC units, internal snubber networks on AC units. No external components required.

Color coded terminal blocks make it easy to identify voltage types: RED for AC, BLUE for DC.

High efficiency aluminum heat radiators enable output modules to handle 4 Amps at 40°C without added heat sinks.

Built-in LED status indicators.

No loose parts to mount.

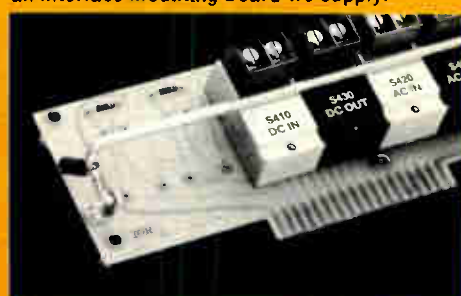
Input modules accept and convert field voltages to an isolated logic level. (TTL, CMOS, etc.)

Solid encapsulation produces rugged modules, environmentally protected for long-term reliability.

Input modules are white, Output modules are black or metallic grey for quick identification.

Modules plug into your PC Board or an Interface Mounting Board we supply.

Gold plated pin terminals
plug-in connection



Crydom Series 4. The completely integrated Input/Output interface modules for use between logic level microprocessors, programmable controllers, computerized machine controls, or other logic control systems, and outside field elements such as motors, solenoids, valves, or heaters. Write for details or contact your local Crydom Rep or Distributor. They're another reason why it pays to "Think Crydom".

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Sales Offices, Agents and Distributors in Major Cities Throughout the World.

Circle 25 on reader service card

Readers' comments

Advisory only

To the Editor: A Washington Newsletter item referring to the National Council of Engineering Examiners and its model law [October 11, p. 63] contains some erroneous information. The National Council of Engineering Examiners does, in fact, have a model law developed over many years and has attempted continually to reflect changes in state rules and regulations as well as in the practice of engineering. This law is promulgated by the National Council as a guide to state boards of registration for engineers or to state legislatures and is used only in an advisory capacity. It serves as a guide when changes are suggested either by state boards or by others who feel state statutes need to be updated. The model law is not "being submitted to state legislatures" to my knowledge, nor is that its purpose. Furthermore the NCEE does not take any role in promoting changes in state statutes.

Morton S. Fine
National Council
of Engineering Examiners
Seneca, S. C.

Screened windmills

To the Editor: Regarding "It's an ill wind for television, study finds" [Sept. 13, p. 96], interference with television reception caused by power windmills could perhaps be eliminated or considerably minimized by constructing coarse-mesh electrical screening fences around the windmill to effectively prevent modulation of the ultrahigh-frequency signals. There may be only marginal reduction in the power available and the shadow affect may be within acceptable limits. Might this be a cost-effective solution?

S. Krishna Rao
Bangalore, India

Correction

Raytek Inc.'s Raynger II temperature gun (Dec. 20, p. 134) can display temperature readings either from −20° to +2,000°F or from −30° to +1,100°C. A typo made the maximum Fahrenheit reading +200°.

Micralign® 200 Series... Higher throughput than step-and-repeat at a much lower price.

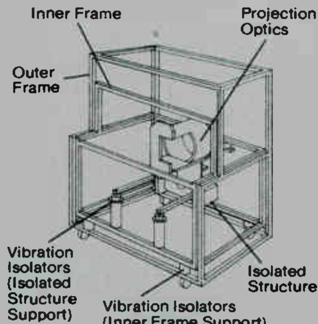
Perkin-Elmer designed the new Micralign Model 200 to be the most cost-effective projection mask aligner available. In performance, it achieves 2-micron geometries or better in production, distortion/magnification tolerance of 0.25 micron, and 4 percent uniformity of illumination. Options available include automatic wafer loading and automatic alignment. Soon to be available: deep UV optical coatings for still smaller geometries.

Compared to the leading step-and-repeat aligner, the Micralign Model 200 delivers outstanding performance for not much more than half the cost. It takes about a quarter of the floor space. It provides consistently higher throughput regardless of die size.

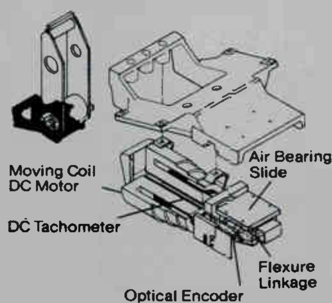
The Model 200's remarkable performance is the result of a number of major innovations.

Improved optical design and fabrication
We improved the optical design to provide increased resolution and depth of focus. Optical manufacturing tolerances are five times tighter to ensure precise overlay from aligner to aligner.

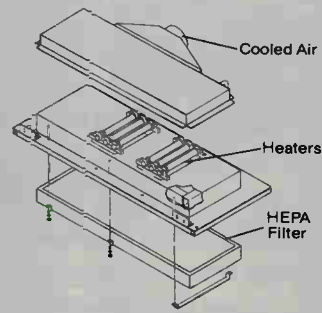
Near-zero vibration
We minimized vibration. We constructed the Model 200 with two frames—one inside the other. The inner frame, which carries the projection optics and carriage drive, is completely isolated from the outer frame.



We incorporated a superb linear motor carriage drive with air bearing slide. This drive does more than eliminate vibration. With the air bearing feature there's no contact and no wear. And no limit to carriage drive durability.



Built-in environmental control
We provided the Model 200 with a built-in environmental chamber. External air, supplied by you or from our optional air conditioning system, is blown through a HEPA filter and heating elements built into the Model 200 top cover. A positive-pressure, class 100 environment is carefully controlled to better than 1 °F.



We included a separate thermal control for the mask, to compensate for mask run-out.

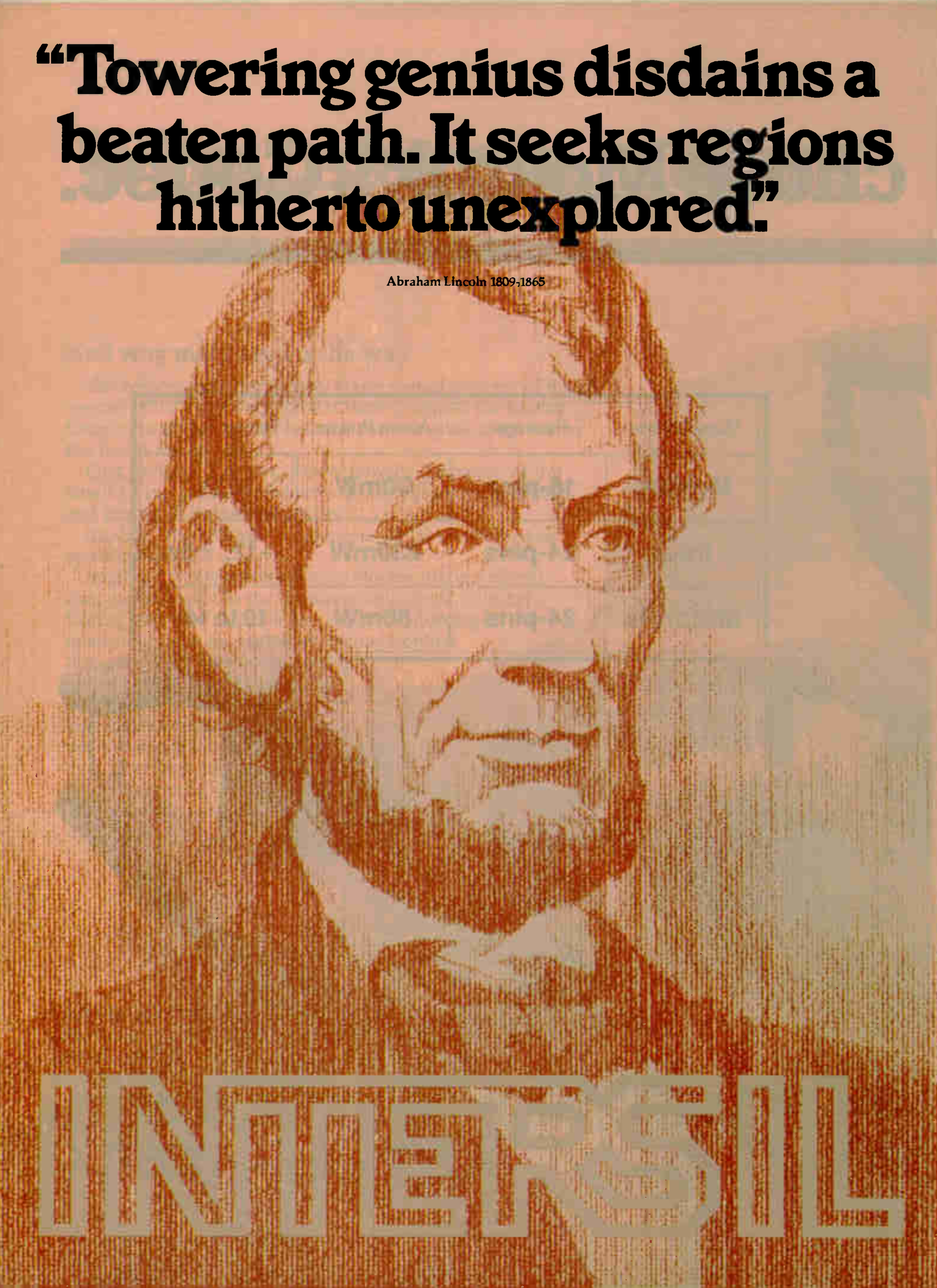
No mask contamination
We designed a sealed mask carrier for the Model 200. You put the mask in the special carrier right in the mask department. Seal it. When you load the sealed carrier in the Model 200, the cover plates are automatically removed. After use, the cover plates are automatically replaced.

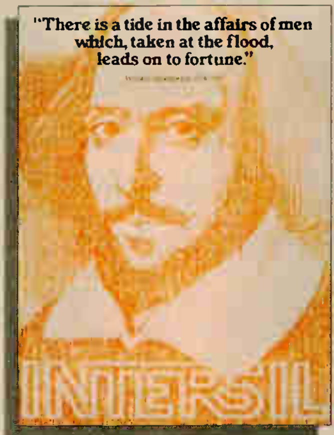
Proven production capabilities
Perkin-Elmer, the leader in projection mask alignment systems, offers six years of proven production capability, with an excellent training and service record.

Get all the facts
These are just a few of the features that make the Micralign Model 200 Series a completely new concept in projection mask aligners. Get more details on how these and other improvements in design can translate into improvements in your production. For literature, write Perkin-Elmer Corporation, Microlithography Division, 50 Danbury Road, Wilton, CT 06897. Or phone (203) 762-6057.

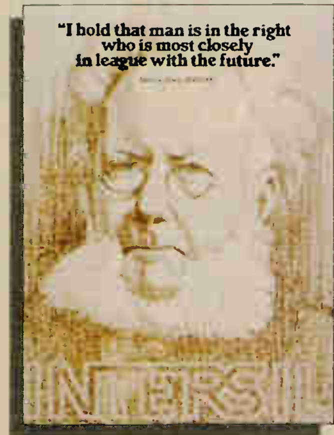
PERKIN-ELMER

Circle 27 on reader service card

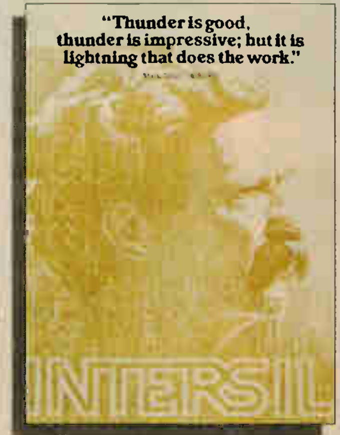

"Towering genius disdains a beaten path. It seeks regions hitherto unexplored."
Abraham Lincoln 1809-1865
INTERSIL



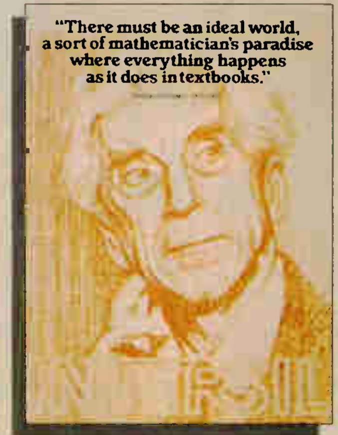
Memory Products



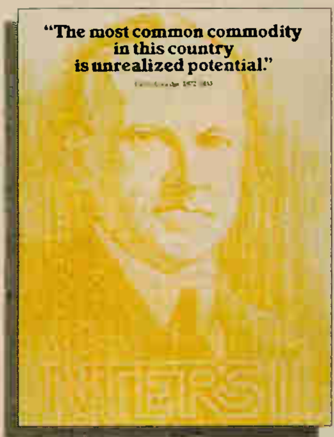
Data Acquisition Products



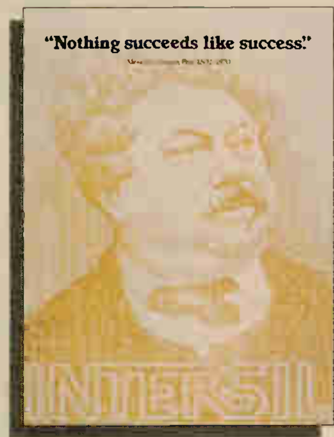
Low Power Products



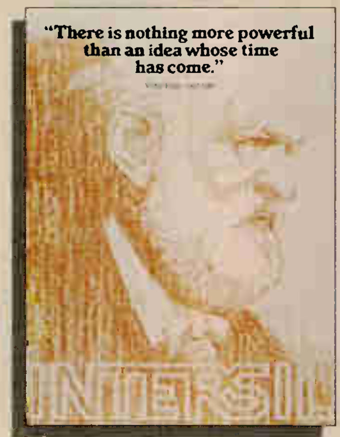
Linear Products



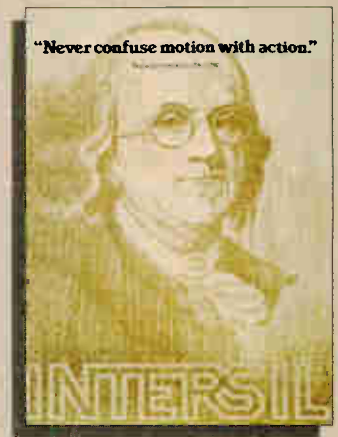
Microcomputers



Memory Systems



Analog Switches



VMOS Products

29 LEADING EDGE PRODUCTS IN '79.

In 1979, Intersil introduced twenty-nine integrated circuits over 7 product lines. Twenty-nine technological firsts. CMOS op amps. Commutating auto-zero amplifiers. An inexpensive CMOS 12-bit A/D converter. 21 deliverable types of VMOS power FETs. A CMOS version of the industry-standard 555 timer. CMOS EPROMs and microprocessors. And, high speed, low power upgrades of the industry standard 2147 Static RAMs.

TWICE AS MANY IN '80.

In 1980, Intersil will introduce more new high-technology devices than ever before. In processes from Bipolar to CMOS. Voltage converters with 98% efficiency. Monolithic CMOS A/D converters with true 14-bit accuracy and speeds approaching Bipolar devices. Drivers and counters for vacuum-fluorescent displays. VMOS power FETs to 450 volts. Single-chip CMOS microprocessor support systems. The new Intercept III microprocessor development system. And there's a reason for all this.

WE'RE COMMITTED TO LEADERSHIP.

This business is future-oriented, and so are we. We're committed to the leading edge. To systems thinking, lower costs and reliability. We're committed to ever expanding technological expertise. Expertise in integrated circuits through our Semiconductor division. Expertise in Data Acquisition systems and subsystems through our Datel/Intersil division. And expertise in OEM mainframe memory systems and microsystems through our Systems division.

WE'RE COMMITTED TO ANSWERS.

We know the future is built on the past. That today's challenges are the groundwork for tomorrow's breakthroughs. Which is why we're committed to answers today. Tough, realistic answers to the critical demands of an industry that long ago departed from the beaten path in favor of regions hitherto unexplored.

For any or all of the posters above, write us on your company letterhead.

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Look to Intersil for answers.

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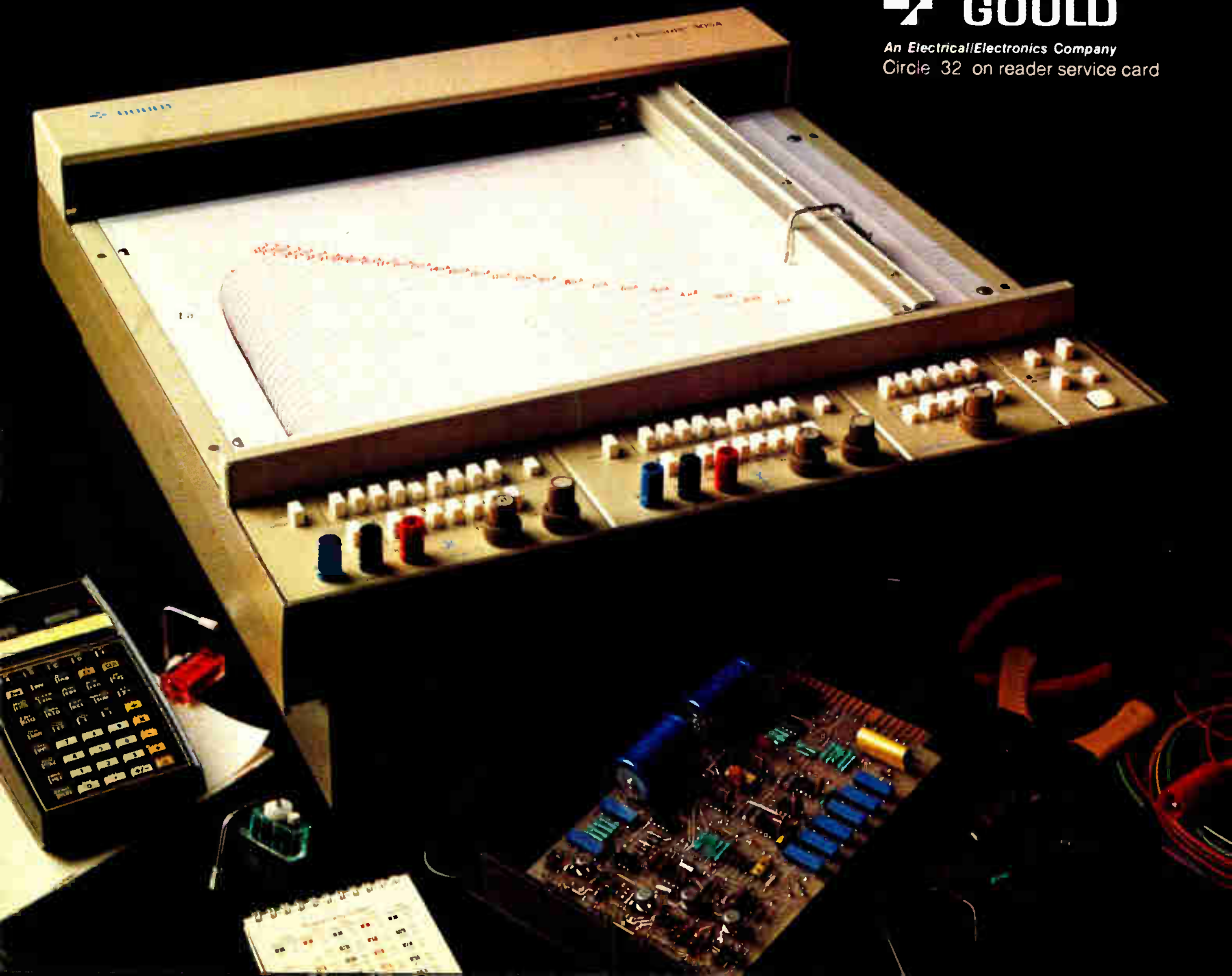

Electronics newsletter

Digital switching, interface hardware for cable coming

The Digital Communications Corp. of Gaithersburg, Md., will soon introduce digital switching and interface hardware operable in conventional cable television networks. An obvious step toward "wired city" applications, the system would offer local networking, multiplexing, and self-diagnostics. **Packet-switched data rates would range from 1 to 1.5 Mb/s.** Called Capac, the approach will use microprocessor-controlled communications-access processors to interconnect terminals and data processors with common-carrier data-transmission systems. In a CATV net, with average signal strength and noise, up to 511 communications-access processors and several times as many data devices could be interconnected without degrading normal TV transmission.

HP's personal computer to make debut in Las Vegas

The long-awaited entry of Hewlett-Packard Co. into the personal computer field becomes a reality this weekend at the Winter Consumer Electronics Show in Las Vegas, which runs from Jan. 5 through 8. That's where HP will formally unveil its new HP-85, code-named Capricorn. Originally called Chestnut [*Electronics*, July 19, 1979, p. 33], the machine has a powerful central processor, typewriterlike keyboard, cathode-ray-tube display, thermal printer, tape cartridge, and interactive graphics capability all in a fully integrated system the size of a portable electric typewriter. **The $3,250 personal computer system, three years in development, is programmed with English-like Basic** language and is manufactured and marketed by HP's Corvallis (Ore.) division.

Codec filter, 2192-compatible, due from Mitel

Look for Mitel Semiconductors Ltd. of Ottawa, Canada, to introduce a codec filter in the last quarter of 1980. The switched capacitor device will be pin-compatible with Intel's 2912 codec filter, says Chris Bailey, Mitel's director of marketing and applications. The ±5-V chip will dissipate only 30 mW and draw 3 to 4 mA. It will be used in Mitel's private automated branch exchanges and digital switches and be available for sale to original-equipment manufacturers. Bailey says that the chip will be made with Mitel's ISO-C-MOS process.

Controller features an all-purpose programming panel

A new programmable controller from Gould Inc.'s Modicon division, Andover, Mass., to make its debut later this month, **will work with a separate programming unit and will perform system diagnostics with cartridges that insert into the programmer.** Designed for industrial process monitoring and control, the 584 controller will use complementary-MOS memory and will be available in 4-, 8-, 16-, and 32-kilobyte versions costing $5,500 to $15,500 without input/output cards. Based on a 16-bit bit-slice processor, the 584 will handle up to 4,096 I/O lines.

TI seeks C-MOS experts, probably for telecomm line

Complementary-MOS technology may play an important role in Texas Instruments Inc.'s view of the telecommunications circuit market of the 1980s. TI's C-MOS offerings are currently limited to custom circuitry and a standard C-MOS version of the TMS 1000 microcomputer. But a recent move to hire more engineers with C-MOS expertise is seen by some to be indicative of the company's plans to use the process—**possibly in combination with other process technologies on the same chip**—for circuits aimed at the telecommunications marketplace. TI's last public word on such circuits came last year [*Electronics,* March 29, 1979, p. 48], when the firm announced plans to second-source Intel's n-MOS coder-decoder. But its linear group is believed to be working on circuitry, including a subscriber loop interface circuit (SLIC), that could need multiprocessing capability.

Honeywell-NEC exchange pact appears dead

Nippon Electric Co.'s 17-year-old technical and business know-how exchange agreement with Honeywell Information Systems Inc. expired at the end of the year, and neither side plans to renew it. A separate patent and licensing agreement continues until 1982 and both firms say that even without a formal agreement, they intend to continue their relationship. Observers note, however, that the agreement may not matter much to NEC, **but that Honeywell may lose a source of technical inspiration.**

Micro Power to add 4-K chip to its RAM list

Having dipped its toes into the complementary-MOS random-access memory waters with the introduction of 1,024-bit static devices earlier this year, Micro Power Systems Inc. is preparing to take a full plunge into the market. The Santa Clara, Calif., firm is quietly supplying samples of the first of several 4,096-bit C-MOS static RAMs planned for 1980 introduction. **Its initial 4-K part, the 6504, is organized as 4 K by 1 bit and will be introduced before the end of the first quarter.** Also in development is a 1-K-by-4-bit part, the 6514, slated for fourth-quarter introduction.

Fast, large FIFO coming from Monolithic

Look for Monolithic Memories Inc. to introduce what is, perhaps, the fastest and largest first-in, first-out (FIFO) serial memory. Expanding its 67401, a 64-word-by-4-bit bipolar FIFO that operates at a guaranteed 10-MHz shift-in, shift-out rate and has hard-disk controller and telecommunication buffer applications, the Sunnyvale, Calif., firm will soon make available **a 15-MHz version for digital video processing.** Also planned for first-quarter 1980 introduction are 64-word-by-5-bit versions in which the additional bit will be used for a parity check.

Laser link called key to new market

With its laser voice and data communicator now operating as a two-mile teletypewriter link in Trinidad, a small Santa Barbara, Calif., firm sees the start of what could be a **new telecommunications market in Third World nations.** The equipment, built by American Laser Systems Inc., costs about $10,000 for two transmitters and two receivers, plus specially configured standard telephone interface modules. It replaces either microwave links (about $40,000) or more expensive coaxial cabling.

Addenda

NV Philips Gloeilampenfabrieken of the Netherlands will consolidate its move into Silicon Valley **when it breaks ground next week on a Sunnyvale, Calif., building** to house both the Philips Research Laboratories, Sunnyvale, and the Advanced Technology Center of its Signetics Corp. subsidiary. . . . Alexander Haig, former U. S. Army general and commander of North Atlantic Treaty Organization forces in Europe, **has been elected president and chief operating officer of United Technologies Corp.** in Hartford, Conn. He succeeds Harry Gray, who will remain as chairman and chief executive officer.

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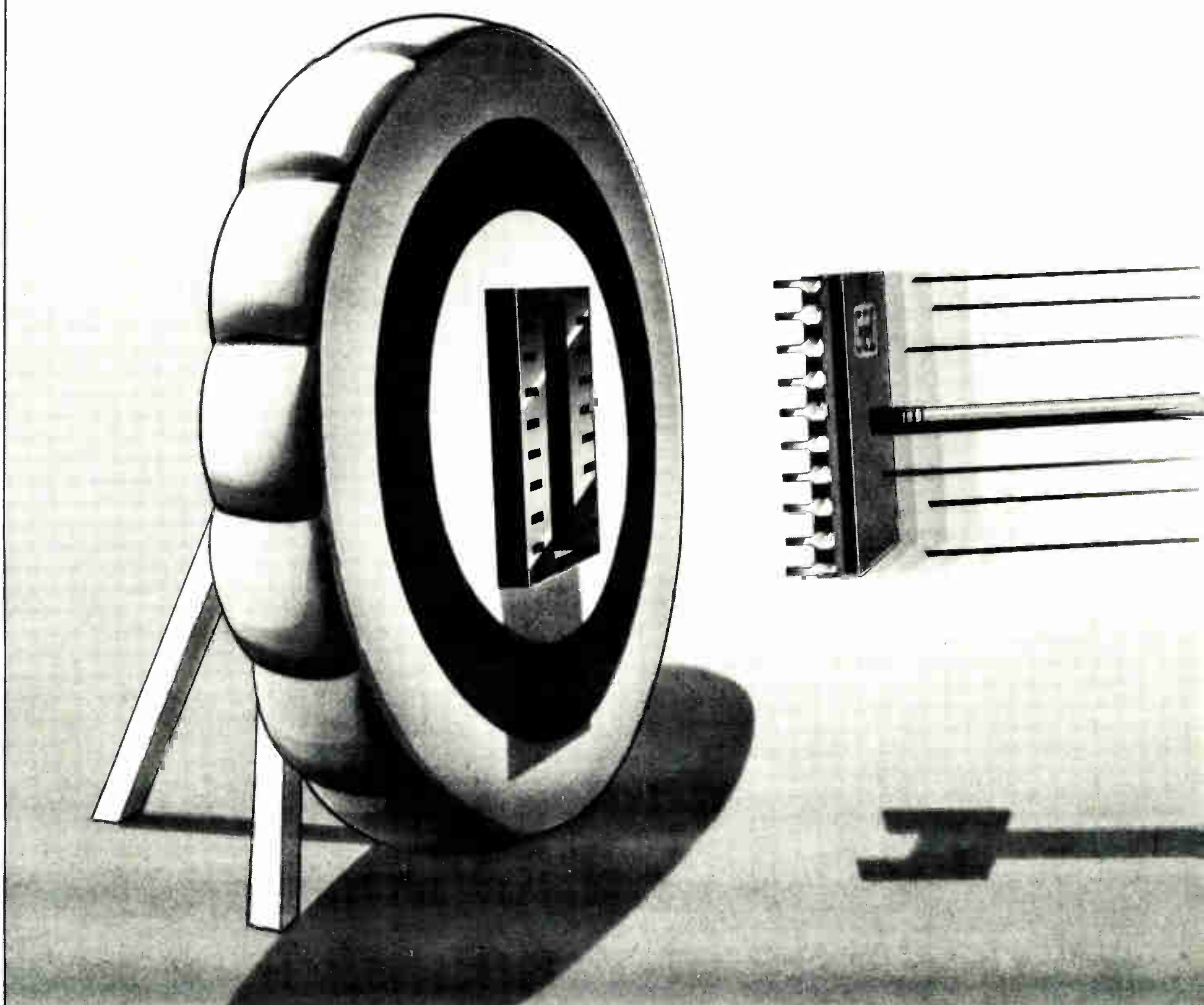

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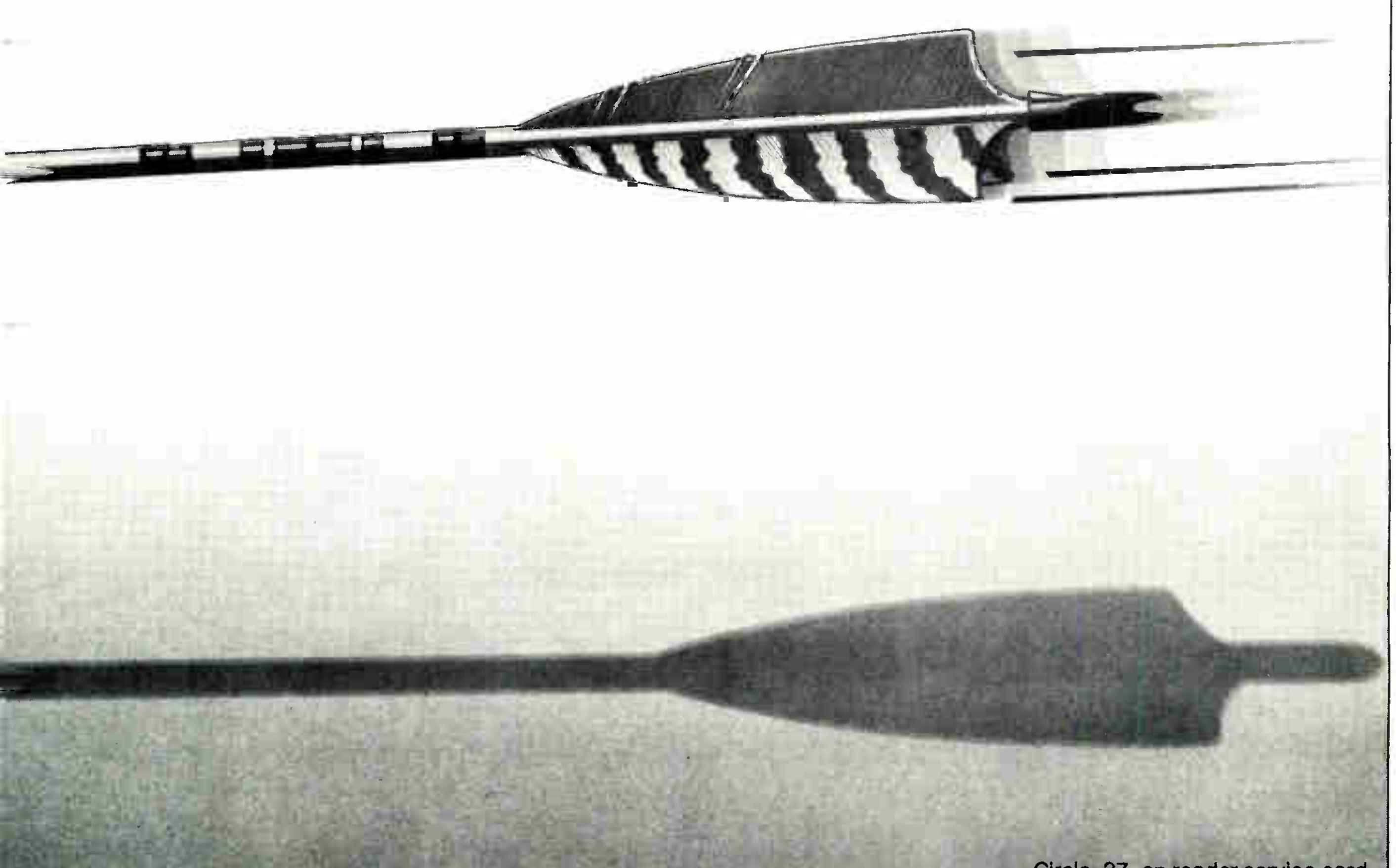

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Thin-film devices on silicon chip withstand up to 500°C

by Roger Allan, Components Editor

Resistors, capacitors fabricated from thin films can share substrate with MOS devices

Using a low-temperature vapor-deposition process, researchers at the University of Arizona, Tucson, have fabricated thin-film hybrid resistors and capacitors operating at temperatures as high as 350° and 500°C respectively—much higher than is possible with components made by other solid-state processes. Moreover, the devices, together with the interconnections, may be deposited on the same substrate.

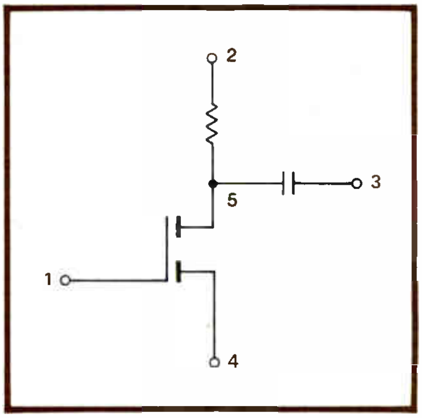
Developed for instrumentation used in geothermal logging, the components can be made in a wide range of resistive and capacitive values. The key advantage of substrate compatibility stems from the use of similar thin-film materials used in the process for the two types of passive components.

In addition, because the process temperature is lower than that for MOS fabrication, depositing resistors and capacitors on such a substrate causes no significant change in adjoining MOS device characteristics. For example, a high-temperature n-channel MOS device can be fabricated by depositing tungsten to form the gate (see figure). Computer simulations show a drop of less than 7% in its threshold voltage as a result of subsequent deposition of the passive components.

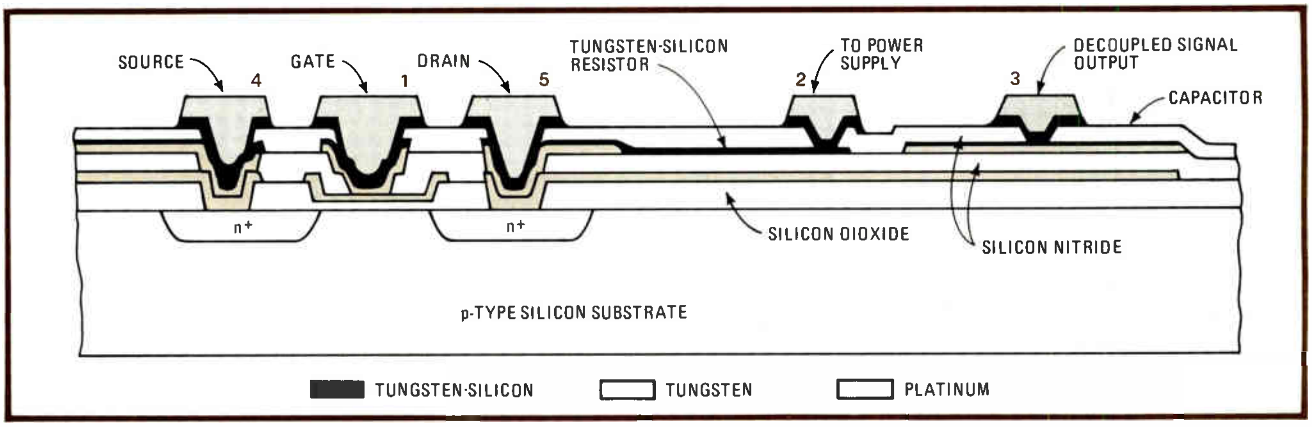
Limited. Commercially available monolithic integrated circuits are limited to an operating temperature of about 150°C. Some custom ICs are available, but they can operate only up to 300°C.

However, the thin-film hybrid technology provides the stable materials needed for higher-temperature operation. Such components will be useful in instrumentation for mineral exploration and exploitation, coal gasification, and nuclear reactors. In describing their process at the High Temperature Electronics and Instrumentation Seminar held in December in Houston, Leonard S. Raymond, Douglas J. Hamilton, and William J. Kerwin said they use oxidized substrates of silicon.

The researchers place the substrates in a quartz reaction chamber where they are heated by radio-frequency induction to about 750°C. They then inject appropriate gases into the chamber through mass-flow controllers. The gases impinge upon the substrate's hot surface and



All together. Vapor-deposition process produces resistors and capacitors that can withstand much higher temperatures than other solid-state passive components. This circuit has an n-channel field-effect transistor with power-supply resistor and output capacitor.



produce a chemical reaction that causes a conductive thin film to be deposited on the substrate.

For resistors, the gases are tungsten hexafluoride and silane, producing a tungsten-silicon thin film. For capacitors, the dielectric and passivation are produced by silane and ammonia gases that form a silicon nitride thin film.

Next step. Metal interconnections for the components and capacitor plates are made from tungsten deposited from tungsten-hexafluoride gas. Bonding pads are aluminum or platinum.

Resistor film thicknesses of 250 angstroms were achieved. The typical sheet resistance obtained was 1,000 ohms/square; however, the researchers point out that sheet resistances of 100 to 5,000 Ω/sq are possible by varying the composition of the gas stream during deposition. A typical temperature coefficient of resistance of 50 ppm/°C was obtained, and no hysteresis was observed during resistor temperature cycling up to 500°C in air.

Capacitor film thicknesses ranging from 2,000 to 4,000 Å were made, with 2,000-Å-thick metal capacitor plates. Capacitance values obtained were typically 20 nanofarads per square centimeter. The use of standard photolithographic techniques for pattern definition allows the fabrication of capacitance values from several picofarads up to 0.1 microfarad. For a 0.1-μF capacitor, a surface area of 4 cm^2 is needed.

The researchers are also developing thin-film resistors that can operate up to 750°C. They are using sapphire substrates and depositing on them tungsten silicon to form the very high-temperature resistors. The bonding pads are made of platinum. These resistors are for the high-temperature ICs under development at the Los Alamos Scientific Laboratory, N. M., they say.

Computer-aided design

Silicon compiler extends CAD, can design VLSI circuitry

A trail-blazing software concept from the California Institute of Technology aimed at extending computer-aided design to very large-scale integrated circuits is already catching the attention of industry heavyweights. Called a silicon compiler, the approach begins with a high-level language description of an IC, then performs computations necessary to implement almost the entire design of the chip.

An entire mask set can be produced from a two-page high-level description of the IC, says David Johanssen, the Caltech graduate student closely associated with the development. The only user input is a definition of circuit core elements and parameters that go into making up the basic cell level of the chip.

The Caltech approach is a three-pass compiler that begins with construction of the chip's core (see figure), which contains data-processing elements, based on user input and low-level cell definitions. A control pass adds the instruction decoder and creates pad connections. The final layout pass adds the pads to the chip perimeter and routes them to proper connection points.

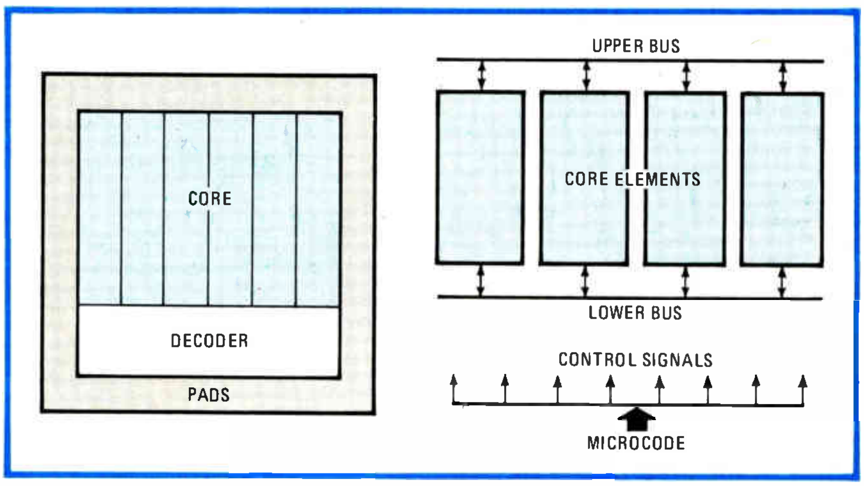
The silicon compiler employs ICL, a high-level, graphics-oriented IC design language that allows users to generate new data structures at any time. At the moment, the system is limited to an architecture Caltech chose earlier for a 16-bit microcomputer, but Johanssen says it can be adapted to others.

Reaction. Industry interest in the concept is high, says Craig Mudge of Digital Equipment Corp. It is "a seminal development," stimulating further advances in automated design, he believes.

Manager of the Maynard, Mass., company's VLSI advanced development group, he gives financial support to the Caltech project. "Johanssen's [structural] descriptions lead to better use of silicon—in chip area, performance, and power," he says. DEC is working on its own version of the silicon compiler, calling it a chip assembler.

The Caltech program was started as a debugging tool, but "it was apparent we had what could become, with more work, an actual system for compiling silicon," Johanssen says. He calls it the "bristle block" system because the connection points between cells "resemble the toy blocks that have bristles to snap them together."

Johanssen draws a sharp distinction between the Caltech silicon compiler and commercial CAD systems. The latter "are little more than



Designing. Silicon compiler starts with a data-processing core (left), then an instruction decoder. In the logic format (right), each core can communicate with either bus.

fancy filing cabinets that help organize data of submodules composing a chip," he says.

Such CAD systems usually do not provide computations of chip layout, he notes, and they require the designer to generate each cell graphically over and over, supply physical dimensions, and specify interconnections. "Our goal is to free the designer from concern with these mechanics," he adds.

The compiler can optimize design rules for a layout size within ±10% of the area possible with human design. Moreover, it takes only about 4 minutes to generate the data to produce a small chip and 10 to 15 minutes for a large one.

Left. In the year or so of work on the program, about 80% of it has been completed. The remaining chores are adding a virtual memory for large systems, as well as generally cleaning it up, Johanssen says.

"Then it's mainly documenting it so that users can take it from there," he adds. Three researchers will spend full time on it as part of the school's silicon structures project. The industrial sponsors of the SSP could have a full compiler by summer's end. **-Larry Waller**

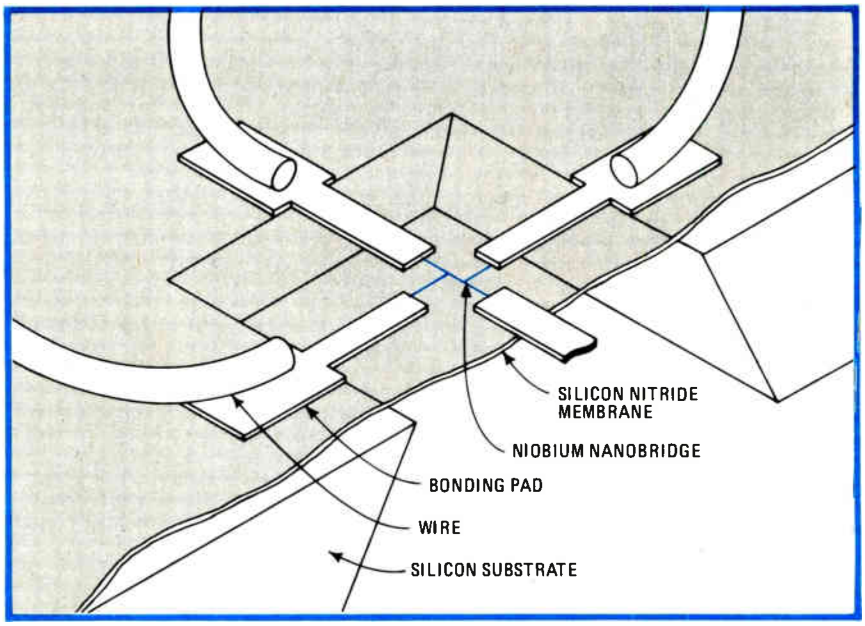
Solid state

Josephson device eschews junction

An experimental Josephson-effect circuit element has dimensions best measured in nanometers. Called the nanobridge, it is the latest feat of the Yorktown Heights, N. Y., research arm of the IBM Corp.

In fact, with widths and thicknesses of only 100 to 200 atomic diameters, the stripes of the bridge represent the most minute circuit elements ever controllably fabricated and tested. The circuit may lead to extremely short switching times, possibly just a few picoseconds.

Though the nanobridge can be modified to function as a switching element, its operation would be different from that of the Josephson tunnel junctions at present being adapted at IBM and elsewhere for computer logic gates and memories.



Junctionless. IBM researchers have devised a nanobridge circuit element (colored, above) that serves as a vehicle for the study of submicrometer Josephson switching effects.

Tunnel junctions are formed by sandwiching a thin insulator between two superconducting metal layers. Electron tunneling through the insulator is controlled by the magnetic field generated by an overlapping control line.

No junctions. In contrast, the nanobridge has no junctions. Instead, its narrow stripes (colored in the figure) act as constrictions, or weak links, between larger, micrometer-sized superconducting thin-film pads.

One possible way to use the bridge as a switch would be to bias it with a dc current near that required for superconduction; then a pulse would be applied to it for switching. The lengths of the stripes in the nanobridge were chosen to be just longer than the smallest distance necessary to support this kind of behavior.

The IBM researchers had made devices with larger bridges, but they decided to shrink the dimensions in hopes that the shorter device lengths would be less sensitive to heating effects—the larger bridges did not dissipate enough of the heat generated in switching from the superconducting to the normal state.

This excess heat was absorbed in the chip, and switching characteristics were affected. But the nanobridge is so small that heat is immediately expelled and performance is not degraded.

To make the device, 80-nanometer-thick superconducting niobium bonding pads were first patterned using an electron-beam direct-write-on-wafer system. Then a 30-mm-thick film of niobium was deposited over the entire chip.

The niobium film was coated with silicone oil using vapor deposition. The bridge pattern was then traced with an electron beam, polymerizing the oil in its path. Finally, ion milling removed the remaining niobium, leaving the pads linked with the superfine bridge.

Window. As the figure shows, the device is constructed with a window in the silicon substrate directly below the bridge. Robert B. Laibowitz, one of four IBM researchers responsible for the device, says it serves two purposes.

First, without the window, the beam would strike the substrate, scatter back, and expose the resist from the other direction, making such fine resolution impossible. Second, the hole in the substrate allows the researchers to employ transmissive electron microscopy to view the specimen. The sample was simply too small to view in detail with a scanning electron microscope.

Laibowitz says that he would like even smaller dimensions. "To study tunneling you wouldn't mind making planar electrodes that are separated by a tunneling distance. This length depends upon the material chosen, but 40 to 50 angstroms would be interesting."

Also, with even finer features, atomic behavior and quantum mechanics could be investigated. "We think we can get to the region where atomic states might come into play," he predicts. **-John G. Posa**

Packaging & production

AMD process uses oxide isolation

The oxide-isolation bandwagon is getting another rider. Advanced Micro Devices Inc. has developed a version of the technology that shrinks die size without requiring scaled-down lines. Called IMOX, for implanted micro-oxide, the new process is already in use in an AMD bipolar random-access memory.

Many semiconductor firms are looking at the switch from diffusion isolation to oxide isolation as a means of shrinking bipolar integrated circuits, following Fairchild Camera and Instrument Corp.'s lead with its Isoplanar process. AMD appears to be farthest along in taking dead aim at what has been pretty much a Fairchild market.

Smaller chips. With IMOX, transistor size is 39% that of the device fabricated with standard diffused-isolation processes, says Ralph Cognac, bipolar memory marketing manager for the Sunnyvale, Calif., firm. Thus, in transistor-dominated RAMs, overall chip size drops by 50%. In fuse-dominated programmable read-only memories, chips are a third smaller.

Now in limited IMOX production is the 93415, a 1-K-by-1-bit static RAM with open collector outputs and the three-state-output 93425. Their 45-nanosecond access time is not quite as fast as the newest 1-K-by-1-bit devices Fairchild is making with its scaled oxide-isolated Isoplanar S [*Electronics*, Dec. 6, p. 137].

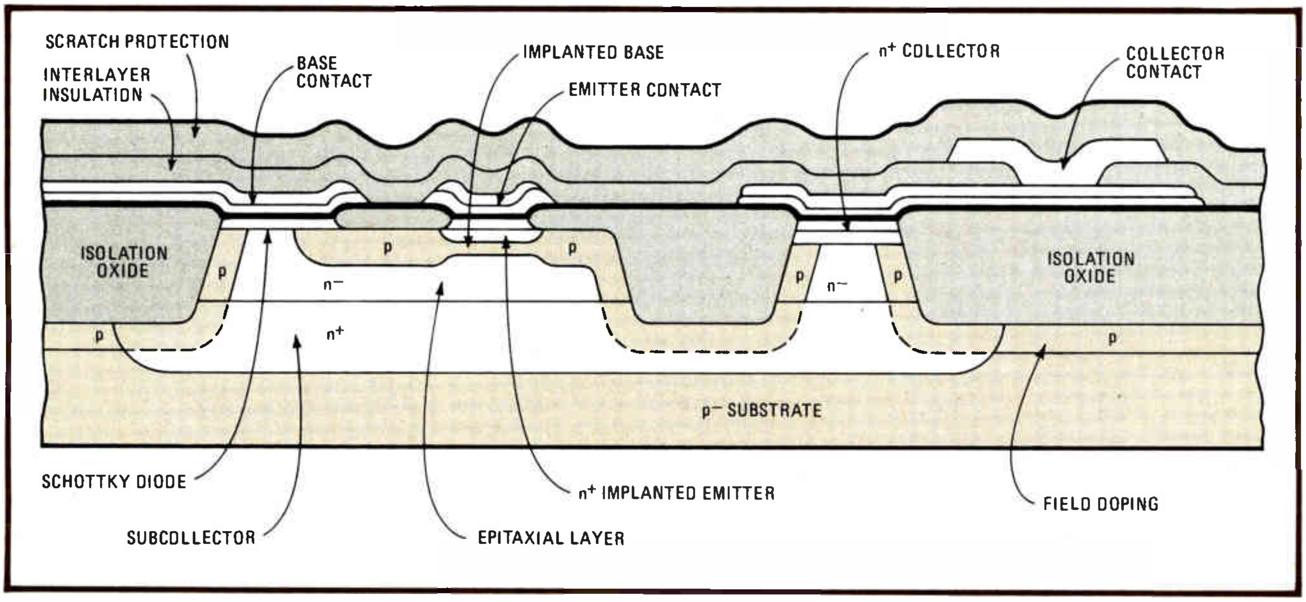
AMD's oxide-isolation process is like the basic Fairchild Isoplanar technique in that both begin with an n-type epitaxial substrate and walled emitters that extend out to the isolation oxide. "It will take us a couple of years to get to the level of sophistication that Fairchild has in the bipolar RAM field," Cognac says. "But the potential is there."

Moreover, the process will be used in other AMD parts, such as the recently announced AM29116 16-bit microprocessor [*Electronics*, Aug. 16, p. 42]. Coming in the second quarter is the AM27S184/5, a 2-K-by-4-bit programmable read-only memory expected to have a maximum access time of 50 nanoseconds. Such speed is much better than similar parts in other processes, and AMD expects even faster speed-selected versions.

Design rules. Initially, the new 8-K PROM is going to be fabricated with standard 5-micrometer processing. "As time goes on, there's a lot of room to go faster and improve overall performance with scaling," Cognac notes.

Itself an active region, the diffusion-isolated area is replaced with the inactive oxide area, so that no depletion space is needed. "This allows us to build the transistor right up to the wall of the isolation area," Cognac says. The result is smaller transistors and cells that lower capacitance and increase speed.

It takes a process like this to create high-density products like the forthcoming 32-K and 64-K PROMs and higher-density RAMs, says Cognac. The company expects



Stacked. AMD is getting into the oxide-isolated bipolar game with its version of the process, IMOX, in which many techniques for fast operation and high density are brought together. Besides an n^+ buried subcollector, it uses Schottky diodes and an implanted base region.

IMOX to become "the workhorse process of bipolar products in all our divisions," he says, and is developing several iterations—including some scaling and reconfigurations—that will yield further improvements in speed and density. **-Bruce LeBoss**

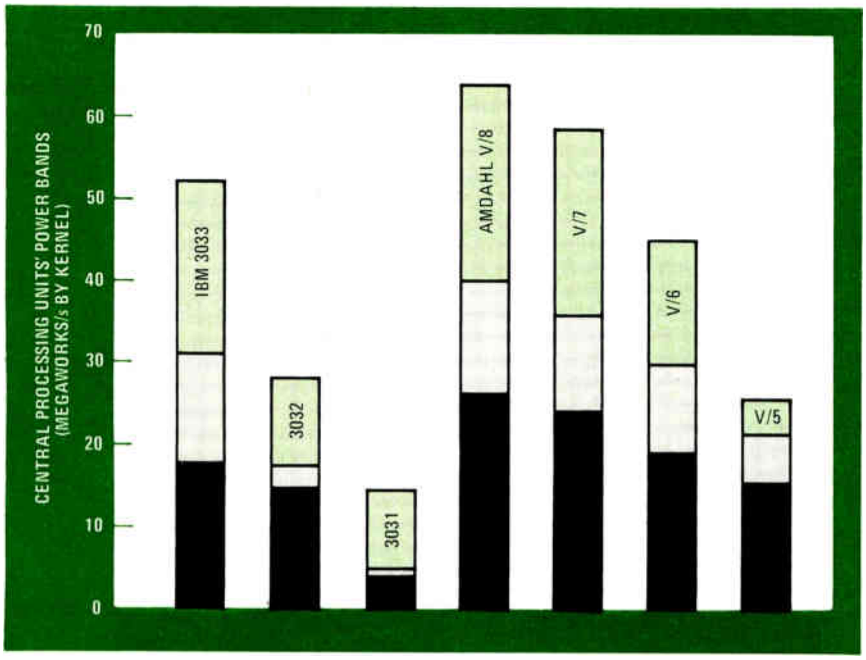
Computers

'Yardstick' measures computer work

Ever since the days of the vacuum-tube computer, engineers have been seeking a standard tool to measure computing power, and now a Palo Alto, Calif., software consulting firm has devised what may be another benchmark. Developed for comparing IBM-compatible central processing units, it aims at comparisons among all mainframes, minicomputers, and microcomputers.

The new unit of measurement comes from the Institute for Software Engineering Inc., which claims that its brainchild is independent of both instruction sets and operating systems. Dubbed simply "work," the unit stands for the movement of 1 byte of information between main storage and CPU, between main storage and mass storage, or from one CPU to another.

Comparison. As the figure shows, the basis of comparison is megaworks per second. These figures are obtained by calculating the number of work units required to execute each instruction and multiplying that total by the number of times this instruction is executed. To obtain work, the products for each instruction are added together. That sum is divided by the time required to perform them to obtain the figure for CPU power.



Power. Amdahl and IBM computer comparison is on basis of kernals optimized for decimal calculations (CO5, color), a scientific mixture (SO1, gray), and sorting routines (CO1, black).

"The problem with traditional approaches to benchmarking the CPUs has been the variation in instruction mixes," asserts Kenneth W. Kolence, president of the institute (a commercial enterprise). Such benchmarking necessarily depends on the nature of the instructions used in the test program and upon the way the operating systems implement the instructions.

Criticism. Proponents of traditional benchmarking note, however, that it is similar to test-driving an automobile, whereas Kolence's work measurement is analogous to merely measuring the horsepower of the engine. Such a horsepower measurement by itself, these proponents note, does not give as true an indication of how the auto—or the computer—will perform in actual use, as does on-the-road testing.

But computer makers use other benchmarking for only relative comparisons, Kolence argues. Model Y is simply reported to be three times as powerful as model X, and "this makes it difficult for the user to answer such simple questions as 'at what point do I really need to upgrade?' " he says.

Kolence is a veteran software

Feerst suit against IEEE postponed

The suit for $1.13, that is $1.13, brought against the Institute of Electrical and Electronics Engineers by Irwin Feerst goes back to the Civil Court of New York County on Feb. 25. Feerst, long-time IEEE critic and past candidate for its presidency, is suing for what he calculates is the portion of his yearly dues that pays for the IEEE's expanded public relations activities [*Electronics*, Nov. 8, p. 92].

On Dec. 17, the IEEE filed a motion to dismiss the case, claiming not only that it had no merit but also that the Civil Court lacked jurisdiction. Feerst, who had subpoenaed "all books and records pertaining to the present public relations activities," is scaling his request down to just those records dealing with the hiring by the institute of Ruder & Finn Inc., New York, as its public relations consultant.

According to Feerst, New York State law puts tight limits on how nonprofit corporations are allowed to spend their funds. Choosing Ruder & Finn without competitive bidding and paying it sizable fees violate those limits, he alleges.

In any case, the court action is costing the IEEE a pretty penny in lawyers' fees. The firm of Donovan, Leisure, Newton and Irvine of 30 Rockefeller Plaza, New York, is defending against the suit. **-Alfred Rosenblatt**

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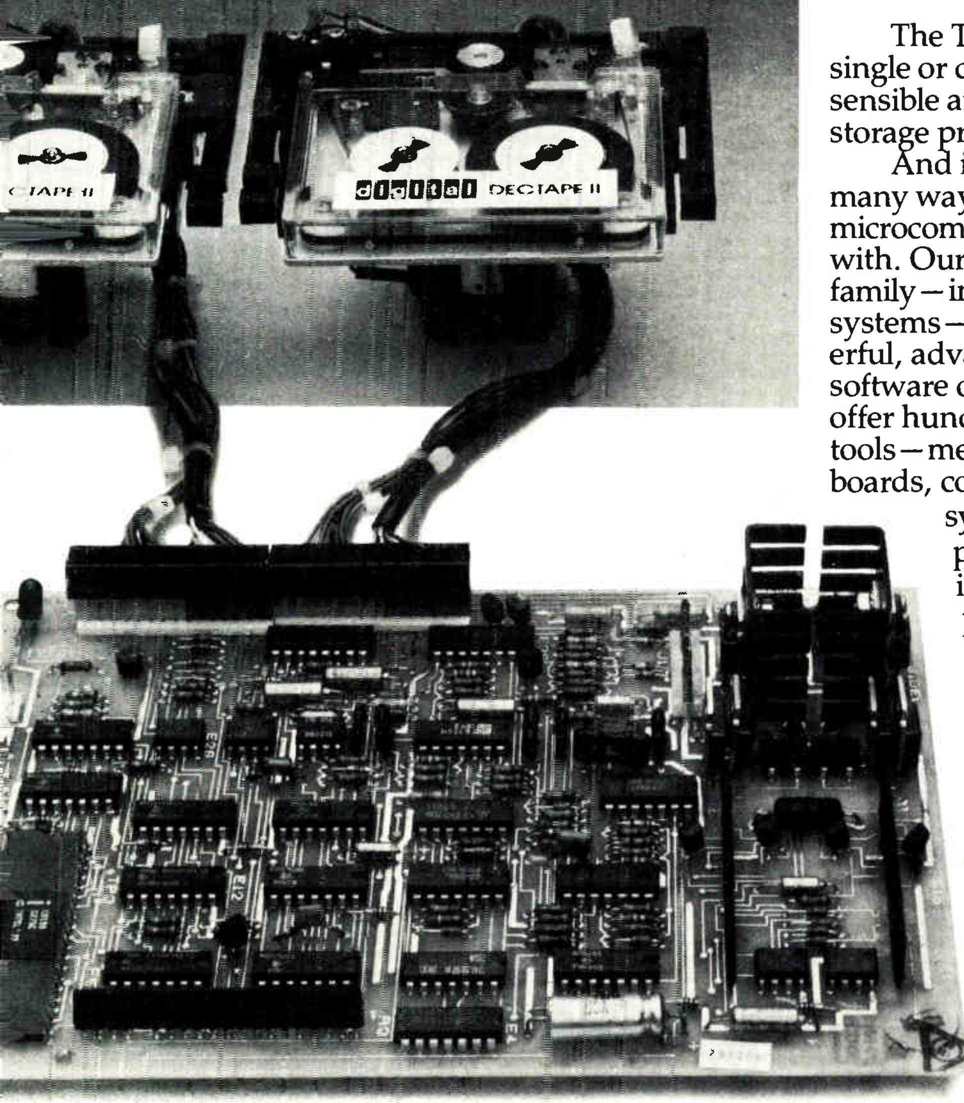

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engineer. He founded his present company in 1975 to serve as consultants on software engineering methodology, to teach software courses, and to perform related services.

"The great advantage [of megaworks per second] is that it allows the user to perform CPU capacity management and thus make his own throughput predictions," he claims. "We make all our experimental parameters available so that he can duplicate our measurements using his own operational mix of programs. This gives him an absolute basis upon which to make an upgrade decision."

No single number. However, the user must be careful to avoid oversimplification. "The upgrade decision is not a one-number answer," cautions one institute subscriber, Robert S. Wilson, marketing support product manager for the V/7 computer at Amdahl Corp., Sunnyvale, Calif. "One must also take into account secondary factors such as the sequence of instructions and their effects upon the different architectures." To help accomplish that, the institute plans to devise two additional sets of measurements to supplement the present two.

Most of the company's work is performed on a continuing basis for clients, but nonclients can subscribe to the yardstick study—"The CPU Power Analysis Report"—for $275 a year. Initially, it covers the IBM 370 and 303X series, the Amdahl mainframes, the National AS/3, /4, /5, and /6, and the Control Data Corp. Omega 480 series. Later this month, the IBM 4300 series will be added, according to Kolence.

The report includes measurements of the effect of various instruction mixes and of pipeline architectures as a function of input/output load. Measurements of the power of the central processing unit as a function of different buffer hit ratios will be added this month, showing the effectiveness with which different memory hierarchies match memory speeds to CPU speeds. Coming in the spring are measurements of the effects of virtual address translation as a function of I/O load. -**Martin Marshall**

Communications

Missing satellite brings woes

In a recent James Bond film, an American satellite was gobbled up by a cannibal satellite. Officials at RCA American Communications Inc. are quite certain that was not the fate of their missing communications bird, Satcom III, but beyond that they cannot say.

Cable TV hurts. It is likely that Satcom III self-destructed, which spells bad news for RCA's customers, especially for operators of cable television systems who had already negotiated to take advantage of the substantial increase in cable TV capacity to be provided.

Lost soon after a successful launching on Dec. 6, Satcom III was entering its synchronous orbit by means of controlled firings of its apogee kick motor when it disappeared from observers' radar screens. At the same time, radio communication stopped.

RCA has no spare satellite ready and will have to rush to prepare what was to be Satcom IV for launching soon, but the earliest launch date possible is June 1981. The replacement will have its 24 transponders assigned to distribute programming to cable TV operators. In the meantime, the operators are left with a shortfall and are scrambling for space that may be available on other satellites.

The spacecraft and its Delta launch rocket were insured for $50 million and the lost business for an additional $20 million, so that RCA at least will not take a financial bath. The real problems will come later when the company and other launchers of payloads try to get insurance, which typically comes from underwriter consortiums.

Insurance going up. What with aircraft coming down everywhere and the space shuttle missions estimated to cost anywhere from $50 million to $100 million per launch, premiums in the edgy aerospace insurance business will probably go as high as the satellites themselves. Already, say several insiders, there are too few insurance companies

No language barrier at consumer show

The Consumer Electronics Show in Las Vegas this weekend will signal the establishment of what might be called the hand-held computer market, based on products introduced over the past year as language translators. The latest example, bowing at the show, is Quasar Co.'s Information Processor, which will translate a dozen languages while serving as a four-function calculator complete with metric conversion tables.

Other programs available include nutrition, calorie, wine selection, and bartending guides. The Matsushita subsidiary is considering developing tables of generic drug substitutions and such specialized programs as a listing of radio frequencies for airports accepting private planes.

Equally prominent will be voice-actuated and talking products. Quasar will have a microwave oven programmed to deliver appropriate announcements to the cook. Toshiba Corp. will show voice-actuated television and stereo-system prototypes.

Moreover, the TV set can even respond (with either "okay" or "repeat") and can recognize 30 words covering power, volume (in levels from 1 to 10), and channel selection (1 through 12). Using the hand-held remote unit, the user can program the set to respond to his or her voice.

The stereo component system will respond only to its master's voice, performing any of 19 operations in response to a spoken command, made up of up to 15 different basic words. The circuitry includes a voice-analyzer unit, a pattern-matching unit that digitizes the sampled characteristics of the voice, an 8-bit Toshiba microprocessor, a 2-kilobyte read-only memory, and a 3-kilobyte random-access memory. **Benjamin A. Mason**

OKI's latest watch circuit breakthrough will be music to your ears.

Multifunction timekeeping with melody.
The OKI 6-digit MSM 5016 features the latest in timekeeping functions—month, date, day, hour, minutes and seconds for two different time zones. Also included are stopwatch functions—start, stop, reset and split—and an alarm for *either* selected time zone. A very special alarm which replaces the usual buzzes and beeps with a bright electronic melody.

OKI keeps you in tune with the times.
The 5016's alarm can be programmed by OKI to play the most complicated melodies with remarkable fidelity. Think of the possibilities: the Yellow Rose of Texas, Reveille, your school fight song, anything from the Halls of Montezuma to Deck the Halls. Just the kind of technical advance you'd expect from OKI, developers of new low power CMOS techniques and CMUX multiplexed circuits with fewer bonds per chip.

Send for a free wall chart of the OKI watch/clock family.
OKI wants you to have a list of our comprehensive line of watch and clock circuits and a way of keeping up to date on our latest circuit developments. We've created a special wall chart with stick-on updates for new circuits as they are introduced. For the wall chart and 5016 Melody Watch stick-on update, write or call OKI Semiconductor, 1333 Lawrence Expressway, Santa Clara, CA 95051, phone (408) 984-4842.

To: OKI Semiconductor, 1333 Lawrence Expressway, Santa Clara, CA 95051

☐ Send OKI's FREE Watch/Clock Product Line Chart Design Guide.

☐ Add me to your list to receive update stick-ons on the brand new MSM 5016 melody watch circuit and all future OKI developments.

I'd like to know about other OKI LCD watch circuits. Send data sheets on:
☐ BASIC circuits ☐ MULTIFUNCTION circuits ☐ CHRONOGRAPH circuits

Name ______ Title ______

Company ______

Address ______

City ______ State ______ Zip ______

Phone ______

EL 1/3/80

OKI

THERE'S A CLOUD ON THE HORIZON FOR MICROPROCESSORS

Needless trouble with static electricity

It's a fact that many of the components that have made possible the recent boom in the electronics industry are the ones most susceptible to damage from static charge — MOS/FETs, Bi-polar transistors, ECL devices and others.

From fabrication to assembly, to transportation and normal operation of the finished product — the danger of static is always present. It is a randomly occurring problem causing a high rejection rate. And, it is the unrecognized cause of many of the "unexplained malfunctions" experienced by end users.

There's no getting away from it. Static is generated in all sorts of weather, and under all kinds of conditions.

Static control for product reliability, fewer rejections, less degradation, fewer service calls

Traditional quality control programs concentrate on detecting destroyed components. Unfortunately, even products which have undergone complete and rigorous testing can experience premature field failure due to static-degraded components, resulting in expensive in-field service calls and product recalls.

In other words, defect detection can never be as complete, nor in the long run, as economical, as defect prevention.

If you think your company and your customers can benefit from fewer static-related rejects and in-field failures, investigate a system to solve the totality of the static problem. A system based on two simple principles:

1. **Handle all static-sensitive components at a static-safe work area**
   A static-safe area is any area that is capable of controlling static charge on conductive materials, people and nonconductive materials.
2. **Transport all static-sensitive components in static shielding containers or packages**
   A static shield must be capable of protecting from static discharge as well as static fields.

A complete static control program requires a total static control system, and only 3M manufactures such a system.

- Grounding devices for draining the static charge from people and conductive materials
- Ionized air blowers to neutralize the static charge on nonconductive materials
- Static shielding products to protect static sensitive devices during delicate transportation.

In addition, only 3M has the static analysts with the expertise to design a complete static control system to meet all of your specific needs. These are trained specialists who can help keep the clouds out of your exciting future.

For information on contacting the static analysts nearest you, see the listing on the facing page.

TOTAL CONTROL OF THE STATIC IN YOUR BUSINESS interested in such high risks.

The developers of satellite communications for the office-of-the-future boom expected in the 1980s are especially wary of the increased costs. Any hike will drive the electronic office business tab even higher than it is now. The high reliability of communications satellites, which generally last years beyond their design time (see p. 21), offers small comfort. **-Harvey J. Hindin**

Industrial

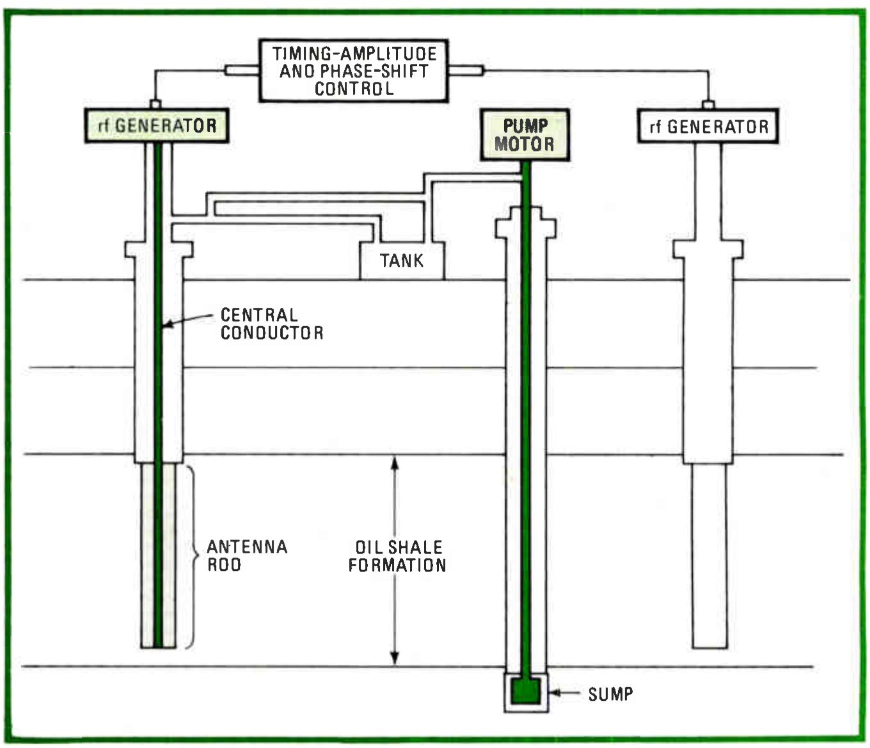
Radio-frequency energy to get tryout in mining oil from underground shale

Recovery of oil from underground oil shale deposits, an industry that nearly disappeared with the discovery of crude oil over a century ago, may be revived in the 1980s by the use of radio-frequency energy to convert the organic material in shale to oil for extraction. The Raytheon Co. technique potentially rivals crude oil production in cost-effectiveness, according to sources at the Lexington, Mass., firm.

Untapped reserves. The payoff could be tremendous. Industry estimates place the oil content of U.S. shale deposits at over a trillion barrels, which is 40 times the amount of current American reserves of liquid crude oil.

The earliest oil shale operations mined shale, heating it above ground to convert kerogen, the organic compound it contains, into oil and gas. In addition to requiring huge amounts of water for cooling, the system amounted to strip mining, produced pollutants, and was ultimately too expensive to compete with crude oil production. Raytheon's method would convert the kerogen underground, with minimal environmental impact, and will be cost-effective, it claims.

A network of antenna rods sunk



New oil rig. Raytheon Co. plans tests of a system that applies rf energy to underground shale, melting the organic components that make up oil. The pump then brings the oil up.

News briefs

Microprocessor-controlled PBX is a hit
By all indications, the EMS automated private-branch-exchange system that Siemens AG introduced in early 1979 is turning into a hot-selling item. During the past nine months, the company has received orders for some 2,000 EMS (for electronic, microprocessor, and stored-program-controlled) systems, worth $170 million, from 13 countries around the world. Siemens is counting on an additional 1,000 orders to come in during the next three months. Prime customers for the system [*Electronics*, April 12, p. 63] are banks, insurance and utility companies, and large automobile firms, as well as international agencies such as the European Economic Community headquarters in Brussels and the European patent office in Munich.

RCA to second-source Motorola's communications chips
RCA Corp.'s Solid State division and Motorola Inc. settled on a joint present just before Christmas: RCA will second-source the latter's family of telecommunication integrated circuits, and Motorola will supply the division with masks and design information. Included in the agreement are the complementary-MOS MC14406/7 coder-decoder, the MC14414 filter, and other chips that the companies would not disclose. Other announced second-source alliances on telecommunications chips include Intel and Texas Instruments [*Electronics*, March 29, p. 48], Mostek and Fairchild Camera and Instrument [*Electronics*, July 5, p. 54], and Mostek and Standard Microsystems Corp. [*Electronics*, Nov. 8, p. 34].

IBM sets new time frame for System/38
International Business Machines Corp. is apparently ironing out the bugs in its System/38 small-business system. The company's General Systems division now says deliveries will start next July, with customer training to begin in February. Last August, when deliveries were originally scheduled to start, the Atlanta division said more time was needed to test and integrate the systems programming [*Electronics*, Aug. 30, p. 88]. Following the trend to increased memory capacity, the System/38 will be available with more main memory—the model 3 can now hold 50% more for a total of 1.5 megabytes, and the model 5 is a third larger with a new maximum of 2 megabytes. Earlier last month, the company's Data Processing division doubled the main memory capacity of its 8100 distributed-processing system to 1 megabyte.

Small-business systems bow at Zilog
Zilog Inc., the Cupertino, Calif., affiliate of Exxon Enterprises Inc., is entering the small-business computer marketplace with four new microcomputer systems. Two of the systems, the $6,990 desktop MCZ-1/20A and the $16,925 rack-mounted MCZ-1/25A, are modular building blocks with no display or software included. Both incorporate a Z80 microcomputer with 64-K bytes of random-access memory, interrupt-driven console capability, and a floppy-disk controller. Two complete systems, the $8,460 desktop MCZ-1/50 and the $18,240 rack-mounted MCZ-1/70, also are available. Optional communications and multiterminal Cobol packages permit the high-end systems to be used in distributed-processing environments.

National will sell Hitachi computers in the U. S.
National Advanced Systems Corp., the recently formed subsidiary of National Semiconductor Corp., will be the U. S. marketer of the IBM-compatible mainframe computers manufactured by Japan's Hitachi Ltd. The Hitachi line was marketed in the U. S. by Itel Corp.'s Data Products group, which also sold IBM-compatible computers made by National. The money-losing Itel group was acquired by National [*Electronics*, Oct. 11, p. 89] and along with the Santa Clara, Calif., company's Computer Products group formed the core of the new subsidiary. Price and availability information on the Hitachi line will be disclosed later this month.

into the ground transmits radio energy in two stages from large rf generators (which Raytheon will describe only as "typical") to a portion of the shale formation. The first stage, using signals of about 1 megahertz, quickly raises the formation's temperature to over 100°C. Free water in the shale then evaporates, fracturing the rock and escaping through the fissures to surrounding areas.

In the second stage, rf energy in the 100-kilohertz-to-100-MHz range heats the shale over a period of hours or days. The water evaporation has left the shale less able to absorb energy; the kerogen, however, changes as it heats, forming intermediate compounds that are increasingly absorbent.

The resulting heat differential allows the kerogen finally to become oil. The shale itself remains cool enough to maintain the fissures, through which the now-liquefied oil can flow, as pumps pull it to the surface.

Temperatures. Controlling temperature in the shale formation is crucial to the operation, since too much heat can cause unwanted chemical reactions, hindering or stopping the process. The Raytheon technique uses phase-shifting signals so that rf waves from various antenna rods cancel one another out to varying degrees, as well as injection of cool gas or liquid through the rods to cool surrounding regions.

Thermocouples contained in the rods monitor temperature and signal the rf generators to shut down if the heat exceeds the proper limits. A central amplitude-timing and phase-control unit drives the generators, which receive their power from conventional three-phase high-voltage lines.

The company and its Cambridge, Mass., subsidiary, the Badger Co., are teaming up with Texaco Inc. for field tests in Utah of the method, pioneered in the 1960s. Just begun, testing should take about a year. Raytheon sources would say only that it will be "a multimillion-dollar project," but the hope is that the new process will be feasible for general use by the mid-1980s. **-Linda Lowe**

"THE 8086 IS HERE TODAY!"

Well, Intel's still out there shouting about the 8086. Still making lots of claims, still running pages and pages of advertising, still forgetting to mention one little fact:

The 8086 isn't the best 16-bit CPU.

The AmZ8000 is.

The AmZ8000 has a more advanced, more powerful, much more flexible architecture than the 8086. It has more addressing modes, more general purpose registers, more powerful instructions. It can even accommodate more data types. It has better I/O capability, larger addressing spaces, and a lot higher throughput using standard NMOS, than the 8086 using HMOS.

What about availability? We're shipping prototype quantities right now.

What about support? Glad you asked.

Our new System 8/8 was designed especially for the AmZ8000. It beats Intel's development system hands down.

System 8/8 can be directly upgraded to a 16-bit system by changing one card. Intel's can't. System 8/8 can translate 8080/8085 and Z80 programs. Intel's can't. System 8/8 has a PASCAL compiler that produces object code for the 8080 and AmZ8000. Intel's doesn't. System 8/8 comes with 8080/8085, Z80, and AmZ8000 macroassemblers. Intel's doesn't. System 8/8's in-circuit emulators include, in

"So is the AmZ8000.
And it's better."

addition to the AmZ8000, the 8080, 8085, 8048, and the Z80. Intel's doesn't. And we let you buy our System unbundled.

To demonstrate the capability of the AmZ8000 we developed a fully assembled and tested Evaluation Board. It's got the AmZ8002 CPU on it, along with RAM, EPROM, and I/O. It plugs right into System 8/8 and can execute the assembler or PASCAL object code. Ask for it by name: AMC96/4016.

Just one more thing: We know it hurts to drop Intel for somebody else. We've been through it ourselves. But it's going to hurt a lot more next year. By then your competitors could be so far ahead of you, you might never catch up.

Call Advanced Micro Devices and we'll send you everything we've got on the AmZ8000. Or come to one of our seminars. Or sign up for a course on the AmZ8000.

Better yet, buy an AmZ8000. Check it out for yourself. Put it through its paces. Compare it with the 8086.

Intel can beat their chests all they want. But they can't beat the AmZ8000.

Advanced Micro Devices

901 Thompson Place, Sunnyvale, CA 94086

Washington newsletter

Postal rate unit wants open competition for electronic mail

Broad and continuous competition will be the hallmark of electronic mail if the U. S. Postal Service's board of governors adopts this month the 3-to-2 recommendation of its overseer, the Postal Rate Commission. **That would permit interconnection of any common carrier chosen by the mailer to transmit computer-generated messages to any of 25 regional post offices for delivery.** The rate commission's plan, a product of its public representative, differs from the electronic computer-originated mail (ECOM) proposal of the Postal Service in that it would circumvent a jurisdictional dispute with the Federal Communications Commission.

The FCC's role under the new plan "would end at the front door of the post office," according to rate commission chairman Lee Fritschler, who hailed the policy recommendation as the most important in the commission's 10-year life. Advocates of the plan, who believe it will nullify pending FCC court action against the Postal Service over jurisdiction, say it will not require terminal standardization, only standard protocols.

ITC urged to continue controls on color TV imports

The remaining seven American-owned domestic manufacturers of color TV receivers "will disappear within a very few years" unless controls on imports from Japan, South Korea, and Taiwan are extended beyond their June 30 expiration by the International Trade Commission. That is the dire prediction in a year-end petition to the ITC by the industry and labor union lobby known as Compact—the Committee to Preserve American Color Television—which contends that Orderly Marketing Agreements negotiated with the three Pacific nations to limit TV shipments have provided U. S. makers **"a scant 10 to 11 months of import relief instead of the three years given us by the President."** The three-year agreement with Japan that went into effect July 1, 1977, spurred "an avalanche" of imports from Korea and Taiwan that was not controlled until separate agreements took effect early in 1979, Compact argues.

But even though the ITC may favor the petition, Government insiders say **the White House might let the Orderly Marketing Agreement with the three nations expire in return for a reciprocal concession in another trade area.** Moreover, Compact concedes that domestic color TV output rose 35% to 8.6 million sets in the second year of the import restraint program from 6.4 million the year before it became effective; plant capacity use was up to 46% in 1978 from 38% in 1976; capital outlays rose to $42 million in 1978 from about $30 million in 1976 and 1977; and research and development spending also improved to $112 million in 1978 from $70 million in 1975. U. S. productivity also is up, says Compact.

Goodyear to build massive processor for NASA pictures

An ultrahigh-speed computer for processing satellite images will be built and delivered in May 1982 by Goodyear Aerospace Corp., Akron, Ohio, under a $4.7 million contract from the National Aeronautics and Space Administration. Called the massively parallel processor (MPP), the system will use Hughes Electronics' silicon-on-sapphire custom chips, each containing eight processors. They can perform a total of 6,553 million floating-point additions—or 1,861 million floating-point multiplications—per second, according to David H. Schaefer, computer development section chief at Goddard Space Flight Center, Greenbelt, Md., where the MPP will be installed. **Simultaneous processing of picture elements, or pixels, will be from 10 to 100 times faster than is now possible,** Schaefer says.

Getting VHSIC's designers into the field

The challenge before prospective contractors for the triservice research and development program in very high-speed integrated circuits makes the Department of Defense's problems in rationalizing VHSIC to the Congress seem very small. It is the problem of selling military users, the field commanders, on the program, which is to be inaugurated this month (see p. 81).

The nature of the problem is illustrated by an army field chief's observation that "the best is the enemy of the good." That is a very real concern to Army commanders charged with being ready to fight tomorrow when told that the latest and best (and probably most expensive) technology will be ready to provide them with a whole new class of zippity-doodah weapons beginning about 1990—if VHSIC goes well.

The skeptical users

Using commands are entitled to view VHSIC with some skepticism, for they have seen such programs before. And more of them have failed than succeeded. That point was well made here last month by Eugene E. Yore, Army deputy for science and technology to the assistant secretary for research, development and acquisition. "At present we are technologically inferior to the USSR in almost every major fielded system," he told an audience of Government and industry advocates of VHSIC. "At one point we used a technology quality argument to rationalize inferior quantities. Now, however, we are both inferior technologically and inferior numerically." Is it any wonder, then, that many field commanders have yet to be convinced of VHSIC's promise?

A second threat to VHSIC's success is the proposal to introduce it by means of "technology insertion" into ongoing weapons system programs throughout the military. The Army's Yore correctly labels this "a tricky process," explaining that if the technologies are not ready and "miss the critical windows, by the very nature of the program manager's job and charter, he must go on with an existing or old and out-dated technology."

Persuading military program managers to stop and make changes in a weapons system is difficult enough in itself, as a VHSIC buff at the Naval Air Systems Command is quick to point out. Successful promotions, after all, are won by bringing programs in with good performance, on time, and within budget. Any of those goals can be skewed by change.

But perhaps the biggest challenge of translating VHSIC technology into successful operational weapons systems that will work when needed and can be quickly fixed when they go down is one that no discussion of this latest DOD effort has addressed to this point. It is the industry's widespread ignorance of the ultimate user's limited capabilities.

Electronics engineering managers can identify the problem by asking themselves when, if ever, they or their superiors and subordinates visited and spoke with a soldier, sailor, or airman who is supposed to be able to operate and maintain the systems and subsystems produced by their companies.

Those few engineers who have made such visits to an operating ship, submarine, airbase, or army field unit should be aware of the young enlisted men and officers that characterize the all-volunteer peacetime force. Although many of them have not completed secondary school, they are expected to maintain and operate computer-driven command, control, communications, information, and guidance and navigation systems that even their developers find demanding despite their advanced degrees. Moreover, say military commanders, those recruits who are successfully trained are all too often lost to private industry at enlistment's end.

Knowledge at first hand

None of these problems is easily resolved in a free society as long as it remains at peace. But programs such as VHSIC and others like it could make a beginning at a solution by requiring contractors and a representative group of engineers to visit with field users of the proposed equipment to learn from them what they want and what would be of most use to them in combat. Procurement commands must not be bypassed in this educational process, for it should give them, too, some insight into how to shorten the decade-long cycle between beginning R&D and the widespread deployment of an operational weapon. Many military procurement managers could benefit from a refresher on what it is like to be the ultimate customer for their purchases—and for the spares that never seem to arrive on time or in sufficient quantities.

VHSIC will never be a panacea for the using command's problems; it was never represented as one. Nevertheless, it might do much more than it already promises if engineers could gain a first-hand appreciation of their ultimate customers and the kind of conditions in which they must operate.

-Ray Connolly

UPDATE:

POWER INTERFACE ICs TO MIL-STD-883

Take the shortcut: The quickest and easiest route to obtaining MIL-Spec ICs can be to check Sprague first. Shown below is a brief listing of recently-developed Sprague products and applicable engineering bulletins.

For the engineering bulletins of interest to you, write to: Technical Literature Service, Sprague Electric Company, 35 Marshall St., North Adams, Mass. 01247.

For application engineering assistance, write or call Walter Sullivan or Paul Emerald, Sprague Electric Company, Semiconductor Division, 115 Northeast Cutoff, Worcester, Mass. 01606. Telephone 617/853-5000.

For the name of your nearest Sprague Semiconductor Distributor, write or call Roger Lemere at Sprague Products Company, North Adams, Mass. 01247. Tel. 413/664-4481.

Device	Series	Package	Max. Output Voltage	Output "1"	Engineering Bulletin
Quad Power Drivers	UHC- & UHD-400, 401-1,500	14-pin DIP or Flat-Pak	40 to 100V	to 250 mA	29300.1
7-Channel Darlington Arrays	ULS-2000H	16-pin DIP	50V/95V	to 500 mA	29304.1
8-Channel Darlington Arrays	ULS-2800H	18-pin DIP	50V/95V	to 500 mA	29304.4
Quad High Current Darlingtons	ULS-2064H to 2077H	16-pin DIP	50V/80V	to 1.25 A	29305.1
Quad Peripheral Drivers	UDS-5700H	16-pin DIP	80V	to 300 mA	29306.1
Dual Peripheral Drivers	UDS-5710H	8-pin DIP	80V	to 300 mA	29307.1
Dual Peripheral Drivers	UDS-3600H	8-pin DIP	80V	to 300 mA	29308.1
8-Channel Source Drivers	ULS-2980H	18-pin DIP	50V/80V	to 350 mA	29310.1
Quad PIN Diode Power Drivers	UDS-5790/91H	16-pin DIP	120V	to 300 mA	29315.1

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ALABAMA, Sprague Electric Co., 205/883-0520 • **ARIZONA**, Sprague Electric Co., 602/244-0154; 604/966-7233 • **CALIFORNIA**, Sprague Electric Co., 213/649-2600; Sprague Electric Co., 714/549-9913; Wm. J. Purdy Co., 415/347-7701; • **COLORADO**, Wm. J. Purdy Co., 303/777-1411 • **CONNECTICUT**, Sprague Electric Co., 203/261-2551; Ray Perron & Co., Inc., 203/268-9631 • **DIST. OF COLUMBIA**, Sprague Electric Co. (Govt. sales only), 202-337-7820 • **FLORIDA**, Sprague Electric Co., 305/831-3636 • **ILLINOIS**, Sprague Electric Co., 312/296-6620 • **INDIANA**, Sprague Electric Co., 317/253-4247 • **MASSACHUSETTS**, Sprague Electric Co., 617/899-9100; Sprague Electric Co., 413/664-4411 • **MICHIGAN**, Sprague Electric Co., 517/787-3934 • **MINNESOTA**, HMR, Inc., 612/831-7400 • **MISSOURI**, Sprague Electric Co., 314/781-2420 • **NEW HAMPSHIRE**, Ray Perron & Co., Inc., 603/742-2321 • **NEW JERSEY**, Sprague Electric Co., 201/696-8200; Sprague Electric Co., 609/795-2299; Trinkle Sales Inc., 609/795-4200 • **NEW MEXICO**, Wm. J. Purdy Co., 505/266-7959 • **NEW YORK**, Sprague Electric Co., 516/234-8700; 914/834-4439; Wm. Rutt, Inc., 914/834-8555; Sprague Electric Co., 315/437-7311; Mar-Com Associates, 315/437-2843 • **NORTH CAROLINA**, Electronic Marketing Associates, 919/722-5151 • **OHIO**, Sprague Electric Co. 513 866-2170; Electronic Salesmasters, Inc., 800/362-2616 • **PENNSYLVANIA**, Sprague Electric Co., 215/467-5252; Trinkle Sales Inc., 215/922-2080 • **TEXAS**, Sprague Electric Co., 214/235-1256 • **VERMONT**, Ray Perron & Co., Inc., 617-762-8114 • **VIRGINIA**, Sprague Electric Co., 703-463-9161 • **WASHINGTON**, Sprague Electric Co., 206/632-7761 • **CANADA**, Sprague Electric of Canada, Ltd., 416/766-6123 or 613/238-2542.

4SS-9114R1

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All precision resistors aren't...

as stable as 0.05% ΔR with tolerances to $\pm 0.005\%$ and TCR of $\pm 0.6ppm/^{\circ}C$... Only a Vishay is!

There's more to resistor precision than meets the eye. The three basic types of precision resistors — Wirewound, Metal Film, and Bulk Metal® — look alike on the surface and may often have similar purchased specifications. But beneath the surface, all three are made differently, and inherent design and processing will strongly influence electrical performance, so that all three behave differently in use. These differences will become apparent as temperature changes, as the effects of load-life, moisture, and other environmentals take their toll with time, and as circuit requirements become stricter for signal to noise ratio and pulse response. Thus, some precision resistors turn out to be not nearly as precise as you might expect.

Vishay Bulk Metal® resistors are virtually insensitive to destabilizing factors. Their element is a solid alloy that displays the desirable bulk properties of its parent material, thus it is inherently stable and noise-free. The alloy and matched substrate form a single entity with balanced temperature characteristics for an unusually low and predictable TCR. Resistance patterns are photoetched to ensure that temperature and stability characteristics remain identical from resistor to resistor and are not subject to process variations.

Vishay Bulk Metal® is the modern generation of precision resistors. Their design gives you a unique combination of characteristics found in no other single resistor — and they're all standard!

0.05% **STABILITY FOR 2,000 HOURS** — *Vishay load-life stability is 0.05% ΔR max. under full rated power of 0.3 watts at 125°C (0.6 watts at 70°C) for 2,000 hours; typically it's 0.02% ΔR, 10,000 hour stability is 0.5% ΔR max. Shelf-life stability is 0.0025% ΔR max. after 1 year; 0.005% ΔR max. after 3 years.*

±0.6ppm/°C **NOMINAL TCR** —

0°C to +25°C	+25°C to +60°C	−55°C to +25°C	+25°C to +125°C
+0.6 ppm/°C	−0.6 ppm/°C	+2.2 ppm/°C	−1.8 ppm/°C

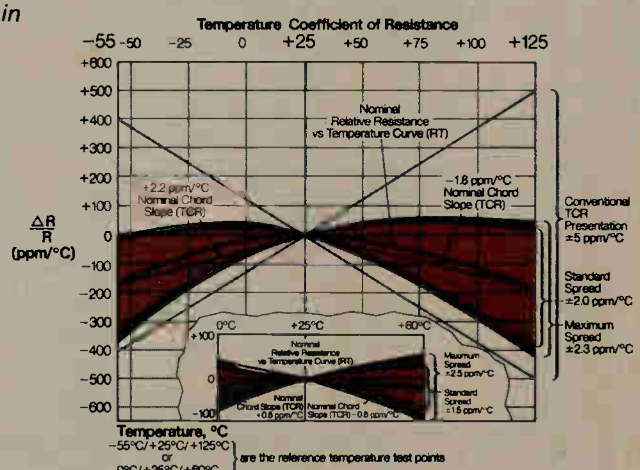
±1.5ppm/°C **VISHAY STANDARD TCR SPREAD FROM NOMINAL**

VISHAY STANDARD		VISHAY MAXIMUM	
0°C to +60°C	−55°C to +125°C	0°C to +60°C	−55°C to +125°C
±1.5 ppm/°C	±2.0 ppm/°C	±2.5 ppm/°C	±2.3 ppm/°C

This is accomplished automatically, without selection, regardless of the resistance value, or the date of manufacturing — even if years apart! Selected TCR tracking is available to 0.5ppm/°C.

±0.005% **TOLERANCE** — *Vishay resistance tolerance is as tight as ±0.005% — standard! ±0.001% available.*

1ns **RISE TIME** — *Vishay rise time is as fast as 1ns @ 1KΩ typical and only increases to a few ns for other values. Operation in the M Hz range is assured by low inductance of 0.1 μH max. and 1.0 pF max. capacitance — both factors due mainly to the leads. 0.08 μH and 0.5 pF respectively are typical. By design, adjacent current pathways carry current in opposing directions eliminating inductance; capacitance is lumped in series.*



<0.025μV(RMS)/Volt;
NOISE — *Vishay current noise is <0.025μV(RMS)/Volt of applied voltage (−32 dB or better). Test equipment resolution is −40 dB.*

0.5μV/°C **THERMAL EMF** — *Vishay Thermal EMF is 0.5μ V/°C max. difference in lead temperature, typically it's 0.3μ V/°C.*

<0.0001%/Volt **VOLTAGE COEFFICIENT** — *Vishay voltage coefficient is <0.0001%/Volt, which is the resolution of existing test equipment.*

Before you specify a precision resistor, take a hard look at how the three different types of precision resistors are made and test them to see how they will perform in service. Because one kind — the Vishay Bulk Metal® Resistor — will clearly outperform the others.

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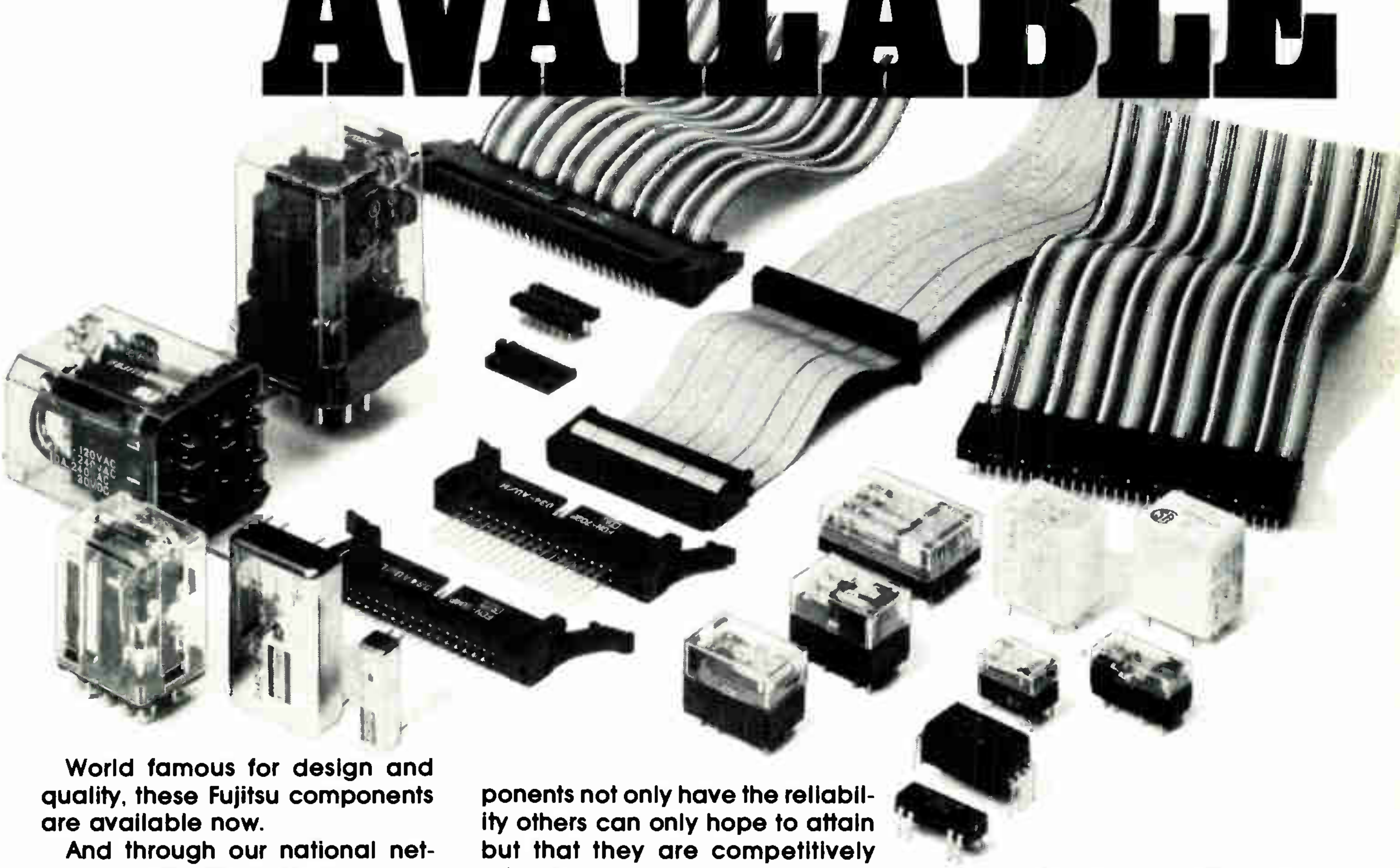

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International newsletter

Schlumberger protects MOS devices from electrostatic charges

Researchers at Schlumberger Ltd. have found a way to protect MOS devices from electrostatic charges and are believed to be incorporating the new technique in a bank and credit card [*Electronics*, Nov. 22, p. 63], although the company will not discuss details. Six French banks and the telecommunications branch of the French postal authority last month called for bids for intelligent, controlled-access cards for both on-line and off-line systems. The Schlumberger entry, to be made by the Franco-American group's Flonic subsidiary, in the Paris suburb of Montrouge, is believed to contain some 150 logic gates and 4 K of programmable read-only memory on a single custom MOS chip.

Hitachi gets OK to ship computerized banking system to China

Hitachi Ltd. says it has received approval from CoCom, the Coordinating Committee of the North Atlantic Treaty Organization and Japan, to deliver a $4.4 million banking system to China that includes 11 Hitac M-150 medium-sized mainframe computers and 21 L-320 office computers. Shipments will start next March and continue for 1½ years. The computers, to be installed on the premises of the Bank of China, the People's Bank of China, and the People's Insurance Co. of China in major cities, will be used for domestic and foreign banking business and for handling freight insurance.

Hitachi will also supply China with a $12.5 million color TV plant featuring the most up-to-date automated equipment, to be installed in Shanghai. With an annual capacity of 200,000 sets a year, it will be the largest in China. The plant will join two others being supplied by Japanese firms—the Victor Co. of Japan and Matsushita Electric Industrial Co.

French optimistic about adoption of digital TV standards

Officials of France's government-owned television broadcasting authority, Télédiffusion de France, are optimistic over the chances for acceptance of the first digital television standards at the European Broadcasters Union meeting in April. They say most major European broadcasting agencies have already agreed not to require black-and-white compatibility in digital color TV production equipment. **There is also general agreement that image quality should be determined by television broadcast criteria,** in contrast to U. S. interests seeking quality standards that would permit large-screen projection of video images and even video quality equal to that of 35-mm film.

IBA removes roadblock to surround sound standards

So-called surround sound systems, which use four speakers to heighten the listener's illusion of hearing the original sound, have lacked compatibility with established monaural and stereo systems. But with its newly patented MSC (for mono-stereo–compatible) system, Britain's Independent Broadcasting Authority claims to have overcome this problem. The three-channel system, which **has already been evaluated in experimental broadcasts,** is based on the Ambisonics surround-sound studio technology patented by Britain's National Research and Development Corp. The IBA says the success of this or any other system depends on the establishment of an international standard and agreement between the record companies and broadcasting authorities. Impetus for these could come with the advent of high-quality digital disks; in the interim, the IBA is contributing its results to European Broadcasting Union discussions on surround sound.

International newsletter

IC drivers for dc electroluminescent displays on the way

In a move to exploit the low-cost potential of dc electroluminescent flat-panel displays, the Royal Signals and Radar Establishment, Malvern, has placed a contract with Swindon Silicon Systems Ltd., a custom design house in Swindon, for two high-voltage integrated-circuit drivers that operate in push-pull fashion. The front- and back-panel drivers will be **manufactured using Plessey Semiconductors Ltd.'s high-voltage process and will be able to deliver the 150 V needed for electroluminescent panels.** Used as building blocks, they will be capable of driving panels with up to 480 or 960 characters. These sizes and smaller panels are either in production or under development at Phosphor Products Ltd. and GEC's Hirst Research Laboratories [*Electronics*, Sept. 14, 1978, p. 63]. The row driver incorporates an 8-bit shift register, an output latch, and an output driver; the column driver is a three-to-one decoder with clock. First samples are expected in 12 months.

ITT Semiconductors ups 1980 memory production goals

ITT Semiconductors is banking heavily on the sales boom for semiconductor memories to continue unabated. The Freiburg, West Germany–headquartered company, which claims to be Europe's biggest memory maker, plans to increase production of 4-K random-access memories from about 5 million units in 1979 to roughly 6 million in 1980. **For 16-K RAMs, a much steeper rise is targeted—from 1.5 million devices in 1979 to well over 8 million in 1980,** a more than fivefold jump. Also, the company will start up a production line for 4-K static RAMs. All memory devices are made at ITT Semiconductors' Memory Development and Production Centre at Footscray, near London.

Motor-drive chip from SGS–ATES handles 100 W

SGS–ATES Componenti Elettronici SpA will add to its catalog this year a switched-mode bridge amplifier that can supply up to 100 W to a dc motor. The Italian company, based in Agrate in the Milan area, maintains that **that is the highest output power achieved so far for a chip integrating both the output transistors and the control circuitry.** The 400-mil^2 driver circuit and two companion chips that make up a precision positioning system were originally designed for an Olivetti electric typewriter, but Olivetti's exclusive rights to the chip set have now expired and SGS–ATES expects it will find applications in many other kinds of hardware.

Addenda

Mitsubishi Electric Corp. announced last month a new top-of-the line mainframe, the Cosmo model 900II, with three times the processing capacity of its previous model 900. The unbundled hardware rents for $29,000 to $104,000 a month, which puts it in the IBM 3031 class, but Mitsubishi says the performance is in the IBM 3032 class. Furthermore, the operating system is designed for Japanese-language processing. **The computer features new emitter-coupled-logic devices with a propagation delay time of 0.7 ns** and up to 250 functions per chip. . . . **Prime contractor for the European Space Agency's large communications satellite, L-Sat, to be launched in 1984 will be the British Aerospace Dynamics group.** The 10-kW satellite—several times more powerful than the European communications satellite—will be able to transmit TV broadcasts at high power for direct reception by individual houses equipped with small rooftop antennas and can carry a considerable volume of telephone and data traffic.

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PARATRONICS

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Universal functional board, system tester mimics any instrument

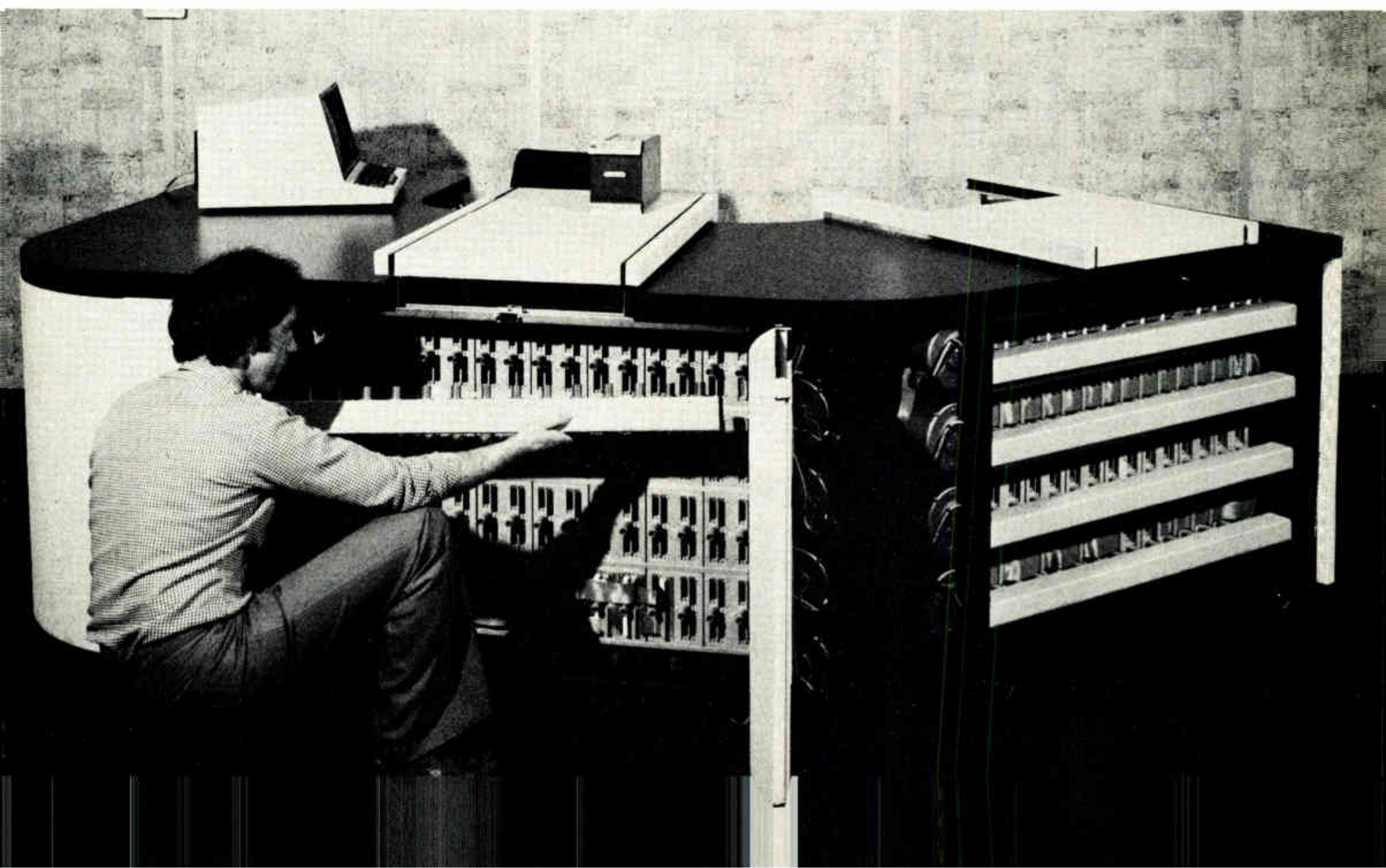
by Kevin Smith, London bureau manager

Naked single-function modules replace standard instruments; CRT display presents mock front panel

Setting up automatic test equipment should be as simple as the manual procedures the equipment replaces, according to ATE engineers at Marconi Space and Defence Systems Ltd., who have come up with the concept of the virtual instrument. They first defined the concept some three years ago and have now realized it in hardware with the Graduate universal functional tester.

The Graduate replaces standard test and measurement instruments with naked single-function instrument modules that mimic any test configuration with the aid of powerful resident software. Any needed test instrument front panel is presented on the tester's cathode-ray-tube display, and with the aid of a keyboard the engineer can select test functions and set test levels as easily as if he were turning the knobs on a real test instrument.

Power. To make the software work, the firm needed a powerful minicomputer with a big address capability, so the Graduate is designed around a 24-bit bit-slice processor with a jumbo-sized, 1-megaword address capability. At the same time, it threw out conventional test instruments and developed a range of single-function test modules. When introduced last month at Automatic Testing '79 in Brighton, the low-frequency—up to 3 megahertz—test modules had been readied [*Electronics*, Dec. 20, p. 55], but the digital test modules and the radio-frequency to microwave-fre-



Changeable. The Graduate's naked single-function modules enable the user to reconfigure it for different needs. Shown is the back of a two-kernel system.

quency modules are scheduled for the last quarter of the year.

The Graduate can functionally test printed-circuit boards, missile equipment, digital telephone exchanges, and other systems by applying digital or analog test patterns to the system under test and checking the response. Conceived both to meet an in-house need to check out military equipment and to win for the company a slice of the booming market for commercial functional testers, it will be marketed by sister company Marconi Instrument Ltd., St. Albans, alongside the in-circuit Autotest 80, introduced last year, and has already received $4 million worth of orders.

Strong points. Daniel S. Gruneberg, manager of MSDS's ATE division, sees several big advantages in his company's ATE philosophy. Foremost is reconfigurability, or the ability to assemble a test system for different requirements from standard building blocks spanning the entire frequency spectrum. This capability cuts hardware costs by eliminating redundant instrument front panels, knobs, and displays—and more importantly, redundant instrument functions. It also allows for easy system expansion and caters to advances in the technology.

Technological obsolescence is a real problem, Gruneberg explains, because instrument manufacturers have no vested interest in retaining compatiblilty between models—the ATE market, after all, is only 10% of their business. He cites one example where a new instrument differed from its predecessor in capabilities, range, interface standards, and size.

Consequently, Marconi engineers set out to define a set of single-function stripped-down modules conforming to standard dimensions and electrical characteristics from which any test requirement could be assembled. For low-frequency applications, they have developed just eight.

For example, a waveform generator with offset is built from a function generator, a precision voltage source, and a selective waveform assembly network. The last is a key element and can combine up to four waveforms. It incorporates a programmable attenuation stage, and a built-in random-access memory can switch the output to create pulses from a dc source or sine-, square-, or triangular-waveform bursts from the function generator.

A frequency-response analyzer can be assembled from programmable gain, fast comparator, and universal counter-timer modules. Completing the low-frequency line-up are the digital voltmeter and universal timer modules.

All modules have been reduced to two standard sizes, a single-width unit with three pc boards and a double unit with six. The units are made of extruded aluminum.

Kernels. The modules click into a kernel comprising four shelves with space for eight double-width units per shelf. Up to four kernels can be assembled into a complete system. Nineteen-inch racking provides for disk drives and other standard equipment. As each module slides into a standard shelf unit, it mates with standard services, such as cooling, power control, and signaling, piped through each kernel.

Each functional module affords the appropriate handshaking and data-decoding and -checking facilities. Deviations from standard performance are stored in programmable read-only memory within each module at calibration time. Thus stimulus outputs and measured inputs can be automatically corrected within the ATE's computer when the tester is running.

When a user sets up his test requirements, the Graduate's computer tells him which modules are needed and where to insert them so as to obtain the best performance.

The Graduate costs between $100,000 and $240,000, depending on configuration.

Israel

Abnormal electrical properties betray breast tumors to scanner

A desktop instrument called a mammo-scanner may offer a safe, inexpensive method for detecting breast cancer early. It measures and displays the differences in electrical properties between healthy breast tissue and tumors.

Present methods all have drawbacks. Palpations by a doctor are often not sensitive enough to pick up very small tumors. Thermography, or surface temperature measurement, does not detect small, deep-seated growths. X rays—mammograms—are costly and can themselves be a cause of breast cancer if administered repeatedly (they are therefore not used in the U. S. for women under the age of 55).

Another drawback is that 1 centimeter is the lower limit of tumor detection by mass-screening methods (excluding X rays). At that size, the tumor has been growing in most cases for approximately four years. If cancerous, it is generally removed by radical surgery of the breast.

Earlier. Of the 14 women out of 100 in the U. S. who contract breast cancer at some point in their lives, 7 die of it. Oncologists believe that earlier detection, well below the 1-cm level, would materially lower the death rate and perhaps reduce the necessity of surgery.

The mammo-scanner, developed over the past four years by Ephraim H. Frei and Bruce Sollish of the Weizmann Institute of Science in Rehovot, Israel, is a computerized device that safely and quickly scans breast tissue by measuring two key electrical properties, the breast's conductivity and dielectric constant, and how they vary over the organ.

The theory behind the device is that the capacitance of tissues at low frequencies is based mainly on the capacitance of the cell membranes, because the interior of the cell behaves essentially as a conductor. The dielectric constant of a tumor is

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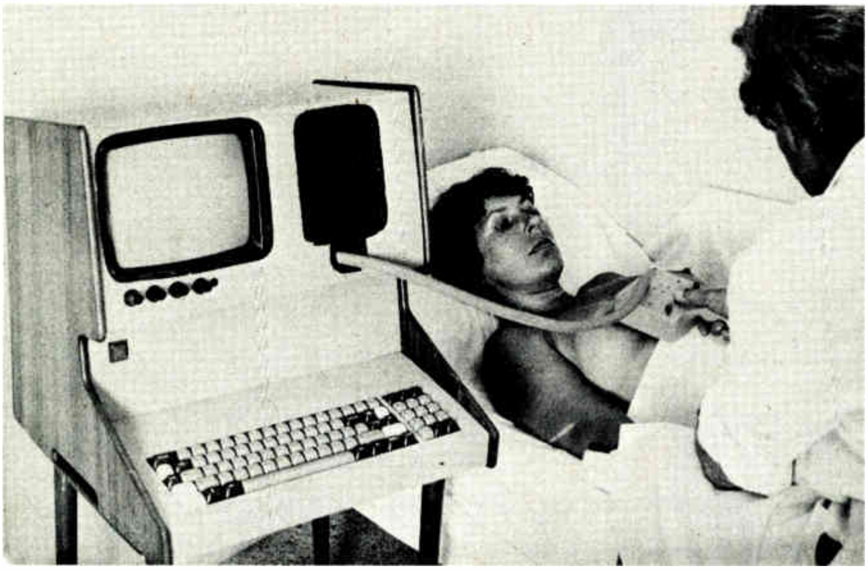

Safe, simple. Mammo-scanner from Israel's Weizmann Institute of Science detects breast tumors by measuring dielectric properties. Hand-held probe contains 64 sensors.

higher because tumor cells are larger than normal ones; therefore, there are fewer cell membranes, and consequently the measured capacitance and dielectric constant are larger in cancerous tissue.

The mammo-scanner comprises two parts: a unit the size of a desktop computer containing the basic electronics, a cathode-ray-tube display, and a keyboard; and a hand-held probe. It can thus be operated on a desk or a small table in a clinic or a mobile medical unit.

The probe contains 64 sensors, 8 on a side, each 7.5 millimeters square. Each sensor forms one plate of a capacitor. The breast is the dielectric medium, and a common-ground electrode forms the second electrode of the capacitor.

Low-level. A very low voltage is applied to the breast. The voltage is regulated by a self-adjusting circuit so that the maximum current flowing is below 100 microamperes per square centimeter. At that level, nothing can be felt nor is there any damage to the tissue. By measuring the current flowing to each of the 64 sensors, the impedance of the tissue beneath each one and the spatial variations from element to element can be calculated by the microprocessor-based system, which uses 64 kilobytes of random-access memory.

Within seconds, a 16-level gray-scale presentation of variations in the dielectric constant in the region examined is displayed. Each sensor is represented by one square, and the 64 together present a picture of one quadrant of one breast. Thus eight scans must be made for a full examination. Points or squares with abnormal conductivity and dielectric constant appear brighter, indicating suspicious areas that should be investigated more closely.

Displayed. Besides portraying the dielectric values of the section being examined, the screen shows the patient's name or other identification and any additional data entered by the physician via the keyboard. A photo of the screen documents the examination, and an optional floppy disk can store other records, as well as make data from previous examinations instantly accessible.

The instrument, now being clinically tested at Meir Hospital in Kfar Saba, Israel, and the Frauenklinik in Zurich can detect tumors as small as 7 mm. Smaller sensors would yield finer resolutions.

At this stage, malignant tumors and some benign growths cannot be differentiated. However, the designers hope that refinements using the analytical power of the microcomputer will reveal sophisticated correlations between electrical properties of benign and malignant pathologies. But for mass screening, the instrument's ability to give a simple indication of breast masses is sufficient. The patient may then be referred to a surgeon for final diagnosis.

Manufactured under license by Agar Electronics of Kibbutz Ginosar, the mammo-scanner will probably be on the market within a year. The company says it will be less expensive than other mass-screening devices. **-Arthur Kemelman, McGraw-Hill World News**

The Netherlands

Thin-film audio head goes magnetoresistive

Although it has been known for more than a century, the magnetoresistive effect—the change in resistance of certain metals under the influence of an external magnetic field—has only recently captured the attention of electronics engineers. The reason for their interest: in recording applications, magnetoresistive read heads can be made more compact and are more sensitive than the widely used inductive types.

What's more, since they lend themselves to simple thin-film fabrication, they are relatively inexpensive to manufacture. However, although the increased compactness and sensitivity make the heads well suited for reading out data from high-density magnetic-tape or other magnetic-storage devices, the noise and distortion they produce all but prevent their use in audio gear.

Highly linear. Solving this problem is a design from the Philips Research Laboratories in Eindhoven, the Netherlands. There, Edmond de Niet has developed an experimental read element that, by virtue of magnetic feedback, provides the high linearity necessary for obtaining distortionless sound reproduction from an audio tape recorder. In fact, the linearity is so good that "the element may even find uses in high-fidelity applications," de Niet says. He has already demonstrated his device in a cassette recorder.

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AEG-Telefunken electronics feel the loss

The losses of more than half a billion dollars incurred this year by AEG-Telefunken, West Germany's second-largest electrical and electronics producer, that recently led a consortium of 25 banks to launch one of the biggest rescue packages in the country's economic history is also affecting the firm's electronics operations. Although they did not perform badly—in contrast to the firm's power engineering activities—some electronics sectors are to reduce their personnel drastically, streamline production, and radically revamp operations to help get the $8 billion company back on its feet.

For example, Telefunken GmbH, the $1 billion entertainment electronics division, is to pare its domestic work force from 8,700 to 6,200 by the end of 1981—a cut of nearly 30%. Also, it is to retreat from the relatively lucrative British market. The office equipment sector is to give up its activities in Sweden and Northern Ireland, reduce those in Brazil, and put more emphasis on producing electronic typewriters and copying machines.

As for the components field, the $530 million rescue package provides for AEG-Telefunken to stop the production of certain types of capacitors and program memories and push the fabrication of commercial vacuum tubes. Color TV tube production, on the other hand, will henceforth be handled by a joint venture of France's Thomson-Brandt group and Telefunken.

Finally, in a move to restructure its operation in industrial process-control technology, the company is acquiring 25% of the U. S. firm Modular Computer Systems Inc. (Modcomp) and 75% of its West German subsidiary, Modular Computer Systems GmbH. By April 1, the latter will be reorganized as a joint venture that will entirely absorb AEG-Telefunken's activities in the process-control field.

Meanwhile, AEG-Telefunken is expanding its production facilties for comunications equipment, a sector whose 15% growth last year lifted the company's 1979 telecom sales to about $340 million. **-J. G.**

By itself, magnetoresistance is a highly nonlinear effect. To some extent, this nonlinearity can be compensated for by applying a constant magnetic field to the element. For high-fidelity applications, though, much better linearity is required. It is obtained by simultaneously applying a constant magnetic field and using magnetic feedback.

In fabricating the new element, de Niet uses thin-film technology. A layer of the magnetoresistive material, nickel-iron, is deposited on a silicon substrate. The element has the shape of a rectangular strip about 20 micrometers wide and roughly 600 μm long, the latter corresponding to the width of a track on casette recorder tape. The strip's thickness is some 50 nanometers.

Feedback. Magnetic feedback is effected by applying part of the ac output signal of the equipment's read amplifier to a thin-film conductor running alongside the strip. This feedback conductor, which is made of gold, is about 0.3 μm thick. The constant magnetic field needed to improve the linearity is obtained by applying a direct current to it.

Under the influence of the tape's magnetic fields, the element's resistance varies. These variations are sensed by another direct current, this one flowing through the element itself. The element output, then, is a voltage alternating in accordance with the variations in resistance.

Besides contributing to high linearity, magnetic feedback also reduces the so-called Barkhausen noise. This noise is caused by the abrupt movements of the magnetic-domain walls that occur when the magnetization changes in a multi-domain magnetic sample.

So designed, the element attains a linearity good enough for high-fidelity sound reproduction. The overall signal-to-noise ratio with tape in the recorder is about 60 decibels when measured according to National Association of Broadcasters standards. Without tape in the recorder, the S/N ratio rises to some 70 dB.

Barber pole. Instead of using a constant magnetic field to shift the operating point, a different kind of magnetoresistive element can be employed. The alternative element, which Philips has already realized, uses a so-called "barber pole" design that obviates the need for a direct current to set up the constant field.

The barber-pole element, too, consists of a silicon substrate with a thin layer of nickel-iron on top. Deposited obliquely on that layer are a number of bands made of a highly conductive material like gold, giving rise to the name "barber pole."

Since the conductivity of the nickel-iron is much lower than that of the gold, the input current does not flow in the direction of the strip's long axis but at an angle with the strip—in this case, 45°. Because the nickel-iron layer is premagnetized in the direction of the strip's long axis, the current in the barber-pole device also makes a 45° angle with the magnetic field to be read out. The result is good linearization and high element sensitivity. **-John Gosch**

Around the world

Philips joins with Brown, Boveri to make LCDs

NV Philips Gloeilampenfabrieken of the Netherlands and Brown, Boveri & Cie., Baden, Switzerland, have formed a 50/50 joint venture to develop, produce, and sell liquid-crystal displays starting Jan. 1. BBC currently manufactures LCDs at plants in Lenzburg, Switzerland, and Hong Kong.

French avionics firms talk merger

At the behest of France's defense ministry, two of the country's avionics equipment makers, SFENA and Crouzet SA, are considering a merger. The two firms already operate a joint subsidiary, SV2, a research and development company specializing in sophisticated autopilots and navigation equipment, such as laser gyros, mostly for military applications.

Circle 73 on reader service card →

HP announces a way to accelerate microcomputer development...

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The new HP 64000 Logic Development System helps you speed microcomputer development and cut costs several ways. First, it uses a universal, rather than a dedicated, approach to microcomputer development. So you can use the HP 64000 to develop an 8080-based system today, and then a 6800-based system tomorrow. Or you can use it for different types of microprocessors in the same product, without paying the price of separate development systems for each. What's more, HP's powerful 64000 architecture is independent of processor type, bus-width or speed. So you'll be able to use this same basic system with future developments such as 16- and 32-bit processors.

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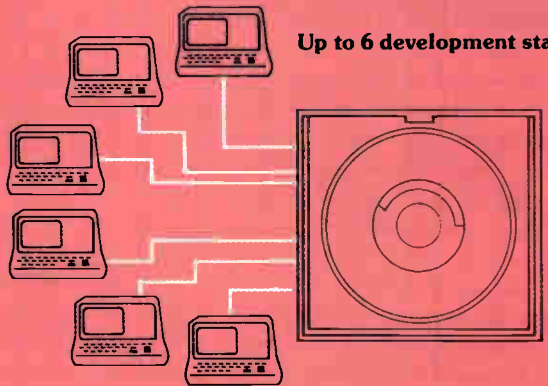
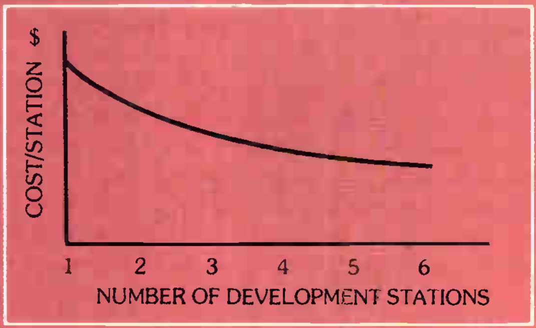


This HP approach is superior to a single-station, dedicated system for two other important reasons: With today's growing emphasis on microprocessor-based products, it's unlikely that any single system will provide the flexibility and growth path you'll need in future years. What's more, the 64000 offers significant savings when multiple development stations are contemplated (see chart below), and provides a practical way for you to obtain high-performance peripherals.



An accelerated path to market. Third, because the HP 64000 has a powerful user-oriented display editor, rather than a teletype editor, it becomes a user-oriented system that speeds editing and debugging. Its advanced real-time emulation shows you precisely how your system will perform at speed, to help eliminate potential production problems and product entry delays.

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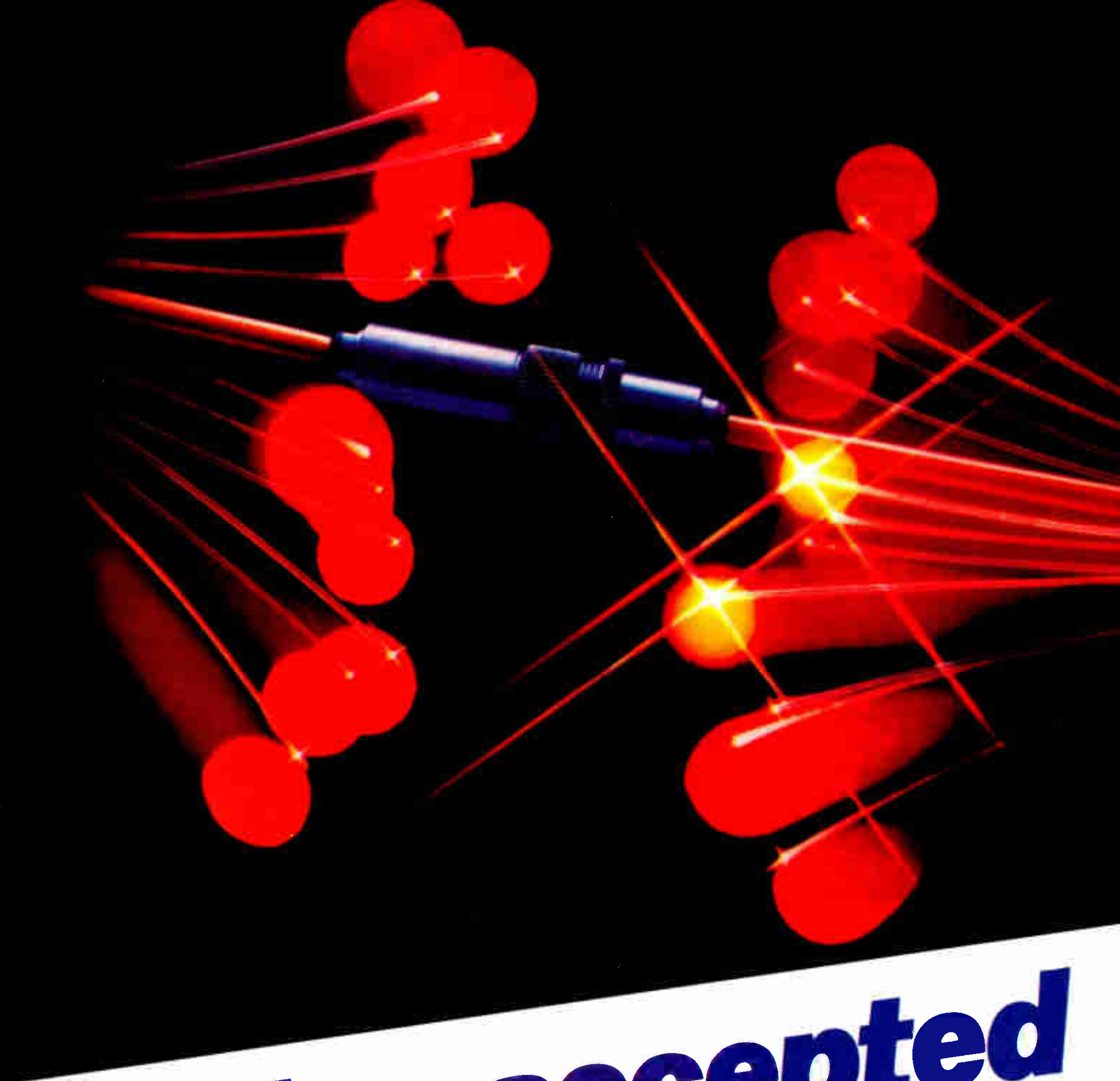

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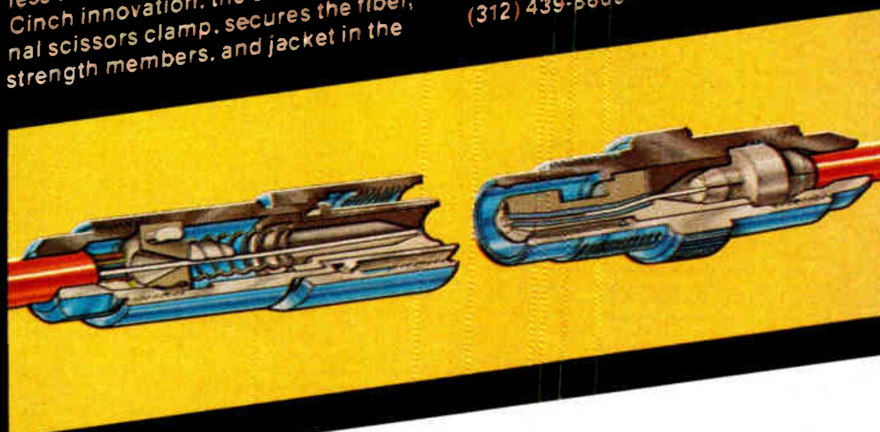

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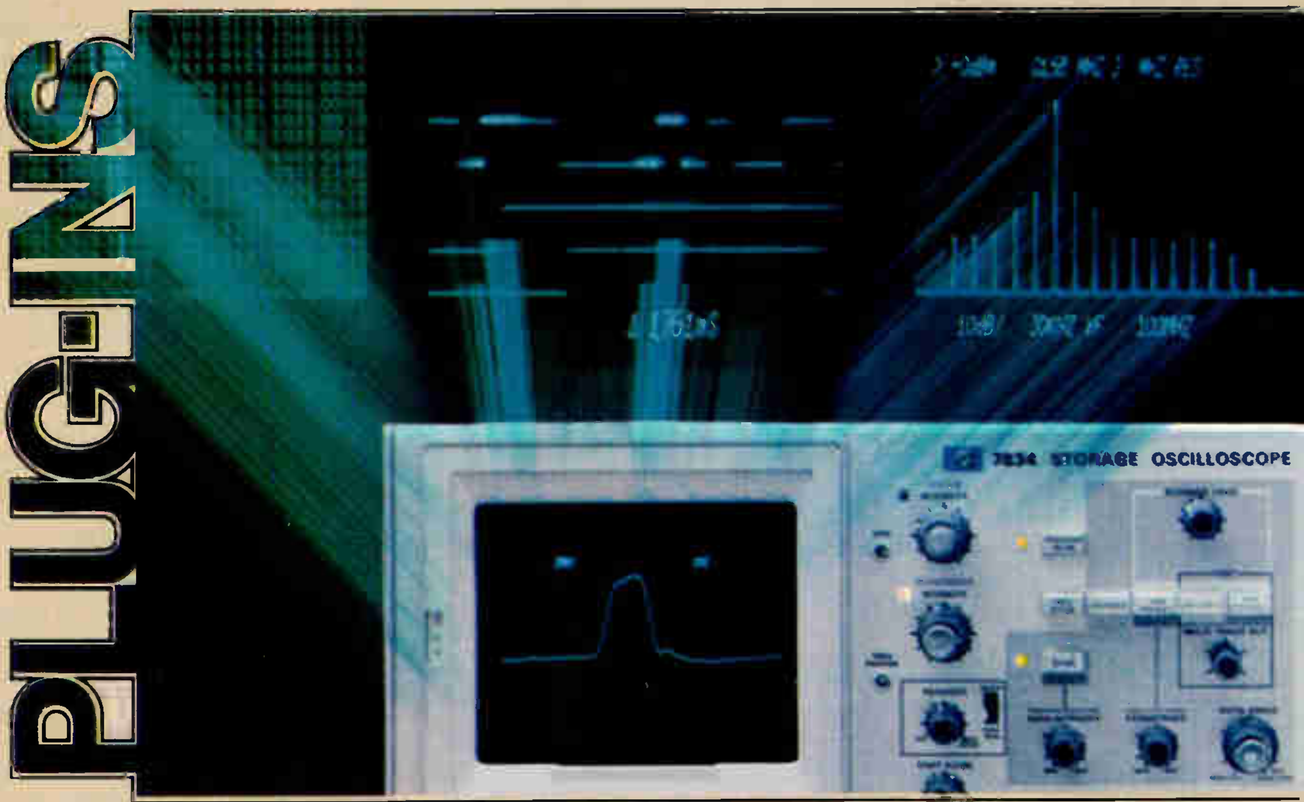

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VHSIC finally gets untracked

Six-year $210 million program gets over congressional hurdle with first nine contracts of Phase Zero to be awarded this month

by Ray Connolly, Washington bureau manager

After a year-long struggle for congressional approval, the $210 million six-year military program to develop very high-speed integrated circuits is set to begin with $30.4 million for fiscal 1980. "We don't see any basis for interruptions after this point," says Thomas Hahn, counsel for the House Armed Services Committee.

VHSIC was initially stalled in that committee while the Department of Defense was asked to show how it would maintain tight central management of the triservice effort. It also had to convince legislators that the research and development effort would not unbalance competition in the semiconductor industry.

The Pentagon's response was to tighten management controls under Larry W. Sumney, VHSIC program manager in the office of the under secretary of defense for research and engineering [*Electronics*, Sept. 28, 1978, p. 12]. The Defense Department also will require VHSIC contractors to license any technology and data coming out of the program to other U. S. semiconductor makers for Government applications.

Target year is 1986. The goal of the program is to come up in 1986–87 with silicon circuits in automated pilot-line production that have up to 250,000 gates, with the minimum dimension as small as 0.5 micrometer on a single large chip—400 mils on a side [*Electronics*, Sept. 14, 1978, p. 81]. The resultant size and power requirements of weapons system would be reduced sharply while system speeds would be up several orders of magnitude from today's levels. VHSIC chips will also have to have a built-in test capability to qualify.

The first nine contracts, totaling $10 million to $12 million, will be awarded for VHSIC Phase Zero before January is over. Winners of the nine-month-long awards will have to show that they have the expertise required to take part in specific weapons programs. They also will have to delineate the architecture and design of the system itself and of the integrated circuits to be developed for the systems.

These selections will be made from 14 proposals involving nearly 30 companies. Reportedly leading the competition are corporate teams headed by Hughes Aircraft (with Signetics), Raytheon Co. (with Fairchild Camera and Instrument), TRW (with Motorola, Sperry Univac, and GCA), Westinghouse Electric (with National Semiconductor, Control Data, and Carnegie-Mellon Institute), plus the go-it-alone proposals of General Electric, IBM, Rockwell International, Texas Instruments, and Western Electric, which is the manufacturing arm of AT&T.

Phase 3 of VHSIC, embracing a multiplicity of supporting functions, comes next, with first awards scheduled for this spring, program manager Sumney says, noting that the timetable is consecutive only for Phases 0, 1, and 2. Phase 3, a continuing effort that will run as long as the program does, is budgeted to consume about one third of the $210 million total and is expected to have "a very sharply rising funding curve" in the years ahead, he says.

More than 200 Phase 3 proposals submitted in mid-December are now being evaluated, he continues. "They come from industry and universities and cover just about every kind of support you can think of, ranging from R&D on lithographic techniques and devices to management-assistance programs." This phase will be characterized by a "broad base dealing with key program areas and should get us off to a fast start,"

TABLE 1: DEVICE AND CHIP CAPABILITY, LSI AND VLSI

Parameter	1979 capability		Mid-1980s capability	
	Silicon MOS	Silicon bipolar	Silicon MOS	Silicon bipolar
Feature size (μm)	2.5	2.5	0.5	0.5
Gates/chip	5,000	5,000	250,000	250,000
T_{PD} = propagation delay (ns)	25	5	5	1
Gate power-delay product (pJ)	2	2	0.02	0.08
Maximum frequency, f_{max} ($\frac{1}{4} T_{PD}$) (MHz)	50	50	50	250
Chip area (mil^2)	250 x 250	250 x 250	400 x 400	400 x 400
Typical device type	n-MOS	npn	n-MOS	npn
Throughput (f_{max} x gates/chip)	5 x 10^4	2.5 x 10^5	1.25 x 10^7	6.25 x 10^7

SOURCE: DEPARTMENT OF DEFENSE

predicts the Pentagon's Sumney.

First awards for Phase 1, which has been separated into two parts, are expected in early 1981, after about a three-months evaluation of the performance of Phase 0 contractors. "Phase 1A will develop everything needed for pilot-line production of circuits with features reduced to 1.2 μm," Sumney explains. "Phase 1B will deal with developing the pieces [of technology] needed for later production of circuits with submicron features" that will take place in Phase 2.

Phase 2, also in two parts and scheduled to begin in 1983, will push ahead with improvements developed in the first phase. "The program will be over," he says, "when we can come up with successful automated pilot-line production of VHSIC circuits with submicron features" and the other characteristics of high-speed, low-power, multiple-system applications and high reliability through built-in testing. "It is not going to be easy," Sumney adds, in what could be an understatement.

Barriers identified by Pentagon. Seven principal barriers to successfully developing VHSIC technology have been identified by the program's managers. Circuit technology is one of them, although several contending manufacturers attending a VHSIC symposium in Washington, D. C., last month lean toward complementary-MOS. The Pentagon ranks technology as a second-order priority, noting that there are several contenders.

Bigger barriers, in the Defense Department's view, are alignment and exposure of circuit patterns, development of resist patterns, and metalization. VHSIC program managers see electron-beam and X-ray lithography techniques as likely solutions to the alignment and exposure problem, but they see no answer emerging from today's technology to the metalization issue.

Problems galore. Second-level problems facing the VHSIC program include material removal from circuits, expected to be resolved through dry processing, and automation of process integration, the solutions to which are seen as coming through evolution. Oxide quality, ranked third in importance in the Pentagon's list of barriers, is also expected to improve with evolution. As for the other third-order challenges of doping and epitaxy, VHSIC program leaders look to ion implantation and annealing techniques to deal with the doping obstacle and low-temperature processes to take care of annealing.

Lithography for VHSIC devices with features below 1 μm is seen as one of the program's biggest challenges, since registration and process control will have to be on the order of 0.1 μm to achieve 0.5-μm resolution. Defect densities of not more than one defect per square centimeter will be another target of the lithography investigators.

Beyond electron-beam and X-ray lithography, the VHSIC program will explore deep ultraviolet light approaches to contact printing and projection printing, ion-beam writing, direct stepping on wafers using optical techniques, and electron projection.

Applications already laid out. Program manager Sumney and other VHSIC advocates lay great stress on the fact that the effort is "systems-driven" by weapons applications that each of the services has already identified. Four Naval Air Systems Command system candidates, for example, are upgradings of the airborne early-warning radar on the E-2C Hawkeye command and control aircraft; the F-14 Tomcat air-superiority fighter's multisensor processor under the effort Cilop (for "conversion in lieu of procurement"); a new fighter attack-integrated radar; and the Tactical Information Exchange System (TIES) planned to provide aircraft with a totally integrated package linked to multiple antennas and able to perform a variety of functions.

VHSIC should help Navair improve its existing inventory of weapons, since the prospect of acquiring new airframes "is pretty bleak," says Elizabeth Reggs, Navair's technology administrator for command, control, and guidance. The challenge within the services, she says, "is to convince [weapons system] program managers that VHSIC will help them" without introducing unacceptable slippages into their closely watched time, cost, and performance schedules.

Army program candidates include a new multimode fire-and-forget missile, a highly mobile integrated electronic warfare weapons system, an advanced target-acquisition and fire-control system, and the tactical Battlefield Information Control System (BIDS) and its affiliated Battlefield Information Control System (BICS), says Eugene E. Yore, science

TABLE 2: OPEN-ENDED ADVANCED MILITARY SYSTEM REQUIREMENTS FOR HIGH-SPEED VLSI

Application	Platform	Signal-processing required (millions/instructions/second) Current	Future
Army tactical signal intelligence	land-based mobile	0.4	40
Cruise missile terminal guidance	small missile	0.1	50
Data correlation for over-the-horizon targeting/fire control	ship- or land-based	1.0	50–100
Airborne radar (SAR)	aircraft or spacecraft	3.0	100–500
Early warning radar pulse processor (1–10 megapulses/second)	aircraft or spacecraft	2.0	200–300
Antijam low-power spread-spectrum communications	small missile, remotely piloted vehicle, aircraft or spacecraft	5.0	500
Wideband data links (1 Gb/s)	spacecraft	10.0	500
Undersea global search (Sosus)	ship- or land-based	0.5	2,000
Electronic intelligence/electronic support measures processor (10-Hz digital spectrum analyzer)	aircraft or spacecraft	10.0	10,000

SOURCE: DEPARTMENT OF DEFENSE

and technology deputy to the assistant secretary for research, development, and acquisition.

The fire-and-forget concept is an interesting one. It is exactly what the name suggests: the crew firing the weapon would actually be able to drive away from the launch site before the missile hit its target. At present, not too many of its class are actually deployed.

The Army VHSIC effort is being managed by the Electronics Research and Development Command's K. H. Zaininger at Fort Monmouth, N. J. Although VHSIC devices will not provide the Army with "commonality across all four systems," Yore says, "we ought to be able to get standard semiconductor memories and microprocessors."

Stiff requirements. The fire-and-forget missile, for example, must resist radiation, perform infrared imaging of targets and lock-on, employ millimeter-wave frequencies, and be a candidate for a multimode seeker. The high-mobility electronic warfare system has "the very demanding assignment" of being able to locate, identify, and target enemy emitters. The newer BIDS, being designed for deployment in the 1990s, is expected to tie together such diverse intelligence and weapons systems as reconnaissance satellites, scout helicopters, remotely piloted vehicles, helicopter gunships, tanks, and ground troops.

The Air Force, whose VHSIC effort is directed by John Blasinghame at the Avionics Laboratory at Wright-Patterson Air Force Base in Dayton, Ohio, also has a bagful of candidate systems. The shopping list includes both upgraded versions of existing system and programs that are still in development.

Aircraft on-board signal processors for a variety of advanced functions come at the top of the laboratory's list. These include a programmable processor for the old reliable E-3A Airborne Warning and Control System, a multifunction radar signal processor, communications signal processors for the joint tactical information display system (TIDS) to coordinate air and ground forces, and guidance processors leading to an autonomous air-launched cruise missile.

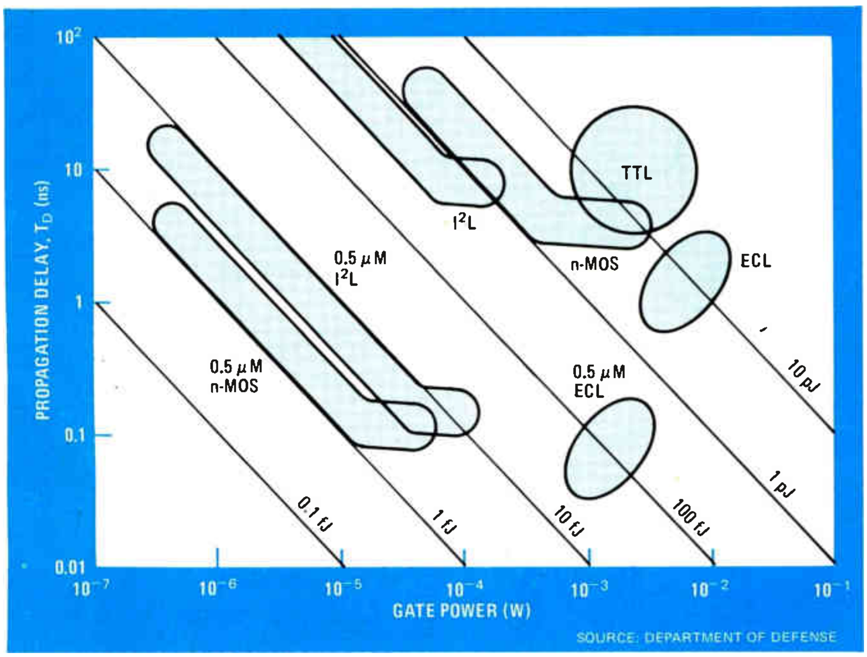
Overview. Though it seems unlikely that the VHSIC program can satisfy all of these optimal military goals with just a handful of standard circuits before the decade is out, there are common military requirements that the Pentagon's Sumney believes the program can fulfill. A flexible general-purpose video-signal processor is one example (see figure). A forward-looking infrared system (FLIR), for instance, could benefit by having the number of its circuits reduced to between 7 and 13 from today's 800, its weight cut to 10 pounds and size to 1 cubic foot—a two-thirds reduction—and its power consumption lowered to only 40 watts instead of 400. At the same time, the new FLIR system's corrections would be enhanced down to 10 gray-scale levels with automatic maximization of the image.

For nose-mounted fighter-aircraft radar, the promise of the program is at least as bright, Sumney says, citing the prospect of a single system performing up to 11 functions. He identifies 5 in the air-to-air mode alone, including long-range search, noncooperative target recognition, target tracking with a look-down capability, threat assessment, and fire control. The 6 air-to-ground functions could be even more critical in tactical situations, since they range from area search, terrain following and avoidance, navigation updating, target detection and tracking, to precision weapons delivery.

Perhaps the greatest commonality made possible by the program will come with the development of a fast low-power microprocessor that is reprogrammable for many specialized applications, according to Sumney. As envisioned by the Defense Department, the new one-chip processor—up to 100 times faster than existing multichip devices—would have a 200-megahertz clock, a read-only memory of 20,000 by 16 bits, a random-access memory of 12,000 by 16 bits, and four direct-memory-access channels of 2 megabits each.

Not only would such a device be reprogrammable for flexibility, but furthermore, the Defense Department argues, the chip would permit more efficient design, "since the increased data rate is compatible with digital signal-processing systems."

After VHSIC? Despite the fact that the VHSIC program is just formally getting under way, the Pentagon is already looking beyond to UHSIC—ultrahigh-speed integrated circuits—says Richard Reynolds of the Defense Advanced Research Projects Agency. As the Darpa Materials



VHSIC goals. The push for finer lithography in the VHSIC program is evidenced by this speed-power curve. At 0.5-μm dimensions, power-delay products drop a hundredfold.

Sciences Office's assistant director for electro-optical materials and devices, he notes that his organization is looking past VHSIC's concentration on silicon circuits toward longer-term programs involving gallium arsenide and such combinations of materials as aluminum, boron, and indium phosphide.

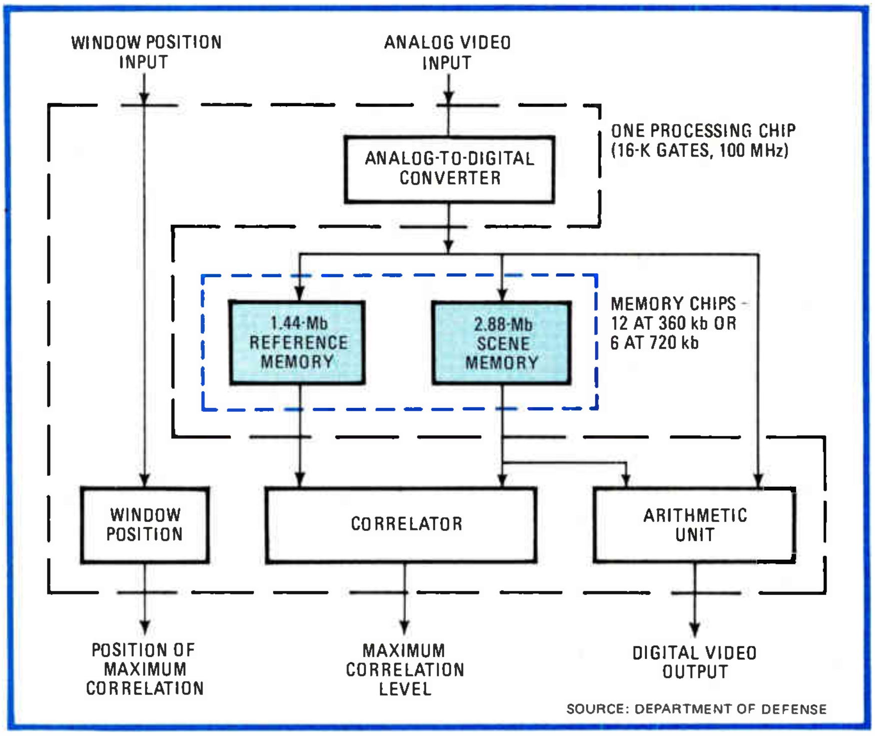
Yet Reynolds admits that Darpa's budget for R&D on ultrahigh-speed circuits is small. It amounts to $8 million to $9 million for fiscal 1980, but is programmed for a 25% increase the following year. Nevertheless, these efforts, plus spinoffs from Darpa's $500 million total for funding all technologies, are expected to produce advances that may be applicable to VHSIC's later phases.

For example, Reynolds notes that a classified program at the Massachusetts Institute of Technology's Lincoln Laboratory in which Darpa made "a substantial investment in the past three or four months" is aimed at developing deep ultraviolet lasers for use in "space-based defense systems. That technology, if successful, could be employed in controlling IC surface processing in order to make localized connections or disconnections at the 1-μm level—a VHSIC goal. A 1-μm connection already is achievable.

UV laser photochemical processing not only promises submicrometer surface processing, but also allows one-step localized doping of semiconductor surfaces. Such laser heating of surfaces has already produced pn junctions on indium phosphide, Reynolds says.

Added dimension. The MIT lab "is just now beginning to explore three-dimensional integration [of ICs] by graphio-epitaxy" that Reynolds notes "is one of our fondest dreams" for advancing the state of the art. Darpa's fiscal 1981 budget increase will include more funds for pursuing 3-d ICs, including nonvolatile random-access memories, already dubbed NVRAMs, and switch structures requiring less than 1.5 volts, well below the 5-V state of the nonmilitary art [*Electronics*, Oct. 11, p. 111].

Whereas the VHSIC effort is principally industry-based, the Darpa executive notes that "submicron technology is almost all university-based," citing the MIT efforts and other work at California's Stanford University on laser-beam annealing, some of it performed in cooperation with Texas Instruments. Lincoln Lab is also continuing a three-year program pursuing hetero-epitaxial growth techniques that promote growth of silicon single crystals on amorphous substrates, as well as use of laser annealing to recrystallize amorphous silicon on fused silica.



Basic block. A common processor built with VHSIC technology could be used with future military imaging systems employing either television, infrared, or radar signals.

But Darpa is also following, and in some cases funding, industry efforts to advance the state of the art, Reynolds says. Among them is the Department of Energy's multimillion-dollar contract for electron-beam processing of photovoltaic cells at Spire Corp., Bedford, Mass. Reynolds says Darpa "is building on that program" for possible VHSIC applications using low-temperature electron-beam technology for annealing 3-inch silicon wafers. Under the six-month-old program, Spire's "research results are excellent," he says, producing high-quality crystal structures.

Reynolds also indicates that Texas Instruments' R&D efforts make it a prime VHSIC contender. It has developed a vertial anisotropic etching process that has produced a polysilicon gate measuring 1,500 angstroms, "smaller than anything else anyone has ever made," he says.

Computer interest. The gallium arsenide technology being pursued for the longer-term VHSIC effort is generating the most industry response from mainframe computer producers like IBM, rather than from signal-processing manufacturers, Reynolds contends. Computer makers, he says, are interested in such products as GaAs metal-semiconductor field-effect transistors. IBM demonstrated under an Air Force R&D contract several years ago that MES FETs can be six times faster than their silicon counterparts. Moreover, computer makers are excited about gallium arsenide's 20 to 50 times lower power requirement.

In other action on the gallium arsenide R&D front, the Darpa executive also discloses that Rockwell International has just started fabricating a 2-by-32-bit shift register with approximately 550 logic gates that works very well up to temperatures of 200°C "with essentially no change in power dissipation or speed" and "is, God willing, expected to be working [in reproducible form] by about April or June." □

Instrumentation

Can new bus codes do the job?

Attempt to sharpen IEEE-488–1978 gets into device areas, with result that some still find too many generalities

by Richard W. Comerford, Test, Measurement & Control Editor, and Martin Marshall, West Coast Computers & Instruments Editor,

Engineers who have sweated to implement the instrument interface defined by the Institute of Electrical and Electronic Engineers' Standard 488-1978 have learned the hard way where that document fails to provide guidance. Now the group that originated that standard, the subcommittee on instrumentation and computer interfaces, is about to begin balloting on a new document that may clear some of the haze around the general-purpose instrument bus—though some experts deny it goes far enough.

It should be noted that the 488 bus standard, as it is known, does cover in good detail the portions of the bus that it set out to describe—the mechanical, electrical, and functional requirements for linking units that use it. But such definitions establish only the beginning of communication, the picking up of the phone when it rings, so to speak. The actual form of communication—the language that flows through the receiver—has not been codified.

In trying to formalize communicating conventions, the subcommittee enters a highly device-dependent area, one in which individual manufacturers may be unwilling at present to accept dictates. In its draft of a recommended practice for such conventions, therefore, it lays down very few absolutes. Instead, it couches its delineations in terms of "preferred" or "recommended" options. As with the origin of many other standards, industry demand for a common practice may strengthen these recommendations beyond their present weight, so that the recommended procedures may have far-reaching consequences.

Most of the proposal describes the alternative header, numeric, and separator (or delimiter) data fields to be used in transmitting measurement, program, status, and display data. In general, the document recommends but does not insist on the elimination of spaces in fields. For example, the preferred header field is simply two uppercase alphabetical characters.

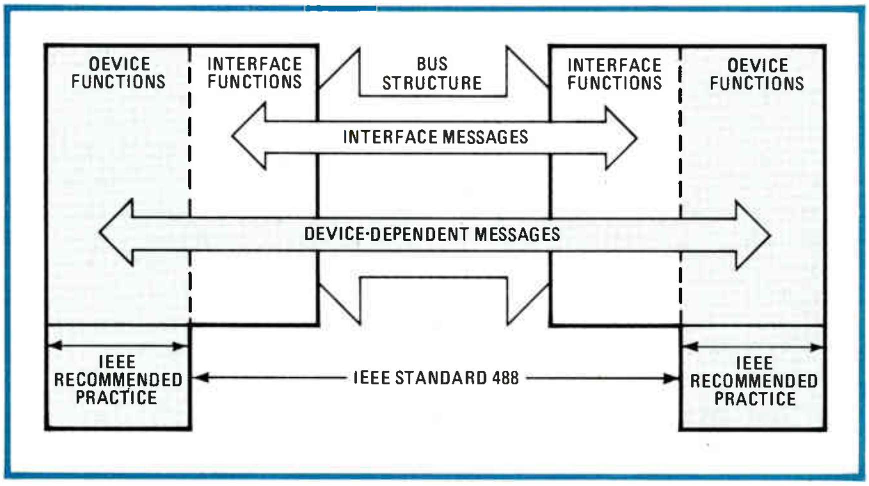
As alternatives, one or three alphabetical characters are allowed, as are letters plus spaces and letters, spaces, and special characters. The special character set excludes plus and minus signs, the decimal, the comma, and alphanumerics in order to avoid confusion with other fields. Headers are required for program, or control, statements but are optional for measurement statements.

To clarify the alternatives it presents, the document uses a special form of diagram called a syntax diagram. The one illustrated on page 88 represents one of the three allowable types of numeric fields.

The proposal recognizes all three types of numeric field representation as preferred: fixed field or implicit point (NR1), floating point (NR2), and exponential (NR3). In each type of representation, the use of spaces is again disdained but not disallowed; the use of a plus sign for positive quantities is preferred, but optional, whereas the use of a minus sign on a zero value is disallowed. If exponential notation is used, the practice recommends that the exponents used be multiples of 3 with the mantissa adjusted accordingly.

Suffix or not. The designer is also given the option of attaching a suffix to any of the three numeric formats when specifying program data only. The suffix, expressed as alphabetical characters, specifies a range multiplier in units such as megahertz or kilovolts.

One recommendation that may



Extending route. Recommended practice will take instrument bus into new territory. IEEE 488 clearly mapped interface operation; new practice is for device-dependent functions.

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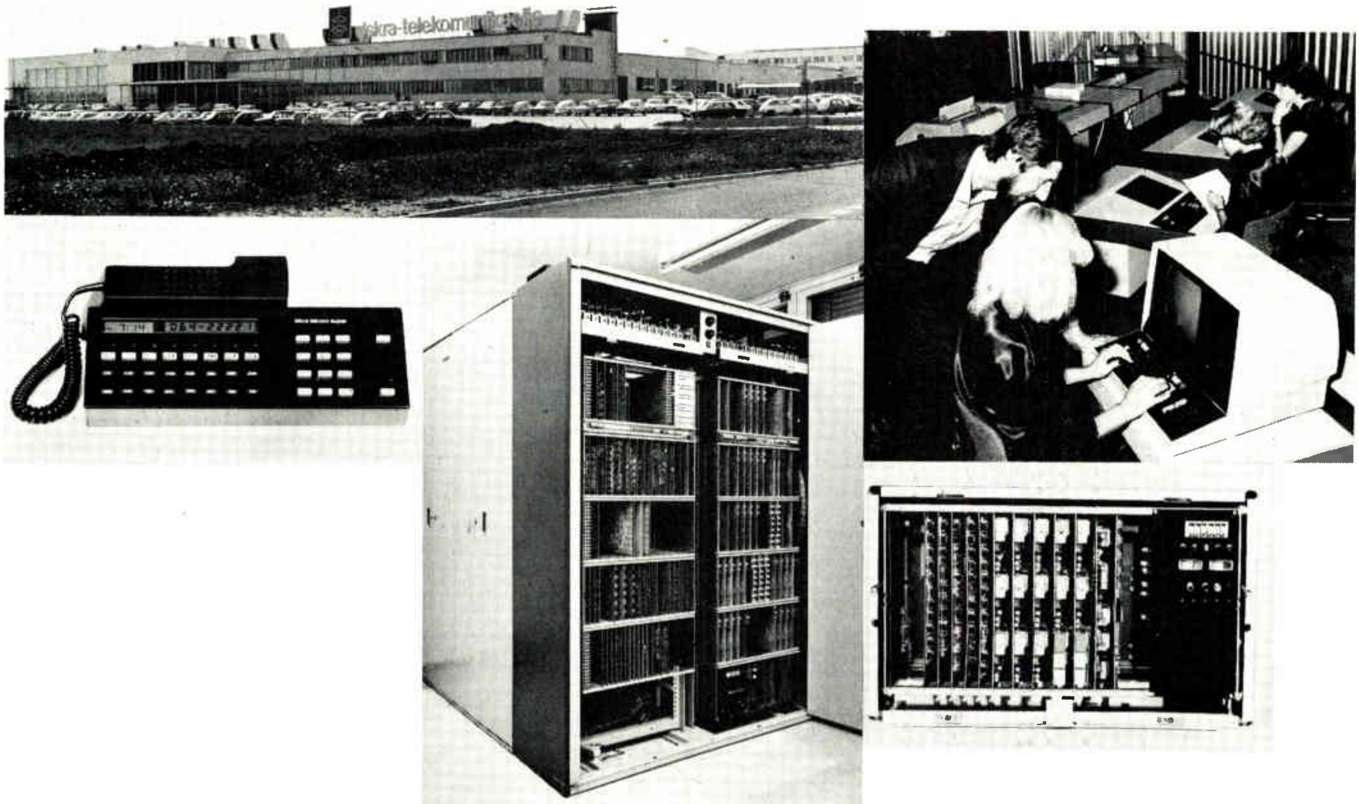

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Iskra

Probing the news

prove internationally significant is the use of the decimal point as a radix. To Americans who are accustomed to its use this may seem trivial, but Europeans have commonly used the comma as a radix point and the decimal as a separator. Thus this recommendation represents a major agreement between the two continents, one that may eventually unify notation in engineering.

Having designated the decimal point as a radix, the proposal goes on to define the comma as the preferred intrarecord separator (SR1), with the semicolon as an alternative. SR1 is used to separate individual measurements in a set and does not take the instrument out of the talker-active state, TACS. A separator is required for a measurement statement but is optional for a control statement.

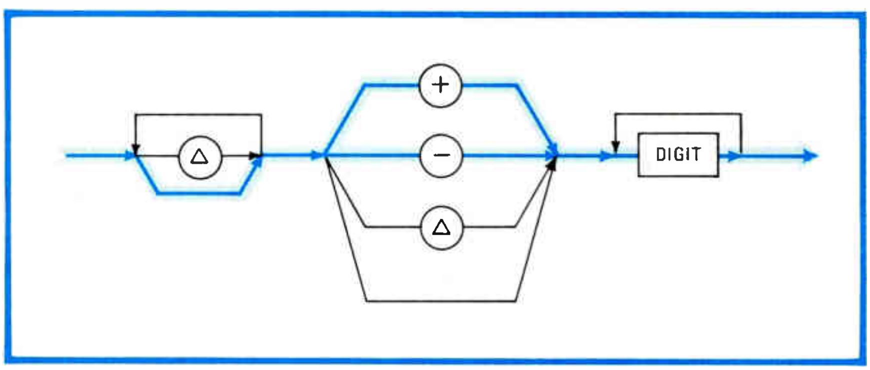
Separated sets. Sets of measurements are separated by an SR2 delimiter, which can be either a carriage-return (CR) followed by a line-feed (LF) character or simply a new-line (NL) character. Both are given equal preference in the document, and the ASCII code for LF and NL are identical. When SR2 is used, an instrument can be called on to shift from the TACS state or it may send another series of measurements at a later time without intervening action by either the controller or another device.

With the sending of the SR3 separator, the instrument signals that no more measurements will be forthcoming until it receives another control statement. The preferred SR3 format is an end message sent onto the end-or-identify (EOI) line concurrently with the last data byte in a sequence. Alternative methods are to send the end message concurrently with an NL character or to send a CR followed by the end message concurrently with an LF character.

The definition of the status byte used in serial polling of instrumentation by the controller is further expanded in the proposal. The IEEE-488–1978 states that one and only one status byte will be recieved from each instrument and that bit 7 of that byte is the service request (RQS) channel. The proposal strongly recommends that bit 5 of the status byte be used to signal that the respondent is either busy or ready and that bit 6 indicate whether its status is normal or abonormal. Definition of the remaining bits is left to the designer, but the proposal recommends that bits 1 through 4 be used before bit 8.

The proposal as it now stands represents many hours of dedicated effort by conscientious men. But the question still remains whether it will provide the industry with the guidance it needs now.

Keep it loose. Don Loughry, interface engineer for Hewlett-Packard Co.'s Computer Systems group in Cupertino, Calif., is secretary of the subcommittee that generated the document. He explains that the rationale adopted in generating the document was to provide a generalized format without restricting the designer. "For example," he says, "if we were to say that numerics always have to be sent in exponential form, we would probably make everyone angry." Pointing also to the status byte as an example, he says the



New picture. Syntax diagram, counterpart of 488's state diagram, makes clear the choices of format for a particular data field, NR1. Highlighting is added to show preferred format.

document describes it in such terms to give "as much freedom as possible so that designers can solve problems." He adds that, "though it may not answer all problems, it is a significant increase in the information interchange between manufacturers."

Hugo Draye, product planning manager for control products at John Fluke Manufacturing Co. in Mountlake Terrace, Wash., is also a member of the subcommittee. He agrees with Loughry that the proposal should offer a high degree of freedom for the designer. "At this point," he says, "it is too early to try and firmly fix codes and formats; too much is happening in the design of instrumentation for it to be rigidly tied to specific forms." Like Loughry, he feels that the document should form a basis for growth rather than a hard-and-fast standard.

Not too loose. But Maris Graube, corporate interface engineer for Tektronix Inc. of Beaverton, Ore., another member of the subcommittee, feels that what is needed is firmer direction. "In one respect there is already a *de facto* standard, because people are doing things a standard way and we're simply putting them down on paper." But he also sees some areas that need to be addressed more firmly. Referring to the end message, he says, "You have to have a single, universally agreed-upon convention—for example, about when you execute something after you receive it, since otherwise data can be misinterpreted or acted upon too soon." He suggests that designers adhere as strictly as possible to the preferred options noted in the new practice.

Nelson Urdaneta agrees. As engineering product manager for Racal-Dana Instruments Inc. in Irvine, Calif., he feels that more decisive recommendations are needed. "If you have to make allowance for all possible forms of communication in a design, you may never get a product off the bench," he says. Urdaneta, who has of late been closely involved with implementing bus design, believes that if firm guidelines are not provided, instrument designers will probably come to an agreement on their own, rallying around the strongest proponent. □

Communications

Chip market overestimated, says ITT

One of the biggest potential customers calls maker's figures 'incredibly exaggerated' even under ideal conditions

by Harvey J. Hindin, Communications & Microwave Editor

"Solutions to problems facing telecommunications equipment manufacturers—how to get the results of large-scale integration into their products—will not be forthcoming rapidly from Silicon Valley. This will be especially true when the semiconductor people begin to temper their research and development decisions with a realistic view of the marketplace."

That's the viewpoint of International Telephone and Telegraph Co.'s Tim Smith and Wil Riner. Smith is telecommunications products marketing manager and Riner is director of marketing, sales, and business development at ITT North's Microsystems division in Deerfield Beach, Fla. What's more, says Riner, "incredibly exaggerated estimates of market size for telecommunications chips on the part of some suppliers are only drawing more people into the market and adding to the confusion." He and Smith are referring to such statements as "$1 billion in open market IC sales in five years" and "a market of $450 million to $700 million" or "$100 million market for codecs within a few years."

ITT believes that even if the most optimistic assumptions about the telecommunications market place are made, these market figures cannot be supported in any way. "Suppose," Smith says, that "the entire industry agrees on standard components for the telecommunications line card. This would include codecs, filters, and subscriber-line interface circuits (SLICs). Let's further say that none of the telecommunications manufacturers have decided to use their own captive suppliers for component fabrication." And adding another supposition—that the semiconductor manufacturers have learned the ins and outs of the specialized telecommunications manufacturers and the particular and unique ways they do business—ITT estimates that 4,080,000 total available digital lines (see the table for the central office component of this figure) will be available for digital switching in 1985 to be shared among the erstwhile suppliers.

To support this estimate, ITT points out that the independent estimates achieved by the Yankee Group, a market research firm in Boston, are very similar to theirs. "This is hardly a vast monolithic marketpace," says Riner. In fact, he explains further, there is barely room for more than two suppliers if equal market shares are assumed.

To make matters even worse, on top of the original assumptions it must be remembered that, in the telecommunications world, a custom chip is in actuality the standard approach since typical system architecture varies widely among manufacturers. And, while equal market share is perhaps remotely possible, some telecommunications equipment makers already have "captured" component capability that they will surely utilize.

Possible error. If the market is nowhere near the size that has been mentioned, what can the semiconductor people have in mind? ITT feels that perhaps in some cases the total Bell System has been included in the available market figures. This would be, says Smith, a serious market-research error, since only varying proportions of this market can be expected to be open given the present structure of the industry and regulatory situation. And any

LOCAL CENTRAL OFFICE EQUIPMENT MARKET
(in thousands of lines)

	1980	1982	1985
Total market	9,397	10,051	11,336
analog	8,651	8,248	8,906
digital	746	1,803	2,430
Available market	1,761	2,154	2,848
analog	1,015	351	418
Bell	–	–	–
independent	1,015	351	418
digital	746	1,803	2,430
Bell	200	400	550
independent	546	1,403	1,880

Note: The available market is the entire independent market plus a varying percentage of Bell System market as the less-than-5,000-line digital market becomes accessible to general trade manufacturers between 1980 and 1985.

SOURCE: THE YANKEE GROUP

changes, even if they are made, would take years to implement. Perhaps, ITT feels, the decision to enter the telecommunications marketplace has been based on other strategies. These strategies might include direct line card sales to telephone companies, direct PABX manufacture, or getting into the office-of-the-future business.

Still more problems. Aside from its size, there are several other considerations that are unique to the telecommunications market. An understanding of these factors, says Riner, is critical to gaining a toehold there.

In the first place, the market is conditioned to a second-source approach. There is just too much at stake to take the risk of a product failure due to silicon problems.

Also, it is evolutionary rather than revolutionary: with some exceptions, it can hardly be said to be driven by technology. Myriad regulations govern the use of anything that goes into the system. Typically, new products are tried on a very small scale, evaluated, modified, and then reapplied again on a slightly larger scale. There are many iterations of this process before anything resembling product adoption is seen.

Related to the evolutionary nature of the market is the fact that most LSI applications in telecommunications—unlike other markets—must interface with an existing system that has evolved over generations.

And, finally, ITT claims that premature product offerings, which Silicon Valley has often been accused of, are not well received in the telecommunications market. Such techniques, says Smith, which have been used in the data-processing and consumer markets, will only destroy product and technology credibility.

Hard-to-find specs. A major difficulty that would-be suppliers of telecommunications chips face is determining just what the industry needs. It is difficult to ferret out the needed information for codecs, for example, as well as other chips, say Smith and Riner.

Echoing this viewpoint is Christopher Bailey, marketing and applications director of Mitel Semiconductor Corp., Ottawa, Ont., Canada. Mitel manufactures both the semiconductor chips and telecommunications equipment. One of the problems, Bailey says, is that typically the codec is just one part of an elaborate system that has an overall system specification budget. "So just what the codec needs to do is not always clear or even well definable. There are lots of tradeoffs to be made."

The semiconductor houses have learned this to a large extent and have hired, or are trying to hire, engineers with inside knowledge of the telephone industry. Those that have succeeded have made it well known to the telecommunications equipment manufacturers.

Another big problem for Silicon Valley is test software and specialized equipment for hardware test. Again this requires not only major investments in material, but in skilled personnel who are in short supply.

Lots of bucks. If a dollar value is assigned to the codecs, SLICs, filters, and few discrete components that go into the 4-million-line market, a $50 million total value is estimated by ITT for the available U. S. market. That is hardly the stuff of which fortunes are made. And, of course, by 1985 the telecommunications industry may well see excellent filters and codecs combined on one chip as well as other developments, thus reducing this figure even further, say Smith and Riner.

If the U. S. market for these chips is small, the worldwide situation is even worse, says ITT. In France, for example, less than 30% of the population even has a telephone. The figure is somewhat higher in West Germany, but even that is still not at U. S. levels.

As for the Third World, that is a big if: no one knows the size of that market. In Brazil, the biggest South American market, LM Ericsson of Sweden seems to have the inside track with the telephone industry.

Finally, there is Japan, and the difficulties of selling into that market—though not impossible to overcome—are well known. ITT has already gotten a foot in the door and supplies Oki Electric with tone receivers. □

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Automotive electronics

Detroit wants higher quality

Semiconductor makers agree that added costs will be repaid in better processes and production for other products

by Larry Marion, Chicago bureau manager

The medicine is expensive and tastes terrible, but the domestic semiconductor manufacturers are almost eager to swallow the castor oil treatment prescribed by their Detroit customers. To improve their quality image relative to offshore auto makers, the domestic giants now insist on higher quality electronic components to make auto electronic systems more reliable than military or aerospace hardware.

All sides agree that, in the long run, fewer returns or field repairs will more than compensate for higher initial chip costs due to upgraded semiconductor fabrication processes, housekeeping, and material controls. While device makers say the improvements are costly and tie up valuable engineering manpower, they concede that all the electronics industries will profit from the pressure from Detroit. Explains Frank Schneider, vice president of the automotive division of Signetics Corp. in Sunnyvale, Calif., "The production changes we made to accommodate the automakers will improve other Signetics products, though it's hard to measure the benefits." Another supplier notes that the improved quality of power transistors used in industrial applications is directly traceable to pressure from Detroit.

About $1 billion in electronic components for the 1981 cars will soon be shipped to General Motors Corp., Ford Motor Co., and Chrysler Corp., and they will feature higher quality levels than ever But auto makers are not yet satisfied and are shooting for more than an order of magnitude improvement from the new level: 200 part failures per million pieces of delivered components is the mid-1980s goal at GM, while Ford expects to halve the 0.1% level within three years.

Acceptable quality levels of incoming parts over the past few years have ranged from four failures per hundred to the current 0.1%, to the dismay of auto makers. "We can't stomach the wide range of failure rates," notes Jerome G. Rivard, chief engineer for Ford's Electrical and Electronics division, Dearborn, Mich., because of disrupted production schedules and the duplicated testing and inspection costs when the buyer must check vendor screening.

The problems are not isolated to a few manufacturers or a handful of special items: "We've gotten some huge headaches from major suppliers" over delayed shipments due to poor quality, he notes.

Weak die or wire bonds and lack of oxide integrity are the kinds of problems that frustrate assembly operations at GM's Delco Electronics division, Kokomo, Ind. Contamination during wafer processing plagues the suppliers too: "We've seen problems with almost every kind of metallic ion," says Frank E. Jaumot Jr., director of advanced engineering at Delco.

Bounties paid. To help their suppliers upgrade product quality, GM and Ford paid bounties to Motorola Inc., Signetics, National Semiconductor Corp., and others, to help them find and correct weak points in the process. Explains Schneider of Signetics, "We found that it was very important to automate much of the production line in order to eliminate human error. We also significantly improved the cleanliness of the manufacturing environment and our materials control." Motorola went the same route, says Joseph Flood, Motorola Semi-

Where GM does its shopping

The biggest of Detroit's Big Three auto makers, General Motors, buys its electronic components through its Delco Electronics division in Kokomo, Ind. For the 1981 model year, Delco is purchasing components for use in radios, engine controls, climate controls, and other electrical/electronic systems like dashboard instrumentation. Also, Delco makes some of its own integrated circuits, such as some microprocessors, based on Motorola designs.

It and other auto makers buy other microprocessors from Motorola, Hitachi, Texas Instruments, Mostek, and Fairchild and low-power Schottky logic from TI, Signetics, National, and Fairchild. They get analog-to-digital converters from National and TI, and bipolar linear circuits from those two, Fairchild, and Signetics. Motorola, RCA, National, and Hitachi supply Detroit with complementary-MOS digital gates. Programmable read-only memories in U. S. cars come from Signetics, Fairchild, and TI; those three along with Motorola and Hitachi supply read-only and random-access memories. Delco will also make its own MOS memories for 1982 models.

conductor Products Group manager of reliability and quality assurance, and, in addition, re-evaluated design margins.

To meet the 0.1% level for the 1981 cars, semiconductor makers shoot for significantly lower failure rates to avoid last-minute problems with the auto makers. For example, Donald L. Denton, Delco division quality assurance manager at Texas Instruments Inc. in Dallas, says its production will have an overall 0.065% failure rate. However, concedes Gene McFarland, assistant vice president and marketing manager for automotive consumer products, TI is not meeting all of the requirements in all types of components at present, particularly the more complex chips.

Language talk. High volume and tight specifications require closely calibrated test instrumentation, and semiconductor makers report extensive discussions with their customers, just trying to talk the same language. "When you're talking about such a small percent [rejection rate], you must have really good electrical correlation between their test machines and ours," says Denton. McFarland reports that up to six weeks is required after start-up to focus on the right test parameters.

Smoothing out the test parameters now is a key factor in the future of the marriage between device makers and auto assemblers—the huge number of integrated circuits ordered by Detroit to meet fuel economy and emission control precludes 100% testing. "Our big hope is to put more of the testing burden on the supplier, because the cost of double inspections is very high," explains Rivard of Ford, and other auto makers share his outlook. To phase out in-house inspections within three years, Ford wants vendors to generate inspection reports and certify that products meet the specifications. Currently, Ford does lot sampling with 100% inspections of lots in which a bad component is found.

Over at GM, large-scale ICs are now undergoing 100% testing, including burn-in at three temperatures. However, notes Robert Costel-

lo, director of purchasing at Delco, "there's not enough inspection equipment in the world to do 100%" of future volume.

If semiconductor makers can deliver the volume and quality levels Detroit wants for the 1981 model year—the year GM converts all of its annual production of 5 million cars to microprocessor-based engine controls—then auto makers will be a big step closer to dismantling their incoming inspection stations. However, Rivard of Ford and others are not yet convinced that the relationship between the two industries has matured to that level of intimacy.

Time needed. Schneider of Signetics says it will take time, perhaps longer than Ford or GM now envision, for consistent high-quality production to obviate the need for buyers to inspect incoming parts: "This question is analogous to the question of when one stops counting his change in a department store checkout line. Eventually you build up faith in the process and you just pocket the change. We agree with the goal of dropping incoming inspection. When will they be ready?"

In the courtship days between the auto makers and the electronics companies, each side criticized the other for not understanding the existing cost and pricing structures. After a few years of working together, though, buyers and sellers are much closer together. For example, Jaumot of Delco says "We are willing to pay for increased reliability, if we can get it. It is painful to pay for higher-reliability parts, but in the long run it saves us money in lower production costs." A Motorola official confirms the new philosophy: "Detroit now does life-cycle costing, and they see that it is worthwhile to pay extra for increased quality."

In fact, Rivard says Ford is willing to pay 10% to 50% more for higher-quality electronic components. Schneider of Signetics notes that going to 0.1% from 1% added about 20% to the cost. "There's no agreement on what is the next step down from the 0.1% level," he says, "but when we get there I suspect the cost factor will become significant." □

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Photovoltaics

MIS spells solar cell hope

Metal-insulator-semiconductor technology should be cheaper than pn junction because it requires less processing

by Martin Marshall, San Francisco regional bureau

Metal-insulator-semiconductor technology is generating some excitement in the solar-energy field. Although there are still major questions on MIS's adaptability to production and its field reliability, it may become the solar-cell technology of the late 1980s.

That possibility rests upon the fact that there are fewer manufacturing steps involved in MIS technology than in pn junction technology, and thus it should be cheaper to produce. In fact, the formation of a pn junction is itself eliminated, because the metal on silicon forms the needed barrier.

"Theoretically, MIS technology should have an advantage over pn junction technology when thin-film polycrystalline material or amorphous thin-film silicon is used," notes Kris Koliwad, manager of technical development for the low-cost solar array project at the Jet Propulsion Laboratory in Pasadena, Calif. "That is because pn junction technology is not easily adaptable to thin films. We don't even know how to dope pn junctions in amorphous silicon."

Since polycrystalline and amorphous silicon are the cheapest forms of silicon for solar cells, coupling these materials with the fewer manufacturing steps involved in MIS technology seems all the more promising. Koliwad hastens to add, however, that it will be at least 1986 before MIS has passed even the intermediate reliability benchmarks.

Others are hoping that the timetable can be accelerated. Rajendra Singh of Colorado State University in Fort Collins points out that the MIS technique is not new. "These are the same techniques used in metal-nitride-oxide-semiconductor memory devices today," he notes. "The difference in photovoltaics is the thickness of the oxide layer."

Key to the sample MIS cell shown in the figure is the growth of a silicon-dioxide layer over the doped polysilicon substrate, followed by deposition of a semitransparent chromium layer. These ultrathin layers become a Schottky barrier junction and are topped with a copper layer reducing device resistivity, a chromium oxidation barrier, an aluminium grid, and a silicon dioxide antireflective coating.

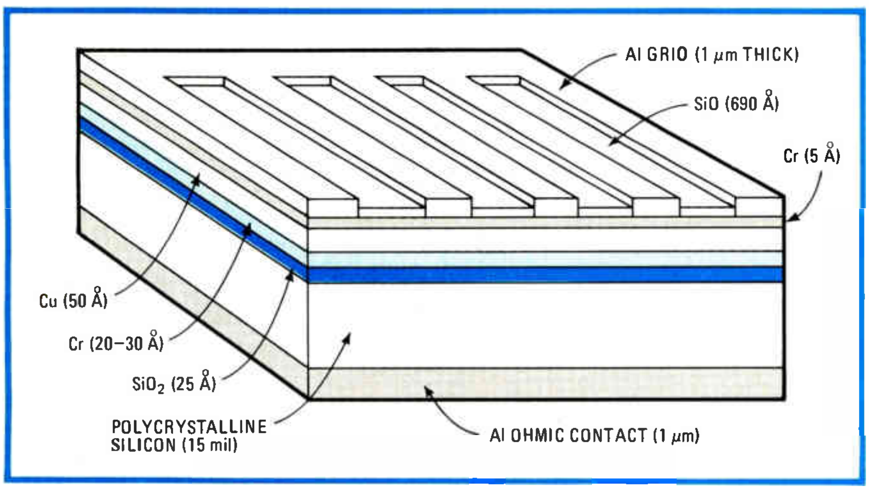
Efficiencies. So far, the best MIS solar-cell efficiency obtained has been an impressive 17.6% (peak watt) obtained by Martin Green of the University of New South Wales, Australia. This cell, however, used a very fine grid layer and single-crystal silicon, both considered too expensive for mass production.

A more practical result is the efficiency of 9% (peak watt) obtained on polycrystalline silicon by Wayne Anderson of the State University of New York at Buffalo. This result approaches the 10% to 11% efficiency targeted by the Department of Energy for 1985 solar cells.

A proposed automated factory geared toward the production of MIS photovoltaic cells may help them meet the DOE's 1985 cost target. The detailed proposal is based upon the Jet Propulsion Laboratory's modeling program for solar-array-manufacturing industrial costing standards (Samics). Singh and his co-workers presented it last month at the Miami International Conference on Alternative Energy Sources.

"From a fabrication point of view, the structure is one of the simplest possible with a minimum of steps involved," asserts Singh. "It has six steps, instead of the eight to ten for conventional pn processes."

Questions. Two dark clouds hang over this rosy picture of future MIS



Metal's the key. In an MIS solar cell, successive layers of silicon dioxide and metal form a Schottky barrier junction, giving a strong inversion at the base-semiconductor interface.

photovoltaics. One is the delicacy of processing and handling the cells. "Since these are surface-type devices, the applications of the metallization layer to the cells—and especially applying the interconnections between the cells—is a very tricky process," explains JPL staff scientist Richard Stirn. "The cell is also difficult to handle in that we can't weld it and in that it requires low-temperature solder."

The second question is the cells' durability in the field. Atmosphere contaminants such as water vapor, oxygen, and even smog can modify the oxide-semiconductor interface properties. Such contaminants can make the oxide insulator layer grow thicker, thus decreasing light absorption and increasing the series resistance of the layer. This resistance, in turn, progressively decreases the efficiency of the cell.

In defense of the process, Anderson points out that an epoxy-based silver paste has been developed that will cure at low temperatures and that may be used instead of nickel-coated low-temperature solder. He also argues that high-temperature processing costs more.

As for reliability, he notes that "varying reliability results have been obtained, because they depend greatly upon the fabrication techniques. If the proper encapsulation techniques are used, a great many reliability problems are avoided."

He acknowledges, however, that much more study and experimentation is needed before MIS photovoltaic technology can give pn junction technology any real competition.

On this point Koliwad agrees, noting that JPL has set aside MIS photovoltaics because it is concerned with meeting objectives in 1985 and that pn junction technology is far enough along to give hopes of meeting those objectives. He speculates, however, that "in the late 1980s, MIS photovoltaic technology may have passed enough benchmarks to have proven itself reliable. At that time it will be a replacement technology, but it is not worth holding up today's pn junction programs simply for that eventuality." □

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BUW25	NPN	600	400	10	1.5	4/1	0.5	3/0.6	125	TO-3
BUW26	NPN	800	450	10	1.5	4/1	0.5	3/0.6	125	TO-3
BUW32	PNP	500	400	15	1.5	5/1	0.8	5/1	125	TO-3
BUW34	NPN	500	400	15	1.5	5/1	0.8	5/1	125	TO-3
BUW35	NPN	800	400	15	1.5	5/1	0.8	5/1	125	TO-3
BUW36	NPN	900	450	15	1.5	5/1	0.8	5/1	125	TO-3
BUW44	NPN	500	400	30	1.5	10/2	0.8	10/2	175	TO-3
BUW45	NPN	800	400	30	1.5	10/2	0.8	10/2	175	TO-3
BUW46	NPN	900	450	30	1.5	10/2	0.8	10/2	175	TO-3
[illegible]X46	NPN	850	400	5	1.5	2.5/0.5	0.8	2.5/0.5	85	TO-3
[illegible]7	NPN	850	400	12	1.5	6/1.2	0.8	6/1.2	107	TO-3
[illegible]	NPN	850	400	30	1.5	10/2	0.8	10/2	125	TO-3
[illegible]	NPN	800	400	15	1.5	5/1	0.5	5/1	125	TO-3
[illegible]	[illegible]	800	400	8	1.5	2.5/0.5	0.5	2.5/0.5	75	TO-3
[illegible]	[illegible]	750	350	8	3	4/1.25	0.5 typ	4/1.25	60 †	TO-3
[illegible]	[illegible]	[illegible]00	400	8	3	4/1.25	0.5 typ	4/1.25	60 †	TO-3
[illegible]	[illegible]	[illegible]	450	8	3	4/1.25	0.5 typ	4/1.25	60 †	TO-3
BU[illegible]A	[illegible]	[illegible]	400	15	3.3	8/2.5	1	8/2.5	125	TO-3
BU[illegible]B	[illegible]	[illegible]	[illegible]5	15	3.3	8/2.5	1	8/2.5	125	TO-3
BU[illegible]C	[illegible]	[illegible]	[illegible]	15	3.3	8/2.5	1	8/2.5	125	TO-3
[illegible]	[illegible]	[illegible]	[illegible]	10	1	3/0.6	0.8	3/0.6	100	TO-3
2N6543	NPN	[illegible]	[illegible]	10	1	3/0.6	0.8	3/0.6	100	TO-3
2N6544	[illegible]	[illegible]	300	16	1.5	5/1	1	5/1	125	TO-3
2N6545	[illegible]	850	400	16	1.5	5/1	1	5/1	125	TO-3
2N[illegible]	NPN	650	300	30	1.5	10/2	0.7	10/2	175	TO-3
[illegible]	NPN	850	400	30	1.5	10/2	0.7	10/2	175	TO-3

† T_C = 75°C

MULTIEPITAXIAL PLANAR

HIGH CURRENT SWITCHING

TYPE	POLARITY	V_{CBO} (V)	V_{CEO} (V)	I_C (A)	$V_{CE sat}$ max (V) @	I_C (A)	t_f (µs) @	I_C/I_B (A)	P_D(W) @ T_C=25°C	PACKAGE
2N5038	NPN	150	90	20	1	12	0.5	12/1.2	140	TO-3
2N5039	NPN	120	75	20	1	10	0.5	10/1	140	TO-3
2N5671	NPN	120	90	30	0.75	15	0.5	15/1.2	140	TO-3
2N5672	NPN	150	120	30	0.75	15	0.5	15/1.2	140	TO-3
2N6032	NPN	120	90	50	1.3	50	0.5	50/5	140	TO-3*
2N6033	NPN	150	120	40	1	40	0.5	40/4	140	TO-3*
2N6354	NPN	150	120	10	1	10	0.2	5/0.5	140	TO-3
2N6496	NPN	150	110	15	1	8	0.5	8/0.8	140	TO-3
BUR20	NPN	160	125	50	1.2	50	0.3	50/5	200	TO-3*
BUR21	NPN	250	200	40	1.5	25	0.4	25/3	200	TO-3*
BUR22	NPN	300	250	40	1.5	20	0.5	20/2.5	200	TO-3*
BUR50	NPN	160	125	70	1.5	70	0.7	70/7	350	TO-3*
BUR51	NPN	250	200	60	1.5	50	0.6	50/5	350	TO-3*
BUR52	NPN	300	250	60	1.5	40	0.6	40/4	350	TO-3*
BUX10	NPN	160	125	25	1.2	20	0.3	20/2	150	TO-3
BUX11	NPN	250	200	20	1.5	12	0.4	12/1.5	150	TO-3
BUX11N	NPN	220	160	20	1.5	15	0.5	15/1.88	150	TO-3
BUX12	NPN	300	250	20	1.5	10	0.5	10/1.25	150	TO-3
BUX40	NPN	160	125	20	1.6	15	0.4	15/1.88	120	TO-3
BUX41	NPN	250	200	15	1.6	8	0.8	8/1	120	TO-3
BUX41N	NPN	220	160	18	1.6	12	0.8	12/1.5	120	TO-3
BUX42	NPN	300	250	12	1.6	6	1.2	6/0.75	120	TO-3

* These transistors are in a modified TO-3 package with a special thick flage and thick copper pins

MULTIEPITAXIAL H.V.

DARLINGTONS

HIGH VOLTAGE HIGH POWER SWITCHING

TYPE	POLARITY	V_{CBO}	V_{CEO}	I_{CM}	V_{CEsat} @	I_C/I_B	t_f typ	P	PACKAGE
BU910	NPN	400	350	8	1.8	2.5/0.05	—	75	TO-220
BU911	NPN	450	400	8	1.8	2.5/0.05	—	75	TO-220
BU912	NPN	500	450	8	1.8	2.5/0.05	—	75	TO-220
BU920	NPN	400	350	15	1.8	7/0.14	—	125	TO-3
BU921	NPN	450	400	15	1.8	7/0.14	—	125	TO-3
BU922	NPN	500	450	15	1.8	7/0.14	—	125	TO-3
BU930	NPN	400	350	20	1.8	10/0.300	—	150	TO-3
BU931	NPN	450	400	20	1.8	10/0.3	—	150	TO-3
BU932	NPN	500	450	20	1.8	10/0.3	—	150	TO-3

2N4895	NPN	120	60	5	40	1★	2	50	7	TO-39
2N4896	NPN	120	60	5	100	1★	2	80	7	TO-39
2N4897	NPN	150	80	5	40	1★	2	50	7	TO-39
2N4898	PNP	40	40	4	10□	0.6	1	3	25	TO-66
2N4899	PNP	60	60	4	10□	0.6	1	3	25	TO-66
2N4900	PNP	80	80	4	10□	0.6	1	3	25	TO-66
2N4910	NPN	40	40	4	10□	0.6	1	3	25	TO-66
2N4911	NPN	60	60	4	10□	0.6	1	3	25	TO-66
2N4912	NPN	80	80	4	10□	0.6	1	3	25	TO-66
2N5151	PNP	100	80	5	20	1.5	5	—	10	TO-39
2N5152	NPN	100	80	5	20	1.5	5	—	10	TO-39
2N5153	PNP	100	80	5	40	1.5	5	—	10	TO-39
2N5154	NPN	100	80	5	40	1.5	5	—	10	TO-39
2N5336	NPN	80	80	5	20	1.2	5	30	6	TO-39
2N5337	NPN	80	80	5	40	1.2	5	30	6	TO-39
2N5338	NPN	100	100	5	20	1.2	2	30	6	TO-39
2N5339	NPN	100	100	5	40	1.2	2	30	6	TO-39
2N5415	PNP	200	200	1	30	2.5	0.05	—	10	TO-39
2N5416	PNP	350	300	1	30	2	0.05	—	10	TO-39
2N5427	NPN	80	80	7	30	0.7	2	30	40	TO-66
2N5428	NPN	80	80	7	60	0.7	2	30	40	TO-66
2N5429	NPN	100	100	7	30	0.7	2	30	40	TO-66
2N5430	NPN	100	100	7	60	0.7	2	30	40	TO-66
2N5679	PNP	100	100	1	40	0.6	0.25	30	10	TO-39
2N5680	PNP	120	120	1	40	0.6	0.25	30	10	TO-39
2N5681	NPN	100	100	1	40	0.6	0.25	30	10	TO-39
2N5682	NPN	120	120	1	40	0.6	0.25	30	10	TO-39

☆ I_C = 50mA °T_C = 50°C † I_C = 0.5A • I_C = 0.25A

□ V_{CE} = 1V ★ I_C = 5A ■ I_C = 2A

• I_C = 20 mA.

EPITAXIAL PLANAR

HIGH VOLTAGE SWITCHING

TYPE	POLARITY	V_{CBO} (V)	V_{CEO} (V)	I_{CM} (A)	$V_{CE sat}$ max (V) @	I_C/I_B (A)	• t_f max (µs) @	I_C/I_B (A)	P_D(W) @ T_C=25°C	PACKAGE
BU406	NPN	400	200	10	1	5/0.5	0.75	5/0.5	60	TO-220
BU406D	NPN	400	—	10	1	5/0.65	0.75	5/0.65	60	TO-220
BU406H	NPN	400	200	10	1	5/0.8	0.4	5/0.8	60	TO-220
BU407	NPN	330	150	10	1	5/0.5	0.75	5/0.5	60	TO-220
BU407D	NPN	330	—	10	1	5/0.65	0.75	5/0.65	60	TO-220
BU407H	NPN	330	150	10	1	5/0.8	0.4	5/0.8	60	TO-220
BU408	NPN	400	200	10	1	6/1.2	0.4	6/1.2	60	TO-220
BU408D	NPN	400	—	10	1	6/1.2	0.5	6/1.2	60	TO-220
BU409	NPN	250	150	7	1	3/0.4	—	—	60	TO-220
BU606	NPN	400	200	10	1	5/0.5	0.75	5/0.5	90	TO-3
BU606D	NPN	400	—	10	1	5/0.65	0.75	5/0.65	90	TO-3
BU607	NPN	330	200	10	1	5/0.5	0.75	5/0.5	90	TO-3
BU607D	NPN	330	—	10	1	5/0.65	0.75	5/0.65	90	TO-3
BU608	NPN	400	200	10	1	6/1.2	0.4	6/1.2	90	TO-3
BU608D	NPN	400	—	10	1	6/1.2	0.5	6/1.2	90	TO-3
BUY18S	NPN	400	200	10	1	5/0.5	1	5/0.5	50☆	TO-3
BU806*	NPN	400	200	15	1.5	5/0.05	1	5/0.05	60	TO-220
BU807*	NPN	330	150	15	1.5	5/0.05	1	5/0.05	60	TO-220
BUW66*	NPN	400	200	15	2.5	10/0.25	0.2 typ	5/0.05	90	TO-3
BUW67*	NPN	330	200	15	2.5	10/0.25	0.2 typ	5/0.05	90	TO-3

D = Integrated damper diode ☆ T_C = 75°C • t_{off} only for TV horiz. deflection

* Fast darlington with integrated speed-up diode

2N6122	2N6125	60	60	4	25	0.6	1.5	40	TO-220
2N6123	2N6126	80	80	4	20	0.6	1.5	40	TO-220
2N6288	2N6111	40	30	7	30	1	3	40	TO-220
2N6290	2N6109	60	50	7	30	1	2.5	40	TO-220
2N6292	2N6107	80	70	7	30	1	2	40	TO-220

°I_C = 5A

EPITAXIAL BASE

DARLINGTONS

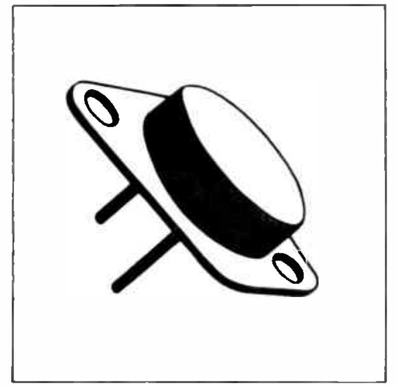
LINEAR AND SWITCHING APPLICATIONS

TYPE NPN	PNP	V_{CBO} (V)	V_{CEO} (V)	I_C (A)	h_{FE} min and	$V_{CE sat}$ max (V) @	I_C (A)	P_D(W) @ T_C=25°C	PACKAGE
BD675A	BD676A	45	45	4	750	2.8	2	40	TO-126
BD677	BD678	60	60	4	750	2.5	1.5	40	TO-126
BD677A	BD678A	60	60	4	750	2.8	2	40	TO-126
BD679	BD680	80	80	4	750	2.5	1.5	40	TO-126
BD679A	BD680A	80	80	4	750	2.8	2	40	TO-126
BD681	BD682	100	100	4	750	2.5	1.5	40	TO-126
BDW23	BDW24	45	45	6	750	2	2	50	TO-220
BDW23A	BDW24A	60	60	6	750	2	2	50	TO-220
BDW23B	BDW24B	80	80	6	750	2	2	50	TO-220
BDW23C	BDW24C	100	100	6	750	2	2	50	TO-220
BDW93	BDW94	45	45	12	750	2	5	80	TO-220
BDW93A	BDW94A	60	60	12	750	2	5	80	TO-220
BDW93B	BDW94B	80	80	12	750	2	5	80	TO-220
BDW93C	BDW94C	100	100	12	750	2	5	80	TO-220
BDX53	BDX54	45	45	8	750	2	3	60	TO-220
BDX53A	BDX54A	60	60	8	750	2	3	60	TO-220
BDX53B	BDX54B	80	80	8	750	2	3	60	TO-220
BDX53C	BDX54C	100	100	8	750	2	3	60	TO-220
BDX85	BDX86	45	45	10	750	2	4	100	TO-3
BDX85A	BDX86A	60	60	10	750	2	4	100	TO-3
BDX85B	BDX86B	80	80	10	750	2	4	100	TO-3
BDX85C	BDX86C	100	100	10	750	2	4	100	TO-3
BDX87	BDX88	45	45	12	750	2	6	120	TO-3
BDX87A	BDX88A	60	60	12	750	2	6	120	TO-3
BDX87B	BDX88B	80	80	12	750	2	6	120	TO-3
BDX87C	BDX88C	100	100	12	750	2	6	120	TO-3
MJ1000	MJ900	60	60	8	1000	2	3	90	TO-3
MJ1001	MJ901	80	80	8	1000	2	3	90	TO-3
MJ3000	MJ2500	60	60	10	1000	2	5	150	TO-3
MJ3001	MJ2501	80	80	10	1000	2	5	150	TO-3
MJE800	MJE700	60	60	4	750	2.5	1.5	40	TO-126
MJE801	MJE701	60	60	4	750	2.8	2	40	TO-126
MJE802	MJE702	80	80	4	750	2.5	1.5	40	TO-126
MJE803	MJE703	80	80	4	750	2.8	2	40	TO-126
2N6037	2N6034	40	40	4	750	2	2	40	TO-126
2N6038	2N6035	60	60	4	750	2	2	40	TO-126
2N6039	2N6036	80	80	4	750	2	2	40	TO-126
2N6055	2N6053	60	60	8	750	2	4	100	TO-3
2N6056	2N6054	80	80	8	750	2	4	100	TO-3
2N6057	2N6050	60	60	12	750	2	6	150	TO-3
2N6058	2N6051	80	80	12	750	2	6	150	TO-3
2N6059	2N6052	100	100	12	750	2	6	150	TO-3

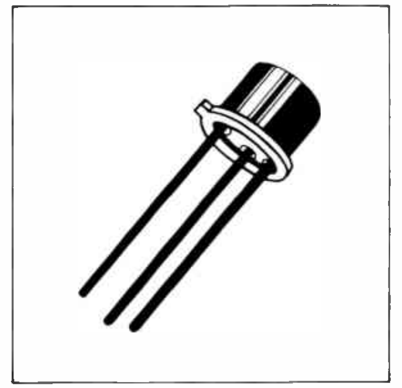
DIMENSIONS OF PERFECTION IN THE UNIVERSE OF POWER

SGS ATES

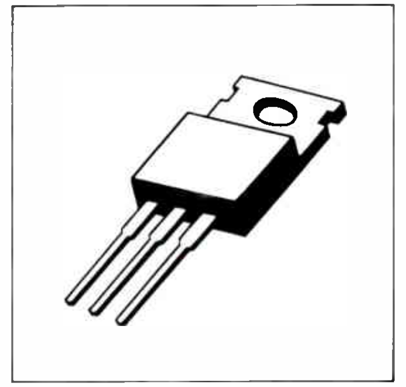
PACKAGES & TECHNOLOGIES



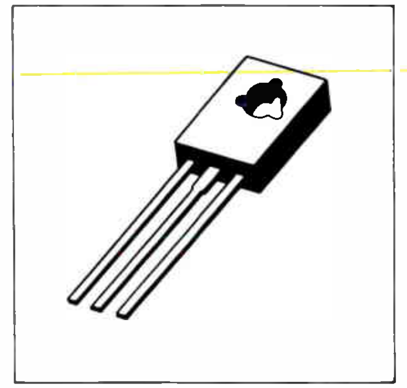
TO-3



TO-39

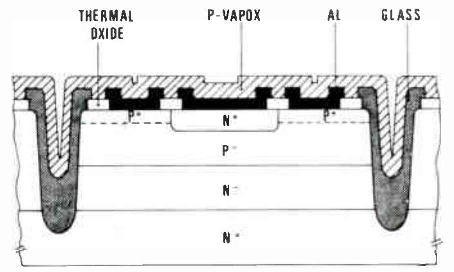


TO-220



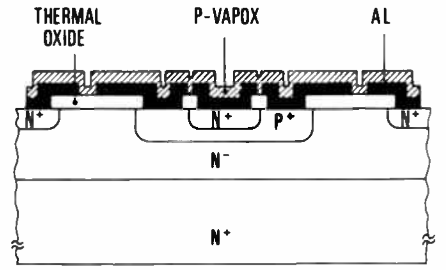
TO-126

EPITAXIAL BASE



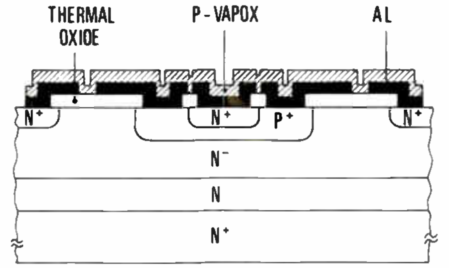
NPN and PNP types
(perfect complementary pairs)
Medium V_{CEO} range (22 to 100 V)
Medium switching speed
Medium f_T (2 to 20 MHz)
High ruggedness
Monolithic Darlington capability

EPITAXIAL PLANAR



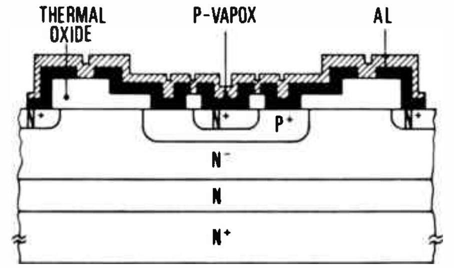
NPN and PNP types
Good voltage capability (V_{CES} up to 400 V)
Low saturation voltage
Low leakage
Very high f_T (up to 100 MHz)
Very high speed
Moderate ruggedness
Total base-collector passivation

MULTIEPITAXIAL PLANAR



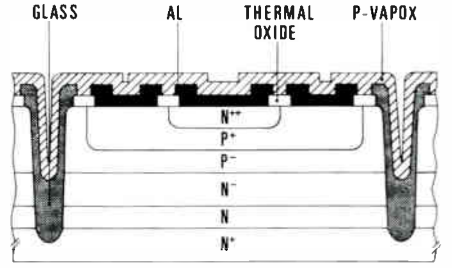
NPN and PNP types
I_C range up to 70 A
Good h_{FE} linearity
Very low leakage
High switching speed
High $E_{s/b}$ capability
Total base-collector passivation

MULTIEPITAXIAL BIPLANAR®



NPN only
High voltage ($V_{CES} = 400$ to 800 V)
Low leakage
Good ruggedness
High switching speed
Total base-collector passivation
Very high stability at high
temperature and high voltage

MULTIEPITAXIAL MESA



NPN and PNP types
High voltage (V_{CBO} up to 2000 V)
High power
Very good $I_{s/b}$ and $E_{s/b}$ performance
High switching speed
High f_T (20 MHz)
Good stability

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POWER FROM SGS-ATES

EPITAXIAL PLANAR

SWITCHING APPLICATIONS

TYPE	POLARITY	V_{CBO} (V)	V_{CEO} (V)	I_C (A)	h_{FE} min	and $V_{CE\,sat}$ max (V)	@ I_C (A)	f_T typ (MHz)	P_D(W) @ T_C=25°C	PACKAGE
BDY90	NPN	120	100	10	20	1.5	10	70	60	TO-3
BDY91	NPN	100	80	10	20	1.5	10	70	60	TO-3
BDY92	NPN	80	60	10	20	1	10	70	60	TO-3
BFX34	NPN	120	60	5	40■	1	5	100	5	TO-39
BSS44	PNP	65	60	5	45 typ	1	5	70	5	TO-39
BSW67	NPN	120	120	2	15	1.5	1	80	5	TO-39
BSW68	NPN	150	150	2	15	1.5	1	80	5	TO-39
BU100A	NPN	150	100	10	40 typ	1.5	5	100	62	TO-3
BU125	NPN	130	60	5	15	1	5	100	7	TO-39
BU125S	NPN	250	150	3	30•	1.5	0.5	15	10°	TO-39
BUX77	NPN	100	80	5	30	1	5	15	40	TO-66
BUX78	PNP	100	80	5	30	1	5	15	40	TO-66
BUY24	NPN	120	60	5	40■	1	5	100	25	TO-3
BUY47	NPN	150	120	10	15	1	5	90	7	TO-39
BUY48	NPN	200	170	10	15	1	5	90	7	TO-39
BUY49S	NPN	250	200	3	40	1.1	0.5	50	10°	TO-39
BUY68	NPN	100	60	5	20	1	5	50	7	TO-39
2N3418	NPN	85	60	3	15	0.5	2	40	15°	TO-39
2N3419	NPN	125	80	3	15	0.5	2	40	15°	TO-39
2N3420	NPN	85	60	3	30	0.5	2	40	15°	TO-39
2N3421	NPN	125	80	3	30	0.5	2	40	15°	TO-39
2N3439	NPN	450	300	1	40*	0.5	0.05	15	5	TO-39
2N3440	NPN	350	250	1	40*	0.5	0.05	15	5	TO-39
2N3440S	NPN	300	250	1	40	0.5☆	0.02	—	10	TO-39
2N3867	PNP	40	40	3	25	0.5†	2.5	60	6	TO-39
2N3868	PNP	60	60	3	20	0.5†	2.5	60	6	TO-39
2N4150	NPN	100	80	10	40	0.6·	5	50	10	TO-39
2N4234	PNP	40	40	3	10□	0.6	1	3	6	TO-39
2N4235	PNP	60	60	3	10□	0.6	1	3	6	TO-39
2N4236	PNP	80	80	3	10□	0.6	1	3	6	TO-39
2N4237	NPN	40	40	3	15□	0.6	1	2	6	TO-39
2N4238	NPN	60	60	3	15□	0.6	1	2	6	TO-39
2N4239	NPN	80	80	3	15□	0.6	1	2	6	TO-39

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TRANSISTORS

LINEAR AND SWITCHING APPLICATIONS

TYPE NPN	PNP	V_{CBO} (V)	V_{CEO} (V)	I_C (A)	h_{FE} min	and $V_{CE\,sat}$ max (V)	@ I_C (A)	P_D(W) @ T_C=25°C	PACKAGE
BD135	BD136	45	45	1.5	25	0.5	0.5	10	TO-126
BD137	BD138	60	60	1.5	25	0.5	0.5	10	TO-126
BD139	BD140	80	80	1.5	25	0.5	0.5	10	TO-126
BD175	BD176	45	45	3	15	0.8	1	30	TO-126
BD177	BD178	60	60	3	15	0.8	1	30	TO-126
BD179	BD180	80	80	3	15	0.8	1	30	TO-126
BD233	BD234	45	45	2	25	0.6	1	25	TO-126
BD235	BD236	60	60	2	25	0.6	1	25	TO-126
BD237	BD238	80	80	2	25	0.6	1	25	TO-126
BD375	BD376	50	45	2	20	1	1	25	TO-126
BD377	BD378	75	60	2	20	1	1	25	TO-126
BD379	BD380	100	80	2	20	1	1	25	TO-126
BD433	BD434	22	22	4	50	0.5	2	36	TO-126
BD435	BD436	32	32	4	50	0.5	2	36	TO-126
BD437	BD438	46	45	4	40	0.6	2	36	TO-126
BD439	BD440	60	60	4	25	0.8	2	36	TO-126
BD441	BD442	80	80	4	15	0.8	2	36	TO-126
BD533	BD534	45	45	8	25	0.8	2	50	TO-220
BD535	BD536	60	60	8	25	0.8	2	50	TO-220
BD537	BD538	80	80	8	15	0.8	2	50	TO-220
BD663	BD664	45	45	10	20	1	2	75	TO-220
BD705	BD706	45	45	12	20	1	4	75	TO-220
BD707	BD708	60	60	12	15	1	4	75	TO-220
BD709	BD710	80	80	12	15	1	4	75	TO-220
BD711	BD712	100	100	12	15	1	4	75	TO-220
BD905	BD906	45	45	15	15	1	5	90	TO-220
BD907	BD908	60	60	15	15	1	5	90	TO-220
BD909	BD910	80	80	15	15	1	5	90	TO-220
BD911	BD912	100	100	15	15	1	5	90	TO-220
BDW21	BDW22	45	45	10	15	1	4	90	TO-3
BDW21A	BDW22A	60	60	10	15	1	4	9	TO-3
BDW21B	BDW22B	80	80	10	15	1	4	90	TO-3
BDW21C	BDW22C	100	100	10	15	1	4	90	TO-3
BDW51	BDW52	45	45	15	20	1	5	125	TO-3
BDW51A	BDW52A	60	60	15	20	1	5	125	TO-3
BDW51B	BDW52B	80	80	15	20	1	5	125	TO-3
BDW51C	BDW52C	100	100	15	20	1	5	125	TO-3
TIP31	TIP32	40	40	3	10	1.2	3	40	TO-220
TIP31A	TIP32A	60	60	3	10	1.2	3	40	TO-220
TIP31B	TIP32B	80	80	3	10	1.2	3	40	TO-220
TIP31C	TIP32C	100	100	3	10	1.2	3	40	TO-220
2N3055	BDX18	100	60	15	20	1/1.1	4	115	TO-3
2N3713	2N3789	80/60	60	10	15	1°/1	3	150	TO-3
2N3714	2N3790	100/80	80	10	15	1°/1	3	150	TO-3
2N3715	2N3791	80/60	60	10	30	0.8°/1°	3	150	TO-3
2N3716	2N3792	100/80	80	10	30	0.8°/1°	3	150	TO-3
2N5190	2N5193	40	40	4	25	0.6	1.5	40	TO-126
2N5191	2N5194	60	60	4	25	0.6	1.5	40	TO-126
2N5192	2N5195	80	80	4	20	0.6	1.5	40	TO-126
2N5877	2N5875	60	60	10	20	1°	4	150	TO-3
2N5878	2N5876	80	80	10	20	1°	4	150	TO-3
2N6121	2N6124	45	45	4	25	0.6	1.5	40	TO-220

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SGS ATES

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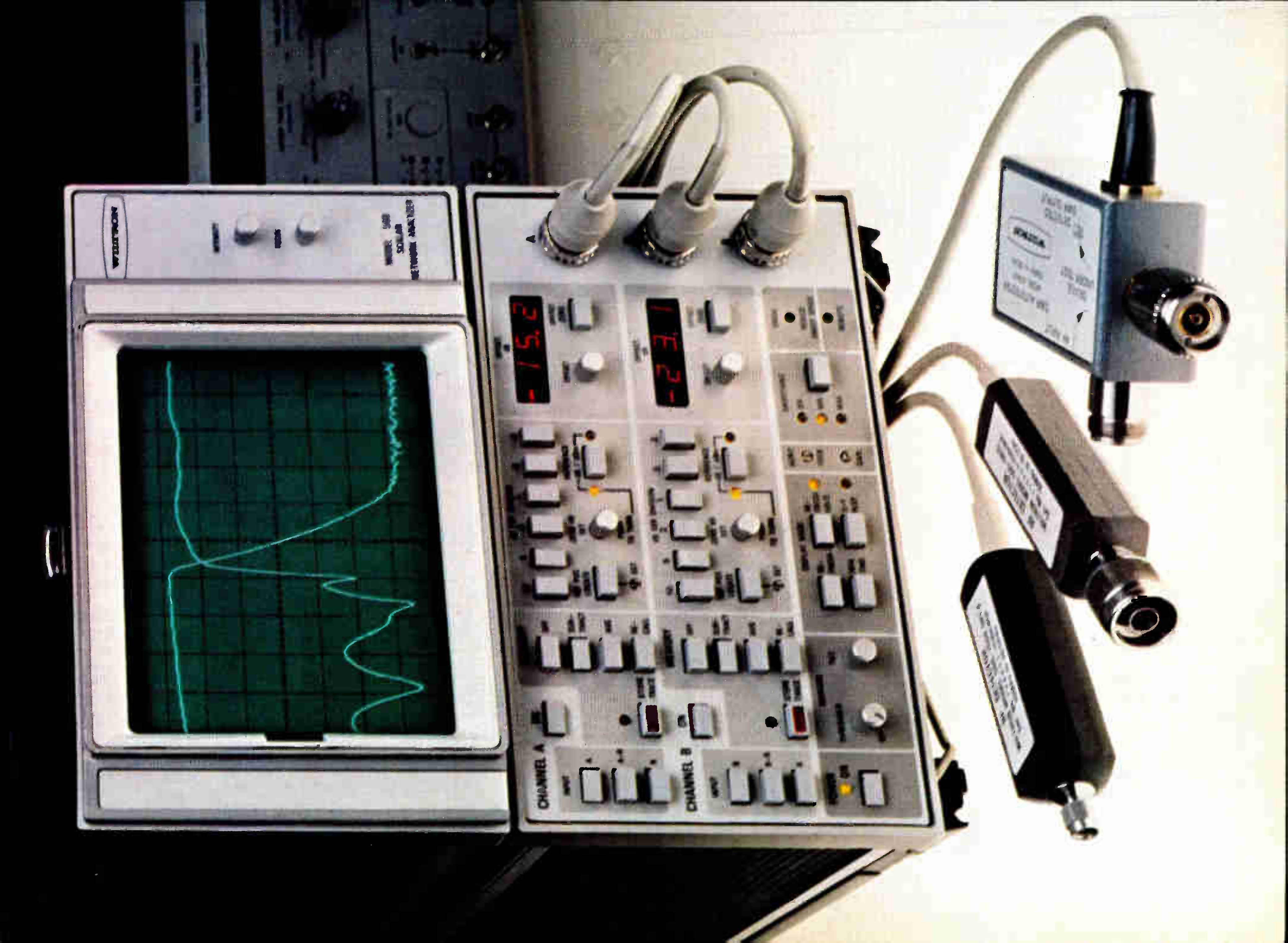
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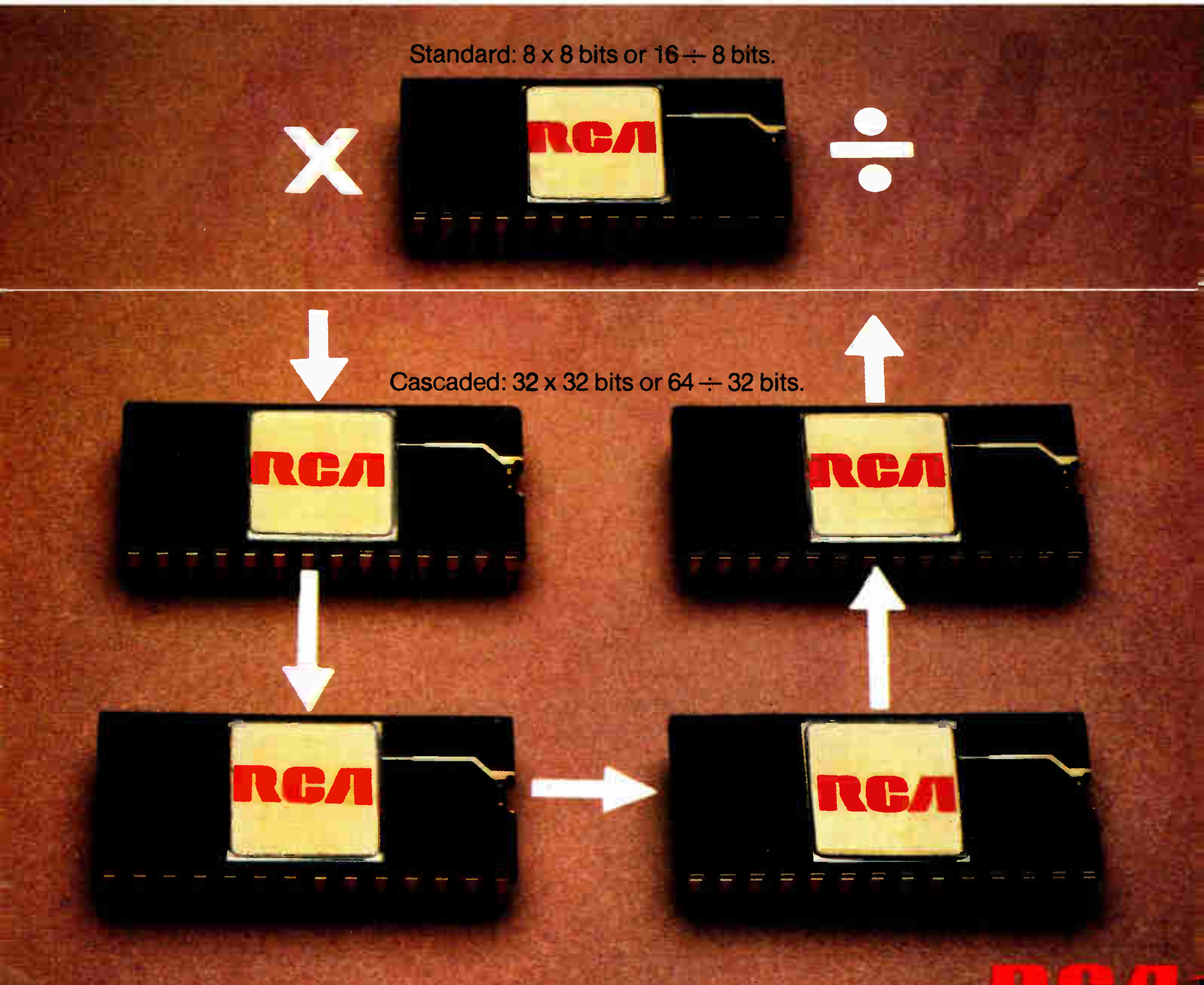
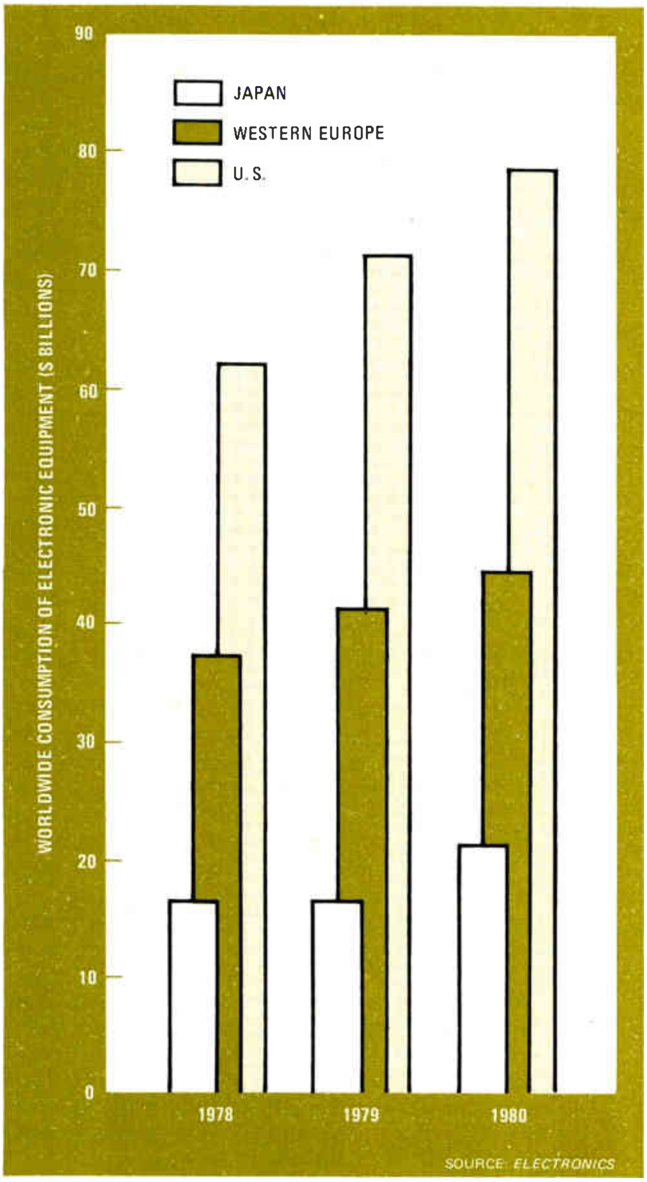


Circle 124 on reader service card

RCA

Market impetus, though slowing, overcomes rocky economies



Closing out a better-than-expected year, the electronics industries of the United States, Western Europe, and Japan entered the new decade in high gear. The slowdown that was supposed to overtake these markets just did not materialize, as total electronic equipment consumption rose 14.1% to $130.7 billion.

This year, however, the growth rate will slow to 10.2%, according to the annual markets survey conducted by *Electronics*. This increase will put total electronic equipment consumption at a little over $144 billion. Individually, the U. S. equipment market will grow by just 10.3% compared with the impressive 16.6% jump last year. Western European countries should fall back to 9.6% growth following an 11.5% increase in 1979. Japan appears to be ahead of the rest in expecting a gain—11.3% for 1980 compared with 10.2% in 1979.

The components markets in the three areas are not quite as healthy-looking as the equipment, according to *Electronics'* figures. At $30.65 billion last year, total components consumption, including semiconductors and passives, was 10.2% ahead of 1978. Growth of 9.8% is expected for 1980.

The reason for the slowdown in electronics consumption is that the general economies of the industrialized nations are stumbling under the burden of inflation and energy costs, already high and still rising. In the U. S., economists spent the year rescheduling the recession until businessmen began to wonder if it was ever coming.

The Wall Street Journal recently summed up this economic confusion with: "Well, now everybody can relax. In the not-so-distinguished view of a majority of often-wrong forecasters, the most widely anticipated slump in U. S. history has—finally—arrived."

Indeed, the indicators are pointing down, with the automobile makers the most concerned. Yet even with the energy crunch and the softening of consumer markets, there is a great deal of momentum in the American economy. In a highly regarded business survey conducted by the National Association of Purchasing Management, 54% of the firms contacted were concerned about the next 12 months, but only 9% were worried or pessimistic. That means that 37% were optimistic, a rather high percentage for the opening of a recession.

The same bullish attitude permeates the electronics industries. Only the consumer sector is hurting, and even within this market there are pockets of prosperity in such areas as video cassette recorders and toys and games.

Computers, communications, and test and measurement instruments all expect double-digit growth this year. Also not to be forgotten is the $22-billion-plus that Uncle Sam will be plowing into electronics. On the whole, as far as U. S. companies go, all slumps should be this bad.

Western European countries are not as sanguine. The general economies of these nations have not been as robust as that of the U. S. during the last decade. The blame rests firmly on the oil shortage, which has not improved despite conservation measures far more stringent than anything the U. S. has considered.

A major bright spot in Europe will be the computer sector. Growth of almost 13% is expected this year. Even in the United Kingdom, where the growth in the Gross National Product is on the minus side, data-processing equipment will enjoy a good year. The European consumer sector, on the other hand, is in for lean times, with only 4.7% growth projected.

As for Japan, its total dependence on imported oil has already produced a flap with the U. S. over the Iranian crisis. That dependence has greatly weakened the economy of the island nation. And with no relief in sight, 1980 looks to be another lackluster year industrially.

Oddly enough, Japan's electronics equipment sector will not only outpoint its GNP—an easy enough task these days—but show a gain over 1979. The reason for this glitch can probably be found in the data-processing sector. Last year computer sales fell short of expectations, gaining only 3.7% instead of the 11.5% predicted. First waiting for the IBM Series 4300 and then adjusting to the price cutting it set off put a dent in the figures. This year data-processing equipment should be back on the track—*Electronics* projects a gain of 10.2%.

Not to be forgotten in the market picture is the rest of the world's consumption of electronic equipment and components. Though much harder to get a handle on than the well-established areas, the figures for countries in Latin America, the Near East, and Asia are encouraging. For example, U. S. officials have estimated that the computers and peripheral equipment market in Argentina will reach $55 million by 1981. Consumption in Australia will top $480 million this year. Minicomputers are growing at 27% annually in Brazil. Even in Taiwan, the minicomputer market is expected to go from $1.7 million in 1977 to $20 million by 1982, whereas peripherals will rise from $12.6 million to $59 million. In Israel, where the demand for data-processing equipment has been increasing by 30% a year since 1977, the figure should be over $110 million this year.

Communications equipment has always enjoyed a solid market in the developing nations. The U. S. State Department estimates, for example, that Brazil will have a market worth $1.7 billion by next year. Algeria plans to spend $1 billion for communications projects over the next five years. Egypt has earmarked $17 billion for communications through 1999. And Venezuela will have a market of about $266.5 million next year.

Estimates for these countries come from International Marketing Opportunities/Electronics, published in 1979 by McGraw-Hill Inc.

U. S. MARKETS

As the decade ended, one recurring question in the U. S. electronics industries was: what happened to the recession? Except for a few soft spots, there was little sign of a decline as total equipment consumption for 1979 jumped almost 17% to $71.55 billion over the previous year.

Now, as the new decade dawns, a second question is: will the recession hit in 1980? The situation is almost a replay of the outlook a year ago—there is enough momentum to carry the industry upward through the first half and maybe even the entire year, despite general economic uncertainties. The annual *Electronics* market survey puts the 1980 equipment total at $78.93 billion, which would be a 10.3% gain over 1979. Total components consumption, including semiconductors and passives, should log $15.87 billion, or a 13.9% growth.

These figures are pretty optimistic in view of the outlook for the general economy. Yes, it is an election year and incumbent presidents running for re-election do not like to send voters to the polls during a slump. Nevertheless, the view at present is rather gloomy.

The McGraw-Hill Economics department predicts that there will be a recession with a decline of real Gross National Product of 1.5%. Making matters worse, the drop in GNP will be accompanied by a predicted inflation rate of 9% and a worsening energy crunch. Thus, with high inflation and high unemployment in the offing, the Carter Administration faces a policy dilemma that, if the past is any guide, will probably be settled on the side of fiscal stimulation at the cost of fueling inflation.

The U. S. economy faces three depressing results of high and rising energy costs coupled with inflation:

- Increased instability in international currency markets, raising the costs of doing business internationally.
- Depressed consumer confidence.
- Raised cost of domestic capital.

All three of these factors will influence the electronics business, slowing somewhat the unexpectedly high growth rate set last year. The bad news is that the problems of high energy costs and inflation are long-term woes inhibiting strong economic recovery. The good news is that the electronics industries seem to be able to handle the downturns and still chalk up decent gains.

So, a third question making the rounds these days goes: are the electronics industries recession-proof? A look at the *Electronics* tables (p. 136) provides an answer of sorts, which is, it depends. Certainly computers, with a growth of 12% expected, communications at 11%, and instruments at 12% are arguments for a recession-proof business. But the consumer sector with no growth, in fact, a loss when inflation is figured, is clearly going to suffer.

Perhaps the best argument for recession-proof industries is the semiconductor sector (p. 134). The memory and logic products that were hot in 1979 are still going strong, with allocations and long lead times more of a factor than economic slowdown. Overall semiconductors will roll along at a 25.7% growth rate this year.

Even the components area has a bright look. According to the *Electronics* survey, components will shrug off most of the effects of the consumer products doldrums and come home w[illegible] a 7.2% increase to $9.50 billion.

Growth despite the recession

No matter what portion of the computer and peripherals industry is examined, the byword for the 1980s is "double digits." The total U. S. market for data-processing and office equipment is the world's largest, topping $26.5 billion in 1979 and expected to reach $45.6 billion by 1983. By far, it is the largest portion of the U. S. electronics markets.

Although the total 1979 figure is up about 29% from the previous year, it is expected to slow down to 14% growth during 1980—not bad for a recession year. Data-processing manufacturers surveyed by *Electronics* do not see the growth falling below double digits between now and 1983, once again enforcing the belief that the industry is somewhat recession-proof.

The 14% growth hides a number of subcategories that will grow at notably better rates of between 20% and 25% this year. Among them are small-business computer systems, Winchester hard disks, terminal and data-communications equipment, and that perennial top performer, minicomputers, as well as minicomputer memory systems. In addition, floppy disks should grow by an impressive 35%.

Ordinarily considered the entry-level system for the neophyte, small-business computers have received a technological shot in the arm in recent years. The advent of microprocessor-based systems and personal computers has expanded the low end of this market, while newer, more compact minicomputers and peripherals have increased the power and appeal of the high-end systems. Recent machines such as Tandy's TRS-80 model II and Hewlett-Packard's HP-300 are representative of the two extremes. IBM further stimulated the market this year with the introduction of its System/38 and the small model 4331 processor. With 1978 shipments of $1.2 billion, the small-business market is expected to grow at some 200% to reach $3.6 billion by 1983. Worldwide, market consultants Creative Strategies International, San Jose, Calif., sees the market growing annually by 34% to $9 billion by 1983 (see chart).

Putting it on disk

An indispensible component of all computer systems these days is the disk drive, a fact borne out by the market size. During 1978 some $1.9 billion of all types of data-storage subsystems were shipped—and to this amount can be added several million dollars more hidden in the figures for total systems shipments.

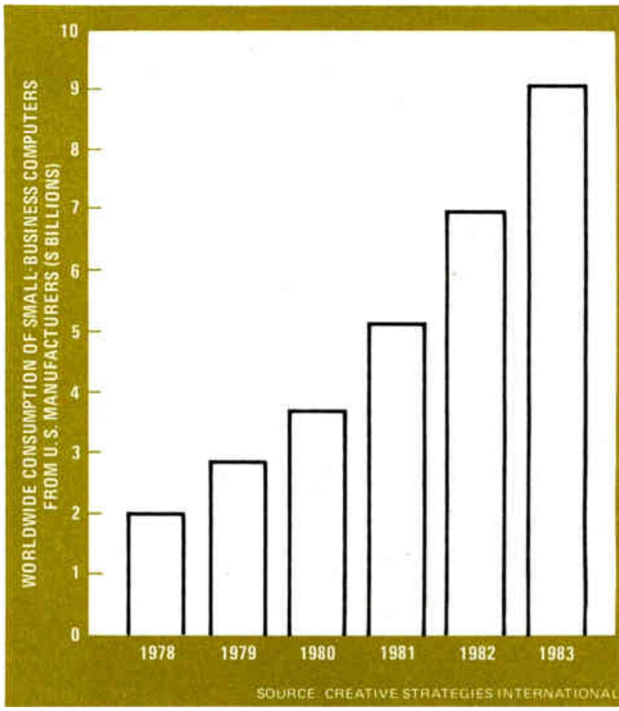
Altogether, the worldwide market for 14-inch disk drives was $3.6 billion in 1978, Creative Strategies says, and is growing at a rate of 19.5% a year, with tape drives accounting for another $423.3 million. By 1983, the firm estimates worldwide market consumption will be $8.88 billion for disks and $1.94 billion for tape.

Two of the most dynamic types of data-storage peripherals are floppy disks and small 8-in. Winchester-style hard disks. Their use in the growing small-business systems, the acceptance of double-sided, double-density versions, and the popularity of the 5.25-in. minifloppies caused this total market to reach $477.4 million in 1978, according to James Porter's Disk/Trend report. Growing at a rate of 39%, they are projected to reach $1.77 billion worldwide by 1982.

The 8-inch Winchesters, scaled-down versions of the sealed media drives popular with large-system users because of their increased reliability, are just going into production this year. But Creative Strategies estimates that by 1983 worldwide shipments of these drives and smaller versions could reach $298 million.

Thanks to the increasingly popular trend toward distributed data processing, the market for data-communications terminals is growing by leaps and bounds. Many manufacturers, most notably IBM and Digital Equipment Corp., are finding it hard, if not impossible, to keep their manufacturing up with the estimated 32% growth in the market. At the same time, source data-collection terminals, most of them specialized, are growing at a rate of 20% a year.

As noted, minicomputers retain their place on the glamour list of market leaders. After several years of breathtaking 30% to 35% growth, however, there was a "mere" increase of nearly 27% between 1978 and 1979.



The right stuff. Small-business computers are setting a blistering pace with new entries introduced at both the high and low ends of the market. Worldwide, the small-business market is expected to grow at a rate of 24% to reach in excess of $9 billion by 1983.

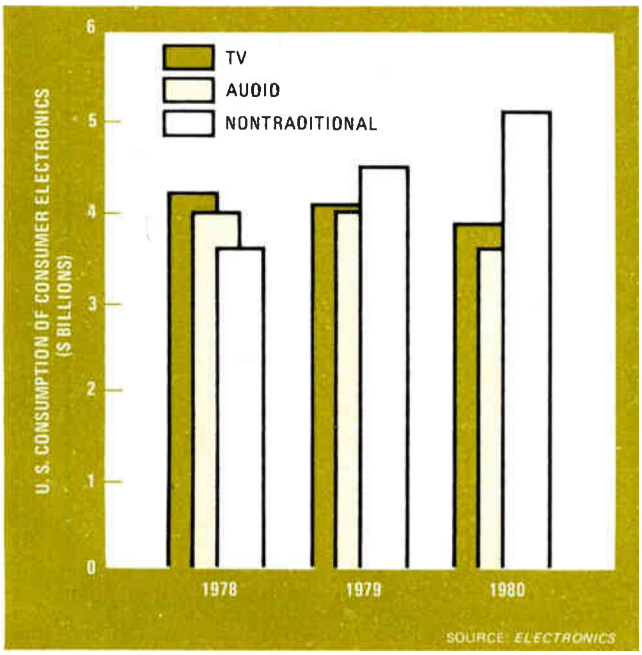
Little entertainment in the figures

The transition from the 1970s to the 1980s will include landmark events in the consumer electronics marketplace—some profitable, some uncomfortable, but all of major importance to the bottom line for equipment manufacturers and their components suppliers.

Several products made major sales gains in 1979 and will continue to make strides in 1980 despite the general decline expected in consumer spending. Long-standing products such as color television receivers, however, will go through severe profitability tests during the 1979–80 recession. Overall, U. S. consumption of consumer electronics will rise by 1%, to \$12.79 billion this year, according to *Electronics'* survey.

First the bad news: color television sales to dealers will record their second straight drop in units sold. From the halcyon year of 1977, with sales of more than 10 million units, the industry dropped to an estimated 9.7 million in 1979. And with the recession taking hold, a drop of 5% is expected overall for 1980 compared with 1979. Sales to dealers will probably not exceed 9.2 million units. Total sales of \$3.37 billion are forecast for 1980, compared with \$3.58 billion in 1979.

However, the interesting news in TV sales for 1980 will be the nature of the marketplace: imported sets are no longer the aggressive predators. Imports were down about 50% in 1979 compared with 1978, thanks to the Orderly Marketing Agreements negotiated by the U. S. Government, although production of Japanese-brand sets in U. S.-based plants increased. Industry sources believe that the most intense price competition over the next year will come among the domestic-brand companies as they struggle for increased market shares through rebates, special sales, and additional advertising and promotion activities. Though 1978 and early 1979 were marked by relatively strong earnings for some of these manufacturers, 1980, as noted, will not be as lucrative.



Changing times. Though the traditional entertainment products—color TV and hi-fi audio gear—drag along at a relatively flat dollar value, the relatively new products in the consumer sector, like VCRs, games, and microwave ranges, will zoom to \$5.2 billion this year.

Another important transition to anticipate over the next decade: the American consumer is using color television increasingly as the display device for nonbroadcast entertainment. However, prospects for 1980 are not very encouraging. Video cassette recorder sales are exceptionally vulnerable to the recession because of the large number of first-time purchasers who could postpone buying until better days. A healthy increase of 24% from 1979's sales level of \$336.6 million is probable.

Video disk players, though lower-priced than the VCRs, will not make much of a showing this year. Magnavox Corp. has been marketing the Philips-MCA optical system on a region-by-region basis and expects to be selling nationwide by the end of the year. And RCA Corp.'s Consumer Electronics division has announced that it will not be ready to market its capacitance player until 1981. The Japanese, too, will make a big splash when they finally decide to jump into this competition.

On the road

The automotive electronics market looks ready to roll, despite the downturn in car sales. The reason for the expected growth is that more electronics is going into each car. In 1978, only a handful of American automobiles contained electronic engine-control systems, but almost all 1981 model year cars will be equipped with at least one microprocessor, assorted memory chips, and a half dozen or more solid-state sensors in systems intended to boost fuel economy and reduce harmful emissions. In addition, the market for more powerful stereo radios, cassette players, and other high-quality components will be a \$1.4 billion cut-throat arena in 1980. Altogether, the value of auto electronics will jump 22%, even though overall auto sales will slump.

Another high-growth area for electronics is the game and toy industry. In 1977, manufacturers' wholesale revenues from electronic games were about \$12 million, but by 1979 hand-held football, baseball, astrology, and skill games accounted for \$417.8 million, with demand far outstripping the capacity of the toy makers and their semiconductor suppliers. In fact, the demand for electronic games in 1979 exceeded any other single toy product category, including stuffed animals, board games, and even Christmas trees and ornaments. But the phenomenal 300% increase in sales chalked up between 1978 and 1979 will slow to a merely terrific 70% growth level in 1980, again limited by production.

Bits and birds catch on

As 1979 rolled along, the oft-predicted economic recession was repeatedly postponed. And now with the pundits still unsure about a *bona fide* recession, the consensus in the communications industry is that, barring a major slump, another good year will chalk up a sales total of $4.7 billion, 11% above 1979.

For this sector of the electronics industries the 1980s appear promising, with various forms of information teleprocessing from office automation to satellite communications expected to blossom.

As in 1979, it is expected that the trail leader in 1980 will be the continued growth of digital communications. This field is being driven by the ever-growing use of large-scale integration technology.

In one of the major moves of the year from the viewpoint of the office-of-the-future industry, American Telephone & Telegraph Co., plagued by software, hardware, and regulatory problems, stopped attempting to get its Advanced Communication Service on the road, at least for the near future. While competitors Satellite Business Systems Inc. and Xerox Corp. were gleeful, their happiness was overshadowed by their own problems with Federal agencies.

Further stirring the brew, the attempt by the Congress to overhaul the Federal Communications Commission and the 1934 Communications Act, which sets the rules for who does what in the communications industry, fell on its face for lack of support. No one was sure whether some definitive action would occur in 1980. Nevertheless, nonmonopoly businesses and even mostly monopoly AT&T were cheered by indications from the FCC that it intended to encourage free and open competition in as many areas of communications as possible.

Meanwhile, AT&T and the non–Bell telephone companies continued to grow in most departments. According to the FCC common carrier statistics, 1979 saw a 4% unit growth rate and 1980 will see one of 3.5% for a total of almost 182,000,000 telephones by the end of the year—this in spite of increased competition from such other suppliers as the growing interconnection industry (see figure).

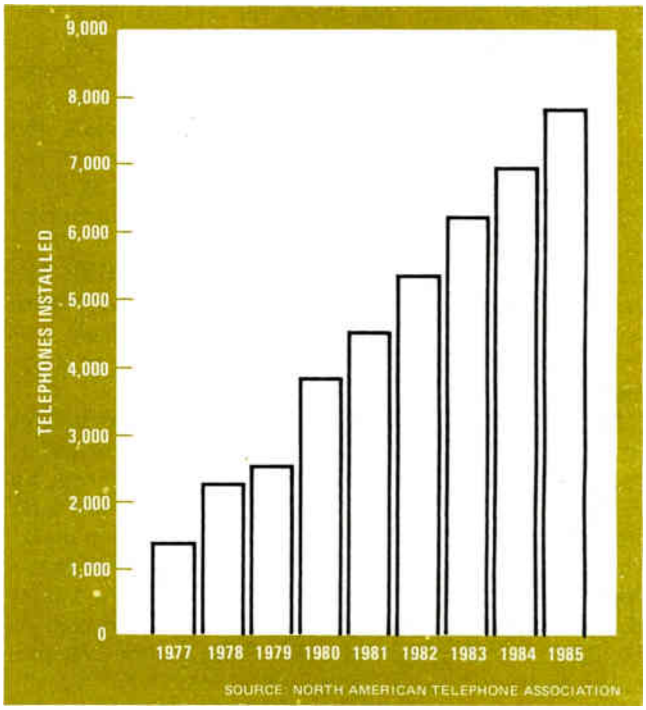
The increase in the use of digital technology in both satellite and terrestrial communications is helping manufacturers of digital devices do almost a land office business. For example, satellite earth stations and associated equipment manufacturers should reach a $150 million total this year. In contrast, the makers of slow analog modems will see a flattening of demand. On the bright side, high-speed digital devices operating in the 4,800- and 9,600-bit-per-second range will see a 12% growth. This reflects the increased need for higher-speed data handling throughout the communications industry.

The ability to put intelligence in almost every piece of communications gear from facsimile machines to private branch exchanges has led to the growth of communications teleprocessing as a discrete industry. In the systems manufactured by companies in this business, it is difficult to define whether the device is a computer or simply a data-generating or data-handling machine with a communications capability. This industry will experience substantial growth in the decade of the 1980s. By 1985 the digital telecommunications market alone should hit $1.5 billion, according to the Yankee Group, a market research firm in Cambridge, Mass.

A braking effect

Tempering the optimistic outlook for the industry is the fact that conversion of already installed large communications systems into integrated digital systems is a costly and time-consuming process. Such a changeover is driven not by technology, but by depreciation economics. Often enough, users are not in a hurry to convert to digital or fiber-optic technology until initial system investment costs have been recovered.

Fiber-optic systems with their environmental and bandwidth advantages will continue their explosive growth in 1980 though the "experimental" installations are still only a drop in the communications industry bucket. Sales in this area, almost nonexistent a few years ago, are expected to be up to $90 million in 1980, according to the *Electronics* survey.



Lots of hookups. The interconnect industry is carving out its own niche in the special-telephone marketplace. As the curve shows, the growth is expected to be even sharper in the next 6 years than it has been in the last 10.

Automation stars

The test and measurement industry bade a fond farewell to the departing decade as overall sales, totaling $2.7 billion, jumped 18% in 1979. The threatened slowdown never materialized, so that the industry's growth was 6% better than anticipated at the end of 1978.

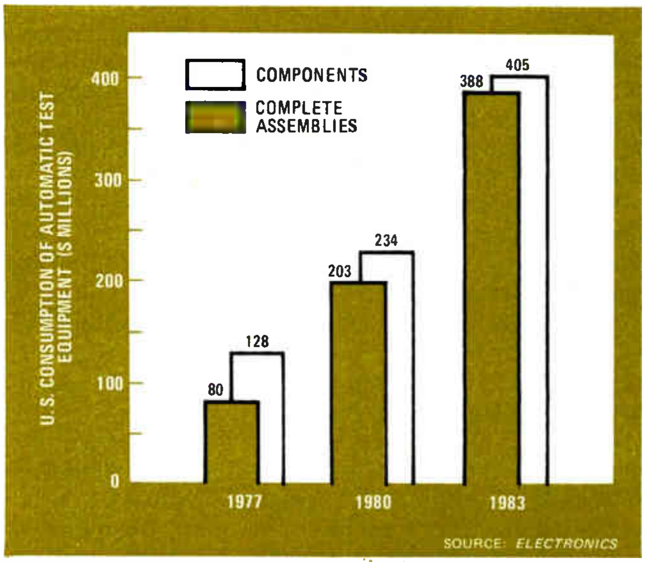
As they looked to the new decade, however, executives were still wary, in spite of their sizable backlogs of orders and plans for numerous product introductions. Conservatively, they see a growth of 11% for the next four quarters, putting the industrywide factory-level sales total at nearly $3 billion by the end of that period. Yet even the spectre of recession is unable to darken the prospects for growth for certain sectors of the market.

Concern for increased production and productivity is most visible in the area of automated test equipment. All facets of the ATE market are likely to shine this year. Sales of equipment destined for U. S. manufacturers will enrich the coffers of ATE companies to the tune of $451.1 million, or 16% more than last year. Leading the ATE pack with a growth rate of 21% will be loaded-board testers—the broadening base of electronic applications will catapult these sales to the $203.3 million level. In addition, a sharp growth of 16% is expected in the sale of bare-board testers as multilayer and other more complex techniques of board fabrication reduce the role of visual inspection as a viable means of catching manufacturing defects. Behind board tester sales in growth but outpacing them in dollars are those for automated device testers. The requirements of faster parts as well as complex analog-digital integrated circuits will boost 1980 sales in the U. S. by 12% to $234.2 million.

As for the market in discrete instrumentation, the microprocessor and the IEEE-488 bus are the leading sales factors. The microprocessor continues to be a twofold blessing. On the one hand, it expands the market for digital test instruments, and on the other, it makes the instruments themselves more capable. The IEEE-488 bus, too, accounts for many instrument sales since more and more companies want to automate bench and production measurements to reduce the drain on engineering talent.

Microprocessor development system sales, which leapt an astounding 41% in 1979, will continue to grow but at about half the pace. Likewise, sales of logic analyzers, up 40% last year, will forge forward more slowly. MDS sales should rise 20% this year to push the $200 million mark, while logic analyzers are predicted to bring in 27% more than last year for total sales of $73.5 million. And sales of dedicated IEEE-488 bus controllers are expected to rise 20% to $56 million in 1980. Pulse generators, too, will enjoy healthy sales, up by 13%.

Still the king among individual instruments in dollar value is the oscilloscope. While the rate of sales growth for scopes, at 12% both last year and this, may not be as dramatic as for logic analyzers and development systems, the scope will still bring in a healthy $276.5 million this year. Plotter and recorder sales, likewise undramatic, will still represent a healthy $206.9 million in 1980.



Everybody needs it. Automatic test equipment will feel demand from users to test both components and complete assemblies, with growth 12% for component testers and over 20% for completed assembly testers. The market will near $800 million by 1983.

Healthy traditions

For drama in traditional instrumentation, market watchers will have to keep their eye on low-end digital multimeters, temperature-measuring equipment, spectrum analyzers, and function and sweep generators. Multimeters with 3½ digits or less should score a 17% sales growth this year, but the increase in competition, most notable in the market in hand-held meters, may dampen that projected growth—to $37.3 million—with unit cost cutting. Temperature-measuring equipment, accounting for $20.2 million in sales last year, seems headed for a 14% increase this year.

Of the last three dramatis personae, sweep generators sales promise to show the most presence, growing by 14% to $70.8 million in 1980. But spectrum analyzer and function generator sales will not be upstaged by much; the former will grow by 13% to $74.7 million while the latter gains 12% to bow out at $41 million by year's end.

The market for analytical instruments grew slowly last year, with overall sales increases of 10% in 1979. This trend should continue through 1980, with gas chromagraphic equipment proving the exception.

In the medical arena, X-ray equipment seems to be succumbing slowly to ultrasound for noninvasive diagnosis. In general, the medical instrumentation market should enjoy a cautious growth of 12% in 1980.

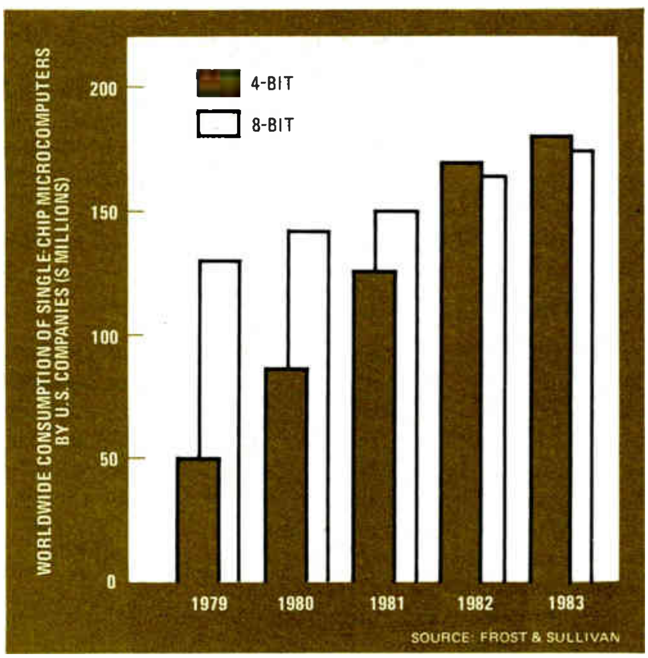
Demand surging ahead of growth

If the 1980s come in the way the 1970s went out, the U. S. semiconductor industry has no worry, except how to get capacity up to meet demand. Last year, producers found themselves unprepared for the increased demand—some 29% overall—in face of what was supposed to be a slowdown.

The bubble has not burst yet, as overall growth will continue this year at nearly the same level, according to *Electronics*' survey. The 26% total gain for semiconductors to $6.4 billion in 1980 will be fueled primarily by sales for integrated circuits—up 32% to $4.9 billion.

Essentially, as Michael Krasko, vice president at Merrill Lynch Pierce Fenner & Smith, New York, points out, it is "no longer reasonable to link the semiconductor industry's fate to that of the general economy," because of the expanding applications. As proof, the order backlogs of the computer and instruments industries, which together consume more than half of all semiconductor production, show none of the sequential changes that would point to a downturn, he says.

However, the industry may no longer be capable of supporting its own rapid growth, as exemplified by the TTL families of small- and medium-scale integrated devices. These so-called "glue" parts, needed for nearly every digital design, will see shipments rising 18% to $833.3 million, still short of demand. Low-power Schottky TTL will have the greatest increase by far—38% to $294.4 million.



Swinging singles. Thanks to electronic toys, games, and microwave ranges, single-chip microcomputer sales will increase at a healthy rate, especially for 4-bit units. According to research firm Frost & Sullivan, shipments of these chips will pass 8-bit units by 1982.

Thanks to computer and automotive demands, TTL memory will enjoy enormous growth this year. Indeed, half of last year's bipolar fuse-link programmable read-only memory sales will be required again this year just to satisfy Detroit; total bipolar PROM sales will be up a whopping 48% to $206 million.

Emitter-coupled logic, too, is on the upswing, the total market rising 31% to $74 million as designs of smaller systems headed for higher speed appear. Still, nothing can compare with the demand for MOS memory, most notably the 16-K dynamic random-access memory. The unanticipated demand for it last year rocketed sales 122% over the previous year to $290 million, and that trend can be expected to continue. The requirements of new, larger computers and add-on memories for them, as well as those of the growing personal computer market, coupled with IBM's recently announced merchant-market requirements for the 16-K chips, will boost 1980 sales 90% to the limits of industry production—$550 million.

64-K RAMs await takeoff

Since only a few manufacturers are currently supplying samples of 64-K dynamic RAMs, the market has not yet emerged. By the end of this year, however, sales of the devices should reach $35 million.

Static RAMs will enjoy great growth, both fast parts for computers and bit-slice processors and slower ones for microprocessor-based systems. The total will rise 33% to $443.7 million.

The ultraviolet-light–erasable PROM will see growth of 44% to $318.5 million and will remain unchallenged for years as the popular read-only storage element for microprocessor systems. However, the electrically erasable PROM, emerging this year in several microprocessor-oriented forms that complement earlier devices, will begin its road to dominance in 1983, when its sales will reach $220 million.

Finally, bubble memories, still in infancy, will rack up respectable sales of $55.5 million this year, as quarter- and full-megabit chips enter the production phase. By 1983, that figure should rise to $136 million.

Toys, games, and appliances are predominantly responsible for the dramatic increase in single-chip microcomputer sales, up 122% this year to $205.5 million. As for standard microprocessor types, growth in 8-bit devices will be steadily above 30% per year, whereas the recently introduced 16-bit types will swell the market by $37.5 million next year.

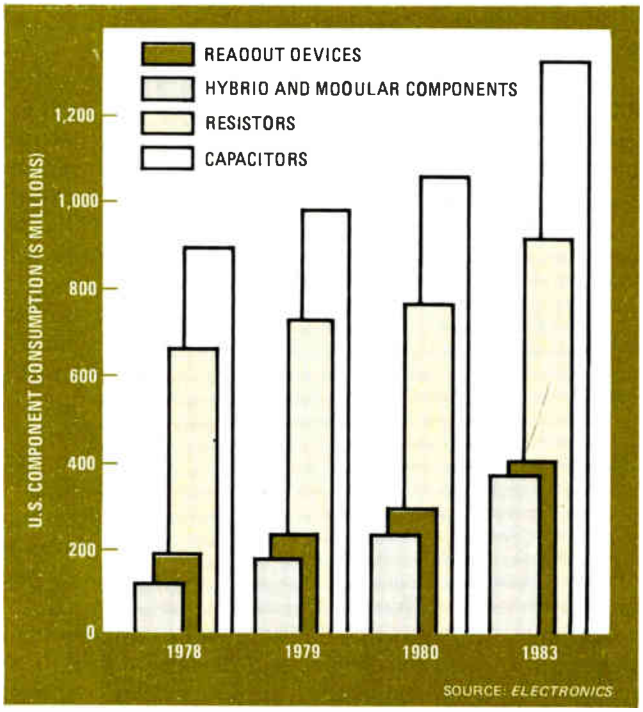
As the demand for microprocessors continues to skyrocket, so, too, will the demand for related linear ICs, particularly data converters, coder/decoders, sensors, and interface products. Sales for linear ICs will be up almost 10% from last year to $746.4 million this year and will grow to a total of $1.2 billion by 1983, albeit at a somewhat slower rate.

Unaggressive growth in store

Undaunted by all the talk about an upcoming recession, components sales closed out the decade well, rising to a total of $8.87 billion last year, up 11% from 1978's totals. Still, projections are that slowdowns in the automotive, consumer, and some industrial sectors will temper component growth going into the 1980s to an increase of only 7% by the end of this year. This growth should pick up, however, once the expected slowdown in the economy ends, and by 1983 component sales should be up by about 26% over 1980 sales.

Passive components like resistors and capacitors should track the overall electronic equipment market trend of higher sales. Last year, resistors and capacitors registered 11% increases each over 1978 sales. Resistors are expected to increase by about 4% to $760.1 million, and capacitors by about 7% to $1.05 billion by the end of this year. By 1983, resistors will be a $917 million market and capacitors a healthy $1.32 billion market. About half of all resistor and capacitor sales will go to the industrial and commercial sectors.

Some resistor sales are expected to flatten out and drop slightly this year. Fixed resistor sales for 1980 should remain virtually flat, whereas composition and metal-film types will register slight increases, but these will be offset by small decreases in deposited-carbon and wirewound resistors. The largest increases for 1980 will be enjoyed by thick- and thin-film resistor networks, which are expected to climb 12% this year and another 36% by 1983 for a $268.5 million market by then.



Still growing. Components such as capacitors and resistors are expected to grow along with the electronic equipment market at an even pace. However, readout devices will benefit from large gains in computers and hybrids will ride coattails of microprocessors.

Sales of film, mica, glass, and vitreous enamel capacitors for 1980 will also feel the general economic downturn expected this year, dropping slightly. Glass and vitreous enamel capacitor sales will continue to drop by small amounts into 1983, while mica capacitors will register only modest gains by then. Large gains will be posted by chip capacitors as hybrid circuits increase in use. Chip capacitor sales jumped last year by 17% over 1978 sales and are projected to increase another 13% this year and a further 55% by 1983. As more switching power supplies become available, electrolytic capacitor sales will benefit, posting another 8% gain for 1980 atop the 9% gain registered last year. By 1983, electrolytic capacitor sales should soar to a total of $435 million.

The industrial market segment is expected to garner a greater share of the total relay market as electronics penetrates more plants and factories to improve lagging U. S. productivity. The total relay market will expand to $559 million by the end of this year. This represents a 10% increase over last year's sales of $508 million. By 1983, an impressive 19% increase can be expected in total relay sales over those of 1980.

Traditional hardware components like switches will hold their own and then some. An expected increase in electronic products across the board from computers to instruments will bring the total switch market to $711 million by the end of this year. This is only a 10% increase over last year's total of $645 million and a smaller growth rate than the 1978–79 period of 14% and reflects the general softening if not downturn of the economy this year. By 1983, the total switch market should climb by about 37% over this year's sales to $975 million. Part of this rapid switch growth will be borne by keyboard assemblies, which will shoot up by more than 50% by 1983.

Digital influences

The trend toward the use of semiconductor memory for computers is indisputable and is taking over a bigger chunk of the once-dominant magnetic-core memory market. Last year's core memory sales of $63 million represented a 10% decrease from 1978 sales of $70 million and should decrease by another 21% by the end of this year to 1980 totals of just $50 million. By 1983, core-memory sales should drop by a huge 80% from 1980 sales, down to a mere $10 million.

As more electronic equipment permeates information handling, the need to display this information will mean a boom in readout devices. Last year, this market grew 25% to nearly $230 million. Another 20% increase is expected this year, and by 1983 this market will hit $391 million, a 41% increase over 1980 sales.

INDUSTRIAL

Electronics to the rescue

There was little real economic growth in 1979 and the likelihood is for recession and decline in 1980, concludes a survey of all types of American businesses conducted by the economics department of the McGrawHill Publications Co. But for industrial electronics companies contemplating specifics, the picture is not nearly as gloomy. Particularly bright areas seem to be those tied to improving productivity and to energy conservation.

The machine tool business was "fantastic" in 1979, according to a spokesman at the National Machine Tool Builders Association, McLean, Va. For the first 10 months of 1979, orders were 34% ahead of 1978, and that year was 45% ahead of 1977. That's good news for makers of numerical controls for the tools.

"We're pretty much solidly booked for next year," says Charles Britton, marketing manager at the Electronics Systems division of Cincinnati-Milacron Inc. in Lebanon, Ohio. "The backlogs in the machine tool areas are very strong."

Big orders are coming in from U. S. automobile makers, despite their declining sales. The reason is that they must add new controls as they convert their lines to the smaller, more fuel-efficient models, points out Theodore F. Fluchradt, manager of the Industrial Automation department, Westinghouse Electric Corp., Orlando, Fla. Aerospace firms and makers of off-the-road vehicles are buying too, he says. And he looks forward to penetration of industries like woodworking as microprocessors get more capable and prices of numerical controls drop.

But even faster growth is being experienced by manufacturers of programmable controllers, the computer-like replacements for hard-wired electromechanical and solid-state relays on things like transfer lines and large machines. "It was another excellent year for programmable controllers," says John A. Blaeser, vice president and general manager of Modicon division of Gould Inc., Andover, Mass. He believes the market expanded by 50% in 1979, and he looks forward to similar growth in 1980, even "if capital spending is flat."

Systems for managing energy and controlling facilities in buildings and factories will continue in 1980 as a "hot new market," according to a study released late last year by Frost & Sullivan Inc., the New York–based market researchers. The study pegs the market at $205 million in 1980 and predicts it will grow at an 8% average annual rate to $350 million in 1988. Such systems could save $5 billion a year, according to the study.

Also related to increasing productivity, process control equipment will sell well in 1980. "The recessionary impact is ahead of us yet," says James W. Turner, director of strategic planning at Honeywell Inc.'s Process Control division, Fort Washington, Pa. "And should there be a recession, we will lag behind it by six to nine months because of the long-range commitments that are made by our customers." In particular, he points to chemical and petrochemical plants as strong buyers of digital process-control systems, with the basic metal industries having difficulties.

Federal

Savoring of SALT-2

The magic number of $22.2 billion for Federal electronics expenditures in calendar 1980 represents a 10% gain from last year despite the fact that 1979 outlays rose more than initially forecast to top $20 billion. Inflation represents the biggest reason for the increases in both years, but there are others that Federal budget specialists in most agencies agree are just as important.

Projected defense expenditures of $20 billion, for example, will account for more than 91% of the Government total. While the gain in military outlays is expected to be much larger after October, when the Federal fiscal year 1981 begins, the last three quarters of fiscal 1980 that began this month will produce a significant share of military electronics' growth. The Defense Department's fiscal 1980 spending program is pegged at 3% "real growth" after an inflation factor of 7.5%. Fiscal 1981 outlays, however, are expected to show 5% "real growth," reflecting President Carter's agreement with Senate leaders to spend more as a condition for their support of ratification of the Strategic Arms Limitation Treaty (SALT-2) with the Soviet Union.

The three-way split of funds among military procurement, research and development, and operations and maintenance will not change much in 1980 from last year. But the respective shares of 48%, 34%, and 18% for each of the three categories for the full year do tend to mask the heavy increases to come in the accounts for RDT&E and O&M in the fourth quarter when fiscal 1981 begins. Contractors are already gearing up for more Federal R&D funds, as well as more money for maintenance as the DOD pushes to keep a larger proportion of its weapons operational for longer periods of time.

The coming DOD supplemental budget request could push 1980 spending even higher. But some of the DOD's gains will come at the expense of other agencies, notably the National Aeronautics and Space Administration. □

U. S. MARKETS FORECAST 1980

Market estimates represent industrywide consumption (at the factory level) of goods shipped by U. S. and foreign manufacturers for the U. S. market. Some product categories have been added, deleted, or redefined. Therefore, these totals are not directly comparable to those of previous years.

COMPONENTS

(millions of dollars)	1978	1979	1980	1983
COMPONENTS, TOTAL	**7,982.0**	**8,873.2**	**9,508.0**	**11,929**
Resistors, total	**660.0**	**730.7**	**780.1**	**917**
Fixed, total	218.5	229.4	229.1	258
Composition	60.0	62.3	62.6	63
Deposited-carbon	21.5	23.1	22.0	26
Metal-film	75.0	79.0	81.0	99
Wirewound	62.0	65.0	63.5	70
Variable, total	239.5	267.2	272	318
Potentiometers, wirewound	38.5	43.0	43.0	50
Potentiometers, nonwirewound	98.5	109.7	109.0	130
Trimmers, wirewound	22.5	24.5	25.5	28
Trimmers, nonwirewound	80.0	90.0	94.5	110
Thermistors	53.0	56.5	60.2	72
Resistive networks, total	149.0	177.6	198.2	269
Thin-film	69.0	79.0	88.0	114
Thick-film	80.0	98.6	110.2	155
Capacitors, total	**882.9**	**979.5**	**1047.1**	**1317**
Paper	88.2	89.3	90.4	98
Film	110.0	119.0	115.0	123
Electrolytic, total	320.9	349.0	377.8	435
Aluminum	153.0	176.0	200.0	220
Tantalum	167.9	173.0	177.8	215
Mica	32.0	34.0	33.0	36
Glass and vitreous enamel	5.4	5.4	5.2	4
Ceramic, except chips	265.4	310.7	346.4	509
Variable	22.9	27.7	29.0	34
Chip	38.1	44.4	50.3	78
Relays, total	**465.8**	**507.5**	**559.2**	**665**
General-purpose	148.0	152.8	170.0	220
Telephone-type	30.0	34.0	36.7	41
Crystal-can	73.5	78	90.2	102
High-sensitivity	29.0	32.0	35.0	46
Rf	88.0	97.0	98.6	104
Reed	35.0	41.5	45.0	55
Stepping and impulse	5.0	4.6	4.2	4
Time-delay	28.8	31.1	35.5	41
Solid-state	28.5	36.5	44.0	52
Switches, total	**566.8**	**644.7**	**711.0**	**975**
Small-movement snap-action	80.5	84.5	88.5	103
Lighted	78.0	89.0	94.0	141
Push-button	91.0	100.0	109.4	131
Toggle	28.5	30.2	33.2	44
Slide	28.0	32.2	36.1	48
Rotary	99.0	121.0	130.7	181
Coaxial	19.3	22.0	25.1	37
Thumbwheel	23.5	26.0	28.5	38
Dual in-line	25.0	30.6	36.2	49
Keyboard, single-key	5.0	5.2	5.2	8
Keyboard, assemblies	70.0	80.0	95.0	143
Solid-state (including Hall-effect)	19.0	24.0	29.1	52
Magnetic, total	**795.2**	**852.1**	**872.0**	**984**
Computer memory cores	70.0	63.0	50.0	10
Transformers, chokes (except TV), total	269.0	299.0	316.0	382
Laminated	172.0	193.0	205.0	237
Toroidal	57.0	62.0	65.0	80
Pulse transformers	40.0	44.0	46.0	65
TV components	171.4	176.4	177.0	200
Rf coils	15.8	14.7	13.0	10
Electron tubes, total	**1,220.7**	**1,308.3**	**1,369.0**	**1,520**
Receiving	111.6	104.0	96.0	34
Power and special-purpose, total	398.6	411.8	436.3	515
High-vacuum	75.7	77.0	81.0	94
Gas and vapor	17.2	18.5	22.5	26
Klystrons	48.0	51.2	54.3	60
Magnetrons (including cross-field amplifiers)	50.0	53.5	57.2	70
TWTs (including backward-wave)	97.5	98.7	105.0	130
Light-sensing tubes	14.8	16.0	17.3	20
Image-sensing (including TV camera and image-intensifier)	35.9	38.6	41.2	51
Storage	14.0	11.0	8.6	6
Cathode-ray (except TV)	45.5	47.3	49.2	58
TV picture, black-and-white	30.5	30.5	29.0	18
TV picture, color	680.0	762.0	807.7	953
Microwave hardware, total	**139.8**	**155.5**	**176.9**	**241**
Mixers	10.7	11.5	12.4	40
Detectors	6.2	7.3	8.6	10
Amplifiers	25.3	29.6	34.6	42
Passive components, total	37.6	41.2	45.1	52
Waveguide	8.6	9.2	9.8	12
Coaxial and strip-line	29.0	32.0	35.3	40
Switches, total	29.3	33.0	37.6	56
Waveguide	10.0	11.0	12.5	19
Coaxial and strip-line	19.3	22.0	25.1	37
Ferrite devices, total	25.1	26.6	31.1	34
Isolators	7.5	8.6	12.6	14
Circulators	11.8	12.7	13.7	17
YIG devices	5.8	5.3	4.8	3
Power limiters	5.4	6.3	7.5	7
Readout devices, total	**183.2**	**229.8**	**276.8**	**391**
Discrete, total	44.8	49.1	53.8	69
Incandescent	4.5	4.8	5.0	6
Fluorescent	2.1	2.3	2.6	3
Light-emitting diode	38.2	42.0	46.2	60
Multidigit, total	138.4	180.5	222.8	322
Gas-discharge	68.0	85.0	102.0	153
Segmented	36.0	45.0	54.0	81
Dot-matrix	32.0	40.0	48.0	72
Fluorescent	3.7	4.3	5.0	6
Electroluminescent	3.1	4.2	5.2	7
Light-emitting diode	46.7	53.2	60.6	76
Liquid-crystal	16.9	33.8	50.0	80
Transducers, total	**192.9**	**217.8**	**240.5**	**331**
Pressure	45.0	53.0	58.3	80
Temperature	29.2	36.9	44.3	77
Motion, linear	30.3	31.8	33.4	39
Motion, angular	28.0	30.0	32.1	39
Torque	21.4	22.1	22.8	25
Vibration	39.0	44.0	49.6	71
Crystals, total	**105.8**	**109.4**	**113.8**	**130**
Discrete crystals, total	46.8	47.4	49.8	61
Communications	28.3	31.9	36.0	44
Color TV	2.7	2.8	2.9	3
Watches	11.0	7.6	5.5	7
Filters	4.8	5.1	5.4	6
Assemblies (including mounts and ovens)	59.0	62.0	64.0	70
Passive filters and networks, total	**320.2**	**336.5**	**357.7**	**420**
Rectifier assemblies	169.0	175.0	180.0	200
LC filters	40.8	41.6	42.0	44
Electromechanical filters, total	45.0	46.3	51.2	60
Crystal	34.0	34.5	39.0	44
Ceramic	8.0	8.5	8.7	11
Other	3.0	3.3	3.5	5
Rfi and emi filters	38.4	44.4	53.2	75
RC networks	12.0	13.0	14.5	19
Delay lines	15.0	16.2	16.8	22
Hybrid and modular components, total	**144.3**	**179.8**	**214.3**	**381**
Operational amplifiers	30.0	35.0	37.0	50

(millions of dollars)	1978	1979	1980	1983
Instrumentation amplifiers	5.0	6.0	7.0	11
Isolation amplifiers	2.0	2.5	3.0	5
Data conversion, total	78.5	96.3	117.5	240
D-a converters	42.0	53.3	68.0	126
A-d converters	30.0	35.0	40.0	100
Multiplexers	2.5	3.0	3.5	6
Sample-and-holds	4.0	5.0	6.0	8
Data-acquisition boards	5.0	10.0	13.0	20
Functional circuits	11.0	13.0	14.0	16
Signal sources (including oscillators)	2.4	2.6	2.8	4
Active filters	8.4	10.2	12.0	16
Miscellaneous custom functions	2.0	4.0	8.0	20
Connectors, total	**976.1**	**1,110.0**	**1,161.8**	**1,486**
Coaxial, total	72.5	77.0	78.5	98
Standard size	53.5	55.5	56.0	66
Miniature	19.0	21.5	22.5	32
Cylindrical, total	194.5	207.0	214.5	260
Standard	64.0	66.0	67.5	72
Miniature	85.0	88.0	89.0	101
Subminiature	45.5	53.0	58.0	87
Rack-and-panel	190.0	214.0	234.0	300
Fused	16.0	17.0	18.0	23
Printed-circuit, total	310.0	380.0	389.0	483
Card-insertion	200.0	245.0	252.0	311
Two-piece, metal-to-metal	110.0	135.0	137.0	172
Flat-cable	53.0	64.0	73.0	123
Fiber-optic	2.1	4.0	6.0	15
Flexible-circuit	6.0	7.0	7.8	9
Special-purpose	132.0	140.0	141.0	175
Printed circuits and interconnection systems, total	**821.5**	**935.0**	**1,034.0**	**1,391**
Printed circuits, total	532.5	611.0	669.0	834
Rigid boards, total	474.0	548.5	602.0	743
Single-sided	70.0	76.0	76.0	86
Double-sided	253.0	277.5	302.0	359
Multilayer	151.0	195.0	225.0	298
Flexible circuits	58.5	62.5	67.0	91
Interconnections, total	289.0	324.0	365.0	557
Sockets and socket panels for DIPs	182.0	200.0	220.0	335
Backplanes	107.0	124.0	145.0	222
Wire and cable, total	**507.0**	**577.0**	**614.0**	**782**
Coaxial cable	155.0	175.0	185.0	225
Flat cable	120.0	145.0	160.0	210
Hook-up wire	105.0	113.0	115.0	126
Multiconductor, shielded	70.0	77.0	80.0	89
Multiconductor, unshielded	50.0	53.0	53.0	57
Fiber-optic cable	7.0	14.0	21.0	75

SEMICONDUCTORS

(millions of dollars)	1978	1979	1980	1983
SEMICONDUCTORS, TOTAL	**3,937.6**	**5,061.7**	**6,360.5**	**11,074**
Discrete semiconductors, total	**1,035.6**	**1,137.1**	**1,202.2**	**1,523**
Diodes	370.2	398.2	421.9	548
Signal	45.5	46.8	48.0	50
Rectifier	179.8	195.1	215.5	258
Arrays	11.2	14.0	14.0	17
Zener, total	90.8	111.1	113.5	162
Voltage regulator	69.8	87.3	90.5	135
Reference	21.0	23.8	23.0	27
Special-purpose, total	42.6	45.2	47.9	61
Microwave	34.0	36.0	38.0	50
Varactor (less than 1 GHz)	7.5	8.1	8.7	10
Tunnel	1.1	1.1	1.2	1
Transistors, total	533.9	606.6	640.4	788
Bipolar, total	489.9	558.5	584.6	716
Small-signal (less than 1 W)	167.5	179.8	184.5	198
Power (1 W or more)	228.7	274.7	287.7	377
Duals and arrays	9.0	10.0	9.0	9
Rf and microwave	84.7	94.0	123.4	132
Field-effect, total	44.0	48.1	55.8	72
Junction, total	25.5	26.7	27.8	34
Small-signal (less than 1 W)	25.0	26.0	27.0	33

(millions of dollars)	1978	1979	1980	1983
Power (1 W or more)	0.5	0.7	0.8	1
MOS, total	18.5	21.4	28.0	38
Small-signal (less than 1 W)	14.5	15.4	16.0	18
Power (1 W or more)	4.0	6.0	12.0	20
Thyristors	114.5	115.0	122.4	162
Protection devices (including varistors)	17.0	17.3	17.5	25
Integrated circuits, total	**2,694.5**	**3,684.1**	**4,876.3**	**9,121**
Standard logic families, total	813.1	1,011.0	1,192.8	1,784
RTL	4.8	4.2	4.0	4
DTL	24.6	20.0	16.0	10
TTL, total	568.5	707.5	833.3	1,129
Standard TTL	364.0	408.0	428.5	485
Schottky TTL, total	204.5	299.5	404.0	644
Standard (S)	66.8	85.7	110.4	180
Low-power (LS)	137.7	213.8	294.4	464
ECL	49.0	56.5	74.0	115
C-MOS	166.2	222.8	265.5	526
Microprocessors and microcomputers, total	210.9	330.8	532.4	1,506
CPUs, total	105.4	133.3	191.4	626
MOS, total	94.0	114.6	163.0	580
8-bit	75.5	90.6	125.5	285
16-bit	18.5	24.0	37.5	245
Bipolar, total	11.4	18.7	28.4	46
Bit-slice	7.0	11.2	15.9	24
Full CPU	4.4	7.5	12.5	22
One-chip microcomputers	40.0	92.5	205.5	515
LSI peripheral chips	65.5	105.0	135.5	365
Dedicated LSI circuits	95.5	155.0	210.5	595
Memories, total	850.3	1,289.7	1,922.2	3,560
Random-access, total	480.4	719.5	1,050.2	1,924
Dynamic, total	234.8	385.6	636.5	901
p-MOS	4.3	2.1	1.0	0
n-MOS, total	230.5	383.5	635.5	901
4-K	100.0	91.5	50.5	16
16-K	130.5	290.0	550.0	485
64-K	0.0	2.0	35.0	400
Static, total	245.6	333.9	443.7	1,023
Bipolar	83.6	95.1	107.5	163
n-MOS	140.5	197.3	260.7	675
C-MOS	21.5	41.5	75.5	185
Read-only, total	322.5	510.6	750.5	1,455
Mask type (MOS)	115.5	136.3	185.0	360
Fusible-link (bipolar) PROM	112.0	138.8	205.5	330
Erasable programmable type	95.0	235.5	360.0	765
Ultraviolet (E-PROM)	86.0	220.5	318.5	545
Electrical (EE-PROM)	9.0	15.0	41.5	220
CCDs	12.7	14.5	21.5	32
Magnetic-bubble devices	14.0	27.4	55.5	136
Shift registers	20.7	17.7	14.5	13
Linear ICs, total	594.7	681.1	746.4	1,158
Analog switches	32.0	37.1	39.0	49
Operational amplifiers	103.0	116.0	128.5	181
Instrumentation amplifiers	4.5	6.0	7.9	18
Comparators	22.0	23.0	24.0	29
Voltage regulators	45.5	52.0	59.4	83
Timers	42.0	48.0	52.0	70
Other	9.5	12.0	13.9	28
Data conversion, total	99.2	115.0	125.7	210
D-a converters	50.7	58.5	63.5	88
A-d converters	29.7	33.0	37.5	84
Multiplexers	13.0	15.5	15.5	21
Sample-and-holds	5.8	8.0	9.2	17
Interface	74.0	90.0	105.0	198
Communications	48.0	60.0	69.0	109
Entertainment	115.0	122.0	122.0	183
Consumer product ICs, total	130.0	216.5	272.0	518
Calculator chips	55.0	54.0	52.0	50
Watch chips	55.0	60.5	66.0	80
Game chips	25.0	50.0	75.0	188
Other	25.0	52.0	79.0	200
Optoelectronic devices, total	**207.5**	**240.5**	**282.0**	**430**
Photovoltaic (solar) cells	12.0	15.0	17.0	35
Photoconductive cells	8.0	9.5	11.0	21
Light-emitting diodes	120.0	140.0	170.0	240
Laser diodes	1.5	3.0	4.5	10
Photodiodes (including arrays)	8.0	9.0	10.5	18
Phototransistors (including arrays)	16.0	17.0	18.0	25
Optically coupled isolators	42.0	47.0	51.0	81

INDUSTRIAL AND COMMERCIAL MARKETS

(millions of dollars)	1978	1979	1980	1983
INDUSTRIAL AND COMMERCIAL, TOTAL	**31,185.9**	**38,784.2**	**43,919.9**	**65,033**
Test, measuring, and analytical instruments, total	**2,837.4**	**3,308.0**	**3,667.6**	**5,424**
Test and measuring equipment, total	**2,277.3**	**2,689.6**	**2,989.0**	**4,557**
Analog voltmeters, ammeters, multimeters	19.4	20.8	21.0	25
Digital multimeters, total	74.3	81.9	90.9	118
3½-digit and below	28.7	31.9	37.3	52
4½-digit and above	45.6	50.0	53.6	66
Multimeter probes and accessories	2.8	3.7	4.1	7
Panel meters, total	108.3	116.5	123.2	143
Analog	78.8	82.2	85.7	93
Digital	29.5	34.3	37.5	50
Counters, time and frequency	62.5	70.3	78.4	104
Microprocessor-development systems	115.3	163.0	195.3	295
Logic analyzers	41.3	58.0	73.5	131
Logic probes	3.9	4.4	4.9	6
Word generators	3.9	4.7	6.1	13
Oscilloscopes	219.7	246.7	276.5	379
Network analyzers	19.9	23.5	26.4	45
Spectrum analyzers	53.7	66.0	74.7	112
Frequency synthesizers	42.6	48.7	52.3	84
Function generators	30.0	36.6	41.0	60
Signal generators	54.2	62.9	69.1	107
Sweep generators	53.2	62.1	70.8	88
Pulse generators	15.0	17.9	20.2	30
Oscillators	17.0	18.5	18.5	25
Waveform analyzers, distortion meters	35.7	40.7	45.5	59
Power meters, below microwave frequencies	3.7	4.4	4.9	6
Calibrators and standards, active and passive	26.1	28.8	30.8	41
Noise-measuring equipment,	8.3	9.9	11.4	16
Temperature-measuring instruments	17.5	20.2	23.1	30
Phase-measuring equipment	25.0	28.1	31.2	42
Amplifiers	35.5	43.0	47.0	57
Impedance bridges	13.0	13.5	13.5	15
Recorders and plotters, total	170.3	191.0	206.9	244
Strip- and circular-chart	65.0	73.3	81.0	101
X-Y	36.4	42.5	47.3	61
Magnetic-tape	68.9	75.2	78.6	83
Component testers, manual	30.6	31.0	31.0	28
Component testers, automatic	152.5	208.9	234.2	405
Pc-board testers, total	128.4	179.9	216.9	412
Bare-board	8.4	11.7	13.6	24
Completed assemblies	120.0	168.7	203.3	388
IEEE-488 bus controllers	38.2	46.9	56.3	91
Microwave impedance-measuring equipment	20.1	22.1	24.2	32
Microwave-power-measuring equipment	7.8	8.9	9.8	13
Microwave wavemeters	0.8	0.8	0.7	1
Microwave modulators	1.4	1.8	2.0	3
Specialized test equipment, total	625.4	703.5	752.7	1,294
Automotive diagnostic equipment	294.0	297.0	304.0	474
Communications test equipment	283.0	352.0	387.0	741
Nuclear spectrometers	26.4	31.0	34.1	40
Radiation-detection and -monitoring, total	22.0	23.5	27.6	39
Analytical instruments, total	**560.1**	**618.4**	**678.6**	**867**
Chromatographs, total	139.8	165.0	195.6	270
Gas	93.8	105.0	120.0	150
Liquid	46.0	60.0	75.6	120
Spectrophotometers, total	186.6	202.3	219.4	274
Infrared	35.2	38.1	40.7	45
Ultraviolet-visible	54.0	59.0	65.0	86
Atomic absorption	37.4	41.2	45.7	61
Other	60.0	64.0	68.0	82
Mass spectrometers	40.0	44.0	48.0	68
Nuclear magnetic-resonance spectrometers	18.5	21.0	22.0	24
pH meters and ion-selective electrodes	27.0	32.0	33.0	45
Thermal analyzers, total	17.2	18.1	19.6	24
X-ray analysis	47.0	50.0	52.0	63
Other	84.0	86.0	89.0	99
Automotive electronics, total	**291.0**	**349.0**	**426.1**	**914**
Voltage regulators	23.0	20.0	18.8	27
Emission-control systems	105.0	145.0	203.0	355
Electronic ignition systems	115.0	117.0	106.3	120
Fuel-injection systems	26.0	28.0	30.0	45
Fuel-metering systems	14.0	30.0	60.0	230
Safety systems	8.0	9.0	8.0	137

(millions of dollars)	1978	1979	1980	1983
Data-processing systems, peripherals, and office equipment, total	**20,605.5**	**26,505.7**	**30,222.8**	**45,594**
System shipments, total	9,842.5	12,303.0	13,782.0	19,440
Desktop computers	262.5	540.0	725.0	1,400
Small (less than $100,000)	1210.0	1540.0	1,852.0	3,615
Medium ($0.1 to $1 million)	3,030.0	3,360.0	3,862.0	4,918
Large (greater than $1 million)	5,340.0	6,863.0	7,343.0	9,507
Micros and minis, total	953.5	1,207.9	1,500.7	2,810
OEM microcomputers	155.5	209.9	268.7	678
OEM minicomputers	798.0	998.0	1,232.0	2,132
Memory systems, total	657.5	719.4	793.7	1,289
Mainframe add-on systems	338.0	396.0	467.0	748
Minicomputer add-in/on systems	67.5	77.4	93.7	157
OEM systems	252.0	246.0	233.0	384
Core	158.0	120.0	84.0	53
Semiconductor	94.0	126.0	149.0	331
Data-storage subsystems, total	1,868.6	2,360.2	2,717.3	4,164
Disk pack	726.0	839.0	869.0	915
Fixed-disk	310.0	525.0	656.0	1,279
Combination fixed/cartridge disk	385.0	400.0	415.0	457
Flexible-disk	168.0	227.0	306.0	530
Reel-type magnetic-tape	254.0	318.0	395.0	873
Cassette and cartridge magnetic-tape	25.6	51.2	76.3	110
Input/output peripherals, total	1,908.3	2,327.4	2,634.5	4,148
Card-read/punch	114.0	103.0	93.0	57
High-speed line printers	112.1	145.8	179.1	309
Medium-speed printers	560.0	700.0	781.0	1,225
Low-speed serial printers, total	416.2	539.6	645.5	1,018
Impact	340.9	435.0	502.3	670
Nonimpact	75.5	104.6	143.3	348
Large nonimpact printers	91.0	114.0	140.0	275
Computer output microfilm	161.0	185.0	208.0	315
Optical readers	315.0	378.0	403.0	675
Magnetic-ink readers	20.0	19.0	18.0	15
Electromechanical plotters	79.0	99.0	119.0	198
Digitizers	13.0	15.0	16.8	24
Paper-tape devices	27.0	29.0	31.0	37
Key entry	282.6	275.3	256.6	215
Data terminals, total	1,477.0	1,828.5	2,230.0	3,482
Teleprinter terminals	156.0	191.0	226.0	300
CRT terminals, total	1,069.0	1,295.0	1,580.0	2,325
Intelligent	486.0	595.0	780.0	1,025
Other	583.0	700.0	800.0	1,300
Graphics terminals, total	202.0	295.0	380.0	820
Storage and refresh	161.0	229.0	300.0	600
Raster-scan	41.0	66.0	80.0	220
Remote batch terminals	50.0	47.5	44.0	37
Source data-collection equipment, total	1,092.0	1,335.0	1,533.0	3,234
Point-of-sale systems	368.0	419.0	465.0	623
Banking systems	177.0	234.0	268.0	371
Industrial data-collection systems	82.0	93.0	110.0	183
Other specialized terminal	465.0	589.0	690.0	1,057
Office equipment, total	3,477.0	4,149.0	4,775.0	7,772
Nonconsumer calculators	240.0	298.0	358.0	787
Word processing	769.0	1,090.0	1,398.0	3,240
Dictation	249.0	276.0	305.0	422
Copying	1,936.0	2,140.0	2,300.0	2,700
Facsimile	38.0	48.0	59.0	103.0
Electronic typesetting	245.0	297.0	355.0	520
Communications equipment, total	**3,530.7**	**4,222.6**	**4,703.3**	**6,464**
Radio, total	1,563.2	1,949.4	2,119.9	2,789
Aviation mobile (including ground support)	49.0	54.0	64.5	84
Marine mobile (ship and shore stations)	32.0	34.4	35.0	44
Land mobile (mobile and base stations)	1,050.0	1,181.7	1,259.0	1,617
Amateur	20.5	22.7	25.7	31
Citizens' band	66.0	69.3	73.2	78
Microwave (complete system, incl. antennas)	177.5	198.7	228.5	321
Analog	160.0	175.0	197.0	257
Digital	17.5	23.7	31.5	64
Broadcast	46.0	51.0	55.5	66
Satellite earth stations	122.2	138.9	150.0	228
Navigation systems	154.0	162.0	169.0	190
Telemetry (industrial only)	46.0	64.0	70.0	91
Voice switching system, total	398.0	443.0	494.7	673
Central office	374.0	411.0	452.0	602
PABX	24.0	32.0	42.7	71
Fiber-optic communications systems	18.5	38.5	90.0	340

(millions of dollars)	1978	1979	1980	1983
Pocket pagers	44.5	56.0	61.0	91
Data-communications equipment, total	939.0	1,094.0	1,246.9	1,705
Modems, total	177.0	189.0	208.8	282
High-speed (2,400 b/s and over)	77.0	82.0	94.0	140
Low-speed (less than 2,400 b/s)	100.0	107.0	114.8	142
Multiplexers	96.0	115.0	138.1	239
Programmable concentrators	88.0	114.0	131.0	174
Front-end communications processors	437.0	525.0	605.0	800
Message-switching systems	141.0	151.0	164.0	210
Facsimile terminals	113.5	132.0	148.3	210
Television equipment	254.0	283.7	303.5	375
Broadcast equipment, total	106.4	116.1	123.3	148
Transmitters	15.8	17.0	18.3	23
Antennas	14.0	16.4	18.4	26
Cameras	32.2	34.6	36.3	42
Auxiliary equipment	44.4	48.1	50.3	58
CATV, total	107.6	121.3	128.9	155
Studio and head-end	16.0	17.0	18.0	22
Distribution	36.6	45.0	49.5	66
Transmission lines and fittings	29.0	31.3	32.0	33
Converters	26.0	28.0	29.4	34
CCTV, total	40.0	46.3	51.3	72
Cameras	27.5	31.3	34.1	46
Monitors	12.5	15.0	17.2	25
Industrial electronic equipment, total	**1,692.8**	**1,910.9**	**2,115.5**	**2,770**
Motor controls (speed, torque).	200.0	236.0	260.0	346
Numerical controls, total	318.4	344.7	361.0	417
Inspection systems, total	51.2	59.1	64.0	75
Ultrasonic	16.0	18.2	20.2	25
X-ray	27.9	32.0	34.0	38
Infrared	5.5	6.8	7.4	9
Ultraviolet	1.8	2.1	2.4	3
Thickness gages and controls, total	111.2	121.0	130.0	146
Photoelectric	83.2	89.0	94.0	105
Radiation-based	28.0	32.0	36.0	41
Data-logging systems	12.4	13.6	14.2	18
Process controllers	90.5	97.0	102.0	123
Process recorders and indicators	87.0	99.8	109.0	149
Sequence controllers, total	112.0	159.0	218.0	404
Programmable	95.0	143.0	206.0	391
Hard-wired	17.0	16.0	12.0	13
Ultrasonic cleaning	14.0	18.0	21.0	26
Pollution-monitoring	225.0	241.0	265.0	320
Induction and dielectric heating and sealing	60.0	66.0	71.0	80
Welding controls	16.0	21.0	24.0	28
Process-control computer systems, total	245.1	272.7	301.3	400
Digital	204.5	228.8	256.3	346
Analog	40.6	43.9	45.0	54
Energy management	150.0	162.0	175.0	238
Power supplies, noncaptive, total	**358.5**	**415.0**	**472.0**	**682.0**
Switching, total	106.0	135.0	175.0	355.0
Pc-board-mountable (encapsulated)	4.0	6.0	7.0	11
Open frame and card	31.0	42.0	58.0	156
Rack-mountable and other system	71.0	87.0	110.0	188
Nonswitching, total	252.5	280.0	297.0	327
Pc-board-mountable (encapsulated)	7.5	9.0	10.0	12
Open frame and card	94.0	110.0	122.0	195
Rack-mountable and other system	140.0	148.0	150.0	100
Benchtop	11.0	13.0	15.0	20
Medical equipment, total	**1,780.5**	**1,969.7**	**2,196.3**	**3,023**
Diagnostic, total	1,083.0	1,191.8	1,316.0	1,854
Tomographic X-ray	160.0	200.0	210.0	240
Other X-ray	625.0	650.0	725.0	1,000
Electroencephalographs	14.0	15.0	16.0	19
Electrocardiographs	39.0	44.0	48.0	62
Ultrasonic scanners	78.7	98.4	123.0	300
Automated blood analyzers	87.3	99.4	105.0	134
Scintillation cameras and counters	64.0	69.0	72.5	81
Audiometers	15.0	16.0	16.5	18
Patient-monitoring systems	160.0	166.0	175.0	188
Prosthetic, total	415.4	461.2	534.5	738
Hearing aids	135.4	144.2	153.5	182
Pacemakers	280.0	317.0	381.0	556
Therapeutic, total	87.9	109.8	124.4	175
X-ray	30.7	43.4	48.2	56

(millions of dollars)	1978	1979	1980	1983
Diathermy, shortwave and microwave	9.4	10.4	11.7	15
Ultrasonic generators	12.0	13.2	14.1	17
Defibrillators	35.7	42.8	50.4	88
Surgical support, total	34.2	40.9	46.4	68
Blood-flow meters	10.0	11.1	11.6	14
Blood-pressure monitors	11.4	13.7	16.4	27
Surgical lasers	12.8	16.1	18.4	27
Lasers and related equipment, total	**89.5**	**103.3**	**116.3**	**162**
Gas lasers	32.0	38.1	43.8	68
Semiconductor lasers	6.0	7.0	8.0	11
Other	23.0	25.0	27.0	31
Laser power supplies	20.0	23.0	26.0	34
Modulators	8.5	10.2	11.5	18

FEDERAL ELECTRONICS

(millions of dollars)	1978	1979	1980	1983
FEDERAL ELECTRONICS, TOTAL	**18,210**	**20,112**	**22,222**	**27,389**
Defense, total	**16,487**	**18,291**	**20,257**	**25,054**
Procurement, total	7,932	8,746	9,705	12,257
Communications and intelligence	1,317	1,374	1,525	1,921
Aircraft, related ground equipment	2,212	2,311	2,557	3,221
Missiles and space systems	2,541	2,857	3,163	3,985
Mobile and ordnance	471	544	610	762
Ship and conversions	1,391	1,660	1,850	2,368
Research, development, test, and engineering	5,440	6,275	6,922	8,514
Operations and maintenance	3,115	3,270	3,630	4,283
NASA, total	**818**	**845**	**887**	**996**
Transportation, total	**421**	**452**	**501**	**632**
FAA procurement	247	267	296	384
FAA research and development	111	121	135	172
Highway and transit systems	63	64	70	76
Health and Education agencies, total	**397**	**425**	**468**	**554**
Education systems	111	112	118	131
Health-care electronics	286	313	350	423
Department of Energy, total	**87**	**99**	**109**	**153**

CONSUMER ELECTRONICS

(millions of dollars)	1978	1979	1980	1983
CONSUMER ELECTRONICS, TOTAL*	**11,984.9**	**12,657.6**	**12,791.8**	**16,489**
Television receivers, total	**4,220.2**	**4,133.2**	**3,890.4**	**4,628**
Black-and-white	542.4	556.2	518.4	539
Color	3,677.8	3,577.0	3,372.0	4,089
Consumer audio equipment, total	**4,082.2**	**4,015.1**	**3,684.1**	**4,564**
Radios, total	1,012.0	962.5	896.0	1,151
Table, clock, and portable	480.0	482.5	450.0	570
Automobile	532.0	480.0	446.0	581
Phonographs and radio-phonographs	492.4	471.9	453.1	548
Tape recorders and players	1,158.8	1,170.7	1,010.0	1,305
Hi-fi audio components	1,252.0	1,260.0	1,205.0	1,425
Hi-fi audio consoles	167.0	150.0	120.0	135
Other consumer electronics products, total	**3,682.5**	**4,509.3**	**5,217.3**	**7,297**
Antennas, TV, and radio	125.0	122.0	119.0	127
Home video players/recorders	251.5	336.6	417.0	638
Home video cameras	30.0	53.0	67.0	117
Video projectors	150.0	180.0	207.0	640
Electronic organs, other instruments	395.0	441.5	480.0	530
Intrusion alarms	200.0	235.0	255.0	450
Microwave ovens	904.0	1,045.0	1,082.0	1,522
Smoke detectors	73.0	87.5	98.0	115
Telephone-answering devices	72.5	88.0	115.0	195
Electronic games, total	284.0	606.7	1,032.3	1,453
Video games	105.8	110.0	137.5	211
Nonvideo games	148.9	417.8	746.7	995
Electronic toys	29.3	78.9	148.1	247
Calculators, hand-held	662.5	675.0	690.0	708
Electronic watches	470.0	564.0	570.0	682
Digital clocks	65.0	75.0	85.0	120

*Includes domestic-made equipment, off-shore products sold under U. S. labels, and domestic- and foreign-label imports.

EUROPEAN MARKETS

□Only a foolhardy forecaster would care to review the economic predictions for 1980 made a decade ago. Since reality almost always falls short of aspiration, the shortfall between real growth during the 1970s and the 5.5% average annual growth a lot of highly regarded forecasters said was in store for Western Europe is not surprising. The actual figure will be something like 3%.

Yet who can fault the forecasters? All their predictions went by the boards when the oil-producing countries quintupled their prices for crude oil nearly seven years ago. The skyrocketing energy prices sent country after country into decline; and because most Western European countries were beset by inflation, their governments could not counter the downturn through massive spending. Jittery currency markets and a wave of competitors from the Far East further skewed the growth curves.

None of these major economic bedevilments can be banished in short order. What's more, the explosive conditions in the Middle East compound the uncertainty that taints the business outlook today. So there is practically no chance that the plots of gross national product will bend upward this year. In fact, most forecasters figure to see further erosion of growth, whittling the 3% rise logged last year in GNP by Western European countries as a whole down to less than 2.5% for 1980.

Still, no one is talking about dire times. West German officials predict growth of 2.5% for their country's economy this year. To be sure, that figure is well below the 4% registered for 1979, but is enough to ensure a passable year, at least, for the dominant economy in Western Europe. France, number two, presumably will wind up with only a barely adequate gain of 2%. Italy, the way things look at the moment, will fare even worse, dropping below 2%. Worst off will be the United Kingdom, where Margaret Thatcher and her fellow Tories will have to cope with a shrinking economy—negative growth between 1.5% and 2%. The only relief from the overall drabness shows up in Sweden, which for the second year in a row should rank as Western Europe's fastest growing economy with back-to-back increases of slightly more than 4%.

Conditions have certainly changed, for what rates as the best GNP growth as the 1980s get under way would have been considered a lackluster performance a decade ago. One thing that still has not changed, though, is the ability of the electronics industries to pull something out of the hat that creates new markets. Obviously, sales of electronic equipment and components cannot surge this year as they would with a balmy business climate. Yet, as always, they will outstrip the growth of the economy overall, this year growing nearly five times as fast, according to *Electronics* annual survey (see chart, p. 147).

Conducted in October and November 1979, the 11-country survey forecasts equipment markets for 1980 at \$44.37 billion and components markets at \$10.39 billion, with a falling growth rate for both. Equipment markets last year rose 11.5% to \$40.50 billion, whereas the forecast for 1980 works out to only a 9.6% gain. A quick glance at the charts explains the stunted growth. Near-stagnant markets for color TV sets have reduced consumer electronics, once the pacesetter, to an also-ran. Fortunately a healthy gain in the computer sector will help offset this drop.

As for components, they edged up 6.8% last year to reach \$9.84 billion. This year's rise is forecast at 5.6%. Again, put the blame mostly on color TV, whose fate weighs heavily on components and on discrete semiconductor totals. By contrast, another year of strong growth seems in the offing for integrated circuits—up 14% to \$1.79 billion.

It must be pointed out that figures in the survey chart tend to magnify the real rise in markets because participants were asked to estimate national markets for equipment and components in local currencies at current prices. These estimates were converted into dollars at the exchange rates in effect in mid-November 1979 (see exchange rate table). No attempt has been made to adjust estimates for inflation, so the market figures include outright price rises as well as market growth.

WEST EUROPEAN ELECTRONICS EQUIPMENT MARKETS
(millions of U.S. dollars)

	1978	1979	1980
West Germany	11,226	12,271	13,170
France	7,939	9,003	9,960
United Kingdom	5,687	6,536	7,354
Italy	3,621	4,131	4,584
Benelux	2,650	2,921	3,219
Scandinavia	2,217	2,432	2,700
Spain	1,937	2,069	2,190
Switzerland	1,053	1,132	1,193
Total	36,330	40,495	44,370

MARKET REPORT EXCHANGE RATES
(The rates below are the ones used to convert European currencies into U.S. dollars)

Belgium: 29 francs/dollar
Denmark: 5.3 kroner/dollar
France: 4.2 francs/dollar
Italy: 830 lire/dollar
Netherlands: 2 guilders/dollar
Norway: 5 kroner/dollar
Spain: 66 pesetas/dollar
Sweden: 4.25 kroner/dollar
Switzerland: 1.65 francs/dollar
United Kingdom: 48 pence/dollar (1 pound = \$2.05)
West Germany: 1.8 marks/dollar

COMPUTERS

Small-business users raise hopes for big sales

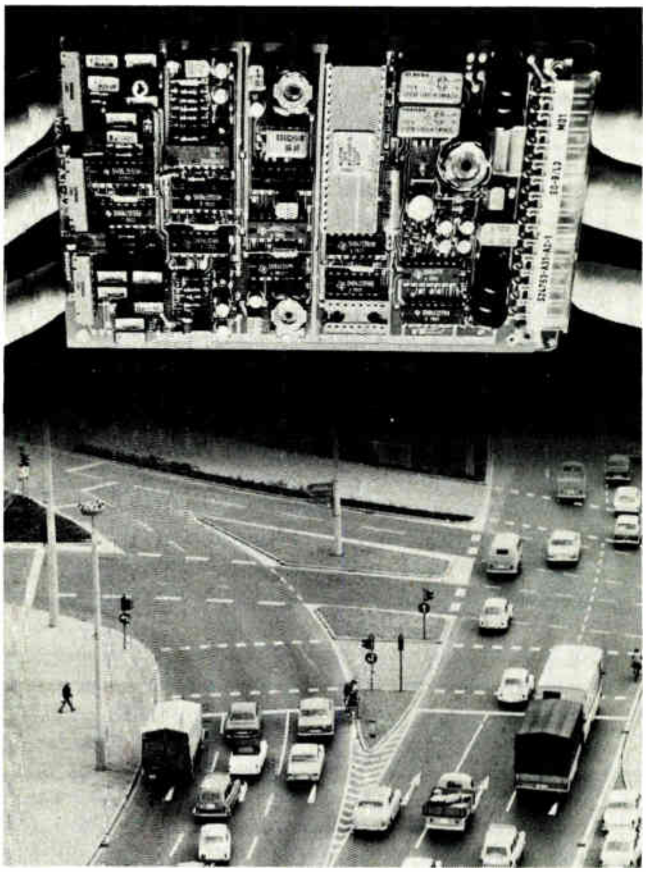
Computer makers traditionally have managed to keep turning up new customers even when the economy overall is faring poorly, and 1980 won't be the exception that tests the rule. For example, the market in the UK is in surprisingly good shape in view of the economy, according to Terrence Stones, director of planning for Honeywell Information Systems Ltd. in Great Britain.

And what is in good shape in Britain, where the economy is on the decline, most likely is in better shape elsewhere in Western Europe. Markets for computers and related equipment this year are forecast to score a strong 12.7% gain to $15.73 billion. Good as it is, it must be pointed out, this increase pales when set alongside the estimated gain for 1979, which ran 15.1% and carried the sector to $13.95 billion. Nonetheless, computer people—except perhaps in Spain—remain optimistic.

For one thing, there are still tens of thousands of potential first-time small-business customers that sooner or later will fit themselves out modestly with data-processing hardware. In Italy alone, for example, more than 30,000 companies employing more than 20 people each still have to take their first fling with computers, according to Honeywell Information Systems Italia SA. For another, once hooked with a basic system, the first-timers almost inevitably migrate upward into the minicomputer and small-system markets. So there is no trouble understanding why minicomputer markets next year are slated to bound up 22.8% to $1.61 billion, according to *Electronics*' survey. For small systems, the rise is forecast at 17.9%, which would send this sector to $2.6 billion.

There is a respectable rise in sight for medium systems, too. Here replacement markets have been bolstered by computer giant IBM, which sets the tone in Western Europe as well as in the U. S. because of its dominant market share—better than 60%. IBM muscled in on European competitors over the past year or so by revamping its product line. The Series 4300 machines, particularly, brought a vast advance in price/performance over the System 370 machines they supplant. The native competitors—notably International Computers Ltd. in Britain, Siemens AG in West Germany, and CII-Honeywell Bull in France—cut prices to follow suit, inspiring computer users to upgrade their systems. The medium systems markets, then, figure to move up by at least 10% this year.

All the same, large systems have not had the early demise that some analysts were predicting for them a few years ago. "Especially in 1979, the large systems market performed well and it will certainly expand in the future," says Jochen Rössner, a market specialist at Sperry Rand Corp.'s Univac division in Sulzbach, West Germany. Anton Peisl, head of Siemens Data and Information Systems in Munich, supports this view. He figures that Western Europe's markets for large machines will grow about 10% annually. Three factors, Peisl notes, will influence computer markets in the decade ahead: stand-alone systems will increasingly be replaced by computer networks; emphasis will shift to real-time processing; and the market for large computers will expand substantially. Peisl also anticipates that the annual price drop for data-processing systems in the 1980s will be more like 10% than 5%.



Microcomputer highway. One of the many new uses of microcomputers is in traffic control. Shown above is a Siemens-made microcomputer board used in a system that controls the traffic lights in a West German city. Other countries are installing similar systems.

CONSUMER

Sated market seeks new product relief

Television sets glare and hi-fi sets blare in so many Western European households these days that consumer electronics manufacturers can count on precious little growth this year. Once the pacesetters, the electronics industries' biggest money generators, they have become the stragglers, surpassed by the computer and office equipment makers.

This year, sales of consumer electronic hardware in the 11 countries covered by the survey are forecast at

$13.78 billion. That is a scant 4.7% over the $13.16 billion estimated for 1979, when the growth was also meager, at 5.6%.

Until a new product comes along to do for this sector what color TV did through the mid-1970s, consumer electronics markets will dawdle, albeit at a high level. Except in France, where color TV got off to a late start, all the countries of Northern Europe have run through the curve that describes a consumer product life cycle. Set sales this year in Western Europe will run about 10.5 million units, figure officials at Grundig AG, West Germany's largest entertainment electronics producer. With the market literally over the hump, they say, sales will edge up only to about 11.1 million sets by 1985.

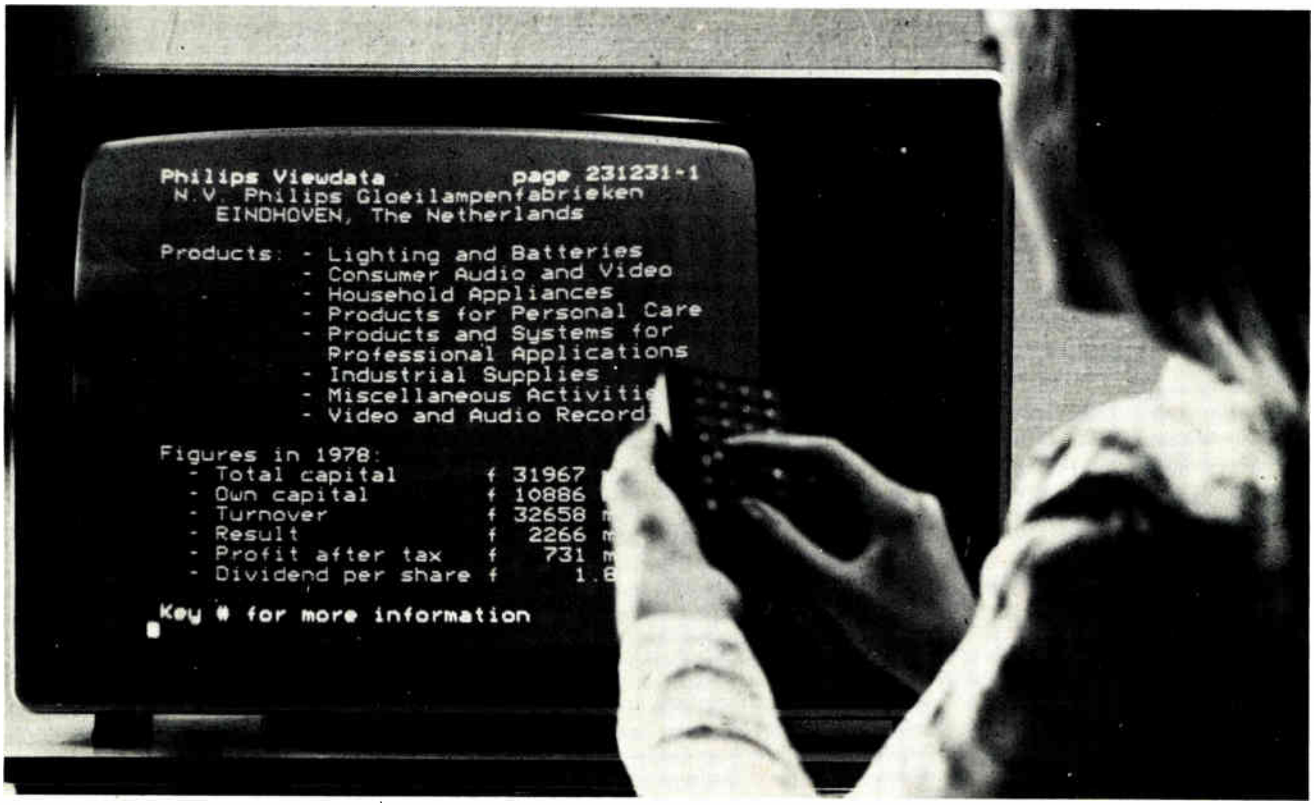
To make matters worse, the hi-fi markets, the second major sector in entertainment electronics, are also approaching the down slope. "We will be at the top of the elbow in two or three years," estimates Jo Jongenheel, an economist at the central market research department of NV Philips Gloeilampenfabrieken in Eindhoven, the Netherlands. The survey suggests hi-fi markets of $1.84 billion this year, a gain of 9.3%.

Even stagnant, the $7.48 billion Western European color TV market looks tempting to Japanese set makers, who have long since learned to make do in their own flat domestic market. On the northern flank, they have already moved strongly into the UK. There, Sony Corp., Matsushita Electric Industrial Co., and Mitsubishi Electric Corp. have plants, and Aiwa Co. plans one. Hitachi Ltd. and Toshiba Corp. have also settled in through joint ventures with the General Electric Co. and the Rank Organisation, respectively. On the southern flank, Sony Corp., Sanyo Electric Co., and Sharp Corp. have taken control of set producers in Italy and Spain.

Through their European plants and through imports, Japanese producers have already captured the small-screen market. The Europeans are out of small-screen production, laments Lüder Beeken, head of the Consumer Electronics division of Philips GmbH, a West German subsidiary of the giant Dutch group. An even stronger Japanese presence seems certain in the early 1980s, when the patents for the West German phase-alternation-line (PAL) color system expire. The licensing arrangements for PAL patents barred Japanese set makers from selling large-screen sets in Europe earlier, but now their chance has come.

The added Japanese competition will accelerate the winnowing out of weak color TV producers that has been going on for the last few years. Few small companies have managed to hang on—Norway's Tandberg Radio A/S was the latest casualty and even large producers have had to slip under the wing of industry giants to survive. Philips, for example, has bolstered Grundig by taking a substantial holding in the West German company. France's Thomson-Brandt SA, which numbers the West German set market Norddeutsche Mende Rundfunk KG (Nordmende) among its subsidiaries, at year-end seemed a strong candidate to take over the color TV activities of ailing AEG-Telefunken. The two companies have already melded their color tube activities.

"A big battle for market shares is on at the moment," says Jongenheel, speaking of color TV. The same can be said for video cassette recorders (VCRs), one of the new wave of products set makers hope will get their business



Terminal services. New telecommunications services like viewdata seen on this Philips home/business terminal with remote keyboard, plus the still-growing traditional services using standard telephone sets, assure strong markets for European hardware makers.

growing strongly again. The market, really just getting started, will burgeon this year. The survey forecasts 1980 sales of $516 million, a near 50% spurt over last year's $348 million. Looking even further ahead, market watchers at Grundig forecast that sales of VCRs will bound up from 700,000 units this year to something like 2.4 million by 1985.

At first glance it looks good, but numbers are only part of the story. Only 18 months ago, Philips and Grundig had the West European market—albeit small—practically to themselves. Since then, the Japanese have invaded and now have about a 60% share. To recapture some ground, the two are counting heavily on their jointly developed Video 2000 VCR, which has eight hours of playing time on a reversible cassette. Volume production is about to start.

Other new-wave products like video cameras and nonvideo electronic games do not yet amount to much. But it is worth noting that one chip supplier figures that some 100,000 TV receivers with telextext decoders will be produced in the UK this year, along with another 50,000 for viewdata.

COMMUNICATIONS

Digital exchanges, military systems to boost sales

The word from communications gear producers these days is that business is booming—or almost. The national networks still have a lot of lines to add to keep pace with the demand for telephones and teletypewriter; more and more of them each year are tied to computer-controlled, semielectronic exchanges or even fully electronic digital time-division switches. On top of this solid base, there is additional business piling up as new services of all sorts go on line.

What's more, the way the *Electronics* chart keeps score of markets, a lot of military hardware like radar, navigation aids, and radio equipment gets counted in the communications category. That adds another solid increase in growth to this market.

All told, the communications sector spurted 18% last year to reach $8.21 billion. Another strong year is in sight for 1980. The forecast is for growth of 12.7%, which means a market of $9.26 billion.

Although the Commission of the European Economic Community in Brussels has started a drive to force its nine member governments to open up their telecommunications market to suppliers from member countries, the marketplace remains compartmented and will for a long time. The 1980 outlook varies from country to country. France, the UK, and West Germany should run strongest. Italy and Spain, whose telephone networks are strapped for investment capital, will fare poorest.

France will no doubt be the most exciting market to watch this year. "The network is growing at the rate of 2 million lines per year, with 70% of them digital," says Jean Sytrota, director of industrial and international affairs at the Direction Générale des Télécommunications (DGT), the agency that runs the telecommunications network. Spending for semielectronic and electronic telephone exchanges, as a result, should bounce up to $678 million this year; the 1979 figure was $595 million.

The heavy spending for electronic switching equipment will taper off after 1982, the DGT's target date for having 20 million lines in service. But the two major native producers of telephone equipment, CIT-Alcatel, a subsidiary of the Compagnie Générale d'Electricité, and Le Matériel Téléphonique Thomson-CSF, a unit in the Thomson-Brandt group, should continue to run strong from the export contracts they picked up last year. And by then, the innovations in "télématique" that the DGT will begin trying out this year could well have evolved into money makers. The communications sector for France as a whole rings in at $2.76 billion, up 10% from an estimated $2.51 billion for 1979.

The outlook is just as good in the UK. There, telecommunications equipment makers have not had it so good in years. A spurt for exchange equipment on the market chart—to $500 million this year—reflects the fast mounting output of semielectronic TXE-4 gear. All three major suppliers to the British Post Office (BPO) are participating—the ITT subsidiary Standard Telephone & Cables Ltd., Plessey Telecommunications Ltd., and GEC Telecommunications Ltd. At the same time, all three are gearing up for System X, the all-digital network the BPO has in mind. The post office has ordered 8 exchanges out of a first batch of 25. By the mid-1980s, System X business should be running at $400 million per year.

But switching gear alone does not a telecommunications network make. The advent of System X means a big buildup in pulse-code-modulation business, points out Norman Manners, a director of Plessey Telecommunications. Data communications is also thriving, as are private branch exchanges. *Electronics*' survey, then, tells the rest of the story in numbers: it forecasts that UK communications equipment markets will jump 20% this year to reach $2.17 billion.

West German communications equipment suppliers expect a solid rise, too, but nothing like the jump in store for the British. The survey sets the market at $1.95 billion, up 12.5% over last year's $1.73 billion.

TEST AND MEASUREMENT

No slowdown in sight thanks to microprocessor boom

Purveyors of test and measurement instruments in Western Europe by and large are convinced that 1980 will be their fourth strong year in a row. Their markets took a turn upward in 1977 and have been clocking good gains ever since. The forecast for 1980: a solid 11.5% gain that will carry the markets to $1.05 billion. The gain is just a shade lower than that estimated for 1979, when the rise was 11.7% on sales of $945 million.

"The question is, how long will it last?" remarks Henk

Bodt, deputy director of the Science and Industry division of NV Philips Gloeilampenfabrieken. No sensible person would try to answer that question in months or years. But Bodt and executives at other instrument companies now are convinced that a growing part of their business is isolated from downturns in the general business cycle because of the pervasion of electronic technology and the new instruments that have been spawned by the proliferation of microprocessors.

It is hard to see, for example, how sales of data-domain instruments could suffer a serious setback soon even though they bounded up some 26% last year and are forecast by *Electronics*' survey to bounce up another 28% this year to reach $49 million. The design departments of equipment manufacturers still have imperative needs for software-generating hardware ranging from single boards on up to sophisticated universal development systems. Furthermore, their after-sales service organizations have to upgrade their inventory to be able to maintain microprocessor-based equipment.

Another test and measurement market segment that continues to surge is automatic test equipment (ATE). As with data-domain instruments, equipment manufacturers have scant choice on whether or not to buy ATE. It is the only way to check out complex boards and systems. The survey chart reflects this situation. ATE logged a near 26% jump to $140.5 million last year and is forecast to rise another 25% this year to reach $175.5 million.

It's another story for conventional standard instruments like counters, timers, and oscilloscopes. Two of their major customer groups—the telecommunications equipment suppliers and the computer makers—are fairly well sheltered against a downturn in general business cycles. But that cannot be said for most other buyers, who can postpone purchases if their budgets are squeezed. Oscilloscope markets, for example, are forecast to rise only 6% this year.

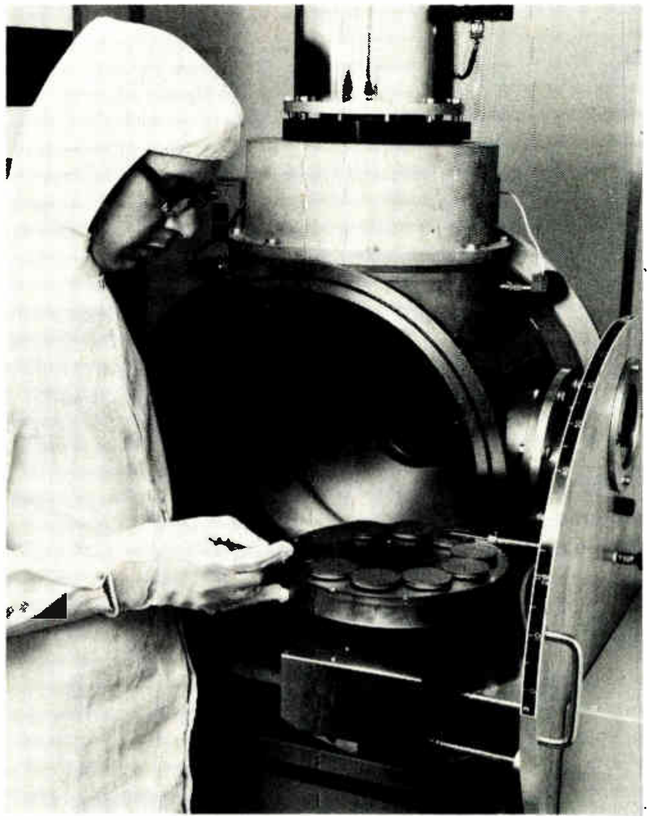
COMPONENTS

Suffering along with consumer market ills

Any year that finds Western Europe's entertainment equipment makers faring poorly translates into a mediocre year—at best—for the companies that supply them with components. The troubles that beset the color TV market, then, are mirrored in *Electronics*' survey of components markets.

The tally for all kinds of components used to produce electronic equipment runs to $10.39 billion for the year ahead. That works out to a 5.6% rise, which was not a particularly good year. Because color TV tubes account for roughly 70% of the tube business, this market seems slated for no gain. A very slight increase—just under 3%—is the lot predicted for discrete semiconductors. Passives should do a little better, although price rises mask an insignificant real gain.

That leaves integrated circuits, which are doing very well, thank you. "We see a scenario with no recession in Europe for 1980 and very heavy demand from the telecommunications and computer sectors," observes Dedy Saban, European director of marketing for Motorola Inc.'s Semiconductor Group. "As far as we can tell from close checks at distributors, inventories are normal and double-ordering is limited," he adds.



Emerging memories. The market in magnetic-bubble memories is still in its infancy in Western Europe, but the UK's Plessey Microsystems has invested in them to stake out a market position. Here a technician loads garnet slices into a ion-milling machine.

Much the same theme, with variations, is sounded by the other heavyweights in the business. What is more, prices for reasonably mature products like low-power Schottky (LS) logic, TTL, and static 4-K random-access memories have been edging upward in recent months. That is one sign of a lusty market; the leap forward in technology for microprocessors and memories is another good sign.

The gain of 14.1% forecast for ICs in the components column for 1980, lifting the markets to $1.79 billion, may look low a year from now. If it does, history will be repeating itself. Twelve months ago, semiconductor makers had just wound up a year when their IC markets had grown by some 16% and figured the growth curve had to turn down in 1979 for cyclic reasons. Actually, it rose again slightly. *Electronics*' survey puts Western Europe's IC markets last year at $1.59 billion, up 17.1% over the 1978 figure of $1.34 billion. Such are the hazards of the forecaster's trade and such are the blessings of supplying semiconductors to industries like computers and telecommunications that can wax even when the general business cycle wanes. □

JAPANESE MARKETS

□Japan came through the first oil crisis in 1973–74 relatively unscathed, but the second one seems to have sent it reeling. A shortfall in supplies appears inevitable. Increased oil prices and fears of further OPEC price increases have fueled a decline in the value of the yen, from a high of 176 to the dollar in October 1976 to around 250 in November 1979—a drop in purchasing power of 29%.

The falling power of the yen increased the prices of the many commodities that Japan must import, setting the stage for inflation. While conventional wisdom says that a lower-priced yen should make for larger exports, its major trading partners are not expected to stand idly by and let Japan increase its share in their markets.

Meanwhile, it has become apparent that the Japanese government can no longer finance its operations by the sale of deficit bonds. In a few years there will be no hope of repaying interest—let alone principal—if the national debt continues its current rate of increase.

So pump priming is now out of the question, and either social services will have to be reduced or new sources of taxation found. The threat of new consumer taxes was a major factor in the poor showing of Prime Minister Masayoshi Ohira's Liberal-Democratic Party in a midterm election that he called for the purpose of enlarging his party's majority. New taxes on business are also possible and could worsen the poor economic climate. Last year the GNP probably missed its goal of 7% growth by 1% or 2%, and 1980's GNP growth could even be smaller than last year's, some economists are warning.

Furthermore, the Prime Minister's shaky regime is beset by an unprecedented split in the ruling Liberal-Democratic Party. Well before the expiration of his government's mandate, he was barely able to remain in office when the dissident factions of his party demanded that he resign to take responsibility for loss of seats in the special election. He has had to pass out cabinet positions to dissident party members and is still not out of trouble. A recession would certainly do nothing to help Ohira's cause.

As for the electronics markets, growth is easily better than the GNP, but the improvement is now by a single digit only. In the important consumer sector especially, the fear of recession plus higher prices may restrain the Japanese consumer's usual urge to buy the latest products. Double-digit growth these days is limited to hot products such as MOS logic circuits, data-storage devices, and video cassette recorders.

Electronics' 10th annual survey of Japan's markets pegs total domestic equipment consumption this year at $20.7 billion, an 11% increase over 1979. Total components consumption domestically, including passive devices and semiconductors, should increase by only 7% in 1980, from $6.88 billion to $7.39 billion.

As in the U. S. and Western Europe, the consumer sector is faltering in Japan with a virtually flat growth trend expected this year. On the other hand, the data-processing market should bound upward in 1980 to a total (including office equipment) of $7.9 billion, or a gain of 18.5%.

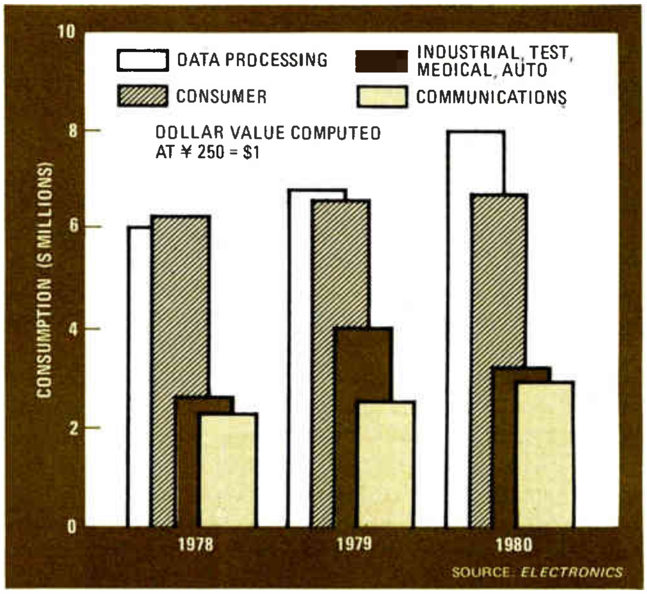
CONSUMER

Tape—video and audio—keeps sales on track

Tape—that's the hope for Japanese consumer electronics this year and perhaps for the next several years. The *Electronics* market survey shows more than a 20% increase in sales of video cassette recorders to $516.2 million, which brings the market size to about one quarter that of the huge color television segment. On the audio front, the advent of metal tape is spurring sales of the new home stereo decks and compact portable cassette recorders needed to record and play it.

Color TV, which accounts for almost a third of the Japanese consumer market, had its best year in 1979, with sales of about 6.3 million sets. People flocked to buy expensive 18- to 26-inch sets (mostly 20 in.) with built-in capability for receiving multiplexed sound—stereo or bilingual—as this form of programming spread across the nation. These sales mainly replace sets purchased during the good years just before the oil crisis.

Rising prices have not posed a threat to small-screen



Above it all. Like Mount Fuji, the Japanese electronic equipment markets will easily rise above the general economy this year. While the consumer sector will not be a big performer, the data processing and the communications markets will log healthy growth.

One bright picture. Even though color television and hi-fi audio markets were unexciting, video cassette recorders were moving rapidly as dealers sold 650,000 units like this low-priced Sharp model. This year consumption of VCRs should be $516.2 million.

receiver sales, however. Manufacturers sold about the same number of 13- and 14-in. sets as of large-screen models, but prices were less than half those for the large units. Some of these small sets went at such low prices that it appears they were being made only to keep the plants running. Overall, domestic consumption of color TV sets this year will be a flat $2.12 billion. Black-and-white TV consumption will drop from $67.2 million in 1979 to $61.4 million in 1980, according to the *Electronics* survey.

Last year marked a big surge forward in the sales of video cassette recorders, with retailers moving the 140,000 or 150,000 that they carried over from the previous year and manufacturers shipping an additional half million units. This year manufacturers' domestic shipments should exceed 650,000 units, worth a total of $516.2 million. However, production is at a much higher level because the export market is more than three times as large as the domestic market.

Although 4-hour models in the video home system (VHS) format and 3-hour extended-playing tapes on Betamax-format units were not offered in Japan, Matsushita Electric Industrial Co., Victor Co. of Japan Ltd., and Hitachi Ltd. have started sales of a 6-hour VHS model. And Sanyo Electric Co. has introduced a 3-hour Betamax model with 4½-hour extended-playing tape. Others could join this competition if need be.

Meanwhile, a latecomer to the VCR competition, Sharp Corp., muddied the waters by bringing out an economy model priced at only about $632, by far the lowest list price anywhere. Two-piece portable VCRs are catching on after a slow start [*Electronics*, June 7, p. 70].

Cameras registered an increase in sales value of more than 63% last year, reaching $38 million, and predictions are for an increase of better than 16% this year. The number of units will increase at a greater pace, though, because there are now economy models at $552—first introduced by JVC—in addition to the standard models priced at about $720 and higher. In about two or three years, major manufacturers expect to replace the vidicon of present cameras with charge-coupled-device or MOS image sensors, which will make for more convenient size and weight.

Sales of audio cassette recorders increased almost 15% last year and tape deck sales almost 10% as consumers bought new units to play metal tape. The rise will be more moderate this year. Sharp came out with a large radio cassette unit with two tape mechanisms for dubbing purposes and expects other manufacturers to design similar units. Radio-recorder combinations will continue to be popular, growing to $487.8 million.

In the hi-fi market, modular units are the fastest-growing segment but, because the price is low, the share of total dollars is still low. Also growing in both the youth and middle-age markets is compact component stereo, which some buyers augment with larger speakers for better sound. A previous audio star, system component stereo, is growing at a lower rate now, while the deluxe component business is practically stagnant. Total hi-fi component sales picked up the beat again last year, jumping 6% to $758.3 million. According to the *Electronics* consensus, this year's total should hit $788.8.

Surprisingly, microcomputers are used only on high-end electronic cooking ranges. Instead, manufacturers are mostly busy adding features such as browners and ovenlike heaters. Although there is now a replacement market for units sold eight to ten years ago and the diffusion index is only 30%, manufacturers cannot seem to find the key to bigger sales. Growth will be a moderate 3% this year to $338.6 million.

The steam appears to have gone out of the $150 million calculator market. Something like 55 million units were sold in the past five years and almost everybody who wants one has one, it seems.

Sharp Corp.'s Calculator division should pick up new business with its Japanese-English translator and also with a calculator featuring voice output. Hitachi will sell a numerical problem dictation unit for practice on the soroban (the Japanese abacus) and a clock radio with speech output. Indeed, synthesized speech products may span the consumer product spectrum in the coming year.

COMPONENTS

Microprocessors slowing, MOS logic still glowing

In the semiconductor market, integrated circuits continue to lead the action, with sales this year forecast at more than double those of the lackluster discrete segment.

Electronics' survey shows that the domestic market for ICs grew by more than 23% in 1979 and will gain almost 16% in 1980. Microprocessors, with a leap of 64%, and complementary-MOS logic circuits set the pace in 1979. Microprocessor growth will slow to 6% in 1980. This deceleration is partly because capacity is limited, partly because prices are falling, and partly because easy markets—like those for air conditioners and TV tuners—have been taken on first.

The next big spurt in microprocessors may come in 1981 when microprocessor control is added to popularly priced 1982 model automobiles—8-bit versions for engine control and 4-bit versions for dashboards. Processors with more than one chip will be required for engine control, though. Additional chips will be needed for analog-to-digital conversion and for read-only memory.

New microprocessors are being developed for specific applications, including more low-power C-MOS chips. While it will not be specific, Nippon Electric Co. intends to market a 4-bit and an 8-bit microprocessor of its own design this year, as well as its version of the Intel 8086. Meanwhile, Hitachi Ltd. will be a second source for the 16-bit Motorola 68000.

This year much of the growth will come in C-MOS logic for both consumer products and digital terminal equipment, bipolar logic for peripheral equipment and mainframes, and linear circuits for consumer products. MOS and C-MOS logic will jump 34% to $184.9 million this year; bipolar logic will gain 19% to $223.7 million; and linear ICs will grow 21% to $356.3 million.

Memory devices are production-limited, despite Japan's well-publicized inroads on export markets. Much of the capital investment is going for fine-pattern 64-K dynamic random-access memories and 16-K static RAMs, but capacity will not increase rapidly. Some two-power-supply 64-K dynamic RAMs will be built initially for in-house use. The mainstream, however, will be designs with pin 1 unconnected.

Three companies have staked out different positions in the 16-K static RAM business, and all will get business because demand exceeds supply. Mitsubishi Electric Corp. backs moderate-speed H-MOS; Hitachi, high-speed C-MOS; and Toshiba Corp., moderate-speed C-MOS.

Hitachi and Fujitsu Ltd. are slugging it out in erasable programmable read-only memories for a market that will include 16-K and 32-K types this year. Hitachi will supply parts with both TI and Intel pinouts and later this year will offer an electrically erasable PROM.

The magnetic-bubble memory market has barely opened, but Hitachi claims to be number one or two worldwide on the strength of the 64-K chips it produces for Nippon Telegraph and Telephone Public Corp. However, since MOS RAM prices will be coming down, Hitachi says 1-megabit and perhaps 4-Mb devices will be necessary for bubbles to be cost-effective.

COMPUTERS

New families introduced to battle IBM 4300 series

The strain of waiting for IBM Corp.'s 4300 series, along with the lower prices that the 4300 triggered, reduced growth in the data-processing sector last year to 3.66%. But business should pick up this year as deliveries start for competing models announced in rapid succession by Nippon Electric Co., Fujitsu Ltd., Hitachi Ltd., and Mitsubishi Electric Corp. The industry consensus is that the domestic market will grow this year by 10.2%, to $3.92 billion—a good gain albeit far below historical levels.

Nippon Electric started the competitive race late in 1978 by announcing its System 100 microprocessor-based business computer, along with its N4700 distributed processing system competitive with IBM's 8100 line. Then NEC was quick off the starting line in February with the ACOS 250, which enables it to compete with IBM's System/38 and the low end of the 4300 series. It took until October, though, for the company to extend its line with the ACOS 350, 450, and 550 for capability competitive with that offered by the 4300. Mitsubishi was also quick with a March unveiling of its Cosmo 700, which competes at the top end of the 4341.

Fujitsu and Hitachi, which cooperated to develop software similar to IBM's, announced their entries in April and June. Fujitsu introduced the Facom M-130F, -140F, -150F, and -160F. Hitachi calls its entries the Hitac M-140H, -150H, and -160H.

Although the systems business itself was slack last year, peripheral and terminal equipment for old and new systems did well. Growth was almost 12% last year, with a forecast of 18.8% this year.

The star performers—data-storage devices—climbed 44% last year and another 49.8% is predicted for this year. Not far behind is data-terminal equipment, with growth of almost 28% last year and more than 30% predicted this year. Also showing gains on the order of 20% each year are the smaller categories of data-entry equipment and data-output equipment.

Although not listed as a separate category, there has been explosive growth in systems that include handling kanji, or Chinese characters, needed to write natural Japanese prose. These systems, which also contain Japanese kana syllabary and alphanumerics, have become practical with the advent of low-priced ROM character generators that store several thousand characters with a dot matrix of anywhere from 18 by 18 to perhaps 32 by 32. Many small business systems cut corners by including only several hundred characters that appear with great frequency. So important are kanji systems for the Japanese market that giant computer manufacturer IBM last year introduced them separately for its mainframes and for its System/34. Other major American companies say they are developing similar systems. In fact, the lack of kanji handling capability could become an obstacle to the importing of American data-processing products to Japan.

Operating systems and software for handling data bases and Japanese-language peripherals are considered so important by the Japanese government that it started a five-year software and peripherals development project last year, just as the famous VLSI project was winding down. The project is financed half by government, half by industry. The government budgeted $80 million for basic software and $14 million for peripherals. Last year's allotment from the government was $5.8 million for software and $1 million for peripherals. This year the Ministry of Finance will request $20.82 million for software and $3.5 million for peripherals. Among the important goals of this project is to develop methods of kanji input suitable for nonprogrammers.

COMMUNICATIONS

Analog and digital nets still going strong

The telecommunications market grew by more than 10% last year and will grow by another 11% this year as the Nippon Telegraph and Telephone Public Corp. completes its analog networks and continues to build its digital networks. The 60-megahertz analog coaxial cable network is being completed and new frequency-modulation, frequency-division–multiplexing microwave equipment, with a capacity of 3,600 telephone channels per carrier, is being installed.

This year more than 100 space-division electronic exchanges will be installed for a growth of 12% compared with last year's 20% gain. Their central processing units have new large-scale integrated circuits that provide more than three times the performance of earlier exchanges. Next year should see commercial tests of exchanges with 64-K dynamic RAMs and 256-K bubble memory chips.

Two D-50 direct digital exchanges (DDX) have been installed and rate setting is all that is required before the start of service in Tokyo, Osaka, Yokohama, and Nagoya. This service is to be followed by packet service for Sapporo, Fukuoka, and Sendai. The D-50 exchanges for DDX are similar to the D-10 exchanges for analog service but have different speech paths and software.

This year five new types of electronic private automatic branch exchanges (EPABX)—the electronic successor to PBX—from NTT will compete against those offered directly by outside manufacturers. Both NTT and the competing manufacturers use space-division technology for their EPABX equipment.

Facsimile equipment will continue rolling along. Last year's growth rate of nearly 30% will be followed by another near 30% jump this year.

TEST AND MEASUREMENT

Steady growth despite currency fluctuations

The price advantage that the American test instruments companies had last year because of the falling value of the U. S. dollar has disappeared now that the exchange rate is back to about 250 yen to the dollar. So the drastic price cutting initiated by Yokagawa-Hewlett Packard Ltd., Sony Tektronix Corp., and others has stopped and tags have eased back up.

As a result, many customers will buy less equipment, though they will spend slightly more. The total test and measuring instruments sector should reach $346.7 million this year, compared with $321.8 million in 1979, a little more than a 7% gain, according to the *Electronics* survey.

The oscilloscope market keeps up its steady growth with an increase of almost 10% forecast this year. The market has become fragmented, however. Portable scopes keep replacing bench types. Iwatsu Electric Co., for example, introduced one rated at 350 MHz, and Matsushita Communication Industrial Co. introduced several lower-frequency types. Companies like Kikusui Electronics Corp. and Trio-Kenwood Corp., which formerly specialized in instruments for TV servicemen, now offer dual-beam scopes for operation up to 50 MHz. Hitachi and Toshiba have scope manufacturing operations that supply all but the highest-performance units to their own manufacturing firms. In addition they compete with other instrument manufacturers in the open marketplace.

Recorders continue their high growth rate with the chart showing better than 14% gains for both 1979 and 1980. In this group, Watanabe Instruments Corp. and others have created a hot new business in intelligent digital plotters for microcomputer output.

INDUSTRIAL

Replacement equipment comes to the rescue

Influenced by the energy crush, Japan's heavy industries are operating at a low level again this year as the government reduces public spending to hold down its deficit. Nevertheless, *Electronics*' survey shows that the process-control systems market will grow by more than 8% this year to $780.5 million.

Though there is also an upsurge in orders from chemical and petrochemical plants, the heaviest demand is for replacements. More than 10 years have passed since the peak of domestic plant construction, and companies must replace aging analog controls.

Replacement equipment often includes more sophisticated energy-saving and pollution-control units. In addition, there is more emphasis on supervisory computers and sequence control. And CRT consoles are replacing banks of instruments in large installations to lower manning requirements.

The market is rapidly switching to digital control systems. Hokushin Electric Works Ltd. predicts more than 60% penetration by 1985, while Yokogawa Electric Works Ltd. predicts 50% by 1983. Decreasing hardware prices and the need for flexibility and assured reliability for critical loops have led to the introduction of 8-loop and 1-loop controllers. These units can be mixed in any combination with 16- or 32-loop units and with analog units. Overall, the industrial electronics sector should struggle to a 5% increase this year, logging a little over $1.5 billion. □

JAPAN/EUROPE MARKETS FORECAST 1980

	JAPAN			WEST EUROPE		
	1978	1979	1980	1978	1979	1980
COMPONENTS, TOTAL (millions of dollars)	**6,217.5**	**6,880.9**	**7,393.5**	**9,206.5**	**9,836.0**	**10,390.8**
PASSIVE AND ELECTROMECHANICAL	**3,146.5**	**3,402.3**	**3,636.6**	**4,722.8**	**5,055.2**	**5,320.8**
Capacitors, fixed	631.0	662.7	684.4	946.8	1,008.1	1,037.6
Capacitors, variable	35.3	37.0	41.4	64.8	64.1	63.6
Connectors, plugs, and sockets	206.8	248.9	278.9	736.1	799.5	844.8
Filters, networks, and delay lines	7.7	9.8	12.6	109.9	115.8	122.2
Loudspeakers, OEM type	105.6	120.0	132.0	162.9	174.6	184.6
Microphones, OEM type	87.8	112.2	125.2	40.8	44.5	47.8
Microwave components	—	—	—	2.7	2.7	3.0
Potentiometers, composition	251.8	271.8	288.8	203.1	214.2	225.2
Potentiometers, wirewound	13.2	14.2	15.0	65.9	68.4	69.2
Printed-circuit boards	361.6	395.8	443.1	700.7	779.7	844.1
Quartz crystals (including mounts and ovens)	42.4	44.0	46.0	104.0	110.3	119.2
Relays (for communications and electronics)	328.4	350.0	370.8	381.2	402.3	423.0
Resistors, fixed (including wirewound)	174.3	189.2	202.2	329.4	334.2	342.9
Resistors, nonlinear	25.2	28.7	32.0	56.8	59.8	63.5
Servos, synchros, and resolvers	36.0	40.0	40.0	60.9	69.7	73.0
Switches	177.1	190.7	206.3	291.9	314.7	336.2
Transducers (pressure, strain, temperature, etc.)	12.3	16.0	19.6	—	—	—
Transformers, chokes, coils, TV yokes, and flybacks	650.0	671.3	698.3	464.9	492.6	520.9
SEMICONDUCTORS, DISCRETE, TOTAL	**829.3**	**841.7**	**855.4**	**1,072.8**	**1,121.1**	**1,153.8**
Microwave diodes, all types (above 1 GHz)	9.3	8.0	9.8	29.2	32.5	36.5
Rectifiers and rectifier assemblies	182.1	190.8	190.6	208.7	221.5	229.3
Signal diodes (rated less than 100 mA, including arrays)	102.0	100.5	100.5	93.9	96.8	99.3
Thyristors (SCRs, four-layer diodes, etc.)	69.8	72.0	75.4	128.9	136.2	141.2
Transistors, bipolar power (more than 1-W dissipation)	178.8	188.9	193.6	209.9	222.8	231.4
Transistors, bipolar small-signal (including duals)	214.1	207.8	201.4	291.1	291.4	289.5
Transistors, field-effect power and small-signal	28.3	25.7	33.8	25.5	29.3	32.4
Tuner varactor diodes	17.1	19.3	21.3	29.3	30.4	31.5
Zener diodes	27.8	28.7	29.0	56.3	60.2	62.7
SEMICONDUCTORS, INTEGRATED CIRCUITS, TOTAL	**1,289.6**	**1,590.0**	**1,838.0**	**1,336.6**	**1,566.3**	**1,788.3**
Hybrid ICs, all types	101.5	125.9	144.5	150.9	168.2	190.6
Linear ICs (except op amps)	276.6	294.6	356.3	286.9	309.7	338.3
Op amps (monolithic only)	32.1	40.4	46.9	61.5	70.3	79.1
Logic circuits, bipolar	167.2	188.0	223.7	254.3	299.1	330.2
Logic circuits, MOS and C-MOS	102.8	137.7	184.9	228.0	270.5	303.6
Memory circuits, bipolar	25.0	32.3	37.8	50.9	60.4	68.1
Memory circuits, CCD	2.5	5.3	7.7	—	—	—
Memory circuits, magnetic-bubble	2.4	18.1	20.8	—	—	—
Memory circuits, MOS and C-MOS (except microprocessors)	135.0	140.5	155.8	179.7	221.4	266.9
Microprocessors (includes CPU, memory, and I/O chips)	154.0	253.8	268.4	71.5	106.1	142.3
Calculator chip sets	98.0	101.1	103.1	3.0	2.8	2.7
Watch and clock chip sets	67.2	88.3	103.4	32.6	36.4	39.6
Other special-purpose circuits	125.3	164.0	184.7	17.3	21.4	26.9
SEMICONDUCTORS, OPTOELECTRONIC, TOTAL	**213.3**	**283.7**	**351.9**	**119.0**	**139.0**	**164.7**
Circuit elements (photoconductive cells, photodiodes, etc.)	35.4	42.8	50.2	38.7	44.1	52.5
Discrete light-emitting diodes	51.9	66.3	80.5	28.7	32.6	37.2
Image-sensing arrays, area (including CCDs and MOS)	—	2.8	5.2	—	—	—
Image-sensing arrays, linear (including CCDs and MOS)	—	4.8	8.0	—	—	—
Readouts	120.0	160.0	200.0	47.7	57.7	69.4
Photovoltaic (solar) cells	6.0	7.0	8.0	3.9	4.6	5.6
TUBES, TOTAL	**738.8**	**763.2**	**711.6**	**1,954.4**	**1,953.5**	**1,962.2**
Cathode-ray tubes (except for TV)	13.2	20.0	22.0	55.6	63.9	74.0
Camera tubes and image intensifiers	54.0	56.0	72.0	57.2	61.0	66.0
Photomultiplier tubes	4.8	5.2	5.6	29.3	30.7	31.7
Power tubes	120.0	118.0	120.0	251.2	268.6	289.2
Receiving tubes	12.0	20.0	12.0	64.5	58.4	52.2
TV picture tubes, black-and-white	49.6	44.0	40.0	85.1	72.5	64.4
TV picture tubes, color	485.2	500.0	440.0	1,411.5	1,398.4	1,384.7
EQUIPMENT, TOTAL (millions of dollars)	**16,884.7**	**18,606.2**	**20,705.4**	**36,329.5**	**40,495.1**	**44,370.2**
CONSUMER, TOTAL	**6,045.1**	**6,506.5**	**6,793.4**	**12,457.7**	**13,156.2**	**13,775.3**
Audio tape recorders and players	514.0	564.4	602.6	678.1	695.3	714.5
Citizens' band transceivers	8.8	9.1	10.0	138.9	83.4	41.7
Electronic ranges (microwave ovens)	312.7	327.8	338.6	—	—	—
Hi-fi equipment	714.8	758.3	788.8	1,521.6	1,680.1	1,837.1
Musical instruments (organs, electric guitars, etc.)	—	—	—	—	—	—
Phonographs and phono radio combinations	147.3	174.8	179.4	481.8	505.0	518.6
Pocket calculators (four-function, personal)	162.4	152.0	124.0	269.3	273.6	280.2
Radios (including car radios)	235.4	240.0	255.1	1,342.3	1,406.7	1,427.9
Radio/recorder combinations	411.6	472.6	487.8	619.5	679.8	733.0
Radio/TV/recorder combinations	69.3	70.9	71.5	—	—	—
TV sets, black-and-white	88.2	67.2	61.4	791.3	759.4	708.5
TV sets, color	2,041.1	2,118.6	2,124.9	6,037.9	6,286.4	6,481.6
Video cameras (for consumer use)	—	—	—	—	—	—
Video games	8.0	6.0	4.0	38.9	42.1	47.2
Video tape machines (consumer)	326.6	426.7	516.2	208.1	348.1	516.5
Watches and clocks, electronic	471.2	464.0	506.0	330.0	396.3	468.5

	JAPAN			WEST EUROPE		
	1978	1979	1980	1978	1979	1980
COMMUNICATIONS, TOTAL	**2,244.8**	**2,473.3**	**2,758.8**	**6,955.3**	**8,210.2**	**9,255.3**
Broadcast	100.5	115.0	133.0	219.8	240.4	259.7
Cable TV	52.0	56.0	56.4	11.5	12.4	13.3
Closed-circuit TV	73.2	95.5	126.7	180.5	197.5	212.5
Data communications	130.4	134.0	146.0	171.6	217.4	227.8
Facsimile terminals	174.7	226.9	294.0	13.0	19.1	28.5
Fiber-optic communications	—	—	—	—	—	—
Intercoms and intercom systems	43.2	46.0	49.2	132.7	142.3	150.7
Microwave relay	124.0	132.0	138.0	250.3	255.1	262.3
Navigation aids, except radar	63.6	66.8	69.5	598.2	683.8	754.8
Paging (public and private)	14.4	16.0	17.6	48.6	50.3	53.6
Radar (airborne, ground, and marine)	102.3	119.0	133.0	1,066.0	1,182.0	1,322.9
Radio communications (except broadcast)	500.9	522.8	557.2	1,428.6	1,606.3	1,773.7
Telephone switching, PABX[1]	16.8	25.3	37.8	430.4	601.9	839.7
Telephone switching, public[1]	283.6	323.2	362.4	1,203.1	1,722.2	1,999.6
Telephone and telegraph carrier	23.2	28.0	33.2	1,201.0	1,279.5	1,356.2
Video recorders and players (nonconsumer)	542.0	566.8	604.8	—	—	—
COMPUTERS AND RELATED EQUIPMENT, TOTAL	**5,953.6**	**6,676.1**	**7,914.4**	**12,116.5**	**13,949.0**	**15,732.2**
Data-processing systems, total[2]	3,427.6	3,553.1	3,915.4	6,853.6	7,936.3	9,053.0
Microcomputers (basic chassis value less than $1,500)	76.8	88.0	96.0	43.4	82.4	112.9
Mini (system value less than $50,000)	307.9	333.6	369.0	1,008.1	1,310.1	1,609.4
Small (up to $420,000)	384.7	467.0	522.5	1,847.1	2,233.2	2,634.8
Medium (up to $1,680,000)	816.4	867.7	933.3	2,149.7	2,365.9	2,604.4
Large (more than $1,680,000)	1,841.8	1,796.8	1,994.6	1,805.3	1,944.7	2,091.5
Add-on memories	168.0	172.0	200.0	68.0	79.0	92.1
Data acquisition	81.2	87.7	93.3	184.8	199.5	208.2
Data entry/output	345.5	417.0	511.9	949.3	1,057.6	1,163.0
Data storage	577.9	832.3	1,246.8	—	—	—
Data terminals	720.0	920.0	1,200.0	1,036.5	1,238.3	1,432.8
Electronic office equipment	565.4	614.0	655.0	2,833.8	3,219.4	3,536.7
Billing and accounting machines	80.0	87.0	97.0	960.3	1,093.0	1,184.0
Calculators, office type	75.0	80.0	85.0	504.2	532.7	564.7
Calculators, scientific type	35.0	55.0	65.0	228.2	264.3	310.7
Copying machines	375.4	392.0	408.0	863.8	985.6	1,079.4
Dictating machines	—	—	—	68.6	72.7	77.0
Word-processing	—	—	—	208.7	271.1	320.9
Point-of-sale	68.0	80.0	92.0	190.5	218.9	246.4
INDUSTRIAL, TOTAL	**1,292.2**	**1,449.5**	**1,527.8**	**2,209.7**	**2,412.4**	**2,636.9**
Inspection and gauging equipment (X-ray)	44.0	48.4	52.0	53.9	59.2	62.6
Inspection and gauging equipment, infrared	36.0	40.0	44.0	—	—	—
Machine-tool controls	110.0	140.0	164.0	139.5	153.7	171.0
Motor controls	148.0	162.8	160.0	181.6	176.0	190.2
Photoelectric controls	—	—	—	45.0	48.2	50.8
Pollution-monitoring systems	102.0	114.6	132.6	32.2	26.6	26.5
Process-control systems	670.7	720.0	780.5	1,666.7	1,854.6	2,034.7
Ultrasonic cleaning and inspection	29.1	31.7	34.7	35.9	38.5	40.9
Welding (with electronic controls)	152.4	192.0	200.0	53.9	55.6	60.2
MEDICAL, TOTAL	**468.2**	**514.9**	**560.8**	**1,449.4**	**1,504.8**	**1,567.0**
Diagnostic equipment (except X-ray)	88.0	100.8	113.2	304.9	319.9	335.8
Patient-monitoring	42.1	47.1	50.7	112.3	119.4	129.3
Prosthetic	18.0	19.2	20.0	178.5	184.9	192.2
Surgical support	16.8	18.0	19.2	—	—	—
Therapeutic (except X-ray)	20.6	21.8	23.0	78.5	80.9	84.6
X-ray equipment, diagnostic and therapeutic	282.7	308.0	334.7	775.2	799.7	825.1
POWER SUPPLIES, TOTAL	**113.2**	**128.8**	**196.2**	**294.9**	**317.2**	**349.0**
Bench and lab	48.0	56.0	64.0	32.9	35.5	48.2
Industrial (heavy-duty)	21.6	24.4	26.6	96.5	103.0	109.4
OEM and modular	43.6	48.4	105.6	165.5	178.7	191.4
ANALYTIC INSTRUMENTS, RESEARCH OR CLINICAL, TOTAL	**358.0**	**396.0**	**436.0**	—	—	—
TEST AND MEASUREMENT, TOTAL	**307.2**	**321.8**	**346.7**	**846.0**	**945.3**	**1,054.5**
Amplifiers, lab type	9.1	14.5	16.0	12.4	13.0	13.7
Analog voltmeters, ammeters, and multimeters	22.5	24.1	25.9	52.9	55.6	58.4
Automatic test equipment (IC, component, and board)	39.9	22.8	21.8	111.9	140.5	175.5
Calibrators and standards, active and passive	8.4	8.8	9.2	12.2	13.3	14.3
Counters and timers	14.0	16.0	16.5	48.0	52.0	56.8
Digital logic (probes, analyzers)	4.8	5.0	5.7	30.2	38.2	49.0
Digital multimeters	13.1	13.4	13.6	51.6	56.0	61.6
Microwave test instruments	12.9	14.0	15.1	70.4	82.5	93.5
Oscillators	18.0	19.9	21.3	20.0	21.1	22.8
Oscilloscopes and accessories	48.7	52.1	57.2	164.1	176.8	187.3
Panel meters	27.6	31.2	34.2	44.0	45.9	47.8
Phase-measuring equipment	2.2	2.4	2.5	—	—	—
Power meters	2.5	2.7	3.0	4.7	5.2	5.5
Recorders	36.2	41.6	47.7	113.5	122.7	131.4
Signal generators, analog	29.5	33.4	34.6	50.1	54.3	60.5
Signal generators, synthesizer	5.9	6.3	6.7	23.1	26.7	30.3
Spectrum analyzers (audio to 1 GHz)	11.9	13.6	15.7	36.9	41.5	46.1
AUTOMOTIVE, TOTAL	**102.4**	**139.3**	**171.3**	—	—	—

[1]Electronic or semielectronic. [2]Includes stand-alone minicomputers but not computers that are integral parts of process-control and similar systems. —No estimate available.

Figures in this chart are based on inputs obtained from an 11-country survey made by *Electronics* in September and October 1979. They show consensus estimates for consumption of components, valued at factory prices, used to produce equipment for both domestic and export markets and for consumption of electronic equipment, with domestic hardware valued at factory sales price and imports at landed cost.

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Practical liquid-crystal display forms forty characters

A more responsive LCD material and better packaging overcome obstacles to multiplexing

by D. Davies, W. Fischer, G. Force, K. Harrison, and S. Lu, *Kylex Inc., an affiliate of Exxon Enterprises Inc., Mountain View, Calif.*

☐ The familiar refrain that runs "liquid-crystal displays of more than a very few characters cannot be multiplexed in a practical, cost-effective manner" is out of date. A compact 40-character alphanumeric dot-matrix LCD that has simple, inexpensive multiplexing and that interfaces with a microprocessor is proof.

The multiplexing scheme used in the LX140 [*Electronics*, Nov. 22, p. 46] is made possible by a development in liquid-crystal materials. For its small size it must thank integrated-circuit technology, both for the custom complementary-MOS chips that drive its rows and columns and for the photolithographic techniques borrowed from IC manufacturing that are used in fabricating the closely spaced elements of its 5-by-10-dot characters. The 5-by-10-dot characters display descenders for letters such as p, q, and y, as seen in Fig. 1.

The display's on-board electronics includes random-access memory, refresh circuitry, and a voltage converter. The converter generates drive voltages for the multiplexed LCD from a single 5-volt supply and provides temperature compensation for optimum drive voltage over the display's operating range of 0° to 55° C.

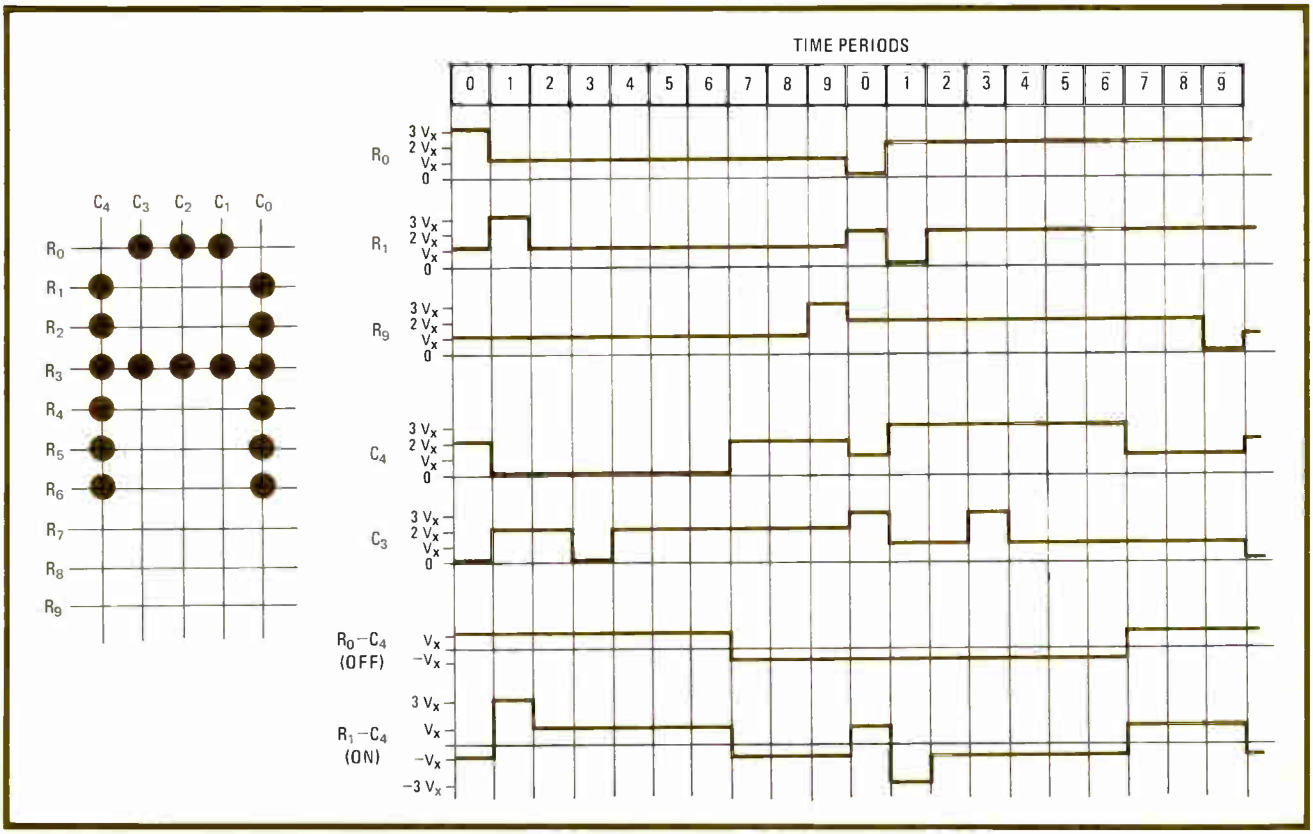
Directly driven LCDs are limited by interconnection complexity to four or six characters. Multiplexing the signals to LCD elements complicates the microprocessor interface and demands high performance from the liquid-crystal material itself [*Electronics*, May 25, 1978, p. 113, and July 5, 1979, p. 141]. Limitations inherent in liquid-crystal materials and display fabrication techniques have forced LCDs to take a back seat to light-emitting-diode displays, plasma panels, and vacuum fluorescent displays.

All those display types have distinct disadvantages when it comes to their use in small, portable equipment. LEDs use a lot of power and tend to wash out in direct sunlight, as do vacuum fluorescent displays. Vacuum fluorescent displays, though fast, inexpensive, and easily multiplexed, require high voltage levels. Plasma panels consume large amounts of power at high voltages and are somewhat bulky. And cathode-ray tubes, which are the first in the field in information density and economy, represent with their power supplies too heavy a burden in applications that require no more than 40 to 80 displayed characters. Word processors, electronic typewriters, teleprinters, electronic banking terminals, portable data-entry terminals and instruments—all these applications call for moderate information levels delivered by small, thin, lightweight devices.

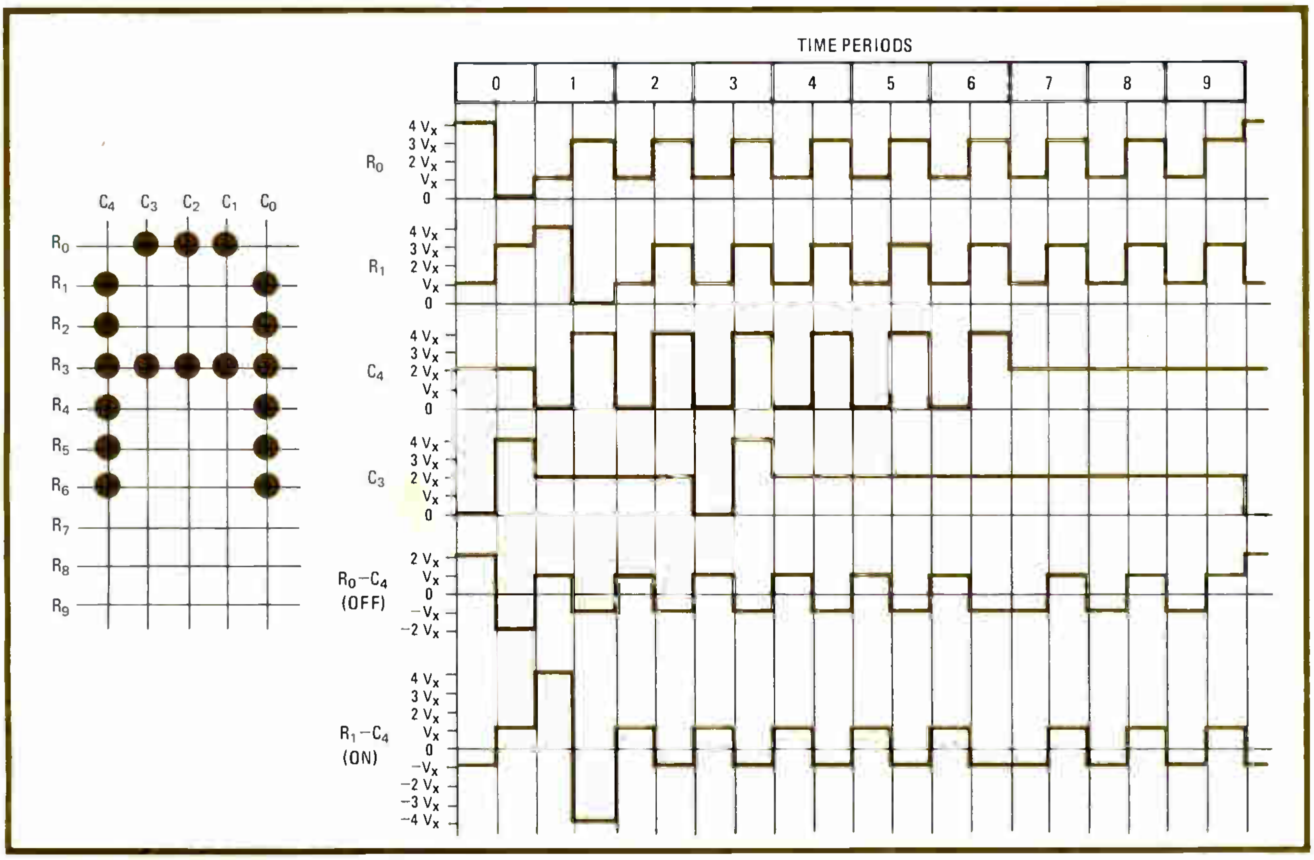
Fabrication and packaging

LCD process technology is critically dependent on the ability to pattern elements with as high a resolution as possible. Most LCDs have screen-printed patterns. The precision photolithographic techniques used to fabricate the large-area LX140 allow the clear definition of elements with separation between them as little as 0.002 inch. This gives a dense appearance to each character. And because the process is readily adaptable to automation, high production yields are possible along the classic learning curve of integrated circuits. The result is a

1. Forty characters. Photolithographic techniques, instead of the usual screen printing, allow closer spacing of the dots in the Kylex LX140 liquid-crystal display. An advance in LC materials made a new level of multiplexing complexity possible; internal circuitry eases interfacing.



2. Three-level multiplexing. The use of three voltage levels in the element-driving waveforms (in addition to O V) results in a very low ratio of on voltage to off voltage (rms) when 10 rows are to be scanned. Tight LC-material performance requirements are the consequence.



3. One more level. The LX140's multiplexing scheme used four voltage levels to bring up the ratio of V_{on} to V_{off}. The waveforms at bottom represent the difference between two of those above, the voltage applied to a matrix element that is off and one that is turned on.

relatively low cost per device—\$299 each in small quantities, \$199 each in 100-unit lots.

The large number of interconnections needed for the display module presented its designers with a tough packaging problem. Each column and each row of the display must of necessity be driven by a unique waveform supplied by an IC. Each chip in turn must interface the system's internal bus, and the system in addition must interface the user's bus.

The solution was the use of a single-piece polyimide flexible circuit. The flexible circuit services all chip-to-display connections, all the system's bus interconnections, and the connections to the voltage-generation board. The custom C-MOS drivers are wire-bonded into 64-pin leadless carriers that are reflow-soldered to the flexible circuit in a single simple step. The flexible circuit connects to the display via elastomeric connectors similar to those used in LCD watches and calculators. The flexible circuit is folded into a compact package. The entire circuit is assembled and tested prior to folding to insure reliability and environmental stability. The leadless carriers allow volume-efficient packaging of the chips, facilitate pre-assembly testing, and simplify substrate reworking.

Tailoring LCDs for multiplexing

The LX140's 2,000 elements call for a very high-level multiplexed addressing scheme. In direct-drive LCDs, zero voltage is typically applied to an unselected (off) element, and an alternating-current potential greater than the threshold voltage, V_{thr}, is applied to selected (on) elements. This kind of addressing is usually used in wristwatch circuits, where no more than four to six seven-segment display digits are used. Typically, the V_{thr} is about 1.5 volts and operating voltage is about 3 V. (The operating voltage must be higher than V_{thr} because the LCD only begins to turn on at V_{thr}.)

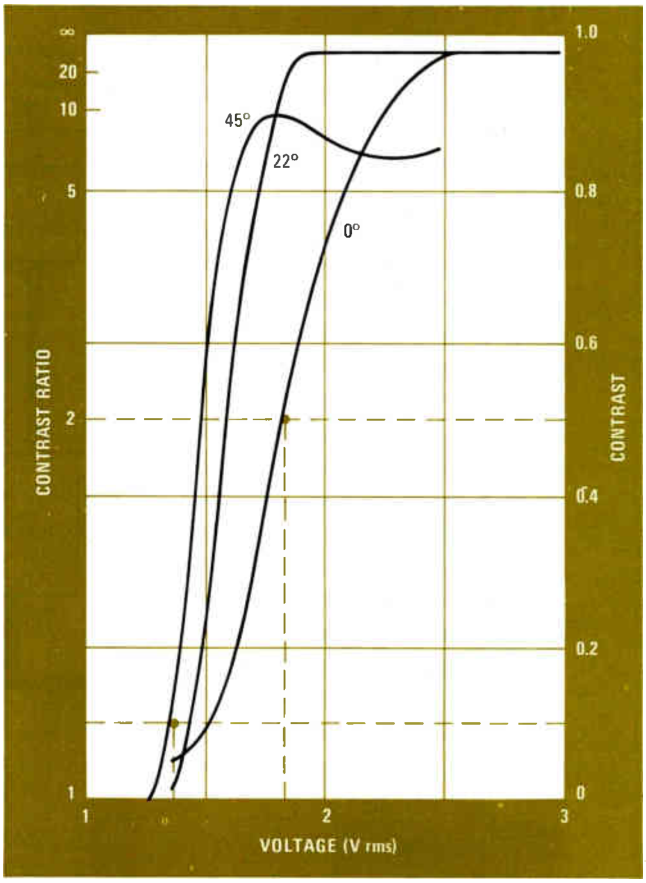
When the number of display characters gets much higher than six, driving them directly is no longer practical since the interconnection complexity becomes unmanageable and higher costs result from the additional hardware needed.

But multiplexing is a problem. LCDs in general and twisted-nematic types like the LX140 in particular change their optical properties in response to the root-mean-square value of the alternating-current driving voltage across the elements. This rms behavior has limited the multiplexing capability of such displays.

In a dot-matrix LCD, the display's rows are scanned one at a time and the columns are driven in parallel. Selected elements are driven with an rms voltage (V_{on}) above V_{thr} and unselected elements are driven with an rms voltage (V_{off}) below V_{thr}, instead of with a zero voltage.

Unfortunately, it is impossible to arbitrarily increase V_{on} without also increasing V_{off}. This is best illustrated by the amplitude-selection scheme of Fig. 2, where a multiplexing waveform is used to display the letter "A" on a 5-by-10-dot matrix. The waveforms for rows R_0, R_1, and R_9, as well as columns C_4 and C_3 are shown.

As mentioned, the array's rows are scanned in sequence. In this example, R_1 is scanned by raising the



4. Electro-optic response. A synthesized liquid-crystal material developed for the LX140 balances a good contrast curve shape with a relatively low temperature dependence. Off-axis viewing (22° and 45° shown) is sensitive to lower voltages than on-axis viewing.

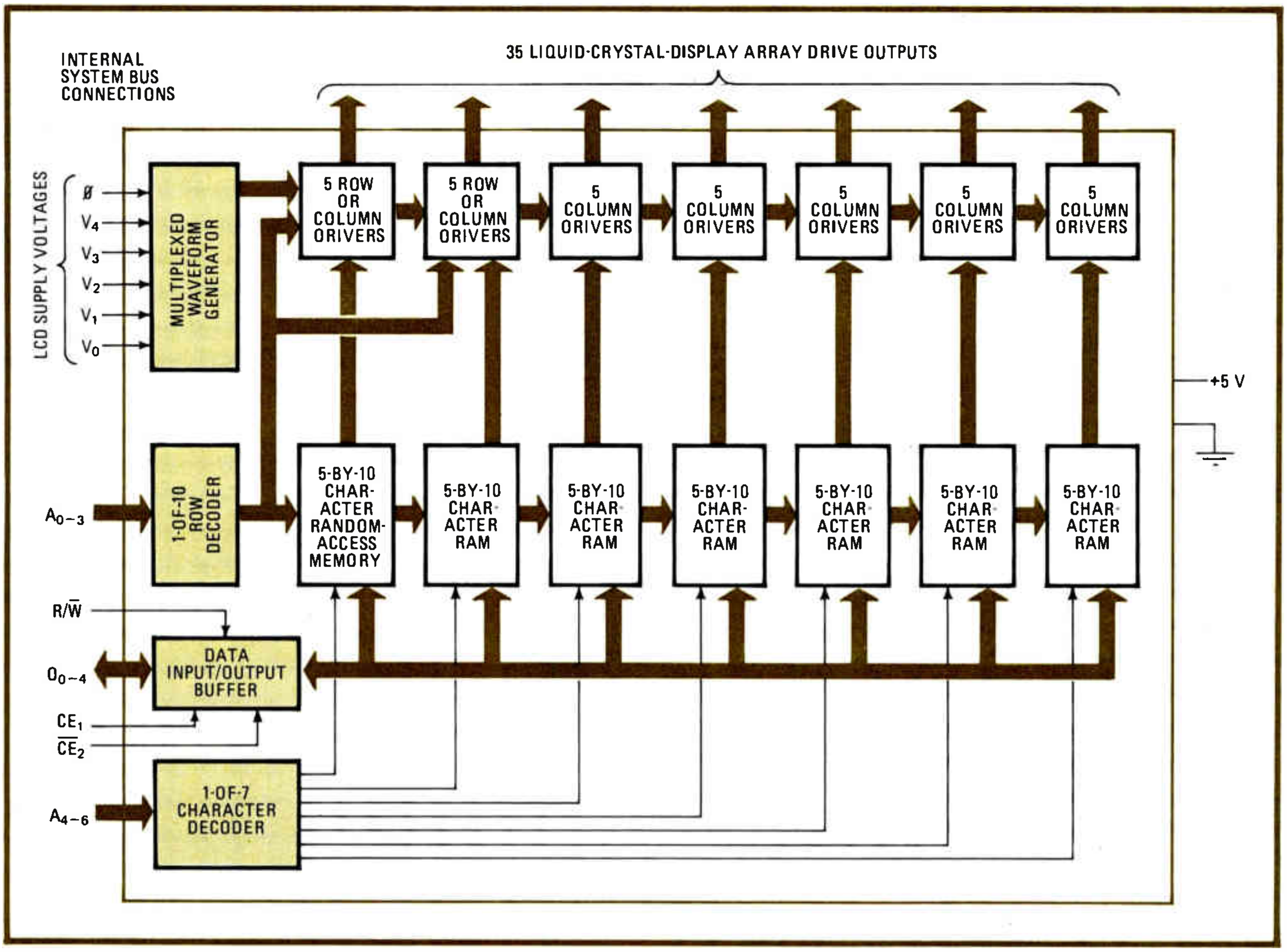
waveform's voltage to $3V_x$ during time period 1. During other time periods, R_1's voltage is V_x. During time period 0, the voltage level for column 4 is 2 V_x (since the element R_0, C_4 is off). During time periods 1 through 6, the voltage level for this column is zero (since the elements R_1, C_4 through R_6, C_4 are on). This column returns to 2 V_x during time periods 7 through 9, to avoid selecting those elements.

An important factor in determining the performance of multiplexed LCDs is the ratio of V_{on} to V_{off}. This V_{on}/V_{off} ratio, which will arbitrarily be called r here, is determined by:

$$r = [(n+8)/n]^{1/2}$$

where n is the number of scanned rows in the 3:1 selection scheme of Fig. 2. As can be seen, for large values of n, r approaches unity rapidly. With n equal to 10, r equals 1.3416. Thus the rms voltage of the selecting waveform is only 34.16% higher than the rms voltage of the unselecting waveform. In other words, an element can be driven at a maximum V_{on} that is only 34.16% higher than V_{off}.

To improve this slim margin of V_{on}/V_{off}, the LX140 was designed with a multiplexing scheme that uses four instead of three voltage levels—V_x, $2V_x$, $3V_x$, and $4V_x$—to generate the waveforms for rows and columns (Fig. 3). Here, r is 1.3868, a value fairly close to the



5. Custom driver. The complementary-MOS integrated circuit designed to drive the rows and columns of the LX140 produces 35 waveforms. The chip can be used to drive 35 columns, or, in a second pin-selectable mode, it can generate 10 row waveforms and 25 column waveforms.

theoretical limit for an LCD with 10 multiplexed rows.

On the other hand, the LCD multiplexing scheme works very well with a very small ratio of V_{on} to V_{off}, given an ideal LC material (the curve of its contrast ratio versus the rms drive voltage would be a step function, unaffected by temperature or viewing angle). The smaller voltage swings give faster display response, less crosstalk, higher duty cycles (making more scanned rows possible), and higher contrast. Any improvement in LC materials that heads towards that ideal will ease the multiplexing difficulties.

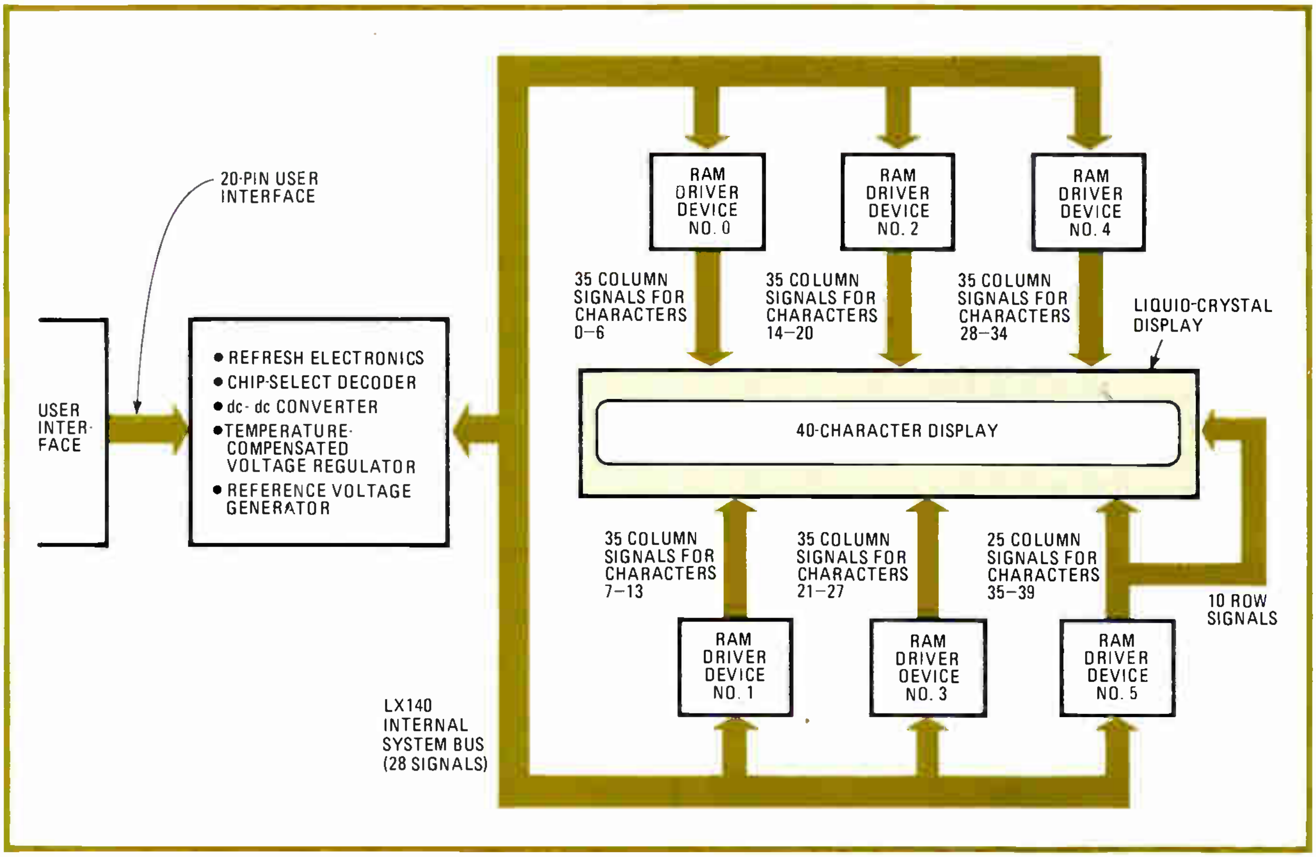
In practice, the threshold voltage, V_{thr}, which determines V_{off}, varies as a function of both viewing angle and temperature. A twisted-nematic LCD like the LX140 is characterized by a shallow curve of contrast ratio versus drive voltage. Therefore, with a small V_{on}/V_{off} ratio, it is necessary to use an LC material with low birefringence and a display with thin cell spacing and zero-tilt surface alignment (the glass surfaces sandwiching the LC material are highly parallel).

Instead of the LC materials of purely positive dielectric anisotropy used in most commercially available LCDs, a mixture of positive and negative dielectric anisotropy materials is used in the LX140. Purely positive materials have shallow threshold curves and thus are not suitable for multiplexing. Positive materials suffer more from dependency of the threshold level on temperature. Some mixtures of positive and negative materials, on the other hand, do have sharp threshold curves and a lower temperature dependency. The selection of the proper combination of positive and negative materials provides the best compromise between threshold-knee sharpness and temperature dependency.

Material distinctions

Detailed investigations of the different classes of liquid-crystal compounds available led to the development of synthesized compounds whose formulations showed considerable improvements in contrast ratio versus voltage over previous LC materials (Fig. 4). Elements of three different classes of the scrutinized materials were used. Typical V_{on}/V_{off} ratios required for good display performance were 1.37 and less, and in certain cases this ratio was reduced to 1.32 and less. Most LC materials that are currently in use exhibit ratios greater than 1.40.

The lower V_{on}/V_{off} ratio was achieved by raising V_{thr} to about 1.5 V, and by the choice of a material with a favorable elastic constant that provides a sharp knee in the threshold curve. The material's birefringence is adjusted for a minimum value for the thin cell spacing employed. The result is a large display-viewing cone.



6. Display system. Six C-MOS drive chips generate 210 signals to control 2,000 dots. Five drivers handle seven characters each; the sixth drives the columns of five characters and the display's 10 rows. System circuitry does refreshing and temperature compensation.

The LX140's head-on contrast ratio is 2:1. The display's contrast ratio is as high as 20:1 at a viewing angle of 20° to 35° from normal (a normal line is perpendicular to the display surface).

The material exhibits nematic behaviour over a temperature range of −40° to 60°C and has excellent alignment qualities over the temperature range of −20° to 60°C. Its positive dielectric anisotropy and its moderate viscosity ensure a maximum response time of 150 milliseconds. And threshold change with temperature is moderate enough to be useful: typically 8 to 10 millivolts/°C. On-board electronic circuitry compensates for this shift. Maximum lifetime and adverse-environment protection is assured by the fact that the material displays no color and has high chemical and photochemical stability.

Purity and life

The material's individual components and mixtures are refined to purities greater than 99.9% and typical resistivities of more than 10^{10} ohm-centimeters. Accelerated life tests have confirmed a mean time between failures of more than 50,000 hours for the LX140 under normal operating conditions. Particular attention was paid to the material's alignment, since an LCD's longevity is critically dependent on this factor. A surface alignment tilt near zero, a uniformly thin cell spacing, and a glass-frit hermetic seal all in fact contribute to the device's long life.

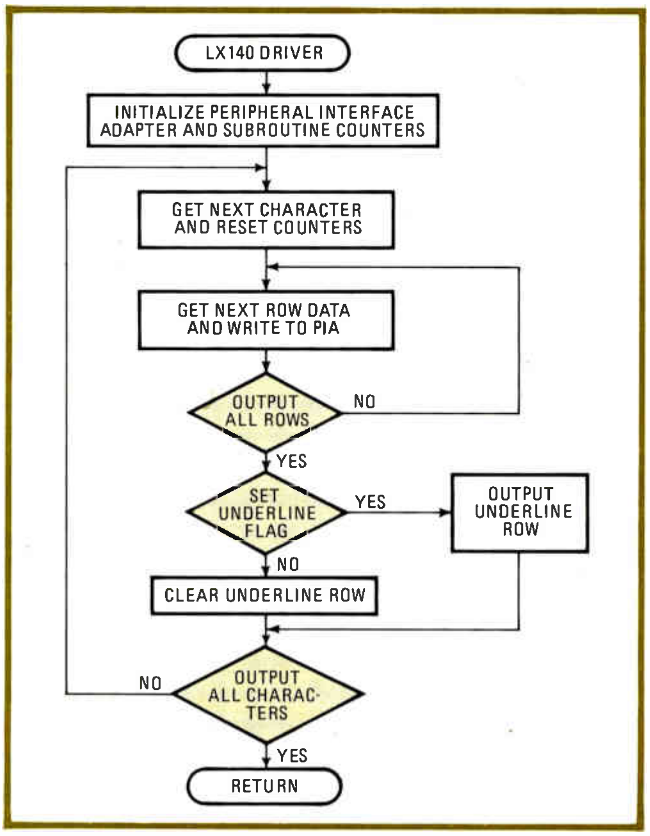
The LX140 was designed to interface easily with a microprocessor. Addressing the display is equivalent to addressing a memory block with a one-to-one correspondence between memory bits and display dots. The display's internal electronics generate all the refresh signals, thereby eliminating the need for continuous data transfer to the display unit. Display data is entered from the system data bus only when a character or the entire display is to be changed.

Interfacing the microprocessor

The LX140's 2,000 elements are arranged in 10 rows and 200 columns to provide the 40-character display. Only 20 lines are required to interface it with a user's system. Lines D_0–D_4 are the five bidirectional data lines used to feed in or read out the dot pattern of a single row of a single character. A logic 1 on one of these lines will turn the corresponding dot on and a logic 0 turns it off. Address lines A_0–A_3 are used to select the row within a character; address lines A_4–A_9 address one of the 40 characters. The read/write ($R/\overline{W}$) line's state determines whether data is to be read from (a logic 1) or written into (a logic 0) the display.

The enable line ($\overline{E}$) controls data transfer between the bus and the display module. A logic 0 means data transfer is enabled: input signals must remain stable while the line is low. A logic 1 means no data transfer may occur; input signals may change. The display is not refreshed during data transfer, so the enabling time should be kept as short as possible.

The custom C-MOS drive chip designed for the LX140



7. Control subroutine. The timing and interface control functions for writing data into the display can be placed in software, thus minimizing the hardware needed for the job. A one-chip peripheral-interface adapter can also be used to keep the parts count low.

(Fig. 5) can operate in one of two configurations, selectable by a mode-control pin. It can be either a column driver or a row and column driver.

The 174-by-204-mil chip contains an input/output data buffer, a character-address decoder, a row-address decoder, 35 waveform generators for supplying the column or row outputs, seven 5-by-10-bit character registers (RAM), and seven 5-bit data buffers.

When operating as a column driver only, the chip supports seven characters, providing 35 column signals, as illustrated by the waveforms of C_3 and C_4 in Fig. 3. Each of these waveforms is determined by the contents of the registers that are selected by the row-address inputs of A_0–A_3.

Six drivers do it

When operating as a row driver, the chip produces 10 row signals, as illustrated by the waveforms of R_0 and R_1 of Fig. 3. It supports five characters in the column mode at the same time.

Five chips are used to drive 175 of the display's columns. A sixth chip drives the 10 rows and the remaining 25 columns. Thus six ICs generate all 210 signals and contain enough memory to support a stand-alone 40-character dot-matrix display of 2,000 dots.

The six drivers are connected together as shown in Fig. 6. This interconnection network uses a separate internal bus. Lines D_0–D_4 of the internal bus are the same as lines D_0–D_4 of the user interface. Lines A_0–A_3 of the internal bus address the rows for all characters; lines A_4–A_6 select the character within the group controlled by a single chip. Chip-select lines CS_0–CS_5 are binary decodings of system address lines A_7–A_9 (A_{10} is expansion) and are the lines that enable devices 0 through 5. The read/write line of the internal bus is identical to that of the user interface. The $\overline{CS}$ line is functionally equivalent to user-interface line $\overline{E}$.

A symmetric timing reference signal is carried on the line denoted ϕ. This signal is used by the drive chips for phase selection and ac modulation of the outputs. Internal-bus lines V_0–V_4 supply voltage information to the drive chips for the generation of the output signals.

Internal refresh electronics provide continuous sequencing of the row address on lines A_0–A_3. This provides continuous refreshing of the display with the information in RAM. The RAM is capable of being interrogated just like any other RAM. Turning on a dot on the display consists of writing a logic 1 in the corresponding RAM register.

Interface hardware and software

The LX140 may be interfaced by using any one of the following: a Z80 programmable input/output (PIO) interface controller, an 8255 programmable peripheral interface (PPI), a 6821 programmable interface adapter (PIA), or a 6522 peripheral interface device (PID).

The use of a programmable parallel I/O controller like the PIO, PIA, or PID assures that the minimum amount of hardware is used to drive the LX140. All of the intelligence, timing, and specialized interface control can be placed in software. The subroutine represented by the flowchart in Fig. 7 can be used to drive the LX140 through the PIA or an equivalent device. The subroutine of Fig. 7 can be modified to handle almost any kind of special display-interface function, including message scrolling, special character fonts, and underlining.

When connecting the LX140 to a programmable parallel I/O controller, the LX140's five data lines D_0–D_4 are connected to the 5 most significant bits of the controller's port A. In the case of the Z80 PIO, these correspond to pins A_3–A_7, and in the case of the PIA or PID mentioned above, they correspond to pins PA_3–PA_7. The LX140 address lines A_0–A_2 are connected to the 3 least significant bits of the controller's port A (pins A_0–A_2 on the PIO, and pins PA_0–PA_2 on the PIA or PID). These connections allow the row address to be automatically incremented as each character row is written into the display.

When using the PIO, address lines A_3–A_9 of the LX140 are connected to the PIO's port B pins B_0–B_6. For the PIA or PID, the LX140's address lines A_3–A_{10} are connected to the interface device's port B pins PB_0–PB_7. Pin B_7 of the PIO is used to strobe in the address and data via the LX140's enable pin. Pins CA_2 and CB_2 of the PIA or PID are used to control the LX140's enable and read/write lines.

The font that defines which bits are on and which bits are off for each character can be part of the driver subroutine. Each font requires 9 bytes per character. The first 5 bits in each byte are used for the row's dot control and the last 3 for the row address. □

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Delay circuit replicates pulses of variable width

by John H. Davis
Warm Springs, Ga.

Unfortunately, the simple and well-known circuit used to provide true pulse delay—whereupon the first of two one-shots connected in series sets the delay time desired and the second is set to generate a pulse having the same width—cannot be used if the input pulse width is variable. Fortunately, however, pulses of variable width can easily be handled by adding only a quad NOR gate and a few RC differentiators to a modified circuit, as shown here.

Differentiator R_1C_1 provides a positive-going spike from the rising edge of the input pulse to be delayed, in

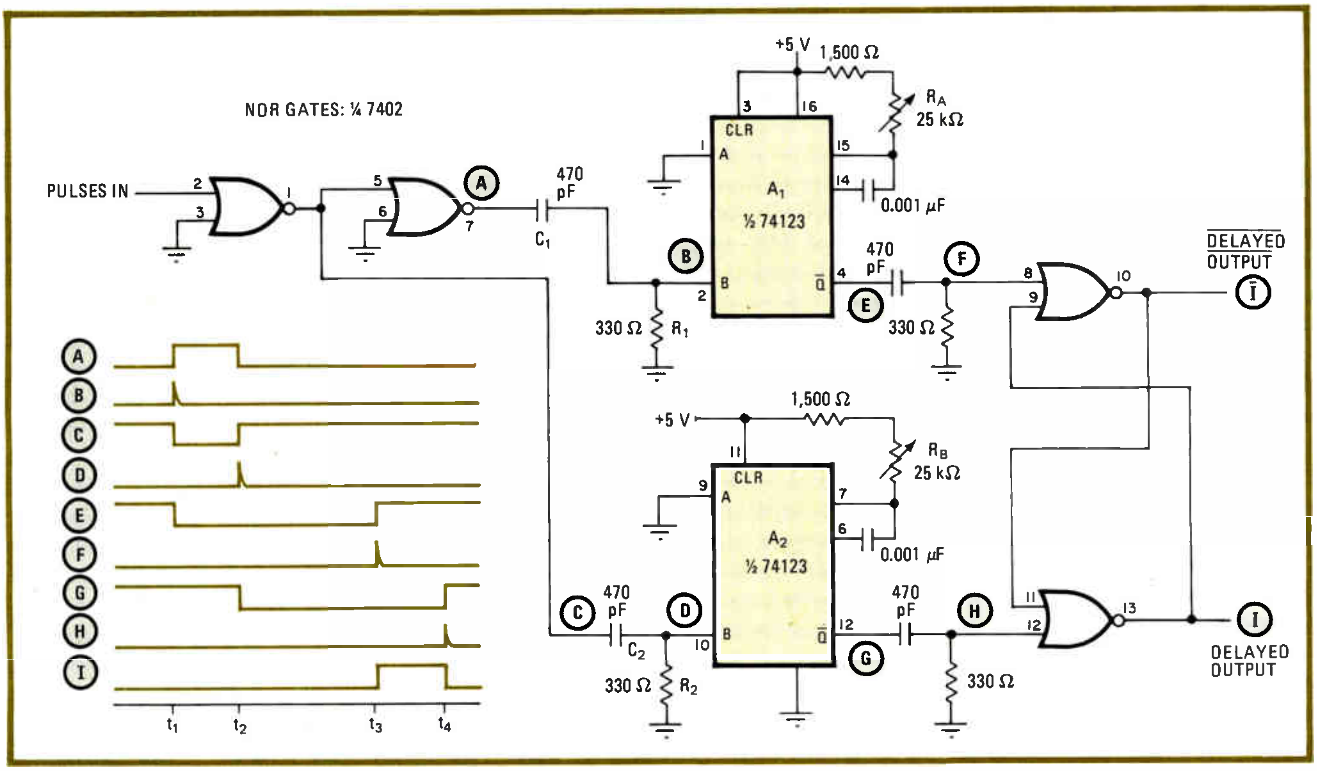
for the desired delay interval selected by potentiometer R_A. When the Q output returns to its high state, the RS flip-flop at the output, formed by two NOR gates, is set and the I port moves high.

One-shot A_2 is triggered by the falling edge of the input pulse through differentiator R_2C_2, and thus its $\overline{Q}$ output goes low for a time (set by R_B) equal to A_1's delay interval. When A_2's $\overline{Q}$ output returns high, the NOR latch returns to its low state. As long as $\tau_{A1} = \tau_{A2}$, the time during which I is high will always be equal to the width of the input pulse, assuming the delays are equal to or exceed the input pulse width. Pulses that are very much shorter than the set delay time will be reproduced less accurately.

This circuit provides delays over the range of 1 through 20 microseconds, but it is a simple matter to change timing components to achieve times into the millisecond region. Note that the maximum delay that may be set will be limited to the shortest repetition period in the pulse train and in practice should be set to a value less than this to allow for the one-shots to recover.

The circuit is equally suitable for implementation with positive or negative logic. Adjustment is simple. With positive logic, R_A should be set for the desired delay. A train of pulses of nominal width is then introduced at the input, and the I port is monitored with a scope while R_B is adjusted so that the pulse width at the output is equal to that at the input. The circuit will then automatically be calibrated for input pulses having any width. The calibration procedure is similar with negative logic, except that then it is easier to adjust R_B first.

Alternatively, both one-shots may be set for equal delay, but in practice this procedure will cause inaccuracies for very narrow input pulses. In any case, it will be advantageous if circuitry can be configured to program R_A and R_B simultaneously, so that the circuit has only one control. □



Delayed duplication. Parallel-connected one-shots and NOR gates provide set delay and maintain width of pulse, independent of its value. Low-cost unit will thus be useful for automatically synchronizing blanking pulses in TV systems and for similar applications.

Frequency discriminator has ultra-sharp response

by S. J. Collocott, *CSIRO Division of Applied Physics, National Measurement Laboratory, Sydney, Australia*

Most rudimentary circuits for discriminating between two frequencies or two bands of frequencies sacrifice selectivity to simplicity. But this simple circuit, which uses just a frequency-to-voltage converter and a couple of general-purpose comparators, can differentiate between two frequencies separated by only a few hertz.

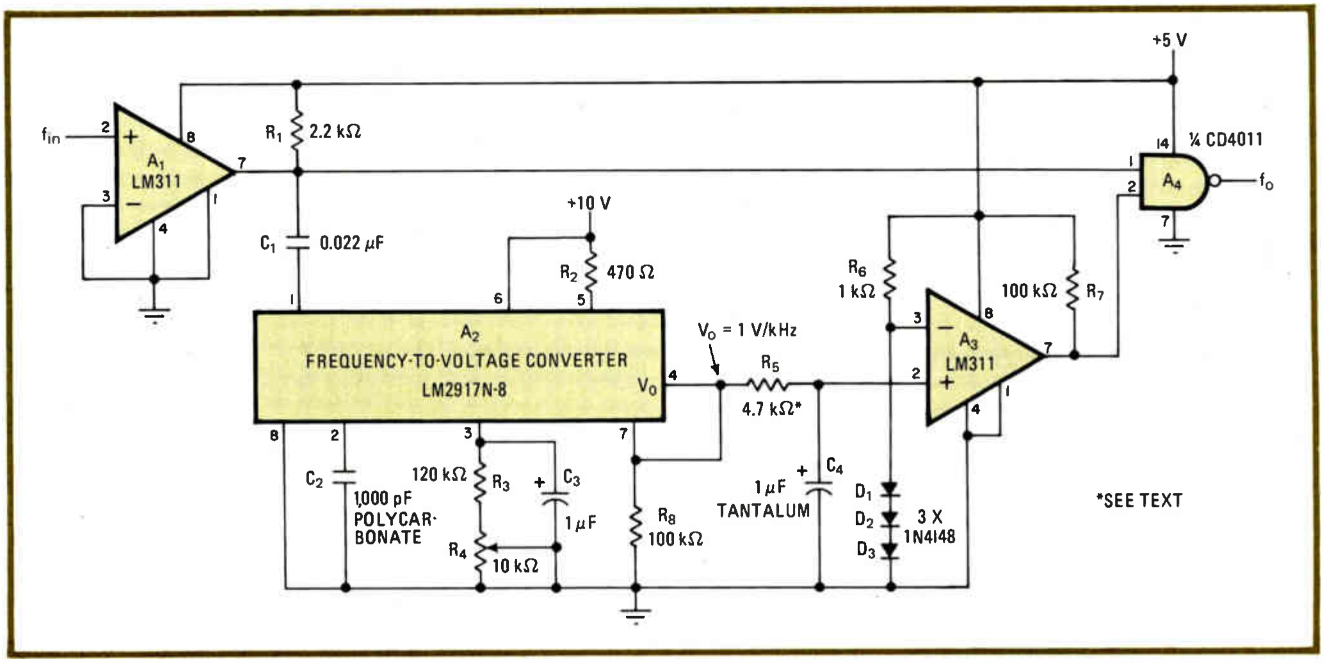
In this application, the circuit rejects all frequencies below 2.1 kilohertz, while passing others, although it is a simple matter to modify the discriminator to handle signals at any frequency. Input signals are introduced into the LM311 comparator (A_1), which operates as a zero-crossing detector. Its output is then applied to one input of a dual NAND gate and A_2, the LM2917 frequency-to-voltage converter.

The converter, which drives the noninverting input of comparator A_3, generates an output of one volt for each kilohertz applied at its input. Thus, when f_{in} is less than 2.1 kHz, the output of the converter is less than 2.1 volts, and A_3 (whose noninverting input is biased at 2.1 V by diodes D_1–D_3) is low. Therefore, output gate A_4 is disabled. If f_{in} moves above 2.1 kHz, A_3 will go high and enable A_4, thereby permitting f_{in} to appear at the output.

The sharpness of the cutoff, which is determined by the transfer function of A_3, is approximately 1 Hz. The response time of the circuit is adjusted by C_3 and R_5C_4. These components act to control the integration time at the output, ensuring that a steady dc voltage is attained after a nominal number of periods of f_{in}. If a fast response time is desired, R_5 and C_4 should be deleted.

The circuit is made to handle signals at any frequency by applying a variable control voltage at pin 3 of A_3, in lieu of the D_1–D_3 and R_6 combination. And the discriminator can be used in other modes, to reject high frequencies, for example, or as a bandpass discriminator.

The discriminator that rejects high frequencies may be realized by simply reversing the inputs to A_3. For bandpass applications, A_3 is replaced by a dual comparator, where the low- and high-cutoff frequencies are set by control voltages on the inverting and noninverting inputs of the comparators, respectively. A_4 must then be replaced with a triple-input NAND gate. □

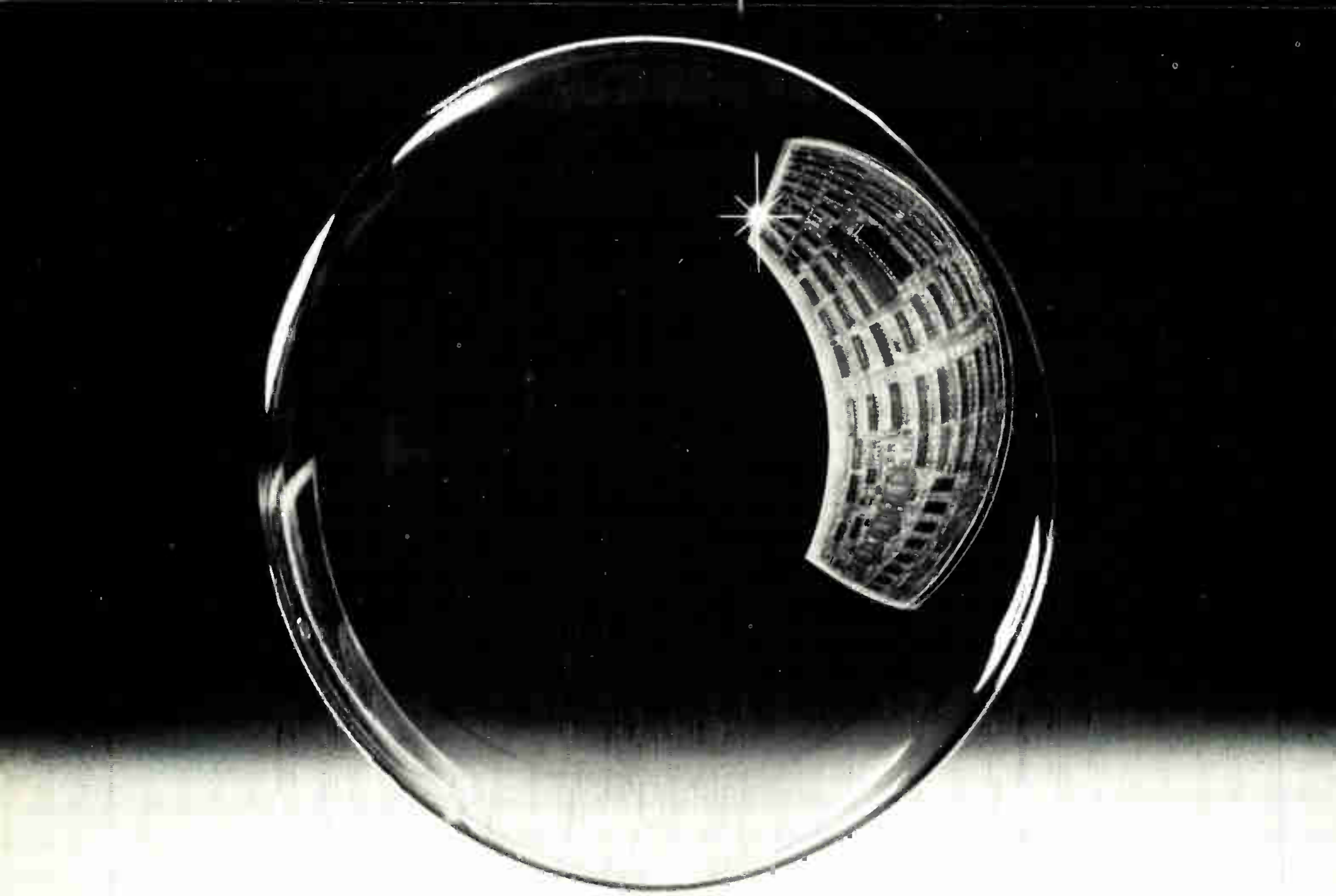


Cycle cutoff. Frequency-to-voltage converter and comparators combine simplicity and selectivity in this frequency discriminator. Transfer function of LM311 determines sharpness of cutoff, in this case being 1 hertz. Circuit can be made to handle signals at any frequency if variable voltage is introduced at pin 3 of A3. Discriminator, configured in high-pass mode, can easily be modified for low-pass or bandpass duties.

Dc-dc converter maintains high efficiency

by P. R. K. Chetty, *Department of Electrical Engineering, California Institute of Technology, Pasadena*

A simple control circuit enables this design to overcome the major drawback of the conventional dc-dc converter—its inability to maintain high efficiency over a wide range of input voltages. Varying the base drive to the converter's power-switching transistors as the inverse square of input voltage in order to achieve a near-constant ratio of output power to circuit losses, this unit attains efficiencies of 78% to 80% for $20 < V_{in} < 40$.



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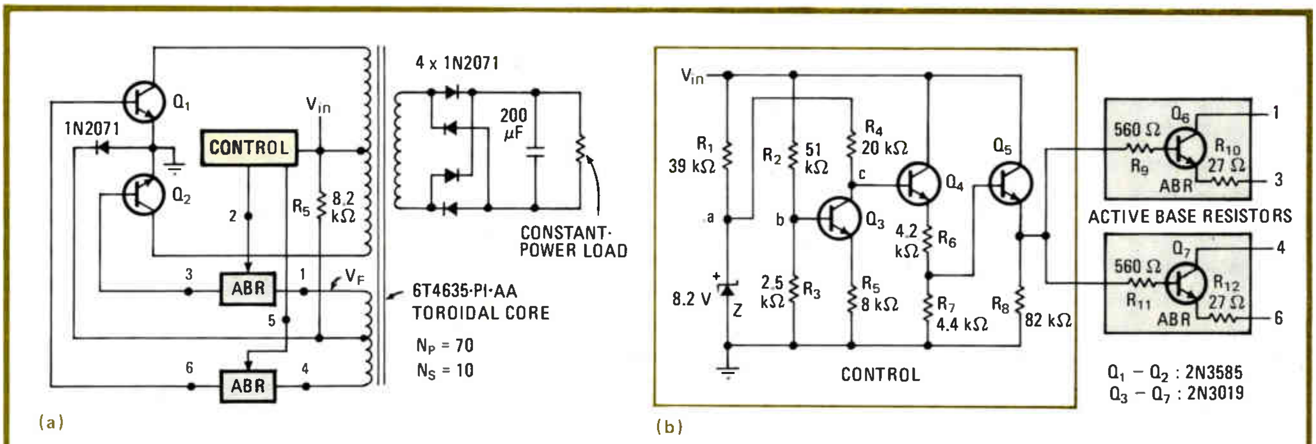


DESIGN EQUATIONS

$V_a = 8.2$ nom for $n \approx 80\%$

$V_b = (R_3/R_2 + R_3)\,V_{in}$

$V_{E_{Q3}} = V_b - V_{BE_{Q3}}$

$I_{E_{Q3}} = V_{E_{Q3}}/R_5$

$V_c = V_a - R_4 I_{E_{Q3}}$

$V_{E_{Q4}} = V_c - V_{BE_{Q4}}$

$V_{B_{Q5}} = (R_7/R_6 + R_7)\,V_{E_{Q4}}$

$V_{E_{Q5}} = V_{B_{Q5}} - V_{BE_{Q5}}$

$V_{E_{Q3}} = (R_3/R_2 + R_3)V_{in} - V_{BE_{Q3}}$

$I_{E_{Q3}} = V_{in}/R_5(R_3/R_2 + R_3) - V_{BE_{Q3}}/R_5$

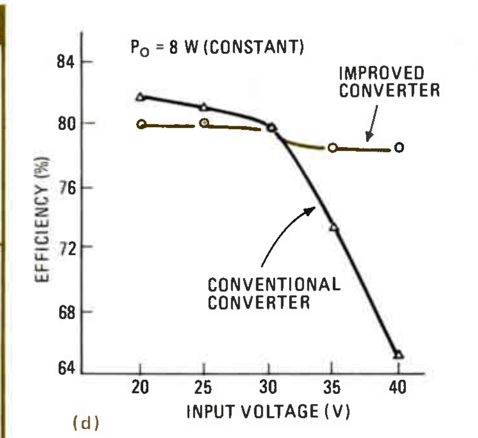
$V_c = V_a - V_{in}(R_4/R_5)(R_3/R_2 + R_3) + (R_4/R_5)V_{BE_{Q3}}$

$V_{E_{Q4}} = V_a - V_{in}(R_4/R_5)(R_2/R_2 + R_3) + (R_4/R_5)V_{BE_{Q3}} - V_{BE_{Q4}}$

$V_{BE_{Q5}} = (R_7/R_6 + R_7)[V_a - V_{in}(R_4/R_5)(R_3/R_2 + R_3) + (R_4/R_5)V_{BE_{Q3}} - V_{BE_{Q4}}]$

$V_{E_{Q5}} = (R_7/R_6 + R_7)[V_a - V_{in}(R_4/R_5)(R_3/R_2 + R_3) + (R_4/R_5)V_{BE_{Q3}} - V_{E_{Q4}}] - V_{BE_{Q5}}$

(c)



Leveled. High efficiency of conventional dc-dc converter (a) is maintained with control circuit (b) that generates base drive to switching transistors Q_1–Q_2 in inverse proportion to input voltage. Equations (c) aid design. Typical performance (d) is plotted.

In the ordinary converter (a), which would not include the control block shown and where a fixed resistor, R_b, would be substituted for the active-base-resistor block, an increase in V_{in} causes efficiency, n, to drop off as the inverse of the square of input voltage. As may be seen, this loss results because:

$$R_b = V_F/2I_b = [V_F\, n(V_{in} - V_{ce\,sat})hfe_{min}]/2P_o$$

and $V_F = K\,V_{in}$, where R_b is selected to drop half of the feedback voltage, V_F, P_O is the desired output power, $V_{cc(sat)}$ and hfe_{min} are the collector-to-emitter drop and current gain, respectively, of either power transistor, and k is a constant dependent on the turns ratio. Thus, combining the two equations above, it is realized that n is approximately equal to $1/V_{in}^2$, keeping other variables constant.

It can be further shown that if R_b is made to vary as approximately V_{in}^2, the efficiency will be a maximum at any given input voltage. Equivalently, efficiency will be maximum if the base drive to the switching transistors Q_1–Q_2 is made inversely proportional to V_{in}.

Although the circuit required to exactly satisfy Eq. 1 would be complex, a relatively simple configuration (b) will provide acceptable performance when it is added to the basic converter. Here, a three-transistor controller (component values given for P_o = 8 W) and two active-base-resistor networks drive Q_1–Q_2.

As V_{in} increases, the voltage at point b increases. R_2 and R_3 are selected so that V_b is about 1 volt at $V_{in\,min}$, enabling Q_3 to operate in active region.

Because the collector of Q_3 is biased from a reference (point a), the drive signal applied to Q_4 is a function only of the voltage applied to Q_3's base. When the voltage at point B increases, the potential at point C decreases. Thus Q_4–Q_5, biased in its nonlinear i_b–e_c region, drives switching transistors Q_1–Q_2 through Q_6–Q_7 with less base current. As a result, the resistance between points 1–3 (and 4–6) will vary approximately as V_{in}^2.

Only one operating variable must be determined empirically, the voltage at the base of Q_5, V_{BQ5}. Breaking the circuit at this point to connect a variable-voltage source, the user sets V_{in} to its minimum expected value. The variable-voltage source is then set to saturate Q_1 and Q_2 for a constant P_o, and its value (V_{b1}) noted. The procedure is repeated to find V_{b2} for $V_{in\,max}$.

Now the design procedure may be initiated using the equations in (c) to determine R_6 and R_7, given that V_{EQ5} equals V_{b1} at $V_{in\,min}$ and is equal to V_{b2} at $V_{in\,max}$. Experimental results for P_o = 8, $15 < V_{out} < 35$ and $20 < V_{in} < 40$ are tabulated (d) versus the performance of a conventional converter. □

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8-bit microprocessor harbors 16-bit performance

Particularly when complex algorithms are applied to byte-wide data, the 8-bit 8088 is the next best thing to a 16-bit 8086

by Irving H. Thomae, *Dartmouth College, Hanover, N. H.*

☐ Anyone weighing a move from an 8- to a 16-bit microprocessor should consider the 8088. This recently introduced microprocessor combines the internal architecture of the 16-bit 8086 with an external multiplexed 8-bit bus. Though requiring two bus cycles to fetch a 16-bit word, it does not inevitably take twice as long as the 8086 to execute a program. In many applications—strongly mathematical ones in particular—the 8088 comes very close to the 8086's computational power.

The 8088's architecture is responsible for this ability. Unlike other 8-bit microprocessors, its architecture is identical to the internal workings of an existing 16-bit machine. More specifically, it is divided into an execution unit and a bus interface unit, just as in the 8086 (see Fig. 1).

A minor difference is that while the interface unit of the 8086 has a 6-byte queue, the 8088 has room for only 4 bytes. But by the time a demanding instruction has been executed, the next one will be ripe for execution anyway. Thus, especially for byte-oriented operand streams, the half-wide data bus is a moot point.

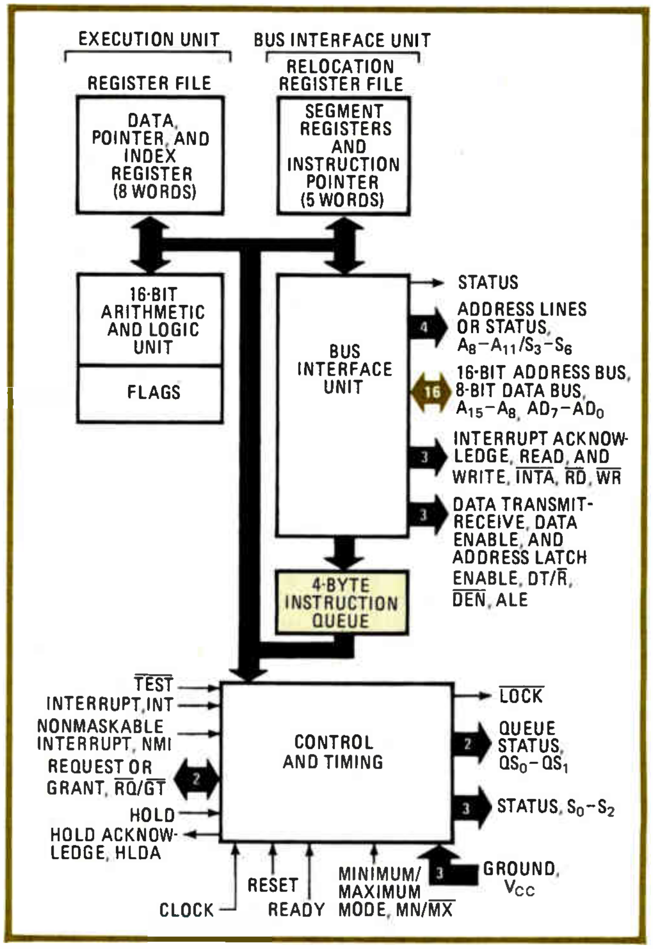
Another attractive 8088 feature is system-level compatibility, a characteristic that Intel Corp. has worked long to preserve. The multiplexed bus closely resembles that found on the purely 8-bit 8085, so that upgrading it to the 8088's hardware is smooth. Also, software originally intended for the 8080 or 8085 can be put through an Intel utility program called CONV-86 that has as its output 8086 (and therefore 8088) instructions. Thus, reworking an existing design for a more powerful family can be done piecemeal, with unconverted portions remaining intact.

A prerequisite

Aside from bus-multiplexing logic and the difference in the instruction queue length, the 8088 is identical to the 8086. Consequently, to understand the operation of the 8088 in general, it is essential to grasp what is unique about the 8086. The architectural philosophy behind the 8086 will therefore be compared with those chosen by Zilog Inc. for its Z8000 and Motorola Inc. for its MC68000, the two other most intensively promoted 16-bit microprocessors. Some provisions unique to the 8086/8 will then be pointed out prior to outlining the specific merits of the 8088.

The more obvious similarities among the 8086, Z8000, and MC68000 include reasonably speedy hardware multiplication and division, string move and compare operations (planned but not yet implemented in the case of the 68000), expanded register sets, and provision for address spaces substantially larger than the (traditional) 64-K allowance of older 16-bit minicomputer and microcomputer systems.

However, there are also some significant differences



1. CPU in two. The 8088, like the 8086, is split into an execution unit and a bus interface unit. The latter contains an instruction queue, 6 bytes long in the 8086 and 4 bytes long in the 8088. The queue minimizes dead time between the execution of instructions.

Computer architecture: a working definition

A number of slightly different definitions of digital computer architecture can be found in current usage [*Electronics*, May 24, 1979, p. 112]. The one adopted here follows the philosophy of IBM as expressed by G. F. Blaauw: the architecture of a digital computer is that set of its attributes (such as registers, addressing modes, and instruction set) that are visible to the programmer. Issues such as the number and width of the buses or the level of integrated-circuit technology used to build the machine (implementation) may greatly affect execution speed of a program, but (in principle) object code that runs on the lowliest member of the 370 family will supposedly produce the same results when run on the most expensive. The machines are then said to be architecturally identical, despite differences in implementation.

It could be, and sometimes is, argued that since nobody in his right mind still uses assembly language (though many programmers admit to doing so), architecture should be defined at the compiler source-code level. Equivalence of the computational results is then much more difficult to verify, however. Also, for the user of microprocessors in original equipment, there are significant economic advantages in being able to regard blocks of object code—not source code—as stock components, usable interchangeably with different implementations of the same architecture.

between the 8086 and the other two, one of which is the maximum size of those address spaces. Motorola provides 24 address bits, Zilog has 23 (when a memory management unit is used along with the 48-pin version of the central processing unit), but Intel settled for 20 (see Fig. 2). Also, in the inevitable tradeoff between the number of general-purpose registers and the number of bits per instruction, Intel has favored code density to such an extent that for many applications, 8086 programs appear likely to require approximately 30% less memory than will Z8000 and MC68000 programs.

Another fundamental difference is the provision by Zilog and Motorola, but not by Intel, of hardware and instruction-set support for a supervisory operating state different from the normal state. There are two distinct stack pointers (normal and system) and certain classes of privileged instructions that can only be executed when the device is in the supervisory state. Attempts to execute privileged instructions while in the nonsupervisory state result in traps. Zilog's memory management unit (MMU) extends these protection concepts to memory accesses as well by allowing segments to be declared off-limits to normal-mode programs.

Such features support sophisticated operating systems intended for multiple users. They place the Z8000 and the MC68000 squarely in competition with high-end minicomputers, for applications in which one computer is used at various times (or in rapidly alternated time slices) for many different purposes. This, however, is a very different market from the dedicated-function applications on which microprocessors have so far made such an enormous impact, and Intel has chosen thus far not to enter it. When the end users of a microprocessor-based product will not in fact be writing programs, there may be no advantage to the added complexity (and input/output overhead) of such system-protection features.

The third issue in which clear differences are apparent between these three vendors' architectural philosophies is the size and use of the register set. The Z8000 has 16 16-bit registers, the MC68000 16 32-bit registers. In contrast, the 8086 family provides just eight 16-bit general-purpose registers, although this tally does not include those used by the memory-mapping or segmentation process (see "Segmentation techniques: the 8086 vs the Z8000," p. 167). Each of the eight can be designated as a source or destination of almost all arithmetic and logical operations, as can any memory location.

On the other hand, Intel has also allocated unique functions to specific members of its general-purpose register set to a far greater extent than have Motorola and Zilog. The greater coding efficiency thus gained permits the 8086 to provide an extra level of array indexing at no penalty in code density.

To a programmer, one of the most appealing aspects of the 8086 architecture is the form of its two-operand instructions. All the register-to-memory operations (except multiply and divide) are fully symmetrical, in the sense that the result may be left either in any register or in the memory location referenced. Those addressing modes involving the use of a second (and sometimes a third) register to point to memory, however, can employ only specific subsets of the entire register set for that purpose.

Two 8086 registers (BX and BP) are designated as base registers, and two others (SI and DI) as index registers. The effective logical address is computed by summing any possible combination of a base, an index, and an 8- or 16-bit displacement. Omitting the first two, of course, is equivalent to direct addressing and all others are forms of register-indirect addressing.

Associating one implicit operand with certain operations, however, reduces the bit count assigned to operand specification, permitting those operation codes to occupy only a single byte in many cases. This of course is the advantage of designating one register as the accumulator, as Intel has traditionally done.

Two formats

In the 8086/8, therefore, most instruction types appear in at least two formats, one of which is completely general, while in the other the accumulator is implied as one of the operands. Even in encoding the general format, however, the indirect-addressing functions have been restricted to four of the eight registers. That makes code bits available for other purposes, such as specifying either word versions or byte versions of nearly all instructions, while still allowing the basic increment of instruction-word length to be 8 bits rather than 16.

The second major attribute of the 8086/8 family visible to a programmer is an instruction set with a richer choice of available functions than preceding 8-bit CPUs have offered. While this is perhaps a consequence of having more code bits available, it is not really dependent on having a 16-bit machine *per se*, since the number of bytes involved in specifying an instruction together with its operands can vary from one to at least six in certain cases (such as move immediate word to memory with 16-bit displacement).

Of the wide variety of these new instructions, perhaps the most interesting to many potential 8088 users are the string operations, which use the source and destination index (SI and DI) registers for automatically-incremented indirect addressing. The scan and compare instructions, respectively, examine a string for a match to either a 1-byte or one-word pattern held in the accumulator or to the corresponding successive elements of a second string. Both memory-to-memory and accumulator-to-(or from-)memory moves are also available for copying or initializing blocks of storage. Normally, a string instruction will be preceded by the extremely useful repeat prefix, which specifies that the instruction will be repeated on successive memory locations, while counting down a block length that has previously been set up in the 16-bit CX register, until either the whole block is completed or a match (or nonmatch) has been discovered.

As an example, a comparison between two strings that might be written in PL/M as:

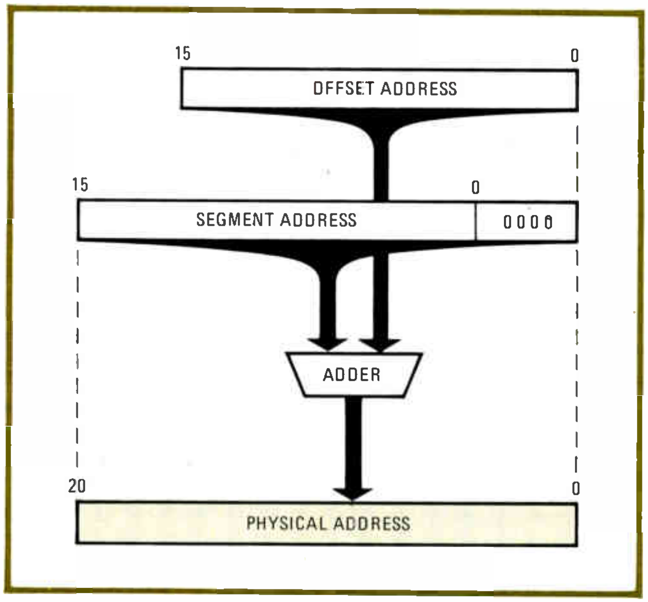
```
DO UNTIL A(I) = B(I) OR I = N
I = I + 1;
END:
```

requires only 2 bytes to encode: CMPB or CMPW preceded by REPEAT. The same looping options are also available for blocks of instructions that use LOOPZ and LOOPNZ. These are decrement-and-test conditional jumps that can be terminated by either the loop counter or the results of operations performed with the loop.

Another extremely convenient instruction, TRANSLATE (XLAT), accomplishes table lookup in one step. A data byte held in the accumulator is used as a pointer into a table, and the entry found there then replaces the previous data in the accumulator. This mechanism in addition aides sequential lookup operations, as might occur in working with a hierarchical data base. As the address of the first entry in a table is taken from the 16-bit BX register, these tables may be located anywhere in memory.

The arithmetic operations of the 8086/8 include built-in multiply and divide, available in 8-bit and 16-bit signed and unsigned versions, as well as data-adjustment instructions that facilitate binary-coded decimal and ASCII arithmetic. For BCD addition and subtraction, data may be stored as either one or two digits to a byte; for multiplication and division, data must be in one-digit-per-byte form.

While the accumulator is implied as one operand of the multiply and divide instructions, there are no restrictions at all on the other source operand—it may come from any register or from memory. The result, however, is left in the accumulator (extended into DX when a 32-bit product results). These operations are respectably fast, too: a 16-bit unsigned multiply takes 26.4 microseconds plus the operand-access time.



2. Address construction. Intel settled for 20 address lines that allow its 8086 and 8088 products to address 1 megabyte. To arrive at a physical address, a 16-bit effective address is added to the contents of a segment register that has been shifted up 4 bits.

The increased internal word length has the most impact on arithmetic-intensive programs, where the data precision (particularly in multiply and divide operations) saves much programming effort relative to 8-bit processors. The input/output options have also been expanded. Besides the 8-bit immediate device code familiar to 8080 users, it is possible to input or output data through one of 2^{16} ports, as dictated by the contents of the 16-bit DX register.

It seems clear that programs written in 8086 family code may require many fewer bytes than if the same functions were written for older 8-bit processors, although the exact numbers would certainly depend on the type of program. While this remark is precisely as valid for the 8088 as for the 8086, the 8088 must obviously perform two bus cycles to access a 16-bit instruction or operand, so it is less obvious that execution speed will be improved. Nevertheless, in many cases, the 8088 will easily outrun a 5-megahertz 8085 or a Z80. To see why, it is necessary to consider briefly some 8086/8 characteristics that are properly described as implementational rather than architectural.

Implementations count

First, the n-channel 8086/8 parts are fast, with a standard clock rate of 5 MHz, and selected parts operate to 8 MHz. The basic 8086/8 bus cycle, however, is actually more leisurely and allows the use of memory parts with 450-nanosecond access times instead of the 350 ns needed to operate with the premium-grade 5-MHz 8085-2. In systems with large amounts of memory, the initially much higher cost of the 8088 CPU may therefore be partially offset by savings in memory costs.

The greatest increases in the rate of program execution, however, come from the internal subdivision of the 8086/8 into a main processor and a semiautonomous bus interface unit, which overlaps instruction fetches with execution. By filling a queue (as mentioned it is 6 bytes long in the 8086, 4 bytes in the 8088) with prefetched instruction bytes, the bus interface unit renders effectively unnoticeable the time involved in performing address relocations and frequently permits the CPU to operate in an execution-bound manner.

Both architecture and implementation, as the terms have been used here, affect the total performance of a system: the former through the efficiency of the typical byte of code or the work accomplished per instruction-fetch cycle; the latter through the rate at which instructions are executed. An equally important attribute of any modern computer family is support software, which ideally has little effect on the performance of a completed system but can completely dominate its design cost.

Similar system software

By having a common instruction set, the 8086 and 8088 also use the same system software. PLM-86 provides more data types than PLM-80 (signed 16-bit integers, pointers, and real floating-point types in addition to the unsigned 8-bit and 16-bit integers of PLM-80) and can directly handle somewhat more complex data structures, so that programmer's effort is reduced. The 8086 assembler copes with the sometimes bewildering variety of options for encoding an operation and its operand references in what might be called an optimizing manner, so that the assembly-language programmer need not be plagued by a host of different mnemonics for essentially the same instruction.

Viewed as a whole, the register structure and the instruction set of the 8086/8 scarcely permit calling it a 16-bit 8080. They represent an architectural design that is well-balanced in its own right. Nevertheless, all of the registers and instructions of the 8080 can be mapped onto the 8086/8. Programs written for the 8080, once translated into 8086/8 code, can therefore be used intact, with either 8-bit or 16-bit operands. The CONV-86 program performs the translation.

As of this writing, all of this support software is offered as a package intended for use only on Intel's development systems. The source code, being a significant development investment, is closely guarded. Customers who prefer to perform their compilations, assemblies, and other support functions on in-house minicomputers or time-shared mainframe computers will apparently have to either look to independent software houses for equivalent 8086/8 tools or buy more Intel development systems.

With this family portrait in mind, the specific merits of the 8088 can be more closely examined. From a hardware viewpoint, the 8088 is completely compatible with the 8085's partially multiplexed bus. All of the software advantages inherent in the 8086 family architecture can therefore be made available to existing 8085-based systems simply by substituting a new CPU board. Backplanes, input/output interfaces, and memory boards designed to work with 8-bit processors can continue to be used, so that radically upgrading the software has only moderate impact on hardware costs.

As mentioned, when a 16-bit processor design is grafted onto an 8-bit data bus, two bus cycles will be required to fetch a 16-bit word. While this appears to imply that an 8088 will execute a program at half the speed of an 8086, that turns out to be a lower boundary. That is only partly because 25% of the operation codes in the 8086/8 instruction set use just 1 byte. There happen to be more instructions requiring 3 or more bytes than there are 1-byte instructions, but the queue makes these facts largely irrelevant.

By the time a reasonably complex instruction has been executed, the next one will have been fetched. (A queue of simple 1-byte instructions, on the other hand, is more likely to empty, so that the processor then becomes fetch-time–limited.) A program segment performing several multiply operations, as in a polynomial evaluation, will therefore run very nearly as fast on the 8088 as on the 8086 because bus access accounts for so little of the total execution time.

It should be pointed out, however, that the impact of the queue on execution rate is not always significant. Whenever a branch occurs (jump, calls, returns, etc.), all of the prefetched instruction bytes in the queue become useless, and fetch time becomes visible until—perhaps a few instructions later—the queue is again full. Since the 8086/8 bus cycle uses four 200-ns clocks, the next few instructions following a branch will be completed at a rate that is actually slower than that of an 8085-2, whose bus cycle uses only three clocks. Whether a given program as a whole will be completed more rapidly by the 8088 than by an 8085-2 depends on the instruction mix. Interpreters (which employ large numbers of calls) and simple control programs (those made up largely of conditional jumps) are not likely to run much faster on an 8088 than on an 8085-2; for those applications only the greater instruction set efficiency favors the 8088.

Because operands do not go through the queue (except immediate operands, which appear in the instruction stream), a program involving frequent memory reads and writes of 16-bit data will probably take almost twice as much time to execute on an 8088 as the same program working with 8-bit operands. Conversely, programs handling byte-oriented data execute on the 8088 at greater than 95% of the 8086's speed.

Where to use it

For what kinds of systems will the 8088 be most useful? The answer is different for existing system designs and for new ones.

Because the 8088 makes the 8086 family architecture and instruction set available on an 8-bit data bus, it becomes an attractive option to upgrade an existing 8080 or 8085 system design. The CONV-86 code-translator allegedly permits quick transplantion of 8080/5 programs to the 8088, where they may or may not run much faster because of the queue alone. As implied above, the greatest performance improvements are likely to be realized with programs that involve either large numbers of multiply or divide instructions or data-handling procedures supported by the table lookup and

Segmentation techniques: the 8086 vs the Z8000

The differing needs of dedicated and general-purpose applications show up in the 8086 and Z8000 microprocessor families even in their detailed philosophies of memory segmentation.

Intel has achieved significantly greater code density by two measures: having only four segments (code, stack, data, and extra), and defining a default reference segment for every memory access. Four correspondingly named segment registers hold the segment starting address. Although a single-byte instruction prefix can be used to override the default choice of segment register, normally no code bits are therefore needed in each instruction to designate the appropriate segment.

Physical addresses are computed automatically on the central processing unit chip by adding the logical address to 16 times the contents of the appropriate segment register. In allocating memory space, segment boundaries therefore start at multiples of 16 bytes. The address-translation process is transparent (invisible) to those programmers who do not alter the segment registers, and because of the instruction queue, it adds a very small cost in execution time.

Zilog, in contrast, has chosen to provide greater flexibility at greater cost. The memory relocation function requires a second 48-pin chip (the memory management unit, or MMU) and a different CPU package and introduces an extra but potentially useful step. When the logical address space exceeds 2^{16} bits, the instruction format must specify a 7-bit segment number. This will come either from a word of the instruction itself or, in the register-indirect addressing mode, from the register following that specified for operand addressing. This is used by the MMU to look up in its stored 128-entry table both the starting address of the segment and certain attributes, such as its total length and permissible accesses. The MMU therefore both maps logical addresses into the physical memory space and provides memory protection, but at the cost of a large chip and one added clock cycle per memory access. Because of the necessity to specify which of the 128 segments is involved in each access, however, programs written for the segmented (8001) version are incompatible with those written for the unsegmented (8002) both at the object code level and in register usage.

string instructions. Some recoding would be necessary to exploit the new instructions, and of course that effort should be focused on those modules the program is known to spend the most time executing.

Major performance improvements to a microprocessor-based product, even though mandated by pressure from competitors' newer designs, are often postponed because of the expense inherent in developing new hardware and new software simultaneously. Because the 8088 is compatible both with 8-bit data buses and (via CONV-86) with 8080/5 software, it permits the conversion to a more powerful family to be made in stages, with certain software or hardware modules continuing in use until their development cost has been recovered. If a product line will eventually require 16-bit precision, the 8088 eases that transition by allowing new software to be developed independently of hardware growth.

When a new product is about to be developed, unconstrained by existing hardware or software, the cost of the 8088 may be justified in several situations. In text-processing, data-communication, and arithmetic-intensive applications, the advantages are similar to those discussed just above. Whenever execution speed is a factor, moreover, both the queue and the architecture will be beneficial. Programs written from the start for the 8088 should also require somewhat less program memory space than earlier 8-bit machines needed.

There may also be cases where the natural word length is 16 bits, but the full execution speed of the 8086 is not essential. Each new random-access memory capacity is introduced first in a 1-bit width, and multiple-bit parts seem to lag them by one to two years. Certain sizes of total memory, therefore, can be implemented much more economically 8 bits wide than 16 bits wide. This is true now for 16-K-by-1-bit RAMs and will be even more true for 64-K-by-1-bit RAMs.

The 8088 has another advantage in the manufacture of a product line since different models offer a number of groups of options, where each option is supported by a different and rather complex mix of subprograms. Such situations often require that the necessary code blocks for different functions be linked and located anew for each model in the product line. Because the segmentation method used in the 8086/8 accomplishes program relocation simply by altering the contents of one segment register, the program code for each function option can be linked, located, and programmed into read-only memories with the same starting address—as if no other program modules were to be present. These modules can then be loaded into any convenient position in the 1-megabyte physical address space of the 8088. A short supervisory user-interface module then suffices to load the code segment register with the physical location of the function module selected by user input. The various program modules can therefore be inventoried as fully programmed ROMs that need not be modified as the software options present in different models are varied.

But perhaps the most valuable asset of the 8088 is the fact that because it is architecturally identical to the 8086, the same programs can be run on either CPU without modification. Two distinct levels of computer cost and performance are therefore available to the original-equipment manufacturer developing a broad product line, without duplication of software effort. Upgrading from a nonsegmented Z8000 system to a segmented one, in contrast, will require careful reexamination of programs. For applications that do not require sophisticated protection facilities, this may well represent the bottom line. □

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Memory finds and fixes errors to raise reliability of microcomputer

Using a Hamming code scheme lets byte- and word-wide memory boards correct single-bit errors, tell system to act when double-bit errors occur

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□ As microcomputer systems advance into more and more sophisticated applications, their reliability becomes of greater importance to manufacturers and end users. They must stay up longer, and when they do fail, they must be returned quickly to service. Furthermore, repairs must be easier to make because field-service costs have become a major consideration.

A major reliability concern on any project using large amounts of memory is data integrity. Error detection and correction in memory go a long way toward improving the overall reliability of the system. Members of the Mupro Multibus-compatible MBC series offer designers just this feature. Available in 8-bit (byte-wide) or 16-bit (byte-or-word-wide) versions, they contain error-checking and -correcting (ECC) circuits that implement a modified version of the Hamming code. With ECC, the sources of error can also be pinpointed and the system made to adapt to their occurrence. Calculations show that these circuits increase the reliability of memory boards 85 times over a 10,000-hour period.

A recent article [*Electronics*, Nov. 22, 1979, p. 103] explained in some detail the workings of the data-coding scheme devised by Richard Hamming of Bell Laboratories in Holmdel, N. J. Basically, that scheme makes it possible to detect and correct all single-bit and to detect all double-bit errors. Since the likelihood of any other type of noncatastrophic error is astronomically small, Hamming codes can make a system practically fail-safe.

Single-bit error detection and correction obviously increase the reliability of microprocessor-based systems, ensuring a higher level of data integrity. Less obvious perhaps are the advantages offered by double-bit detection, which lets the system operate more intelligently in the presence of uncorrectable errors. By taking advantage of the board's error-detection capabilities, servicing can be simplified too.

ECC coding

For a full understanding of how these boards, in particular, allow increased system intelligence, their operation must be considered. This involves an examination of the modified coding scheme and how it is used to provide the board's special features. To simplify the explanation, an 8-bit data scheme (Fig. 1) will be discussed first and will then be extrapolated for 16-bits.

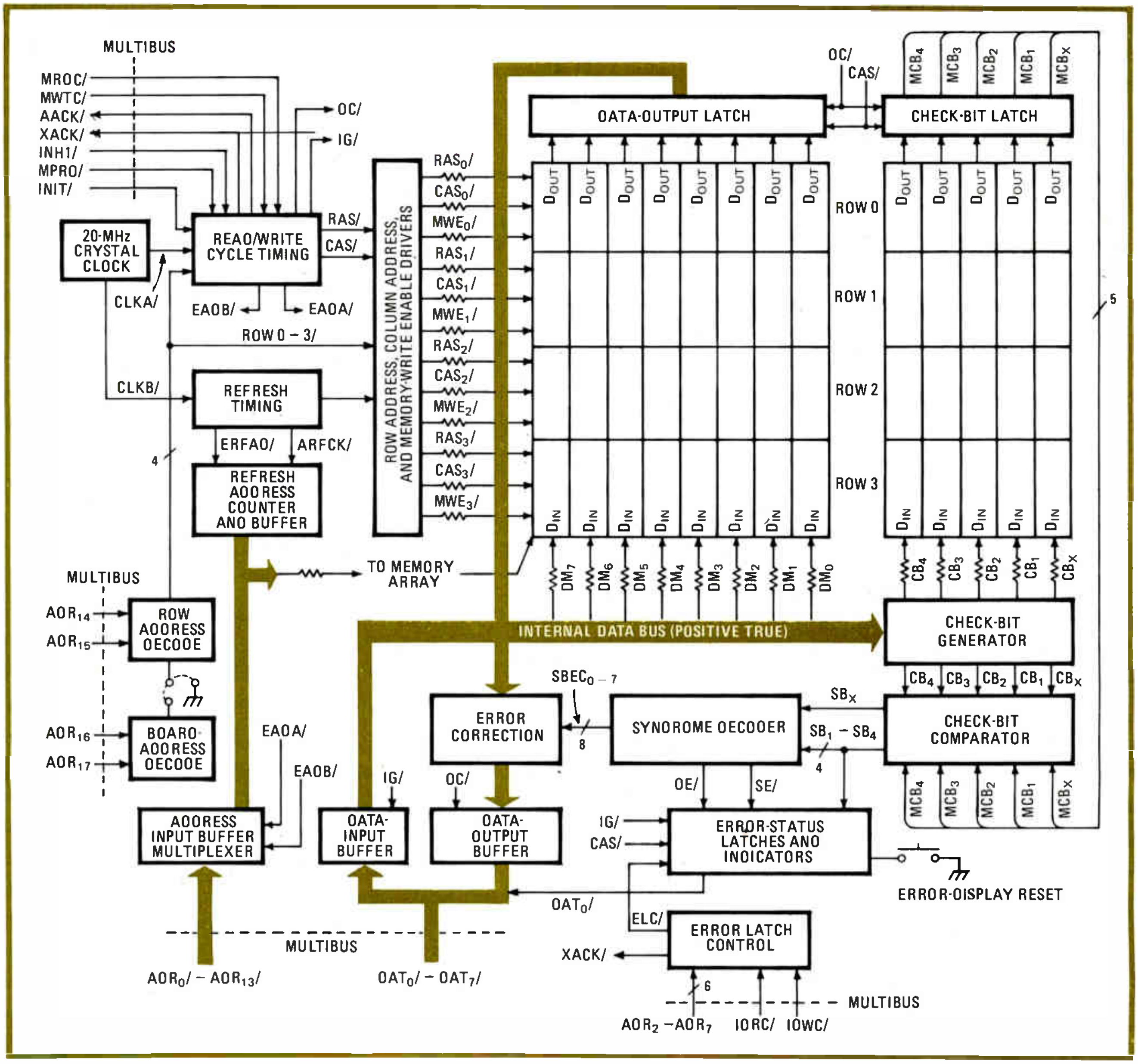
The primary object of this particular scheme is to locate the position of single-bit errors, whether they occur in the data itself or in the Hamming code. The total number of bits in the data and code must therefore be indicated by the code. A 4-bit binary code, for instance, can designate any of 2^4 (16) different locations. For an 8-bit byte, then, a 4-bit code is more than sufficient to detect single-bit errors. The Hamming technique can also be used to detect the presence, though not the locations, of double-bit errors. An extra code bit, or check bit, is needed for this. So for a byte, the total number of check bits used is five.

In the modified technique used for the MBC boards, the check bits are derived by taking the odd or even parity (see "A parity review," p. 170) of the sum of certain bits. The bits chosen differ from those in the scheme presented in the previous article, because of the modified mathematics used, but have the same basic rationale. Thus, for a byte-wide board, the check bits are derived according to the byte-masking precedure indicated in Table 1. The last bit, C_x, is generated by a group of bits that make it equivalent to a parity sum of all bits. It is also a parity sum of the other four check bits, the importance of which will be shown.

When data is written into an MBC board, this procedure of check-bit generation is performed, and the data word and check bits are stored in memory. During any read operation, the board forms a new set of check bits for the data word read. It does this in the same way as when data was written in. The new set of check bits is then compared to the write-in set by taking a modulo-two sum of each corresponding pair of old and new check bits. The resulting 5 bits are called syndrome bits.

Syndrome bit S_x, the result of comparing the old and new C_x bit, is first examined. If this bit is equal to 1, Hamming theory says that a double-bit error has occurred. Therefore, at the user's option, an interrupt can be generated immediately, informing the processor of an uncorrectable error. If the bit is a 0, the remaining four syndrome bits can be examined to see if any other error has occurred.

The logic that decodes the remaining syndrome bits can be regarded as a map like that shown in Table 2. If the syndrome bits are all zero, the old and new codes are identical and no error has occurred. If any one of the syndrome bits is a 1, either a single check or data bit is in error, or there are multiple bit errors. In the case of a single data-bit error, a signal is sent to a gate to invert that particular bit, correcting it; check bits, with no influence outside memory, need not be corrected. A multiple error indication causes an interrupt. This entire



1. Righting a bit. When data is read from the 8-bit memory board shown, a new set of check bits is created and compared to those generated when the data was written in. The result is sent to the syndrome decoder, which inverts any single-bit error that has occurred.

A parity review

As ordinarily used, parity is a relatively simple method of detecting an odd number of bit errors in a data word. A parity bit is generated by counting the number of 1s and 0s in the word and assigning a value of 1 or 0 to the parity bit based on this count. The value assigned depends on whether an odd or even parity scheme is being used.

The most common approach is to use an odd parity scheme. The value of the parity bit is determined such that the number of 1s in the combination of data word and parity bit is always odd. Thus if the data word is 00110101, the parity bit will be 1, and if the word is 11000111, the parity bit will be 0. Odd parity has the advantage of guaranteeing that there is at least a single 1 in the data-parity combination, thus helping to detect shorted data lines.

For even parity, the rule states that the number of 1s in the data-parity combination will always be even, so data word 00110101 gets a 0 parity bit and 11000111 gets a 1.

Any parity bit is generated by first taking a modulo-two sum of the data bits. In modulo-two math, the binary digits 0 and 1 add as in ordinary additon, except that the sum of 1 and 1 is 0. The modulo-two sum of all bits in a data word is equal to the even parity bit and the same sum plus 1 is the odd parity bit. The symbol used to denote modulo-two addition is $\oplus$ and the logic that realizes the function is usually composed of exclusive-OR gates.

TABLE 1: CHECK-BIT GENERATION MASK

Parity	Check bit	Data bits 0	1	2	3	4	5	6	7
Odd	C_1	X	X	X		X		X	
Even	C_2	X			X	X			X
Odd	C_3		X				X	X	X
Even	C_4			X	X	X	X	X	X
Odd	C_X	X	X	X	X		X		

TABLE 2: SYNDROME MAP

S_4S_3	S_2S_1 00	01	10	11
00	no error	C_1	C_2	D_0
01	C_3	D_1	*	*
10	C_4	D_2	D_3	D_4
11	D_5	D_6	D_7	*

*denotes multiple errors

detection and/or correction process take place within the board's 380-nanosecond access time.

Although the discussion has so far centered on byte-wide data, the procedure is basically the same for 16-bit words. An entire word is handled the same way, except that an extra check bit is needed to encode the location of single-bit errors; the extra bit lets the code handle 25 to 32 locations.

Many 16-bit processors use 16-bit data words that are often modified one half at a time; either the upper or the lower byte is changed. This adds another dimension to the board's operation, because the check bits are formed based on the entire word.

When an upper or lower byte is written into a 16-bit-wide memory to modify a stored word, that entire word is read and checked for errors. Once the checking and correcting process is complete, the new byte is added to the word and a new set of check bits generated. The word and code are then rewritten into memory. This process adds to the access time, since a read operation must be performed each time a byte is written. Aside from this time difference, both 8-bit and 16-bit boards appear to the system as operationally identical.

Locating error sources

Both boards use the ECC to ease maintenance. A row of light-emitting diodes at the top of each board is controlled by the ECC circuitry. There are ten LED indicators on an 8-bit board and 11 on an 16-bit board. The first four LEDs have numbers from 0 to 3 printed above them, which correspond to the row locations of the RAM chips on the board. Of the next two LEDs, the first is labeled SBE (single-bit error) and the second DBE (double-bit error). Depending on whether it is an 8- or 16-bit board, there are four or five additional LEDs, respectively, that can indicate a column address in binary form. When a single-bit error occurs, the SBE LED lights up, as do the LEDs indicating the row and column location of the chip where the error occurred. Thus a technician can quickly locate and replace a failing chip by simply looking at the LEDs.

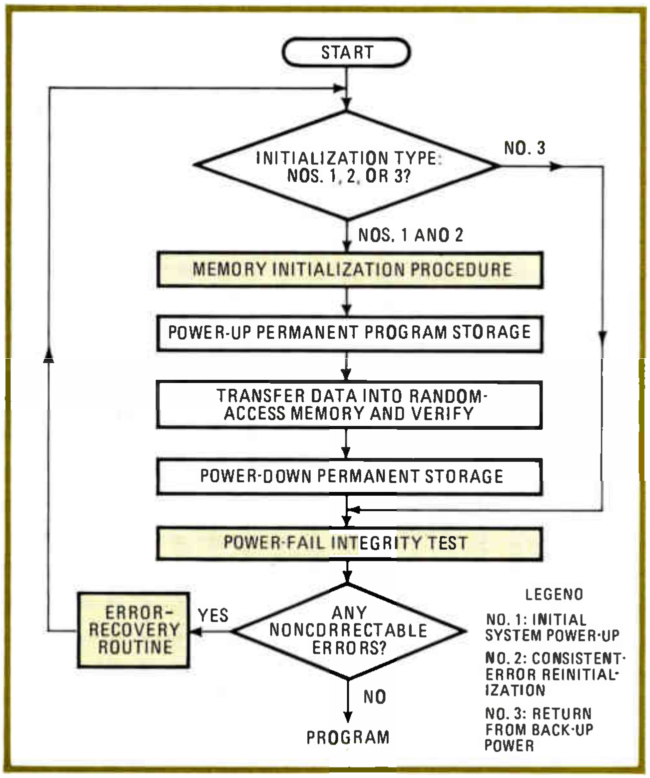
Also under ECC control is an error-status register. In this register, the board stores the row, syndrome, and single- or double-bit error status. The information can be read by the processor to examine memory locations for noncorrectable errors or to keep a log of failure trends.

The ECC can also be strapped to an external line so that when a double-bit error occurs the processor is interrupted. This lets the processor make an intelligent decision on the next course of action. A typical system in which this and other attributes of ECC are fully realized is one that keeps the operating program in RAM, an arrangement called RAM-intensive.

The block structure of a RAM-intensive system (which usually uses 64 kilobytes of RAM or more) is the same whether it uses ECC memory or not. In either case the operating software is usually transferred into RAM, from, for example, an internal read-only memory board or a programmable-ROM board. Or the program may initially reside on disks or tapes.

Transferring the program into low-power RAM saves power, because the power-hungry ROM/PROM board or serial-medium drive used during bootstrapping can now be powered down while the processor goes to work. Powering down any system components can cause glitches that may introduce single-bit errors, but ECC boards can correct them without stopping the processor.

The ability to correct single-bit errors without shut-



2. Start or restart. The reason for system initialization determines the way it is done. With ECC memory boards, one reason might be to try to overcome a double-bit error, in which case the data that is stored for the initialization test is intentionally changed.

ting down the processor is extremely important, since many such errors are nondestructive and nonrecurring, or soft. But of equal importance is the ability to stop the processor when an error cannot be corrected. Upon receipt of an interrupt, there are many possible corrective actions the processor may take. The choice depends on the routine being run when the error occurs.

Processor choices

In a process-control routine, for example, a double-bit error may occur when the sampled data is read from a particular memory location. There is often sufficient time to log the fact that an error has occurred and retake the data. If a number of attempts to read the data in that location fails, the bad location can be recorded and another location used to complete the operation.

In another instance, the particular routine that accessed the memory when a noncorrectable error occurred could be started again from the beginning. To prevent the routine from looping continuously, a timer could be set to interrupt the process and cause an exit from the routine. A standard or control value might be substituted for the desired result and a message sent to an operator to notify him that this has been done. Thus, the operator is alerted to the fact that some repairs may have to be made, and the system can continue working until it is convenient to make them.

Though in many instances a faulty routine can be bypassed by inserting a predetermined, standard value for a process, there are times when this should not be done. In general, it is not advisable to use this procedure

TABLE 3: ERROR-RECOVERY ROUTINES

```
      EQUATE STARTING'ADDRESS = #8000,
             ESR = #60;
      GLOBAL SECTION;
      ENTRY  START'PROGRAM;
INTO'2                                   ! 24 BYTES OCCUPIED BY
      DS 24;                             ! INTERRUPTS 0, 1, AND 2
INT3:
<<  A MEMORY READ ERROR HAS OCCURRED. RESET THE ERROR
    STATUS ON THE MEMORY BOARD. THEN LOAD THE ACCUMULATOR
    WITH THE CONTENTS OF THE SECTION STATUS REGISTER AND
    BRANCH TO THE ERROR RECOVERY ROUTINE.      >>
    CALL RESET'MEM'ERROR;
    A = SECTION;
    GO TO ERROR'ROUTINE;
INT4'7:                                  ! 32 BYTES OCCUPIED BY
    DS 32;                               ! INTERRUPTS 4 THRU 7
START'PROGRAM:
<<  THIS IS THE INITIALIZATION SECTION OF THE PROGRAM,
    DESIGNATED AS SECTION "A". LOAD THE SECTION STATUS
    BYTE WITH 3 TO INDICATE THAT THE PROGRAM IS IN
    SECTION "A".    >>
    A = 3
    SECTION = A;
    ENABLE INTERRUPT;
<<  CONTINUE WITH SECTION "A" PROGRAM    >>
START'B:
<<  THIS IS THE PROGRAM SECTION DESIGNATED AS "B". LOAD
    THE SECTION STATUS BYTE WITH 2 TO INDICATE THAT THE
    PROGRAM IS NOW EXECUTING SECTION "B".      >>
    A = 2;
    SECTION = A;
    ENABLE INTERRUPT;
<<  CONTINUE WITH SECTION "B" PROGRAM    >>
START'C:
<<  THIS PART OF THE PROGRAM IS SECTION "C". LOAD THE
    SECTION STATUS BYTE WITH 1 TO INDICATE THAT THE
    PROGRAM IS EXECUTING SECTION "C".      >>
    A = 1;
    SECTION = A;
    ENABLE INTERRUPT;
<<  CONTINUE WITH SECTION "C" PROGRAM    >>
ERROR'ROUTINE:
    A = A - 1;
    IF ZERO THEN
      BEGIN
<<    SECTION STATUS REGISTER CONTAINS A=1. INITIALIZE
      THE APPROPRIATE PARAMETERS. THEN . . .    >>
      GO TO START'C;
      END;
    A = A - 1;
    IF ZERO THEN
      BEGIN
<<    SECTION STATUS REGISTER CONTAINS A=2. INITIALIZE
      THE APPROPRIATE PARAMETERS. THEN . . .      >>
      GO TO START'B;
      END;
<<    SECTION STATUS REGISTER CONTAINS A=3 . . .    >>
    GO TO START'PROGRAM;
RESET'MEM'ERROR:
<<  CLEAR THE ERROR STATUS ON THE MEMORY BOARD BY
    ISSUING AN I/O READ FOLLOWED BY A MEMORY READ.
    THEN RE-ACTIVATE THE ESR BY ISSUING AN I/O WRITE.    >>
    HL = STARTING'ADDRESS;
    A = INPUT(ESR);
    A = MEM(HL);
    OUTPUT(ESR) = A;
    RETURN;
    END.
```

when the results of the routine determine whether or not a critical process should be halted. When an uncorrectable error is found in a critical process, a message should be immediately sent to the operator, after which the system can retry the routine as it did above. Should retrying the routine prove unsuccessful, instead of continuing with a predetermined value the system can be shut down.

Alternatively (depending on the amount of time that can be spent before shutdown), exit from an uncompleted routine could begin a system reinitialization. In that case, the operating program is loaded into RAM from the permanent storage medium, as was done when

TABLE 4: POWER-FAIL INTEGRITY TEST

```
  EQUATE   NUMBER'OF'BYTES = #8000,     ! ASSUME 32K OF MEMORY
           STARTING'ADDRESS = #8000,    ! FROM 32K TO 64K.
           ESR = #60;

  ENTRY    INTEGRITY'TEST;

INTEGRITY'TEST:
  DISABLE INTERRUPT ;                   ! PERMIT ALL LOCATIONS TO BE
                                        ! READ WITHOUT SYSTEM INTER-
                                        ! RUPTS OR AN ERROR INTERRUPUPT
  HL = STARTING'ADDRESS ;               ! SET ADDRESS POINTER
  DE = NUMBER'OF'BYTES ;                ! SET BYTE COUNTER
  A = IMPUT(ESR) ;                      ! PUT ESR IN NONLATCHING MODE
  A = MEM(HL) ;                         ! CLEAR THE ERROR STATUS
  OUTPUT(ESR) = A ;                     ! PUT ESR IN LATCHING MODE
READ'LOOP:
  A = MEM(HL) ;                         ! SET ESR IF ERROR IN MEM(HL)
  HL = HL + 1 ;                         ! INCREMENT ADDRESS POINTER
  DE = DE - 1 ;                         ! DECREMENT BYTE COUNTER
  A = D ; A = A OR E ;                  ! SET ZERO FLAG ON BYTE COUNT
  IF NONZERO THEN GO TO READ'LOOP ;     ! ALL MBC ADDRESSES READ?
  A = INPUT(ESR) ;                      ! READ THE ERROR STATUS
  RAR ;                                 ! SET CARRY FLAG ON STATUS
  IF CARRY = 1 THEN
    BEGIN
      << ROUTINE TO HANDLE INVALID DATA CONDITION >>
    END;
<<*********************************************************>>
  ENABLE INTERRUPT ;                    ! AS REQUIRED FOR APPLICATION
<<*********************************************************>>
  RETURN;                               ! DATA VALID--PROCEED !
  END.
```

TABLE 5: MEMORY-INITIALIZATION PROCEDURE

```
  EQUATE  NUMBER'OF'BYTES = #8000,  ! ASSUME 32K OF MEMORY
          STARTING'ADDRESS = #8000, ! FROM 32K TO 64K.
          RST'3 = #DF,              ! RESTART 3 INSTRUCTION
          ESR = #60;

  ENTRY   MBC'INITIALIZE;

MBC'INITIALIZE:
  DISABLE INTERRUPT;         ! INSURE ROUTINE COMPLETES
  A = INPUT(ESR);            ! SET ESR TO NONLATCHING MODE
  HL = STARTING'ADDRESS;     ! SET ADDRESS POINTER
  DE = NUMBER'OF'BYTES;      ! SET BYTE COUNTER
  B = RST'3                  ! LOAD B WITH "RESTART 3"
WRITE'LOOP:
  MEM(HL) = B;               ! WRITE "RESTART 3"
  HL = HL + 1;               ! INCREMENT ADDRESS POINTER
  DE = DE - 1;               ! DECREMENT BYTE COUNTER
  A = D; A = A OR E;         ! SET ZERO FLAG ON BYTE COUNT
  IF NONZERO THEN GO TO WRITE'LOOP;

  A = INPUT(ESR);            ! SET ESR TO NONLATCHING MODE
  HL = HL - 1;               ! POINT TO LAST MBC ADDRESS
  A = MEM(HL);               ! READ CYCLE UPDATES ESR
  OUTPUT(ESR) = A;           ! SET ESR TO LATCHING MODE
<< ************************************************** >>
  ENABLE INTERRUPT;          ! AS DESIRED FOR APPLICATION
<< ************************************************** >>
  RETURN;                    ! MEMORY AND ESR INITIALIZED
  END
```

the system was initially powered up. If the results are still unsatisfactory, the system can be shut down.

These kinds of choices can be made by error-recovery routines such as the one given in Table 3, which directs the processor to three different subroutines in the event of an uncorrectable error. Routing to a particular, user-defined subroutine depends on the nature of the error-producing program.

One of the user's options, as indicated earlier, is to reinitialize the entire system after other attempts have been made to recover from the error. This initialization follows much the same procedure as when the system was first powered up. The basic difference between the two is that the procedure is initiated by hardware upon power-up and by software in the event of an error.

A third event that could call for reinitialization is the return of power after a brownout or blackout. During such power shortages, the memory is usually kept alive by a backup supply so that data will not be lost. So in all likelihood the memory contents are still good when line power returns, making it unnecessary to go through an entire initialization. The system should be designed to distinguish the type of initialization necessary.

For an ECC memory system, an initialization program flow is shown in Fig. 2. The first step in that program is to determine the cause of initialization. This is done by examining the contents of five predesignated locations, whose contents determine the path to follow.

Getting started

If these contents are certain known values—values inserted by the operating program when it is loaded—the program assumes the system is recovering from a power failure in which backup power kept the operating program from being lost. In practice, the criterion used is that four of the five locations be valid, so that a bad location can be bypassed without causing a full initialization. If this condition is met, the program bypasses the full initialization routine and jumps to the power-fail integrity test given in Table 4.

This test places the error-status register (ESR) in the nonlatching mode and clears it. It then puts it back in latching mode and reads all memory locations. Once all memory locations have been read, the ESR is again checked to see if any errors have been detected. If not, the system can start operation again.

If errors do occur, perhaps due to glitches during the power-up or backup power failure, the system can start the initialization procedure again under software control, just as it might for an error-recovery routine. However, since the operating program has been loaded, the five checking locations are first loaded with incorrect data by the software control routine. Then when a check is performed, the initialization program will not jump to the power-fail integrity test. It will proceed as if the system had just been powered up and the operating program never loaded; it will perform a complete initialization procedure such as that given in Table 5.

The initialization procedure begins by writing in all memory locations so that the check bits correspond to the data. This ensures that, when data is read later on, there are no double-bit errors due to random data being left in memory. In the program shown, RESTART 3 is written into all locations, to call an error-recovery routine if an unused location is read.

After the initialization procedure is complete, the permanent operating-program storage is powered up, the program is transferred into RAM and verified, and the permanent storage powered down. the integrity test is then run to be sure that data has not been disturbed. □

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Circle 173 on reader service card

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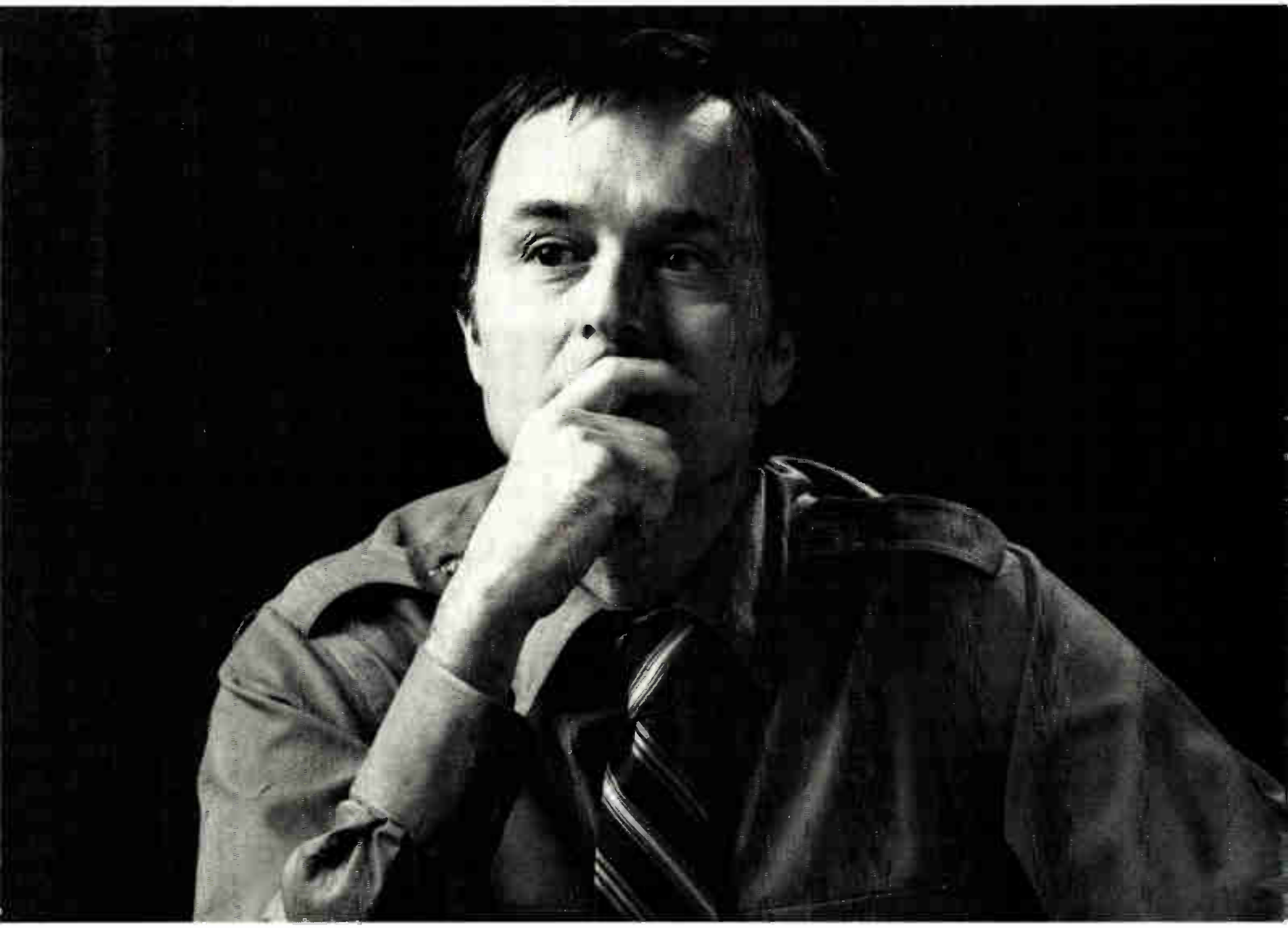

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It's called the IM7147. And Intersil makes it. It's a low-power, 4K static RAM with 55ns access times.

	Operating Power	Standby Power	Access Time
IM7147	125mA	20mA	70ns
IM7147L	100mA	10mA	70ns
IM7147-3	**125mA**	**30mA**	**55ns**
IM7147L-3	**110mA**	**20mA**	**55ns**
(military) IM7147LM	125mA	20mA	85ns

Now, you're probably thinking you'll have to pay an arm and a leg for that combination of performance. Not so. Intersil 4K statics are super competitive with anything even near to equivalent in the market today.

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NEEDS IS A LOW-POWER 2147."

A FAMILY THAT WON'T QUIT.

Don't get us wrong. We have the high-performance 4Ks, but we also have a raft of the regular 4Ks. So, if you need standard 2147s for existing sockets, we've got you covered. Same with 2114s and 7141s (2141s).

Any way you slice it—1K x 4 or 4K x 1, low-power or industry standard, commercial or military—Intersil's got your part. At a competitive price. And we're quoting immediate delivery. Off the shelf. It you don't believe it, just try us with an order.

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Sounds like we have our act together, right? Well, we're not stopping there.

To give just a peek at the future, in first quarter 1980, we'll be bringing out the IM7148. It's a new high-performance, low-power 4K especially well-suited to mainframe memories.

FROM THE LOW-POWER WHIZ KIDS.

Actually, it shouldn't surprise you that Intersil is doing all this. Since we're known for our innovation in CMOS technology. But it hasn't been by accident. We've focused on it. Because one of the things we thought this country needed was a good low-power technology company.

INTERSIL NMOS STATIC RAM FAMILY		Operating Power	Access Time
1K x 4	IM2114-2 (D2114-2)	100	200ns
	IM2114-3 (D2114-3)	100	300ns
	IM2114 (D2114)	100	450ns
	IM2114L2 (D2114L2)	70	200ns
	IM2114L3 (D2114L3)	70	300ns
	IM2114L (D2114L)	70	450ns
	IM7114L2	50	200ns
	IM7114L3	50	300ns
	IM7114L	50	450ns
4K x 1	IM7141-2	70	200ns
	IM7141-3	70	300ns
	IM7141	70	450ns
	IM7141L2	50	200ns
	IM7141L3	50	300ns
	IM7141L	50	450ns
1Kx4	D2147	160	70ns
	D2147L	140	70ns
	D2147-3	180	55ns
	IM7147	125	70ns
	IM7147L	100	70ns
	IM7147-3	125	55ns
	IM7147L-3	110	55ns
	MD2147	180	85ns
	IM7147LM	125	85ns

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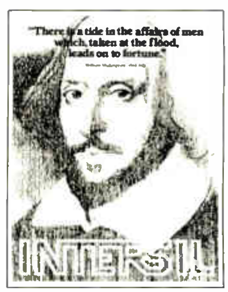

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E1380

Five-chip circuit transforms scope into logic analyzer

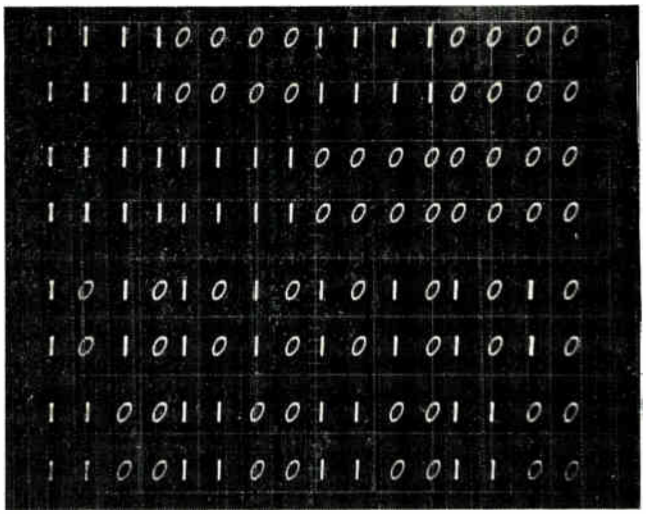
by P. Martinez, A. Roy, and J. Barquillas
Department of Electronics, University of Zarogoza, Spain

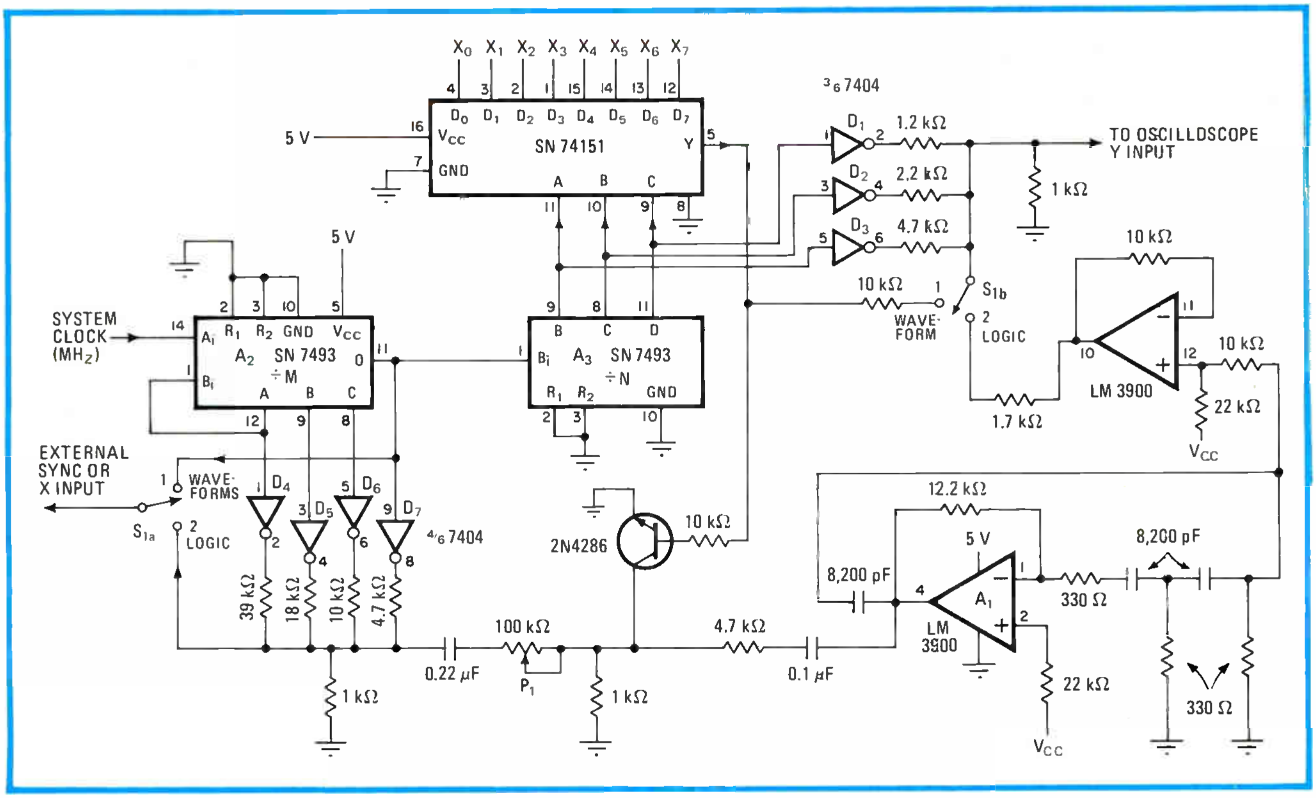
Adapting a general-purpose oscilloscope to use as a logic analyzer, this inexpensive five-chip circuit will permit the numerical display of 1s and 0s for as many as eight digital wavetrains simultaneously. The design is vastly simplified through the use of a rudimentary adder circuit and two primitive digital-to-analog converters, which combine a derivative of the multiplexed signals to be displayed with the numeral-forming circuitry.

In general operation, logic variables X_0–X_7 are introduced into the inputs of the 74151 eight-line multiplexer, as shown. Meanwhile, the LM3900 generator, A_1, produces a sine wave in the vicinity of 150 kilohertz; and the 7493 divide-by-M counter, A_2, which in conjunction with the 7404 inverters and weighted-resistor network forms a d-a converter, is advanced by the system clock. The divide-by-M circuit drives a second counter, A_3, which advances the multiplexer at a rate equal to 1/M that of the stepping frequency of A_2.

If the mode switch, S_1, is placed in position 1, X_0–X_7 are applied directly to the scope's Y input. A_2 drives the sync input with a logic 1. Thus the scope may be utilized to display eight digital waveforms.

The unit is placed in the analyzer mode when the switch is brought to position 2. When the numeral is to be displayed for a given X_i, the sine-wave output of A_1





Adaptation. Inexpensive five-chip circuit adapts scope for duties as logic analyzer. Circuit generates sine wave at Y channel and 90°-displaced sine wave at X channel to produce skewed 0 numerals for any digitally multiplexed X_i input. Unweighted sawtooth is generated at X channel for display of 1s. Mode switch S_1 selects either eight digital waveforms or logic states of the input waveforms as in the photo.

appears at the scope's Y input along with weighted voltage of d-a converter D_1–D_3, which ultimately determines the vertical position of the trace on the screen. At the X input, A_2's weighted output delivered by converter D_4–D_7 adds a component of voltage to A_1's output that effectively displaces its sine-wave signal by 90°. Thus a small numeral 0, slightly skewed, appears on the screen as a result of the Lissajous addition.

If, on the other hand, a 1 is to be displayed, the Y output of the 74151 moves high and brings point A to ground. Consequently, the X input is driven by a waveform, generated only by D_4–D_7, that is an approximate sawtooth. Under these conditions, the trace can rise only vertically, being bound in the horizontal direction at any instant.

In either case, because A_2 steps forward at M times the speed of A_3, the trace will sweep across the entire screen to monitor the variable under observation before the multiplexer is advanced to its X_{i+1} port. Note that the sweep is not continuous, but proceeds from left to right in discrete steps, as a result of A_2's stepped output.

The process is then repeated for the next variable. Because the speed of the system clock is high and the persistence of the scope's phosphor is high, the 1s and 0s appear to be scanned simultaneously. The display format generated is illustrated in the photo. □

Dynamic VCO test detects V-f nonlinearities

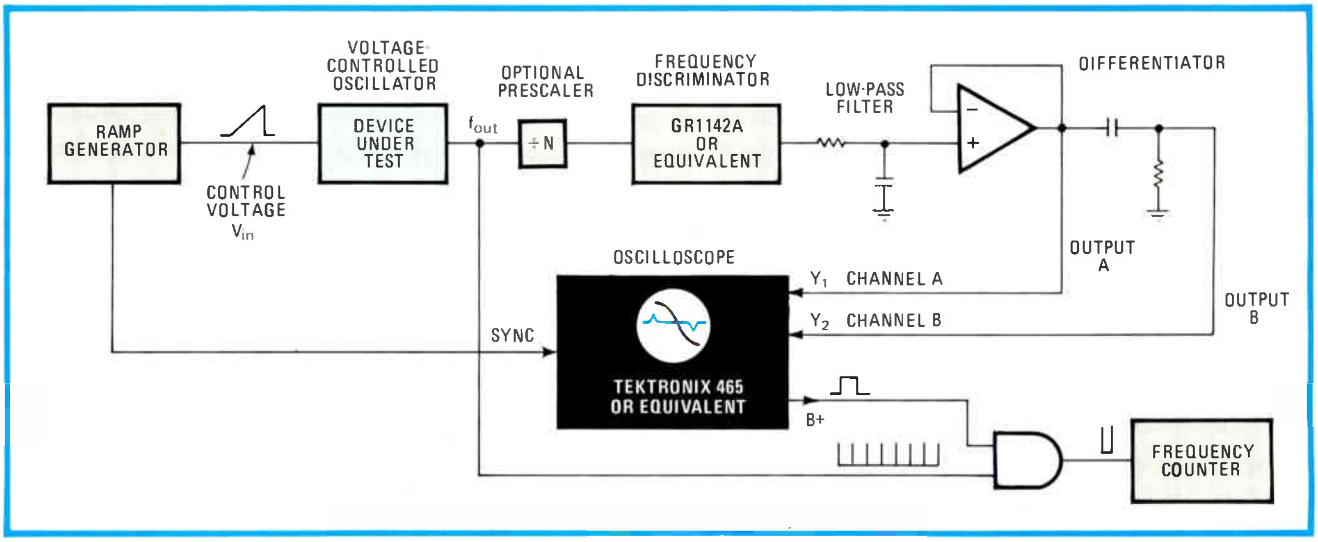
by Hanan Kupferman
Century Data Systems, Anaheim, Calif.

Checking the dc response, or static behavior, of a voltage-controlled oscillator is easy enough to do, requiring only the plotting of output frequency versus a discrete set of control voltages. But more often than not the dynamic, or ac, response is the parameter of interest, especially if a small nonlinearity in the voltage-to-frequency response exists. Fortunately, running a dynamic check is relatively uncomplicated, as the method described here makes evident. With it, nonlinearities are quickly spotted, and the frequency at which the anomalies occur can be readily measured.

As can be seen, the input of the VCO is driven by a ramp voltage that sweeps it over its range of frequencies. Its output is then introduced into a frequency discriminator, which generates a voltage corresponding to the VCO's dc response. If the range of the discriminator is limited, a divide-by-N module should be used to divide down the output frequency of the VCO beforehand.

The discriminator's signal is then applied to one vertical input (channel A) of the scope. Appearing at channel B is the differentiated version of the signal at output A. Thus the scope displays the VCO's voltage-versus-frequency/time characteristic and simultaneously shows if the change in its output frequency per unit voltage is other than linear. The magnitude of the nonlinearity shown on channel B will be proportional to the amplitude of the positive- or negative-going spike created by the differentiator.

The frequencies at which nonlinearities occur can be measured by placing the scope in the A-intensity mode to intensify the part of the trace where the irregularity is suspected (that is, the region of the curve A corresponding to the location of the spike on channel B). The duration of the pulse output at the scope's B+ port during each scan, corresponding to the intensified area of the curve selected, is thus used to gate the output of the VCO through to the frequency counter. Note that the accuracy of the measurement will be inversely proportional to the width of the area that is intensified. □



Dynamic response. Tester readily spots nonlinearities in VCO's voltage-to-frequency curve. Channel A of scope displays dc response, channel B the dynamic information, whose spike amplitude is proportional to the magnitude of the nonlinearity present. Frequency at which irregularity occurs is measured by intensifying portion of curve A at which spikes appear, in order to generate gating pulse for counter.

Hall-probe adapter converts DMM into gaussmeter

by Henno Normet
Diversified Electronics, Leesburg, Fla.

Using a constant-current dc source to maintain the specified accuracy of a Hall probe, this circuit adapts a 3½-digit multimeter for measuring magnetic flux density. The DMM can thus be made to measure densities of 20 kilogauss or more with a resolution of 10 gauss, and this accuracy is more than adequate for all but low-level leakage checks.

The current source built around the 723 voltage regulator will deliver upwards of a constant 50 to 210 milliamperes to the Hall probe (F. W. Bell BH-705 or Siemens FA22e, etc.), ensuring that the internal resistance of the probe, which changes with the field strength encountered, has little effect on the accuracy of the measurement. The linearity of the voltage-versus-flux response will be dependent on the probe's load resistor, R_1, whose value will be a function of the type of probe used (see individual data sheets).

Typical values will range from 3 to 10 ohms. Even with an optimum load, however, most probes will become nonlinear above 10 kilogauss, and at 15 kilogauss the error is considerable. High-flux-density probes are available at increased cost.

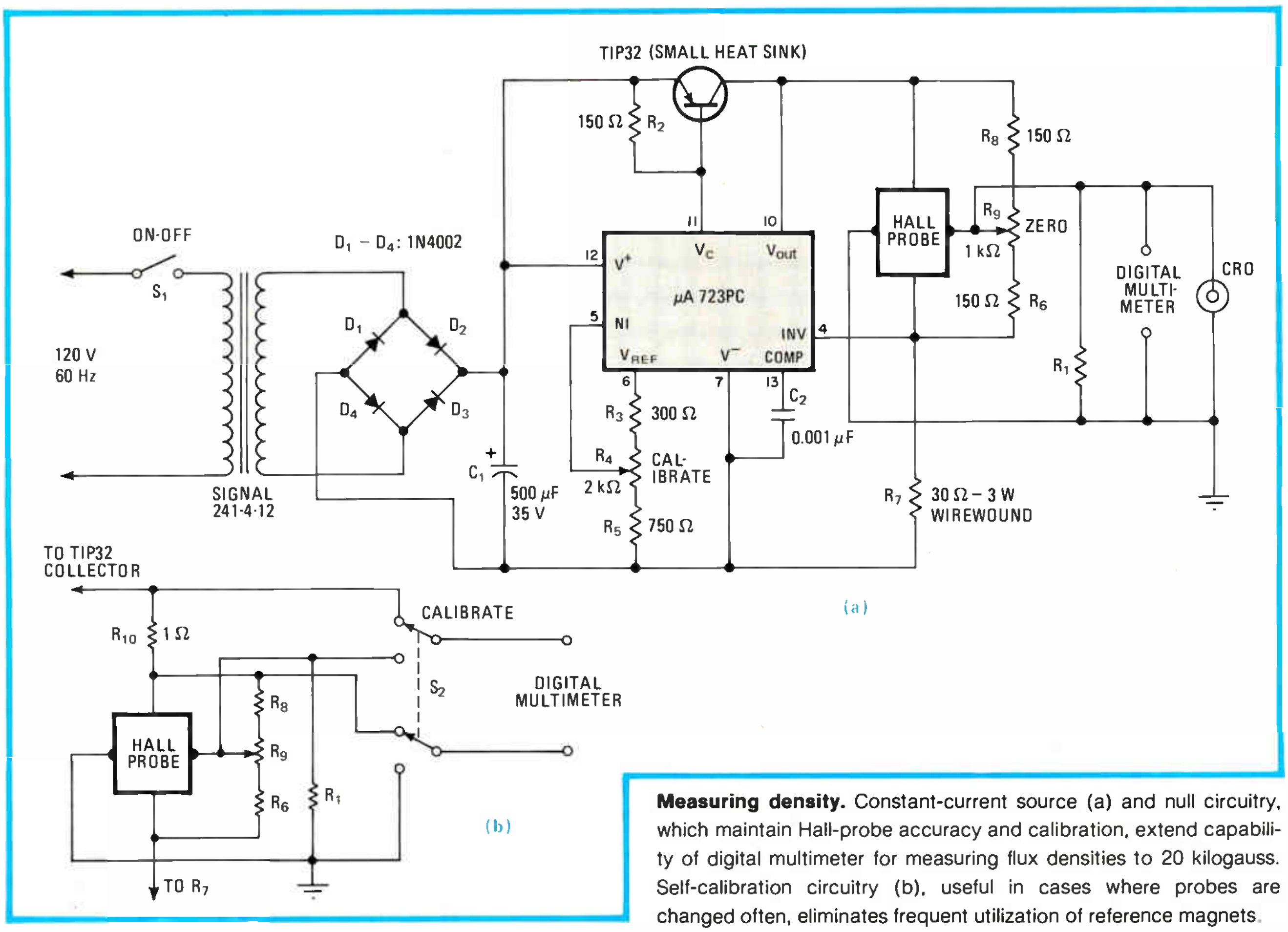
To calibrate the adapter, the DMM is set to its 200-millivolt dc range. With the probe isolated from any magnetic field, potentiometer R_9 is adjusted for a zero reading on the DMM. The probe is brought into the field of a calibrated reference magnet, and potentiometer R_4 is adjusted so that the DMM displays a matching value. At these settings, the probe will deliver exactly 10 mV per kilogauss of flux density measured.

The adapter, in conjunction with an oscilloscope, will measure and display ac or pulsed fields; recalibration is not necessary. When used with a scope set for a vertical-channel gain of 10 mV per centimeter, the vertical axis calibration will be 1 kilogauss/cm.

A self-calibration feature that permits the unit to be calibrated without a reference magnet (after the initial adjustment) may be secured by adding a current shunt in the control-current circuit, plus a double-pole, double-throw switch, as shown in (b). This feature is useful when Hall probes are changed frequently.

Calibration is simple. Once the calibration constant for any given probe is determined (see the procedure above), it is only necessary to set switch S_2 in the calibrate position and adjust R_4 for an identical reading on the DMM when that probe is employed. □

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.



Measuring density. Constant-current source (a) and null circuitry, which maintain Hall-probe accuracy and calibration, extend capability of digital multimeter for measuring flux densities to 20 kilogauss. Self-calibration circuitry (b), useful in cases where probes are changed often, eliminates frequent utilization of reference magnets.

Plastic shields solar panels from earthly ills

Solar cells for use on earth must be engineered to withstand severe thermal and physical shock and to resist moisture absorption. They may also need **a rugged case to protect them from vandals.** Silicon Sensors Inc. of Dodgeville, Wis., solved this problem by encasing its line of standard solar power panels in General Electric's Lexan 143 polycarbonate plastic. This transparent material has high impact strength, low water absorption, ultraviolet stability, and, most important, optical clarity for long-term maximum light transmission.

Each of Silicon Sensors' panels uses an injection-molded case open at the back. A silicon cell is placed in the case and encapsulated in transparent silicone rubber. For more information on Lexan resin contact the Lexan resin products department of General Electric Co.'s Plastics division at 1 Plastics Ave., Pittsfield, Mass. 01201.

ASTM sets the standard for testing electronic materials—again

It's hard to keep up to date on materials testing for the electronics industries because the state of the art changes so rapidly. But it would be even harder without the American Society for Testing and Materials' annual book of standards.

The latest edition, a 1,194-page opus, contains **196 standards for electron tube cathodes and insulators, laser materials, wrought metallic materials, semiconductor crystals, hybrid microelectronics, magnetic materials, and contamination control,** among others. Totally new standards concern the threshold voltages of MOS field-effect transistors, photomask fabrication, and current pulse measurement, as well as more esoteric subjects. Part 43 costs $36. Refer to Publication Code No. 01-043079-46 when you order it from the society, whose address is 1916 Race St., Philadelphia, Pa. 19103.

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Are you considering establishing an in-house printed-circuit-board manufacturing facility because of difficulty in obtaining an adequate supply of boards? A specialized group with expertise in the design, construction, and startup of pc-board plants has recently been formed by PCK Technology division of Kollmorgen Corp. for just this purpose. Its International Projects Group provides custom services to firms that wish to begin their own pc production. IPG offers its help in building any type of pc plant—**print-and-etch, subtractive, additive, semi-additive, flexible, multilayer or discrete wiring, you name it**—anywhere in the world. For more information write International Projects Group, PCK Technology division, Kollmorgen Corp., 31 Sea Cliff Ave., Glen Cove, N. Y. 11542, or phone (516) 448-1212.

Robots rate a definition

Sure you know exactly what a robot is? The Robot Institute of America defines a robot as **"a programmable, multifunction manipulator** designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks." The Dearborn, Mich.-based RIA agreed on this definition after an RIA committee consisting of robot users, manufacturers, and researchers voted on it recently.

-Jerry Lyman

Facts from Fluke on low-cost DMM's

Conductance: What it is, and what it can do for you.

We've often referred to conductance as the "missing function" in DMM's – the capability so many of you have wanted in a DMM but couldn't find until we introduced the 8020A Analyst.

Since its introduction, the Fluke 8020A has become the world's best-selling DMM. And four more low-cost models with conductance ranges have been added to our line. But you'll still find this function only on Fluke DMM's.

Simply stated, conductance lets you make resistance measurements far beyond the capacity of ordinary multimeters. Until the 8020A, there was no way to make fast, accurate readings from 20 MΩ to 10,000 MΩ – ranges typically plagued by noise pickup. Yet, measurements at these levels are vital in verifying resistance values in high-voltage dividers, cables and insulators.

With conductance, the inverse of ohms, which is expressed in Siemens – Fluke DMM's can measure extreme resistances. Simple conversion of direct-reading conductance values, then, yields resistance measurements to 10,000 MΩ (and 100,000 MΩ with the 8050A), without special shielding and using standard test leads.

Here the 8020A is being used to check leakage in a teflon pcb. With a basic dc accuracy of 0.1% and an exclusive two-year warranty, this seven-function handheld DMM has made hundreds of new troubleshooting techniques such as this possible, and more are being discovered every day.

For more details, call toll free **800-426-0361**; use the coupon below; or contact your Fluke stocking distributor, sales office or representative.

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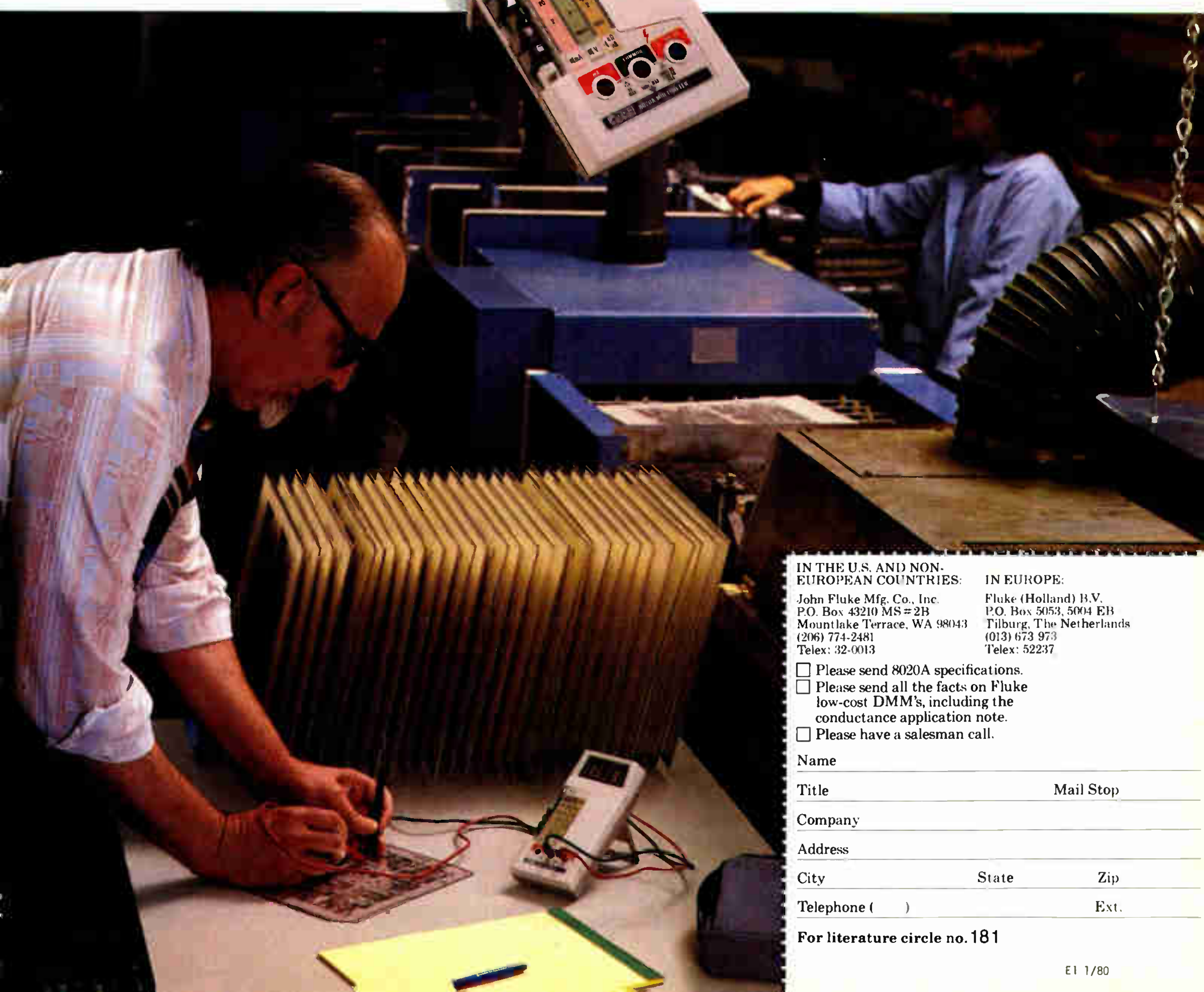

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☐ Please send 8020A specifications.
☐ Please send all the facts on Fluke low-cost DMM's, including the conductance application note.
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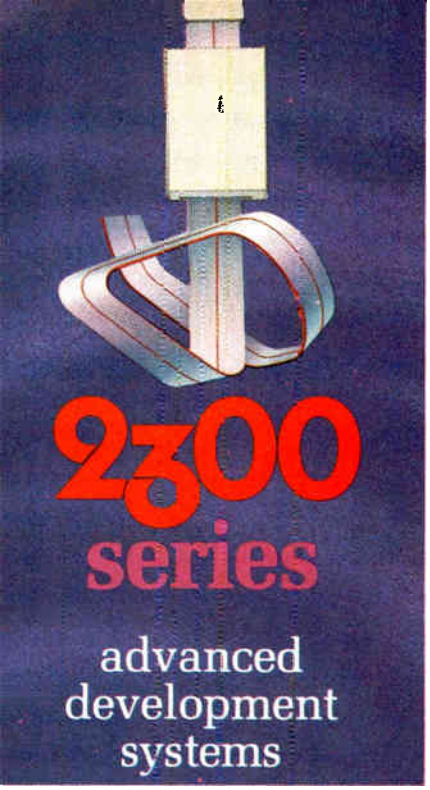
Ours is the only system capable of delivering transparent, non-stop, full-speed emulation



to 10 MHz. And it's the only system capable of emulating many different processors simultaneously.

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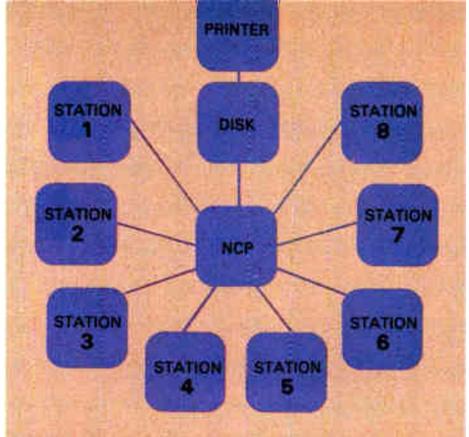

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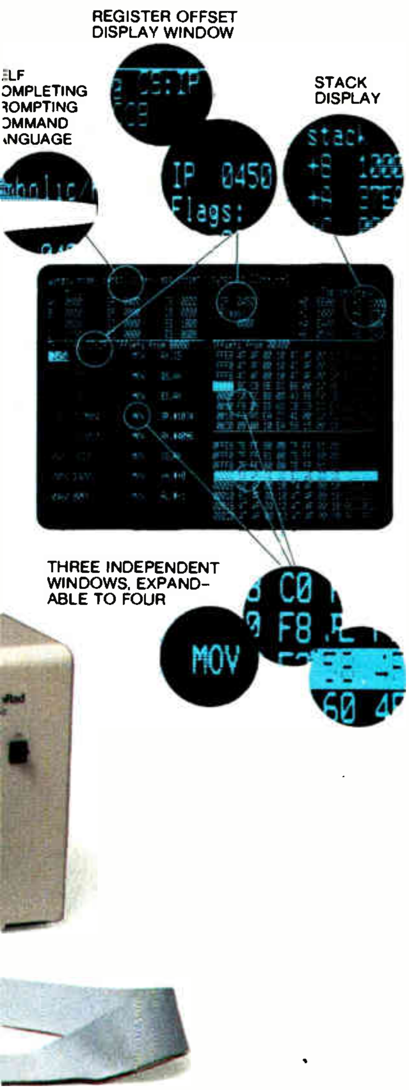

TYPICAL 8086 SNAPSHOT

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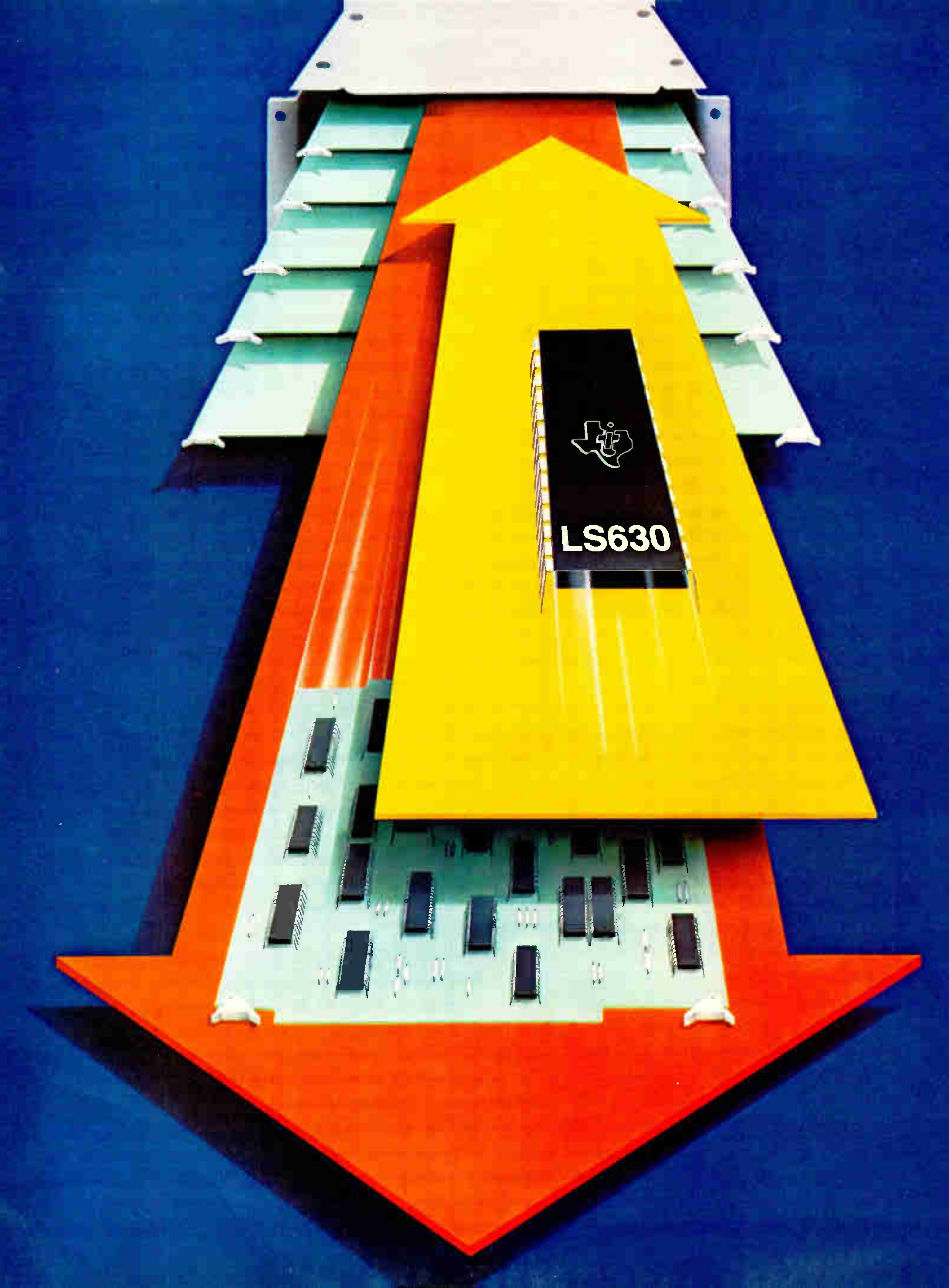
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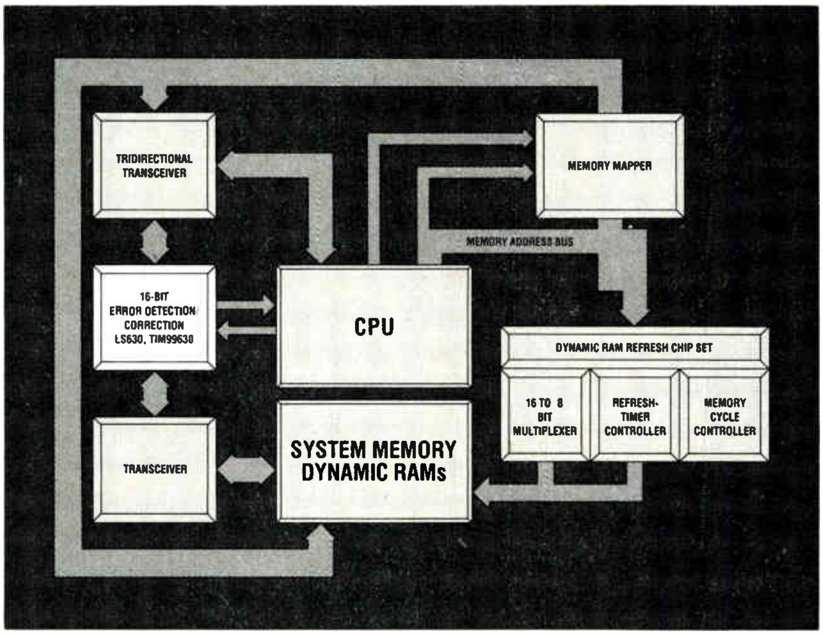

This is the first in a series of innovative Low-Power Schottky devices to be introduced by Texas Instruments over the next few months. Watch for the new Octal Transceivers announcement and find out how you can save design time and production costs.

TI's new EDAC circuits use a modified Hamming code to generate a 6-bit checkword from a 16-bit data word. This checkword is stored in memory along with the data word. During the memory read cycle, the 22-bit word is processed by the EDAC to determine if errors have occurred in memory. Single-bit errors are corrected. Dual-bit errors are flagged. And, a gross error condition of all highs and lows will also be detected.

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And there's more on the way. Over the next few months we'll be introducing more new devices in the TI LS Family.

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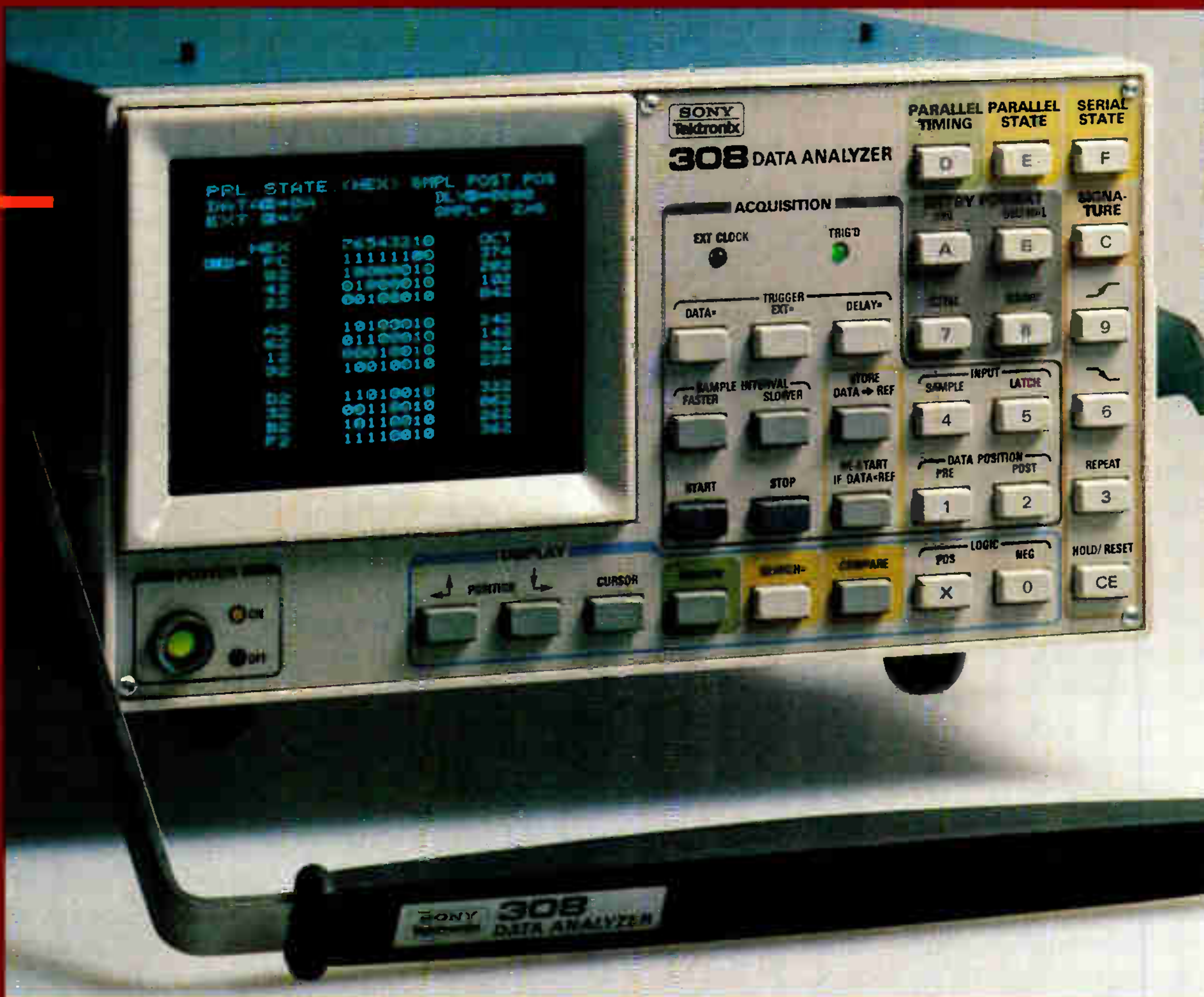
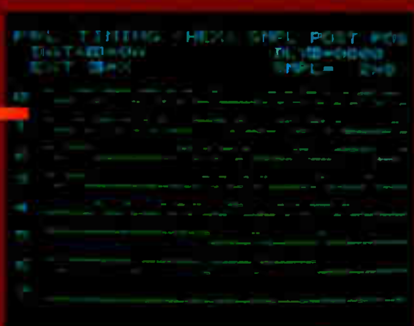
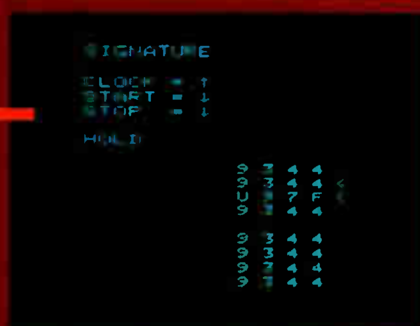


308 display of parallel state data.



Parallel timing diagram can also be displayed as a state table in hex, binary and octal.



Signature display will hold and display up to 8 signatures at once.

Serial display includes ASCII readout in addition to hex and binary.

The 308 is lightweight (3.6 kg/8 lb) and portable.

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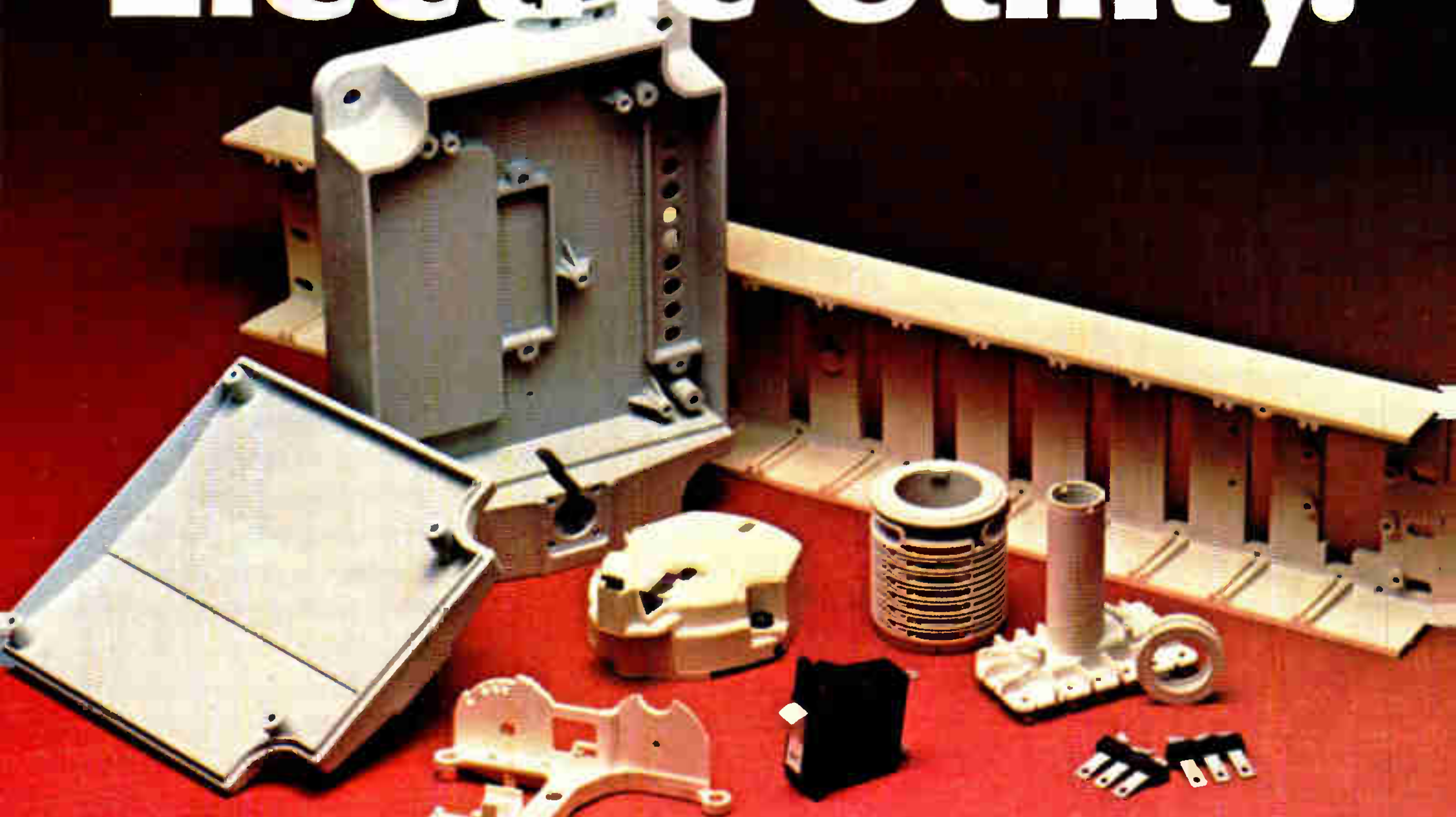

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GENERAL ELECTRIC

Circle 188 on reader service card

E-PROM runs with fast 16-bit micros

32-kilobit memory with 200-ns access time keeps pace with the 500-ns instruction cycle time of the second-generation 8-MHz 8086-2

by Raymond P. Capece, Managing Editor

Memory access times have till recently been fast enough to let microprocessors run through their paces. But the ultraviolet-light-erasable programmable read-only memory, or E-PROM—the widely used program storage medium for microprocessors—has been just squeezing by with an access time that hovers around 450 ns. Now Intel Corp. has improved the E-PROM process through scaling and circuit redesign to produce the 2732A, a 4-K-by-8-bit device, on a die less than half the size of the earlier 2732, with a premium access time of 200 ns.

Small, fast. The die size of the 2732A is 21,000 mil²—smaller than the standard 2716 16-K E-PROM and paving the way for a 64-K follow-up. But more importantly, the memory can serve faster microprocessors without the need for the insertion of wait states—pauses in the memory-access cycle required whenever the memory device cannot have data ready within the usual cycle time. It is no surprise, then, that the company has coordinated the introduction of the 2732A with that of the 8086-2, an 8-MHz version of its 5-MHz standard 8086, because the faster processor could not be used to advantage without faster program memory.

The use of wait states to operate the 8086-2 with a slower memory would be intolerable in view of the time the processor spends dipping into program storage. According to the company, 95% of a processor's external references are to the program store, with only the remaining 5% for peripheral devices.

It is often said that Intel carries on production of bipolar fuse-link–programmable ROMs to satisfy the strictest speed requirements of its processors. The 5-MHz 8086 needs memories that cycle in 800 ns and access data (from address to output) in 460 ns, a requirement satisfied by industry-standard 450-ns memories like the 2716 and the 2732. The 8-MHz 8086-2, however, needs devices that cycle in 500 ns and access data in 295 ns. What's more, in large-memory systems—up to a megabyte—that requirement can tighten to as little as 210 ns. In those systems, even Texas Instruments' 8-K 2508, the fastest E-PROM made to date, with an access time of 250 ns, would not be adequate.

The 2732A E-PROM is a fourth-generation design based on H-MOS-E technology, Intel's most recent process for erasable memories.

Not a selection. The 8086-2 is not a speed-selected version of the earlier part, but employs the newest H-MOS II processing for microprocessors [*Electronics*, Sept. 13, 1979, p. 124] that scales some devices down to effective channel lengths of 2 μm. However, the faster microprocessor is fully software-compatible with the earlier device. According to David Gellatly, marketing manager of Intel's microprocessor and peripheral operation, if the system were designed properly from the start, "it would require only minimal changes to operate at 8 MHz."

Gellatly adds that the enhanced-speed microprocessor should appeal to many more markets than its predecessor. "It was always in our plans to advance the machine to 8 MHz, because certain areas like industrial controls and real-time process control—and especially telecommunications—really require the higher speed," he explains.

The 8086-2 is available now at $200 each in hundreds. The 250-ns 2732A is available in sample quantities at $570 each.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. Phone (408) 987-8080 [338]

COMPARING 16-K AND 32-K E-PROMS

	2716	2732	2732A
Technology	n-MOS	n-MOS	HMOS-E
Organization	2,048 x 8	4,096 x 8	4,096 x 8
Chip area (mil^2)	30,000	40,000	21,000
Number of package pins	24	24	24
Access time (ns)	450	450	200
Power dissipation (mW)	500	750	750
Power dissipation per bit (mW)	0.04	0.025	0.025
Standby power (mA)	25	30	30
Standby power per bit (mW)	0.008	0.005	0.005
Power supplies	+5	+5	+5
TTL compatibility	yes	yes	yes
Two-line control	yes	yes	yes

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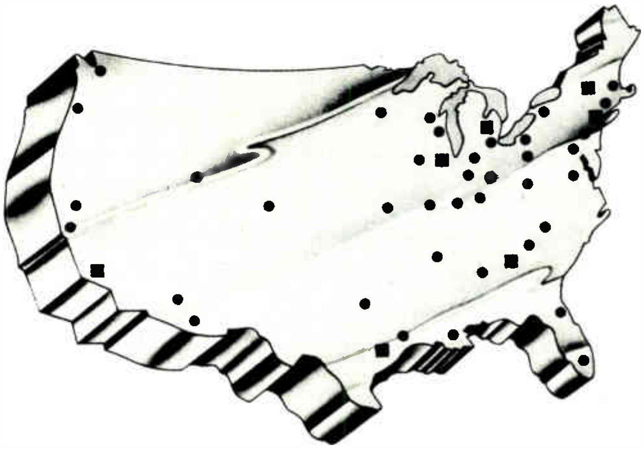

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Circle 195 on reader service card

Semiconductors

Watch chip sings four tunes

LCD watch circuit features 60-note melody alarm with a one-octave frequency range

Although the Winter Consumer Electronics Show begins this coming weekend (Jan. 5–8) in Las Vegas, somewhat northwest of the Rio Grande, one sound heard around the exhibit floor may well be "The Yellow Rose of Texas." That's because at least one supplier of watches with liquid-crystal displays will be introducing a digital timepiece that uses an LCD watch circuit with a unique melody alarm.

Designated the MSM5016, the multifunction chip is an ion-implanted, metal-gate complementary-MOS device that produces all the signals needed to drive an LCD watch with six digits, 10 flags, and four information segments. Supplied by Oki Semiconductor, a Santa Clara, Calif.–based division of Oki Electric Overseas Corp., the chip will make its debut in LCD watches manufactured by National Electronics Consolidated Ltd. and, possibly, in digital timepieces that the Hong Kong firm makes for other suppliers.

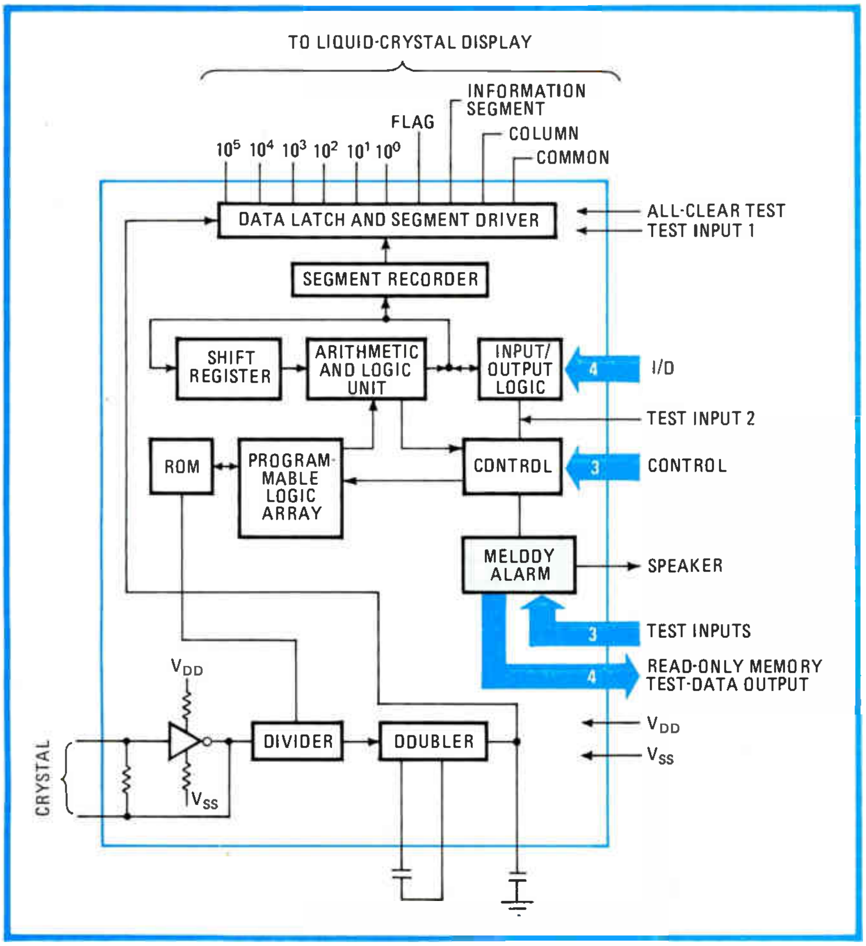
Melodious. At approximately 153 by 253 mil² (6.45 by 3.9 mm), the MSM5016 chip is slightly larger than conventional LCD watch chips. It has to be because, besides the standard alarm, it includes a slice of logic and read-only memory that generates the melody. Unlike the chips in musical calculators that generate only whole notes, the MSM5016 can form anywhere from a 1/64 note to 1½ notes (dotted whole notes). Tempo can be up to 700 quarter notes per minute, and the frequency range of the chip is "a little more than one octave," explains Jerry Crowley, president of Oki Semiconductor.

The duration of the songs played by the MSM5016 ranges from 30 seconds to 1 minute. In all, the chip plays 60 notes, which account for 60 of the words in the chip's 72-word-by-13-bit ROM. The remaining 12 words are for test programs. Initially, watch manufacturers can choose one of four different fixed melodies that can be programmed into the watch circuit. In addition to "The Yellow Rose of Texas," available programs include: "When Irish Eyes Are Smiling," "Greensleeves," and "Reveille." User-selectable songs will be available later.

The MSM5016 operates from a single 1.35-V-to-1.65-V power supply and has an on-chip voltage doubler for generating the display drive voltage. The circuit time base is a 32,768-Hz crystal-controlled oscillator, which is counted down to provide hours, minutes, seconds, date, day-of-week information for two different time zones in the normal watch mode, as well as hours, minutes, and seconds on six digits and tenth of a second on 10 flags in the stopwatch mode. In the melody alarm mode, hours and minutes are displayed on four digits along with the characters AL on two digits.

Based on microprocessor technology and an algorithm that allows a lot of data to be compressed into a ROM, the MSM5016 is of itself not the most startling announcement. "But the technology behind it is—namely, small, battery-powered microprocessor chips for audiovisual presentations," says Crowley. The MSM5016 is, he continues, "the precursor of a speech-synthesis chip, a very modest offering initially," that Oki expects to have available by this coming June's Summer Consumer Electronics Show. "It is the first step toward the talking watch, a data communicator on a wrist," Crowley observes.

Because the melody watch chip

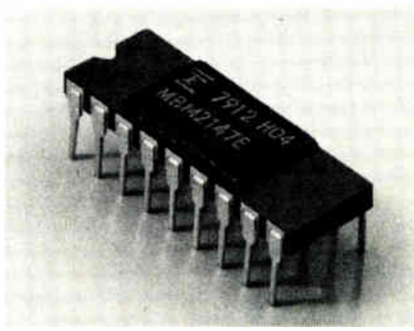


takes up little more real estate than most currently used LCD watch circuits, Crowley expects watches that use the MSM5016 to be priced at about the same levels as last year's alarm/chronograph LCD watches. Such high-end, multifunction timepieces, of which about 40 million were made last year, were purchased from Hong Kong at an average selling price of $14.75 and retailed in the U. S. from $79 on up to $115, he notes. This year's market, which is expected to total 100 million digital-watch movements, Crowley says, will continue to reflect a dramatic change that began in 1979 with a trend away from low-end watches that simply display time toward more exotic, multifunction units. The cost of the MSM5016 is $4.85 each in quantities of 50,000. It will be available in volume this month.

Oki Semiconductor, 1333 Lawrence Expressway, Suite 405, Santa Clara, Calif., 95051. Phone (408) 984-4840 [411]

N-MOS static RAM is TTL-compatible

The MBM 2147 is an n-channel MOS 4,096-bit static RAM that is compatible with the industry-standard 2147 and with TTL families for inputs and outputs. It needs only a single 5-V dc power supply. Guaranteed access times are 55 ns maximum for the MBM 2147H and 70 ns maximum for the MBM 2147E. The RAMs are housed in an 18-pin dual in-line package and have an automatic power-down feature. Power dissipation for the 2147H is a maximum of 990 mW while in operation



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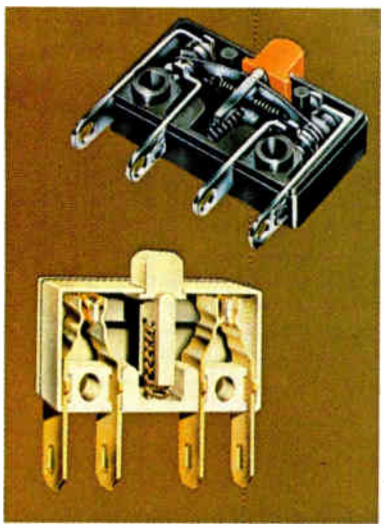

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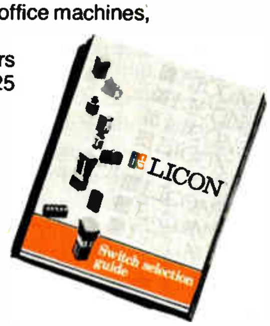

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and 165 mW when in standby. For the 2147E, power dissipation is 888 mW maximum while in operation and 110 mW on standby. In quantities of 100 and up, the MBM 2147H sells for \$38.60 each, and the MBM 2147E sells for \$26.70 each. Delivery is from stock.

Fujitsu America Inc., 2945 Kifer Ave., Santa Clara, Calif. 95051. Phone Dan Buist at (408) 866-1700 [413]

V-MOS power transistors come in three voltage ranges

A family of V-groove silicon-gate MOS power transistors includes both n- and p-channel types. The n-channel VNO-2 transistors come in three voltage ranges: 40 to 90 V, 100 to 150 V, and 160 to 220 V. In the lowest voltage range, the transistor supplies 4 A of current with a 1-Ω typical on-resistance and a threshold voltage between 0.8 and 2.4 V. In the intermediate and high ranges, the current is 3 A with a 2-Ω on-resistance and 2 A with a 4-Ω on-resistance, respectively. Threshold voltage for these upper ranges is 1 to 3 V.

The p-channel VPO-2 models are available with breakdown voltages between 40 and 90 V. They supply 2 A with a 2-Ω on-resistance. The threshold voltage for this range is from −1.5 to −3.5 V. A higher-voltage p-channel device will be available this quarter.

These devices come in TO-3 and TO-39 packages, with a TO-220 package to be introduced soon. In lots of 10,000 and housed in TO-39 packages the 40-V VNO-2 is priced at \$2.25 apiece and the VPO-2 at \$2.81.

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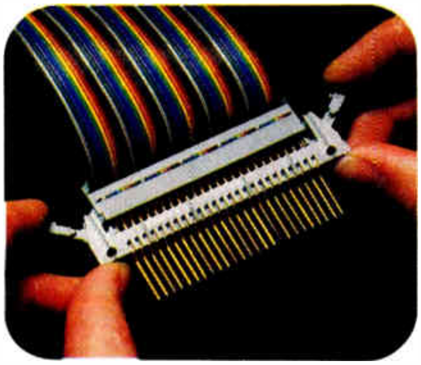
National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. Phone John Thomas at (408) 737-3967 [415]

1.220-V reference device has bias current of 50 µA

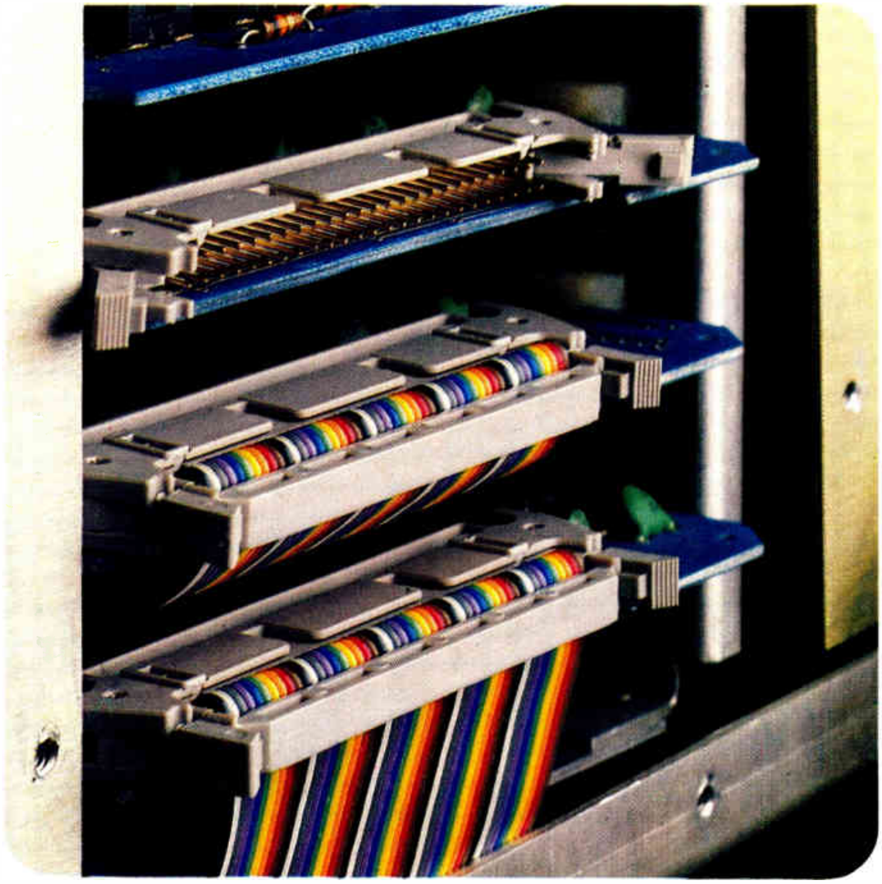
The MPS-5010 is a temperature-compensated, low-voltage reference device that has a typical breakdown voltage of 1.220 V and a low bias current of 50 µA; its tolerance is 1.2 to 1.25 V. The device's typical low-frequency noise is 5 mV peak to peak. At an operating temperature range of −55° to 125°C, the temperature coefficient is 100 ppm/°C for the models in TO-92 packages and 50 ppm/°C for models in TO-52 cans. The devices' long-term stability is guaranteed by the manufacturer. The MPS-5011 can be used in battery-operated equipment, low-power applications, and data-acquisition and -communication systems. The devices are delivered from stock to 30 days. The MPS-5010 GN, a model that comes in a TO-92 plastic can, sells for 72¢ each in 100-unit quantities.

Micro Power Systems Inc., 3100 Alfred St., Santa Clara, Calif. 95050. Phone Don Gilbert at (408) 247-5350 [417]

We've made sockets and headers a snap to connect...

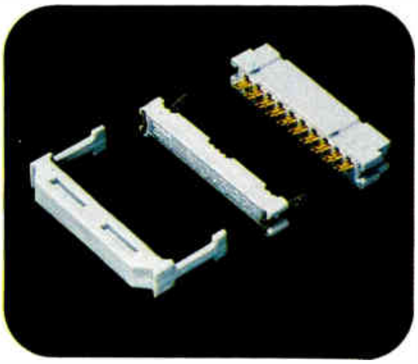


Now from 3M come several important design changes in Scotchflex brand socket connectors and headers. Changes aimed at bringing you faster assembly, increased reliability and reduced maintenance.

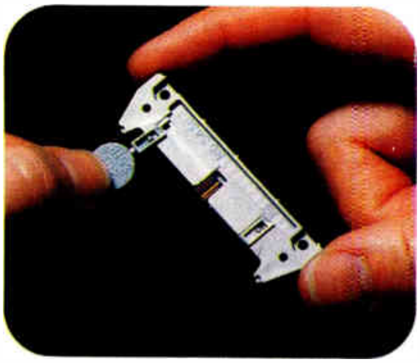


Scotchflex headers (.100" x .100" grid series) now include built-in retainer/ejector latches that snap up to lock sockets firmly in place and snap down to disconnect them quickly and easily. Latches hold tightly against vibration and shock, and their ejector feature also helps reduce wear and damage from disconnection and reconnection. They work with or without strain relief clips on both new and previous .100" x .100" Scotchflex socket designs.

and a snap to unplug.

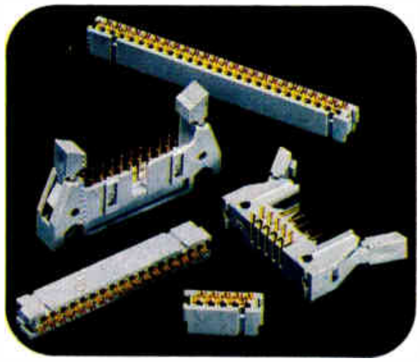


Mating socket connectors have been redesigned with metal spring clips that lock cover to body tightly, providing greatly increased cover retention. And a new one-piece strain relief clip now reduces parts inventory and cuts assembly labor time.



An improved keying system permits positive polarization without pin loss, helps reduce equipment damage and field maintenance. Connectors snap into polarized headers to insure positive mating and provide increased retention.

New socket and header sizes have been added, too. Scotchflex sockets and headers with .100″ x .100″ grid spacing are now available in 10, 14, 16, 20, 26, 34, 40, 50 and 60-pin sizes to suit your design needs.



Only 3M offers you so wide a choice of mass terminating cable, connectors and system components. Plus proven reliability. A nationwide network of stocking distributors. Off the shelf availability. And the unmatched experience of the people who pioneered the concept of electronic mass termination.

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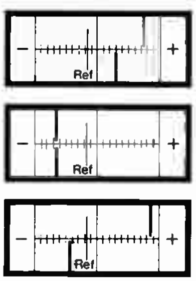

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Circle 207 on reader service card

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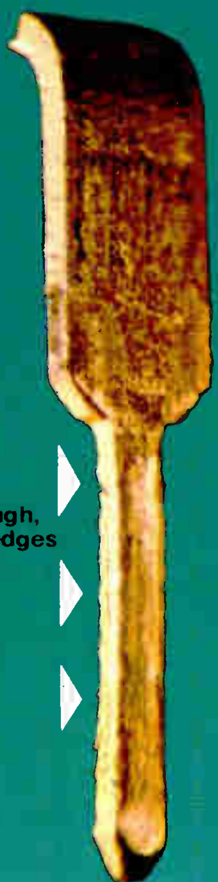
MICROPHOTOS



Note rough, jagged edges always present.

Arrows indicate scars and abrasions made by rough edge of lead frame.

22X magnification, unretouched.

Arrows indicate contact surface still smooth, clean, free from abrasions.

22X magnification, unretouched.

Your IC lead frames look like this at 30X enlargement (unretouched). Because they are punched out of metal, the edges are rough, jagged and irregular. In contrast, the flat sides of the lead frame are smooth, even and perfectly plated.

THEIRS

An ordinary edge-bearing socket contact after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. Notice how the contact has scars and abrasions from *rough, irregular edge of IC lead frame.* Electrical contact is degraded and resistance is increased. Reliability is obviously reduced.

Lead frame in place in an ordinary edge-bearing contact.

OURS

ROBINSON-NUGENT "side-wipe" socket contact after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. See how the RN contact—because it mates with the *smooth, flat side of the IC lead frame*—retains its surface integrity. This 100% greater lead frame contact results in continued high reliability.

Lead frame in place in RN "side-wipe" contact.

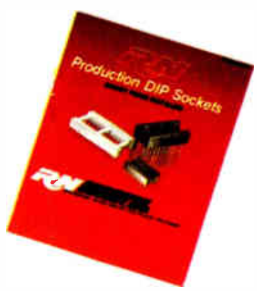
expose 'junk' socket problems

Secret of RN high reliability 'side-wipe' DIP sockets revealed by microphotos

Here's microscopic proof that high reliability Robinson-Nugent "side-wipe" DIP sockets make 100% greater contact than any edge-bearing socket on the market. This advance design provides constant low contact resistance, long term dependability—trouble-free IC interconnects. Yet RN high reliability DIP sockets cost no more than ordinary sockets!

Get the high reliability that eliminates trouble. RN "side-wipe" DIP sockets make contact with the wide, flat sides of your IC leads. You get 100% greater surface contact for positive, trouble-free electrical connection.

WRITE TODAY for latest R-N "Short Form" Catalog of R-N production DIP sockets. Contains full specs, dimensions and material data. Get yours now.



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Computers & peripherals

Board links PDP-11, LSI-11

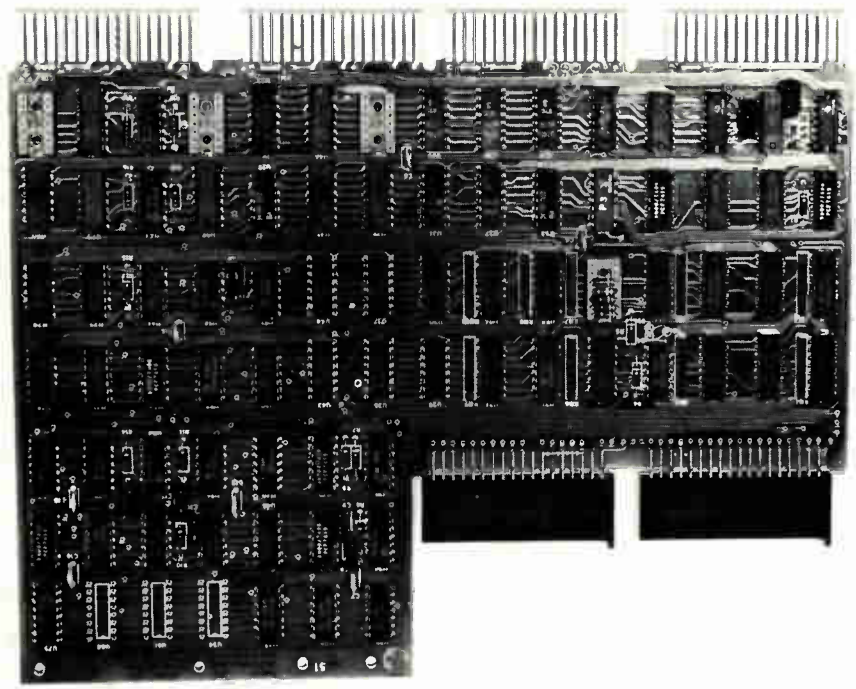
Dual-purpose bus converter lets Q-bus, Unibus devices operate within same system

Continuing to bring out add-on enhancements that aid users of Digital Equipment Corp. minicomputers, Able Computer is aiming its latest product at DEC's recently introduced 16-bit LSI-11/23 board computer. Called the Qniverter, it is a quad-height board that serves as a dual-purpose bus converter, according to Able's president, Kenneth J. O'Mohundro.

"It takes LSI-11s into the large PDP-11 minis, so that they can use the bigger peripherals when necessary," he says. Also, the Qniverter lets a PDP-11, which has a Unibus system, access LSI-11–compatible controllers and memories operating on a Q-bus. "What it means is that a user can go either way: a large machine accessing the lower-cost, compact LSI-11 Q-bus peripherals, or vice versa," he observes.

With the Qniverter, Able is upgrading its earlier Univerter unit, which has had sales of several thousand and has been on the market for two and a half years. The earlier offering could only handle the 16-bit LSI-11 that accesses 64 kilobytes of memory. But the LSI-11/23 uses an 18-bit address to access a full 256-kilobyte memory and the Qniverter fully supports all of this board's features, says O'Mohundro. In addition to addressing a quarter of a megabyte of memory, the LSI-11/23 supports a four-level interrupt structure and memory parity.

When the Qniverter is functioning as an extended bus loader, it can add a Q-bus drive—equivalent to a single LSI-11 computer—to a Unibus computer system. Or conversely, 19 Unibus loads can be hitched to an LSI-11 system. The dual-purpose converter installs into a quad slot of an LSI-11 backplane and is software-transparent to host computers. Memories and controllers may be located on both the PDP-11 Unibus and the LSI-11 Q-bus. Qniverter's dual functions are easily selected by



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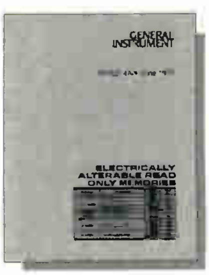
Continuous performances by the ER3400 have led users to judge it the "just right" EAROM for all-around applications. Among the features which helped the ER3400 to win this recognition are a 1024 x 4 bit organization, and a high speed read-access time of 900 nsec. As an electrically alterable ROM, you can erase in-circuit a single word or the entire chip. And, of course, the ER3400, like all EAROMs is non-volatile and retains its memory without power.

Other features which contribute to the successful performances of the ER3400 are write and erase times of only 1 and 10 ms, and TTL compatible inputs and outputs. Application notes are available to help you interface the ER3400 with your system.

You are invited to learn more about the "just right" ER3400 and General Instrument's other EAROM products. Write or call General Instrument Microelectronics, 600 W. John St., Hicksville, NY 11802. For literature, 516-733-3107; For EAROM applications, 516-733-3192.



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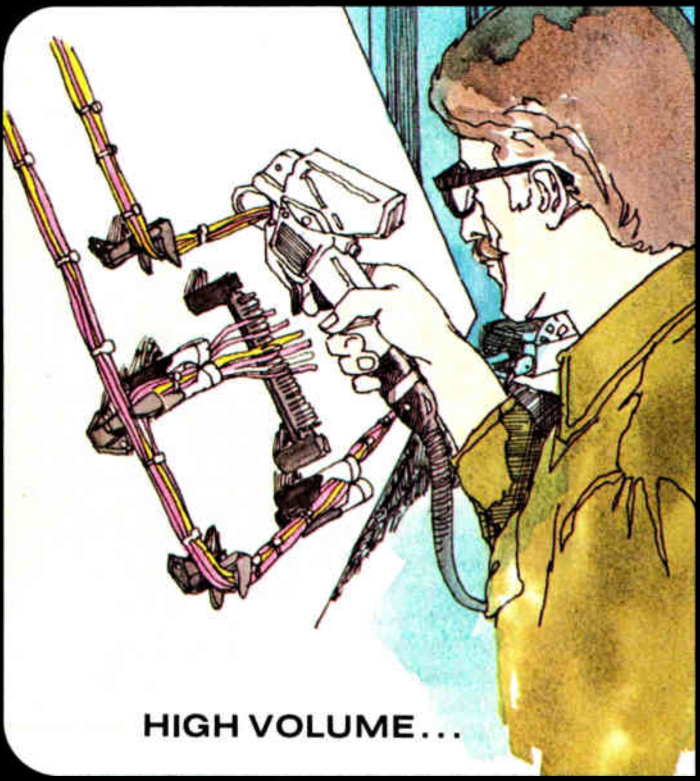

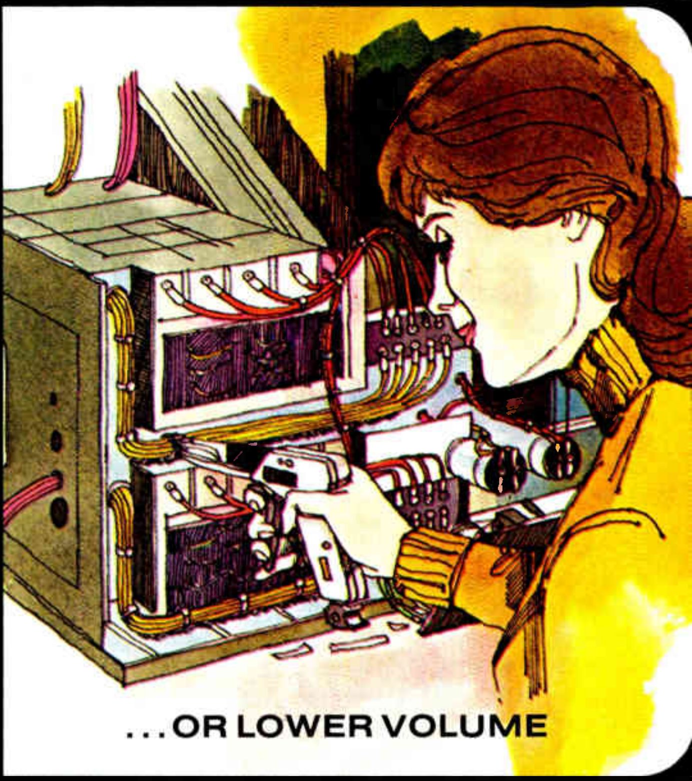

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Circle 212 on reader service card

the user, according to O'Mohundro.

The new Able board specifically permits the following DEC computer systems to access Unibus-compatible controllers and memories: LSI-11, LSI-11/12, LSI-11/23, PDP-11/03, and PDP-11/23. The LSI-11 remains as a bus arbitrator and all latency specifications are bound by the LSI-11.

For an LSI-11 system with Unibus devices, the power requirement is 2.5 A at +5 V; a +12-V supply is not required. For a Unibus system with LSI-11 devices, power is 3.2 A at +5 V, which includes the Q-bus terminator. In both configurations, user-supplied equipment includes the Unibus cable, appropriate backplanes, and a power source.

The company cautions in its specifications that the Qniverter is designed to operate with a single computer for bus arbitration and not as an interprocessor. Furthermore, LSI-11/2s and 11/23s mounted in dual-height backplanes will not physically accommodate the new quad-height board.

U. S. prices of the Qniverter start at $750, compared with $675 for the earlier Univerter. Delivery takes about 30 days.

Able Computer, 1751 Langley Ave., Irvine, Calif. 92714. Phone (714) 979-7030 [361]

System simplifies Japanese character input, display

The development of Japanese-language input and display capabilities for data-processing equipment encounters one huge obstacle: how to encompass in a simple, usable form a written language that uses nearly 7,000 ideographic (kanji) characters and whose phonetic complexities are seemingly endless. The first Japanese efforts in this direction date back almost nine years and display and printing systems have only appeared commercially in the last two years, a lag that gives some idea of the problem.

Probably the simplest system is the recently introduced Interactive Kanji Input System (IKIS) from

Nippon Mini-Computer Corp. Designed for use with Data General Corp.'s Eclipse computer systems, IKIS adopts the 53-character phonetic (katakana) set generally used in converting English to Japanese. This allows a manageable, 68-key adaptation of a standard English keyboard. An earlier Fujitsu system [*Electronics*, July 6, 1978, p. 68] required an operator to choose one character at a time from over 2,600 kanji characters in a matrix; even the newer system from IBM Japan Inc. has a keyboard with 228 keys [*Electronics*, Oct. 11, p. 73]. While the IKIS approach may take several keystrokes to complete the phonetic set for one kanji character, the burden on the operator is much less.

A 74,000-word dictionary—about 2 kilowords of which may be assembled by the user for special applications such as medical reporting—outfits the host processor for converting phonetics into kanji. The associated cathode-ray-tube display is a Data General 6053, with a microNova microprocessor chip, read-only memory, and programmable ROM. It displays kanji as 24-by-24 dot-matrix characters—up to 768 at a time on a 12-in. screen. The figures are approximately twice the size of English-letter displays.

Also simplifying input is IKIS's ability to determine the appropriate character conversion to use in cases involving homonyms—phonetic sets with more than one possible kanji translation.

Explains J. Thomas West, Data General's engineering manager for Japanese business development, IKIS reads syntax, grammar, and context to select the proper translation, producing accurate choices about 99% of the time. This, he claims, represents an improvement over the IBM system, which stops each time and displays alternative translations for the operator to select. Stop-and-choose interruptions, says West, may take up to a third of an operator's total input time.

IKIS's editing capabilities are still limited, according to West, and do not approach the word-processing capabilities of the Fujitsu system. IKIS, however, does produce formatted data and reports for commercial data processing and management reporting, he adds; full word-processing applications will come later.

The IKIS printer, developed entirely by Nippon Mini-Computer, gives hard-copy output at a rate of about 30 kanji characters per second. Printing is horizontal, left to right. The font pattern allows printing of all kanji characters, in addition to numerics.

The total IKIS price for the Japanese customer amounts to about $25,300 and includes CRT display, keyboard, printer, and character-conversion software package. Nippon is beginning marketing efforts in Japan, where it has exclusive production and marketing rights for Data General products. And, notes West, because kanji is based on Chinese-style symbols, "we hope an IKIS-like system may someday find application in Chinese data-processing markets."

Data General Corp., Route 9, Westboro, Mass. 01581. Phone (617) 366-8911, or Nippon Mini-Computer Corp., 2165 Mochida, Gyoda, Saitama 361, Japan [362]

Disk systems for HP-3000 hold 2 or 4 gigabytes

The MSC 1694 controller, which is compatible with any HP-3000 computer system, handles up to eight industry-standard disk drives with capacities of 300 megabytes each; the MSC 1696 controller handles up to eight 600-megabyte drives. A system package that includes the MSC 1694 controller and one 300-megabyte drive sells for approximately $23,500, with add-on drives costing $18,500 each. A 1696 controller and one 600-megabyte drive sells for about $39,500; add-on drives are $30,000 each. Total capacity of the 1694 is 2 gigabytes; it is 4 gigabytes for the 1696.

A base system uses 1,040 W and includes a controller, a host adapter, and one disk drive. The host adapter is a single printed-circuit board that

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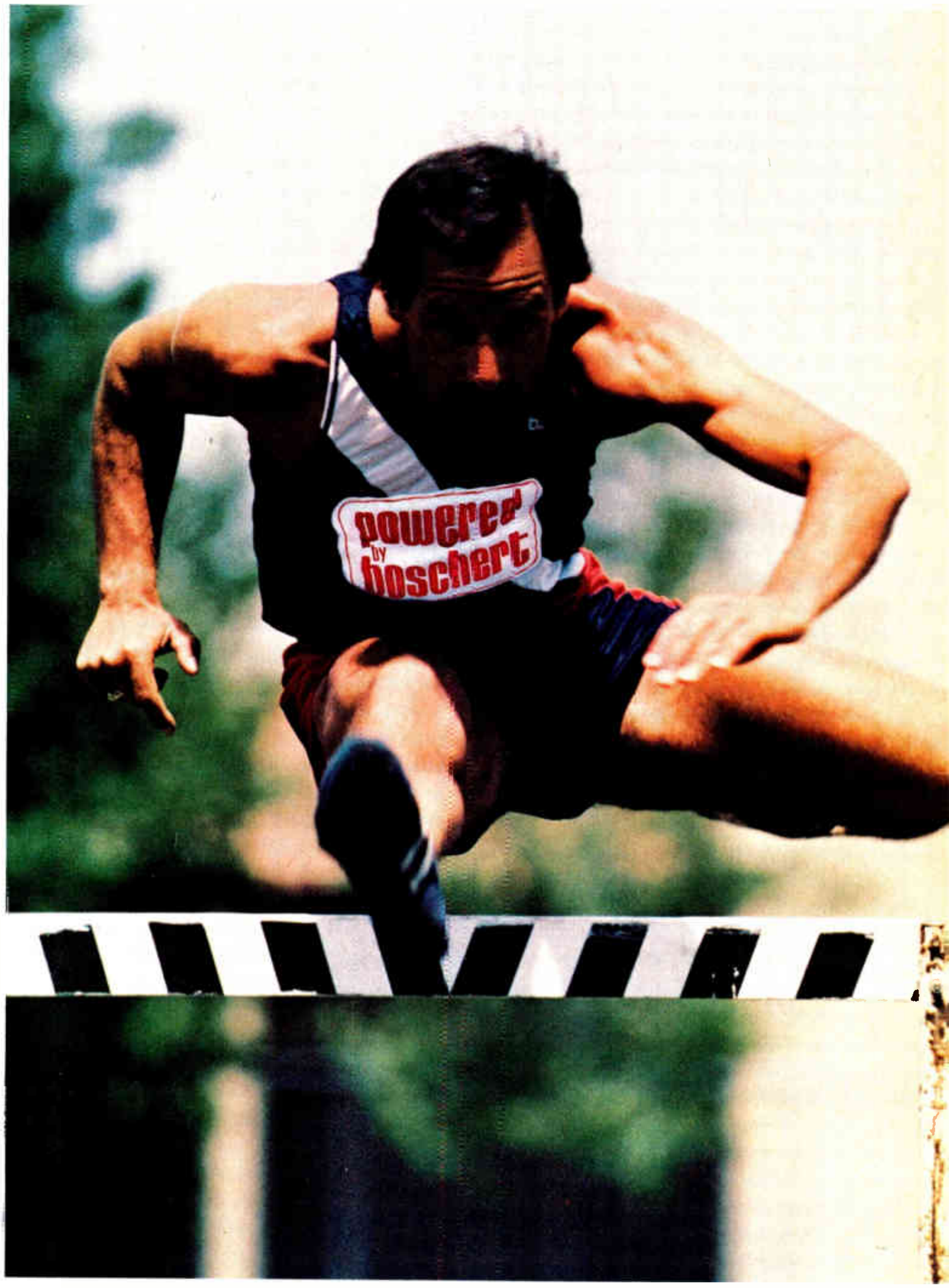

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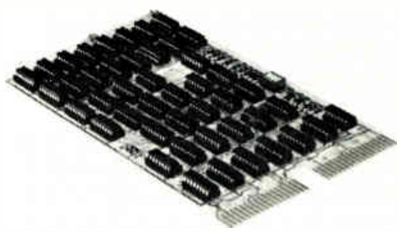
plugs directly into the HP-3000 selector channel. The rack-mounted controller unit to which the disk drives are attached is connected to the adapter. Each drive measures 36 by 19.5 by 33 in.

Additional features include data buffering by 40-byte first-in, first-out buffer memories; automated track seeking and position verification; error checking and correction of bursts of errors up to 11 bits long; and extensive resident diagnostics. The microprocessors of the two controllers are microprogrammed for transparent operation with the standard HP-3000 MPE operating system. MSC 1694-based systems are available within 60 to 90 days. MSC 1696-based systems will become available in early 1980.

Microcomputer Systems Corp., 432 Lakeside Dr., Sunnyvale, Calif. 94086. Phone Don Sumner at (408) 733-4200 [363]

Memory diagnostic card troubleshoots computers

To track computer failures, a memory diagnostic card functions as a "flight recorder" for LSI-11-based systems. The DM-11 card resides in the computer and supplies the user with bus transaction information when failures occur. The information comes out of the computer's own input/output lines, although the DM-11 operates independently of the operating software. While the computer is in the run mode, the unit continually stores the last 256 words of data appearing on the 16 address and data lines of the LSI-11 Q-bus. If the computer halts for any reason, the information in the memory is held until it is retrieved through manual or programmed commands. The trace provides a record of the




"Finally, a flat cable as tough as me."

bus program flow—both address and data—from normal operation through bus-error traps to systems halt. The DM-11 sells for $590.

Scanoptik Inc., P. O. Box 1745, Rockville, Md. 20850. Contact Jerry L. Shumway at (301) 762-0612 [364]

Disk system for PDP-11/70 stores more than 2 gigabytes

The Plessey PM-DSW11/300 is a disk subsystem for the PDP-11/70 that consists of a pedestal-mount disk drive, a controller chassis, and a data and control coupler. The controller supports up to eight 254-megabyte drives for a maximum capacity of over 2,000 megabytes. Each disk pack has a formatted capacity of 253.6 megabytes, and removable packs provide off-line storage. The data and control coupler plugs directly into module slots, interfacing with the central processing unit over the Unibus and the cache bus. Lead time on the disk subsystem is 60 days; each sells for $28,795.

Plessey Peripheral Systems, 17466 Daimler Ave., Irvine, Calif. 92714. Phone Cynthia Read at (714) 557-9811 [366]

Desktop thermal printer sells for $395

The models 6450 and 6460 are desktop thermal printers that produce easy-to-read letters, numbers, and symbols with first-line-up printout. They print 64 different characters, 21 characters for every one of the 6,500 lines that can be printed on a roll. The model 6450 accepts serial data with RS-232-C or 20-mA current-loop interfacing at data rates of 110 and 300 bauds. The model 6460 is compatible with an 8-bit parallel bus and data rates up to 1,000 characters/s. In very large quantities, the printers are priced at $395 each; delivery is from stock.

United Systems Corp., 918 Woodley Rd., Dayton, Ohio 45403. Phone (513) 254-6251 [367]

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Well, let me tell you—this has reduced termination time by 97% and cut our costs by 36%. I liked their thinking so much, I checked them out and found that they were a terrific source for all my flat cable needs—cable, connectors, and even complete terminated jumpers and custom assemblies, fully tested and ready to go.

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But don't ask for Dave—he's at home taking care of the baby."

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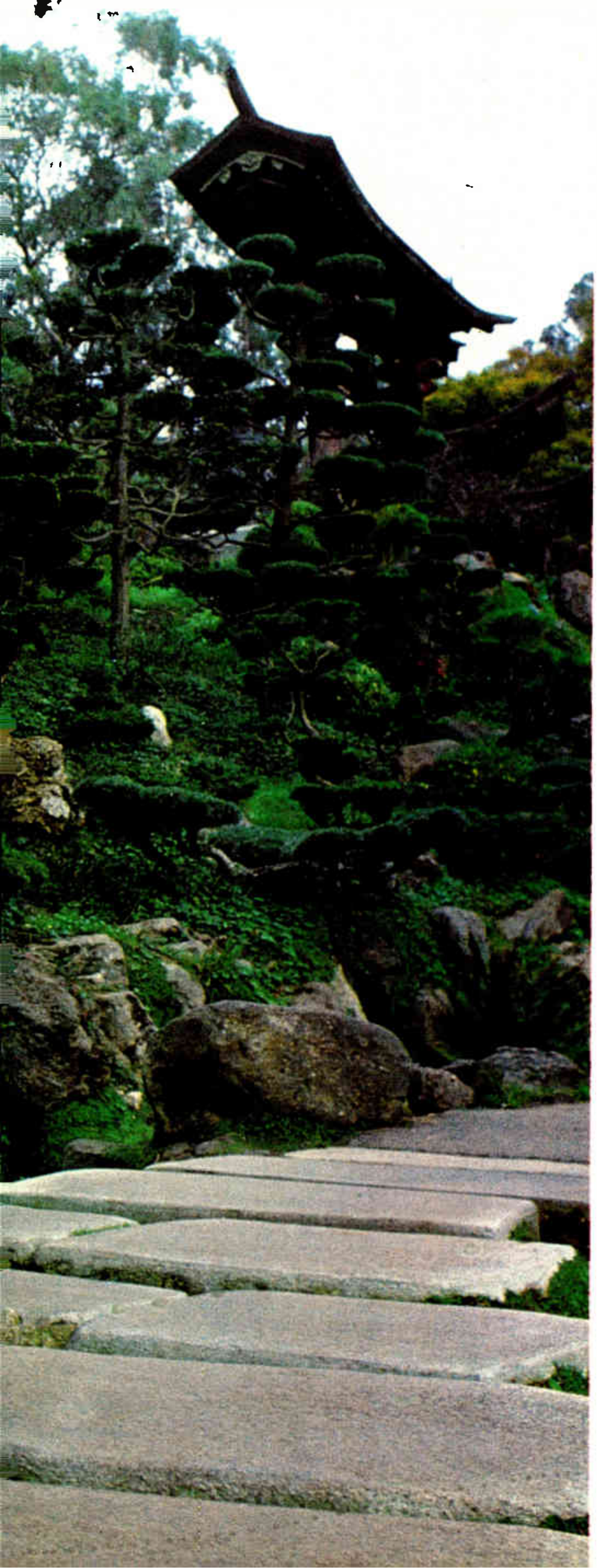

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digital

Circle 223 on reader service card

How Nicolet fits into this box than

Fitting more oscilloscope into a cubic foot took one big first step—the use of modern digital methods. Plus a lot of little steps such as recognizing what's *"oscilloscope,"* what's not, and keeping the *"not"* outside where it belongs. Here are some of the great things the digital method has made possible.

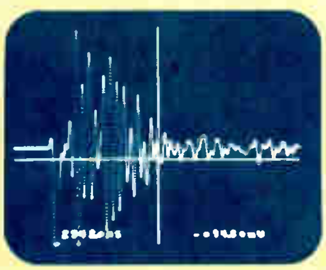
Resolution and Accuracy

Scientists and engineers (thousands of them)

are delighted with the Explorers' 4000-line resolution, and accuracy literally an order of magnitude better than that of analog scopes and other digital scopes.

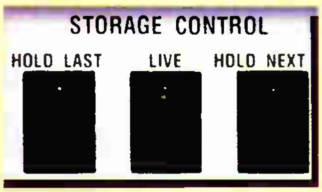
Super Storage

Users appreciate the Explorer's waveform



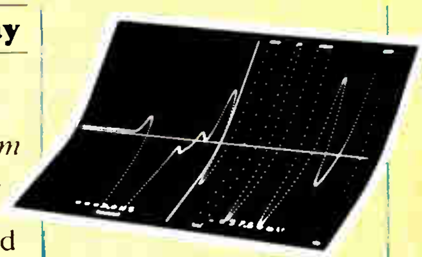
storage. At equivalent writing rates of up to 50 cm/μsec an Explorer can clearly remember, every time, without fade or bloom, literally hundreds of times as much about signals as the finest analog

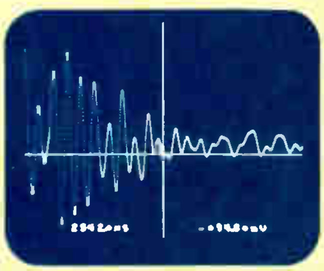
storage scopes. Best of all, Explorers store waveforms with no hassle.

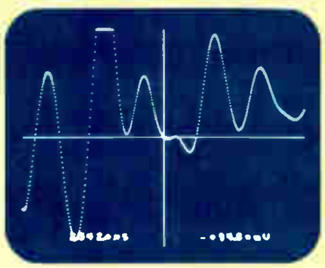


64X Zoom Display

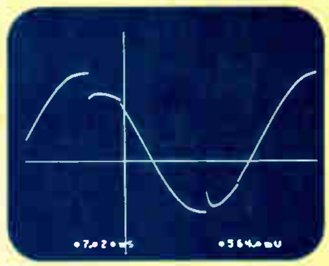
Explorer users enjoy the convenient display that allows them to *zoom in* on details of interest. They also can superimpose "old" signals and

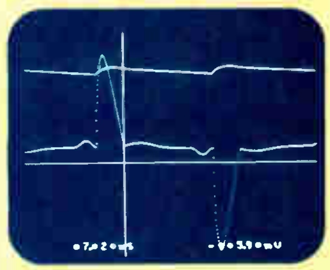


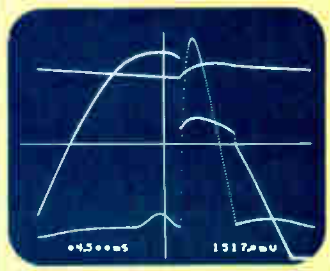




live, "fresh" signals for extremely sensitive observation of differences or changes. They can







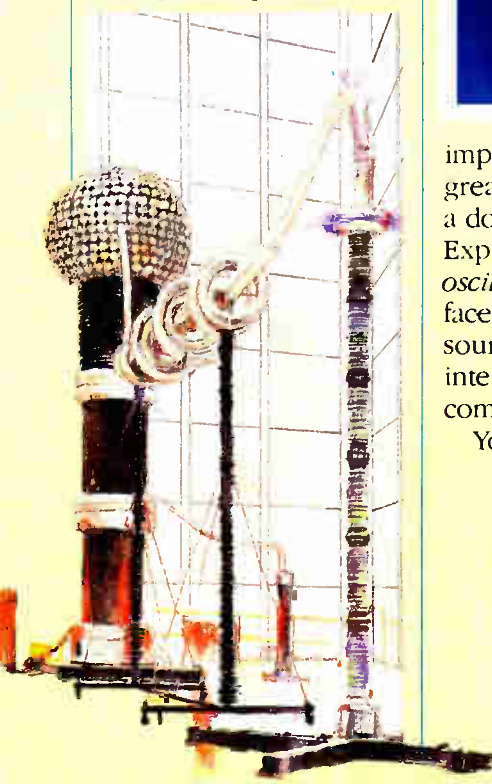
superimpose two (or four) old waveforms, or two live waveforms. And zoom in on details with up to 64X digital display scale magnification.

more oscilloscope anyone else.

They're Pure Oscilloscopes

The digital method results in other welcome improvements. Sweep speeds that range down to days in length to allow you to precisely measure very slow phenomena. Pre-trigger sweep start

allows you to see what precedes an event as well as what follows. XY operation provides even greater precision



than servo-driven XY recorders, but at speeds a million times greater. Speeds as high as most analog XY oscilloscopes.

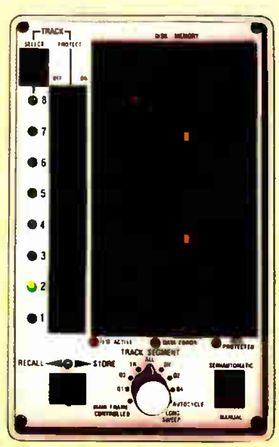
All of these are oscilloscope function improvements. The

improvements include greater ease of use, for a dozen reasons. The Explorers are *"pure oscilloscope."* They interface between the signal source and the most intelligent and powerful computer in the world.

You.

Disk Memory Option

The optional, built-in disk memory can remember signals for years, storing as much data per disk as you could capture on thousands of photos. Disks are inexpensive and reusable, don't need developing, and store data at the touch of a button.



Matching Your Needs

You can choose the Explorer model that fits your measurement needs from a family of instruments, plug-ins and IEEE-488 or RS-232 options.

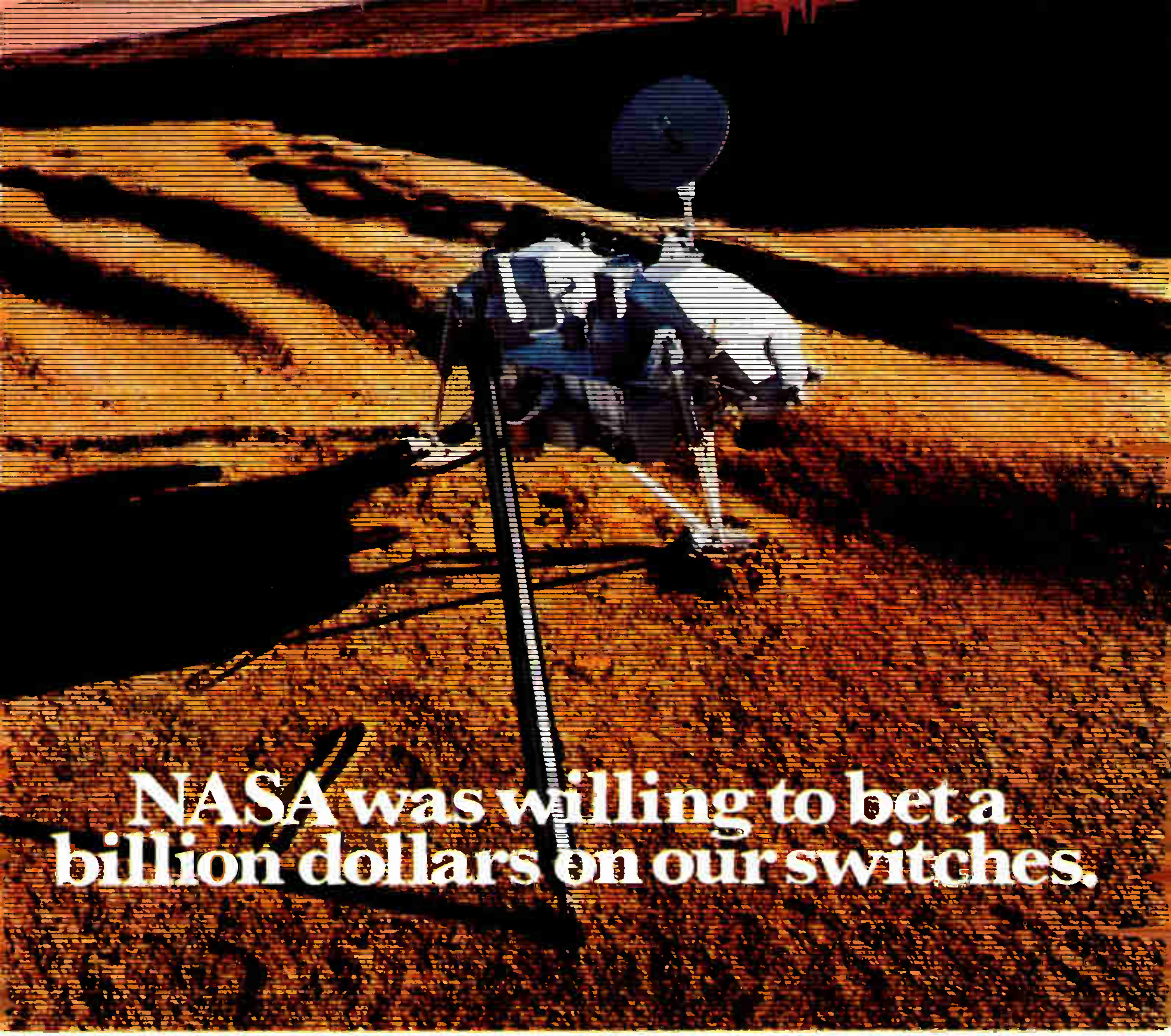
For More Details

To get complete information quickly, call free **1-800-835-2246** *(in Kansas, 1-800-362-2421) anytime and request our new brochure.*

To discuss your application or to arrange a demonstration, call (608) 271-3333.

NICOLET INSTRUMENT CORPORATION
OSCILLOSCOPE DIVISION
5225 Verona Road
Madison, WI 53711
Telephone: (608) 271-3333
TWX: 910-286-2737
Sales and Service Offices Worldwide

Circle 225 on reader service card



The planet Mars has long been the object of Man's curiosity. Perhaps because it is the most likely of all planets to have life on it.

After traveling over 400 million miles, and after rejecting three sites as too dangerous, the Viking I spacecraft set down safely in the northern hemisphere. Its search for life began when it reached out a mechanical arm for samples of Martian soil.

That arm depended on two of our limit switches.

Three years earlier, project technicians came to us in search of switches that could survive the long trip, the rough landing, and the intensely cold Martian nights.

Communications

Modems replace Bell's 212A

Units transmit data at 300 or 1,200 bits/s, automatically select speed in answer mode

By making improvements in the popular Western Electric 212A data-set modem and by offering its own units as items for purchase rather than on an installation-plus-lease basis, Prentice Corp. hopes to penetrate the rapidly expanding market for this type of unit. There are two versions of the Prentice modem, the P-212A, which sells for $895, and the microprocessor-based P-212C, selling for $1,135.

"With a Bell 212A, there are substantial installation charges for both the modem and a special telephone, as well as ongoing lease payments for each," notes Bill Myers, vice president of marketing for Prentice. "On the other hand, our P-212A and P-212C modems can be purchased rather than leased, and they require only a 502- or 503-type key telephone set or a standard business phone with an inexpensive voice-data switch like the Prentice VDS-100." The VDS-100 sells for $50, he adds.

Both modems transmit serial binary data in full-duplex mode at 300 or 1,200 b/s over two-wire dial-up lines. They have automatic speed selection in the answer mode, allowing them to match the transmission rate of the originating modem. "This represents another cost reduction because users can select an operating speed without needing two separate modems," Myers points out. The P-212C also lets the user select the speed manually.

The incorporation of a microprocessor into the P-212C provides, among other things, a brief self-testing routine during each of the modem's idle periods. If the modem fails any portion of the self-test, it automatically puts the line it is attending into a busy state.

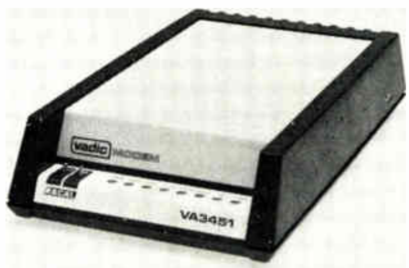
An additional feature of the P-212C allows the user to set the modem into a busy state without interrupting service. When selected, this delayed busy state lets the modem become busy again as soon as the line becomes clear.

The delivery time for either modem is 60 days.

Prentice Corp., 795 San Antonio Rd., Palo Alto, Calif. 94303. Phone (415) 494-7225 [401]

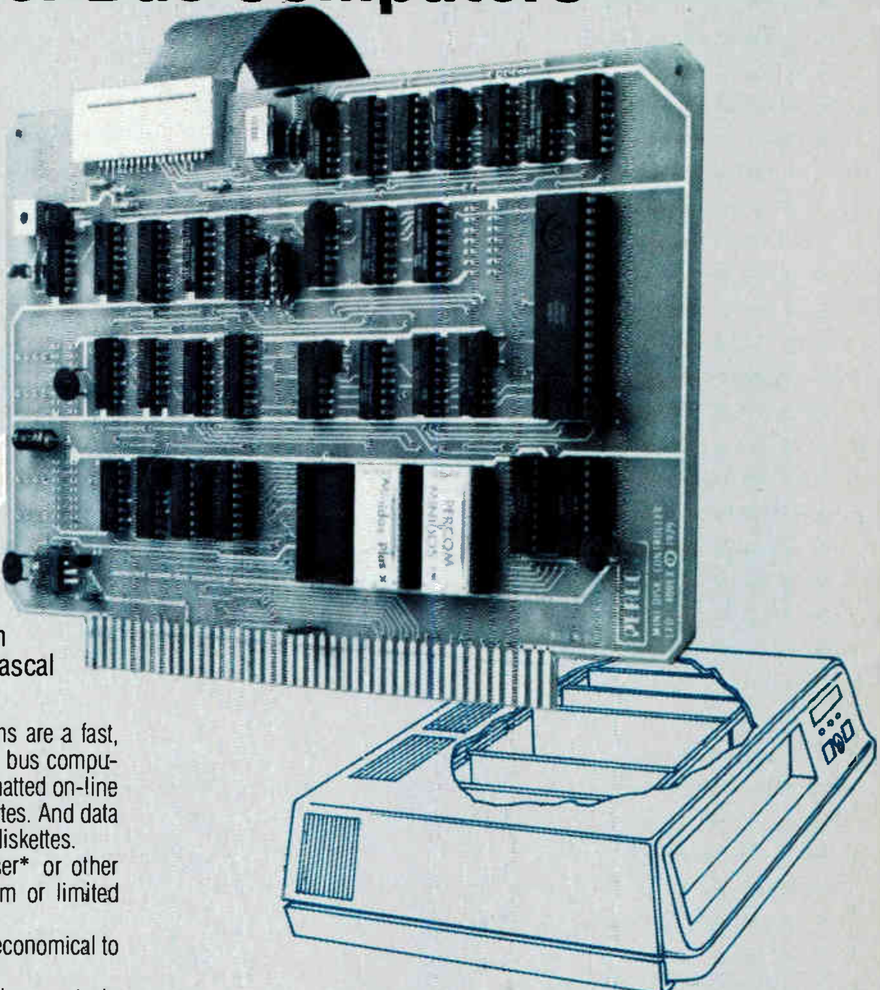
Single unit connects with 212A, 103, VA3400 modems

A single modem at a remote terminal satisfies every conventional originate-and-answer application for switched-network full-duplex data transmission from 0 to 1,200 b/s. It may also be one of a series of triple modems that combines a Bell System type 212A, a Bell System type 103, and a Vadic VA-3400 in a compact stand-alone package. The model VA-3450 includes six switched-network originate-and-answer models, which have all been registered for direct connection under Part 68 of the Federal Communications Commission rules. In addition, there is an originate-or-answer version for leased-line applications. A VA-3450 at the remote terminal can call the three different types of modems listed above and automatically identify the called modem. The series incorporates such diagnostics as idle test, analog loopback and busy state, digital loopback, and self-test. A switch-controlled "standard option" mode forces the unit into a standard configuration to simplify



From Percom . . .

Low Cost Mini-Disk Data Storage for EXORciser Bus Computers



- Compatible with EXORciser* and other 6800/6809 computers based on EXORciser* bus concept.
- 40- or 77-track drives in one-, two- and three-drive configurations add 102K bytes to 591K bytes of random access data on-line.
- 40-track LFD-400EX® drives store data on both surfaces of mini-diskettes — almost 205K bytes per disk.
- EXORciser* bus compatible controller includes 1K of RAM, provision for 3K of PROM. Mature design features explicit clock-data separator, drive motor inactivity time-out function, and more.
- Support software includes disk operating systems, a file manager, text editor, assembly language program development/debugging aids, an extended BASIC interpreter, an SPL/M compiler and business programs. Numerous programs available from other suppliers may be used with LFD-400/800EX mini-disk systems with little or no modification. Watch for FORTRAN & Pascal announcements.

Low cost Percom LFD-400/800EX mini-disk data storage systems are a fast, dependable alternative to tape storage for 6800/6809 EXORciser* bus computers. A single 40-track LFD-400EX® drive adds 102K bytes of formatted on-line storage; a single 77-track LFD-800EX® drive adds almost 200K bytes. And data may be stored and read from either surface of LFD-400EX® minidiskettes.

Fast mini-disk data storage makes your Motorola EXORciser* or other EXORciser* bus computer more than just a development system or limited evaluation system.

For example, at the low LFD-400/800EX prices it becomes economical to use your development system as the final working system.

Data capture/retrieval in research, test and production environments is another application where versatile, random-access LFD-400/800EX storage can provide efficient operation.

Equipment control is yet another area where the speed and facility of mini-disk storage greatly expands application possibilities. Even if you use a mini-disk only to load and control programs you'll save simply by taking a lot less time than with slow, inconvenient tape storage. Moreover, by storing programs on fast-loading, low cost minidiskettes you eliminate the overhead of burning PROMs — an expense that quickly adds up to far more than the price of an inexpensive Percom mini-disk system.

The bottom line? An EXORciser* or Micromodule*, with percom LFD-400/800EX mini-disk data storage, is a remarkably adaptable microcomputer — a system that meets the quality and dependability demands of industry yet is competitively priced with personal computing systems.

PRICES

Model	1-drive system	2-drive system	3-drive system
LFD-400EX®	$649.95	$1049.95	$1449.95
LFD-800EX®	$945.95	$1599.95	$2245.95

MPX Disk Operating System (2-chip ROM set)
Standard versions for most popular monitors $69.95
LFD-400/800EX Users Instruction Manual:
Includes driver utility listings, controller schematic $15.00

The system prices are single-quantity prices. A system includes (1) the drives, power supplies and enclosure, (2) the EXORciser* bus compatible controller PC card with 1K RAM and provision for three 2708 EPROMs, (3) an interconnecting cable, (4) an 80-page users instruction manual, and (5) a system minidiskette. The Percom Software Services Group will customize the MPX DOS for a nominal charge if one of the standard versions is not suitable for your monitor. LFD-400EX® systems use 40-track drives; store 102K bytes of formatted data per minidiskette side. LFD-800EX® systems use 77-track drives; store almost 200K bytes on one side of minidiskette.

Orders may be placed by dialing 1-800-527-1592 (outside of Texas) or (214) 272-3421 (in Texas). For additional technical information dial (214) 272-3421.

PERCOM DATA COMPANY, INC.
211 N. KIRBY GARLAND, TEXAS 75042
(214) 272-3421

PERCOM

Circle 229 on reader service card

® trademark of Percom Data Company, Inc. • trademark of Motorola Corporation

Prices & specifications subject to change without notice.

and speed up diagnostic testing.

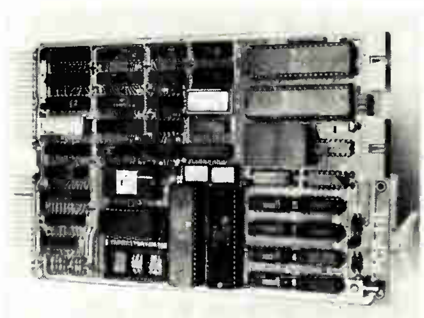
Prices for the VA-3451, which handles all three modems, start at $900. The VA-3452, which handles the 212A and VA-3400 modems, is priced at $850, whereas the model that handles the 103 and VA-3400 modems—the VA-3453—sells for $825. Delivery is in 60 days.

Racal-Vadic, 222 Caspian Dr., Sunnyvale, Calif. 94086. Phone Dave Peters at (408) 744-0810 [402]

Single-board processor links to LSI-11

Contained on one dual-width printed-circuit board, a programmable communications processor, the PCP-11L, is a peripheral computer compatible with the entire LSI-11 family from Digital Equipment Corp., including the recently introduced LSI-11/23. Using a Z-80A microprocessor, the unit supports any mix of 8-bit parallel, asynchronous or synchronous serial and color video graphics. The PCP-11L may be programmed in conjunction with an optional dialer interface to provide auto-answer, auto-dial support for virtually any serial communications protocol, including asynchronous, bisynchronous, IBM's Synchronous Data-Link Control, and Digital Data's communications message protocol. Data-transfer rates that exceed 48 kilobauds may be used. Low-resolution color video alphagraphics are optional, including fully programmable resident text fonts loaded into RAM.

A bidirectional 8-bit parallel port comes with the basic unit. This allows the unit to be augmented by



Sure winners
S-D 4½-digit DMM's
DIGITAL MULTIMETER MODEL 7344A
Queen(s) of the bench:
Model 7244A
Identical to Thin-Line Model 7344A except for case. Since you're going first class with our thin-line systems DMM, why not use the bench version too? Price $945 includes IEEE-488 interface.
Model 7241A
• ±0.02% DC accuracy
• VAC, VDC, ohms, current AC & DC • Optional BCD programming in lieu of current. Price $495 to $745.
Jack(s) of all trades: the rugged portables
Model 7141 A/B
• Unbreakable clamshell case • VAC, VDC, ohms, current AC & DC
• Optional battery pack. Price $395 to $450.
Model 7142 A/B
Same as Model 7141 A/B except for dBm capabilities in lieu of current. Price $445 to $500. Features common to all S-D 4½-digit DMM's: true RMS, autoranging, 20,000 counts. All prices U.S. only.
For complete technical details, call Scientific Devices or contact Systron-Donner at 2727 Systron Drive, Concord, CA 94518. Phone (415) 676-5000.

unencoded keyboards, touch screens, digitizer tablets, and printers. Control software can either reside on board in nonvolatile memory or be downloaded from the host computer. By using industry-standard byte-wide memories, the PCP-11L may be equipped with a mix of up to 8 kilobytes of RAM and up to 16 kilobytes of read-only memory.

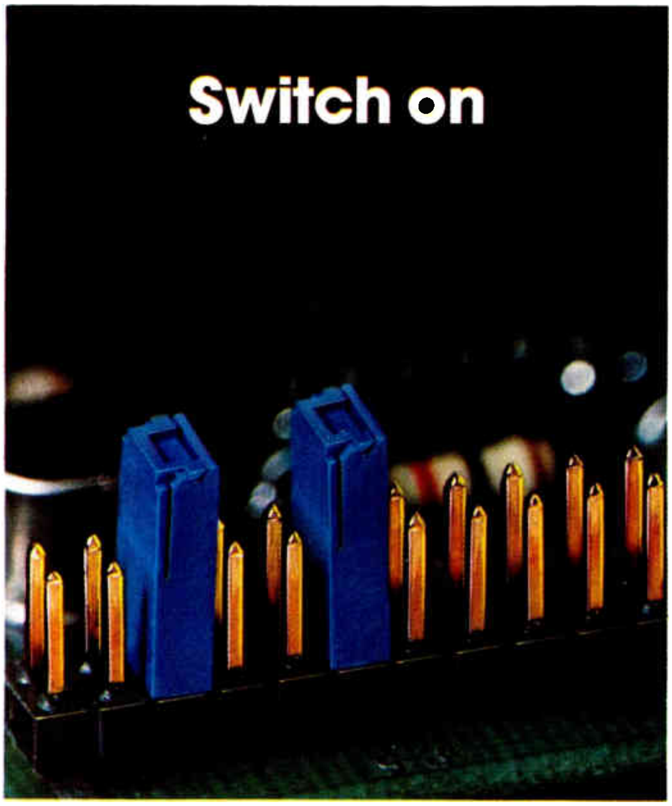
The base price for the PCP-11L with parallel port, a 2-K erasable programmable ROM monitor, and 1-K RAM is $525. A typical configuration consisting of a basic unit upgraded to 4-K RAM plus dialer interface is $665 in lots of 100 units. A basic video package lists for $900 apiece. A development version for original-equipment manufacturers is available to develop and test control software on a host LSI-11 system. It comes with a macro cross-assembler and a relocating linker that operate under RT-11; a down-line loader and debugging package; a source-code resident monitor and model device handlers; and full technical documentation, all for $1,950. Shipments start this month.

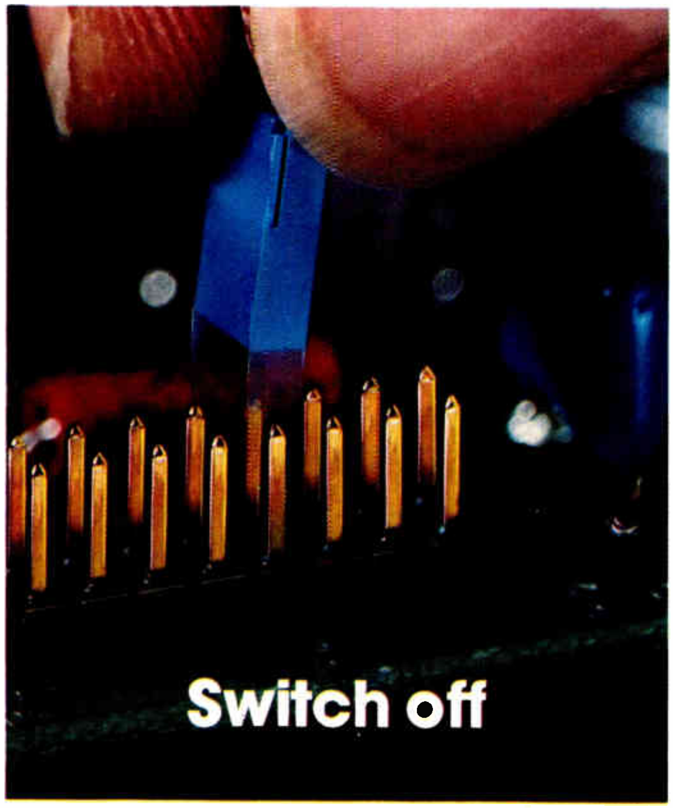
Nortek Inc., 2432 N. W. Johnson St., Portland, Ore. 97210. Phone (503) 226-3515 [403]

Solid-state SCR modulator is available off the shelf

An off-the-shelf silicon controlled rectifier magnetic modulator with all solid-state components can be used to retrofit radar systems for the growing use of pulse techniques, as well as in designing new systems. An electronic pulse-selection circuit in

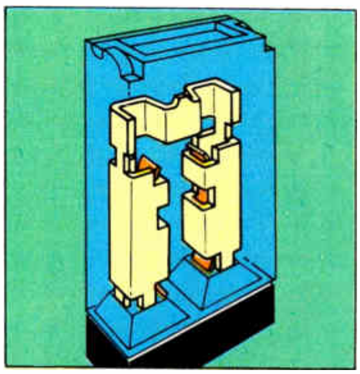
DIP switches can deprogram. Berg's Mini-Jump™ can't. Our design guarantees it.





Far more reliability. Far less field service. Accidents, vibration — anytime you'd expect a DIP switch to fail, you can count on Mini-Jump* to stay programmed. Careless fingers can't deprogram it because there's no switch to hit. Only a deliberate action can change the circuit.

The interior spring of the "Mini-Jump" maintains a high normal contact force for reliability during vibration — even severe vibration. And, because you install the "Mini-Jump" after soldering, you avoid contamination which can lead to corrosion.



Inside the "Mini-Jump", dual metal PV† contacts provide excellent electrical and mechanical performance.

Permits higher density packaging. The "Mini-Jump" is available in single position, stackable on 0.100", 0.125", 0.150" and 0.200" centers. Also in two positions on 0.100" centers and three and five positions on 0.150" centers.

Write for literature. The Du Pont Company, Berg Electronics Division, New Cumberland, PA 17070. Telephone (717) 938-6711.

*Du Pont trademark for its .025" disconnect jumper.
†Du Pont trademark for its .025" dual metal female disconnect.

Berg Electronics

DU PONT
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the VBM-3407 allows a user to switch pulse widths over a three-to-one range in 1 second or less by pushing one of five front-panel buttons. Pulse widths range from 0.2 to 0.6 μs, with other pulse widths available on request. The X-band modulator was designed to drive high-energy magnetron tubes operating at up to 300 kW. It provides pulses in the 28- to 30-kV range and can be packaged with the same pulse-switching parameters for airborne as well as ground-based applications. The unit ranges in price from $30,000 to $35,000, depending on configuration and on the prices of available components.

Varian Associates, Beverly Division, Salem Road, Beverly, Mass. 01915. Phone John Denman at (617) 922-6000 [405]

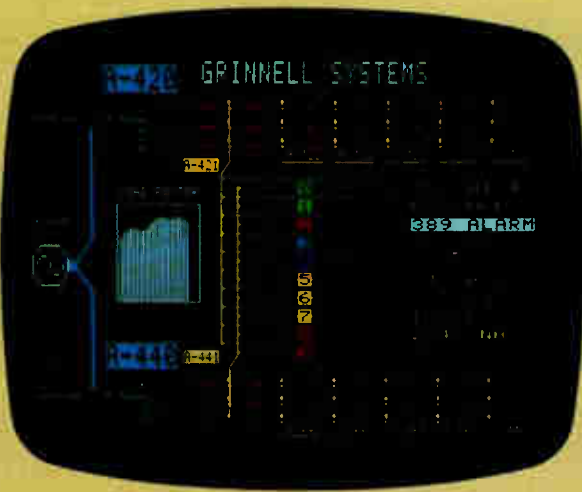
Modem test set performs bit error rate tests

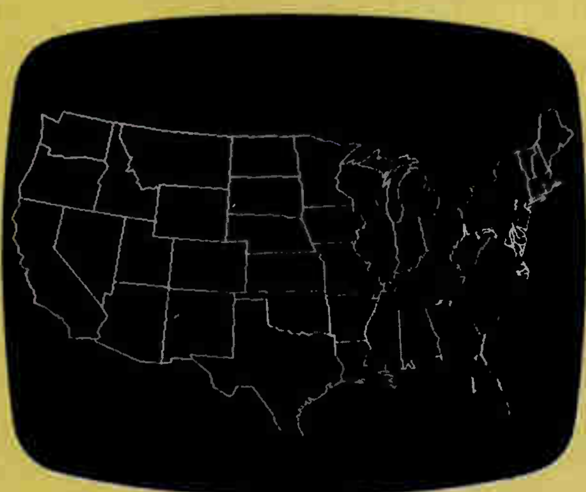
The model 65 is a complete miniaturized modem test set that can perform bit-error rate tests on synchronous and asynchronous EIA data-communications channels. It has separate transmitter and receiver sections, so full-duplex tests can be performed in either end-to-end or loopback configurations. The transmitter continuously generates one of four switch-selectable data patterns. These include 63-, 511-, and 2047-bit repeating pseudorandom sequences. The test unit also has an alternating mark-space pattern. Steady all-mark or all-space signals may also be transmitted to detect mark-to-space or space-to-mark transitions.

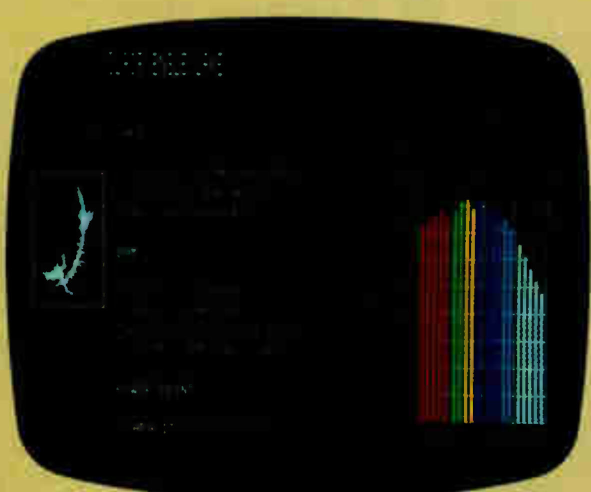
The receiver section generates a true replica of the selected transmitted data pattern and compares this error-free replica with the received data pattern. Detected bit errors are counted and displayed on a three-digit light-emitting diode with overflow indication.

The model 65, together with a "blue box" EIA monitor and breakout panel—the model 60—makes up the model 65/60, which is priced at $850. The composite model is a

Vector graphics. OEM prices.







Now, with Grinnell's GMR-37 graphic display systems, you can have the resolution and input advantages of dot matrix television for about the same price as more limited character-based systems.

And, every GMR-37 display is a complete operating system: display generator, MOS refresh memory, vector and rectilinear graphics, alphanumerics in 4 sizes, bi-directional RS-232 computer interface and RS-170 video interface. Systems, including power supplies, are housed in a 7″, rack-mountable chassis and drive standard closed circuit monitors.

Four basic GMR-37 models can be tailored to fit into almost any computer-based system. Here are just a few examples. (Prices are F.O.B. San Jose, and quantity discounts are available. TV monitors are extra.):

GMR 37-20: $3700
256 x 512 resolution, one channel RGB color plus blink. (Two channels: $4500)

GMR 37-30: $4500
512 x 512 resolution, one channel RGB color plus blink.

GMR 37-60: $4700
1024 x 1024 resolution, one channel B/W.

In addition, you can also have several economical options: independent cursors, joysticks, keyboards, special character sets and 16 bit, plug-compatible parallel minicomputer interfaces.

Further, if you ever want to move up, Grinnell has a complete line of larger systems—all software compatible with the GMR-37—to do things like animation, image processing and real-time frame grabbing.

So, if quality graphic displays are important to your product, look at the GMR-37 line. For a quotation on the system that meets your specific requirements, call or write.

GRINNELL SYSTEMS

2159 Bering Drive, San Jose, California 95131 (408) 263-9920

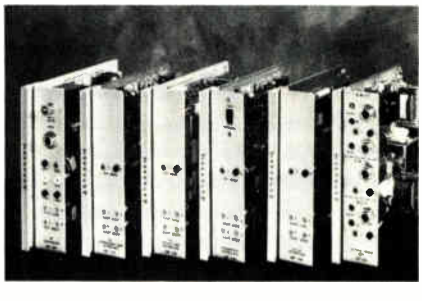
Circle 235 on reader service card

hand-held, battery-powered unit for testing and monitoring data-communications systems at the EIA RS-232 and CCITT V.24 modem-terminal interface. Rechargers are priced at $20 for either a model 22 for 115-V application or a model 23 for 230-V use. Delivery is in 60 days.

International Data Sciences Inc., 7 Wellington Rd., Lincoln, R. I. 02865. Phone (401) 333-6200 [406]

Inband signaling system uses 24 or 48 V

The SSP-inband signaling system for termination and signaling of voice-grade telephone lines features an SSP-200 amplifier and terminating set that allows four-wire amplification and four- to two-wire conversion on one card. The system uses a variety of interchangeable plug-in modules and mounting chassis. All the modules employ voltage regulation for 24- or 48-V operation. The unit is compatible with Western Electric and other E- or F-type single-frequency signaling equipment. It includes amplifiers with less than 5 dBrnC noise level and less than 0.25% distortion at a 10-dBm output from 200 Hz to 10 kHz. It also has converters and interfaces for foreign-exchange, E and M, and ringdown signaling. The mounting chassis range from two-slot units,



which can terminate two four-wire lines, up to units with space for 26 plug-in modules. The SSP-inband signaling system, depending on configuration, ranges in price from $341 to $371.

Transcom Electronics Inc., 1170 East Main Rd., Portsmouth, R. I. 02871. Phone (401) 683-3000 [407]

Neff Series 500 Measurement & Control I/O. One System.

Versatile.

Most computer-based measurement and control applications have one problem in common — a variety of diverse signals. Each with its own interface and control problems, and any one capable of generating bad data and destroying system performance.

The Solution?

Neff Series 500. It's a complete measurement and control subsystem with a plug-in standard interface to your computer. The Series 500 is compatible with virtually any process or measurement I/O signal. The system is supplied with complete software and uses only one of the computer's I/O ports.

Solving Your Problem

Many standard features assure a Series 500 configuration to match *your* requirements.

Versatile Input Structure Plug-in function cards accommodate a variety of input signals including analog, TTL, contact closures and frequency.

Control Signals Computer controlled signals are generated in the Series 500 for driving elements requiring analog levels, TTL signals, contact closures and frequency.

On-Board RAM The Series 500 contains a 4096-word RAM in which the computer stores scan lists and instructions to control the peripheral devices.

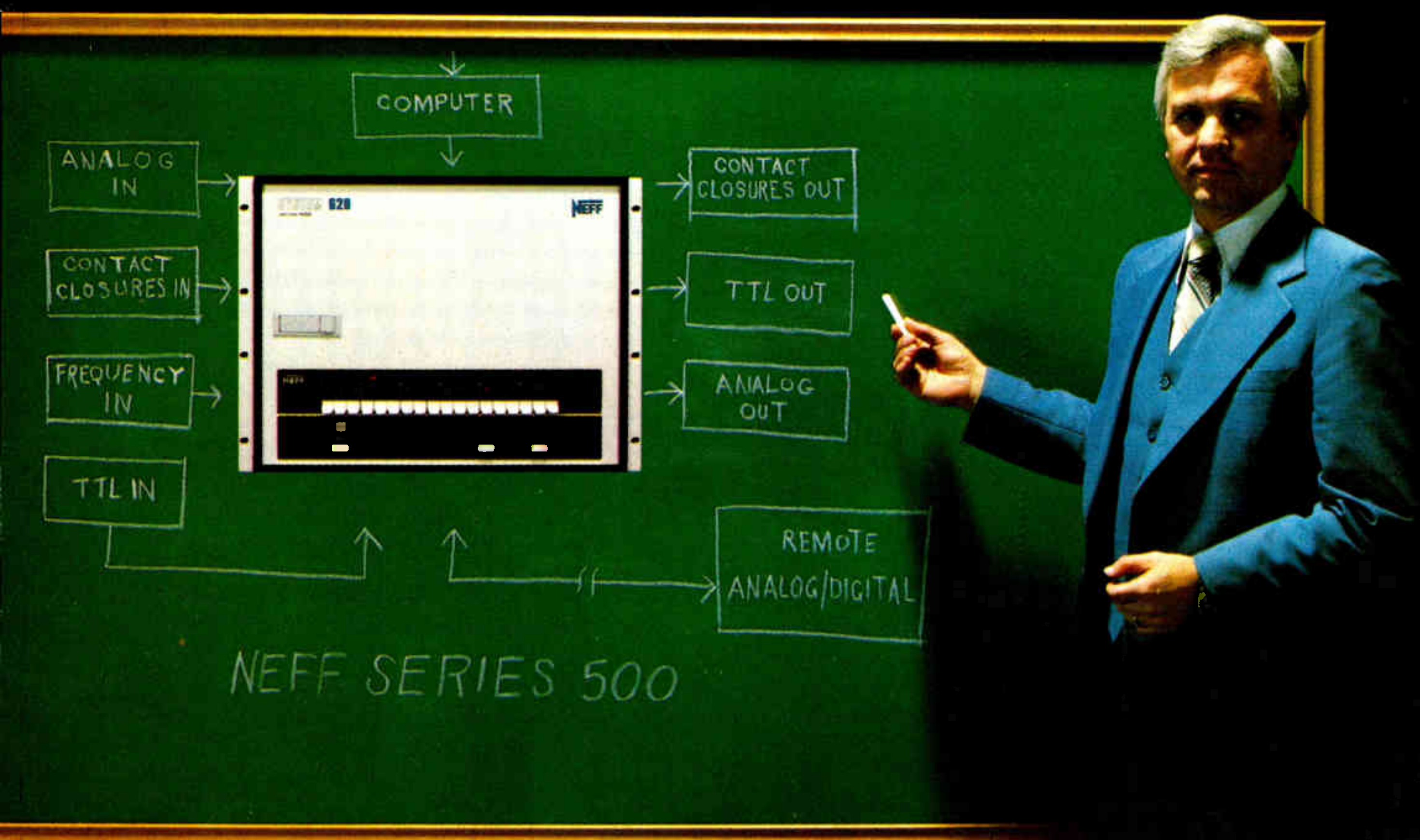
Remote Operation A Serial Controller permits the operation of systems located at eight or more separate remote sites — up to 20,000 feet from the computer.

Expandability All systems are expandable at both local and remote sites.

Analog Input The Series 500 supports operation of the Neff high-performance analog input subsystems - the most powerful and versatile in the world.

These are just a few of the reasons for Series 500's success. The rest are described in our new full-line catalog. Send for it today.

NEFF INSTRUMENT CORPORATION
1088 E. Hamilton Rd., Duarte, Calif. 91010
Tel. (213) 357-2281 TWX 910-585-1833



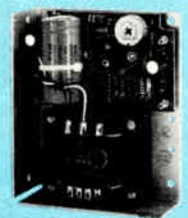
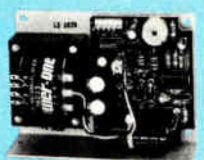
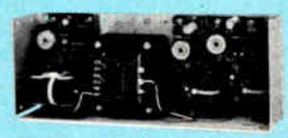
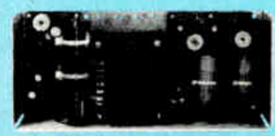
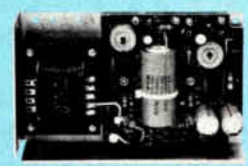
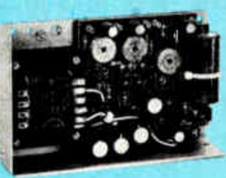
Circle 237 on reader service card

POWER-ONE D.C. POWER SUPPLIES

Now available for small systems applications

Power-One, the leader in quality open-frame power supplies, now offers a complete line of single, dual, and triple output models for small computer systems. Also available are special purpose models for Floppy Disk and Microcomputer applications.

Below are just a few popular examples of the over 90 "off the shelf" models now available from stock.

SINGLE OUTPUT & LOGIC POWER SUPPLIES • 56 "off the shelf" models • 2V to 250V, 0.1A to 40A • ± .05% regulation • 115/230 VAC input	**5V @ 3A, w/OVP**  HB5-3/OVP $24.95 single qty.	**5V @ 12A, w/OVP**  HD5-12/OVP $79.95 single qty.	**5V @ 40A, w/OVP** **NEW**  SK5-40/OVP Switching Model $250.00 single qty.
FLOPPY-DISK SERIES • 8 "off the shelf" models • Powers most popular drives • Single/dual drive applications • 2-year warranty	**5V @ 0.7A, w/OVP** **12V @ 1.1A/1.7A PK** **NEW**  CP340 For one 5.25" Media Drive $44.95 single qty.	**5V @ 1A, w/OVP** **−5V @ 0.5A, w/OVP** **24V @ 1.5A/1.7A PK**  CP205 For one 8.0" Media Drive $69.95 single qty.	**5V @ 2.5A, w/OVP** **−5V @ 0.5A, w/OVP** **24V @ 3A/3.4A PK**  CP206 For two 8.0" Media Drives $91.95 single qty.
DUAL OUTPUT MODELS • 15 "off the shelf" models • ±5V to ±24V, 0.25A to 6A • I.C. regulated • Full rated to +50°C	**12V/15V @ 0.25A** **NEW**  HAD12-.25/HAD15-.25 $32.95 single qty.	**5V @ 2A, w/OVP** **9 – 15V @ 0.5A**  HAA512 $44.95 single qty.	**±12V @ 1.7A or** **±15V @ 1.5A**  HBB15-1.5 $49.95 single qty.
TRIPLE OUTPUT MODELS • 10 "off the shelf" models • 5V plus ± 9V to ± 15V outputs • Models from 16W to 150W • Industry standard size	**5V @ 2A, w/OVP** **± 9V to ± 15V @ 0.4A**  HTAA-16W $49.95 single qty.	**5V @ 3A, w/OVP** **±12V @ 1A or** **±15V @ 0.8A**  HBAA-40W $69.95 single qty.	**5V @ 6A, w/OVP** **±12V @ 1.7A or** **±15V @ 1.5A**  HCBB-75W $91.95 single qty.

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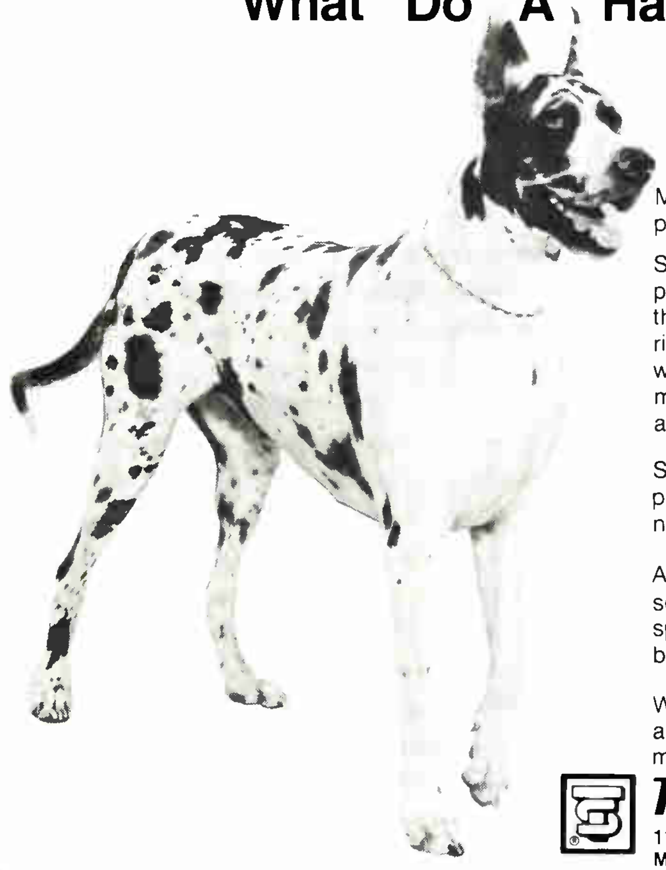
What Do A Harlequin Great Dane and ALNICO 9 Have In Common?



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INTERRUPT POWER Multilevel, priority vectored interrupt system handles context changes in less than 2 microseconds.

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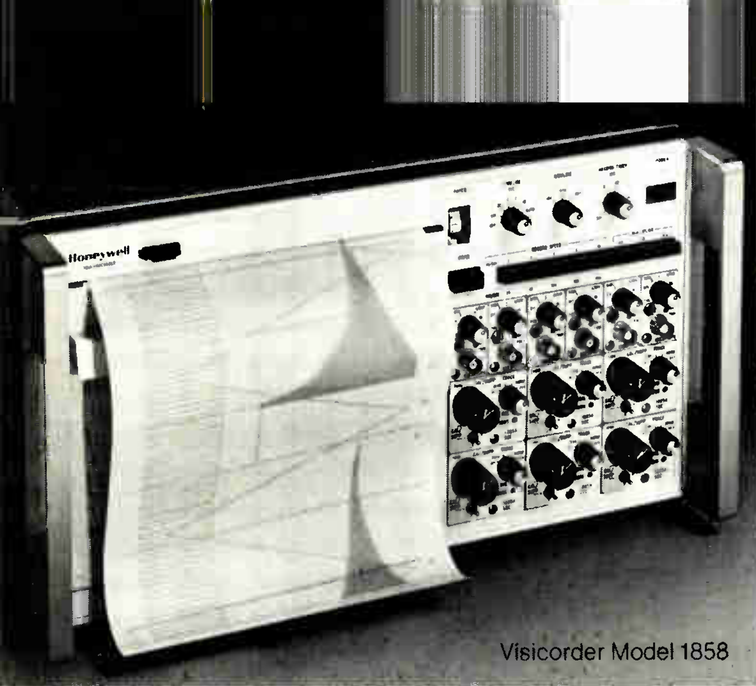
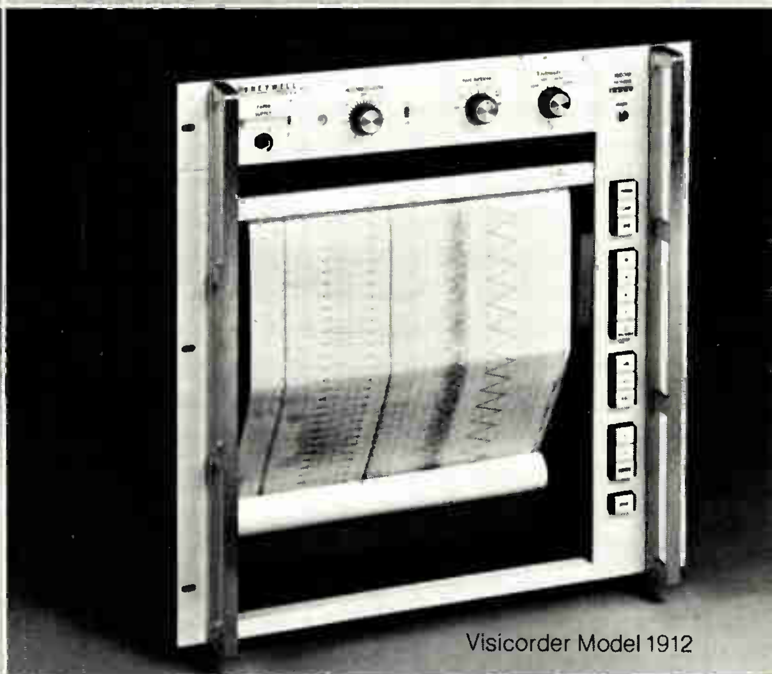


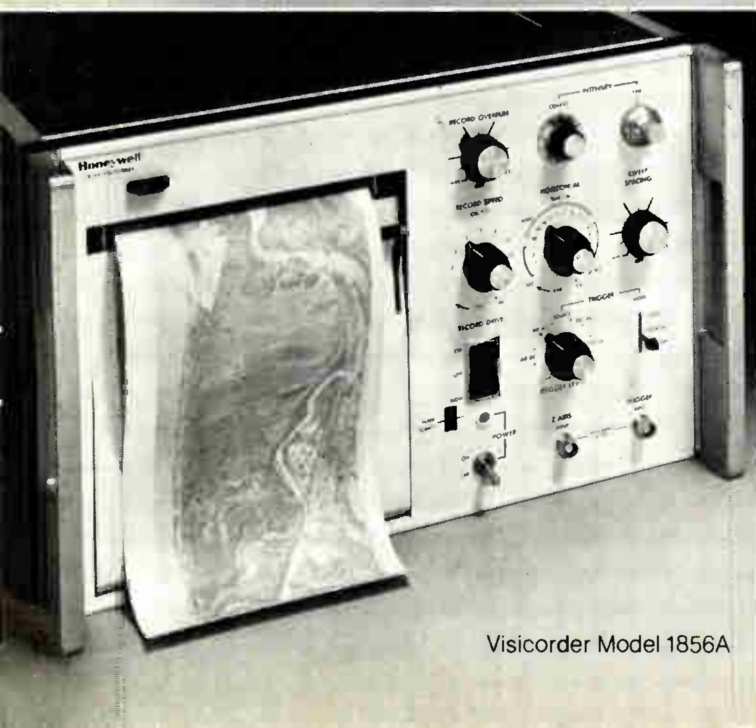
Visicorder Model 1858

Visicorder Model 1508B

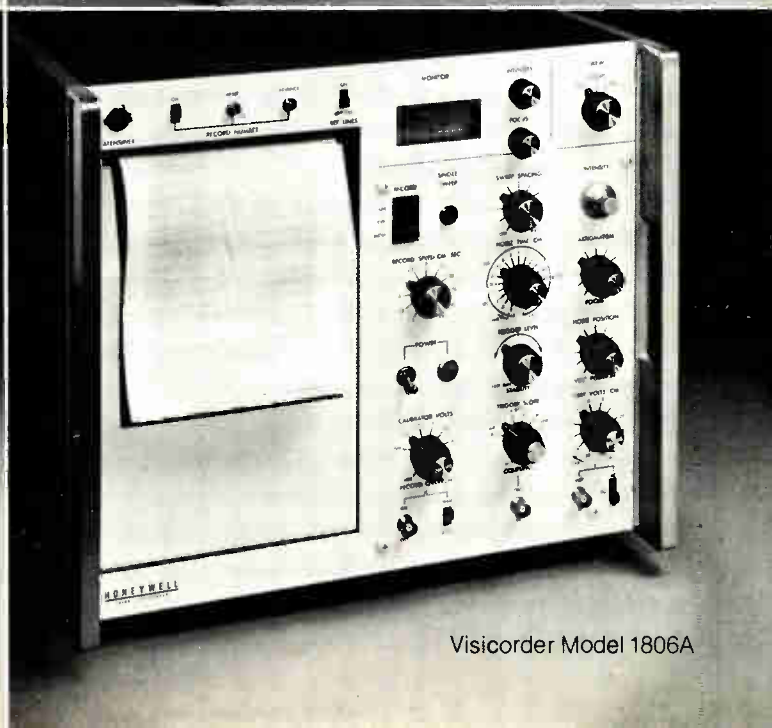
Visicorder Model 1508C



Visicorder Model 1912



Visicorder Model 1856A



Visicorder Model 1806A

Microcomputers & systems

Chip eases host's printer duties

Controller chip mediates between Epson printers and most 8-bit microprocessors

NEC Micromputers Inc. is introducing a large-scale integrated printer-control circuit that will free most 8-bit microprocessors from directly controlling any of Epson American Corp.'s 500 series dot-matrix printers. The µPD781 controller accepts nine different instructions, including six commands, in the form of single 8-bit bytes from a host processor; it not only activates the printer, but also reports on its own and the printer's status.

Software control will adapt the µPD781 to each Epson 500 series printer model. The controller's printer-buffer capacity is 40 columns when used with the Epson 512 and 522 and 2 to 18 columns with the Epson 542. The host processor writes characters to be printed into the controller, which contains its own 96-symbol character generator, and issues a single-byte command when the buffer is full. The µPD781 then executes printing instructions for a full line, incrementing the print head, activating print solenoids, and performing independent or simultaneous line feed. Printing is bidirectional, at approximately three lines per second.

The interface between the controller and the processor is TTL-based, with the two units communicating over a data bus. Four standard control signals transmitted over any address bus line determine the type of data transfer—say, status information and data into column buffer. The controller and the printer connect through open-collector TTL buffers to discrete transistor circuits that activate the print solenoids and paper-feed mechanisms.

The µPD781 features a 6-MHz oscillator, which requires an external crystal. The chip operates from a single +5-V power supply, over a temperature range of from 0° to 70°C. The storage temperature range is from −65° to +125°C. A 40-pin plastic package houses the printer-control chip.

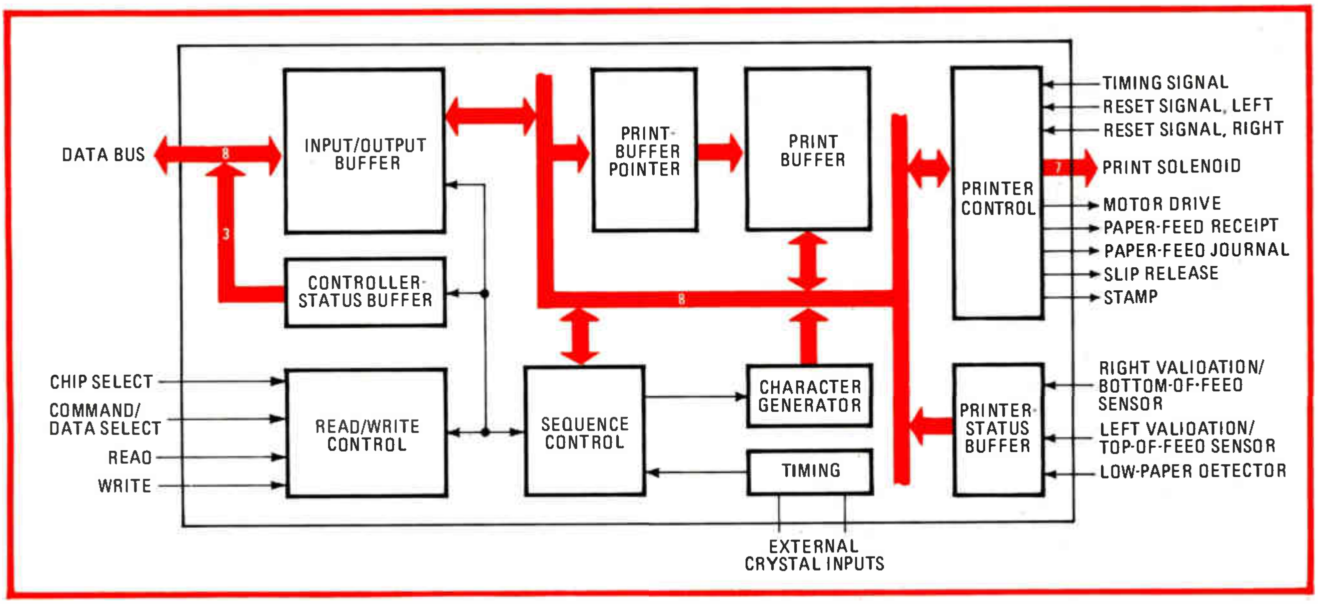
The unit price is $12. Discounts for large quantities are available, as are application notes, according to Henryk Szejnwald, product marketing manager at NEC Microcomputers. He says that makers of point-of-sale systems and instrumentation appear to be the major source of potential customers. One point-of-sale industry source notes that manufacturers seeking fast production times and wishing to avoid developing printer control firmware will find this kind of device most useful. Epson, located in Torrance, Calif., reports shipments of its 500 series printers at 30,000 per year, according to Szejnwald.

Szejnwald also says the µPD781's on-board character generator contains 30 Japanese characters, making applications in the Japanese market a possibility for the future. Domestically, the controller is currently available to customers from stock.

NEC Microcomputers Inc., 173 Worcester St., Wellesley, Mass. 02181. Phone (617) 237-1910 [371]

Multibus processor board is based on the Z8001

A Multibus processor board based on the Zilog/AMD Z8001 (segmented) 16-bit central processing unit has been designed by Central Data Corp. to be used in multiuser systems and scientific processors. A memory management system divides the entire 16-megabyte memory into 2-kilobyte pages. The pages are mapped to allow 16 totally independent address spaces of a 4-megabyte maximum each. Each



page of memory can be write-protected to ensure data integrity, and it is easy to share pages among different independent address spaces. Peripheral chips that are put in to decrease the workload on the Z-8000 include an Intel 8253 programmable interval timer, an Intel 8259A programmable interrupt controller, and an optional AMD 9511 arithmetic processor.

Two 2716 erasable programmable read-only memories can be added to the board for a monitor or bootstrap program. These E-PROMs are enabled automatically upon initialization and can be disabled with a single Z8000 instruction. The board can work with any other processing or direct-memory-access board in a Multibus system, because it fully conforms to the proposed IEEE Multibus standards.

The board operates from a 5-V power supply but requires a 12-V supply if the 9511 option is included. The price for the standard Z8000 CPU board is $995 each, although in quantities of 100 items, it is priced at $635 each. In addition, the large-quantity price of the monitor option is $75 apiece, and for the 9511 arithmetic processor option the large-quantity price is $225 each.

General Data Corp., P. O. Box 2530, Station A, Champaign, Ill. 61820. Phone Jeff Roloff at (217) 359-8010 [373]

10-megabyte memory system expands the 6800 Exorcisor

The Storage Demon memory system expands the memory of the Motorola 6800 Exorcisor system. The memory system comes with a disk controller, a 10-megabyte Winchester disk drive, and the SDOS software disk operating system. The Storage Demon provides a capacity of 19,000 512-byte sectors and is compatible with the Exorcisor I and II from Motorola Inc.

The SDOS software support allows disk and keyboard data to be entered in the system for later use; it also features disk sector pooling and dynamic files that can randomly access data by bytes. SDOS also gives each device complete independence. Additional data storage is available through the use of Exordisk floppy-disk drives to back up the hard-disk drive.

The Storage Demon is priced at $6,995 with dealer discounts available. Delivery is in 30 days.

Software Dynamics, 2111 W. Crescent Ave., Suite G, Anaheim, Calif. 92801. Phone Ira Baxter at (714) 635-4760 [375]

Voice-recognition module on single board is 99% accurate

A single-board voice-recognition module for adding voice input technology to intelligent terminals, small business systems, and machine controllers provides recognition accuracies in excess of 99%, regardless of dialect, accent, or language. The discrete-word, speaker-dependent device is supported by a portable control chassis—called Voterm I—and a VRM emulator package for software development and vocabulary definition.

The microprocessor-based VRMs come with vocabulary capabilities for either 40, 70, or 100 words. A discrimination threshold—to reject undesired inputs—may be controlled by a switch, or by the host processor. The device's communication protocol is compatible with such languages as Fortran, Basic, and Pascal. The unit's single circuit board is standard Multibus-card size. Parallel TTL interface ports are also standard; serial ports that are selectable for RS-232-C or 20-mA current loop are optional.

During operation, input words are analyzed by a 16-filter spectrum analyzer and are converted into digital descriptions of the time and frequency characteristics. The digital data is compressed into templates for each vocabulary item trained into the device, and these are then used for comparison with incoming words. A 40-word VRM sells for $1,525, and a 100-word model sells for $1,830, for 100 to 199 units. Delivery is within 60 days after

Grayhill's New

SEALED KEYBOARDS

SPILLPROOF! TACTILE FEEDBACK! LONG LIFE!

ACTUAL SIZE

a sealed keyboard that lets you hear and feel the actuation!

These new Grayhill Series 88 sealed keyboards are available now in 3x4 and 4x4 button configurations with one-half inch button centers. The graphic overlay, which seals the keyboard surface and the contact system, resists the vast majority of common contaminants. Thus, these keyboards can be used out-doors as well as in applications that require a washable front surface. Graphic overlays come in a variety of standard colors and formats; custom nameplates can also be provided.

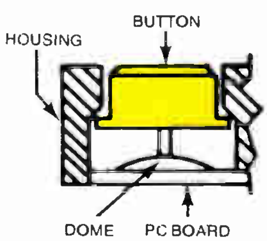
Grayhill Series 88 keyboards are flange mounted. Special gaskets seal the flange surface for either front panel or sub-panel mounting.

The Grayhill Series 88 electrical characteristics have been designed to be compatible with logic circuitry and are rated at 3,000,000 operations per button. The Series 88 is offered with matrix, 2 out of 7, 2 out of 8, or single pole/common bus circuitry. The snap dome contact system provides positive audible and tactile feedback to the operator.

Engineering data and prices are yours for the asking in Bulletin No. 297.

Spill-proof, contamination-proof

Snap-dome contacts give positive operator feedback



One of five standard 3x4 legends

One of four standard 4x4 legends

Custom graphic overlays to your exact specifications

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Circle 249 on reader service card

an order has been received.

Interstate Electronics Corp., 1001 E. Ball Rd., Anaheim, Calif. 92803. Phone (714) 635-7210 [376]

Unix-like software runs on Z80 microcomputers

Beginning this week, an operating system compatible with Bell Laboratories' Unix will be available for Z80-based microcomputers. Called Omnix, the system implements and extends the capabilities of the popular Unix operating system. A license for Omnix to operate on a single central processing unit is priced at $350, with support and annual updates costing $75 per year.

A command-line interpreter—called the shell—accepts input from a user's console or from a file. The shell itself may be programmed in a structured macro language because shell commands include control statements and macro substitution.

Tasks may be scheduled and run automatically at preset times or at predetermined intervals. They can also branch or fork into independently running copies of themselves and can be linked so the output of one task serves as input to another. Input/output may be redirected freely to and from files and devices, and users have access to the output spooler as well as the event queue manager.

Omnix file directories are organized in a hierarchical tree, with files protected by passwords at every branch. Files and devices may be accessed randomly, and disks with up to 4,000 megabytes on line may be accessed as single devices. The system runs in an address space of at least 64 kilobytes and is available in load-and-go versions for Industrial Micro Systems and Cromemco System 3 microcomputers. Via a conversion utility programs and files may be transferred from Digital Research's CP/M to Omnix to be run without recompiling or relinking.

Yourdon Software Products Group, 1133 Ave. of the Americas, New York, N. Y. 10036. Phone (800) 223-2452 [374]

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INNOVATIVE 6502 PRODUCTS

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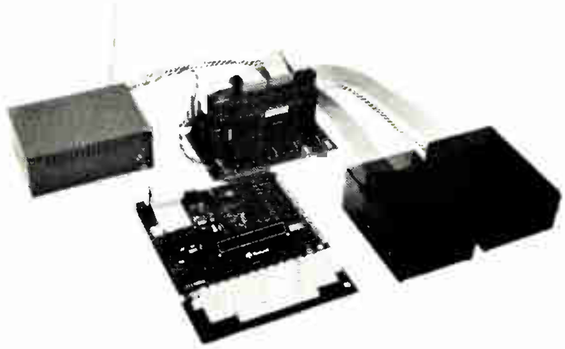
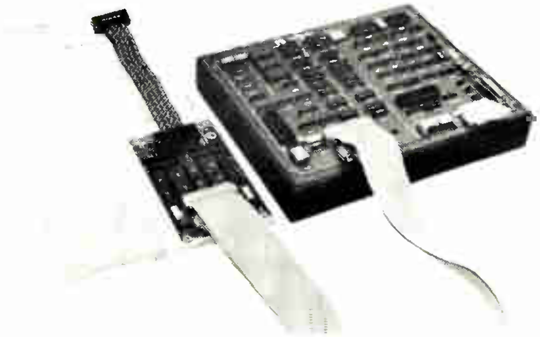
Floppy disks for the Rockwell AIM65



- Rockwell motherboard compatible
- 4K operating system EPROM
- Packaged power supply for two drives
- Protective cases for minifloppys
- System 65 compatible disk format
- Same commands as System 65
- PROM-RAM card also available
- PROM programmer also available

HIGH TECHNOLOGY 6502 PRODUCTS



DB/65

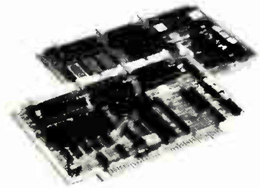
Complete hardware/software debug system for the Rockwell, Synertek, MOS Technology 6500 microprocessor family

- Standard in circuit emulator
- Hardware breakpoints
- Single step mode
- Symbolic disassembly
- Serial/parallel load capability
- Prom resident debug monitor
- Scope sync output
- User NMI and IRQ vectors supported
- User program may reside in high memory

PRE-ENGINEERED 6502 PRODUCTS

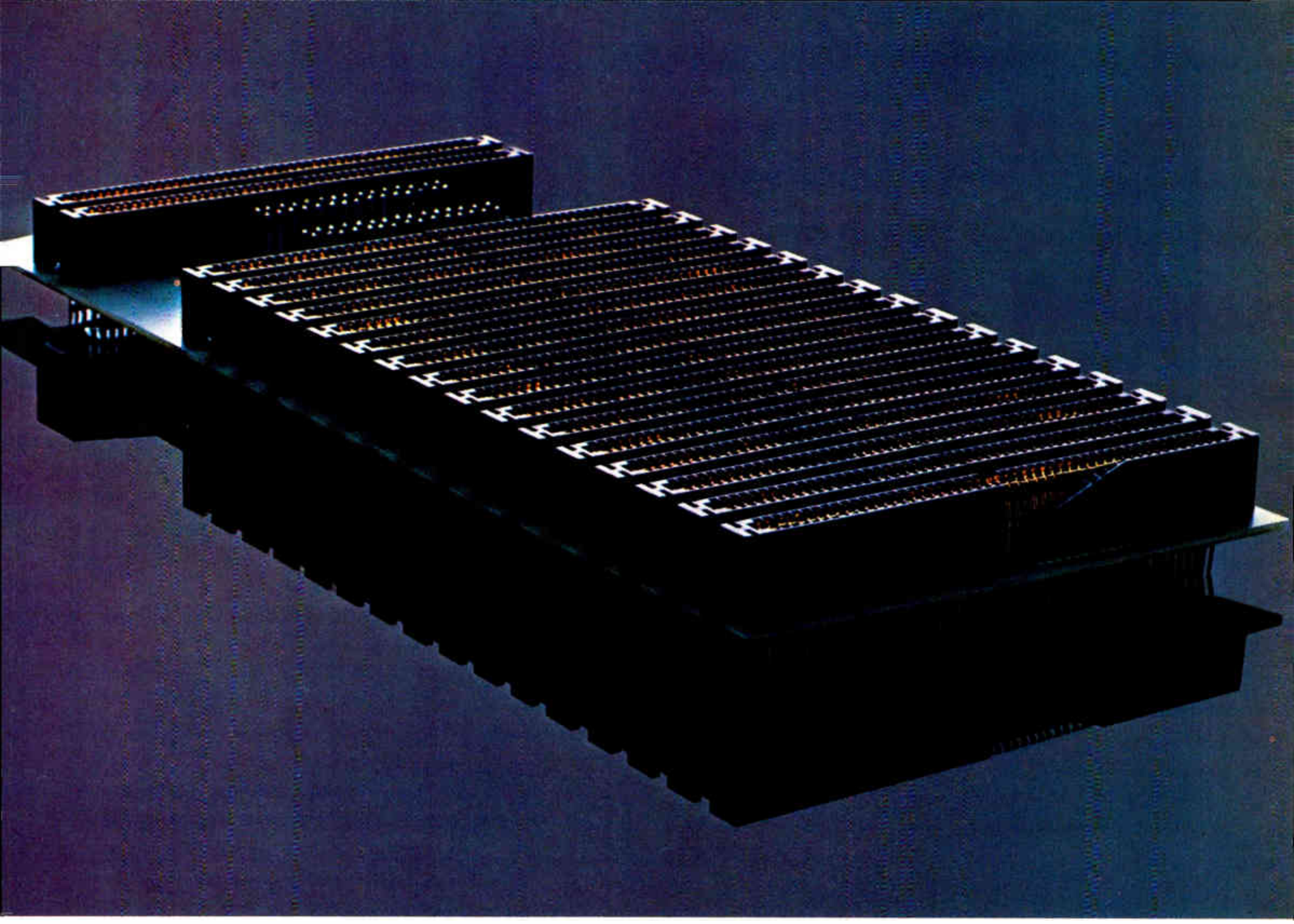
CSB1, CSB2

Single board computers

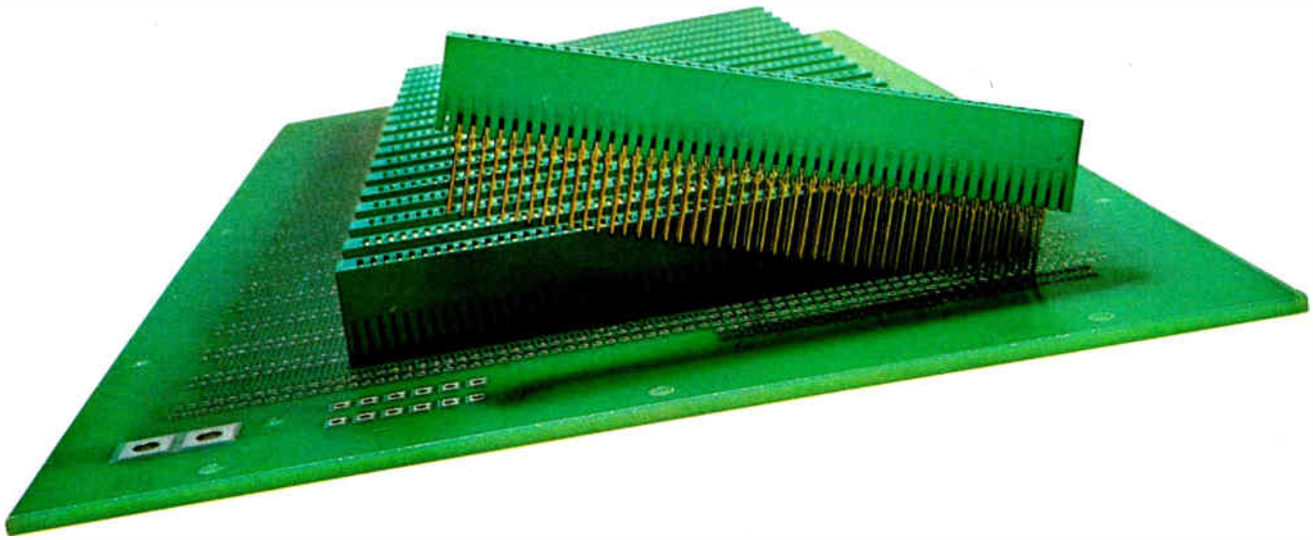


- System 65 bus compatible
- 2K RAM
- Sockets for 8K 2716 (2326, 2732, 2332, and 2364 also)
- CSB2 has serial RS232-C interface
- CSB2 has 30 input or output lines
- CSB1 has 50 input or output lines
- 10 buffered output lines
- 2 powerful interval timers

Circle 140 on reader service card

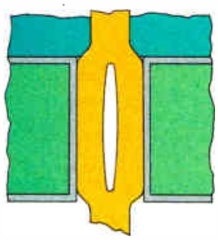


Building Backpanels? Elco's discrete press-fit card-edge connectors make it easier.



Lower costs

Elco's pre-assembled, press-fit card-edge connectors insert with simple tooling, and require low insertion forces due to a compliant press-fit section on the contacts. They achieve both mechanical stability and a reliable gas-tight electrical connection in one operation, without the use of solder, screws, or other fastening devices. This results in lower installation costs.



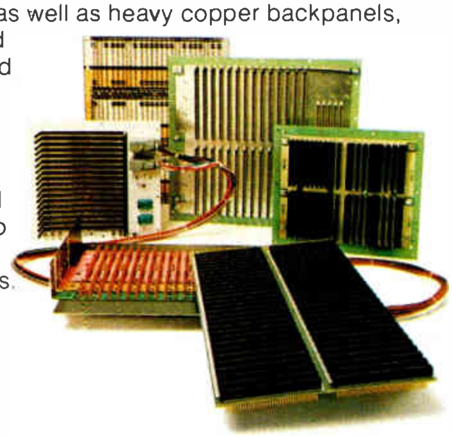
Since much circuitry can be etched on a Printed Circuit Board backpanel, wire wrapping can be dramatically reduced or even eliminated. When wire wrapping is required, Elco's discrete press-fit card-edge connectors make it easier because the PC board places the connector tails in a known position.

The discrete advantage

Now the advantages of a press-fit connector are available with no need to cut insulators and reels of contacts. Elco offers immediate delivery on one-piece connectors of any length up to 50 pairs, with a .100 x .200 grid pattern. Other grid patterns will soon be available. The standard finish is 20μ" gold, selectively plated over 50μ" nickel. However, other plating thicknesses and overall plating are available.

Total Interconnect Package

Of course, Elco will be pleased to build your backpanels for you. Our capabilities extend into a broad range of press-fit, metal plate and card-edge connectors, as well as heavy copper backpanels, sophisticated multilayer and aluminum backpanels and backpanel systems—all assembled to your specifications. For more information, call or write:



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2PDT POWER SWITCH
UL and CSA Listed
TV-5 5 amp @ 120 VAC
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SERIES NE 15
2PDT POWER SWITCH
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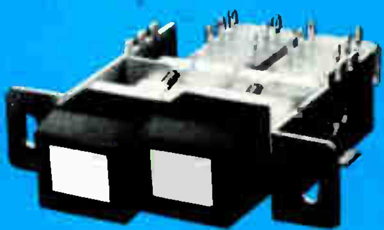
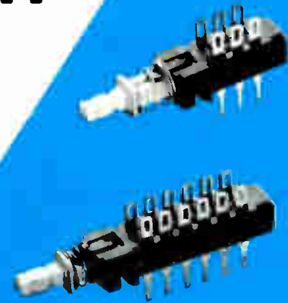


SERIES CA 110 LAMPLESS SWITCH
Indicates function mechanically, eliminates costly lamp replacement.
Life: C Series, 500,000 operations, rated at 1 amp, Dual bifurcated contacts.

DIGITAST
SPDT Momentary Switch
Available with or without LED illumination 5 different cap styles available to suit your requirements, available in all standard colors. Life: 5x10^6 @ 20mA.

SERIES REK
Flat Pack with or without Button, SPDT, Tactile Feel. Cycle Life: 1x10^6 @ 10mA.



SERIES F
PUSH BUTTON SWITCHES
2 PDT-16 PDT available in Push-Push, Momentary and interlock. 4 terminal options available. Spring loaded contact system provides long life, consistent, low contact resistance and excellent self-cleaning capability.

SERIES ZFL
Illuminated bushing mounted F series. Can be used with F series 2 pole — 16 pole and NE 15 power switches. Available with 6V, 12V, or 28V neon.

SERIES MDP DISC SWITCH
SPST momentary, sealed against moisture and solvents to permit flow soldering and cleaning without concern for contact contamination or the removal of lubricants. All standard button colors available.

SERIES FL
ILLUMINATED SWITCH
Available on 17.5mm centers. Utilizes snap fit lampholder on standard F Series lamp, replaceable from front. 3 different lampholder variations available — 2 different button styles available with graphics upon request.

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Circle 257 on reader service card

New products

Data acquisition

System monitors 64 inputs

Controller, interface module, and 16-channel a-d board sell for less than $2,500

For designers looking to reduce the cost of their 16-, 32-, or even 64-channel data-acquisition systems, an analog interface module from Dynabyte Inc. may provide the key. Dynabyte's model BCX-30-001 Analog Interface Module (AIM) provides the necessary link for the direct connection between the company's low-cost Basic Controller and the RTI series of analog-to-digital and digital-to-analog boards from Analog Devices Inc.

"Together, the controller, the interface, and one 16-channel a-d board can form a 16-channel data-acquisition system for under $2,500," notes Hank Skawinski, director of marketing for Dynabyte's Industrial Control Products division. "Just to get started on a comparable system from Itel, National, or Zilog, you would need about $4,000 worth of cards," he says. The configuration cited includes $1,600 for the controller, $250 for the AIM, and about $330 for the 16-channel a-d board.

The AIM has two card slots, each of which may accept either an RTI-1220 data-acquisition board or an RTI-1221 analog-output board from Analog Devices. The RTI-1220 provides 16 channels of a-d conversion with 12-bit accuracy (0.025% nonlinearity), whereas the RTI-1221 provides four channels of d-a conversion with 10-bit accuracy (0.1% nonlinearity). The RTI-1220 can supply 200 a-d conversions/second, and the RTI-1221 allows the controller to execute a complete slew cycle every 2 s.

The interfacing provided by the AIM makes construction of a data-acquisition system a very easy matter. The boards from Analog Devices plug directly into the AIM's card slots, and the module, in turn, connects to the controller through a flat-ribbon cable. Thermocouples and other sensors can then be attached directly to the boards.

Since the AIM card slots are independent, a user may close the interaction loop by mixing a-d and d-a boards within a single module, providing 16 channels of monitoring in addition to four channels of controller action through the d-a levels. The Basic-language controller accepts the inputs from two stacked AIMs, enabling the system to monitor up to 64 analog inputs.

The AIM's metal enclosure shields any interference-sensitive circuitry on the a-d boards. Power for the module is supplied by the controller's system power supply. The module's dimensions are 2 in. by 4.75 in. by 10 in.

Delivery is within 30 days.

Dynabyte Inc., 115 Independence Dr., Menlo Park, Calif. 94025. Phone (415) 329-8021 [381]

8- and 10-bit converters settle in 10 and 15 ns

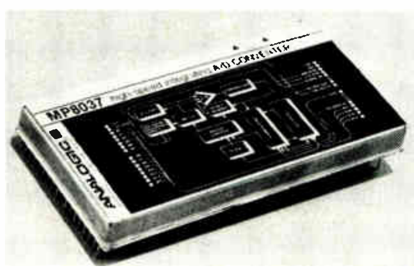
Two hybrid digital-to-analog converters feature 10- and 15-ns settling times for 8- and 10-bit accuracy, respectively, so the manufacturer considers them the industry's fastest hybrid converters in those accuracy ranges. The HDS-0810E with 8-bit and the HDS-1015E with 10-bit accuracy feature a glitch energy of 200 pV-s and guaranteed monotonicity over temperature. The glitch energy can be reduced to less than 100 pV-s by deskewing the digital inputs with appropriate latching. The converters make 100-MHz update rates possible for raster scan and X-Y graphics, TV video reconstruction, digital voltage-controlled oscillators, and other ultrahigh-speed applications. The 75-Ω output impedance allows the devices to drive a 75-Ω cable directly and to provide 1 V peak to peak at the load, a standard requirement in video applications.

The converters come in two versions guaranteed for operation at 0° to 70°C or −55° to 125°C. Temperature coefficients are 5 parts per million per °C for nonlinearity, 1 ppm/°C for zero offset, and 80 ppm/°C for gain. Data inputs are compatible with emitter-coupled logic and are binary-coded. Outputs are 27 mA with −1.1-to-+1.1-V compliance. They come in a 24-pin package and operate from a single −5.2-V, 180-mA supply. The 8-bit converter's prices start at $129 and the 10-bit unit's at $149. The devices are available from stock.

Analog Devices Inc., Computer Labs div., 505 Edwardia Dr., Greensboro, N. C. 27409. Phone Ed Graves at (919) 292-6427 [383]

Integrating converter has true 17-bit resolution

A triple-slope integrating analog-to-digital converter offers true 17-bit resolution. The device measures 2 in. by 4 in. and sells for $199 in large quantities. It can make 250 conversions per second and is TTL-compatible; both of these features make it useful for universal interfacing with high precision data-acquisition and control systems such as gas chromatography and precision pharmaceutical mixing and grading. The model MP8037's monotonicity and true 17-bit resolution are guaranteed by an integral linearity within ±0.00075% (7.5 ppm) of full-scale range and a differential linearity of ±0.00025% (2.5 ppm) of full scale. The unit automatically autozeroes whenever it is in the standby mode, and it has a gain temperature coefficient of ±5 ppm/°C. It is also able to make true ratiometric measurements and has an input current of 50 nA at 100



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28 VDC to DC Power Modules (Model "C") — feature smaller volume, lower weight, and higher performance. Low peak-to-peak ripple and close regulation meet even the most demanding specs. The standard Model "C" line converts 24-30 volts DC to any output between 5 and 100 volts DC.

For Catalog Circle Card Number 100

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For Catalog Circle Card Number 102

See Power Supply Section 4000, and Transformer Section 5600, Vol. 2, of your EEM catalog; or Power Supply Section 4500, and Transformer Section 0400, Vol. 2, of your GOLD BOOK for complete information on Abbott products.

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conversions/s and an input impedance of 1,000 MΩ minimum and 50 pF maximum. The 17-bit conversion, including autozero, is completed in 4 ms maximum.

Analogic Corp., Audubon Road, Wakefield, Mass. 01880. Phone Theodore Beloin at (617) 246-0300 [384]

$199 8-bit d-a converter has 9-bit accuracy

An 8-bit digital-to-analog converter that is accurate to 9 bits provides twice the accuracy of the manufacturer's own 8-bit part. It is intended for use in high-speed instrumentation and communication equipment, display processing, storage oscilloscopes, radar processing, and TV-broadcast systems. The converter has a 15-ns settling time and a 51-mA full-scale output current. The model MC10318L9 guarantees a maximum nonlinearity of ±0.10% over the 0°-to-70°C temperature range. It operates from a −5.2-V supply and has an output compliance range of −1.3 to ±2.5 V. These features allow convenient interfacing between high-speed processors and video-level circuitry. The 16-pin ceramic MC10318L9 is available from stock at a price of $45 apiece in quantities of 100 to 999.

Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Ariz. 85036. Phone Roger Janikowski at (602) 962-2124 [385]

Chip encrypts 64 data bits per encoding cycle

The MC-884 data-encryption chip encrypts or decrypts 64 bits of data per encryption cycle, based on a 56-bit key variable stored in its key register. It uses the National Bureau of Standards Data Encryption Standard algorithm. The variable, once loaded in the chip, cannot be accessed. A battery option may be used to prevent destruction of the key variable. Since a parity error does not affect operation, it may be ignored by the user. Therefore, the

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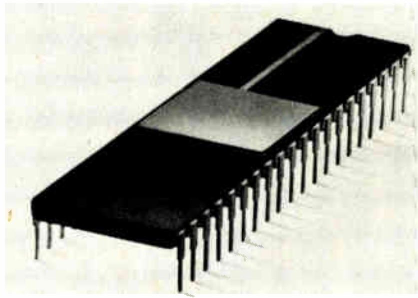
Circle 261 on reader service card



key bytes are checked for off parity. The MC-884 sells for $60 each in large quantities.

Burroughs OEM Marketing Corp., Burroughs Place, Detroit, Mich. 48232. Phone (313) 972-8031 [386]

Multiplexer handles 16 I/O channels at 56 kilobits/s

A high-speed digital multiplexer, model CMX-100, can handle up to 16 input/output channels at rates of up to 56 kilobits per second on all channels with a bit error rate of 10^{-9} or better. Each channel can accommodate data in either asynchronous or synchronous data formats. Three different interfaces are available—RS-232-C, CCITT V.35, and MIL STD 188.

An optical channel interfaces with the manufacturer's own asynchronous and synchronous modems at a distance of up to 3,000 ft apart. This eliminates the need for a limited-distance modem or line driver at the multiplexer location. The multiplexer features built-in diagnostics to isolate faults to a single plug-in card, as well as data-error checking. Built-in automatic error detection disables all operational channels if there is a loss of synchronization, but the channels are automatically reenabled once there has been a reestab-

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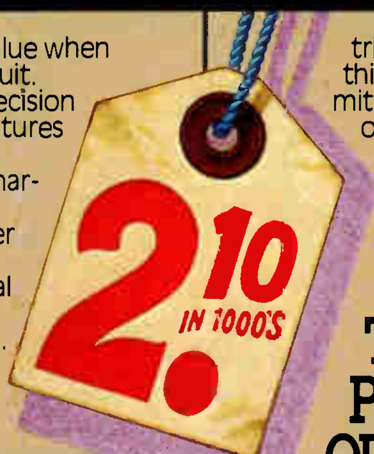

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Analog Devices, Inc., Box 280, Norwood, MA 02062; East Coast: (617) 329-4700; Midwest: (312) 894-3300; West Coast: (213) 595-1783; Texas: (214) 231-5094; Belgium: 031/37 48 03; Denmark: (02) 845800; England: 01/94 10 46 6; France: 686-7760; Germany: 089/53 03 19; Japan: 03/26 36 82 6; Netherlands: 076/879 251; Switzerland: 022/319704; and representatives around the world lishment of synchronization. Thus there is no data lost or misdirected to the incorrect channels.

The multiplexer is priced at $9,000 for a full 16-channel configuration; smaller configurations, such as 4 and 8 channels, are also available. The unit can be ordered with a mix of electrical and/or optical channel interfaces. Delivery is 8 to 10 weeks after receipt of order.

Canoga Data Systems, 6740 Eton Ave., Canoga Park, Calif. 91303. Phone (212) 888-2003 [387]

12-bit d-a converter updates at 50-MHz rate

A low-glitch 12-bit digital-to-analog converter features a 50-MHz update rate. The model DAC-LGT converter has an output current capability of 50 mA, maximum glitch energy of 5,000 mV-ns, and a linearity error of ±0.0125%. The settling time for an input change of 1 least significant bit is typically 50 ns, and for a full-scale input change it is typically 400 ns.

The unit is TTL-compatible and has a low-skew digital register in addition to an internal reference. Output voltage ranges are pin-programmable, and the only external components that may be needed are optional offset and gain-trim resistors. The voltage ranges are ±2.5 V, ±5 V, ±10 V, 0 to −5 V, and 0 to −10 V. The coding is binary or offset binary, and ±15-V and ±5-V power supplies are required. The unit is ideal for use in cathode-ray-tube-display systems, high-speed automatic-test equipment, video reconstruction, and closed loop-servo systems that cannot tolerate large transients.

The encapsulated module measures 6.7 by 8.0 by 1.25 cm. Since it is manufactured to meet MIL STD 202E, it is suited to the military and industrial environment. Prices start at $595 for small quantities and delivery is four to eight weeks.

ILC Data Device Corp., Applications Engineering Group, Airport International Plaza, Bohemia, N.Y. 11716. Phone (516) 567-5600 [388]

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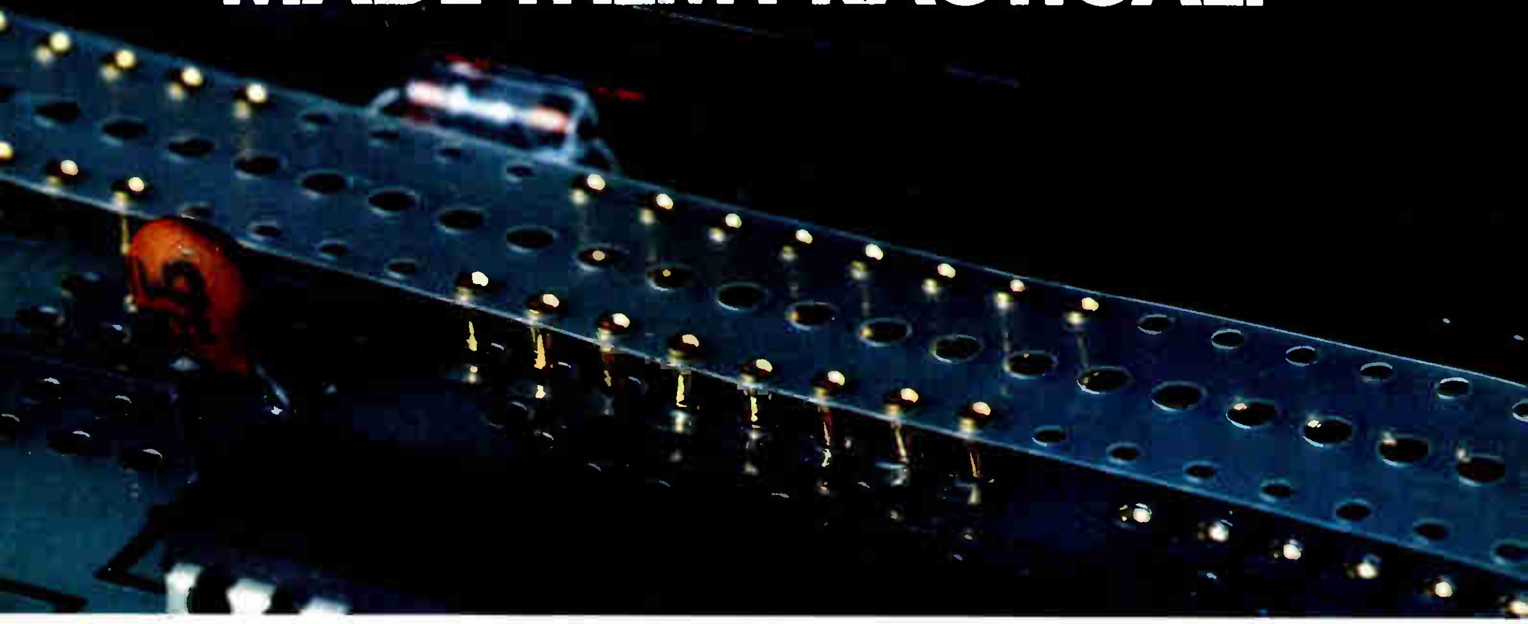


Not long ago Augat introduced the Holtite™ concept of solderless sockets, to give you zero-profile component plugability without conventional sockets or solder, and the unmatched dependability of machined beryllium contacts.

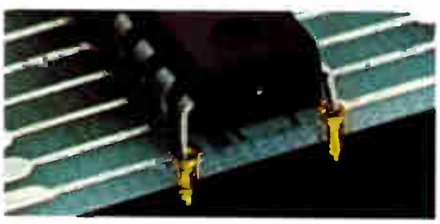
Now we've made the Holtite idea practical for almost every application – including ones where PC boards already contain soldered components. The Holtite System now offers a new,

low cost (just $695) pneumatic insertion machine which presses Holtite contacts into plated-through holes converting the holes into plug-in sockets. Contacts for this new system are preloaded in DIP patterns on a Mylar carrier strip supplied on reels. Typical insertion rate for the machine is 5,000 contacts/hour.

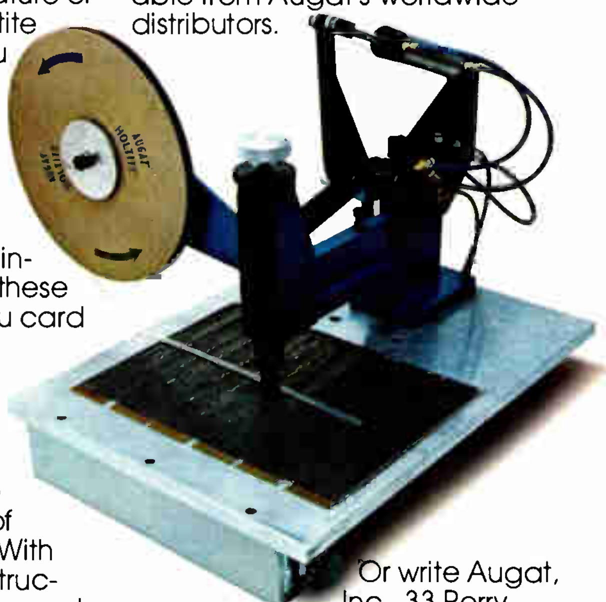
And if you need mass loading capability, we can lease you a machine that loads more than 50,000 contacts/hour.

The thing to remember is no matter what the size or nature of your application, the Holtite System can now offer you all the advantages of sockets: reduced test cycle times, less damage to ICs and PCs from soldering, easier component changes, and economical field maintainability. Holtite delivers all these benefits and still gives you card spacing as low as .400".

You don't have to change a thing to use Holtite; simply drill the holes to the recommended diameter. Prove it for yourself. Order one of our Holtite Prototype kits. With all the tools, contacts, instructions, and test reports you need to judge the system on your job.



The kit costs only $94.50. The reels, the insertion machine, and the trial kit are all available from Augat's worldwide distributors.



Or write Augat, Inc., 33 Perry Avenue, P.O. Box 779, Attleboro, Mass. 02703. Tel. (617) 222-2202.

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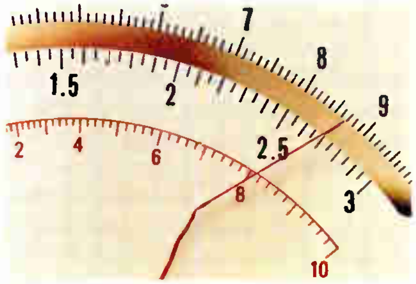

Our new 169 is a tough, lightweight, battery-powered digital multimeter for use in the field or on the bench. It is a 3½-digit, full 5-function DMM with respectable .25% DC accuracy.

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Cost-conscious ease of maintenance is so thoroughly designed into the 169 that only one calibration adjustment a year is required. That adds up to a cost-of-ownership no other competitive DMM can touch. For example, the 169 needs only one battery change per year at a cost of about $3.50. Its nearest competitor requires 10 changes costing three times as much.

When you factor in features like function and range annunciation right on the display, auto-zero, auto polarity, 60% larger display than other DMMs and the easy-to-read, color coded front panel, we think you'll get the point. No analog meter or DMM can match the price/performance of the new 169. It costs **$149.**

For information on the 169 or any Keithley DMM, contact your Keithley representative or call us at (216) 248-0400. Telex: 98-5469.

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3H ELECTRONICS INC

Circle 268 on reader service card

Products newsletter

Hewlett-Packard improves scope line

Hewlett-Packard Co.'s Colorado Springs, Colo., division has come up with a production line method **for doubling the writing rate of the company's model 1741A 100-MHz variable-persistence storage oscilloscopes.** The process yields much greater consistency in the deposition of dielectric material onto the scope's variable-persistence mesh within the cathode-ray tube. As a result, the writing rate has been doubled from 100 to 200 cm/s, allowing the user to capture much faster single-shot waveforms. It will also mean that fewer iterations are required to build up a visible trace in some repetitive experiments. Scopes built using the new process will be available by mid-month.

Astrocom's data analyzer weighs only two pounds

A data analyzer that **measures 2.5 by 5.75 by 7.5 in. and weighs 2 lb** may well be the industry's lightest, says the manufacturer, Astrocom Corp. The St. Paul, Minn., company has priced the portable unit at $895.

Called Maxicheck, the microprocessor-controlled system with random-access memory checks out either computer terminals or the central processor by simulating them. Alternatively, it can perform bit- or block-error rate tests to check modems and phone lines. It can operate at 110 to 9,600 b/s in the asynchronous mode and at up to 19,200 b/s in the synchronous mode, full or half duplex.

R-Ohm shrinks parts count in thermal print heads

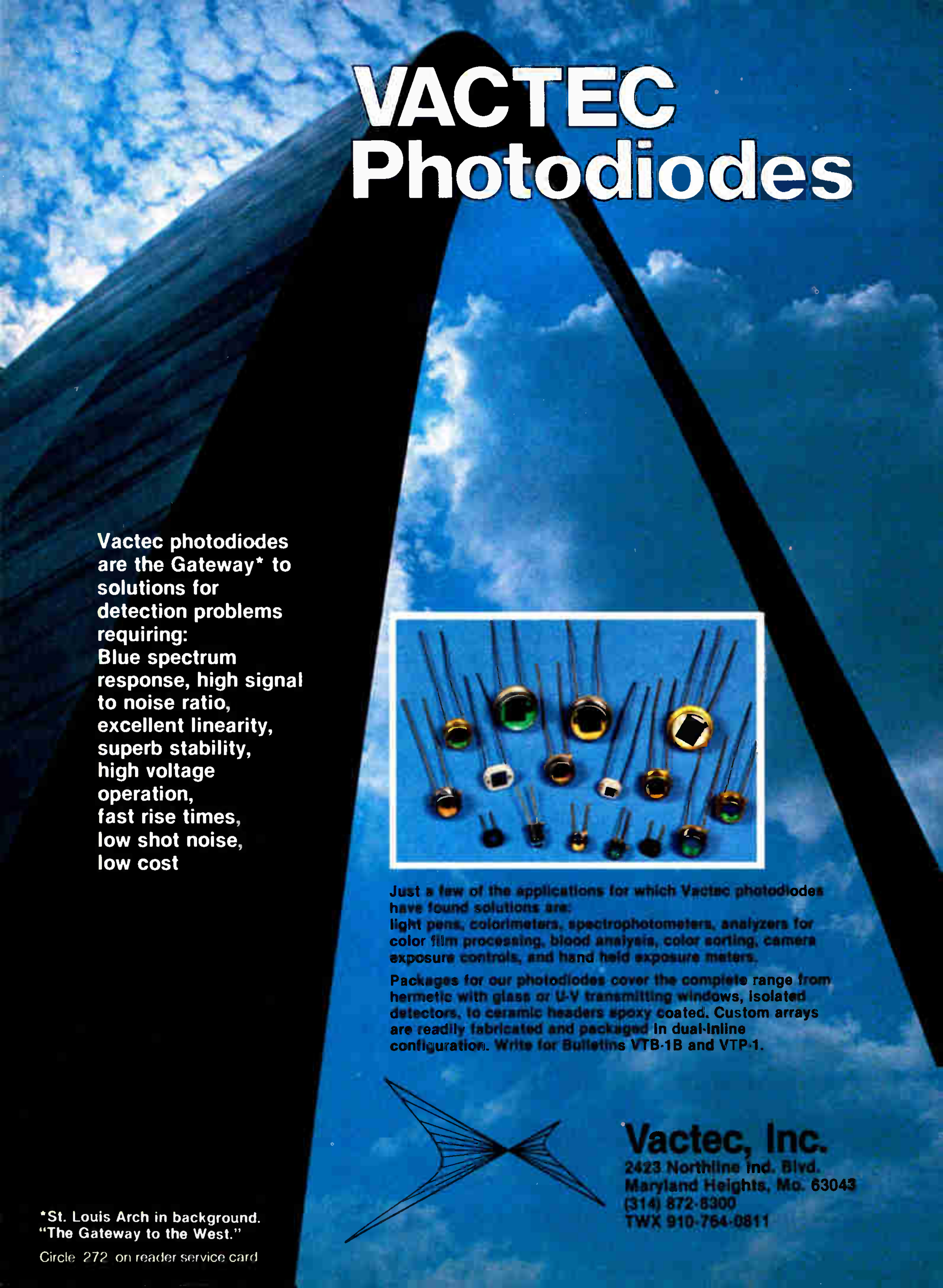
Within a few months, R-Ohm Corp., Irvine, Calif., will introduce a line of thick-film thermal print heads whose component count has been dramatically reduced **by replacing many of the individual diodes in the drive electronics with integrated diode arrays.** The parent company, Toyo Electronics Industry Corp., is building the heads, which R-Ohm expects to sell for $600 to $700. The new heads have a resolution of eight dots/mm and print a line in anything from 4 to 100 ms.

ECL RAM accesses data in 7 ns

A 256-bit bipolar random-access memory—the first in a family of emitter-coupled-logic RAMs from National Semiconductor Corp.—**accesses data in 12 ns maximum and 7 ns typically;** chip-select access time is typically 3 ns. The DM10414 is organized into a 256-k-by-1-bit format and is contained in a 16-pin ceramic dual in-line package. Compatible with Fairchild's 10414 and Motorola 10142 ECL RAMs, it has an unterminated emitter-follower output to allow wired-OR interconnections. The Santa Clara, Calif. company is pricing its RAM at $10.65 each in 100-unit lots.

Emi testing comes home from Europe

Penril Corp.'s Electro-Metrics division, Amsterdam, N. Y., is now offering expanded software for electromagnetic-interference testing to be used with its CCS series of Calculator/Computer-Controlled Systems. **The software library now includes test programs to determine compliance with international emi procedures and limits** as established by CISPR and VDE; specifications covered include VDE 0871 and 0875, as well as the U. S. MIL STD-461/2. The software is available at no additional cost when any of the firm's DIU series of digital interface units is purchased, either separately or with the CCS series.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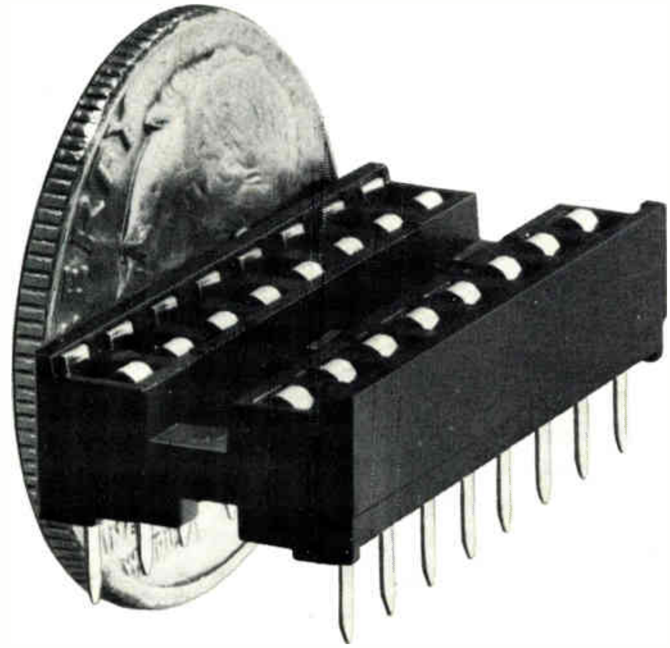

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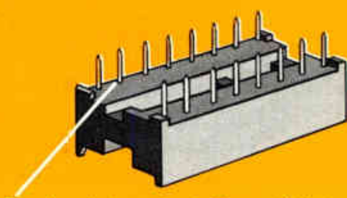

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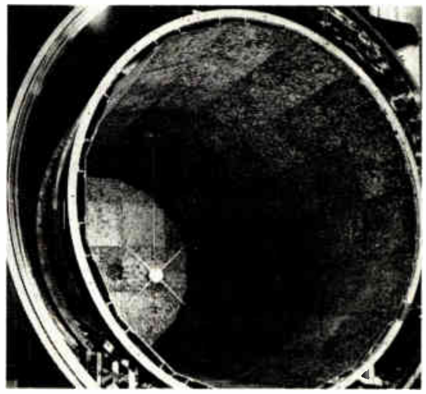
New products/materials

Sintered ferrite materials for use over the frequency range from below 50 MHz to 15 GHz can be bonded to flat or moderately curved conductive surfaces. The individual Eccosorb NZ square tiles should be mounted with minimal spacing between them



and the conductive backing of the curved surface. The materials have a typical thermal conductivity of 45 BTU-in./hr-ft^2-°F and a typical specific heat of 0.2 BTU/lb-°F. They are useful in high-temperature, high-power, and space environments.

Emerson & Cuming Microwave Products, Dewey and Almay Chemical Division, Canton, Mass. 02021 [476]

Polyvinyl chloride tape can be used for sawing and scribing, as well as die-bonding of semiconductor wafers. The tape comes in two varieties: one is clear and nonadhesive, the other is blue and adhesive. Both of the materials have a high tear strength and elongation. The clear material should be heated to approximately 110°F for light wafer or die adhesion, which may be controlled by the addition or reduction of heat during the wafer- or die-mounting process. The film can expand to up to 130% of the wafer or die size. It comes in sheets on noncontaminating backing paper 5.75 in.^{2} by 0.004 in. thick. The blue film has a synthetic acrylic adhesive bonded to it. No heat is required to mount wafers or die to this material. Adhesion strength is 5 oz/in. of width. The adhesive film can expand up to 60% of the wafer or die size. It comes in rolls 660 ft long by 6 in. wide by 0.003 in. thick. Other widths

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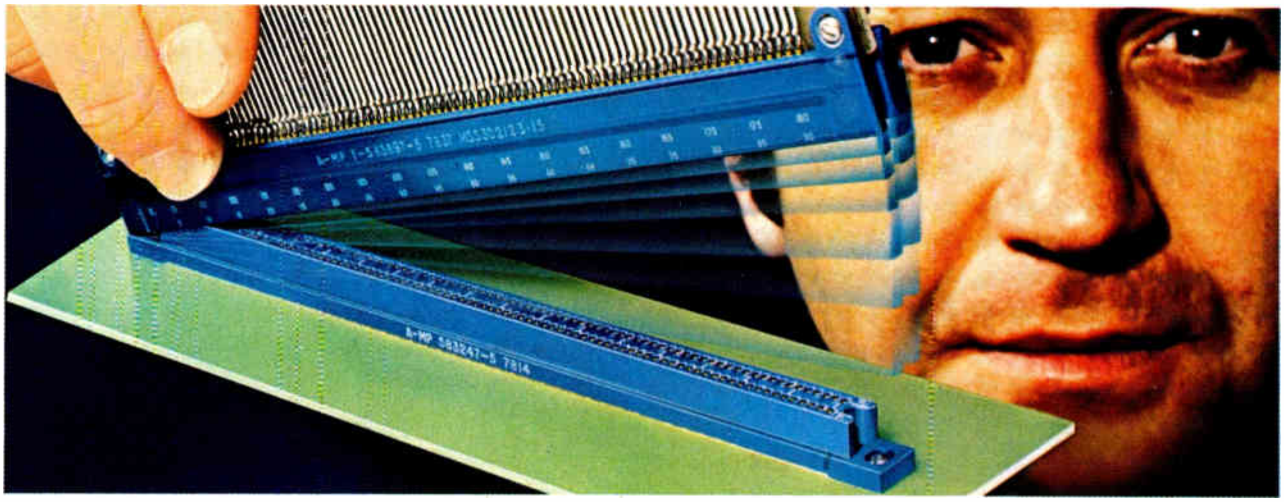

As the requirements for a connector increase, so does our commitment. We appreciate that in order for you to implement design improvements with greater tolerances and higher reliability, you need the connectors to help deliver those improvements. And our MIL-C-55302 Box Contact Connector is the answer.

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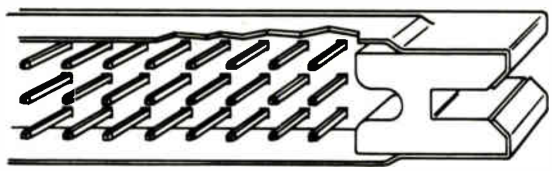

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Circle 3 on reader service card

and lengths are available for both types of material.

Semiconductor Equipment Corp., 853 Lawrence Dr., Newbury Park, Calif. 91320 [479]

Three solvent-based coatings that shield against radio-frequency and electromagnetic interference maintain good stability even when exposed to harsh environmental conditions. All three need neither primers nor top coating, can be air-dried, and can be sprayed onto the surface.

A 2-mil coating of Electrodag 440 has a resistance of 1 Ω/sq and provides 60 to 65 dB of attenuation from 0.1 to 500 MHz. This attenuation will show minimum change when thermal shock tests are made from −40° to +160°F for 10 cycles. The material sells for $94.50 per gallon. Electrodag 436 can be exposed to 150°F and 95% relative humidity for 72 hours. A 2-mil coating has a resistance of 0.15 Ω/sq and provides 65 dB of attenuation. It sells for $50 per gallon. Material 114, at a 2-mil thickness, has a resistance of less than 5 Ω/sq and attenuation is 45 to 50 dB. This coating sells for $15 per gallon.

Acheson Colloids Co., Port Huron, Mich. 48060 [478]

A thin-film composite, made up of a combination of aluminum oxide and titanium carbide, is expected to be particularly suitable as a substrate for recording disk heads. AlSiMag 204 may be diamond-polished to a surface finish of less than 1 μin.; its crystals average 1 to 1.5 μm and maximum pore size is 3 μm. The material's hardness is typically measured at 93.5 on the Rockwell A scale. Because of its hardness and physical stability, AlSi Mag 204 can be machined into intricate designs with tight tolerances. The thermal conductivity is higher than that of alumina substrates, according to 3M. Initially, the material will be offered in 2- and 3-in.-diameter disks as prototypes, but other stock and custom sizes and shapes will be offered in both polished and unpolished forms.

3M, P. O. Box 33600, St. Paul, Minn. 55133 [477]

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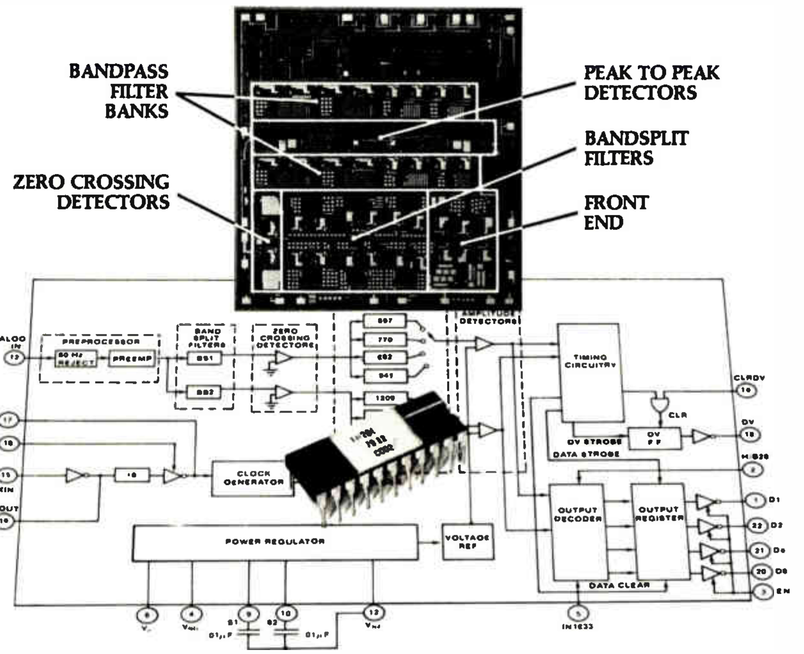

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*(Described in the paper "A Monolithic Dual-Tone Multifrequency Receiver—WAM2.6" presented at the February 1979 International Solid State Circuits Conference.)

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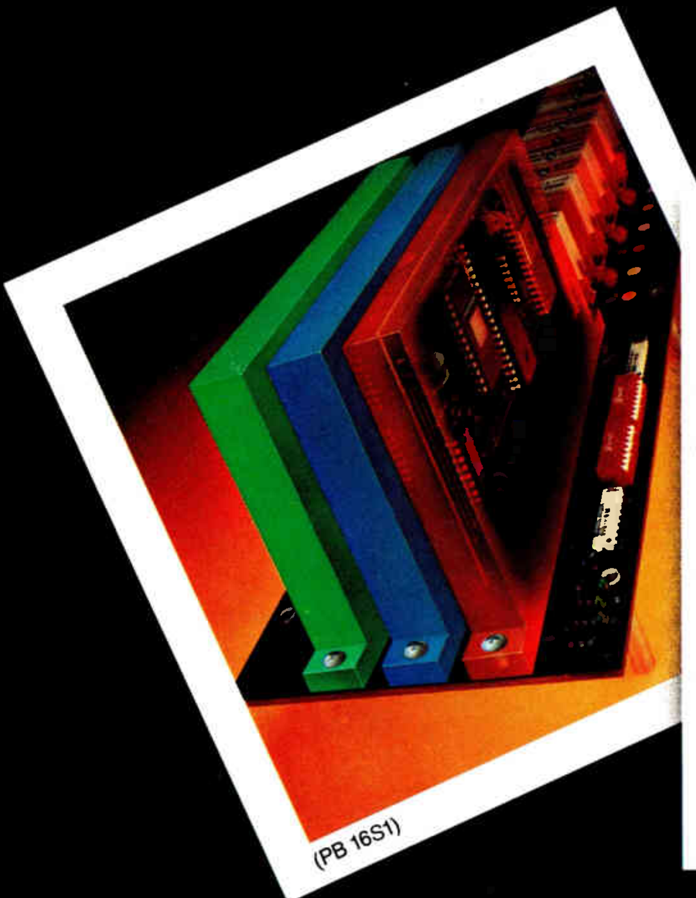
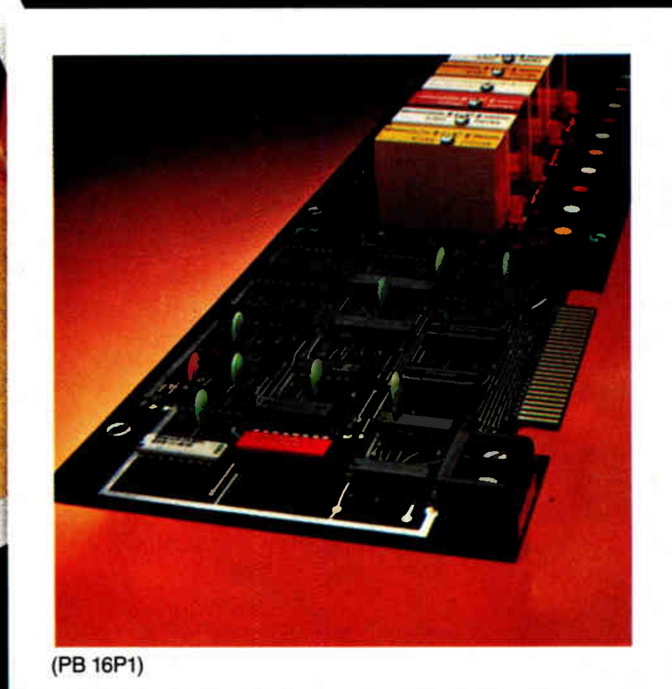

(PB 16S1)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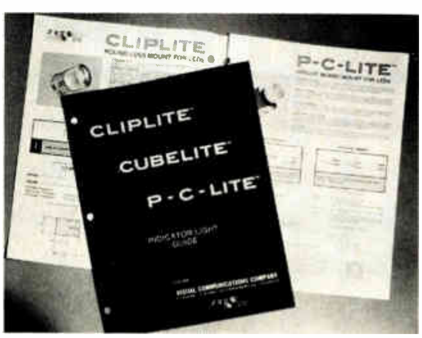
New literature

Standards. Publications 39 and 40 of the Annual Book of the American Society for Testing and Materials Standards together contain more than 300 standards for electrical insulating solids, liquids, and gases, as well as protective equipment for workers. Part 39 deals with test methods for electrical insulating materials, for which there are 114 standards—some are new, others are revised, and still others have changed in status, since 1978. Part 40, with specifications for electrical insulating liquids and gases, lists 193 standards. Part 39 sells for $33 and Part 40 sells for $38. American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103

Thermistors. The "Capsule Thermistor Course" booklet instructs users and potential users of thermistors in what the devices are as well as where and how they are used to measure, indicate, and control temperature. The 24-page booklet explains what the thermistors do, how they behave, how to use them in thermal conductivity instruments, how they compare with thermocouples and resistance thermometers, and how they compensate for temperature. It also charts thermistor resistance in relation to temperature change and provides a resistance-temperature conversion table, matched thermistor characteristics, and temperature compensation factors. Fenwal Electronics, 63 Fountain St., Framingham, Mass. 01701. Circle reader service number 422.

Lens mounts. A six-page brochure shows how to install printed-circuit board lens mounts for light-emitting



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Designing a new circuit is always challenging, but turning an on-paper design into a functioning prototype is where the fun really begins. Signal substitution is an excellent way to speed this process and find potential design faults. For digital applications, the B&K-PRECISION Model 3300 pulse generator is the ideal signal source, because its capabilities are as wide ranging as your applications.

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Circle 36 on reader service card

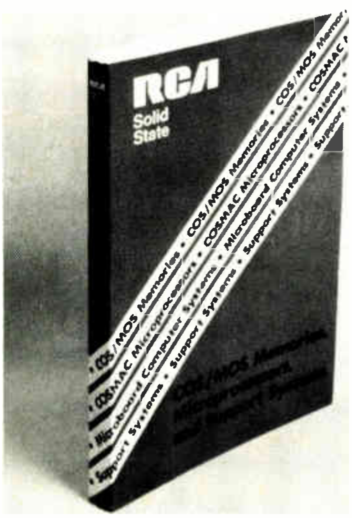
New literature

diodes and gives specifications and dimensions for them. The brochure also shows how the lens mounts can be adapted for use with neon and incandescent lamps. Visual Communications Co., P. O. Box 986, El Segundo, Calif. 90245 [423]

Soldering. A 120-page manual on soldering tools and materials discusses the latest automatic soldering methods and how to choose the correct method and materials to solve particular soldering problems. The manual also gives typical applications and includes tables of international standards. It sells for $6.95. Multicore Solders, Westbury, N. Y. 11590

Fiber optics. A collection of technical articles and application data on fiber optics is contained in an 11-page booklet. The subjects include: finishing and terminating fibers, designing fiber-optic data links, pigtailing sources and detectors, and measuring attenuation of fibers. Math Associates Inc., 376 Great Neck Rd., Great Neck, N. Y. 11021 [425]

Solid state. "COS/MOS Memories, Microprocessors, and Support Systems," a 440-page databook, comprises technical data, application notes, classification charts, and cross-reference and ordering information on the following products: the CDP1800 series of Cosmac



microprocessors and associated memory and peripheral circuits; the MWS5000 and CD4000 series of general-purpose memories; the CDP18S600 series of Cosmac microcomputer board systems; and the CDP18S000 series of Cosmac microprocessor development systems. The book sells for $7 per copy. RCA Solid State Division, Box 3200, Somerville, N. J. 08876

Computer terminals. The "Display Terminal Price Index" is a reference guide that lists 500 display terminals by manufacturer, model number, and screen capacity, separating them by price. The terminals are divided into six categories: full graphics, intelligent, partial graphics, editing

and word processing, alphanumeric, and numeric. The price index is available for $9.50 (prepaid) or Marrett Rd., Lexington, Mass. 02173

Standards. Publication RS-463, "Fixed Aluminum Electrolytic Capacitors for Alternating Current Motor Starting, Heavy Duty (Type 1) and for Light Duty (Type 2)," provides the standard for an up-to-date set of recommended requirements and characteristics for capacitors for intermittent-service single-phase induction motors. It replaces the National Electrical Manufacturers Association's Standard Publication No. CP-1957. A free EIA and Jedec Standards and Engineering Publications Catalog is also available upon request. Copies are available at $6.50 each from the Electronic Industries Association's Standards Sales Office, 2001 I St., N. W., Washington, D. C. 20006.

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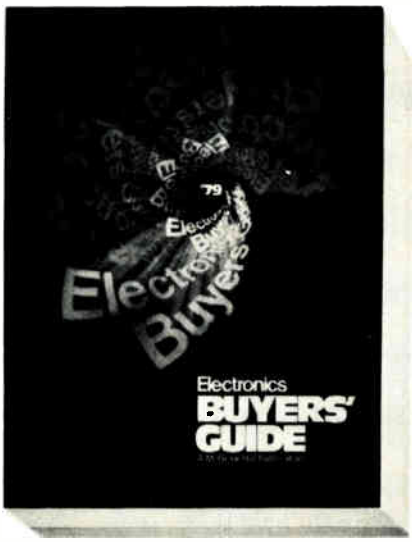

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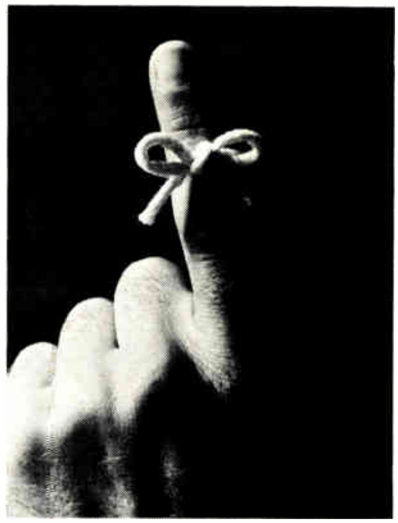

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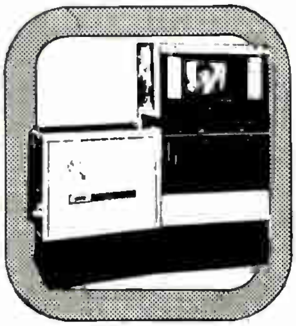

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Texas A&M University
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and an
Electronics Technician

to expand the present capabilities of the Physics Department Electronics Shop. The Electronics Engineer would direct the shop and supervise work involving design and construction of prototype devices for teaching and experimental research programs, the advising of students and faculty, as well as the repair of sophisticated instrumentation used throughout the Department. The person filling this position will encounter both analogue and digital type problems. The salary is negotiable. The Electronics Technician position is being added to assist the Engineer and will have a hand in developing new instrumentation, to help advise students and faculty, and to repair existing equipment. The projects undertaken in the Electronics Shop are often unique and one of a kind. If interested in either of these positions, please send resume to:

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1. **Electronic Engineers with broad background in application of Transducers, Signal Conditioning, RF and Microwave.**
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Free summer job listing

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NAME/TITLE (of individual to be contacted) ____________________

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Electronics Engineer for the Facility for High Resolution Electron Microscopy. This Facility recently established within the Center for Solid State Science, Arizona State University by a grant from the National Science Foundation has a position for an electronics engineer who will be involved with the development and maintenance of computer interfacing, data processing and instrument control systems associated with the several electron microscopes used for the Facility operation and the associated developmental research programs. The minimum qualification required is a bachelor's degree or equivalent. Experience with computer interfacing and data processing is preferred. The appointment will be to a temporary position. Employment beyond the grant period (4 years from October, 1979) can not be assured. Send resume and arrange for 3 letters of recommendation to be sent before December 10, 1979 to John M. Cowley, c/o Center for Solid State Science, Arizona State University, Tempe, Arizona 85281. Arizona State University is an Equal Opportunity/Affirmative Action employer.

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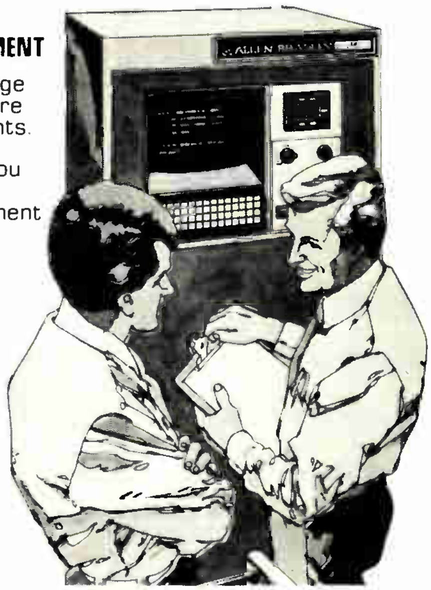

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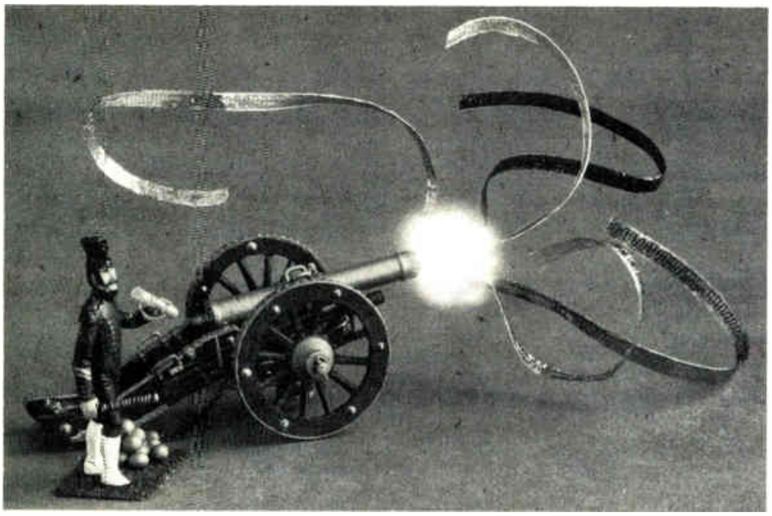

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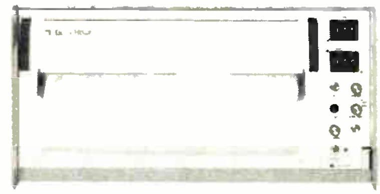

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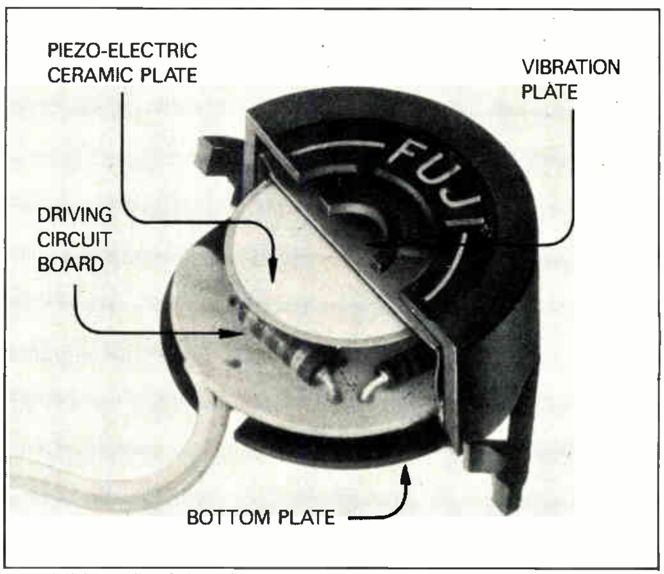

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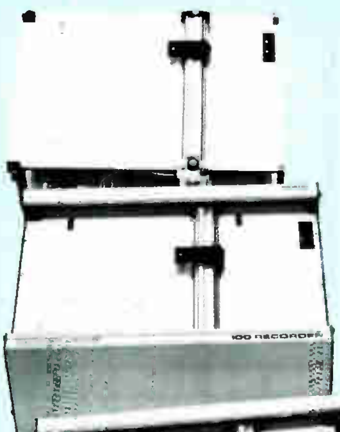

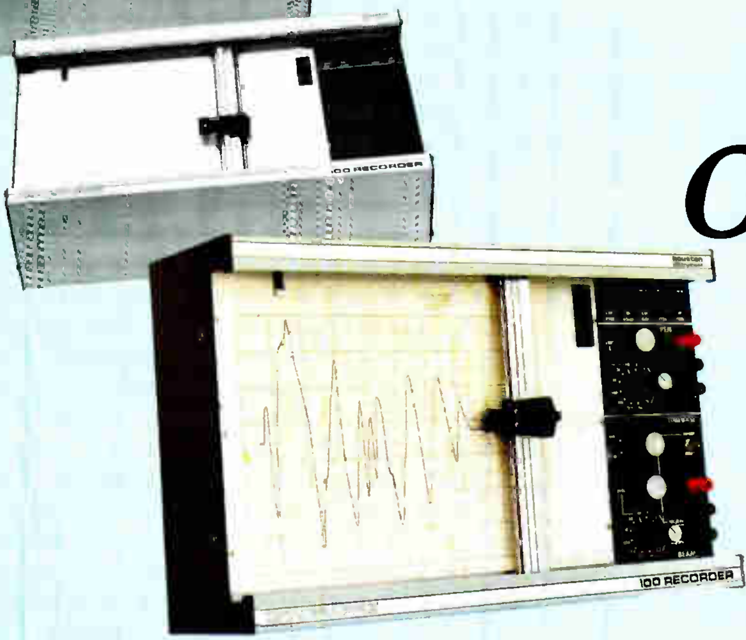

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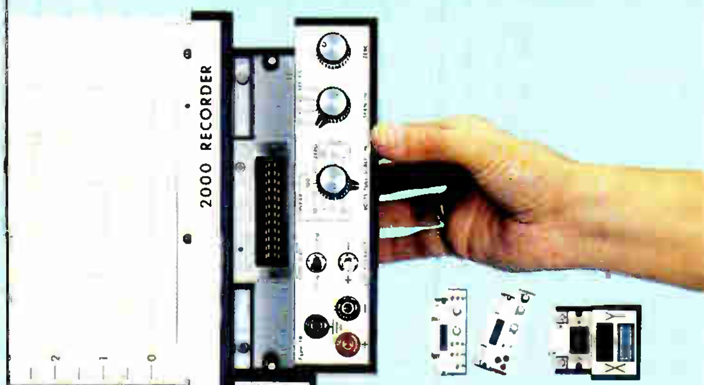

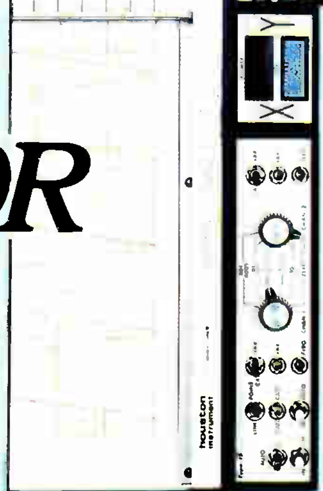

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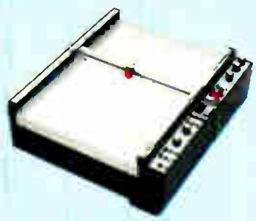

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- Best commom mode rejection
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No more slidewire cleaner • No more slidewire lubricant

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Houston Instrument's patented non-contacting capacitance feedback transducer replaces the slidewire and potentiometers, neatly eliminating the most troublesome components of X-Y servo systems.

For complete information on the Model 2000 or the Series 100, contact Houston Instrument, One Houston Square, Austin, Texas 78753. (512) 837-2820. For rush literature request and sales office information, outside Texas call toll free 1-800-531-5205. In Europe, contact Houston Instrument. Rochesterlaan 6, 8240 Gistel Belgium. Phone 059/277445.

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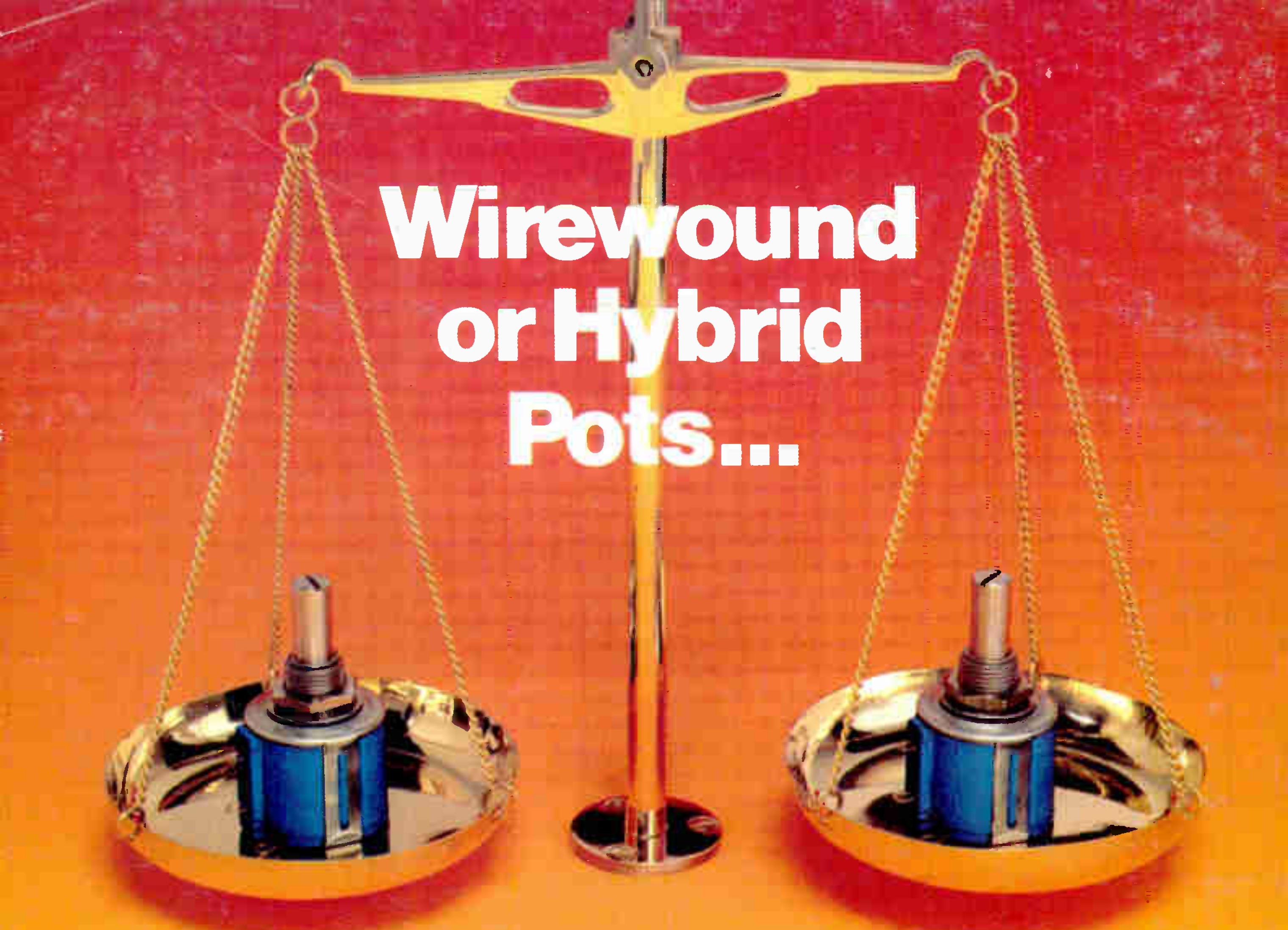

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Your choice of either wirewound or hybrid conductive plastic/wirewound elements: If your precision pot application requires a low tempco, tight linearity and excellent resistance stability, choose the Model 3540 wirewound potentiometer. If you **also** need extremely long operational life, infinite resolution and excellent output smoothness, choose the Model 3541 Hybritron® potentiometer. Both models are field-proven, 10-turn, ⅞" diameter precision potentiometers, with a range of resistance values to satisfy the most demanding applications.

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Hybrid — The Model 3541 pot features our exclusive Hybritron resistance element, combining the best features of both wirewound and conductive plastic.

The Hybritron element — conductive plastic material on a wirewound mandrel — extends rotational life to 5 million shaft revolutions, provides essentially infinite resolution and output smoothness of 0.015% maximum. It's priced just slightly higher than the wirewound version.

Both the Model 3540 and 3541 pots are available with a variety of special electrical and mechanical options for additional design flexibility. Whether your choice is wirewound or hybrid, Bourns provides worldwide availability and fast delivery through your local distributor. For your specific requirement, call our design-experienced applications engineers today. Or, see us in EEM, Volume 2, pages 3775 and 3776.

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