SEPTEMBER 8, 1981

64-K RAMs: THE BATTLE FOR MARKET SHARE/89

Casting a standard operating system in silicon/135

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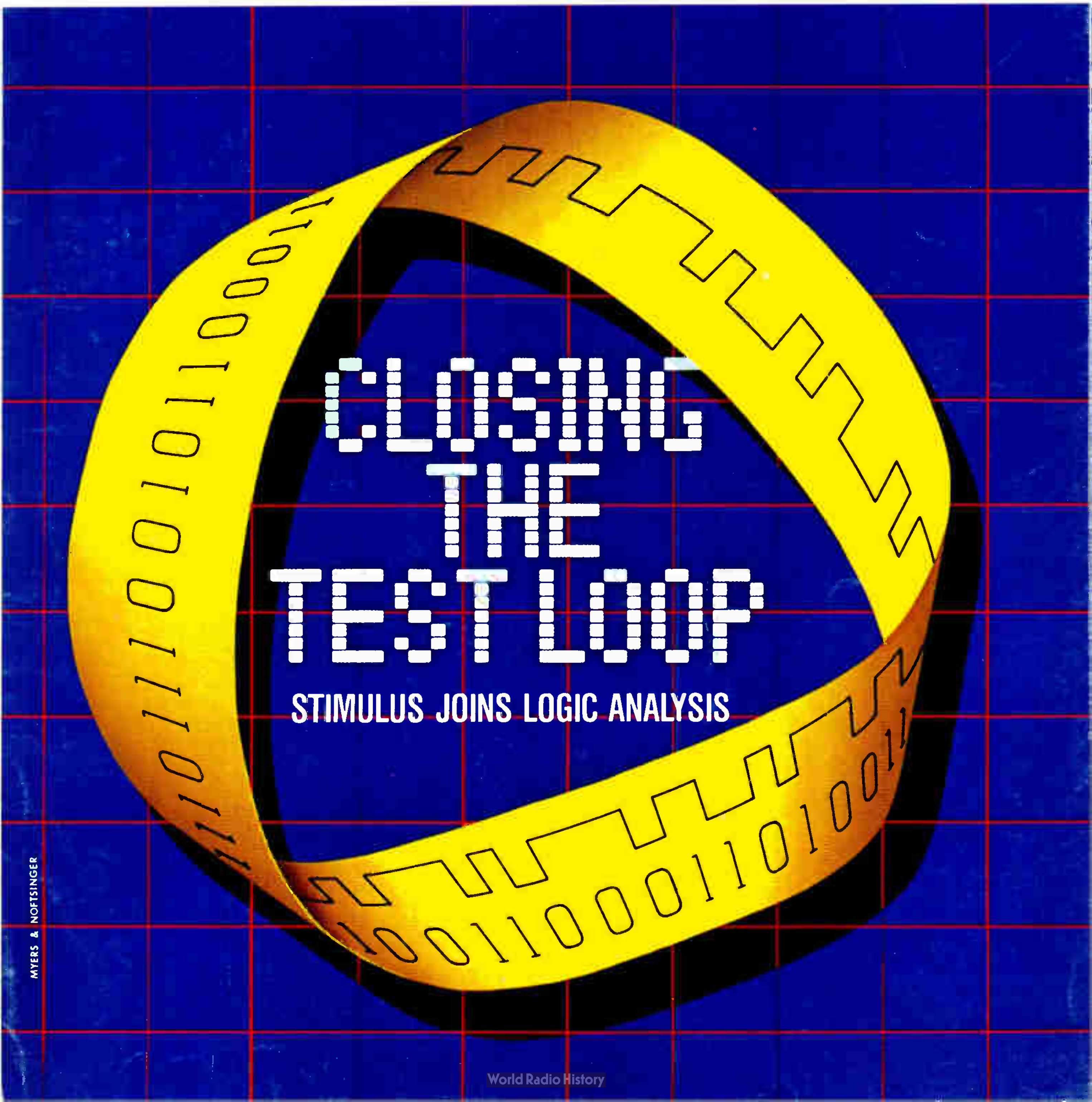

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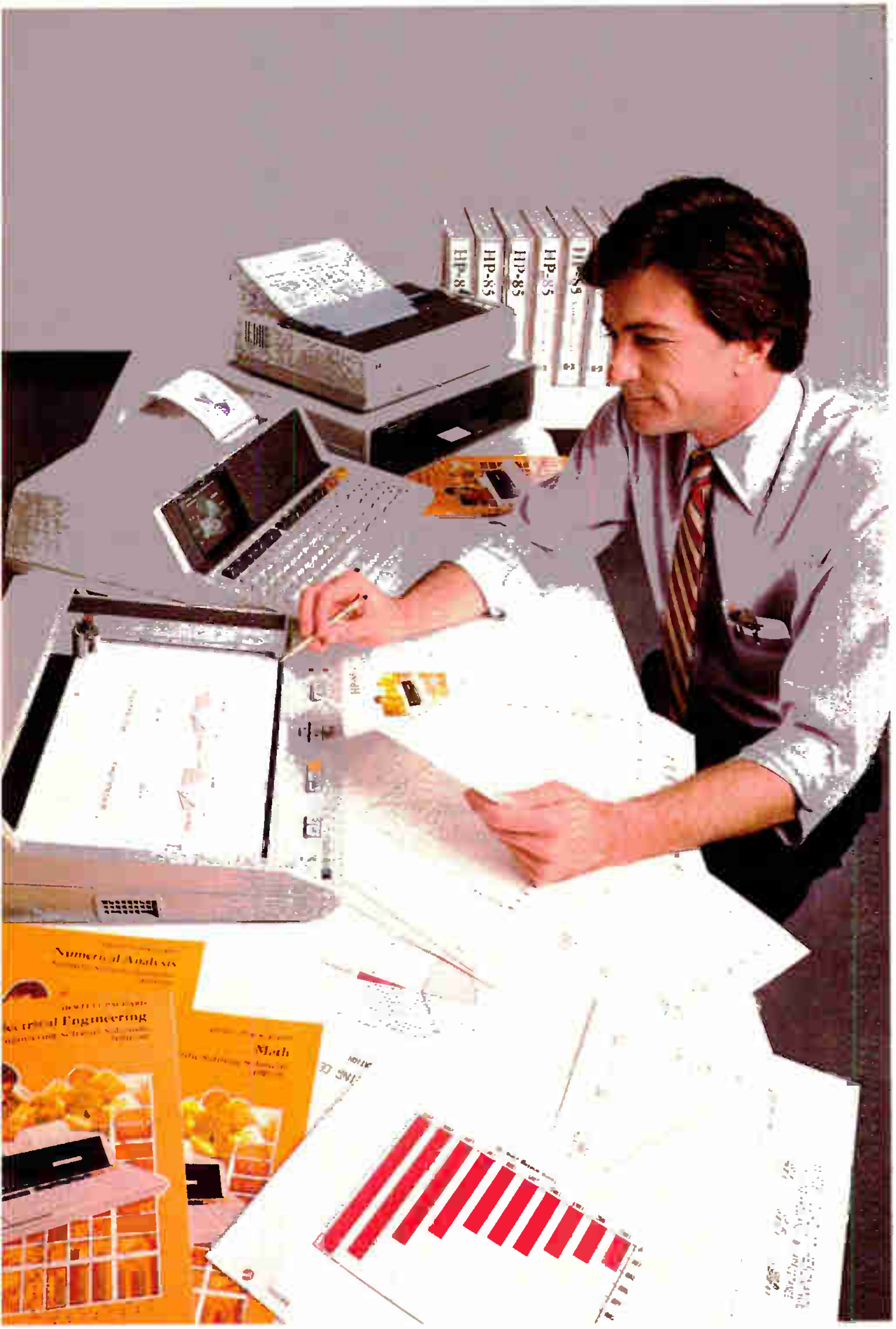

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Electronics
The International Magazine of Electronic Technology
Vol. 54, No. 18 • September 8, 1981

113 Technical Articles

Electronics

Highlights

In the next issue . . .

A highly portable development language . . . sophisticated line switching at a low-level telecommunications interface . . . a high-speed digital waveform analyzer . . . microprocessor-controlled printing of color-TV images . . . a dual-laser method of terminating flexible circuitry . . . how to test analog-to-digital converters for linearity.

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AT-20	20	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1	1W

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67-2 REV. A

Publisher's letter

Digital designers have been looking for an instrument like that featured in this month's cover story—Tektronix's DAS 9100—for a long time, and so has our test, measurement, and control editor, Rick Comerford. Like all engineers, he was taught that testing requires the application of a known stimulus and the measurement of a system's response to that stimulus.

"But to do that," Rick recalls from his test-bench days, "I had to spend a couple of days setting up a bunch of sources and instruments, getting all the grounding and test-point hookups right, before I would spend maybe a half day doing the actual test." He remembers the frustration, too, of having to go through the process again when he had to repeat portions of the test after the setup had been broken down.

"Fortunately for the industry, authors Steve Palmquist and Gerd Hoeren of Tektronix had had similar experience—so they built the DAS," he says. The instrument is described in the article on pages 113–119.

It was a recollection of his experience, in part, that made Rick find a similar (though custom) system built by Xerox Corp. and called Fast [*Electronics*, Feb. 24, 1981, p. 42] so interesting. Rick sees such units as "some of the best examples of what instrument design is going to mean from now on."

Having had a chance to preview a number of really different instruments and finding the common elements that are going to typify instrument design in this decade, he now presents those elements in the probing the news section on page 96. "The increasing sophistication of instrumentation will be key to all kinds of gains in engineering productivity," he adds.

Of particular note, too, in this issue are the details of a chip from Intel Corp. that starts a trend: casting parts of an operating system in silicon. Not that software in silicon is new—calculator and language-translator makers have adopted the process, and several manufacturers have programmed read-only memories with Basic interpreters.

But the story beginning on page 135 tells of a new direction: standardization of operating system components that can be put together with hardware components—microprocessors and peripheral chips—to construct a system with minimal programmer effort.

The notion of software components has been a long time coming. As microsystems and software editor Colin Johnson, who edited the Intel story, points out, "Software functions are not inherently different from hardware functions—after all, a computer can be thought of as hardware that rewires itself each time it executes an instruction."

Colin thus envisions many software functions that, once standardized, will be cast in silicon. "Some day we should be able to purchase standard software modules for almost any function," he suggests.

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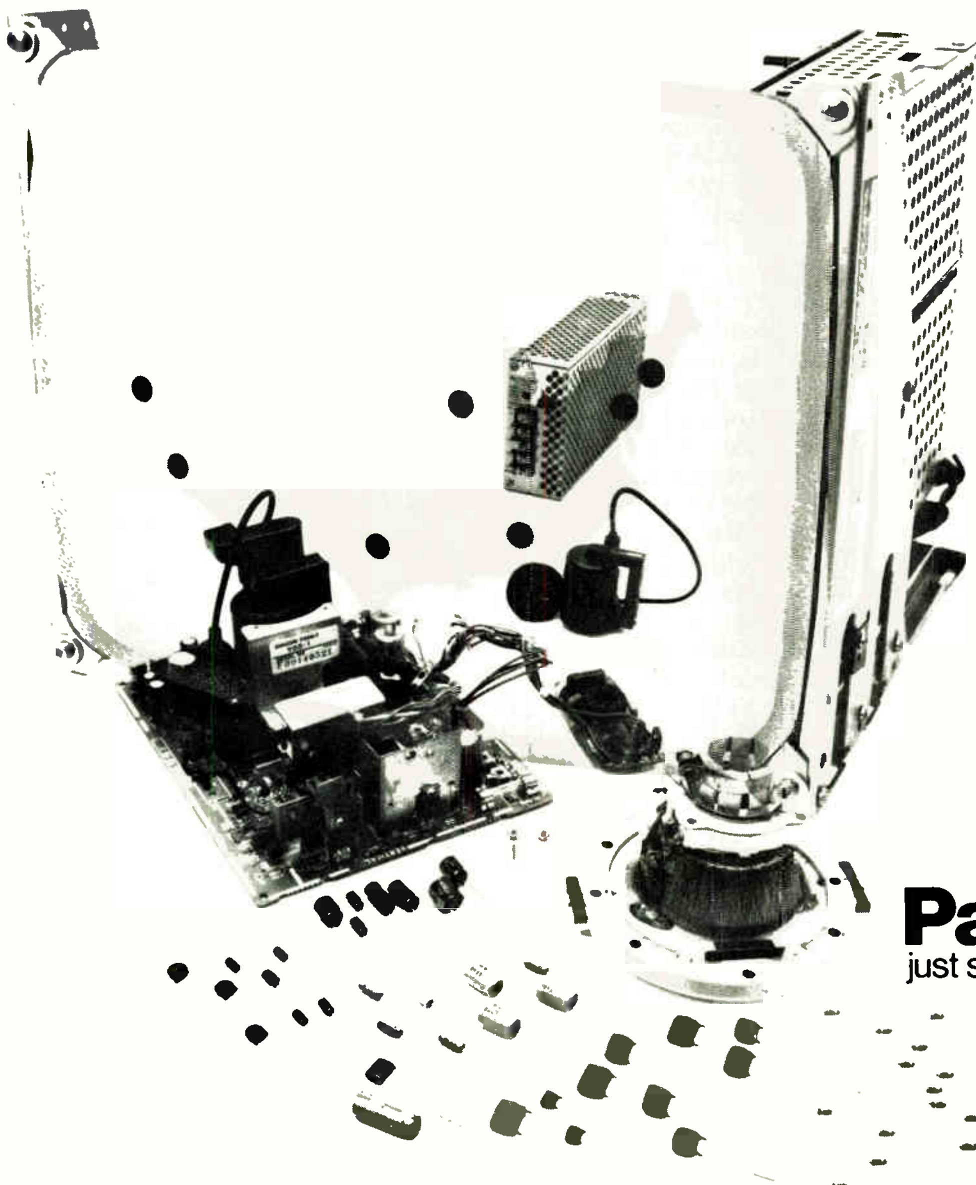

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Readers' comments

Of arms and engineers

To the Editor: The fine article about the Defense Department's buildup ["The Pentagon goes shopping for technology," June 30, p. 88] is marred by the author's uncritical acceptance of the mouthings of large corporations regarding the engineering profession.

Ray Connolly, the author, says that contractors are concerned about "recruiting skilled engineers and technicians in order to match the Reagan buildup," and speaks of the "shortage of engineering talent throughout the electronics industry" as a possible impediment to this buildup. He quotes a representative of Hughes Aircraft as conceding that it is having difficulty in attracting qualified people and, as a result, would like to train "para-professionals and para-engineers." The article also states that Litton Industries is "hiring lots of foreign nationals for nonclassified work."

These industry complaints share a theme that is common enough but totally without merit. There is no shortage of engineers. There is, however, a shortage of competent engineers who are willing to work for the small salaries offered. Even the Institute of Electrical and Electronics Engineers has conceded that average salaries have decreased in terms of real dollars over the past few years. If the shortage of engineers were genuine, one would have expected to see a rapid escalation of real-dollar engineering salaries.

Importing aliens and promoting technicians is no solution to industry's supposed problem; only a rapid escalation of salaries (such as a 50% increase), improved fringe benefits (such as the unlimited use of a company-owned car), and improved working conditions (such as eliminating bullpens) are.

Irwin Feerst
Massapequa, N. Y.

■ The author replies: *That there is a shortage of professional engineers in industry (not to mention the military) has been well documented in a variety of separate studies by Government and industry organizations. Reader Feerst apparently overlooked* Electronics' *editorial discussion on page 23 of the June 30 issue of the most recent study of that shortage by the American Electronics Association in its survey of 1,265 companies. The report found that U.S. industry will require an additional 113,000 engineering and computer professionals by 1986—far more than can be provided by the 17,000 to 20,000 now being graduated annually in the U.S., even when it is assumed that all those graduating are competent and enter the field in which they have been trained. Other documentation exists at the National Science Foundation, its affiliated National Academy of Engineering, the National Education Association, the Department of Defense, and the Congress, to name a few. As to the effects of inflation that have led the IEEE to conclude that "average salaries have decreased in terms of real dollars," it can only be said that IEEE members are not alone in that national dilemma.*

No cause for concern

To the Editor: The Career Outlook column of July 14 ["Help wanted everywhere," p. 180] described "gloomy predictions" and "dire warnings" about "the current and future shortages of engineers." Why all this hand-wringing? The vast majority of *Electronics* readers should be delighted that there aren't enough engineers to go around.

Doesn't anyone remember the last time there was a supposed shortage? In response to all the publicity, universities began turning out engineers by the carload. Soon there was a glut, whereupon many of us found ourselves reduced to silk-screening T-shirts. Why make such a fuss about the situation?

Dale Hileman
Sphygmetrics Inc.
Woodland Hills, Calif.

Correction

The silicone resin coating used on Texas Instruments Inc.'s harsh-duty microcomputer boards is made by Dow Corning Corp. of Midland, Mich., not Owens-Corning Fiberglas Corp., as stated on p. 34 of the August 25 issue and p. 234 of this issue.

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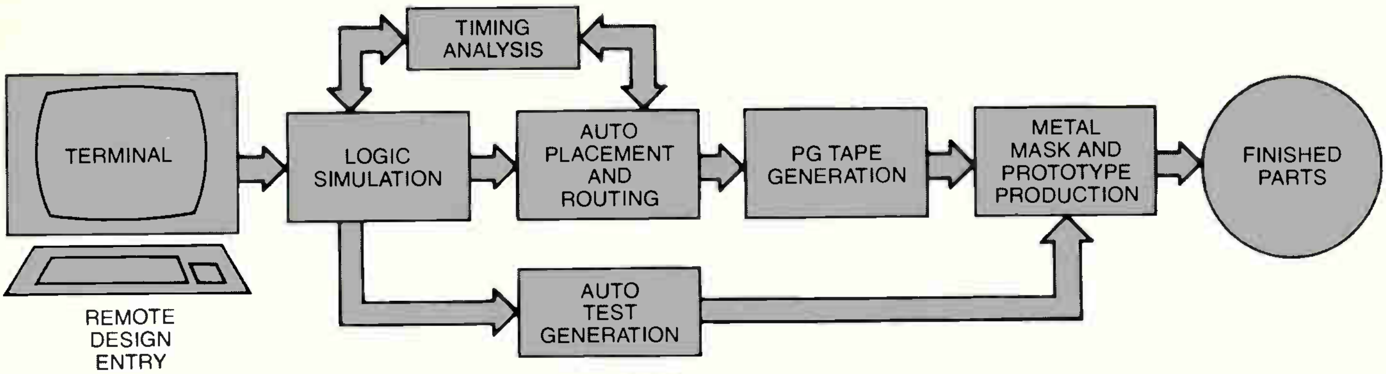

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News update

■ Encrypting data according to the Data Encryption Standard developed by the National Bureau of Standards has not yet generated any great rush to the special chips or boards that began being introduced last year [*Electronics*, June 5, 1980, p. 96]. But there is a lot of activity on the part of industry associations, as well as the Federal government, aimed at developing the exact methods for implementing the 56-bit-word NBS encryption algorithm, says Miles Smid, a mathematician in the System Components division of NBS in Gaithersberg, Md.

Smid cites the American Banking Association and the American National Standards Institute in the private sector, plus the Federal government's General Services Administration, as three organizations working at applying the NBS documentation.

GSA is concerned with laying down the exact rules for handling data for the Government when encryption is required. The banking association is concerned with authenticating funds transfer and personal identification numbers. Perhaps unique in its efforts is ANSI, says Smid, for the institute is developing a software, rather than a hardware, implementation of the DES algorithm.

Another use. Smid also points to data authentication as a new area to which the DES is being applied. A simple check sum, similar to that used in error-detection techniques [*Electronics*, March 29, 1979, p. 91], can be generated by the data recipient during the decryption process. If the check sum is wrong, the data may have been tampered with.

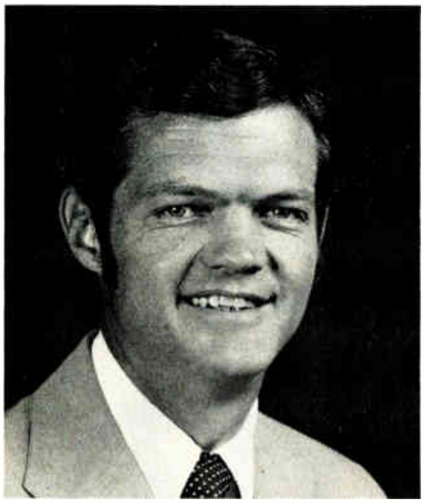
Smid concedes that the need for encryption has not yet been proven to many potential users. Nevertheless, manufacturers of chips that implement the DES have been gearing up. A validation service set up by NBS has approved 15 chips or boards from a dozen manufacturers, says Smid. And he expects about four more devices to be submitted for approval this year. When all these will begin to be used in any great numbers, Smid is not at this time ready to say. **-Harvey J. Hindin**

People

Motorola's Johnson covers a worldwide territory

Now that Motorola Inc.'s MOS operation has gained group status in the corporation, a top challenge facing its management will be maintaining communications in the company's growing network of worldwide production plants. That's the view of Gary M. Johnson, who became general manager of the new MOS Integrated Circuits Group on Sept. 1.

Under special scrutiny will be the Toko-Motorola 11-month-old joint-venture manufacturing operation north of Tokyo, Johnson hints. Currently, only a small quantity of Motorola complementary-MOS logic and memory products is being produced at the Aizu-Toko facility, which is also 50%-owned by Toko Ltd. of Japan. Motorola entered the joint venture with the Japanese MOS manufacturer to gain a foothold in the nation's buzzing electronics industry. Now the U. S. firm wants to step up activities. "The long-term production plans for the facility are virtually unlimited," Johnson says.



Global outlook. Gary Johnson heads Motorola's widespread MOS operation.

Johnson, who replaces James R. Fiebiger as the head of the Austin, Texas, operation, was director of MOS wafer processing for the past two years. Fiebiger [*Electronics*, June 30, p. 14] is now in Phoenix, Ariz., as assistant general manager of the corporation's semiconductor sector.

The new MOS chief, also a semiconductor vice president, took his first permanent position with Motorola 13 years ago as product engineer for small-signal discrete devices. This followed a rotation in the firm's engineering training program for college graduates. "I found [the training program] a tremendous drawing card. When I graduated from college, I was very uncertain as to what I wanted to do in terms of a career," recalls the Hobbs, N. M., native, who received his bachelor of science degree in electrical engineering from the University of Colorado. In the early 1970s, he also held positions as production manager and general manager at Motorola's Hong Kong test facility.

"I think the new group status will have little effect in the near future," Johnson comments. "Obviously, we are positioning ourselves for many years of growth, and I would envision—in fact, I'm confident—that as we continue to grow and demonstrate sound judgment, more and more authority will be pushed out to the entities like MOS. But much is still in an embryonic stage," he adds.

For North Atlantic's Widenor, data peripherals are the key

The obvious way to shift an established company into gear from a stalled product line is to diversify. Not so obvious, sometimes, is the way to do it. For Malcolm D. Widenor, the quiet-spoken 58-year-old president of North Altantic Industries Inc. in Hauppauge, N. Y., the diversification road led to several dead ends before his company found its way with its current line of computer peripheral equipment.

Widenor, who left Sperry Corp. to become one of the three founders of North Atlantic in 1955, saw it carve out a reputation as a reliable ac measurement house, well known for its servo and synchro products. It grew at a rate of 30% to 40% per year, but in the 1960s, when defense spending

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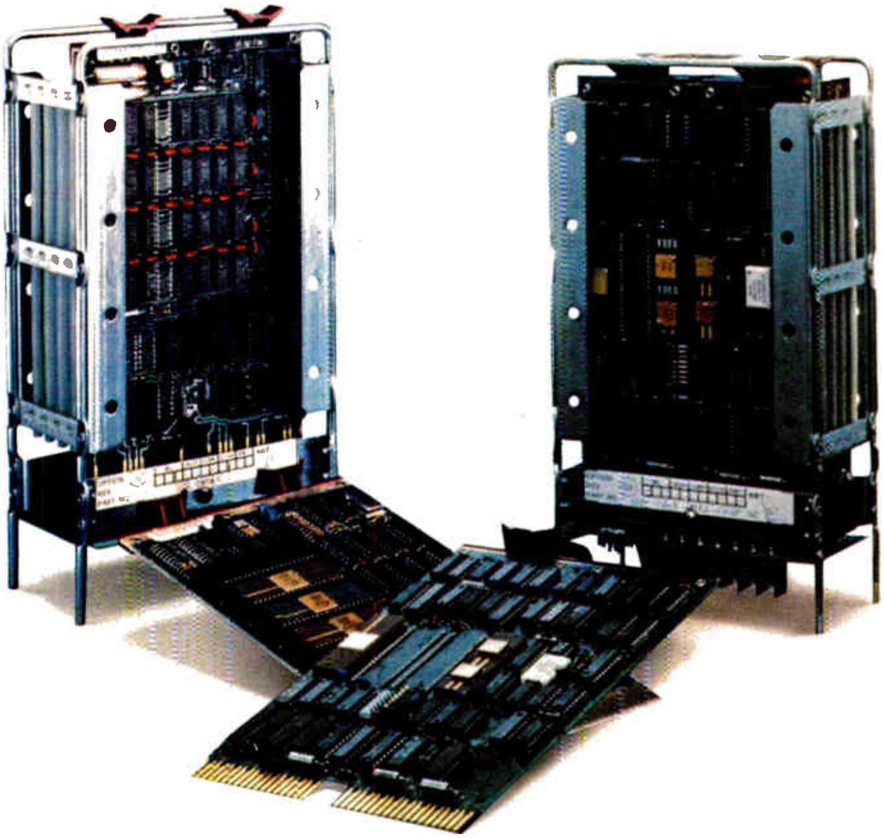

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Broadened base. Malcolm Widenor is taking North Atlantic deeper into peripherals.

reached a plateau, the company's sales leveled off in the \$3.5-million-to-\$4-million range.

The result was that Widenor, who has a bachelor of science degree in mechanical engineering from Stevens Institute of Technology in Hoboken, N. J., and a master of science degree in electrical engineering from the University of Illinois, tried moving in different new directions, among them leasing and industrial security. But the road did not open until the company started making data products for internal use. Today, North Atlantic's Qantex Data Products division with its tape drives and tape storage devices has become the company's major earner: it was responsible for \$11 million of the \$18 million in sales the firm rung up last year.

Widenor is quick to emphasize that his company is now really a peripheral equipment firm. "We have expanded from drives into tape storage and even have a dot-matrix printer." Another element in North Atlantic's new thrust, dealing with a new generation of aircraft and a new computer application for fuel management, is the 2765 (see p. 220): "It takes our militarized tape drive and adapts it to Arinc data-loader requirements for use with the Sperry Univac fuel management system aboard the new Boeing passenger aircraft." Widenor says the device "exemplifies [North Atlantic's] goal: to become a broad-spectrum peripherals supplier."

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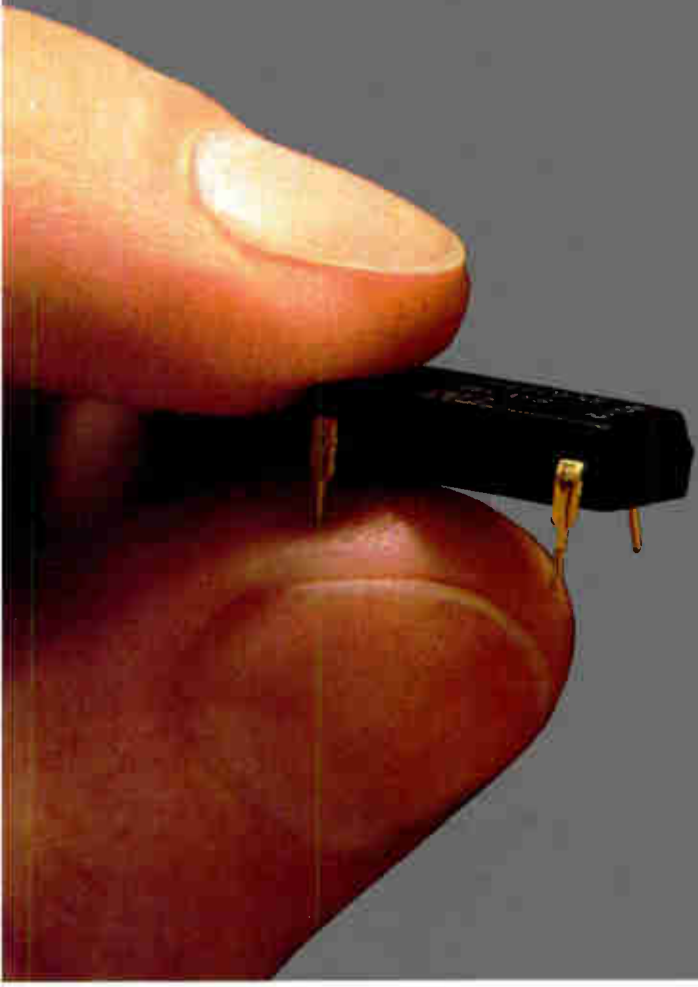

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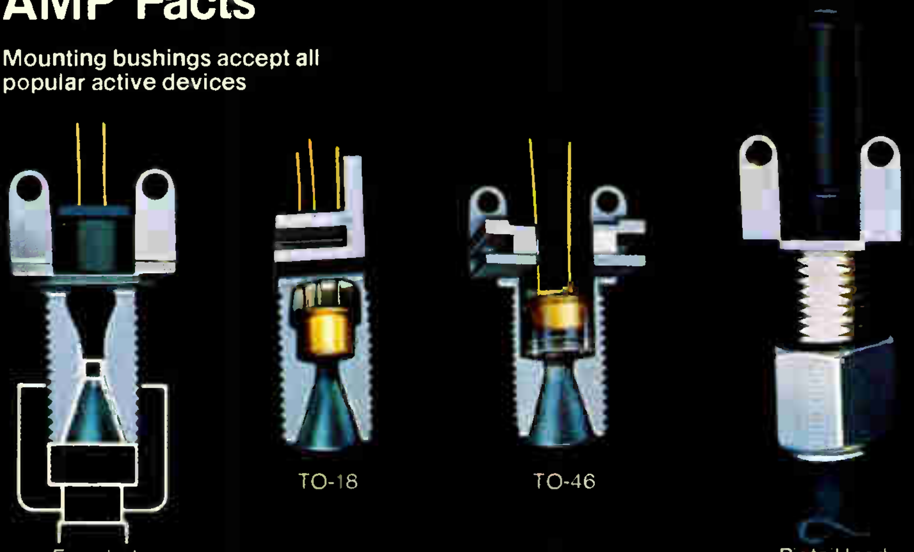
AMP Facts

Mounting bushings accept all popular active devices



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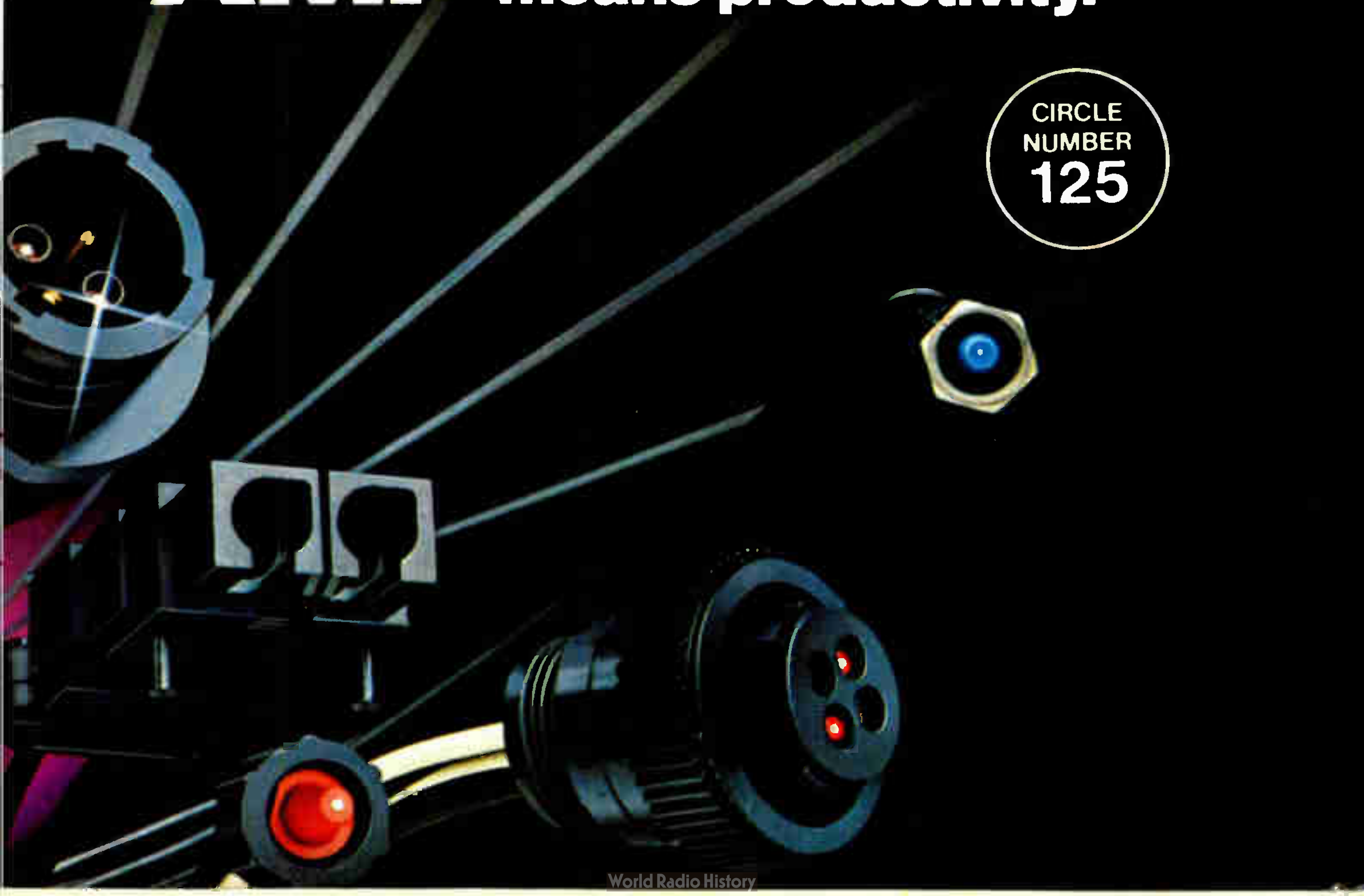

Editorial

The 64-K in three acts

The story of the 64-K dynamic random-access memory is beginning to take on some of the qualities of a Broadway play, complete with mystery, drama, and suspense.

Most of the mystery surrounds attempts to follow accurately the ebb and flow of the infant market as semiconductor makers work to develop and build the devices. One veteran observer of the semiconductor industry allows that it has been more difficult to keep track of the progress of 64-Ks than any other product yet. He is not quite sure why, he says, except "it's very difficult to separate the reality of what's actually happening from the smoke of what Japanese producers say is happening [p. 89]."

The drama and suspense involve what seems to be the painfully slow progress of U. S. manufacturers into the market. To some, this might signal a lack of will, a waning of the good old American relish for a challenge. If that were the case—and it's extremely doubtful at this stage—it would be a tragedy, because the 64-K RAM is not just another semiconductor memory; rather it is expected to be the first semiconductor component to develop into a billion-dollar market. With such a large market at stake, there is room for several participants as long as their products are right in performance and price.

At the moment, only two Japanese and two American firms are delivering 64-K RAMs in any quantity. There is no reason to believe that their head start gives them a permanent advantage. In fact, an executive of one of the U. S. producers states flatly that the "lead will bounce back and forth quarter by quarter."

The puzzling aspect of the situation is in the pricing, however. Prices have fallen rapidly since the beginning of the year, despite the facts that no real demand has yet developed, and that deliveries are relatively slow in coming. One observer ascribes this to an early onset of the "self-destructive tendencies" of the semiconductor industry when pressed to gain market share. Another infers a more machiavellian reason: the Japanese are forcing prices down to discourage American participation so as to keep U. S. firms from developing the 256-K RAM, the next really big moneymaker.

Whether that is true or not, the Japanese are reported to have up to 70% of the market, and the declining prices may be diluting the enthusiasm of U. S. competitors. In the face of today's market conditions, the last thing American semiconductor manufacturers need is another loss leader.

This creates a dilemma, because the successful 64-K RAM design is necessary for entry into the 256-K market. Complete dominance by the Japanese will give them the wherewithal to forge ahead into the computer mainframe marketplace, which is their ultimate goal.

We're betting that the U. S. firms will get their act together soon, and that they will be fighting hard for their share of the 64-K market. No major firm can ignore such a major product and expect to stay competitive. The ramifications of not being competitive extend to the national interest.

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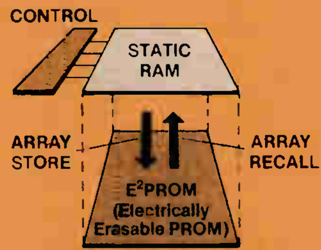

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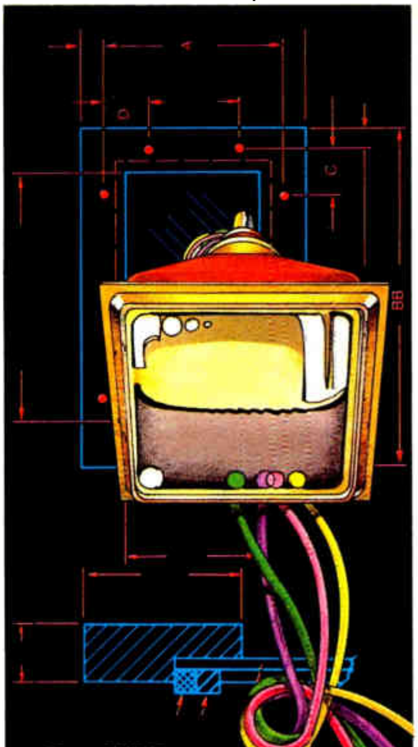

Meetings

Electrical Overstress/Electrostatic Discharge Symposium, IIT Research Institute (Nan Pfrimmer, Rome Air Development Center/RBRAC, Griffiss Air Force Base, N. Y. 13441), Aladdin Hotel, Las Vegas, Sept. 22–24.

National Conference on Software, Commission on Software Issues in the '80s (U. S. Professional Development Institute, 12611 Davan Dr., Silver Spring, Md. 20904), Shoreham Hotel, Washington, D. C., Oct. 5–6.

International Electrical and Electronics Conference and Exposition, IEEE (IEEE Canada Office, 7061 Yonge St., Thornhill, Ont. L3T 2A6, Canada), Canadian National Exhibition, Toronto, Oct. 5–7.

Industry Applications Society Annual Meeting, IEEE (S. P. Axe, Arco Chemical Co., Room 3010-G, 1500 Market St., Philadelphia, Pa. 19101), Marriott Hotel, Philadelphia, Oct. 5–9.

Electronics Test and Measurement Conference, Benwill Publishing Corp. (Tillie Najjar, Benwill, 1050 Commonwealth Ave., Boston, Mass. 02215), Hyatt Regency Hotel, Chicago, Oct. 6–8.

ISHM 1981, International Society for Hybrid Microelectronics (P. O. Box 3255, Montgomery, Ala. 36109), Palmer House, Chicago, Oct. 12–14.

6th Conference on Local Computer Networks, IEEE (Abe Franck, University of Minnesota, 227 Experimental Engineering, 208 Union St. S. E., Minneapolis, Minn. 55455), Hilton Inn, Minneapolis, Oct. 12–14.

Semicon/Southwest '81, Semiconductor Equipment and Materials Institute (625 Ellis St., Suite 212, Mountain View, Calif.), Market Hall, Dallas, Oct. 13–14.

2nd Annual North Atlantic Organization Symposium, Armed Forces Communications and Electronics Association (N. Allen, AFCEA, 5205 Leesburg Pike, S. 300, Falls Church, Va. 22041), Brussels Sheraton Hotel, Brussels, Oct. 14–16.

27th Annual Vhf Conference, Western Michigan University (Glade Wilcox, Department of Electrical Engineering, WMU, Kalamazoo, Mich. 49008), Kohrman Hall, WMU, Oct. 17.

Autotestcon '81—International Automatic Testing Conference, IEEE (Autotestcon '81, P. O. Box 5837, MP 362, Orlando, Fla. 32855), Hyatt House, Orlando, Oct. 19–21.

7th Annual Symposium, International Society for Testing and Failure Analysis (P. O. Box 742, Lawndale, Calif. 90260), Marriott Hotel, Los Angeles, Oct. 19–21.

Careers Conference, IEEE (Jill Gerstenzang, Suite 609, 1111 19th St. NW, Washington, D. C. 20036), Stouffer's Inn, Denver, Oct. 22–24.

123rd Technical Conference and Equipment Exhibit, Society of Motion Picture and Television Engineers (Conference Department, 862 Scarsdale Ave., Scarsdale, N. Y. 10583), Century Plaza Hotel, Los Angeles, Oct. 25–30.

Symposium on Adaptive hf/vhf Systems, Defense Nuclear Agency (Patrick Crowley, Defense Nuclear Agency [RAAE], Atmospheric Effects division, Washington, D. C. 20305), site in Washington not yet selected, Oct. 27–29.

Seminars

Fall 1981 training seminars and workshops, including courses on semicustom and custom large-scale integrated-circuit implementation, gate array design, bipolar linear circuit design, MOS digital circuit design, and new IC product testing, beginning in September in Boston, Scottsdale, Ariz., and Sunnyvale, Calif.—Integrated Circuit Engineering Corp., 15022 N. 75th St., Scottsdale, Ariz., or call (602) 988-9780.

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5V-programming is the key. Because with NOVRAM, you can electrically alter system firmware or configuration data 'in-system' using 5 volts only—including nonvolatile programming! NOVRAM's 5V-programmability means you can now eliminate extra high-voltage power supplies, batteries, UV light sources, unsocketing, or electromechanical counters and DIP switches.

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NOVRAM offers you proven n-channel, floating gate MOS technology—in a bit organization that's right for your application: 1K x 1 (X2201), 64 x 4 (X2210), or 256 x 4 (X2212). And NOVRAMs are available in the commercial, industrial, and military temperature ranges.

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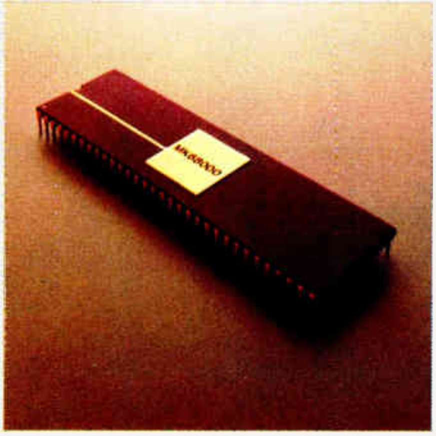

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*"A Tale of Four MPUs: Benchmarks Quantify Performance." Robert D. Grappel and Jack E. Hemenway, April 1, 1981 EDN Magazine, a Cahners Publication

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"Digital Filters — Part II: Performance Comparisons of 16-Bit Microcomputers," V.P. Nelson and H.T. Nagel, February, 1981, IEEE Micro, Vol. 1, No. 1

† Annual Minicomputer Survey, November, 1980, with permission of DATAMATION MAGAZINE, G.S. Grumman/Cowen & Co.

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Whatever your application might be, there's a CØMPLØT digitizer and plotter combination that's exactly right for your needs. Talk to the graphics experts at Houston Instrument. We have the selection and the know-how to recommend a system that will save you time and money while producing drawing quality and precision you never dreamed possible.

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Strip heater anneals ion-implanted silicon

Scientists at the Massachusetts Institute of Technology's Lincoln Laboratory in Lexington have successfully used a 4-by-7-cm strip of electrically heated graphite to anneal ion-implanted silicon in as little as 10 s. **The results are said to be at least as good as those achieved in 30 min in a 1,000°C furnace.** With the new approach, wafers are placed face down on the graphite and as much as 350 A of alternating current are passed through the strip. This method increases the temperature of both the strip and wafer to 700° to 1,200°C in about 5 s. Temperature is maintained for 10 s and then allowed to taper off. Already far faster than furnace annealing, the new technique may offer better control of implant geometry: additional diffusion depths using the graphite heater are only about 18 Å compared with some 950 Å for the furnace.

Thin-film technique used in membrane keys

Hoping to crack the market for full-travel membrane keyboards, the W. H. Brady Co., Milwaukee, is developing a new technique believed to be the first to rely upon thin-film technology for membrane switches. Brady vacuum-deposits a 1,000-Å layer of nonprecious metal like copper or aluminum on a polyester membrane to form conductive tracks, then uses capacitance switching in the final keyboard design. According to the company, the result is **a unit that is more reliable, requires fewer system components, and is cheaper to manufacture than conventional full-travel membrane units** that rely upon contact switching and thicker, silk-screened layers of conductive ink containing silver. Brady plans to show prototypes at the Wescon show in San Francisco that is scheduled to run from Sept. 15 through 17. Production of thin-film membrane-switch cores or complete keyboard units is set to begin during the second quarter of next year, says the company.

Motorola pushing opto-isolators

With two additions to its MRD900 triac family slated for later this month, Motorola Semiconductor is starting a stepped-up move in optical electronics. **The new triacs come without a light-emitting diode; they are activated instead by ambient light.** Mounted in a TO-92 package are silicon-controlled-rectifier and zero-crossing versions that are designed to switch loads on 120-V ac lines and to handle 300-mA rms forward current. Hobbyists and security alarm makers look to be big users, says an official of Motorola's High Frequency and Optical Products division in Phoenix. Other new devices for input conditioning and coupling are set for early 1982 production.

Lisp computer due from Western Digital

Another computer established around the Lisp language developed at the Massachusetts Institute of Technology for artificial intelligence development has been spawned by a joint venture between Lisp Machines Inc. of Los Angeles and Western Digital Corp. of Irvine, Calif. Lisp Machines selected a system being developed by Western Digital in conjunction with MIT [*Electronics*, May 19, p. 14] as the hardware to go with its operating and applications software. **Both firms will market the system, expected to be in production by mid-1982,** shortly after the shipment date of the Lisp-oriented 3200 recently announced by Symbolics Inc. of Woodland Hills, Calif. [*Electronics*, Aug. 25, p. 40].

Electronics newsletter

Perkin-Elmer adds Unix-using system

The popularity of the Unix operating system gets a boost with Perkin-Elmer Corp.'s new Edition VII Workbench version of its family of 32-bit minicomputers. This implementation of Version 7 of the program licensed by Western Electric Co. includes a comprehensive set of software development tools. The Oceanport, N. J., firm is currently **the only minicomputer manufacturer to offer a standard version of Bell's Unix and fully support it.** A variety of Unix versions and look-alikes is available for microcomputers and Digital Equipment Corp.'s PDP-11—the system on which Unix was developed. Amdahl Corp. of Sunnyvale, Calif., offers a Unix version for IBM-compatible mainframes. Much software has been written for Unix, particularly on DEC systems, so this move puts Perkin-Elmer in a stronger competitive position to go after DEC customers.

Hyperbus joins local network field

Yet another local network is coming off the drawing boards and into the field this month with the first pilot installation of Hyperbus, a hierarchical-bus network scheme from Network Systems Corp. that is designed to link equipment from a variety of manufacturers using coaxial or fiber-optic cable. The initial pilot, installed at an unnamed East Coast firm, will be followed by **two to three additional test installations next year before formal product release,** says an official at the Brooklyn Park, Minn., company. Hyperbus will run at Bell system T2 data rates of 6.312 Mb/s and will be compatible with multiple protocols including Synchronous Data-Link Control, X.25, and Standard Network Architecture. Any RS-232-C device, as well as IBM 3270-oriented equipment and a variety of minicomputers, can be attached to the network via bus-interface units controlled by dual MC6809 microprocessors from Motorola Inc.

Beckman merges seven businesses

Reacting to continuing slow sales of electronic components, Beckman Instruments Inc. of Fullerton, Calif., has retrenched by merging seven businesses into one group. The new Electro-Products Group **provides common marketing, manufacturing, and engineering formerly done in three divisions,** according to George E. Walters, Beckman vice president and group manager. The top official departing is Mathew P. Crugnale, director of sales and marketing, who resigned over policy differences. Sales of the group were about $150 million annually in the year completed June 30. Principal products include potentiometers, resistor networks, hybrid circuits, digital multimeters, and displays. Also, the company decided to cease manufacturing liquid-crystal displays for watches (see p. 50).

Addenda

Newly formed International Robomation/Intelligence of Carlsbad, Calif., headed by ousted General Automation Inc. founder Lawrence Goshorn, **has come out with an industrial robot selling for $9,800.** The 200-lb. robot, controlled by a Motorola 68000 microprocessor, has early 1982 delivery times. . . . Fiber-optic component consumption in U. S. commercial communications will reach the billion-dollar level by 1990, according to a newly released report, "Fiber Optics in Commercial Communications," from Gnostic Concepts Inc. of Menlo Park, Calif. **Cable will account for about two thirds of total communications fiber-optic component value in 1981,** climbing to almost three fourths in 1990 as submarine cable becomes a major factor.

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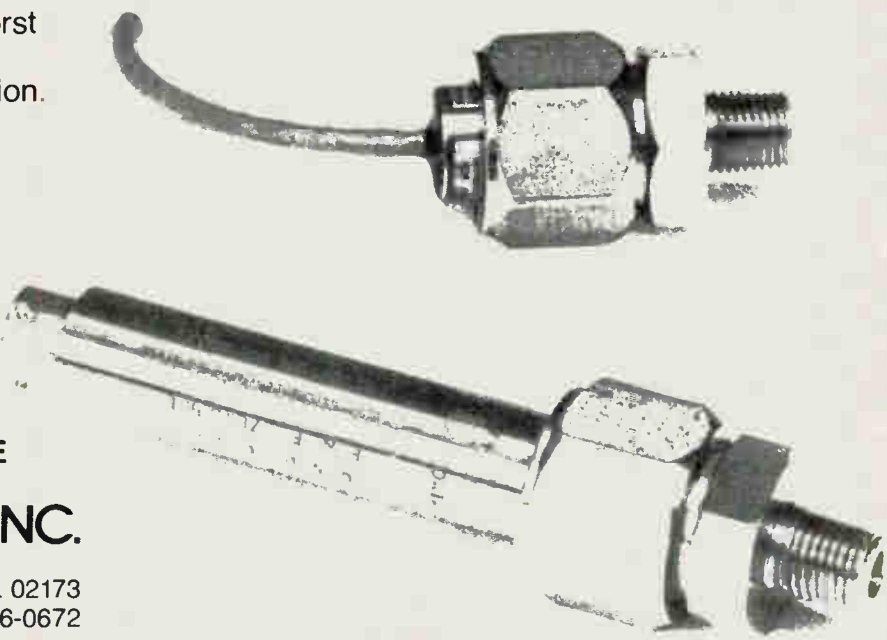

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The materials are screened base metal resistor and copper cermets fired in inert N_2 at up to 1000° C, chosen by *Industrial Research/Development Magazine* as one of the top 100 industrial product developments of 1978.

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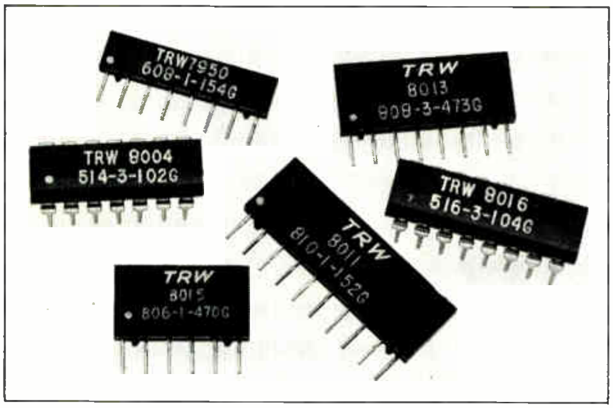

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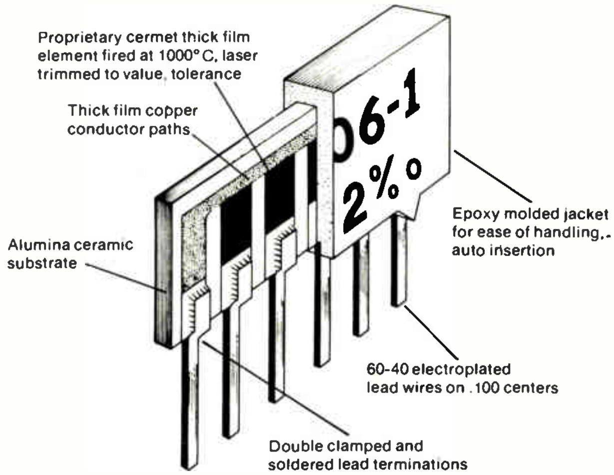


- ☐ Feature TRW/IRC's non-noble thick film technology
- ☐ 6-, 8- or 10-pin packages
- ☐ Transfer molded for mechanical stability and automatic insertion

STANDARD RESISTANCE VALUES (OHMS)

33	180	1.0K	5.6K	33K	180K
39	220	1.2K	6.8K	39K	220K
47	270	1.5K	8.2K	47K	270K
56	330	1.8K	10K	56K	330K
68	390	2.2K	12K	68K	390K
82	470	2.7K	15K	82K	470K
100	560	3.3K	18K	100K	560K
120	680	3.9K	22K	120K	680K
150	820	4.7K	27K	150K	820K
					1 MEG

ELECTRICAL SPECIFICATIONS

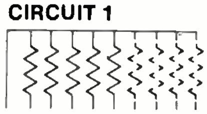
Resistance Range: 33 ohms to 1 Meg
Resistance Tolerance: ±2%, ±5%
Temperature Coefficient: ±200 ppm/°C
TC Tracking: 50 ppm/°C typical
Power Rating at 25°C: (see derating curve)

	6 Pin	8 Pin	10 Pin
Circuit 1			
Total package	1.5W	2.1W	2.7W
Single resistor	.3W	.3W	.3W
Circuit 3			
Total package	1.5W	2.0W	2.5W
Single resistor	.5W	.5W	.5W

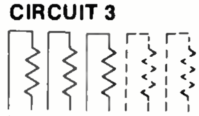
(Rating at 70°C is 67% of 25°C rating)
Maximum Continuous Working Voltage: 50V
Operating Temperature: −55° to +125°C

STANDARD CIRCUITS (Resistors all same value)

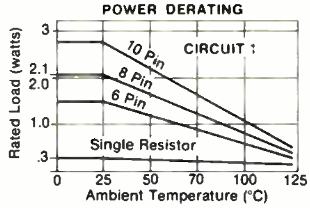
CIRCUIT 1



CIRCUIT 3



POWER DERATING



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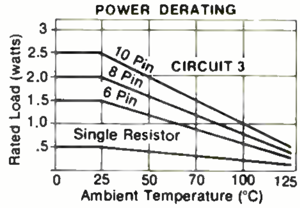

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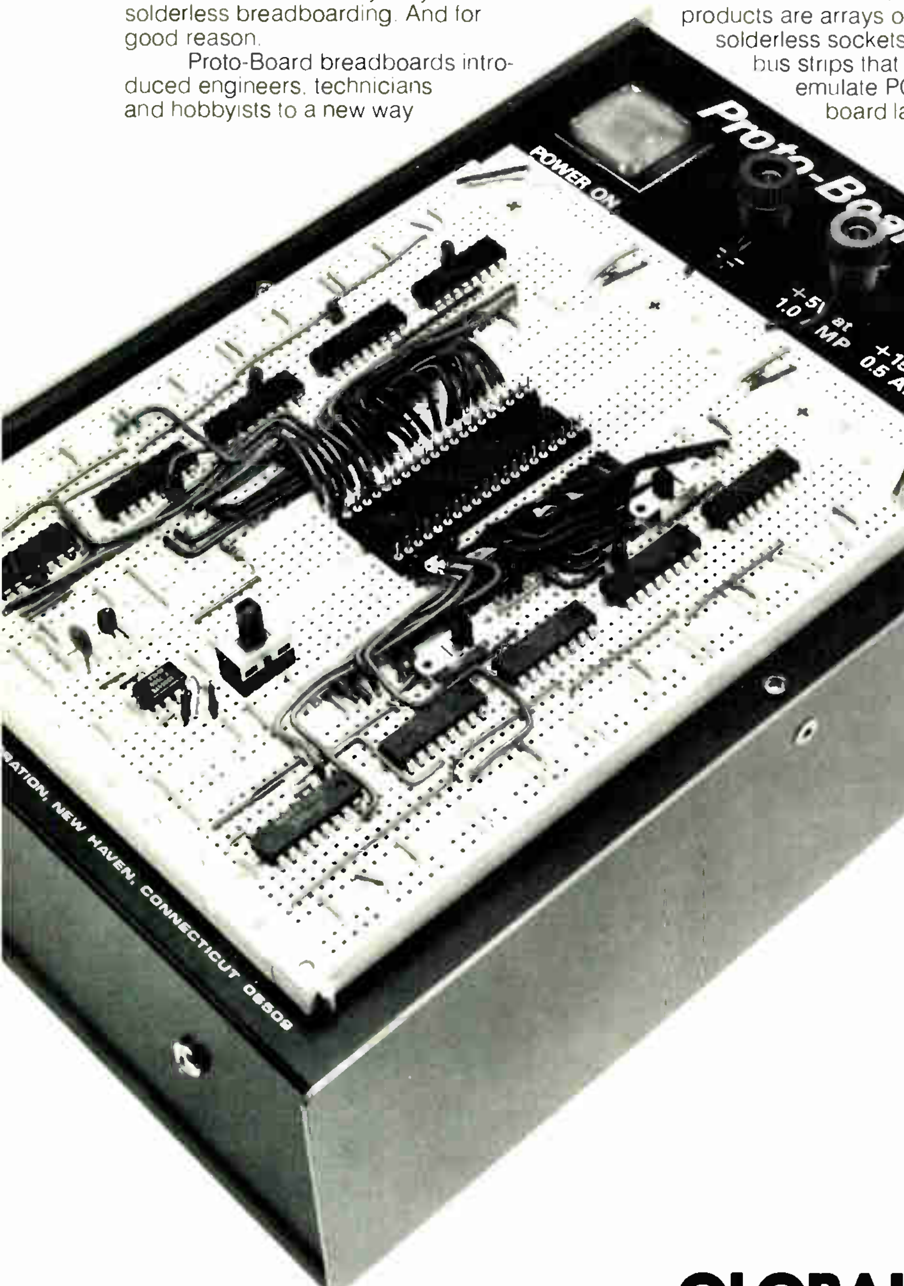

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Intel goes third party for 16-bit software

by R. Colin Johnson, Microsystems & Software Editor

Publishing-house operation has already sponsored three operating systems, four high-level languages

When the first 16-bit microprocessors hit the market several years ago, the laborious and expensive task of developing software for them proved just too much for engineers conditioned to the surfeit available for 8-bit chips. But that inertia is gradually being overcome, with Intel Corp. organizing to give its 8086 a critical momentum all its own.

In a move that is becoming increasingly popular, the Santa Clara, Calif., company is turning over the software chore to independent, or third-party, software houses. IBM Corp. did the same thing for its 16-bit personal computer [*Electronics*, Aug. 25, p. 50].

With its move to software suppliers for its 8086 chip, Intel has put into place the last piece of a plan to supply the systems arena traditionally served by original-equipment makers using minicomputers. The company will offer the OEMs a single source of hardware and software for 8- and 16-bit microcomputers for applications ranging from process control to office automation. The only other microprocessor maker in this market now is Texas Instruments Inc., with its 9900-based 990 minicomputers.

Intel is able to rely on the third-party software houses because the 8086 has proved to be the pacemaker among 16-bit microprocessors. For example, its first-quarter 1981 shipments topped 110,000 versus an estimated 12,000 for Motorola's 68000 (expected to double in the second quarter) and 8,000 for the Z8000, states Dataquest Inc., a Cupertino, Calif., research firm. Consequently, the software independents have been sharpening their pencils and developing software for the 8086.

Publishing house. Intel has set up what it calls its software distribution operation, or SDO. It will act as a software publisher, soliciting programs that are needed and then picking vendors to develop them.

"We feel that the 8086 is becoming the industry-standard 16-bit processor, and the best way to ensure its success is to provide it with superior software," says Judy Ross, the director of SDO. "Our primary focus is to support the 8086 and future-generation Intel processors, although we are going to publish [8-bit] 8080 and 8085 software, too."

However, the other major contenders recognize the need for software as well. Motorola's second sources, particularly Philips Data Systems, are promising full software support for the 68000, and Zilog has already adapted Unix—the Bell Laboratories operating system [*Electronics*, March 24, 1981, p. 119]—to its Z8000.

Initially, SDO is sponsoring three

Forging ahead in the foundry business

While one part of Intel knocks on doors for software, another has opened its door to outside chip designers, allowing them to take advantage of its design-automation and integrated-circuit-processing facilities. Though it has been providing the service for six months, the company is just making public the fact that it has set up a silicon foundry in Chandler, Ariz.

Intel is supplying customers with complete sets of design rules for its high-performance MOS and complementary-MOS processes. Also on offer is its scaled-down H-MOS II technology, and even more advanced processes like H-MOS III will be added as they become available. Computer-aided-design facilities for circuit layout and simulation will also be provided, as well as services for testing and packaging finished devices.

A manufacturer's willingness to invite this kind of business usually indicates an overcapacity situation, and Intel's case is no exception. Indeed, the company says it is setting aside about 10% of its manufacturing capacity for the foundry. However, mixed with this excess capacity is a sincere desire to tap into the foundry business, states manager Peter Jones. "We kicked around the idea when there wasn't a spare wafer in the industry," he says of the firm's long-standing interest in such services.

Referring to more sophisticated customers, Jones explains that "at the system level, their knowledge is greater than ours, so if we don't process their designs, we'll lose that share of the business." The market for the silicon foundry industry could grow from about $50 million to nearly a half billion dollars by 1985. It is all but certain that Intel will eventually enter the gate-array business as well, perhaps by next year. At present, it seems to be leaning toward a family of C-MOS arrays with high gate count. **-John G. Posa** operating systems. Two, Unix-86 and CP/M-86, are likely to spawn the greatest number of applications programs because so many OEMs are using them. The third system, iRMX-86, is Intel's own, the one it supplies with its OEM microprocessor systems. The only other manufacturer to attempt such a wide range of operating systems is TI, which is supporting the P-system, developed at the University of California at San Diego, and CP/M, in addition to its own proprietary offering. Intel's SDO also is sponsoring four high-level languages—Pascal, Fortran, Cobol, and Basic—with C and Ada farther down the software road.

For the 8086, Digital Research Inc., Monterey, Calif., has been retooling its own CP/M and will have PL/1-86 subset G in place sometime next year. It will also offer a version for the 8080, called CP/M-80. Intel has not yet chosen its Unix supplier.

For now, most of the high-level–language chores are being handled by Microsoft Inc., Bellevue, Wash. It will bring Pascal, Fortran, Cobol, and Basic under CP/M for the 8086 and perhaps, says Ross, under Unix. Micro Focus Inc., Santa Clara, will implement its version of Cobol for all three operating systems. Negotiations are also under way with Whitesmiths Ltd., New York, and TeleSoft Inc., San Diego, for their C and Ada compilers.

Once the high-level languages are in hand, Ross expects to see a myriad of applications packages. Among the first will be Microsoft's version of a spread-sheet program—similar to Personal Software's Visicalc—called Electronic Paper. A word-processing package will follow.

Gains. Intel should also benefit from whatever software IBM develops for its personal computer. The machine uses an Intel 8088, which is software-compatible with the 8086. Also, Lifeboat Associates, one of the well-established CP/M publishers, is supporting the 8086, and it looks as if all the Japanese contenders, except possibly Hitachi, are choosing it for their 16-bit personal computers.

All software developed under Intel's auspices will be tested and validated by Intel, but, Ross stresses, it will not maintain the software. This will be left to the software originator. Intel will publish a software catalog and pay royalties on each package. Ross also points out that independent software vendors are being informed of the details of Intel's 32-bit iAPX-432 microprocessor, and they will also be supporting it in the future.

Publisher. Judy Ross, director of Intel's software publishing operation, says it will focus primarily on support of the 8086 and future-generation microprocessors.

Magnetic bubbles

Chip combines logic with memory

Attempts to build logic devices with magnetic bubbles have persisted almost since the discovery about 20 years ago that the technology was suitable for data storage. The latest success with bubble-based logic circuits results from a team effort between IBM Corp.'s Yorktown Heights, N. Y., Thomas J. Watson Research Center and Carnegie-Mellon University in Pittsburgh.

In fact the team, Hsu Chang and W. W. Molzen of IBM and J. P. Hwang and J. C. Wu of Carnegie-Mellon, has done more than devise a novel AND-OR logic gate. In order to replicate the elements in a string-pattern–matching bubble chip, it has also used some of the same hierarchical design techniques exploited by designers of very large-scale integrated semiconductor circuits.

Ironically, this news comes as a third U. S. bubble-memory manufacturer withdraws from the market, evidently concluding that the technology is a bad investment (see following story). Nevertheless, there could be benefits from a high-density bubble chip that combines storage and logic.

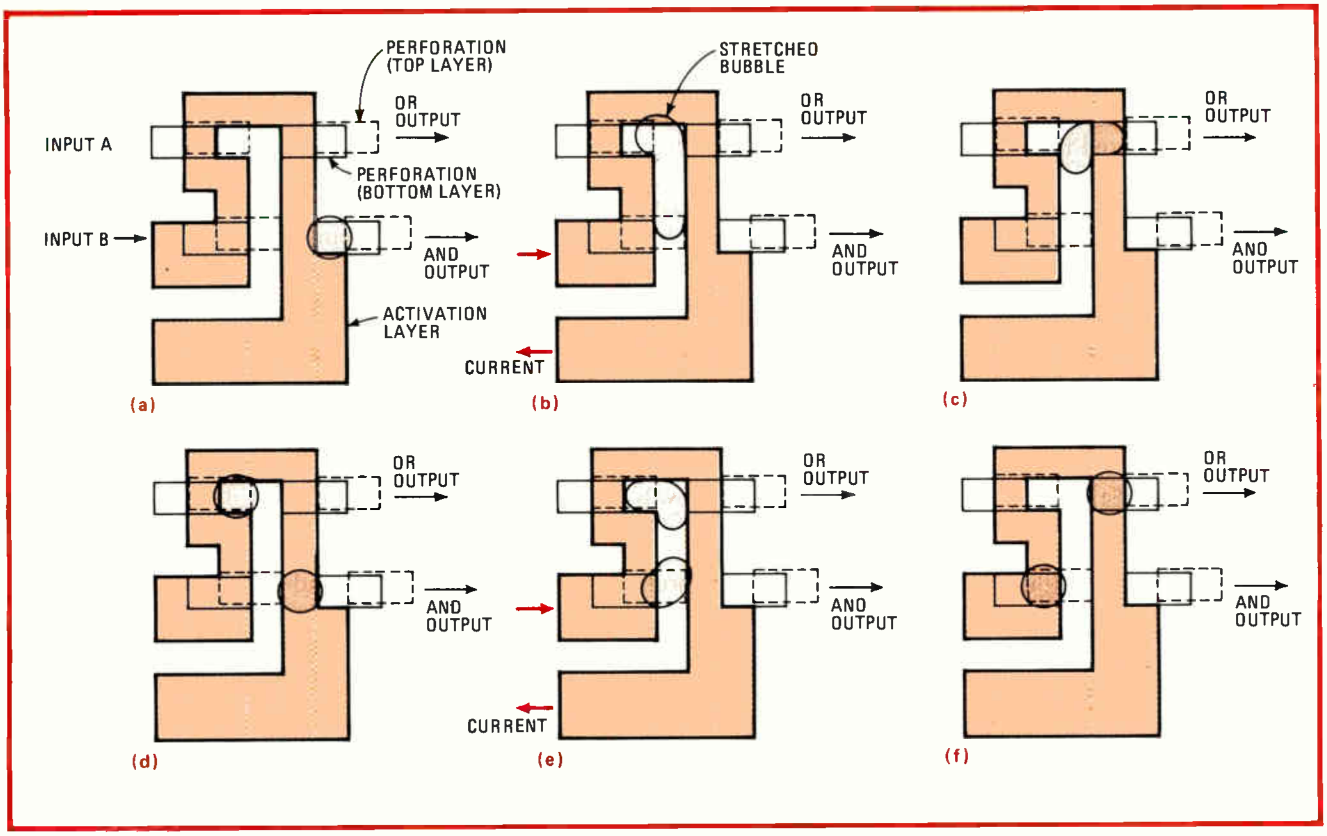
The chip would eliminate data transfers between separate memory and processor units, more than compensating for the relatively slow speed of bubble devices. Such applications might include string and pattern matching for voice- and image-recognition, relational data bases, and associative memories.

Current access. The bubble-logic chip relies on the current-access technology pioneered by Andrew H. Bobeck, the Bell Laboratories technical staff member credited with having invented the bubble memory. Unlike commercial bubble memories, which use orthogonal coils of wire for bubble propagation, current-access devices use two or more thin layers of metal deposited on top of and covering the garnet chip holding the bubble domains.

The layers contain minute rectangular perforations. When current passes through the layers, the turbulence in the current flow around the holes creates magnetic poles that attract and repel the magnetic bubbles. Two or more sheets, whose perforations lie along a straight line, are used to phase the current pulses to achieve smooth, fast bubble propagation.

The figure illustrates the topology and operation of the AND-OR gate used by IBM and Carnegie-Mellon. Two perforated sheets form two propagation tracks. The solid- and dashed-line rectangles are the holes in the top and bottom sheets, respectively. Atop these tracks is a third conductor pattern, indicated in solid color, that is responsible for the operation of the logic gate.

The gate has two inputs and two



Bubble logic. Perforations in each of two metal layers deposited atop a garnet chip in IBM/Carnegie-Mellon device form tracks that guide the magnetic bubbles. Current flowing through the activation layer maintains the bubbles in the appropriate tracks for OR or AND outputs.

outputs. One output along the top propagation track and the other along the bottom track indicate OR and AND logic results, respectively. If only a single bubble has propagated along the bottom track into the gate, as shown in (a), a current through the third, or activation, electrode will stretch the bubble onto the top track (b) and out the OR output line (c). (If the bubble came in on the top track, it would remain there and appear at the OR output.)

If two bubbles move into the gate, as in (d), mutual repulsion will not allow the bubble on the bottom to leave its track (e). In this circumstance an AND output will be seen at the next cycle, as in (f). The upper track bubble moves ahead of the one on the lower track, but this is unimportant since the OR and AND outputs are correctly delivered.

Comparison. In the string-matching chip, a data stream is made to flow against a fixed pattern of bits so that corresponding pairs of bits can be compared on each cycle. Only two basic cells are required to build the chip: a 1-bit comparator and an accumulator, each consisting of the AND-OR gate, plus the bubble chip's usual complement of generators, annihilators, splitters, and switches.

On a small experimental layout, eight of the accumulator cells were placed adjacent to an array of eight by eight comparators. The researchers envision feature sizes reduced from 2 micrometers now to 0.5 μm. For this, vector-scanned electron-beam lithography will be used to fabricate a much larger cell array.

Replicating the array pattern serves to simplify the matching chip's manufacture. Moreover, bubbles naturally occur in streams that lend themselves to parallel and pipelined operations. A characteristic that further simplifies the application to logic is the fact that bubble devices are inherently self-clocking and are renormalized automatically on each cycle. **-John G. Posa**

National quits bubble market, leaving Intel as last U. S. supplier

National Semiconductor Corp. has become the third U.S. maker of magnetic-bubble memories to pull out of the business this year. Before the Santa Clara, Calif., firm's surprising announcement last month, Texas Instruments Inc. of Dallas called it quits on bubbles in June and Rockwell International Corp., Anaheim, Calif. halted commercial production in February.

These departures leave Intel Corp.'s Magnetics subsidiary in Santa Clara as the only remaining U. S. supplier of commercial bubble chips. Motorola Inc. does have a pilot bubble line, but first Rockwell, and then National, were its alternate sources. Now, with three strikes already called, some wonder who will stay in the game.

There is a market for the dense, nonvolatile chips, and if the credibility of the technology has not been irreparably impaired, the pot as it now sits will be split between Intel, Hitachi Ltd., and Fujitsu Ltd.—if the Japanese firms decide to push their parts in the U. S. Nippon Electric Co. is said to be weighing an entry into the business, possibly as a second source to Intel.

Size disputed. However, estimates as to the size of the market vary widely. Intel Magnetics, which claims more than a 90% hold on U. S. sales, says the market for components alone—including devices sold on a captive basis but excluding support circuits—is $50 million and will double next year.

Venture Development Corp., a Wellesley, Mass., industry analyst that monitors the bubble business, says the market is roughly half that size. Also, James Cunningham, once director of National's bubble memory program before moving to Advanced Micro Devices Inc., Sunnyvale, Calif., says the Intel estimates must include the lucrative Japanese market because U. S. sales of chips and support devices right now cannot be much more than $10 million.

The withdrawals from the market have been increasingly surprising. When Rockwell tossed in the towel, there were enough players to speculate that the company was discouraged by the glut of competitors.

TI's departure was a shock, though, since it had developed the commercial market with 92- and 254-K devices, and it was working on a new family of 256- and 512-K and 1-megabit chips when Intel surfaced with its 1-megabit part.

TI says it got out of the business because it was making no money, but that predicament was partly its own fault. The earlier 92- and 254-K chips would have been more popular if they had had binary organizations.

The company's later series fixed this blunder, but the initial support circuits for the new family had no error detection and correction. When Intel announced a 1-megabit part and support electronics with error detection, it threw TI's marketing plans into a tailspin, and National began to doubt the viability of the market.

Profitability. Just like TI, National has been experiencing profitability problems in general, and it decided to trim excess baggage. "But National's support circuits were head and shoulders above the competition's," states Cunningham. "We were all done."

Yields on National's bubble parts were low but reasonable, and it had designed a removable bubble cassette, a Multibus-compatible board storing 1 megabyte, and a 4-megabit chip that looked promising.

So, many think that it was a mistake for National to get out of the bubble business; that the only unfinished work was marketing the units and reaping the profits. But what's done is done, says Cunningham.

None of the quitters will go back into the business, he says, because "there's just too much pride—too much crow to eat." Besides Motorola, National had a second-source agreement with Sagem SA of Paris, which will continue supplying military and aerospace applications (see also p. 63). **-John G. Posa**

Solid state

Optical AND gate has current output

Logic-element design received another boost at Bell Telephone Laboratories—only it involved optical systems rather than magnetic bubbles, with the construction of an experimental two-input AND gate on a semiconductor chip that reacts to a pair of light signals at different wavelengths. The output is an electrical signal that can be used, for example, to trigger a light-emitting diode or a laser.

The ability to gate light signals in this way is crucial to an optical processing system. With high-speed logic integrated in a semiconductor chip, as John A. Copeland and his associates at the Crawford Hill facility in Holmdel, N. J., have done, the system could be extremely compact, consume little power, and allow designers to take fuller advantage of light as a coupling medium between subsystems.

Series junctions. The gate structure has a pair of photodetecting pn junctions in series. They are epitaxially grown on a substrate of n-doped indium phosphide, as shown in the figure at the top of page 44. One photodiode is a heterojunction of indium phosphide–indium gallium arsenide phosphide; the other is of indium gallium arsenide.

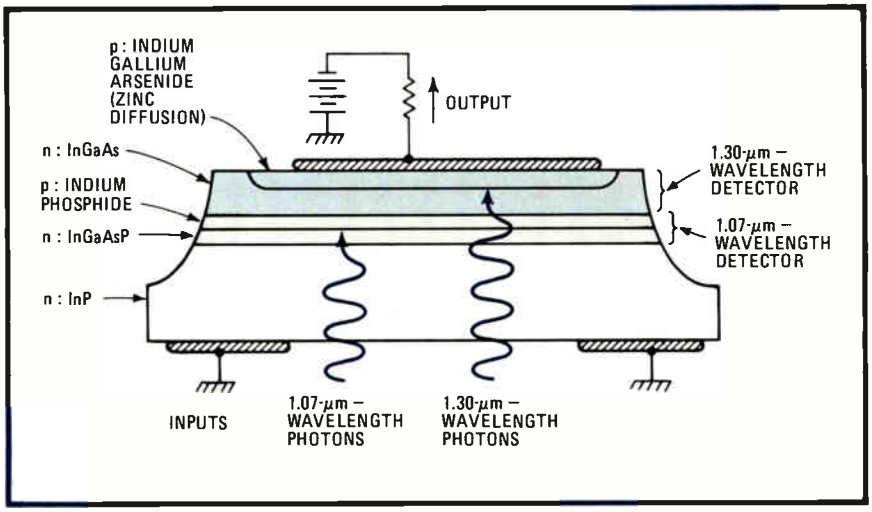
The two photodetectors have different band-gap energies and are sensitive to different wavelengths. One diode is sensitive to light at 1.07 micrometers, the other to 1.30-μm waves. The longer-wavelength signal passes through to the second diode; the shorter wavelength is absorbed by the first.

The device typically operates with a reverse bias of 5 volts and exhibits no gain, so power output depends directly on power input. Moreover, appreciable current will flow only when both of the input signals are present.

Response time of the device is determined by the capacitance of the back-biased junctions, Copeland explains. On the order of 5 nanoseconds, the response time may be decreased significantly as the device is made smaller.

In early gate models, Copeland continues, small spurious pulses would be amplified by the gate's internal bipolar transistors, a by-product of having two pn junctions in series. In addition, the reverse-biased photodiode junctions were too close to the forward-biased (pn) junction between them.

Injected carriers. This forward-biased junction injected minority carriers that could be collected by the photodiodes to produce an unwanted output current. By heavily doping the layers next to the forward-biased junction, it was possible to reduce carrier lifetimes and, along with making the layers thicker, to



Light logic. Two light signals are converted into an electrical output in this AND gate consisting of a pair of photodetectors in series that are sensitive to different wavelengths.

provide adequate isolation for the photodetectors, Copeland says.

He next wants to extend the number of inputs—to N diodes, with N different input wavelengths. The stack of series-connected diodes would conduct only when all input signal wavelengths were present, resulting in an AND function.

Bell also plans to integrate a so-called trap-doped laser with an AND gate. In a practical device, such as an optical repeater in an optical-fiber transmission line, the laser could be triggered by the current output from the gate.

This type of laser generates a beam with a fixed-width pulse. Thus, the combination could act to restore the shape of the optical signal, which is broadened as it travels down the light pipe.

Copeland, whose work on the AND gate will appear in a forthcoming issue of Applied Physics Letters, says the InGaAsP-InP system offers great promise for making monolithic optical systems. This possibility is due to the fact that epitaxial layers may be grown on InP with a wide range of band gaps, optical indexes, and p- and n-type conductivities.

The materials have been fashioned into a variety of devices, including lasers, light-emitting diodes, and photodetectors. Studies are in progress at Bell to integrate the devices in combination. **-Harvey J. Hindin and Roderic Beresford**

Components

Resistor's tempco falls below 1 ppm

In the relatively slow-moving world of passive components, the big breakthroughs are few and far between. However, resistor technology will be able to boast of one next week at Wescon, when Vishay Intertechnology Inc. unveils its HP100 Thermotropic line of precision resistors: nickel-chromium devices with temperature coefficients well under a single part per million per degree Celsius.

Several years of research by the Resistive Systems Group at the Malvern, Pa., operation paid off in this approximately order of magnitude improvement in temperature performance where the coefficient averages out to about 0.25 ppm/°C. To achieve a total change in resistance of only 30 ppm over the range 0° to +125°C, Vishay builds its resistors so that a strain-induced change in resistance compensates for the characteristic variation of the metal alloy's resistivity with temperature. The strain results from the difference between the coefficients of thermal expansion of the foil and the substrate supporting it.

"We knew all along what had to be done," notes Felix Zandman, president and scientific director of Vishay. "The problem was how to implement this fairly simple physical concept." Vishay, a well-established resistor manufacturer, last year totaled about $40 million in sales, half in resistive systems, half in stress-analysis equipment. Zandman calls the HP100 the "most significant leap forward in resistor technology in 10 years or more."

Previously, Vishay's best available temperature performance was about 2 ppm/°C in its standard S102C series parts, developed some 15 years ago. Like these older components, the HP100 series resistors are made by cementing nickel-chromium foil to a ceramic substrate and patterning the metal in a photoengraving process. The problem with the older process was that strain-induced changes in resistance are a linear function of the temperature. Since the nickel-chromium alloy has a resistivity that varies nonlinearly with temperature, the two effects do not cancel each other out.

Canceling. "What we have come up with," says Zandman, "is a choice of materials and a manufacturing method that will produce the nonlinear strain characteristic necessary to cancel out the resistor's nonlinear temperature coefficient." Zandman declines to give the details, but says that both composition and structure of the substrate are critical to the low-tempco resistors.

Furthermore, the technique readily lends itself to optimization of resistor performance for specific temperature ranges. Military and avionics applications call for the 0° to +125°C range, but an instrument maker, for example, can specify +25° to +90°C only, for a total change in resistance of just 5 ppm/°C over that entire range. (Below 0°C, there is no improvement in temperature coefficient over the 2 ppm/°C of the S102C line.)

Since the resistance in fact oscillates about its nominal value in a way predictable with changing temperatures, the components can be designed for essentially zero tempco at a given operating point. The

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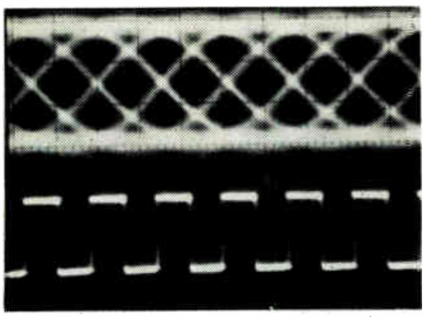
HDDR COMES OF AGE

..."So forget the code and let's talk format"...

By the end of the 1970's, when everyone involved in high density digital recording appeared to be talking codes, it could be argued that there had been no significant advance in this area for several years. Then, on January 13th 1981, a paper entitled "The Application of 3-position Modulation Coding (3PM) to Longitudinal Instrumentation Tape Recording," was presented to a meeting of the American Tape Head Interface Committee (THIC).

Not surprisingly it was enthusiastically received by users and others close to the industry – because it provided an important new initiative in the approach to user requirements. Quite simply it showed how this new coding scheme could extend bit packing densities up to 45 kbpi while lowering the minimum data rate to 5 kbps – in itself a major advancement of HDDR recording techniques.

Not that 3-position modulation in itself was anything new – it was first used in fixed speed computer disc systems – but its application to the special needs of multi-speed instrumentation tape recording is a development which opens up a wealth of intriguing possibilities.

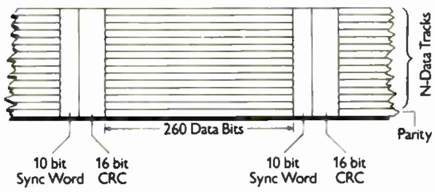


3PM eye pattern and recovered data clock 30 kbpi

3PM Plus – and its benefits are only the beginning.

3PM coding is a highly attractive proposition if your primary requirement involves tape economy, crossplay and adjustment-free operation over extended periods, as well as high data throughput and bi-directional operation at regular and non-standard tape speeds.

Obviously a code that can increase packing densities by up to 50% is significant in itself, but it is only when one considers the format as a whole that the extent of user benefits becomes apparent. In the first place it is now possible – many would say essential – to invest some of this extra packing density into such highly desirable operational features as positive synchronization and



3PM recording format

error detection while still attaining unprecedented levels of data density.

These and other benefits are now incorporated in a new generation high density record/reproduce system – called SE 9000 HD. The recording format employs a block length of 260 data bits plus a 10-bit sync. word and a 16-bit error detection character. The sync. word is an efficient code violation – a transition pattern which cannot occur naturally according to the rules of the code. One or more lateral parity tracks are also included as part of the format.

A break with tradition

The recording format is highly innovative, marking a departure from traditional thinking in many areas. There was for instance more than one raised eyebrow at our choice of a block length as short as 260 data bits. Surely, it was argued, the longer the data block with respect to the sync. word, the better the efficiency. Quite true, but it should also be remembered that any parallel recording system requires the data to be blocked for synchronization and deskewing purposes.

It is important, therefore, that re-synchronization should be achieved as quickly as possible following a discontinuity in the reproduced data stream. As a consequence it is now considered good practice to trade a little efficiency to this end.

A similar situation is true for error detection. Although low error-rate tapes are available, these can deteriorate with use, and periodic cleaning and rehabilitation are necessary to maintain performance. An alternative philosophy is to accept that errors are inevitable and build into the recording format a reliable and effective method of error detection and correction. This type of system is demonstrably cost-effective in the SE 9000HD and well worth the sacrifice of a few per cent of efficiency.

But undoubtedly the most important user benefit of the format is the unique auto-ranging bit synchronization facility, made possible by certain characteristics intrinsic to the format.

Add to this such other features as bi-directional operation, constant density recording, intermediate speed operation, auto-ranging equalization and you'll see why SE 9000 HD has caused such widespread interest.

For further information on how the 3PM format can help you to advance into a new era of HDDR recording, send for our full HDDR data pack. Call us... in France on 859-0042 in Germany on 6105-2941 in U.K. on 01-890 1477 in U.S.A. on (404) 952-8502.

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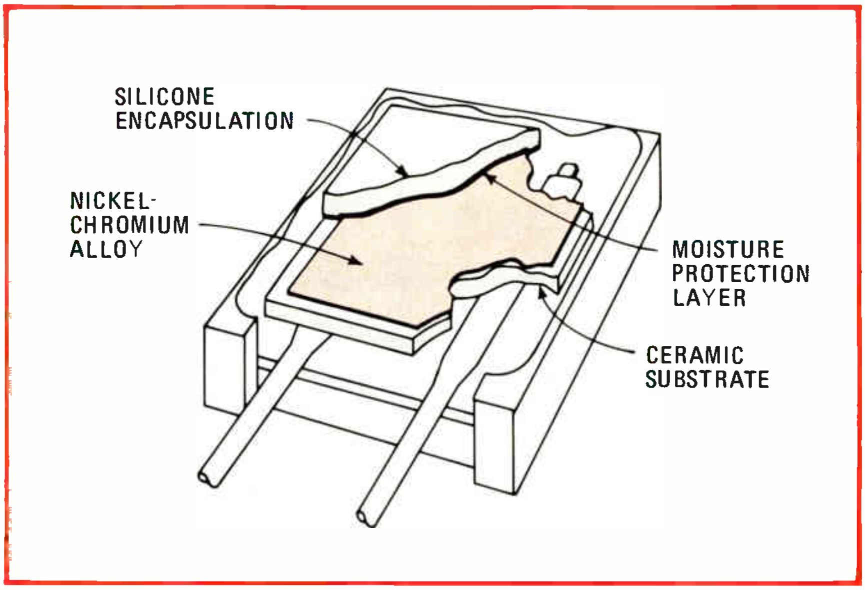


Compensator. Vishay's new precision resistor, measuring about 1 cm^2, resembles older units. Both are fabricated from nickel-chromium foil cemented to a ceramic substrate.

prices of the resistors, whose tolerances measured at 25°C are available from ±0.005% to ±1%, are about twice those of Vishay's older precision metal-foil line, or between $10 and $20 each, depending on quantities. The resistance values range from 100 to 100,000 ohms.

Most benefit. Applications needing two closely matched resistors, like voltage dividers, bridges, and ladder networks, will benefit the most from the new technology since the worst-case tracking—10 to 30 ppm—is about one tenth that obtainable with previously available components. **-Roderic Beresford**

Peripherals

Disk backup gets production boost

Users of the smaller-diameter Winchester-technology disk drives perked up last month when Cipher Data Products Inc., San Diego, Calif., announced it would manufacture a 1/4-inch streaming tape-cartridge drive. Cipher's move meant that a company with a solid reputation making higher-capacity, 1/2-in. streaming drives would provide what many regard as the fastest backup for the fixed 8-in. Winchesters.

The move also led to speculation that the virtually moribund market for 1/4-in. streaming drives may finally live up to the promise predicted for it. At the same time, it pointed up the troubles that have plagued Data Electronics Inc. This is the firm that in early 1980 announced the first 1/4-in. drive to be applied to streaming, and it was expected to reap sizeable benefits. Held back by production problems, it has not.

Early success. Cipher has been successful with a 1/2-in. reel-to-reel backup for Winchester disks with upward of 40 megabytes capacity. Its new 1/4-in. cartridge drive, called the Quarterback F440, will serve 8-in. Winchesters with lesser capacities. Data streams continuously from a disk to the tape cartridge; the cartridge is then removed, and the disk is free for other chores.

Technology for the F440 is being licensed from Archive Corp., a Costa Mesa, Calif., firm established early in 1980 to produce streaming drives. The F440 will have a 20-megabyte capacity and operate at either 30 in./second or the more common 90 in./s. Single units are priced at $1,550, and in quantities, the price drops to around $1,000 each.

As for Data Electronics, the worst

may be over, although it will certainly feel the new competition. Marketing vice president Sam Thompson, claims the number of hardware complaints about the drives have not been inordinate for a new product using new technology. Some of the problems, however, proved more than just annoying.

Renney Bosch, vice president of new product research at Point 4 Corp., says Data Electronics' Streamer model lacked complete specifications and could not meet some that were provided. He has since purchased Archive units.

Another user who asks not to be identified speaks of poor documentation. "We had to figure out the interface parameters ourselves," says this customer. There was also an oscillation problem, but now, he says, "it seems to work, though we have yet to run a read-after-write test on it. In any case, we will probably offer an interface capable of working with Archive's drive as well." He emphasizes that Data Electronics cooperated closely with his company and the drives are now working well, with low error rates.

Inroads. Alternative backup methods have made inroads that could be tough to overcome, however. Streaming drives boast high data-transfer rates (90-K-bytes/s for Archive and Cipher), but Pertec Computer Corp. and Kennedy Co., as well as Data Electronics itself, have made strong markets with start-stop drives. Makers of low-capacity 5¼-in. Winchester drives say floppy-disk drives are the most cost-effective backup for them.

As for the market for streamers, Archive, with a claimed $8 million in contracts this year, could be the leader. Dataquest Inc., a Cupertino, Calif., market-research firm, predicts that shipments in 1981 will total 5,500 units, climbing to 57,500 units next year. Freeman Associates, Santa Barbara, Calif., puts the 1982 market above 50,000 units, a figure it had originally predicted would be reached in 1981. If everything is shipshape, sales should then top $50 million, a figure certainly worth waiting for. **-Terry Costlow**

Production

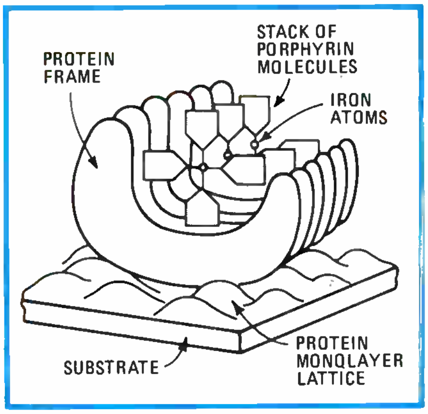
Bioelectronics to spawn circuits

The science-minded would like to know when advances in very large-scale integration and genetic engineering will breed some sort of bioelectronic supercomputer. Toward that end, a biotechnical research firm called EMV Associates is using a one-molecule-thick layer, or monolayer, of organic polymers to pattern micrometer-sized conducting lines without the need for masking or etching the pattern.

The company believes it possible to shrink geometries to the 10- to 25-nanometer range, where dimensions overlap those of molecules in living organisms. In addition, the company envisions interfacing with molecules that could be gated to switch electronic currents, most likely via recombinant-deoxyribonucleic acid techniques. The result: extremely dense and fast bioelectronic computing machines and other useful systems.

Well before such a science-fiction scenario becomes fact, the metal-deposition technique being perfected by the Rockville, Md., concern will benefit the electronics industry in other ways, says James H. McAlear, a member of EMV's research team. He will present a paper on his work at the 1981 Symposium on VLSI Technology, being held this week in Maui, Hawaii. The technique offers a new materials technology, he says, one that might result in high-resolution proximity masks, compound semiconductors, and even optical sensors.

PMMA on protein. To fabricate the fine metal lines, EMV deposits a monolayer of the synthetic protein polylysine on a glass substrate and covers this with PMMA, or polymethyl methacrylate, the popular resist chemical. Lines are traced with a direct-writing electron beam. The exposed areas are then dissolved in alcohol, uncovering tracks of the



Chain gang. EMV Associates thinks it may be possible to gate current in a stack of organic molecules fastened in a protein frame that is, in turn, tied to a substrate.

polylysine layer beneath.

Next, the glass substrate is immersed in a solution containing the salt, silver nitrate. The salt binds to the exposed polylysine and is converted into a solid metallic conductor by a later chemical reduction.

A biocomputer. To construct a bioelectronic system, EMV proposes to use a long molecule that conducts electric current from one end to the other. Another type of molecule could be attached to influence, or switch, the current flow.

This assembled combination could then be attached to an array of the ultrafine metal conductors. Alternatively, individual molecules could be made to assemble themselves spontaneously onto exposed regions of the protein monolayer in accordance with the physical laws of protein binding.

In the latter case, this protein coat consists of an ordered array of molecules. With certain electrically polarized macromolecules, it is possible to form lattice arrays with an electric field.

Fine metallic conductor patterns would be deposited onto exposed areas of the monolayer using EMV's silver deposition process, for example. Next, regions of the monolayer close to the conductors would be uncovered, allowing molecules with switching behavior to bind onto the lattice, and connections would be made to the conductor pattern.

If the switching molecules are first

assembled and then attached to the conductor pattern, the molecules would act as discrete components analogous to transistors. The system's logic would be determined through the metal interconnections.

However, with the spontaneous subassembly process, much of the logic could be embodied in the kind of proteins and enzymes used. This could in turn make possible a variety of functional elements such as semi- and super-conductors.

For discrete devices, McAlear and his colleagues are eyeing the organic molecular porphyrin, which binds with iron to facilitate electrochemical reactions in living organisms.

Advances in genetic engineering should make it possible to design a framework, as shown on page 49, with which to attach the porphyrin in precise orientation to the protein-coated substrate, says McAlear. For some connections between the molecule and fine metal lines deposited close by, EMV envisions a biological soldering process using enzymes supporting a chemical reaction that would promote the growth of metallic conducting bridges.

McAlear points out that the materials and assembly costs would be low. The molecular building blocks could contain all of the information for assembling themselves. Moreover, states McAlear, "this could lead to an evolution of electronic devices analogous to that of living things, except that human logic may direct the evolution instead of natural selection."

-John G. Posa

Displays

Big makers bow out of watch LCDs

With the world's appetite for digital watches dulled by both recession and saturation, plummeting component prices have forced from the business the three major suppliers of liquid-crystal watch displays. Dropping out permanently last month from supplying what for years has been a high-profit, big-demand item were

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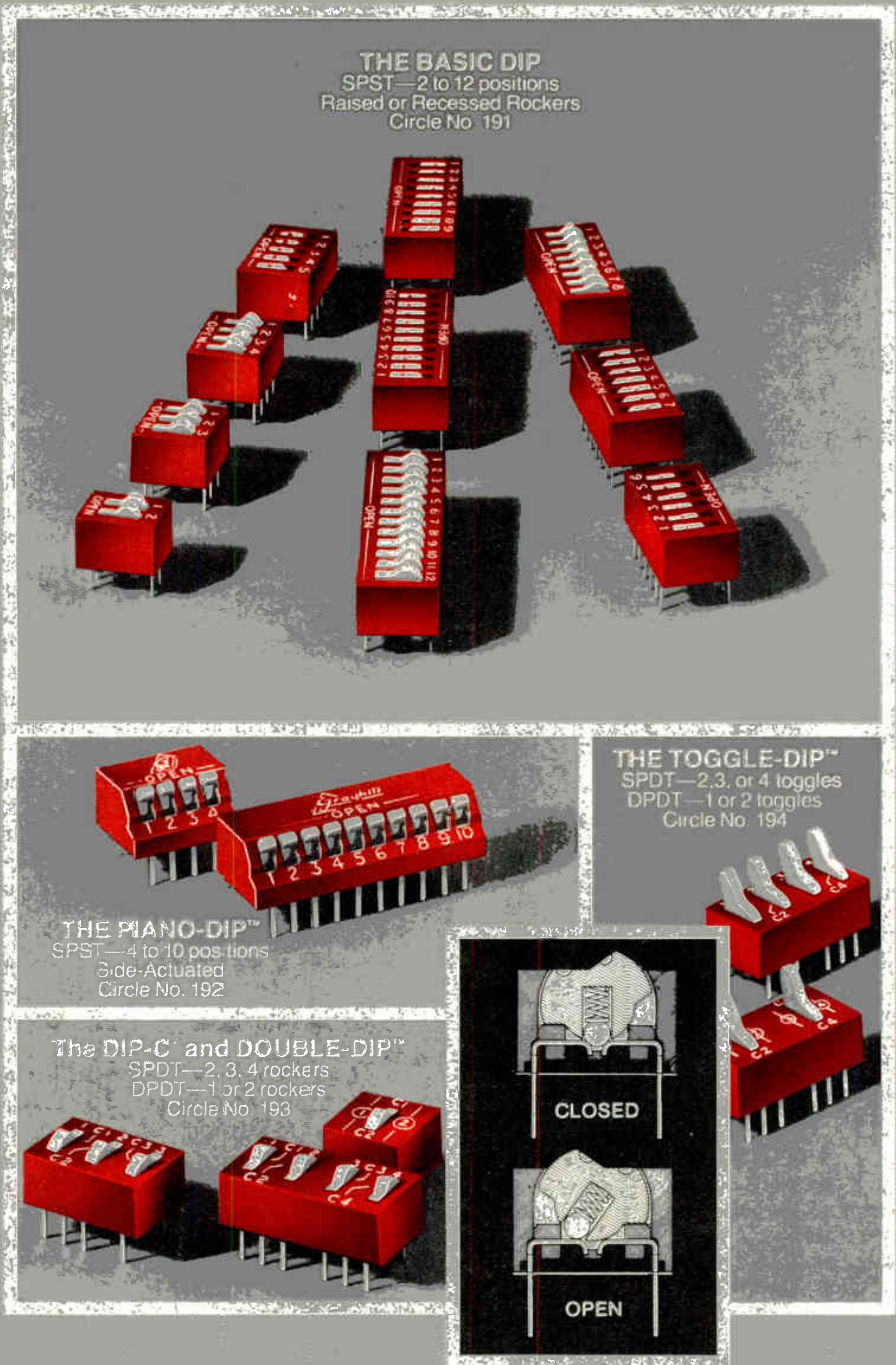

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the two largest U. S.-based manufacturers, Beckman Instruments Inc. and Fairchild Camera & Instrument Corp. Also joining the exodus was Switzerland's Brown, Boveri & Co., which, unlike the others, says it might resume operation if demand picks up.

The rapid LCD shakeout of this summer again points up how quickly volatile electronic components can change direction, agree sources at the three firms. The only remaining major producer of watch LCDs seems to be Hitachi Ltd., which continues to manufacture in Japan for assembly in Hong Kong. Indeed, most knowledgeable sources finger Hitachi as the culprit in pushing down prices to about 20¢ per display, or one quarter the level prevailing in late 1980.

In 1980 the world market for watch LCDs was about $125 million, 40% supplied by independent producers. These suppliers serve the merchant market; large users like Timex and Seiko still have captive LCD plants. LCDs for calculators are another matter, with a different set of suppliers maintaining long-running relationships with customers who make a standard product.

The overriding cause of the simultaneous withdrawal of the watch LCD producers is rooted in the shifting nature of the customer base, which never developed the loyalties necessary for the product's improvement by the makers.

Beckman's customer list reportedly suffered 85% annual turnover; Fairchild reports a similar experience. Both firms have closed their Hong Kong production and assembly operations and pulled all display work, mostly on large-area LCDs, back to U. S. headquarters—Beckman in Fullerton, Calif., and Fairchild in Mountain View, Calif.

Interestingly, in some months Beckman's production hit a high of 2 million units, and its highly automated plant turned healthy profit margins. Fairchild's production hit at the million-per-month rate. Some smaller LCD producers remain to pick up any business Hitachi cannot handle, sources say. **-Larry Waller**

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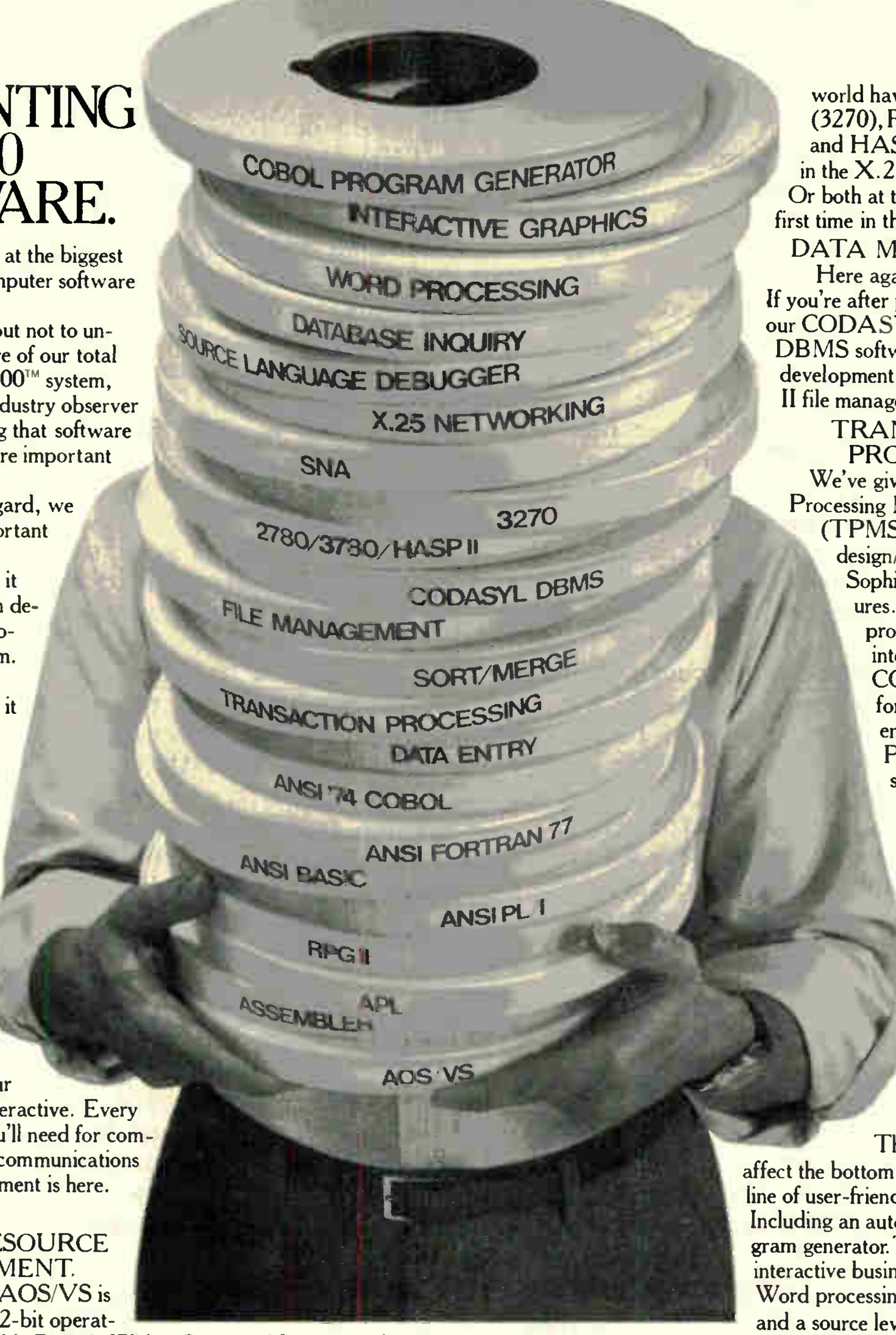

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Circle 55 on reader service card

SCIENCE/SCOPE

In a major advance in computer-aided design (CAD) that eliminates the need for breadboard models, Hughes engineers have created software that checks integrated circuits. The CAD module, called VISTA, tests all hardware from transistors through logic gates, registers, chips, or an entire system. It can test circuit functions and timing parameters, and can help develop and verify system software and test algorithms. The module includes a virtually new simulation language based on PL/1. The CAD module will be used in developing very large-scale integrated circuits for missiles and other military electronics.

An all-optical digital computer has been demonstrated at Ohio State University using a liquid-crystal light valve. This unique Hughes device accepts optical images and replicates them on a completely separate light beam from an arc lamp or laser. The device uses technology similar to that of liquid-crystal watches. Optical equivalents to electronic logic gates and flip-flops were constructed with the light valve much as transistors are used in an electronic system. Computers that use photons instead of electrons would be smaller and faster.

A safely concealed gunner could guide a missile toward a battlefield target with a new fiber-optic communications system. The concept calls for a missile with an imaging seeker in its nose to be fired toward an enemy force. What the missile sees is relayed back to the gunner over a glass thread that pays out from a spool in the missile's aft end. The cable, unlike ordinary wire, can transmit broadband signals required for video. The gunner looks at a display and picks a target. Guidance commands are transmitted automatically to the missile over the fiber-optic link. Hughes and principal subcontractor ITT Electro-Optical Products Division are developing the Integrated Fiber-Optic Communications Link for the U.S. Army for possible use in a low-cost anti-armor missile.

Hughes Ground Systems Group, the world's leader in ground-based automated air defense control systems, is currently staffing for opportunities in the field of automated large-scale command and control information systems. Immediate challenging positions exist for systems engineers, software engineers, operational requirements analysts, telecommunications systems engineers, and programmers. If you are interested in advancing your career, please send your resume to Hughes Ground Systems Group, CCIS Employment, Dept. SE, P.O. Box 4275, Fullerton, CA 92634. Equal opportunity employer. U.S. citizenship required.

The thrust of a spacecraft ion engine has been increased fivefold through simple modifications. Hughes scientists, working under a NASA contract, made the improvements on a model of the 8-centimeter thruster built for flight test on the U.S. Air Force SAMSO-601 spacecraft beginning in 1983. The increased thrust was obtained by raising the discharge power from 18 to 124 watts and slightly increasing the beam voltage. Thermally conductive attachments were added to the vaporizers to provide heatsinking in the more severe thermal environment. Also, the diameter of the electron baffle was increased to stabilize the discharge voltage during operation at high beam current.

Washington newsletter

ITT, Westinghouse win jammer award

One of the largest development contracts for electronic countermeasures ever awarded by the military, $14.3 million for the Airborne Self-Protection Jammer, has been awarded to the team of ITT Avionics division, Nutley, N. J., and the Westinghouse Electronic Warfare division, Baltimore, Md. The program has a potential value of $1.2 billion. Loser in the two-year competition was the team of Northrop Corp., Rolling Meadows, Ill., and Sanders Associates Inc., Nashua, N. H. Under the initial contract from the Naval Air Systems Command, the manager of the ASPJ effort for both Air Force and Navy aircraft, **full-scale development will begin on the internally mounted AN/ALQ-165 system whose mission is to protect tactical aircraft against radar-directed weapons.** Outlays for the new phase are expected to total $80 million to $85 million before its conclusion in 1984. After building and military testing of about 16 ASPJ prototypes and eight Comprehensive Power Management Systems for the AN/ALQ-131, the winning team will be dissolved, with each company competing for production quantities.

U. S. to investigate charge NEC dumped

Aydin Corp. of Fort Washington, Pa., has won its first round before the International Trade Commission on its charges that Japan's Nippon Electric Co. sold high-power amplifiers to Communications Satellite Corp. at less than fair value [*Electronics*, Aug. 25, p. 42]. In a preliminary 3-0 finding, the commission ruled that **Aydin's complaint of dumping by NEC warrants further investigation by the Commerce Department's International Trade Administration.** The ITA must now investigate and decide by Dec. 31 if the Japanese company was dumping. Should Aydin's charges be upheld, the amount that NEC will have to pay the U. S. for higher duties and penalties, if any, must be determined by next April.

Air Force looking for digitally controlled ejection seats

A request for proposals due about Oct. 1 from the Air Force's Aeronautical Systems division at Wright-Patterson Air Force Base, Ohio, should trigger development of technology for the first digitally controlled air-crew ejection seats. Present mechanically controlled seats use mid-1960s technology and are steadily falling behind the margins of speed and safety needed for new jet aircraft. Spokesmen say the Air Force wants a system with enough growth capability to carry it into the next century. **Present concepts include use of very high-speed microprocessors, perhaps 32-bit devices or multiple smaller machines,** and possibly as much as 32-K bytes of high-speed random-access memory. The system would solve complex thrust-vector and seat-attitude control problems, plus order sequencing, and make timing calculations based on data from a wide variety of sources. Inputs would come from a built-in inertial platform similar to that used in modern small missiles, with air-speed, altitude, and attitude information possibly being taken from an aircraft data bus. Air Force engineers hope the effort is well under way by early 1982.

Multibeam antenna simultaneously receives 4-to-12-GHz signals

Communications Satellite Corp. says it has developed the first multibeam antenna able to simultaneously receive multiple video feeds from different satellites operating on 4-to-12-GHz frequencies. At its first demonstration of the unit late last month, Comsat said it expects the antenna to **save satellite users substantial costs in operation, equipment, maintenance, and real estate for earth stations.** The 4.5-m antenna, called Torus and developed by Comsat Laboratories, will be manufactured under a license by Radiation Systems Inc. of Sterling, Va.

Trade offset practices surveyed by EIA, AIA

International trade offsets are the subject of a confidential survey being conducted jointly by the Electronic Industries Association and the Aerospace Industries Association in cooperation with the U. S. Treasury Department. Offsets are the compensatory trade often demanded by a foreign buyer in the form of production licenses, local subcontracts, investment in the buying country, technology transfer, or countertrade. Japan is the most widespread user of trade offsets, including countertrades involving the exchange of finished goods for foodstuffs or raw materials like coal. The associations' survey of member companies is being developed because **offsets "as a condition of international business have become a significant distorting factor"** in both commercial and military sales, says EIA president Peter F. McCloskey. Names of companies, programs, and products will not be disclosed in collecting aggregate data, McCloskey emphasizes. The associations hope to have their survey completed in time for House Banking Committee hearings on offsets and foreign sourcing, scheduled for late September.

U. S. maintains lead in computer trade . . .

The U. S. is maintaining its big lead in world computer trade, but is generating a deficit in other business equipment—a category defined by the Computer and Business Equipment Manufacturers Association as embracing everything from word processors, automatic copiers, and typewriters down to handheld calculators. CBEMA's analysis of Census Bureau data on trade in these categories for the first half of 1981 **shows exports of computers and parts totaled $4.3 billion, up 24% from last year, while imports climbed nearly 48% to $774 million.** Although the rate of growth for exports and imports of computers alone remained the same at 17%—with exports totaling nearly $2.5 billion and imports at $312 million—imports of parts alone rose sharply by more than 78% to $462 million, compared to a 34% climb in exports to $1.8 billion.

. . . as deficit narrows in business equipment

The U. S. trade deficit in business equipment declined 43.7% to less than $146 million in the first half of 1981, compared to last year, the CBEMA figures show. Imports totaled nearly $955 million compared to exports of more than $809 million. **The narrowing deficit resulted from an 18.7% jump in exports,** while imports rose just 1.6%. Overall, CBEMA estimates that the U. S. should wind up 1981 with a $7 billion trade surplus in computers and business equipment—an increase of $1 billion over 1980.

Navy names Gould for fiber sonar study

Reductions in the size, weight, and cost of towed military underwater sensors through the use of acoustic-optic sensors and fiber-optic data transmission are the goal of a Naval Research Laboratory program. Under a new contract, the value of which is not disclosed, Gould Inc.'s Chesapeake Instrument division in Glen Burnie, Md., and Gould Laboratories in Rolling Meadows, Ill., will demonstrate the feasibility of using a Navy-developed acousto-optic sensor **to detect sonar signals and transmit them through a fiber-optic cable to a shipboard receiving station.** The program is called FOSS—for fiber-optic sensor system.

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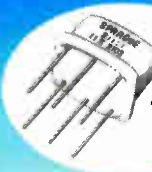

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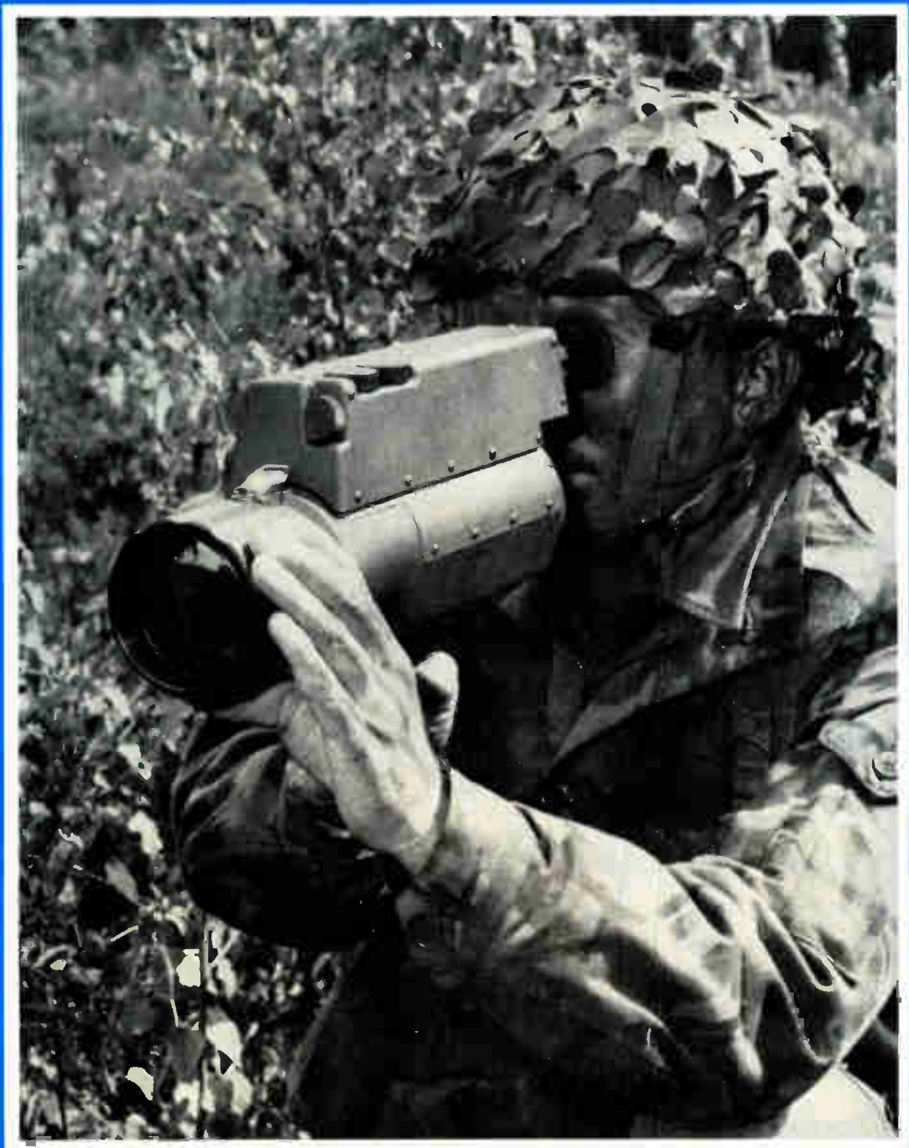
Electronics International

Stationary system focuses camera automatically: page 73

British soldier can see over a mile away at night with a new highly portable breed of infrared imager: page 74



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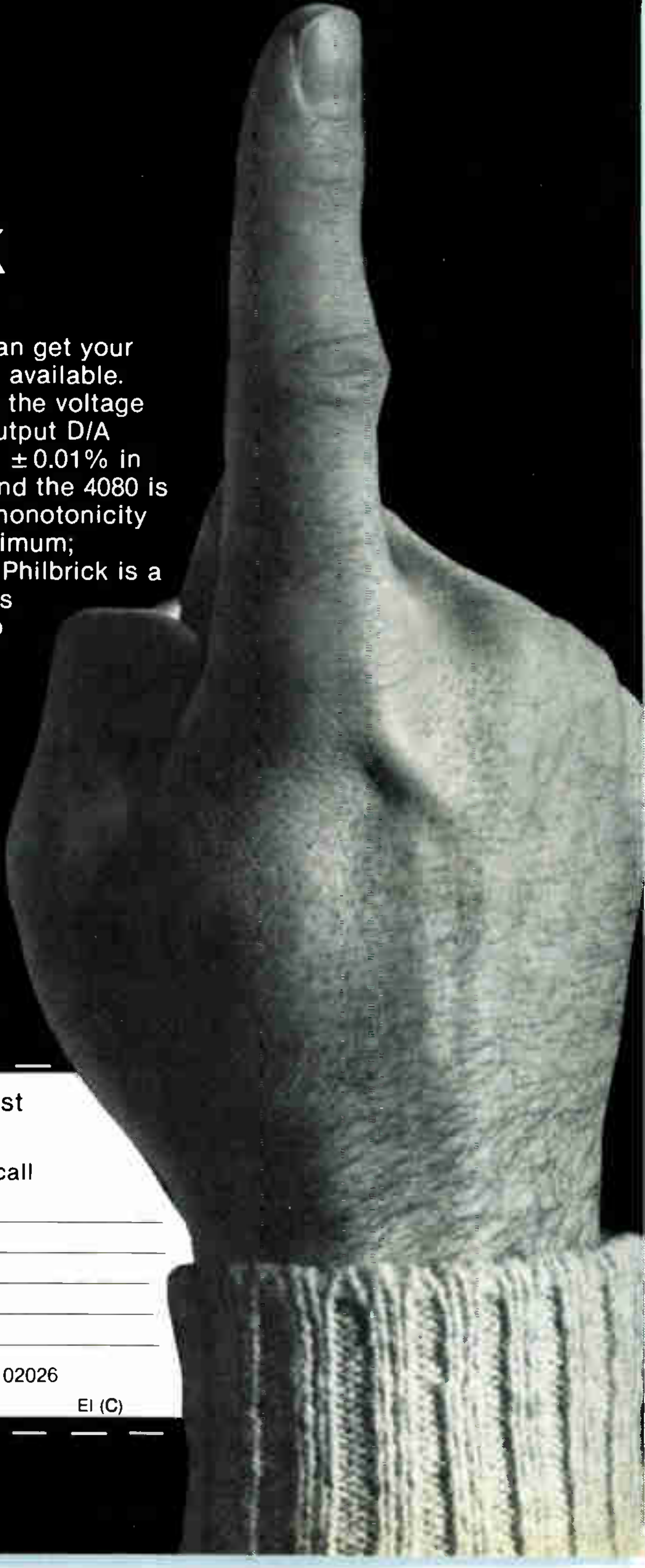

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International newsletter

Philips aims at consumer-bus standards

Philips Gloeilampenfabrieken NV in the Netherlands is now seeking standardization of two consumer-type bus systems it has developed—the D^2B, for domestic digital bus, and the I^2C, for inter–integrated-circuit. The two-wire D^2B system standardizes the interfaces of and interconnects all types of domestic electronic equipment, enabling its user to initiate any sequence of equipment operation at the push of a button. With the I^2C two-wire bus, equipment makers can standardize the interfaces between different integrated circuits and modules used in their equipment and developed as dedicated building blocks.

Going on the interest of a number of European equipment makers, notably in France and West Germany, Philips is confident that **by 1982 both buses will be well along their way to becoming standard in Western Europe.** Eventually, the Dutch company hopes, they will be accepted as standards in other parts of the world as well.

U. S. gate-array market attracts Fujitsu . . .

Fujitsu Ltd.'s subsidiary, Fujitsu Microelectronics Ltd. in Santa Clara, Calif., has started taking orders for custom bipolar and complementary-MOS gate arrays fabricated by the parent in Kawasaki, Japan. A satellite transmission link between Santa Clara and a computer design center in Kawasaki will speed turnaround. Among the devices offered are **low-power Schottky TTL arrays with 200 to 500 gates and C-MOS devices with 770 to 3,900 gates.** The process could enable Fujitsu to start operations faster than Toshiba, which plans to ship unfinished C-MOS arrays for completion to LSI Logic in California [*Electronics*, Aug. 25, p. 64].

. . . and Britain's GEC

Watch for Britain's General Electric Co. Ltd. to launch its gate-array and cell-based technologies in the U. S. through Circuit Technology of Farmingdale, N. Y., a recently acquired hybrid manufacturer. Marconi Electronic Devices Ltd., GEC's UK semiconductor operation, plans a two-tier strategy: it will license its GEC 4000–based and VAX-based design software to large corporations and will offer **a local design service, both using its 560- to 2,114-gate Iso-C-MOS arrays.**

France's Sagem sticks with bubbles

Though National Semiconductor Corp.'s decision to leave the bubble memory market (see p. 41) is forcing the Société d'Applications Générales d'Electricité et de Mécanique to reconsider its own role in the market for commercial applications, the Paris company affirms that it will carry on with bubble memories for aerospace and military uses. Sagem had a second-source agreement with National for bubble memories, but **will take a hard look at the potential of commercial versions** before deciding whether to stay in this sector or drop out. For military and aerospace applications, Sagem has developed its own technology with the Laboratoire d'Electronique et de Technologie de l'Informatique in Grenoble.

4-bit microcomputer shifts Toyota gears

Toyota is offering a luxury car featuring control by a one-chip 4-bit microcomputer of its three-speed and overdrive automatic transmission, including lockup of its torque converter. The system offers three shift patterns—the normal selection one, plus **a fuel economy pattern and a power pattern for mountain driving or better braking.**

Microcomputer control provides more precise gear changes and expands the lock-up range, thus economizing on fuel, making shifting freer of jolts, and reducing engine noise and vibration because of a better match between engine conditions and gear ratio. The new system, which consists of an analog-to-digital converter chip, the microcomputer chip, and bipolar transistors for driving the solenoids that actuate transmission shifts, looks much more practical than the earlier system developed by Toyota [*Electronics*, Feb. 16, 1970, p. 69].

Chip recognizes Japanese syllables

Next month Nippon Electric Co. will start shipping what it claims is the world's first commercial voice-recognition device to comprehend syllables as well as words. As a result, the device reacts to an unlimited variety of words and numbers in Japanese. Most other languages contain far too many possible syllables for this approach to work, so NEC plans no exports. The new SR-200 can **recognize 68 syllables at a rate of about 4 per second with 95% accuracy,** as well as numbers and up to 50 whole words at 99.8% accuracy. Each user must prerecord each syllable and word before using the system. The standard input unit with microphone and remote control pad will sell for $13,825 and can easily be linked with such devices as word processors and electronic translators.

West Europe making too few ICs

As the European Economic Community Commission sees it, West Europe is turning in a rather poor performance in integrated-circuit production and will depend on imports of such devices at least for the near term. This year, for example, it expects overall worldwide consumption to climb to $14.2 billion, with the U. S. and Japan producing $10.7 billion and $2.2 billion, respectively, but West Europe **producing only $750 million worth of ICs while consuming $3.2 billion worth.**

As for next year, the EEC commission foresees worldwide IC consumption going to $17.3 billion, with the U. S. producing $12.9 billion and Japan $2.7 billion. Western Europe, in contrast, will produce a meager $825 million next year but consume $4 billion worth.

Large TV display to brighten up spectator sports

A large color TV display, measuring 34 ft diagonally and intended for use as an advertising display and in such places as stadiums, has been developed by Matsushita Electric Industrial Co., which has started taking orders. **Its pictures can be clearly seen from as close as 170 ft and as far off as 500 ft.** The first will be installed by next spring at the Nishinomiya baseball stadium near Osaka, Japan. The display uses 37,800 incandescent lamps with external color filters to form 12,600 red-green-blue dot trios. It is conceptually similar to a much earlier 8-ft experimental TV display using 78,000 lamps [*Electronics*, April 15, 1968, p. 92].

Addenda

Look for CII-Honeywell Bull of Paris to decide by the end of the year to change all the substrates for the thick-film hybrid circuits in its middle-range DPS 7 computer line **from gold to copper wiring** [*Electronics*, May 19, p. 82]. Beside the obvious cost advantage, copper's lower electric resistivity improves the speed of logic signal transmission. . . . Sooner than anticipated, West Germany's Siemens AG can now **ship the faster versions of the 16-bit microcomputer family SAB 8086** that operates at 8 and 10 MHz within a temperature range of from 0° to 70°C.

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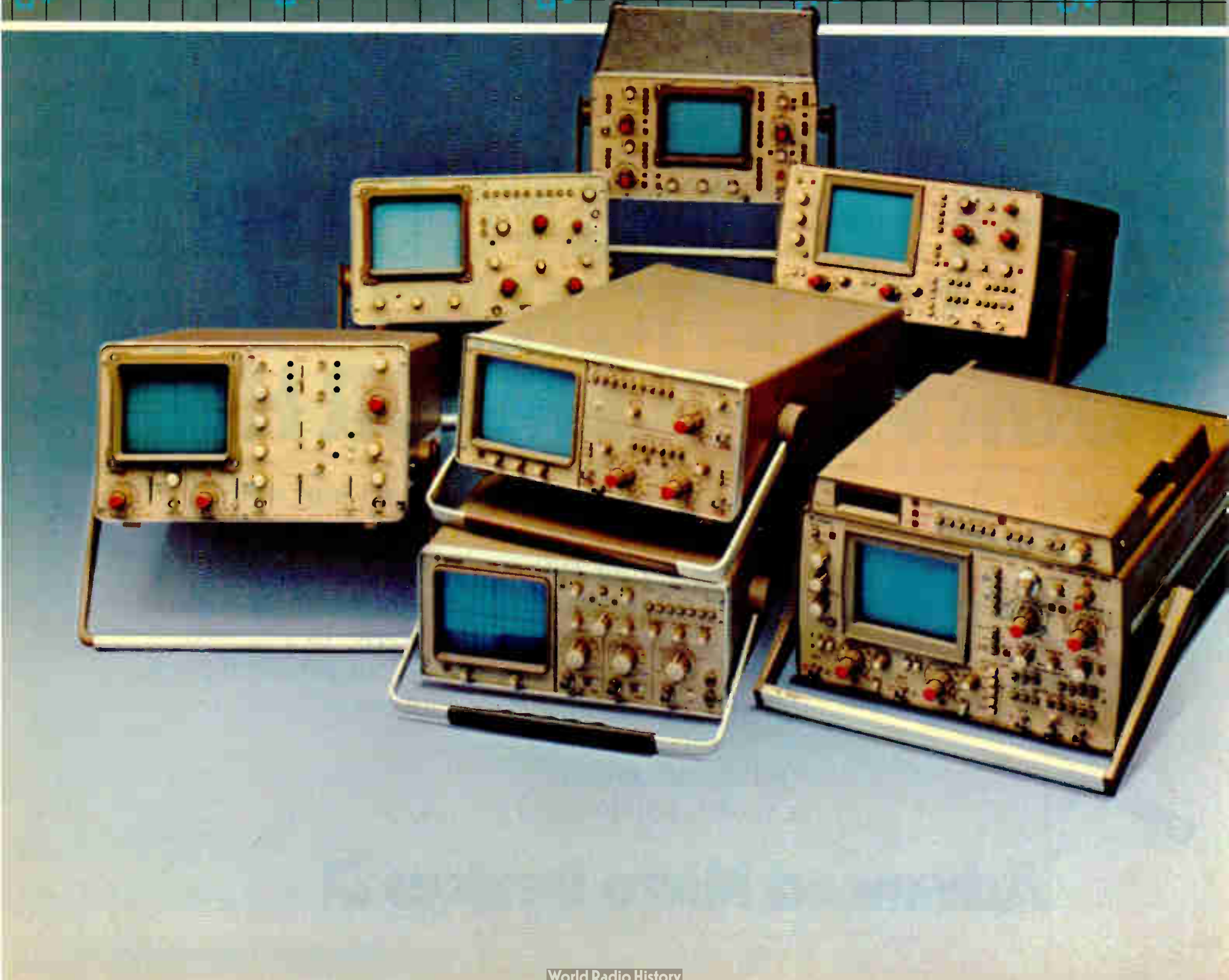

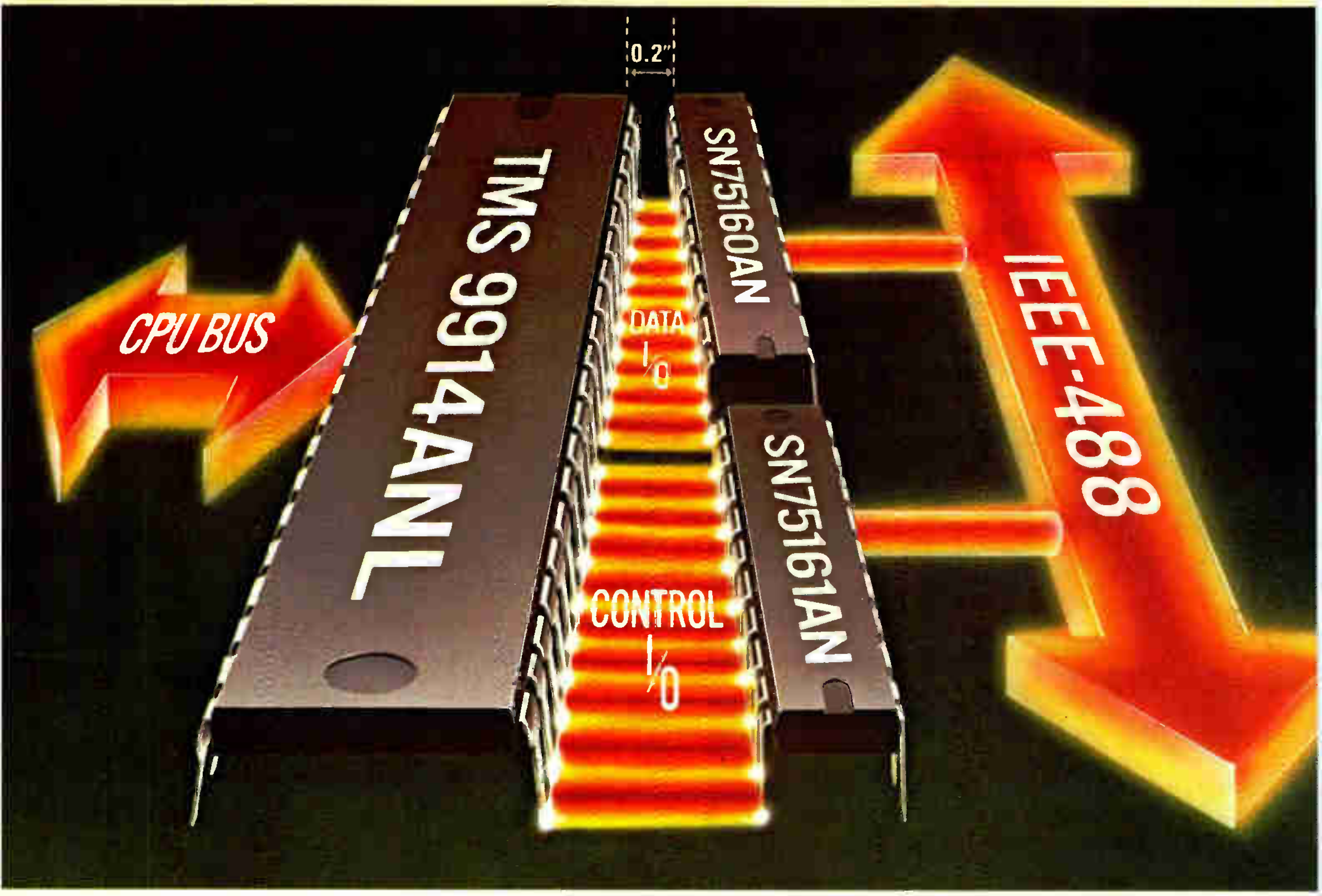

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Motionless optics, diode array focus camera lens

by John Gosch, Frankfurt bureau manager

Experimental chip uses simple method to sample and compare twin images from mirror arrangement

A relatively inexpensive automatic focusing device for lens-shutter cameras could result from an experimental MOS chip developed at the research laboratories of Siemens AG. Significantly, it works without any moving parts. That, together with simple chip design and signal-processing techniques, should help keep the cost for a practical device low.

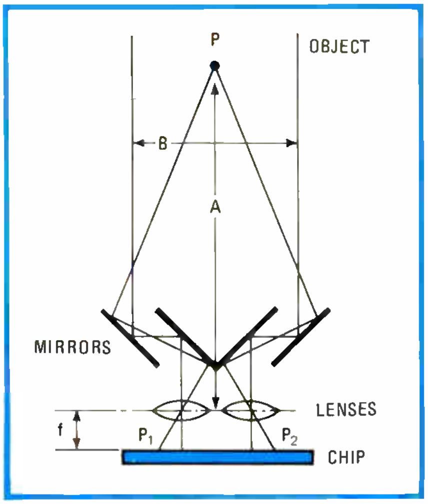
Officials at the Munich company's components division are quick to point out, however, that so far no decision has been made to produce the device in volume. "Some design and test work still needs to be done," cautions Heiner Herbst, one of the developers. He will discuss the device at the Seventh European Solid-State Circuits Conference running Sept. 22 to 24 in Freiburg, West Germany.

The autofocusing device is based on principles known for more than a century. If in the optical module shown in the figure the object P moves toward the two lenses—that is, when the distance A decreases—the two images P_1 and P_2 projected onto the plane move away from each other. The sum of the offsets of P_1 and P_2 from their original points, established when the distance A is infinity, is inversely proportional to A and directly proportional to B and f, where B is the base length of the module and f is its focal length.

In the Siemens device, the projection plane is the chip. It contains two lines of 52 photodiodes onto which the two images of the object are projected by a stationary system of mirrors and lenses. Each linear array samples its image and, with the accuracy of its 24-micrometer diode spacing, determines how much that image is offset.

En route. In operation, an analog signal from a photodiode passes through that diode's individual sense amplifier and is submitted to a comparison process whose outcome is a digital signal. One possibility, Herbst says, is to compare the signals with a reference voltage. But he and his associates chose a simpler method: use the sign of the difference between neighboring samples as a criterion for the comparison.

That way, Herbst explains, the effects of variations in lens, photodiode, and sense-amplifier parameters on adjacent samples are smaller. Also, only 1 bit is assigned to each signal sample—a technique that requires fairly simple circuitry and thus reduces both chip area and power consumption.



No moving parts. Optical schematic shows that the closer object P comes, the more images P_1 and P_2 diverge. In the autofocusing system, chip logic infers image is sharpest when P_1 and P_2 are most nearly identical.

After the integration period, which typically takes 20 milliseconds, the signals from the two arrays are shifted against each other in two phase dynamic shift registers. The degree of correlation is deduced by using an exclusive-OR element and counting the number of individual signals that coincide.

After all signal correlation cycles are performed, a specific cycle exhibits a maximum of signal coincidence. That maximum occurs at a certain focusing range. Finally, signal-processing circuitry produces an output that operates on the lens adjustment mechanism to bring the object into focus.

Fixtures. In the Siemens experimental optical module—it measures about 4 by 1 by 1 centimeter (1.5 by 0.4 by 0.4 inch)—all parts, including the mirrors, are fixed. This is in contrast to some autofocusing systems for cameras now on the market, in which either the mirrors or the diodes tilt. Such schemes, of course, add to a system's price.

To be sure, at least one Japanese camera maker also has an autofocusing device without moving parts. But that system is found only on film cameras, Herbst points out, because it uses complex and elaborate circuitry and is based on an expensive semiconductor technology—not the well-established n-channel MOS technique of the Siemens device.

On top of its low cost comes the

high sensitivity of the Siemens device. It responds to a minimum scene brightness of 4 candelas per square meter, which Herbst calls a relatively low value for a passive autofocusing system. (Active systems sense an object's distance with the aid of an ultrasonic transmitter, for example.)

Many ranges. Also of note is the large number of focusing ranges that the Siemens device provides—15 between 1 meter and infinity, as against the 5 or 6 ranges usual in ordinary low-cost cameras.

The MOS chip in the Siemens device measures about 2.5 by 6 mm. Into that area are packed not only the 104 photodiode and sense amplifier combinations but also a buffer memory, the shift registers, and anti-blooming elements. The latter are two elongated diodes located along the photodiode arrays that drain off the local charge caused by overexposures. The chip's minimum feature size is 5 μm.

Great Britain

Infrared imagers become portable

Infrared imagers that see in total darkness are fast shrinking in size as advances in solid-state technology boost their performance. Once they were bulky tripod-mounted units, but now a new generation of truly hand-held products is emerging.

In the commercial sector, for example, a lightweight (4-kilogram, or 8.8-pound) hand-held pyroelectric vidicon camera is now being evaluated for use by Britain's fire services. With a 70° field of a view, it could be used to guide firemen safely through smoke-filled rooms (see picture). Made by the English Electric Valve Co. of Chelmsford, Essex, it has a built-in monitor but will also connect to a conventional 625-line International Radio Consultative Committee external monitor. Another such device from Thermal Technology Ltd. of Bodmin, Cornwall, is also being evaluated for this purpose.

Less robust versions for industrial and commercial applications have recently been introduced that measure differential temperatures to within 0.5°. Their performance, says John Taylor, managing director of Thermal Technology, has improved out of all recognition since the first pyroelectric systems were introduced four years ago (see "Better heat than light" below).

Military units, too. Defense IR photodetectors are also entering the hand-held era. Class 1 imagers—not to be confused with image intensifiers that work on residual light—for Britain's Common Module Infrared Equipment Program still weigh up to 10 to 12 kg (22 to 26.5 lb). But Marconi Space & Defense Systems Ltd. in Frimley, Surrey, has been showing potential customers a prototype portable imager that at 3 kg (6.6 lb) is a third to a quarter the weight of existing systems yet performs almost comparably and will be cheaper. It consists of a short, thick cylinder with a germanium lens 4 or 5 inches in diameter, plus a built-in eyepiece. Consuming less than 3 watts, it is effective over 0.5 to 2 kilometers (0.3 to 1.2 miles). Vehicle-mounted versions have 5 to 10 times that range.

A first version of the 12-element cadmium-mercury-telluride photo-

Better heat than light

The pyroelectric vidicon is fast emerging as the front runner in commercial infrared imaging equipment. It is fundamentally different in principle from the photodetection systems used in most military systems. The latter employ materials such as cadmium mercury telluride that generate charge carriers internally on being hit by infrared photons. They are more sensitive than pyroelectric detectors, but need to be cooled and require a mechanical scanning system.

The pyroelectric vidicon, on the other hand, suffers from neither disadvantage. It is a thermal detector that measures the heating effect of the incident radiation. In place of the conventional photosensitive surface, it uses a thin slice of pyroelectric material, usually triglycine sulphate. Variations of the electric polarization of the target with temperature distribute charge over the surface in proportion to the quantity of heat absorbed. Neutralization of the charge by the scanning electron beam gives rise to the signal current.

Scanning is therefore electronic (though a simple light chopper is still needed), the angle of view is a wide 70°, cooling is unnecessary, operation is in the 8-to-14-micrometer-wavelength window—and the cost is lower. But image quality was inadequate until the latest equipment came on the market using pyroelectric vidicon tubes from companies like English Electric Valve Co. in England, Thomson-CSF in France, and Philips Industries Ltd. **-K.S.**

detector system is cooled by liquid nitrogen to 200 K to reduce thermal noise and increase its sensitivity in the 12-to-14-micrometer–wavelength window. These longer wavelengths allow greater visibility through smoke and mist and of objects at room temperature. A subsequent version uses a more compact heat pump and operates at 77 K. (A similar product from MEL, a division of Philips Industries Ltd., is based on a cadmium-mercury-telluride in-line detector from its sister company, Mullard Ltd. in Southampton.) Marconi plans to bid with a U. S. partner for an upcoming U. S. gunsight program.

Underpinning these advances in defense gear is the development of more sensitive photodetecting materials. The properties of cadmium mercury telluride, for example, were discovered at Britain's Royal Signals and Radar Establishment whose latest application of it even processes signals to some degree within the crystal itself.

Sprite. Called Sprite, for signal processing within the element, it is intended for use in high-performance serial-parallel scanned imagers in which the image is scanned a line at a time across the detector array by a rapidly rotating prism. As each line is completed, a flapping mirror shifts the image vertically. During each line scan, the infrared image, composed of a sequence of picture elements, or pixels, is swept along the detector row, producing a practically identical signal in each detector—though incrementally delayed by the time needed to scan the pixel between detectors.

The signal-to-noise ratio can be improved by adding these signals, introducing a delay between successive detector outputs to compensate from the scan delay. Each detector element typically requires its own preamplifier and delay circuit housed outside the Dewar cooler.

The Sprite detector does away with this additional circuitry, performing summation and delay within a single homogeneous strip of cadmium mercury telluride mounted on a sapphire substrate. Only three connections have to be made to it—a collector and two bias connections.

When a small region in the strip is exposed to infrared radiation, excess current carriers are generated there and drift towards the collector region under the influence of a bias voltage. By careful choice of bias voltage and system scan rates, this drift velocity can be matched to that with which the image line is scanned across the strip.

Sensitive. Consequently, excess carriers are swept along the strip in step with the infrared image, until all arrive in the readout region simultaneously. A single preamplifier boosts the detector output.

The Sprite detector, now being manufactured by Mullard, incorporates eight such strips fabricated monolithically, while a novel method for making connections allows the ends of the strips to be aligned without staggering, thus simplifying the parallel-scan electronics.

With an information rate of 10^6 pixels per second from each element, the Sprite is designed for the very highest-performance class 2 and class 3 imagers, offering full CCIR 625-line compatibility. **-Kevin Smith**

Japan

Experimental camera records color slides on small disk for display on TV set

Some Japanese may be taking color slides on 4.5-centimeter ($1^3/_4$-inch) floppy magnetic disks within two years. Sony Corp. chairman and chief executive officer Akio Morita claims this will give his firm enough time to produce and then market in Japan (but not overseas) a video slide camera that picks up video signals by means of a charge-coupled device and records them on the disk. He envisions that camera creating a new market, rather than replacing film cameras.

On trial. At present, only experimental prototypes exist, but for the eventual production models Morita quotes prices of $650 for the camera, $2.60 for a floppy disk that holds 50 slides, and $220 for a playback unit that displays the disk contents on an ordinary TV set. This unit accesses the desired slide (or frame) directly even from a partially recorded disk.

Moreover, such a disk can be reinserted in the camera, for a built-in counter in the disk sheath tells the camera where the remaining blank frames start.

A hard-copy printer is in development, but print size will initially be limited to 12.2 by 17.78 cm (5 by 7 in.) or smaller. The company also expects to provide an adapter for telephone-line transmission.

Familiar. The experimental camera prototype is called Mavica, for magnetic video camera. In size and weight, it is like a standard 35-millimeter single-lens-reflex camera: it measures 13 by 8.9 by 5.3 cm (5.1 by 3.5 by 2.1 in.) and weighs 800 grams (1.76 lb).

Another similarity is that it takes pictures at the same lighting levels as ASA 200 film. The Mavica controls exposure via the amplitude of the video signal recorded on the disk and in the prototype form has just one shutter speed of $^1/_{60}$ second.

The camera uses the same frame-transfer CCD color sensor as Sony's video camera-recorder does [*Electronics*, July 17, 1980, p. 48] and in

Future focus. For all its resemblance to a single-lens-reflex camera, this experimental video-disk camera will not aim to replace film units but to create a new market.

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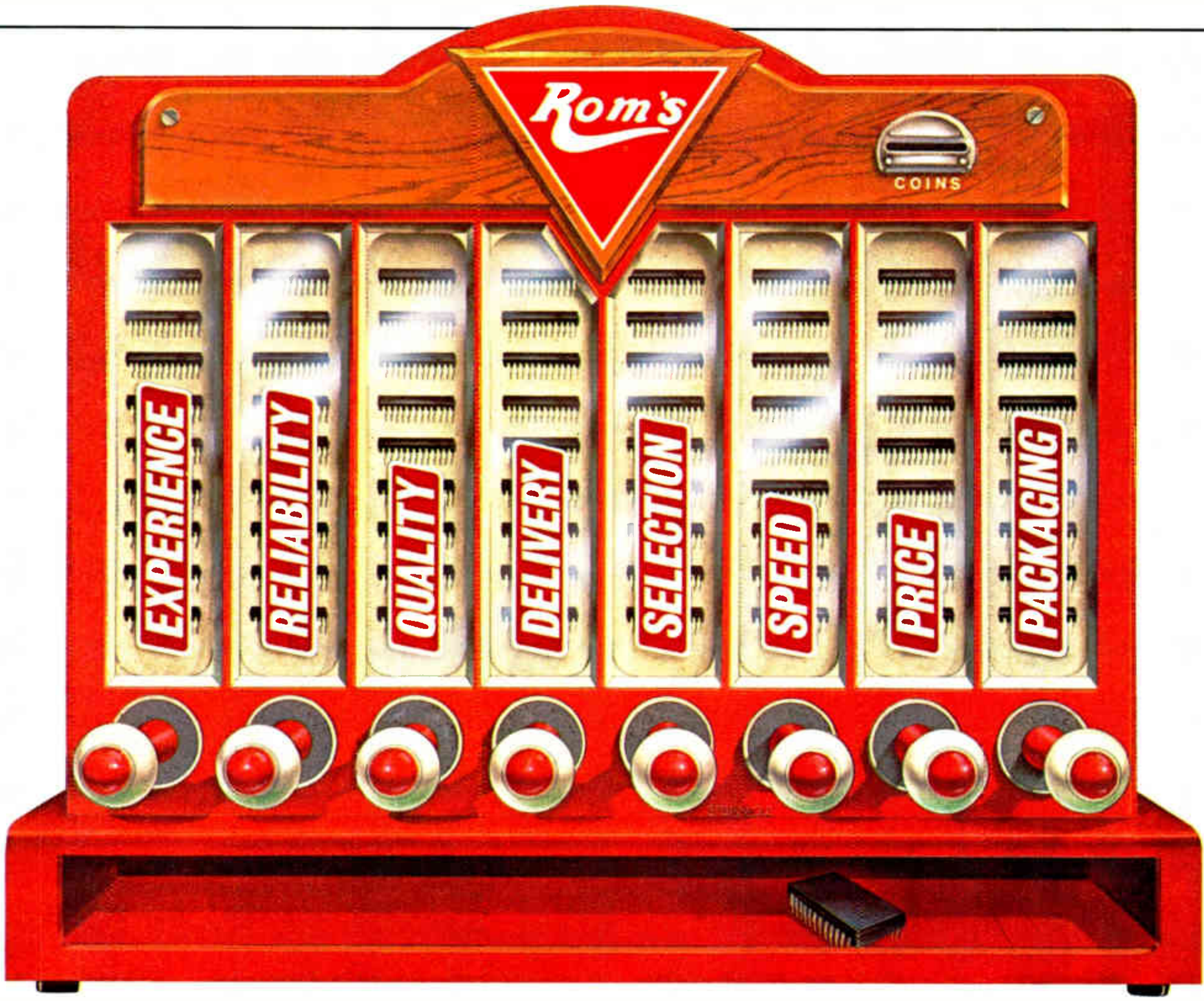

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*BYTEWYDE is a trademark of Mostek Corporation fact can be adapted for use as a video movie camera. Signals picked up by the CCD are recorded on the disk in a 1-cm-wide ring with an inner and outer diameter of 3 and 4 cm. That configuration makes the length of the track for each field approximately the same as in Betamax video-cassette recorders. But a metal-coated medium, with characteristics similar to the quarter-inch tape in Sony's camera-VCR, gives better performance.

Since the signal source is not an NTSC signal, as it is in video-cassette recorders, there is freedom in selection of recording frequencies. That and the wider bandwidth available make it possible to record the chroma difference signal as a frequency-modulated carrier with a bandwidth of 1 megahertz. By way of comparison, VCRs record the color difference signal as an amplitude-modulated carrier with a 0.5-MHz bandwidth.

Rich color. The wider bandwidth and the better signal-to-noise ratio of the chroma signal are specially apparent in large saturated-color areas of still slides. The ability to record the luminance signal with a full 4.5-MHz bandwidth also adds to picture quality. Nobutoshi Kihara, general manager of the video tape recorder engineering development division, says that the recorded information is 50% greater than on Sony's Beta III VCR.

The prototype disk pack is called a Mavipak. Although at 6 by 5.4 by 0.3 cm (2.4 by 2.1 by 0.12 in.) it is smaller than the one developed earlier by Sony for business machines [*Electronics*, Jan. 13, p. 46], its rigid plastic sheath is similar, as is the disk's solid hub. Each side of the disk is recorded as one field during one revolution on a track 60 micrometers wide, with a 100-μm center-to-center track spacing. Only one of the two interlaced fields displayed on the TV screen is recorded. The second field is synthesized by processing the recorded signal.

Sony does not expect at present to build a different camera for countries using PAL and Secam television standards. Instead, says Kihara, the playback units will be designed to convert the NTSC recording into the requirements of the European standards, basically by inserting an extra horizontal line after every fifth line. In the future, though, the company may make cameras with high-resolution design that resembles the equipment it showed in April [*Electronics*, May 5, 1981, p. 72] when it is able to make equivalent sensors in the far-off future.

Before the camera is offered for sale, Sony may add either an electronic or a mechanical shutter. It is also possible that the company will foresake the ability to use the camera for taking video movies because a camera for still pictures only could be built with a much brighter viewfinder than the one the prototype has. **-Charles Cohen**

Film stops electrons leaving molybdenum

Because of its low resistivity, molybdenum seems a much better bet than polysilicon for the extremely narrow interconnections and gates that will characterize tomorrow's high-speed, high-density memory chips. The problem has been that threshold voltages in molybdenum gate devices tend to be unstable because of impurities in the metal to start with or generated during processing produce mobile ions.

But a group headed by Koichi Kugimaya at the Semiconductor Research Laboratory of Matsushita Electric Industrial Co. in Osaka, Japan is confident it has licked the problem with a highly reproducible molybdenum-gate fabrication technology. In three separately fabricated lots of ring oscillators, the threshold voltage variation of MOS field-effect transistors with 1-micrometer-long gates fell within ±0.1 volt both as fabricated and after 24 hours of operation at 125°C.

On the level. Another advantage of such a process is that gate and line height is low enough to create an essentially planar surface. This eases the creation of multilevel interconnections, for it eliminates the need for extra processing steps to fill in low-lying regions.

The Matsushita group started from the observation that silicon nitride film stops mobile ions. Accordingly, in their experimental devices they interpose a 20-nanometer-thick nitride film between the 30-nm-thick oxide gate insulator and the molybdenum gate. A second nitride film above the gate prevents mobile ions from entering the overlying passivation oxide.

To create the nitride film, a plasma chemical-vapor deposition process is used in which the wafer is heated to 300°C to deposit the nitride from ammonia and silane. A nonplasma process heats the wafer to 700°C, creating molybdenum nitride and raising contact resistance.

Ring oscillators of 21 and 101 stages using enhancement-depletion inverters were fabricated to verify the technology. The starting material was p-type <100> silicon wafers with a resistivity of 10 to 15 ohm-centimeters. Punch-through in the enhancement transistor is suppressed by a boron ion implantation with a surface concentration of 1.5×10^{16} atoms per cubic centimeter.

The threshold voltage of the enhancement transistor is 0.9 V, while that of the depletion transistor is adjusted to −2.7 V. The molybdenum film for gates and interconnections is deposited by direct-current magnetron sputtering to a thickness of 300 nm. It has a resistivity of 0.3 ohm per square.

Low power. An asset of the enhancement-depletion geometry is that gate propagation delay decreases very little for low power-supply voltages of the kind that will be used in future very large-scale integrated circuits. When operated from a 2-V supply, the 101-gate ring oscillator has a propagation delay of 450 picoseconds and a power-delay product of only 11 femtojoules. Thus Kugimiya concludes that the process technology is suitable for very high-speed high-density VLSI chips.

A paper on this work will be given by the researchers at the 1981 Symposium on VLSI Technology in Hawaii on Sept. 9. **-Charles Cohen**

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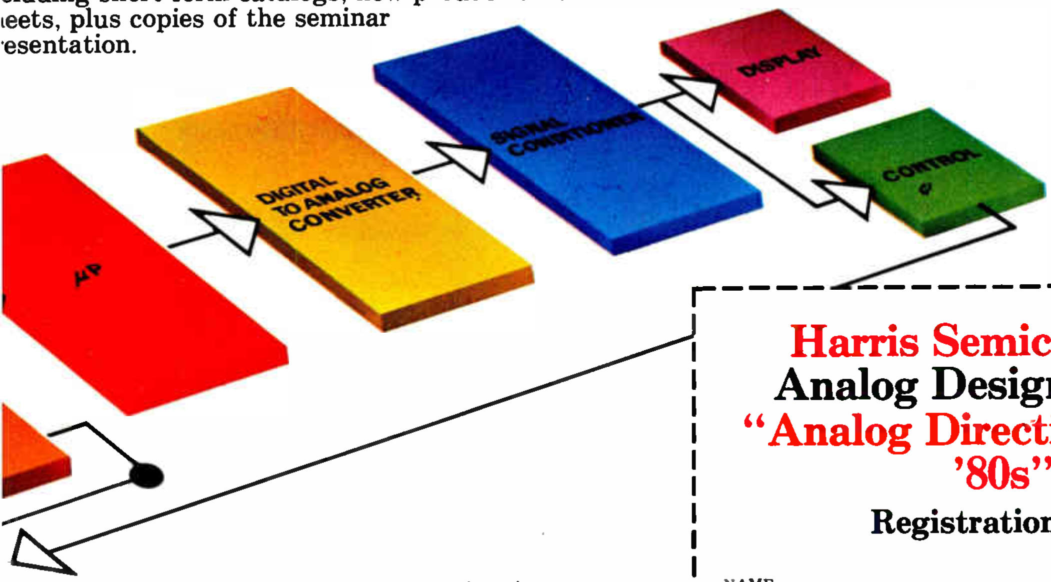

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Designed with

If you could design your own µC before you designed your next µC-based system, you'd probably specify the following features:

- 8048 type instruction set
- hardware serial I/O and multi-transmitter capability
- choice of memory capacity
- three interrupt possibilities
- full support services
- fast, reliable delivery.

Add all that up and you'd be specifying our new 8400 µC family, one member of which is almost certainly exactly right for you.

Europe's foremost µC family
The 8400 family is Europe's foremost µC family and an exciting new development. It's firmly based on the 8048, which we manufacture in both the USA and Europe. The 8400, however, has hardware serial I/O and multi-transmitter capability. Both these features are ideal for many of the applications listed below.

Another significant feature of the 8400 family is the wide choice of memory capacity. This currently extends to 4K of ROM.

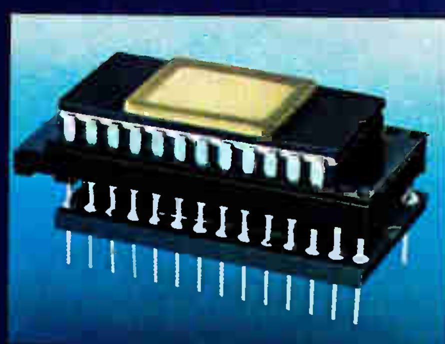
True single-chip systems
The advantages of the 8400's design are obvious. There's no need to add other chips when you add up your memory requirements. Your software gets simpler because the serial I/O and multi-transmitter facilities simplify communication between µCs and peripherals. And simpler software makes more effective use of available ROM capacity.

These innovative hardware features are due to the 8400's flexible architecture. This will also allow hardware customisation to be offered for large-volume applications, which could well be the competitive edge you're looking for in today's increasingly look-alike marketing world.

THE 8400 FAMILY. IDEAL FOR:

Audio | Video | Home Appliances
Telecoms | Office Equipment
Instrumentation | Process Control

The Philips Group of Companies
Austria: ÖSTERREICHISCHE PHILIPS BAUELEMENTE Industrie G.m.b.H., WIEN. Tel. 62 91 11. **Belgium:** M.B.L.E. BRUXELLES. Tel. 523 00 00. **Denmark:** MINIWATT A/S, KØBENHAVN. Tel. 69 16 22. **Finland:** OY PHILIPS AB, HELSINKI. Tel. 1 72 71. **France:** R.T.C. LA RADIO TECHNIQUE-COMPELEC, PARIS. Tel. 355 44 99. **Germany:** VALVO, UB Bauelemente der Philips G.m.b.H., HAMBURG. Tel. 3296-1. **Ireland:** PHILIPS ELECTRICAL (IRELAND) LTD. DUBLIN. Tel. 69 33 55. **Italy:** PHILIPS S.p.A., MILANO. Tel. 2-6994. **Netherlands:** PHILIPS NEDERLAND B.V., EINDHOVEN. Tel. 79 33 33. **Norway:** NORSK A/S PHILIPS, OSLO. Tel. 46 38 90. **Portugal:** PHILIPS PORTUGUESA S.A.R.L., LISBOA. Tel. 68 31 21. **Spain:** COPRESA S.A., BARCELONA. Tel. 301 63 12. **Sweden:** A.B. ELCOMA, STOCKHOLM. Tel. 67 97 80. **Switzerland:** PHILIPS A.G., ZÜRICH. Tel. 43 22 11. **United Kingdom:** MULLARD LTD, LONDON. Tel. 580 6633. **U.S.A.:** SIGNETICS CORPORATION, SUNNY VALE, Tel. (408) 739-7700. **Other countries:** Philips Industries, Electronic Components and Materials Division, Eindhoven, The Netherlands.



The ROMless 8400 employs a 4 or 8 K EPROM that plugs on top. Apart from program memory, it provides the same functions and has the same pin-out as the rest of the family.

PHILIPS Electronic Components and Materials

you in mind

The 8400 family is therefore a cost-effective, single-chip answer to a wide range of application requirements.

The current range
Right now the 8400 family looks like this:

Type No.	ROM K bytes	RAM bytes
8400	piggy-back	128
8405	0,5	32
8410	1	64
8420	2	64
8440	4	128

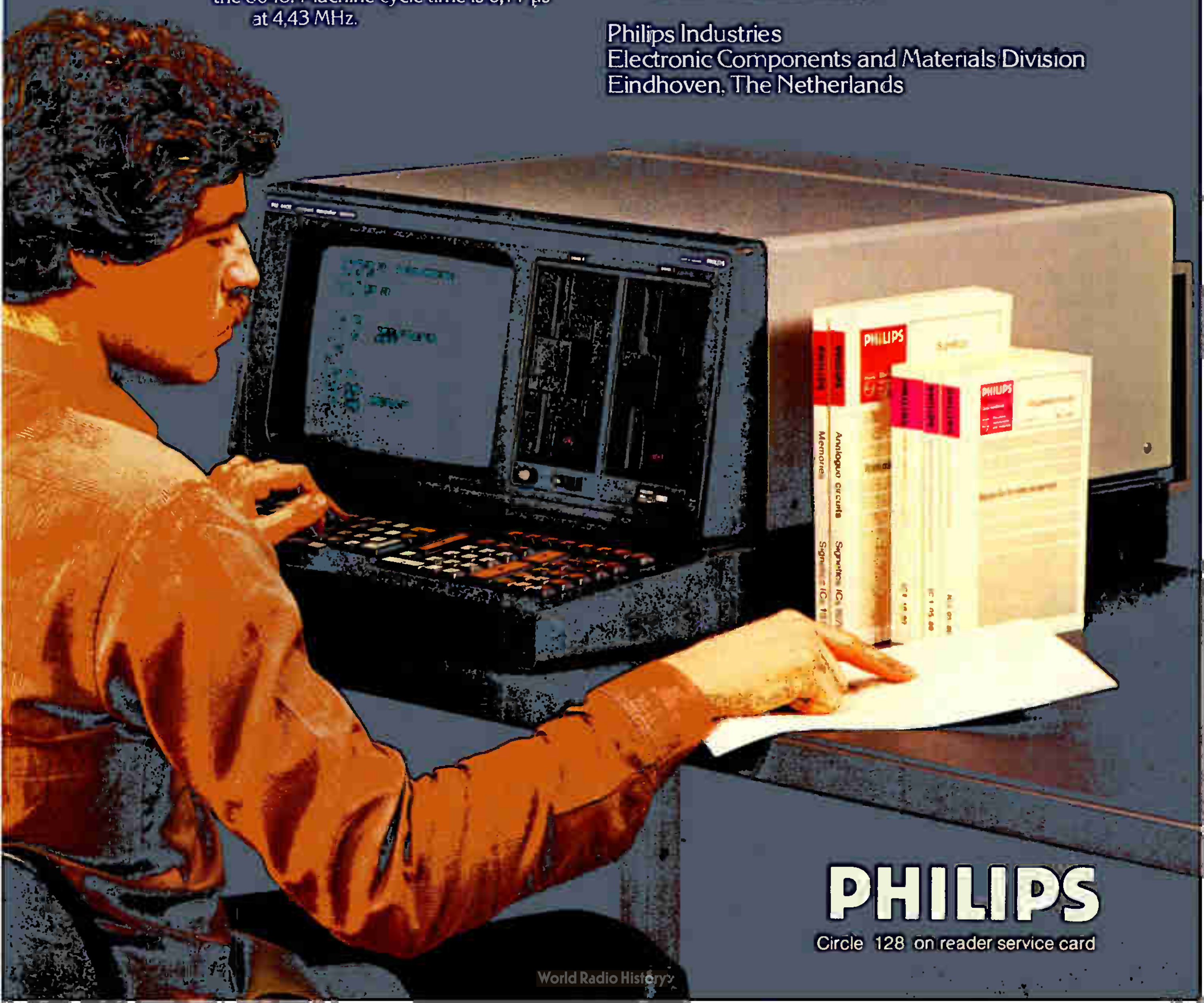
Basic spec. details are as follows: 8-bit CPU, ROM, RAM, timer/event counter and 23 I/O lines in a single 28-pin package. Instruction set is about 90% the same as that of the 8048. Machine cycle time is 6,77 μs at 4,43 MHz.

Easy development
With Philips you have three routes to easy development. One, the low-cost design aid PM 4300 for evaluation, prototyping and debugging. Two, the Philips Microcomputer Development System (PMDS), illustrated below, which is a complete development lab in itself, able to handle every 8400 family operation from preliminary design through to the final integration of hardware and software. And three, the ROMless 8400 shown below left, which employs a 4 or 8 K EPROM and is therefore ideal for prototyping, testing and low-volume production.

Nor are the PM 4300 or the PMDS limited to the 8400 family, but can handle all popular μC and μP types. Which is yet another feature we designed with you in mind.

Send for details today.

Philips Industries
Electronic Components and Materials Division
Eindhoven, The Netherlands

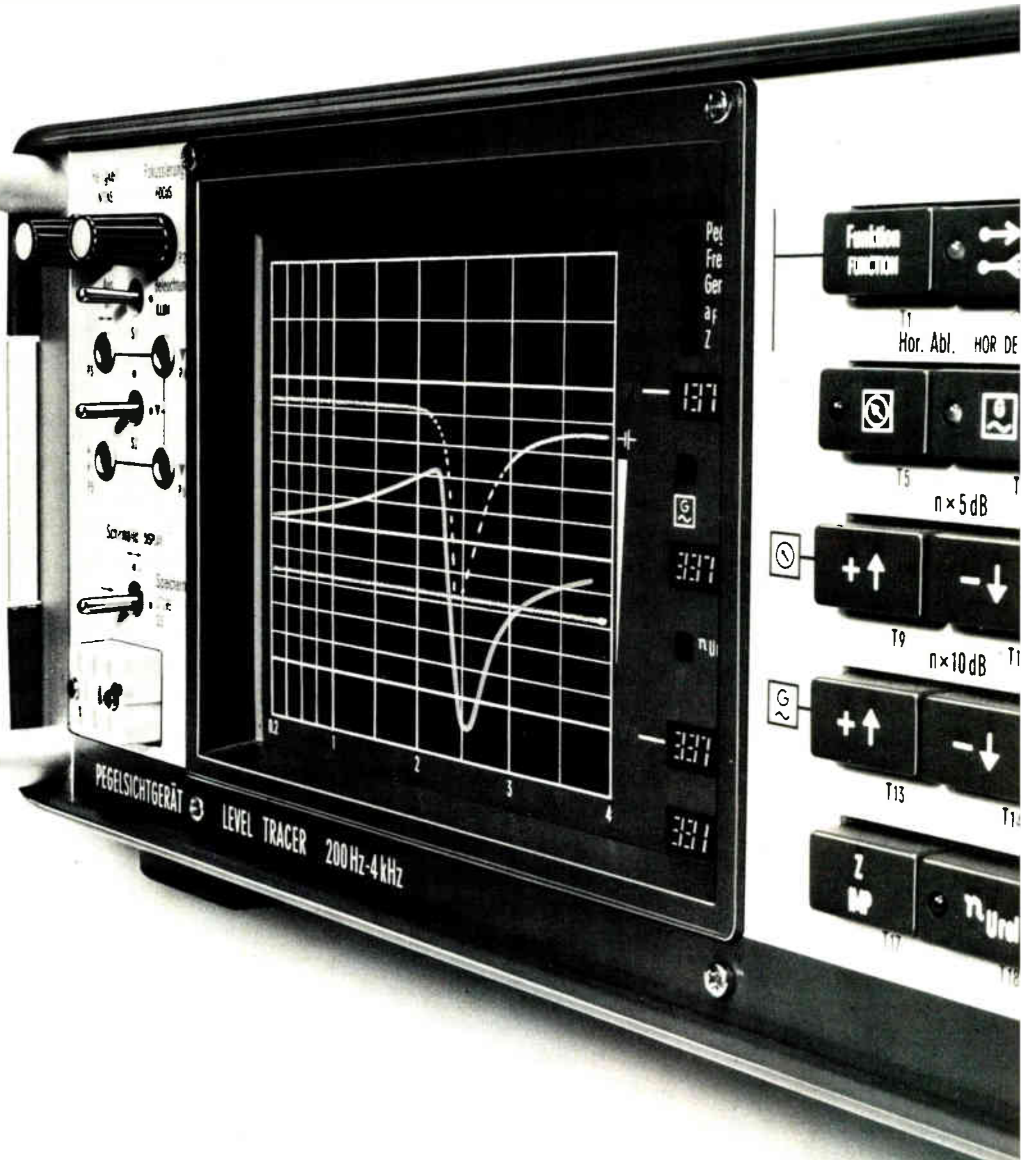


SIEMENS

Results storable

Level tracer 200 Hz to 4 kHz

The K2202 level tracer by Siemens with CRT display of stored results is as easy to operate as a pocket calculator and as handy as a portable radio. Yet it is a full-scale swept-frequency test set capable of measuring all major VF equipment parameters in telecommunication networks, e. g. level (including relative level), return loss, weighted and unweighted noise and impedance. Thanks to a digital store, the measured variables are displayed with a constant repetition rate, resulting in a flicker-free image. The trace can be presented in three ways: as a single curve, in combination with a stored reference curve or as forward and return traces (solid and broken lines).
The exact level and frequency (accurate to 1 Hz) of any point on the screen can be read off. Further details and information on this new level tracer can be obtained from the specialist advisers at Siemens branch offices, or write to:
Siemens AG, Info-Service,EI
Postfach 156, D-8510 Fürth.



Siemens communications test equipment

Circle 129 on reader service card

Traveling-wave tube's brazed construction helps heat escape

by Robert T. Gallagher, Paris bureau

Copper helix is brazed to support rods in air-cooled, 3-kW, 6-GHz tube for earth-station transmitters

By using a brazed helix technology, the Electron Tube division of Thomson-CSF has developed, with the support of the French telecommunications agency, a high-output traveling-wave tube that is particularly light and compact and at the same time offers exceptional life expectancy. Designed for use in telecommunications-satellite earth stations built to Intelsat VI specifications, the TH3640 operates in the 5.925-to-6.425-GHz band and delivers a minimum output power at saturation of 3 kW.

"There are three ways to design a tube to these specifications," says Jean-Jacques Giraud, an engineer in the ultrahigh-frequency department of Thomson-CSF's Electron Tube division. "Usually they are made by the coupled-cavity method or by the hot-fitted helix method. We, however, braze the helix, and this offers a host of advantages. I feel quite certain that we are the only manufacturers currently capable of creating this type of tube in this way."

The Thomson-CSF tube consists of a copper helix brazed to three beryllium oxide support rods, which are in turn brazed to a copper sleeve. The structure boasts low thermal contact resistance, high heat dissipation capacity, and very small radio-frequency losses.

Compared with the other two possibilities, the brazed-helix method offers some obvious advantages. In the pressed, or hot-fitted, helix method a tungsten helix is forced with three dielectric insulating rods (usually quartz, alumina, beryillia or boron nitride) into a stainless steel sleeve. The materials are chosen in part for their elasticity to accommodate manufacture, and they are not up to the quality of materials chosen solely for their operating performance. The hot-fitted units show poor thermal contact resistance and even worse heat dissipation. The coupled-cavity method avoids these pitfalls, but cannot match the efficiency of helix-based tubes for telecommunications applications.

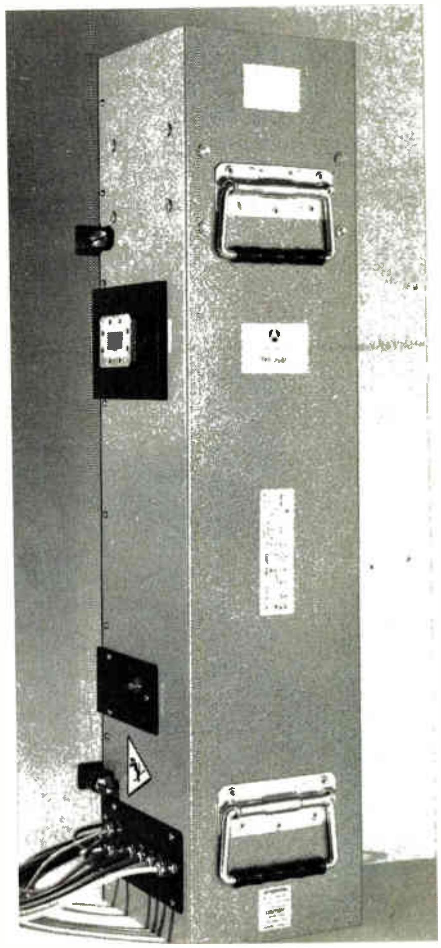
Cool behavior. "Perhaps one of the more significant advantages of our brazed-helix method is that its heat-dissipation efficiency allows it to be completely cooled by compressed air," points out Giraud. "A hot-fitted tube of these specifications would require water-cooling, and that is a fatal flaw, given the high voltage required in an earth station."

Using a dispenser-type cathode made of specially treated barium-impregnated tungsten, the tube has an estimated life of more than 10,000 hours. Its life can be further prolonged because the electron-gun design permits readjustment of the cathode current as the tube ages, without changing the helix voltage.

The tube is 20 by 20 by 85 cm and weighs about 25 kg. It has a collector voltage of 9 kV, shows a minimum gain at rated power of about 50 dB with an amplitude modulation/phase modulation conversion factor of 3°/dB and a noise figure of 33 dB.

Surprisingly, the price of the TH3640 may well be lower than its competition. "We shall not be publishing a price as this type of equipment is supplied only on a bid and contract basis. But I feel certain that it will be significantly lower than anything comparable," says Giraud. The company expects to deliver its first TH3640 TWTs during the first half of 1982.

Thomson-CSF Electron Tube Division, 38 rue Vauthier, 92100 Boulogne-Billancourt, France [441]



Functional system tests microprocessor boards

Because so many printed-circuit boards today are built around microprocessors, it makes sense to devise functional test strategies and even test hardware that exploits the microprocessor's inherent bus structure. That at least is the philosophy adopted by the designers of Columbia Automation Ltd.'s new dynamic functional test system, which has been engineered specifically to exercise microprocessor boards.

Test boards are exercised by applying test stimuli through the printed-circuit board edge connector or a test probe that clips over the installed microprocessor, creating a high-impedance state so that the board is tested as if the microprocessor socket were empty. Most microprocessors, says Mike Portsmouth, a Columbia Automation engineer, can be held in this state.

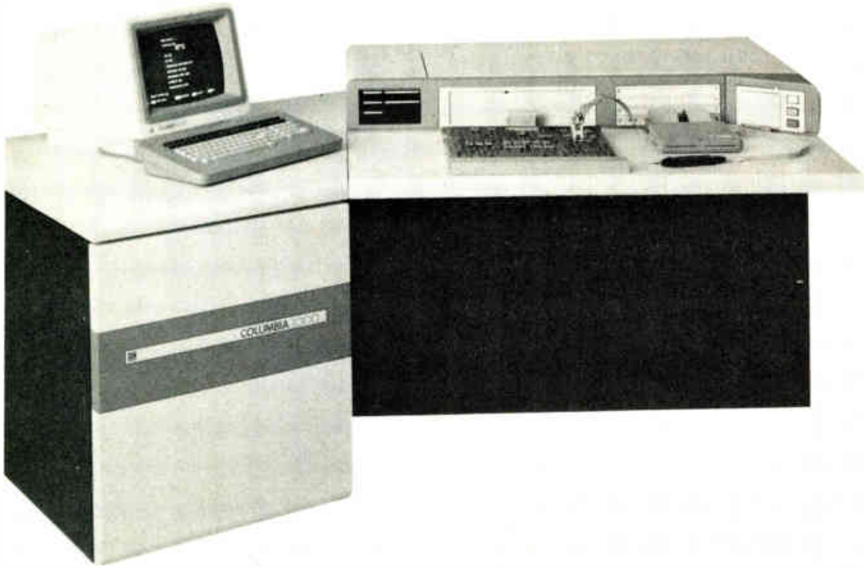
The board can now be exercised in three separate stages. First, static devices on the board are addressed and exercised through the bus. Second, the dynamic memory parts are exercised. The microprocessor is exercised last, in what is by this stage a known good board. In this last stage, the microprocessor probe acts as a monitor only.

The large-scale integrated test interface for this mode of operation has a 16-bit data bus and a 24-bit address bus and can cycle at 10 MHz. Non-structured medium-scale integrated parts can also be tested by applying test patterns on specified board pins and observing the response for up to 300 lines.

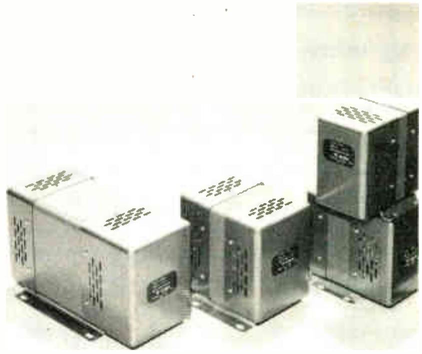
Programming is simplified by high-level dynamic instructions: short program statements can call up long test sequences—often generated by hardware modules—to fully exercise dynamic random-access memories and other parts. Diagnostic aids include signature analysis and transition-counting techniques. These techniques can locate faults quickly and accurately.

Though the Columbia 2000 is primarily a digital functional tester, it does incorporate an IEEE-488 bus controller that can control up to 14 instruments simultaneously. The system can therefore test simple hybrid boards that carry circuitry with some analog functions.

Columbia Automation Ltd., Hanover Way, Windsor, Berks., England [475]



The T357 discrete semiconductor test system probes wafers, conducts final and quality-assurance tests, and in general evaluates a wide range of devices. It has a 64-K-byte memory, dual 3M tape drives, and software. Teradyne Ltd., Clive House, Queens Road, Weybridge, Surrey KT13 9XB, England [442]



The GT range of constant-voltage transformers eliminates line noise and stabilizes normal line-voltage variations. Line and load regulation is better than 8%; noise attenuation exceeds 1,000: 1. Gould Power Conversion Division, Rhosymedre, Wrexham, Clwyd. LL14 3YR, England [443]

The PCA-3 pulse-code-modulated codec analyzer is a reference decoder for single-channel PCM signals. Testing follows recommendations of the International Consultative Committee for Telegraphy and Telephony. Wandel & Goltermann, P. O. Box 45, D-7412 Eningen, West Germany [444]

The SM-Relay from ITT:
Hermetically sealed*

Ringelimperialfish «Pomacanthus annularis»

Key characteristics of the SM Relay:

- Extremely small dimensions: 15,7 x 12,8 x 9,5 mm
- Various rated voltages from 5, 12, 24 to 48 V
- Reliable switching from dry circuit to 30 VA≃
- Large voltage range: 3,55...100 V at 20 °C
- Wide ambient temperature range: −40...+85 °C
- Outstanding component climatic category 40/085/56
- High shock resistance: half-sine shock, duration 11 ms: >15 g
- Superb vibration resistance: sinusoidal vibration between 10 and 500 Hz: >15 g
- Top mechanical endurance: $>2 \times 10^8$ operations

* Sealed in epoxy resin

- No problem with automatic wave soldering
- Best protection against flux
- Makes PC board cleaning an easy job
- Reliable performance even under unfavourable environmental conditions

Circle 131 on reader service card

ITT Components Group

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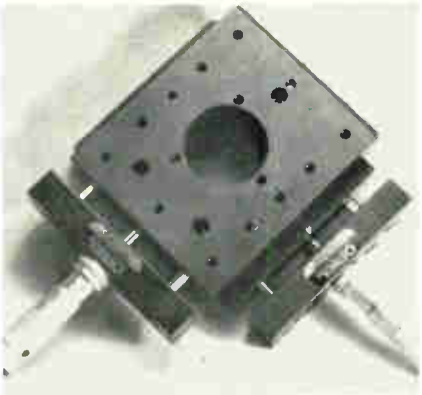
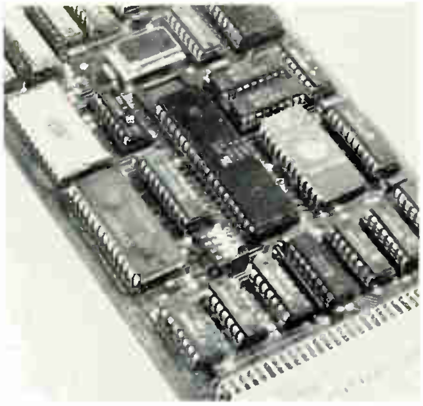
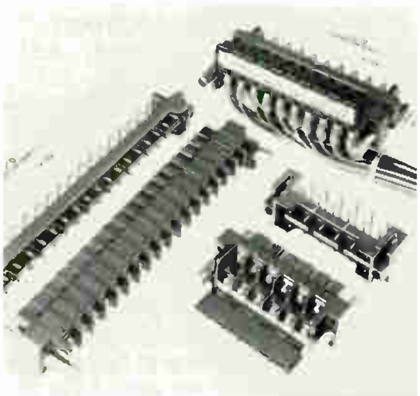


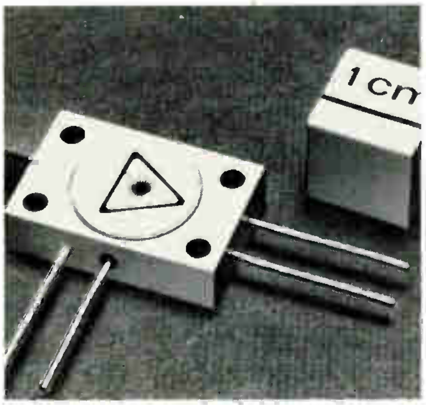
Linear and rotary position-translation devices can be stacked to produce stages with up to three translations and three rotation axes. Their resolution is typically below 1 μm and 0.05 second of arc. Oriel Scientific Ltd., P. O. Box 136, Kingston-upon-Thames, Surrey KT1 1QU, England [445]



The Eurocard module ECB/CV provides alphanumeric and semigraphic outputs of six colors plus black and white for videotex displays with 24 lines of 40 characters. It is used as an interface in microcomputer control systems. Kontron, Breslauer Str. 2, D-8057 Eching, West Germany [449]



The AMP I/O series of Multi-Tap two-piece connectors contain terminal blocks that eliminate the need to remove screws as a result of miswiring or defective components. Insertion and withdrawal force requirements are low. Amp Ltd., 7-15-14 Roppongi, Minato-ku, Tokyo 106, Japan [447]



The LS-7754 gallium-aluminum-arsenide laser diode has a long operating life (it has been operated continuously for five years) and a bandwidth of up to 1 Gb/s. It couples 3 mW into a glass fiber with a 50-μm core. ITT Components Group, Platenstr. 66, D-8500, Nuremberg, West Germany [456]

The type 5807 charge monitor is designed to control production processes. In conjunction with piezoelectric quartz transducers, it measures pressures and forces, stores the peak values measured, and allows two limits to be set. Kistler AG, CH-8408, Winterthur, Switzerland [448]

The Babe bus- and byte-expandable microcomputer system consists of a S-100 computer, display, keyboard, and 80-column printer. It can be upgraded by adding memory, hard-disk drives, or terminals. Digital Devices Ltd., 134 London Rd., Southborough, Kent TN4 OPL, England [457]

Cutting the high cost of micro-system service

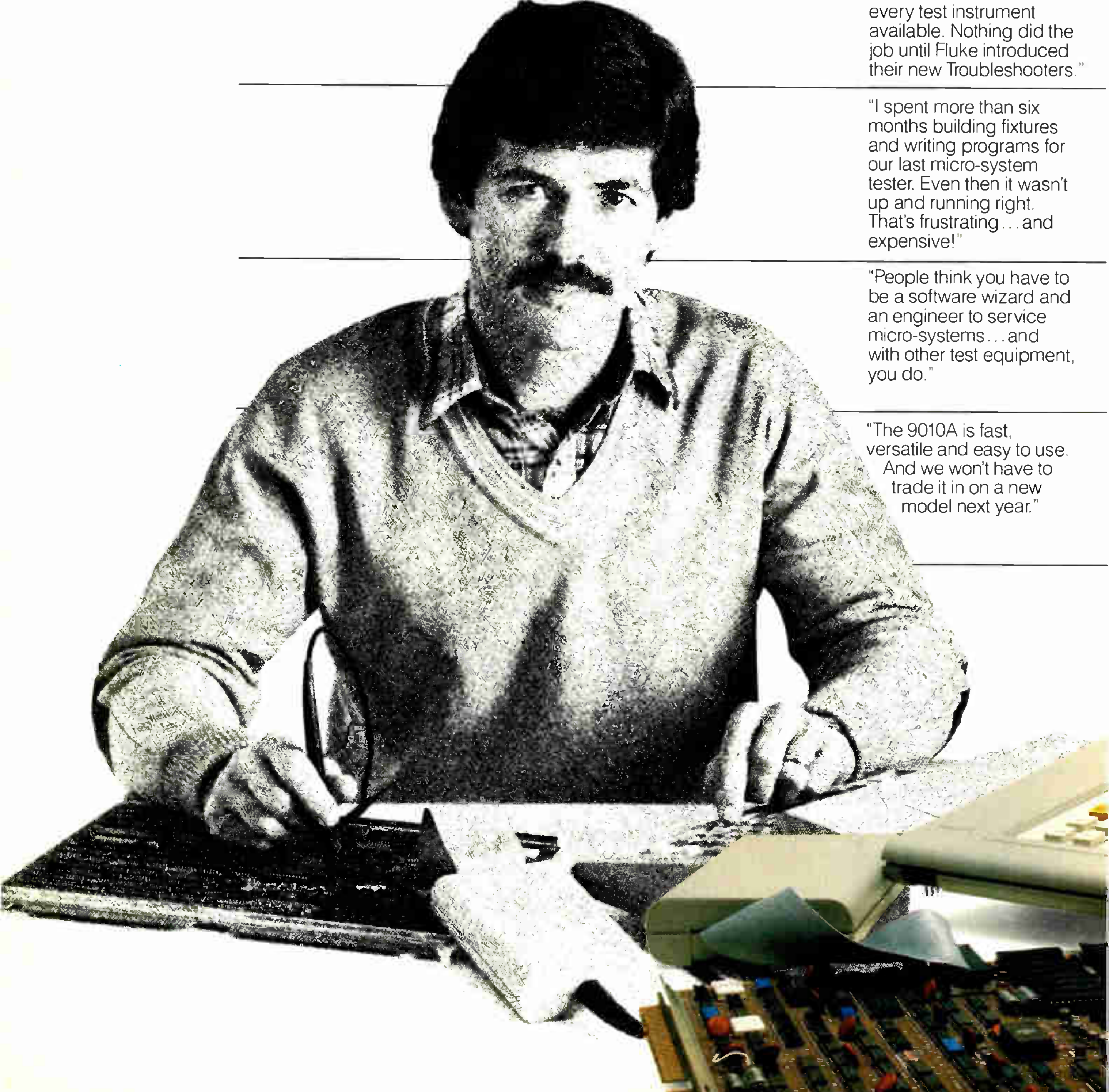
Fluke simpli
micro-system

"Our biggest headache with micro-systems was fault isolation. We tried every test instrument available. Nothing did the job until Fluke introduced their new Troubleshooters."

"I spent more than six months building fixtures and writing programs for our last micro-system tester. Even then it wasn't up and running right. That's frustrating . . . and expensive!"

"People think you have to be a software wizard and an engineer to service micro-systems . . . and with other test equipment, you do."

"The 9010A is fast, versatile and easy to use. And we won't have to trade it in on a new model next year."



fies service

At Fluke, we spent over two years talking to frustrated manufacturing and field service people around the world about this critical problem, and designed the 9000 Series Micro-System Troubleshooters in direct response to their concerns. The 9010A, the first in the series, is available today.

The real value, however, lies in what the 9010A doesn't cost. It frees you from front-end programming, software documentation, signature records and tedious wiring hookups. The 9010A represents a whole new class of service instruments. It lets you start testing today.

Fluke's solution is simple. The 9010A has the most practical interface you'll find: a self-contained pod for each microprocessor type. Just plug into the μP socket of a known good board, press the LEARN key and a revolutionary algorithm goes to work.

The 9010A automatically locates and identifies the RAM, ROM, and read/writable I/O on the bus of the unit under test and stores their characteristics in memory. No need for current software listings; this feature alone can literally save you months of front-end programming time. Operators without extensive training in digital logic can use the 9010A with confidence. . . and without delay.

Not with the 9010A. Automated tests for the entire kernel (RAM, ROM. I/O, power supply and clock) can be run with the push of a button. Also provided: automatic patterns to stimulate components like readouts, print heads, relays, interfaces and CRT's; a unique "loop-on-failure" control for isolating intermittent faults; and a "smart" probe that can be synchronized to μP timing. These features give you a solid head start in developing special programs for off-the-bus testing as well. And the 9010A is fully interactive, so these programs can be generated and debugged directly on-line.

That's right. The 9010A is one of three Troubleshooters Fluke will introduce between now and January 1982. All of them will be fully compatible with 8-, 16-, and 32-bit μP's, All μP-dependent functions are located in the interface pods. Currently available pods include the **8080, 8085, Z80, 6502, 6800** and **9900.**

For details, and a schedule of future pod support, use the coupon below.

FLUKE®

Fast Response Coupon

E1 9/81

IN THE U S AND NON-EUROPEAN COUNTRIES
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☐ Please send me 9000 Series information
☐ I'd like a demonstration. Please contact me.

We use the following microprocessor types in our products ______

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Title ______ Mail Stop ______
Company ______
Address ______
City ______ State ______ Zip ______
Telephone ( ) ______ Ext ______

For technical data circle no. 144

Logical Logic Analysis

The only logical way to analyse multiplexed data is to demultiplex it. Which is just what Philips PM 3543 and '42 Logic Analyzers do.

Moreover both instruments feature a disassembler option, allowing data to be displayed in the same language as the relevant processor.

So what you see, is what you thought and wrote.... for most popular 8- and 16-bit μPs.

Dual clocking enables 37 channels of information to be collected.

Disassembly mnemonics available at the touch of a switch - 8085 shown here.

LAs with dual clocks mean that multiplexed address and data can be captured sequentially, but displayed side-by-side, on the same line. Philips LAs also make the same kind of savings on probe connections as the multiplexed devices make on pins.

This makes PM3542 ideal for 8-bit μCs like the popular 8048, while PM3543 covers all 8-bit and multiplexed 16-bit μPs.

The multiple disassembly option enhances analysis even further by supporting the 8048, 8080, 8085, Z80, 6800 and 6502 in a single package. (Note: a single package supporting 8086/88, Z8000, 6809 and 1802 will be available by end '81.)

Both LAs feature a real-time analysis facility, allowing the software instruction and hardware implementation to be related directly. They also, as an added bonus, function as excellent 35 MHz/2 mV oscilloscopes.

Full details from:

Philips Industries, TQ III-4-62, Eindhoven, The Netherlands.

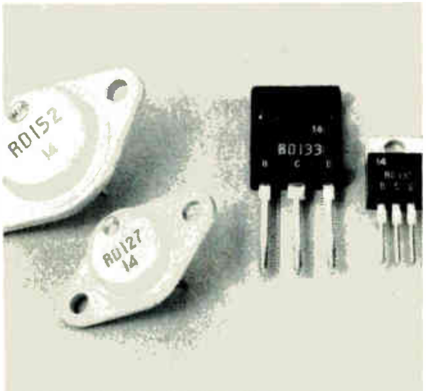
From Philips, of course

PHILIPS

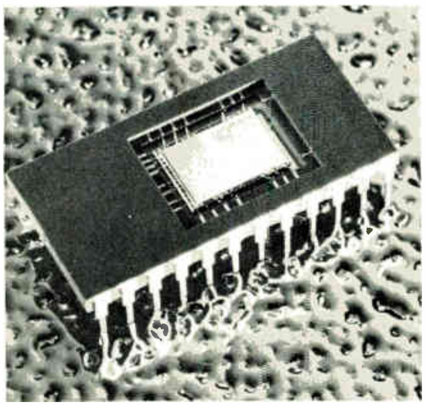
Circle 145 on reader service card

PHILIPS

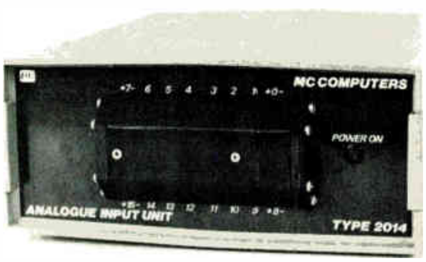
New products international



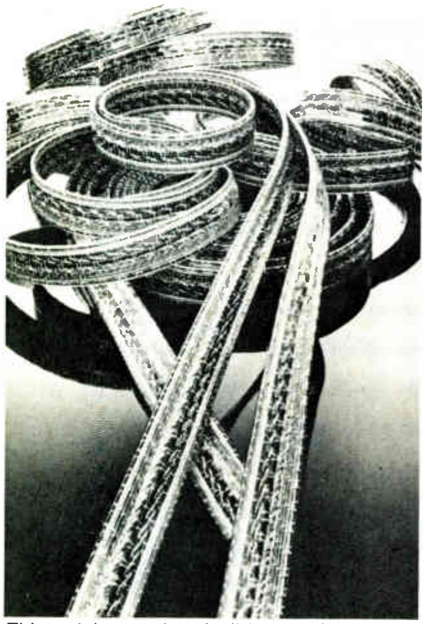
The Base-Island Transistor (BIT) series, for switching power supplies operating over 100 to 200 kHz, have a 40-ns fall time, a saturation voltage of 0.2 V and come in a metal case. Shindengen Electric Manufacturing Co., New Otemachi Bldg. 2-2-1 Otemachi, Chiyoda-ku, Tokyo 100, Japan [452]



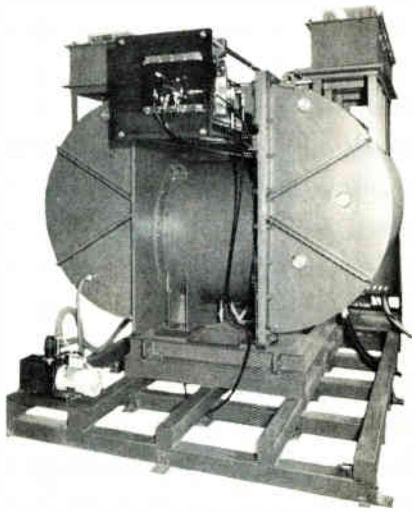
Color images can be picked up by a television camera that employs TH X31135 sensors. These include an area-array biphase charge-coupled device, frame storage, and a readout register. Thomson-CSF, Division Tubes Electroniques, 38 Rue Vauthier, 92100 Boulogne-Billancourt, France [453]



Type 2014 analog input unit, for use with such IEEE-488–compatible microcomputers as the Commodore Pet, accepts up to 16 channels, expandable to 112 channels if additional units are attached to the IEEE-488 bus. MC Computers Ltd., Park Street, Newbury, Berks. RG13 1EA, England [454]

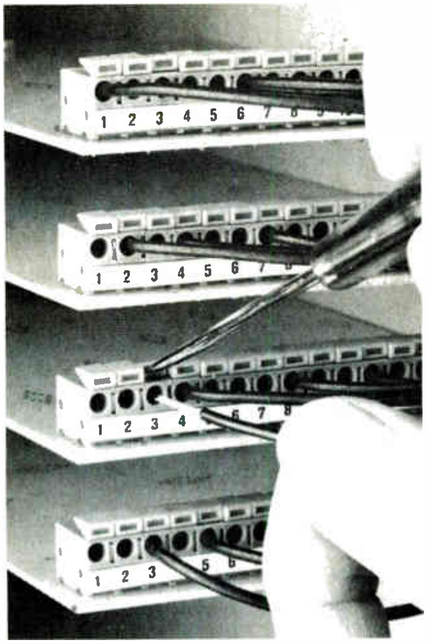


This rainbow-colored ribbon cable has a transparent overjacket through which the user can identify individual wires and spot any damage without removing the outer cover. Tekdata, Westport Lake, Canal Lane, Tunstall, Stoke-on-Trent ST6 4PA, England [450]

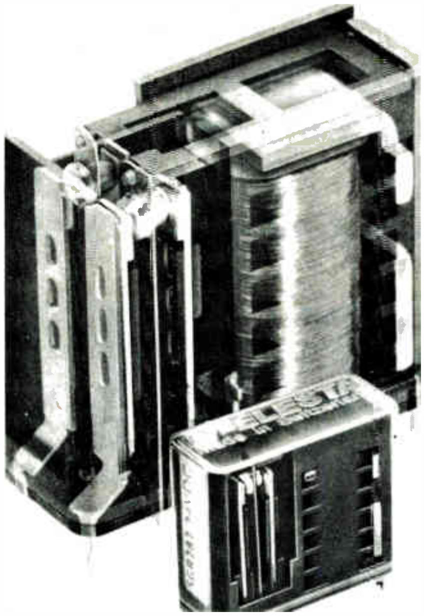


This carbon dioxide laser cuts, welds, and heat-treats with high precision materials in the automotive and aircraft industries. It has a continuous-wave power output of 2.5 kW and a maximum power output of 3.2 kW. Toshiba Corp., 1-6-1 Uchi Saiwai-cho, Chiyoda-ku, Tokyo 100, Japan [451]

Type 4621 digital indicator, for piezoresistive transducers, has a $3^1/_2$-digit display and a selectable indication in units or percentages of the measuring range. It has an output of ±10 V at 5 mA with an impedance of 10 Ω. Kistler AG, CH-8408, Winterthur, Switzerland [455]



The FFKDS spring-tension connectors are designed for printed-circuit-board mounting. Leads, from 0.7 to 1.5 mm^2 in cross section, can be simply inserted into the connector holes to make contact. Phoenix, P. O. Box 149, D-4933 Blomberg, West Germany [462]



Relay type SGR 282, for industrial applications, is a compact unit measuring only 30 by 25 by 12.5 mm, but can handle 220 V ac at 6 A. It has an operating voltage of 6 to 60 V and an operating life of better than 30 million cycles. Elesta AG, Elestastr. CH-7310, Bad Ragaz, Switzerland [463]

The SKT 50 thyristor is designed for 1,600 V and a maximum continuous current of 50 A at 78°C. The SKT 25 F thyristor can handle voltages of up to 1,200 V and has a maximum continuous current of 25 A at 85°C. Semikron, Sigmundstr. 200, D-8500 Nuremberg 82, West Germany [464]

Now, a Fourth-Generation Logic Analyzer!

Simultaneously displays the timing of 8 channels at a sampling rate of up to 100 MHz and the state of 16 channels at a sampling rate of up to 20 MHz so that it's ideal for the analysis of the time relationship between timing and state.

The Iwatsu SL-4601 analyzes the mutual relationship between software and hardware in real time. Timing and state data obtained at different sampling rates can be displayed on the same frame; the timing relationship between the two can be analyzed easily. 8 channels of combination trigger and glitch trigger are provided; it also has a missing trigger function.

- 3 ns glitches detectable
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- 7-inch electrostatic deflection CRT
- 2 external clock inputs for time-sharing bus signal measurement
- 4-level sequential trigger
- Easy time delay setting
- Set parameters protected by back-up battery

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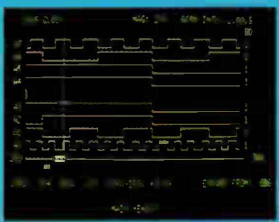
Logic Analysis System

The *PI*-540 packs virtually every measurement function you'll need in a single, easy-to-use instrument.

Advanced State Section

Up to 40 channels. Display data in hex, octal, decimal, binary and ASCII. Includes powerful qualification features, branch analysis, and 16 levels of triggering.

Dedicated µP probes with disassembly simplify software development tasks. *PI*-540 can accommodate 3 resident disassemblers.



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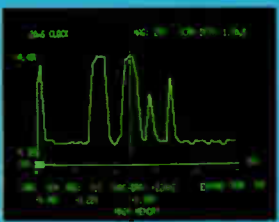

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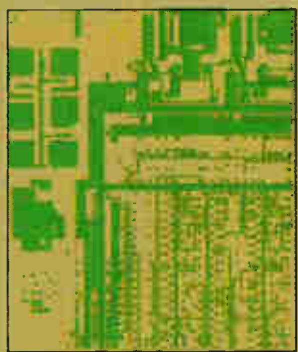

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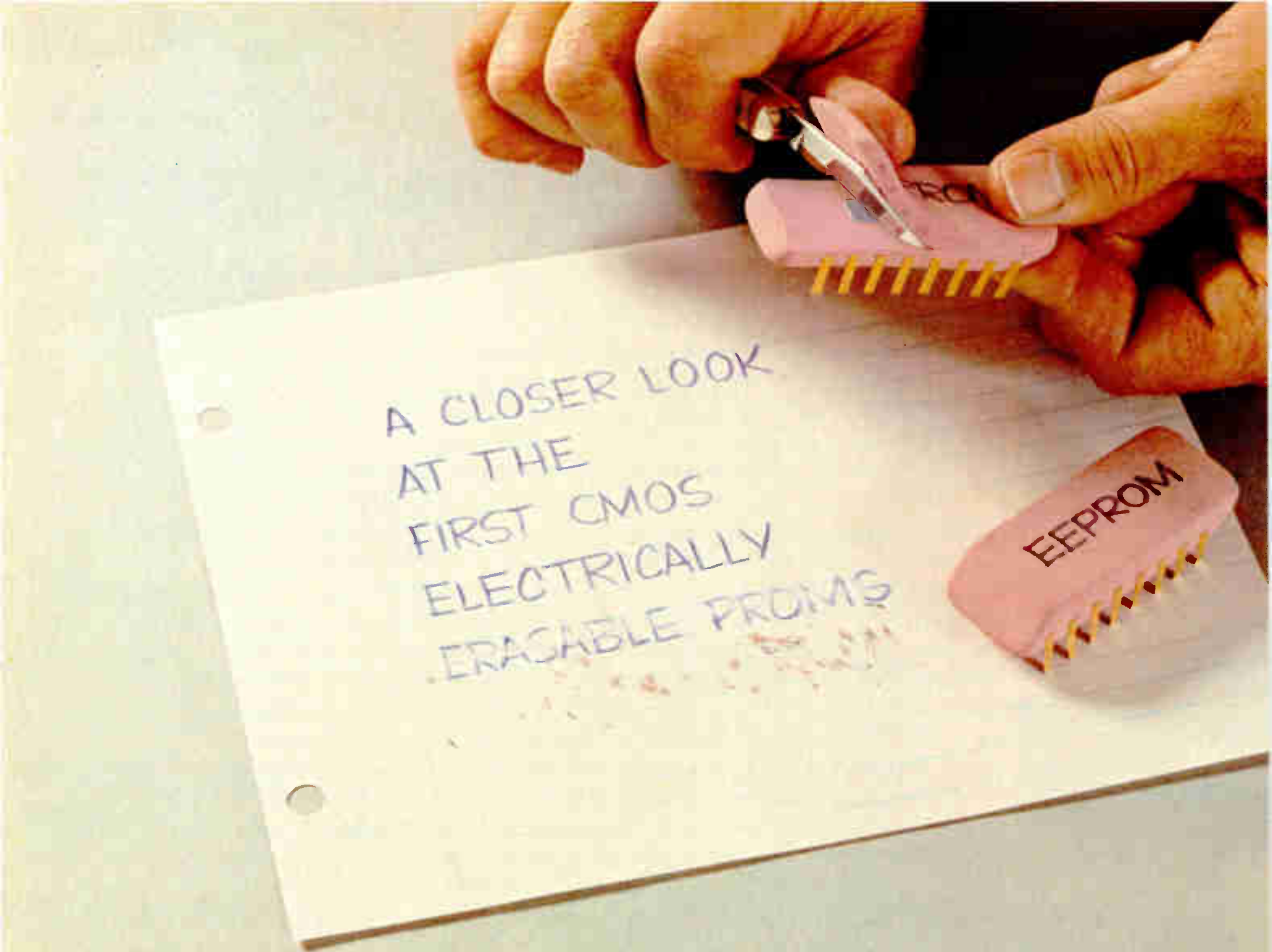

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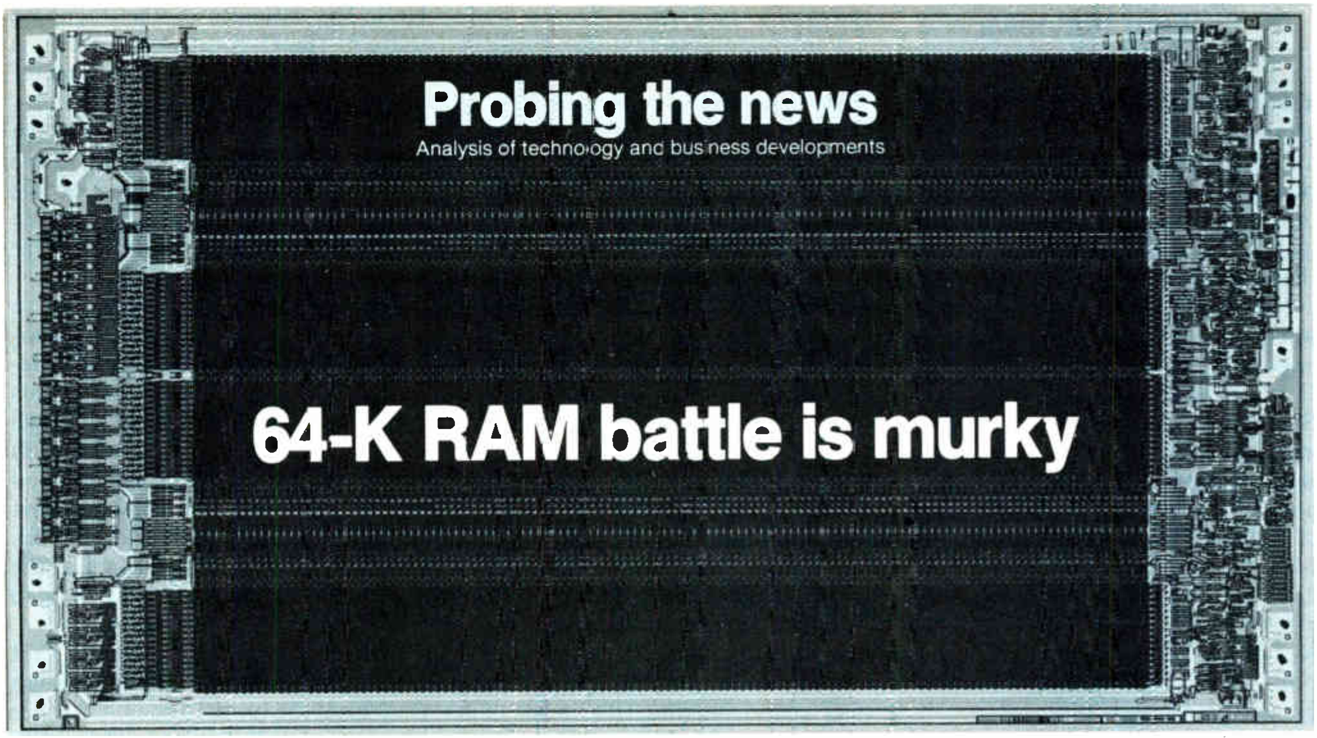

Probing the news

Analysis of technology and business developments

64-K RAM battle is murky

With major marketing questions abounding on the parts, Fujitsu and Hitachi take early lead over Motorola and TI

by Howard Wolff, Associate Managing Editor

The battle for market share in 64-K random-access memories is a bizarre one. Insiders' estimates of how much business is being done, who is doing it, and what is coming next are as disparate as they can be. Here are the schools of thought:

- The Japanese have all but wrapped up the U. S. market. Their share is 60%—or 70%—or 80%.
- The market has not developed enough for the Japanese to be in control, and there are still many opportunities for U. S. suppliers.
- It is still held by U. S. companies.
- It makes no difference because the 64-K RAM will not have time to become fully established before it is overrun by the next generation, a 256-K version.

Four firms now. Only four makers, two Japanese and two American, are shipping parts in volume. They are Fujitsu, Hitachi, Motorola, and Texas Instruments. Said to be moving toward volume production are three Japanese producers: Mitsubishi, Oki, and Toshiba. Waiting in the wings are Japan's Nippon Electric Co. and Intel and National of the U. S., while Mostek, Inmos, and Fairchild are somewhat further from production. The seers put Fujitsu and Hitachi in the lead over Motorola and TI.

Two respected market research firms, Dataquest Inc. of Cupertino, Calif., and Integrated Circuit Engineering Corp. of Scottsdale, Ariz., agree that the Japanese now have 70% of the 64-K market. However, Integrated Circuit Engineering vice president Mel H. Eklund concedes that he has no precise figures and doubts that anyone has because of an absence of solid sales data.

Eklund expects worldwide sales in 1981 to amount to 11 million units. Dataquest vice president Fred Zieber puts this year's figure at 8 million, up from 1980's 400,000. Further out, Zieber sees the figures as 60 million parts in 1982, 200 million in 1983, 380 million in 1984, and 650 million in 1985.

He calculates Hitachi as the Japanese volume leader with Motorola on top in the U. S. and TI "coming on strong." However, he adds, "In 1982 we will see a whole new generation of chips. Ultimately, this will lead to market-share changes."

One factor that has turned out to be extremely important in the 64-K RAM marketplace is speed. The demand for 150-nanosecond-and-faster parts is higher than once projected, but attaining that performance is more difficult than manufacturers once thought. TI is having good luck here, with high yields in the 120-to-150-ns range. Hitachi and Fujitsu are also able to ship quantities of parts at this level of performance; but Motorola, the other volume shipper, has had some trouble meeting this goal. So Motorola is designing a second-generation circuit with performance enhancements and redundancy. Later on, it and others hope to add silicide interconnections for even higher speed. The late entry of Intel, Nippon Electric, and the others may also be linked to the speed requirement.

However, qualification by the key big accounts takes valuable time—original designs are only now getting accepted. Worse still, redesigns must go through the same rigorous evaluation process, and designs incorporating redundancy may be subjected to ever harder scrutiny. Such issues will make it even more difficult for the latecomers to catch up.

New chips. That redesign is in the works is acknowledged by at least one semiconductor house, Intel Corp. in Santa Clara, Calif. There, Barbara Nelson, sales development manager for memory components, says the new chip, scheduled for volume production in the first quarter of 1982, will come in three versions with delay times of 150, 200, and 250 nanoseconds. Intel has formed a separate 64-K RAM operation under Ken Moyle as manager. It will function within the Memory Products division in Aloha, Ore.

Among the market leaders, Motorola Inc.'s David C. Ford, strategic marketing manager for MOS memories in Austin, Texas, says that "by 1984 we should begin seeing a trend toward a more classical 60% U. S. share of the world market." That market, he says, will peak at $2.1 billion in 1986, with average selling prices of $3 or $3.50.

Ford maintains that the battle is still on, and that, while the Japanese "may not always command 60% of the market, they do have a very reasonable chance." He does not see quality and reliability as major issues. "Everyone seems to be pretty equal," he says.

At Texas Instruments Inc.'s Houston operation, Donald W. Brooks, vice president and manager of MOS memories and microcomputers, differs from his competitors when he says that U. S. manufacturers' major concern is the economic slowdown and high interest rates—not the Japanese. TI also makes 64-K RAMs in Japan.

In Japan, Hiroyuki Nishimi, general manager of the Semiconductor Products Marketing division at Fujitsu Ltd., expects the market to explode to about 60 million units next year from the 1981 level of 8 million to 10 million. That total should grow to 200 million in 1983.

For its part, Fujitsu says it is turning out 300,000 units a month and will double that by December. Some 15% to 20% are being used in house, estimates Nishimi, with 20% being sold to domestic outsiders and the remainder exported, mostly to the U. S. His estimate of the Japanese share of the U. S. market—40%—is conservative compared with that of the Americans.

Nishimi does foresee that, if the Japanese share gets too large, there is a possiblity of trade barriers. He also expects the current average price of $10 to $12 to fall next year by $2.

Hitachi Ltd.'s Takashi Kaiho, a marketing and sales promotion manager in the Semiconductor and Integrated Circuits division, says his company is also turning out 300,000 devices a month, a total that will reach 600,000 to 700,000 by the end of the year and 1 million by next spring. He, too, is conservative in his estimate of the Japanese share of the U. S. market, pegging it at 40% to 60%.

Nishimi and Kaiho agree that their companies are on top, though they disagree on the order. Of other competitors, Kaiho says of NEC, "They are announcing very big quantities, but we can't detect their devices in the market."

At NEC, associate senior vice president Tomihiro Matsumura says his company is producing 100,000 devices a month and will increase that to 200,000 by October and 300,000 by January. "I don't believe other companies' quantity claims," he says, "the market is not that big."

Others. The impression gained from consulting those in and close to the market is that the Japanese lead will narrow and possibly disappear as more U. S. companies enter production. One of those is Mostek Corp., where Tim Propeck, memory products marketing manager of the Carrollton, Texas, firm, says. "I think the market, which is still going to be huge, will split up in a bunch of little pieces. I don't think we'll see any one firm with more than 25%." Propeck labels high performance as the key, leading to a second-generation 64-K device utilizing the same new technology that will be used to make 256-K RAMs.

"This will increase the ability to manufacture the 64-K, increasing its life cycle against the next-generation RAM," he says. "Maybe the new technology will drive the prices down to the $2 level that we all shudder about today." □

The best of both worlds

Producing 64-K dynamic random-access memory chips in both the United States and Japan can make a world of difference when it comes to competing in global markets, says Donald W. Brooks, Texas Instruments Inc. vice president and manager of MOS memories and microcomputers in Houston. That's one reason why TI selected Miho, Japan, as the site for its newest 64-K wafer-fabrication line.

For two years, the Dallas semiconductor manufacturer has been producing 64-K chips in the west Texas city of Lubbock. Last spring, TI became a dual-nation producer with the opening of the Miho front end. TI production is 1.6 million 64-K units this year [*Electronics*, July 28, p. 33].

"The overriding advantage in dual sources is the cross-fertilization. Anything you learn in one place, you can put into practice in the other, so you've got redundant efforts," Brooks explains. Having production plants on opposite sides of the world also increases sensitivity to key market moods in both the U. S. and Japan, he says.

The Japanese plant gives TI "real-time communications in terms of competitive moods" there, Brooks states. Dialogues with major Japanese customers allow TI to win business from what it sees as some of its chief world memory competitors on their own turf. It also allows TI to quickly evaluate its own performance in the tough Japanese marketplace. "If we were not producing in Japan and not active in that market, it would be very difficult to keep tabs on what our competitors were doing," Brooks says. Overall, TI plans to serve Japanese and European markets with its new Miho plant, while keeping the Lubbock facility busy filling U. S. orders. If there is a U. S. shortage, parts could be shipped over. **-J. Robert Lineback**

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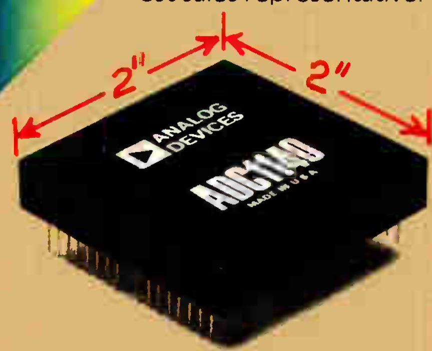

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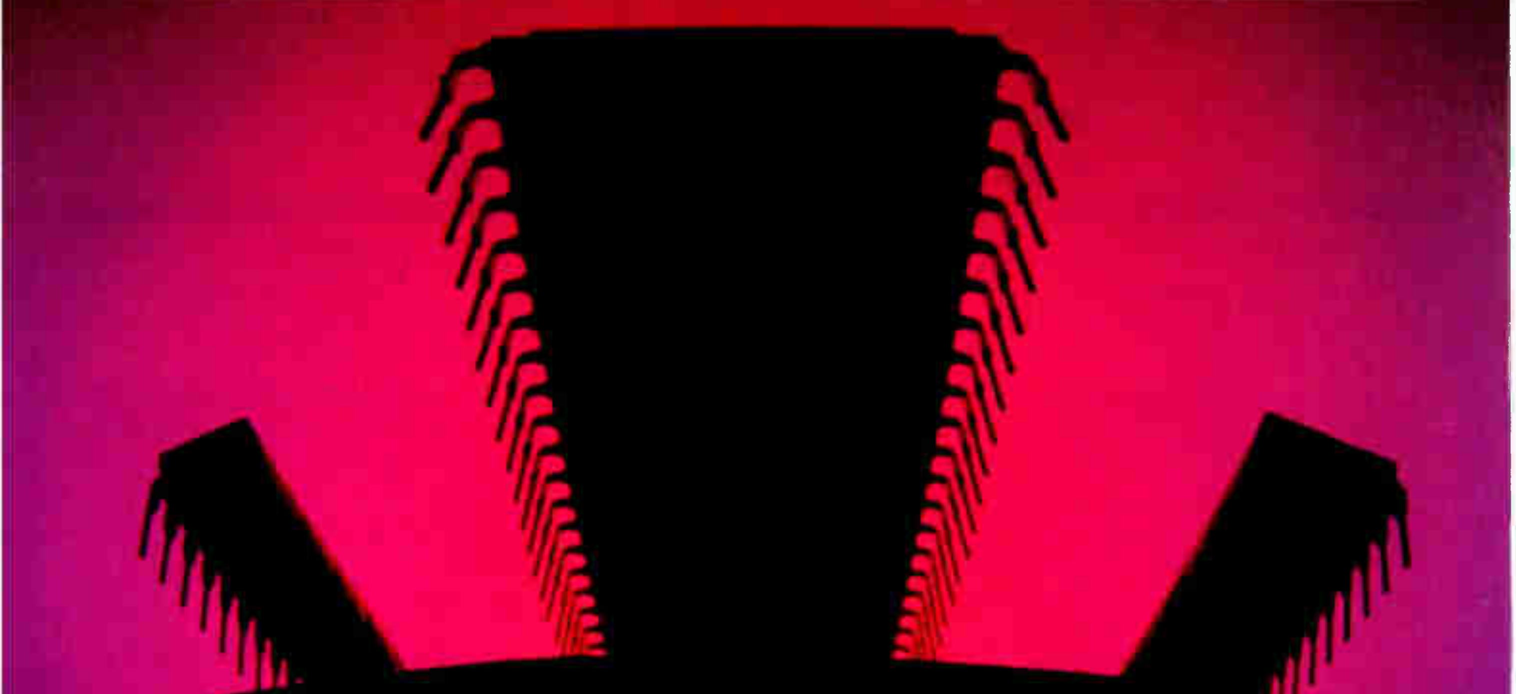

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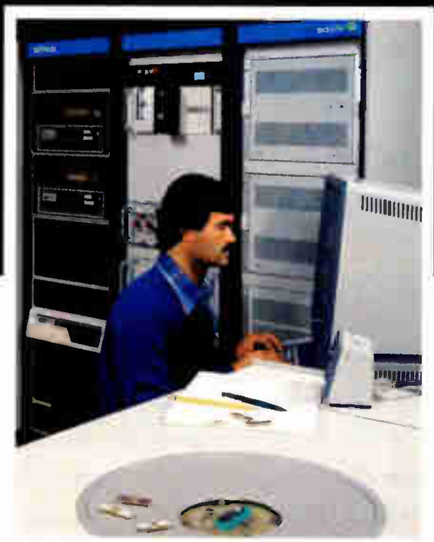

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Solid state

Europeans eye memory, logic advances

European Solid-State Circuits Conference to cover wide area of technology in informal atmosphere at Freiburg

by John Gosch, Frankfurt bureau manager

Freiburg, a medieval city in the southern foothills of West Germany's Black Forest mountain range, is known as "the town of the woods, wine, and Gothic architecture." That is the picturesque setting for the Seventh European Solid-State Circuits Conference—Esscirc 81—a Sept. 22–24 meeting of semiconductor experts from around the world.

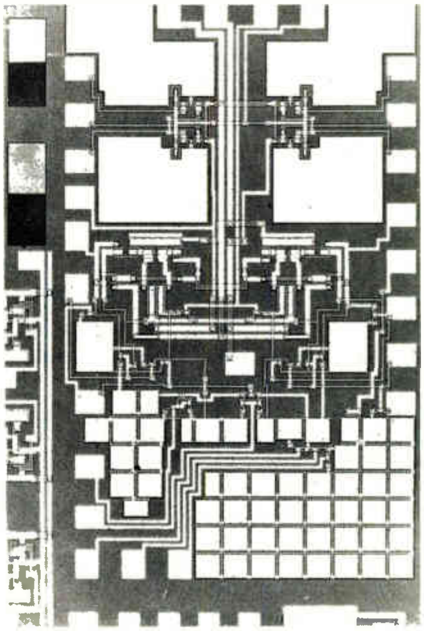
A getting-to-know-you atmosphere distinguishes an Esscirc meeting from its counterpart in the U. S., the International Solid State Circuits Conference. "The ISSCC is a 'quick-information' meeting where things are rather hectic and formalized," points out Esscirc 81's program chairman, Bernd Höfflinger, head of the Electronic Devices department at West Germany's Dortmund University. At Freiburg, 43 papers will be heard by an estimated 350 to 400 people, a far cry from the 2,000 or so the ISSCC usually attracts.

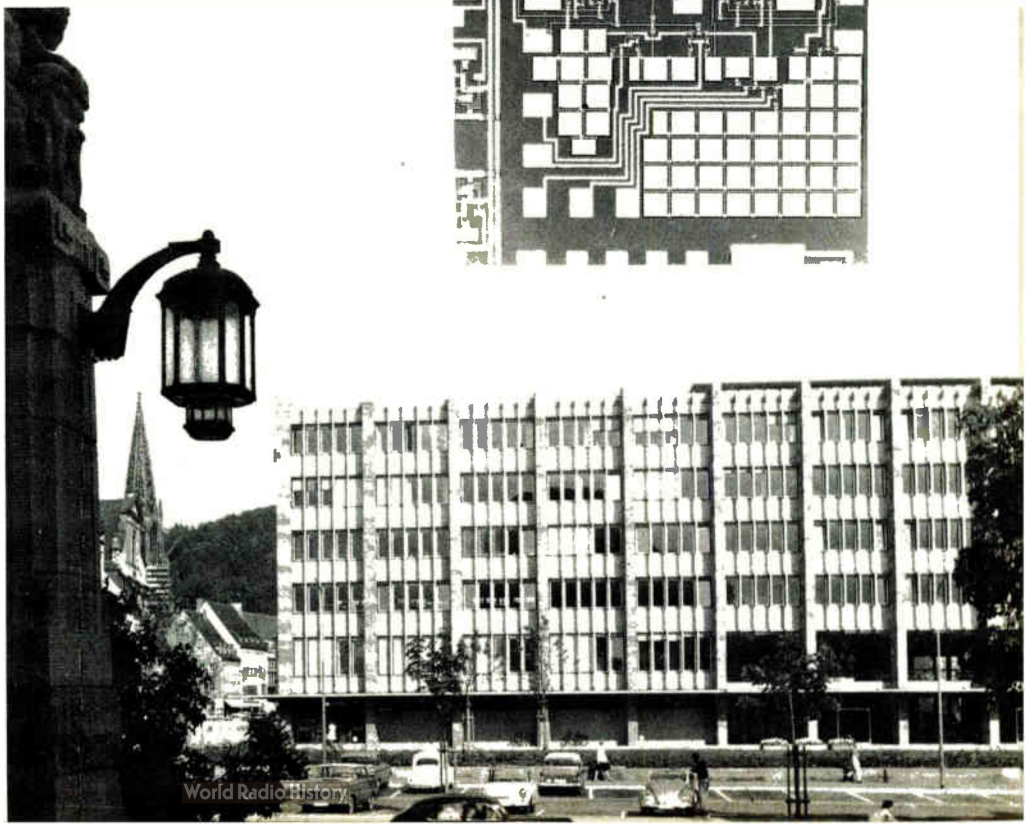
Besides exuding congeniality, Esscirc conferences not only break news but also have tutorial functions, Höfflinger says. Invited papers from top specialists summarize recent occurrences in specific fields, thus offering participants a chance to catch up on news from neighboring areas.

Breaking news. But for all its informality and relative smallness, Esscirc has become a forum for presenting significant advances in solid-state technology. An example is a 256-K random-access memory from Japan, a 100-nanosecond chip. Developed at Nippon Electric Co. Ltd. in Osaka and the Nippon Telegraph and Telephone Public Corp.'s Electrical Communication Laboratory, the RAM uses 1.5-micrometer design rules, uses polysilicon- and molybdenum-gate technology, and is housed in a 16-pin dual in-line package. The pin configuration is compatible with the Joint Electron Device Engineering Council standard.

NEC's new chip uses two-layer metal interconnections and is arranged as a 256-row-by-1,024-column matrix organized internally as two 128-K RAMs. It is 42.8 square millimeters in area, and the cell checks in at 71.7 mm². The refresh mode is 256 cycles at 4-millisecond intervals. Active power dissipation is 300 milliwatts at a 270-ns cycle time, and standby power is 20 mW.

Also to be described are gigabit logic chips made with a new n-channel MOS field-effect-transistor technology at Bell Laboratories in Murray Hill, N. J. Employing X-ray lithography and reactive ion etching to obtain 1-μm features and submicrometer channel lengths, the technology has been used to develop cir-





Get together. At Freiburg, West Germany's, modern university, Esscirc participants will discuss such solid-state developments as Dortmund University's bandpass filter.

cuits with propagation delays of 30 picoseconds and power-delay products of 44 femtojoules. For other Bell circuits, the corresponding figures are 75 ps and 5 fJ. The chips have been operated at clock frequencies up to 2.5 gigahertz.

At home. Naturally, on their home turf in Freiburg, West German firms and institutions or German-based affiliates of U.S. companies will make a strong showing. Among them is the IBM laboratory in Böblingen, whose experts will present a three-part paper dealing with a density-enhancement study on a bipolar master-slice very large-scale integrated circuit using four layers of metal. The paper describes follow-up work done on the System/370 processor chip at the IBM Data Systems division in East Fishkill, N. Y. [*Electronics*, Oct. 9, 1980, p. 139].

In addition to those papers, Esscirc 81 will emphasize two general themes. One is the design of VLSI circuits including computer-aided design, processor architecture (as discussed in an invited paper by one of Europe's masters in the field, François Anceau of the Institut de Mathématique Appliquée in Grenoble, France), and related areas. The other main theme is circuit implementation, emphasizing digital signal-processing devices and professional communications circuits.

CAD for VLSI. The VLSI design category includes a paper from the University of Leuven in Heverlee, Belgium. It discusses an integrated CAD system supporting the hierarchical design of n-channel MOS ICs. The system includes both simulation and layout programs, sharing a common data bus. The front end is a cell design system with graphic stick-diagram input that is compressed into a real layout based on a set of layout rules. Design management is ensured by a file management system running on a VAX 11-780 computer from Digital Equipment Corp. or a Tektronix 4014 and written in Fortran.

Typical of the circuit-implementation category is a paper from the Philips Research Laboratories in Eindhoven, the Netherlands, which treats a multifunction digital signal-processing chip. Made in 4-μm n-MOS technology with implanted undercrossings, the chip stands out because of the speed it achieves—as high as 40 megahertz. It should prove to be useful for processing digital video signals.

To the mountains. The site of Esscirc, Freiburg, in the foothills of the Black Mountains, is known for its Gothic architecture. Typical is the cathedral of the city of 200,000.

At meetings like Esscirc 81, there are always signposts indicating the direction of new technologies. A case in point is a paper from Plessey Ltd.'s Allen Clark Research Centre in Caswell, Northants., England, which discusses a gallium arsenide process that can be used to fabricate ICs with either digital or analog high-speed functions. One of the first circuits developed as a test vehicle for the new process is a unity-gain amplifier that can be used to generate two clock signals for a high-speed divide-by-2 logic circuit.

Combination. The Plessey researchers will outline the techniques developed to fabricate ICs and devices such as field-effect transistors, Schottky diodes, monolithic inductors, and metal-insulator-metal capacitors and interconnections achieved with double-layer metalization. The ability to combine analog with digital functions will be particularly useful in fast sample-and-hold parts, as well as in digital-to-analog and analog-to-digital converters.

Researchers from West Germany's Dortmund University will talk about a real-time programmable monolithic switched-capacitor second-order bandpass filter based on the voltage-inverter-switch principle using inverse recharging devices. The filter is significant, says Höfflinger, one of its developers, for introducing complementary-MOS amplifiers, which translate into ultralow power dissipation—less than 200 microwatts at 8 kilohertz, a feature that should prove useful for speech applications.

Another group of Philips researchers will describe a 200-ns 12-bit n-MOS multiplier-accumulator for signal processing. Implemented on a 12-mm^2 chip, the device contains a 12-by-12-bit parallel array multiplier and a 24-bit accumulator. The Dutch design uses inverting full adder cells that make for a very compact and efficient array. The absence of output-inverter stages helps conserve chip space and reduces both delay and power dissipation, the latter only 250 mW. The maximum clock rate is 5 MHz.

Phone talk. A paper from AEG-Telefunken in Frankfurt, West Germany, will detail a new bipolar design. The paper discusses an integrated telephone speech circuit that, on a 9.43-mm^2 chip, contains a line-fed loudspeaker amplifier, a line-loss compensation network, and a line-length–dependent sidetone network. The maximum power dissipation is less than 300 mW at 100 milliamperes line current, and the total harmonic distortion is less than 1% for a −10 dBm send-and-receive level.

French researchers will deliver a paper on a four-valued emitter-coupled-logic encoder and decoder circuit. Developed at the CGE Laboratoires de Marcoussis and the Université P. et M. Curie in Paris, the circuit is intended to decrease the number of connections between microprocessors in a calculator. Essentially, it converts binary information into information coded in four values—1, 2, 3, and 4—instead of 1 and 0. This reduces the number of connections by a factor of two. □

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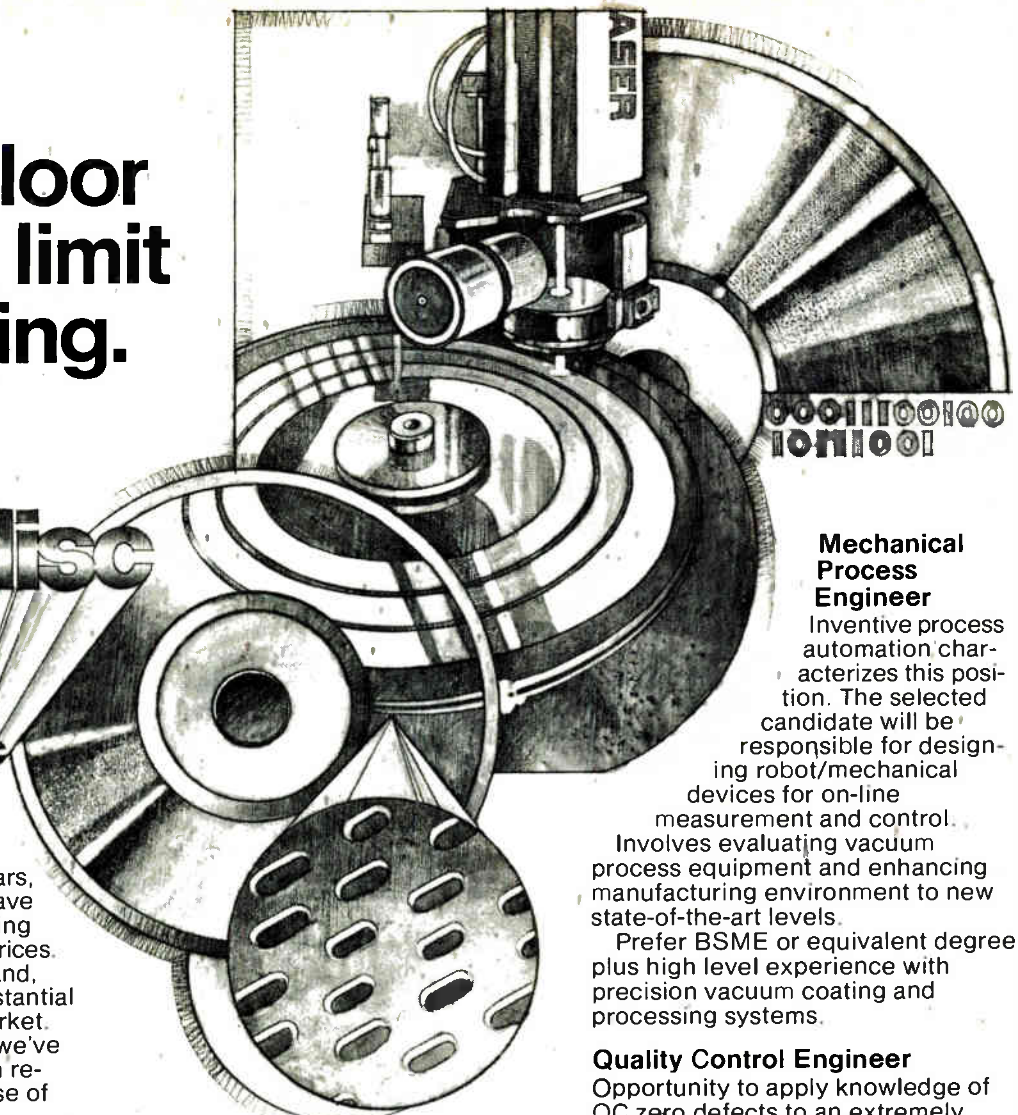

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Instruments

Measurement-computer era arrives

Earlier units held their processors captive, but newest systems let users dictate computations

by Richard W. Comerford, Test, Measurement, & Control Editor

Wescon/81 will probably mean different things to different people, but many engineers will come to regard it as the start of the instrument-as-computer era. In San Francisco next week, genuinely new types of instruments will be introduced whose design and functionality are due to a thorough knowledge and application of microprocessor power.

As Ira Spector, president of Nicolet Paratronics Corp., says, "The computing power of instruments is finally coming out of the closet." He notes that where earlier instruments used processing chips, they did so in an invisible fashion—a user would press a range key on a digital multimeter and the processor would configure the DMM's internal circuitry for that range. All the user knew or cared about was that the right range had been set for the measurement.

This application of the processor made possible such things as autoranging, but it did not actually change the nature of the instrument In spite of the fact that they had computers inside them, the DMM was still basically a DMM, an oscilloscope was a scope, and so on.

Now, however, instrument designers are building what can best be described as measurement microcomputers. Spector points to such units as his own firm's NPC-764, the Tektronix DAS 9100, and the Data Precision Data 6000, all of which will be on display in San Francisco. Gould-Biomation, Hewlett-Packard, Systron-Donner, and other instrument companies are also developing systems of this type.

New sophistication. What the presently announced units have in common is that they employ a microprocessor, not only to give users a wide choice in the kinds of functions they can perform, but also to permit a sophisticated linking of functions to get the final result, not a pile of data that needs to be reduced.

In the NPC-764, which Spector's San Jose, Calif., firm calls a full-function logic-analyzer system, a user can insert printed-circuit cards that provide 48 channels at 15 megahertz for state analysis and 16 at 50 MHz for timing analysis, event counting and signature analysis, and waveform digitization. Operation of the various cards is controlled by an 8085-based central processing unit, which can also handle future cards—spectrum-analysis and emulator offerings are "not unlikely" additions, according to Spector.

This configurability-by-card is also seen in the DAS 9100 (p. 113) from Tektronix Inc. of Beaverton, Ore., which emphasizes this aspect of its system by referring to the cards as "card modules." At present, Tektronix provides cards for pattern generation—up to 80 channels' worth—along with three types of cards for logic analysis. It, too, plans to expand the system with future introductions, the same way it has continued to enhance the capabilities

New breed. Nicolet Paratronics' NPC-764 logic-analysis system is one of the new breed of instruments whose computing power can be used by a knowledgeable operator.

of its 7000 line of scopes, first introduced in 1969.

Processor buses. Although both of these 8-bit-processor-based instruments are aimed at digital design, the Data 6000 (p. 205) applies its 16-bit processor to the analog world. The 6000 from Data Precision Corp. of Danvers, Mass., uses plug-in modules like those seen in the Tektronix 7000 series, but the similarity between the two systems' design ends there. Like the new card-based modular systems, the interface between the 6000's plug-ins and the rest of the system is primarily the well-structured bus of the microprocessor.

Because this bus is the connecting element of the system, the memory accessed by the processor may be spread out among the various modules or cards in the system—information that is germaine to the use of a particular card can be stored on the same card. This conserves address space, since the same address block can be used for different information depending upon what cards are in the system. This feature results in a high degree of configurability.

Furthermore, the instruments' bus-based design permits a network of processing power. Individual cards, such as the DAS 9100's pattern-generator card, can have their own processing capabilities communicating with the host CPU through the main bus.

Range of skills. The trick for instrument designers is to let an operator use this sophisticated computer system without having to learn computer theory. At the same time, they would like to let the more knowledgeable operator fully utilize the system's power. Thus, they have turned to a combination of schemes for user interfaces.

In the NPC-764, a full ASCII keyboard may be used by a programmer to create applications programs that run under the system's CP/M operating system. Although Nicolet Paratronics does not plan to supply general-purpose software at present, there are Basic and Pascal programs widely available that will run under

CP/M, as will 8085 assemblers.

For simple instrument operation, the system presents a menu whose blanks are filled by typing in the appropriate information using the ASCII keys. There are also six software-configurable keys under the 9-inch cathode-ray tube for single-keystroke manipulation of the display and menu selection.

No code. The DAS 9100 provides menus, too, seven in all, but these are filled in by scrolling through possible choices. This choice relieves the user of having to know special code words when starting to operate the system. For a more sophisticated user, the unit's 16 shiftable alphanumeric keys can be used to define the mnemonics of systems being tested.

The Data 6000 does not use menus, but has three different sets of keys for different functions. One group calls parameters that set up another set of software-configurable keys. The latter then can scroll through a variety of options, making it fairly easy to set up the instrument. The third group of keys resembles and provides the programming capability of a sophisticated scientific calculator.

Thus, although all three companies have taken different approaches to the interface, they have come up with design solutions appropriate to the way they see such instruments being used. Although those views differ, they all see the instruments becoming part of design networks.

Full treatment. Nicolet Paratronics sees its system being used with such equipment as stand-alone emulators and disk drives to form a full development system. It therefore provides IEEE-488 and RS-232-C interfaces so users can hook up such systems, as well as an RS-449 interface for higher-speed transmissions.

The DAS 9100 also has IEEE-488 and RS-232-C interfaces, but the designers believe these will be most useful in transferring design data and documentation into the production arena, as well as for remote testing. Still a third possibility is envisioned by Data Precision: using its system's interfaces to hook up automated test stations. □

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Computers

ICL is down to its last shot

British government picks semiconductor executive to turn firm around after $61 million loss in 1981's first six months

by Kevin Smith, London bureau manager

It's of no little significance that a semiconductor man was chosen to rescue Britain's London-based computer heavyweight, International Computers Ltd. Before being enticed to the managing directorship of ICL with a $270,000 salary, stock options, and the use of a $500,000 home, 35-year-old Robb Wilmot was managing director of Texas Instruments (UK) Ltd., where he won plaudits from many quarters for turning a laggard overseas subsidiary into one of TI's star performers.

Wilmot, together with new chairman Christopher Laidlaw, formerly of British Petroleum, represent the British government's last-ditch attempt to save ICL. In the wake of a collapsing home market and with export sales throttled by an overvalued pound, the company has come close to going under. It turned in a pretax loss of $61 million in the first half of 1981, has outstanding debts of $446 million, and suffered a massive loss of confidence that depressed its stock value from a high of $3.53 a share to 54¢ today.

Wilmot's short-term objective is to restore profitability by shedding 5,200 jobs, reestablishing customer confidence, and streamlining management on the TI model: pushing decision-making down the line and creating more profit centers. His long-term strategy for the company's survival reflects a professional career spent entirely in the semiconductor industry—he joined TI Ltd. on graduating from Nottingham University and is the complete company man.

According to Wilmot, ICL will:

- Make more aggressive use of semiconductor technology.
- Slim down the mainframe line with bigger increments of power between machines and just a single operating system for the 2900 series.
- Move into high-growth areas like distributed processing and office automation through alliances with companies, possibly Japanese, to offer complementary products.
- Get British software and systems houses to equip ICL hardware, much as they do for Digital Equipment Corp. machines, a policy that foundered under the old management.

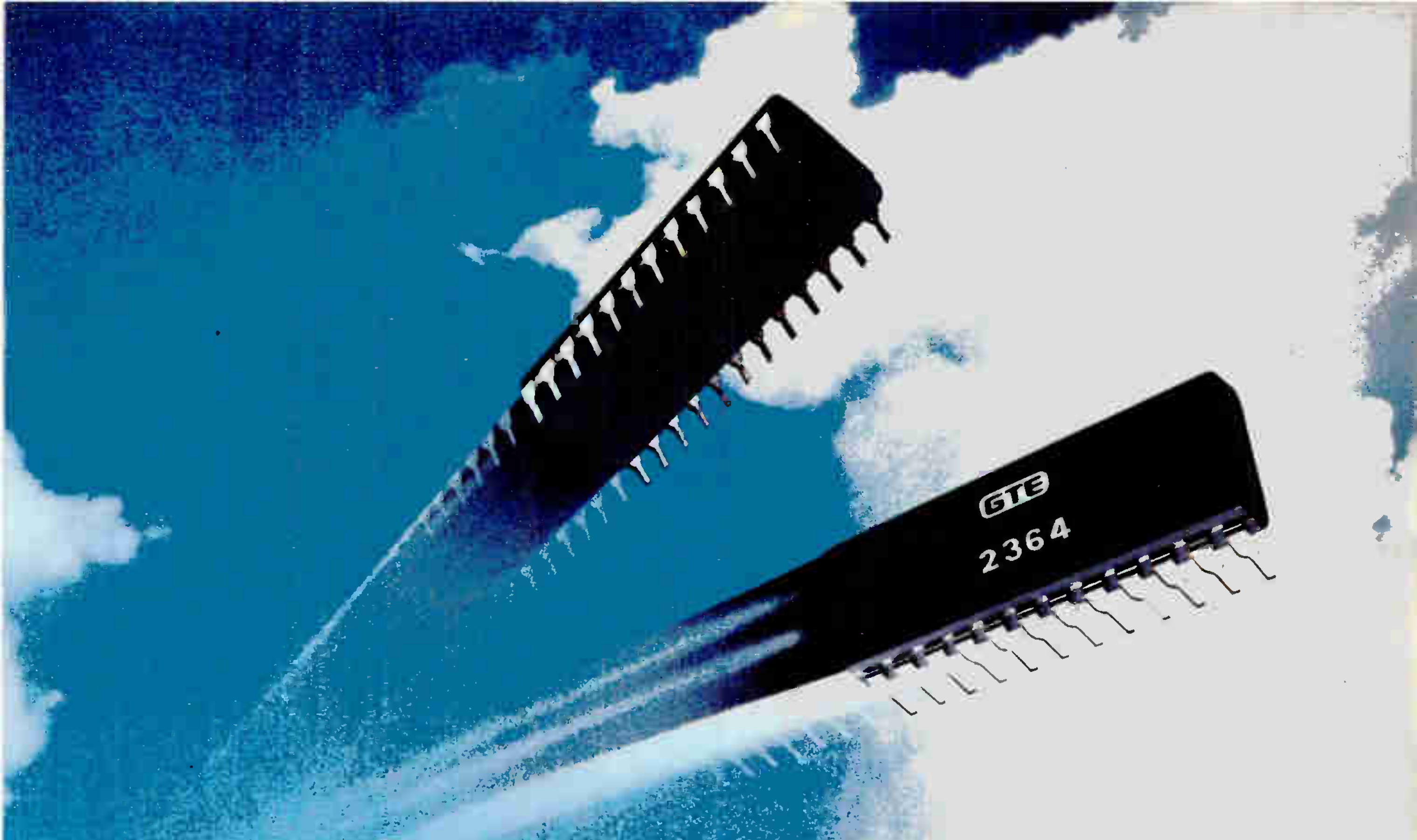
Adventure sought. "ICL must become technologically more adventurous, if it is to survive," Wilmot says. "We have to adopt the attitude of taking more risks by setting more aggressive cost-performance goals. If we can get another two years' life out of our products we will need to develop 30% to 40% less hardware," he adds, echoing a manufacturing objective that is a way of life in the semiconductor industry.

Pathfinder. Robb Wilmot will try to steer Britain's computer manufacturer, ICL, out of red ink and back to profitability.

Playing the game of technological leapfrog, explains Wilmot, takes two forms. Small systems like ICL's newly released System 25 almost exclusively exploit standard microprocessor products. So to accelerate product-development cycles and "intercept that technology," Wilmot wants to set up more teams like the one that developed the system, working apart from the usual design group at West Gorton.

The big mainframe nowadays uses a different kind of technology: gate arrays that can be customized to achieve very large-scale integrated-circuit densities. The price-performance target is set by the scale of integration achieved and by the use of high-speed emitter-coupled logic or Schottky transistor-transistor-logic technology. ICL has made heavy investments in the design-automation techniques needed to connect these gate arrays, but it is still behind IBM Corp. and DEC and has yet to get a gate-array machine to the market.

To make its development buck go further, Wilmot says, ICL will rationalize its 2900-series mainframe line, spanning the same 5-million-instruction-per-second performance spectrum in fewer and bigger steps, but offering customers easy field upgrading ability. "We have novel ideas on how to do that," he hints. ICL has also dropped its no-frills VME/K operating system, freeing money for its VME/B operating sys-



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Probing the news

tem and for its Information Processing Architecture, a distributed-processing operating system that supports the open systems network standard.

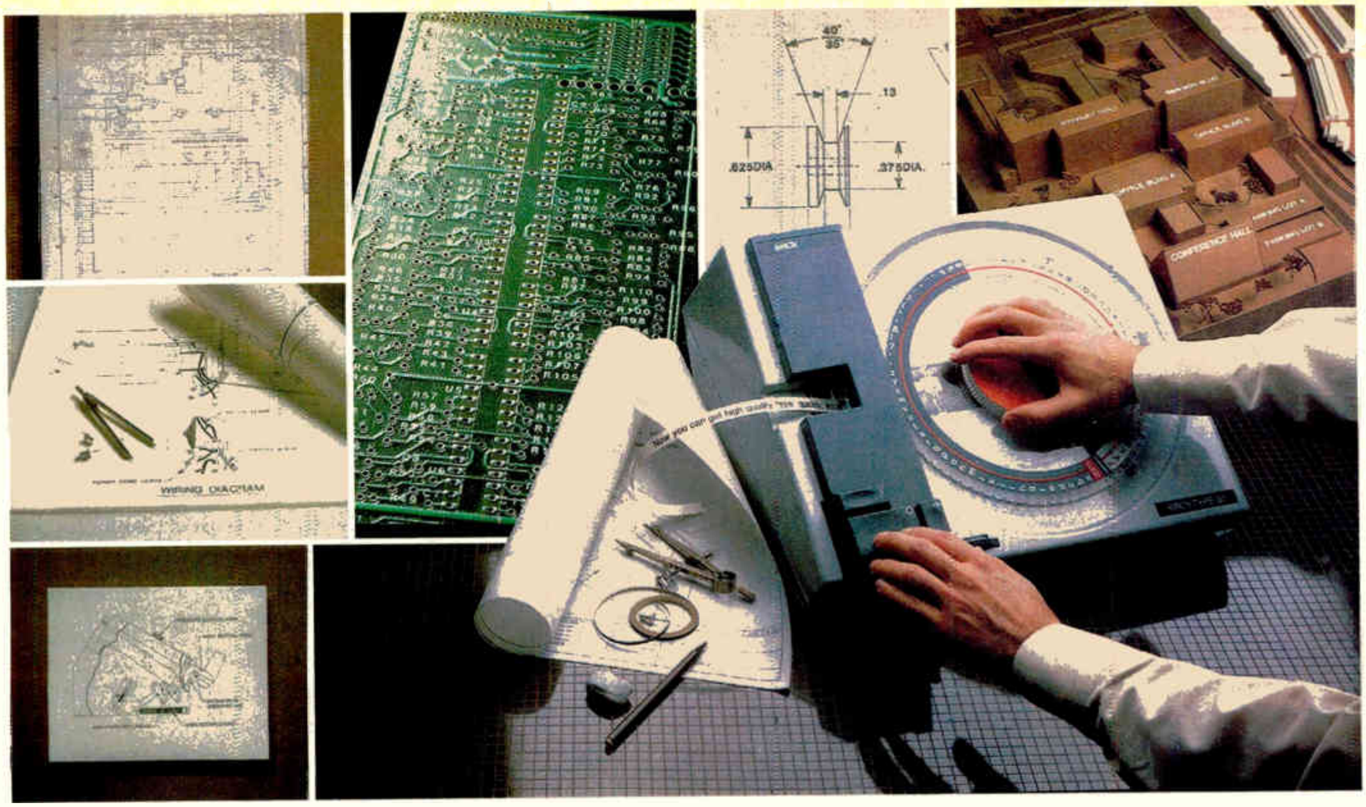
Distributed processing using IPA, and hardware compatible with IBM communications protocols is a key element in ICL's product strategy of seeking new opportunities and new challenges. "It allows us to surround IBM mainframes and to listen and talk to them," says Wilmot, adding that no plug-compatible machine is contemplated by ICL.

Communications is one area where ICL will likely seek alliances, buying hardware with which to put together X.25 packet-switched and local-area networks. As an initial move, the company has signed with Computer Technology Ltd. for its microprocessor-based front-end communications processor.

Look at the office. A second target area is office systems, where ICL has been slack, but where its content-addressable file store, or CAFS, gives it the world's most sophisticated file-and-retrieve system, Wilmot says. But ICL will need more than that system and plans within the next three months to complete alliances with manufacturers of work stations, desktop computers, and similar hardware. Its bait is a well-developed marketing platform and the CAFS technology.

Software development is another overhead that still could sink the waterlogged ICL ship. Chris Wilson, the former managing director, attempted with little success to get British software and systems houses to equip ICL hardware. Since this is also one of Wilmot's priorities, he says, "I have retained consultants to tell us what to do to present a clear commercial posture to our software industry." Still to be worked out by Wilmot is the role of ICL's distributed array processor and of its microcircuit development center.

Some of this product strategy was already in place before Wilmot came on board. His biggest contribution may be to push it through with urgency. Only time will tell if the strategy can save ICL. □



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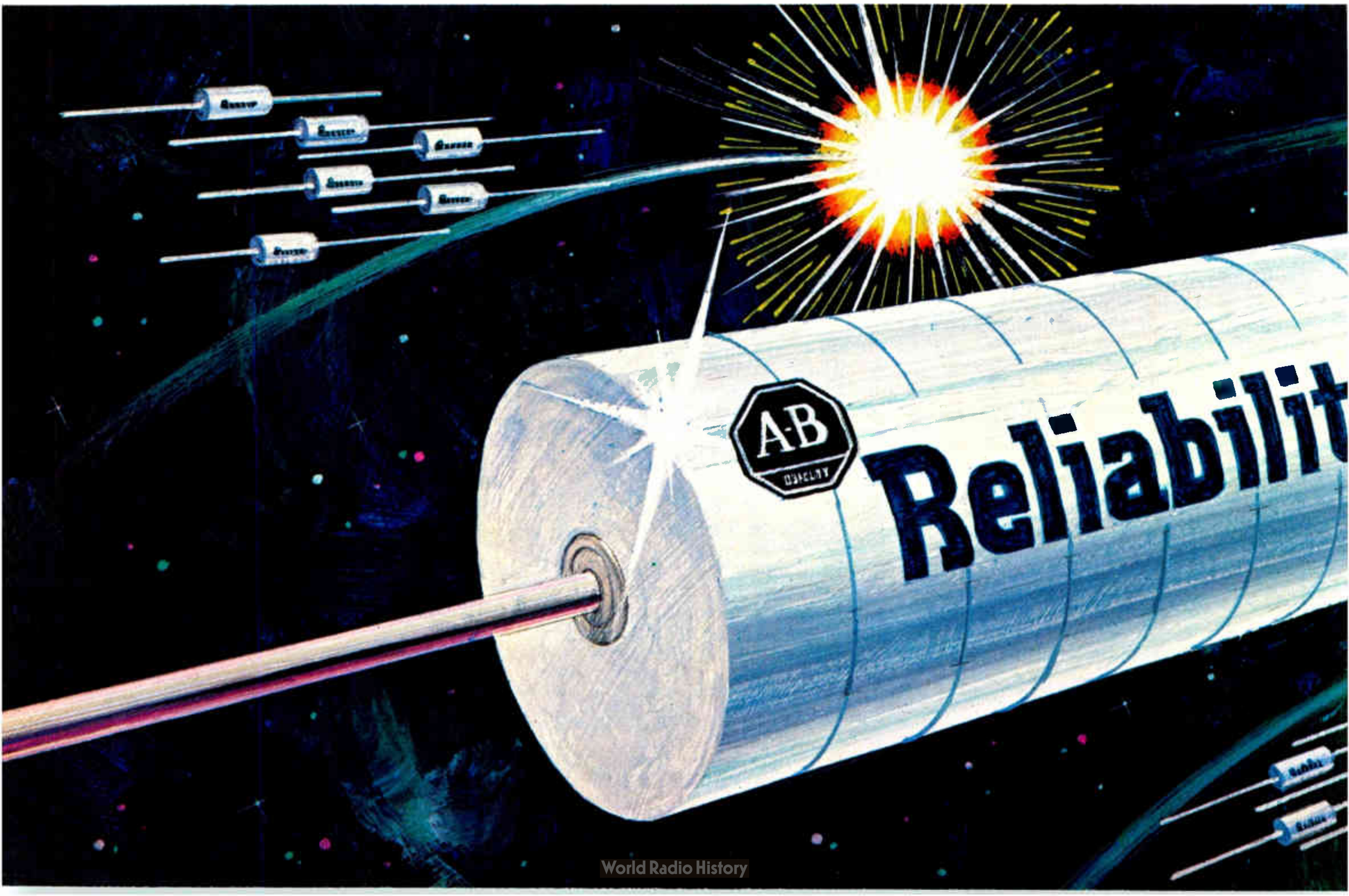

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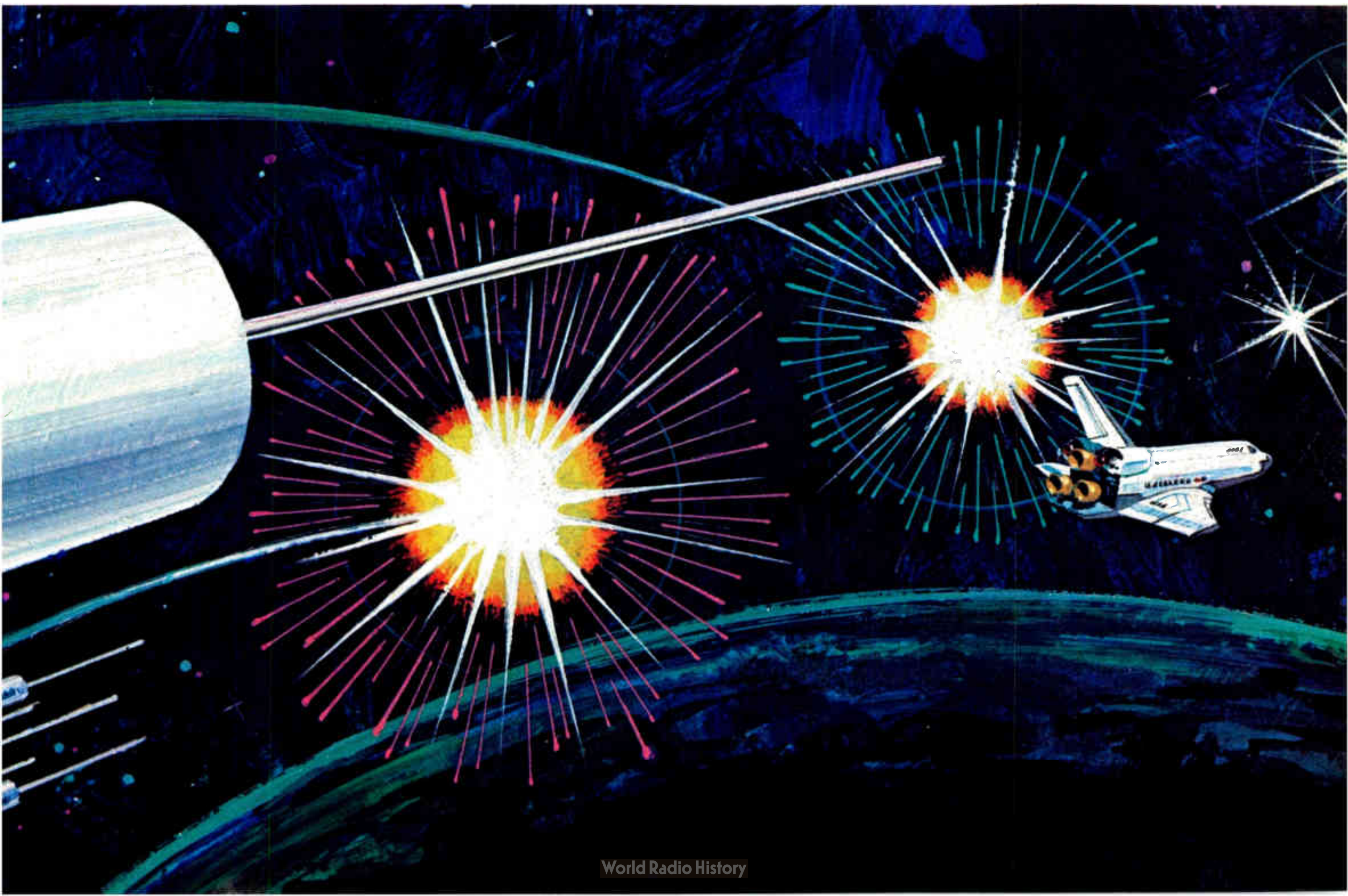

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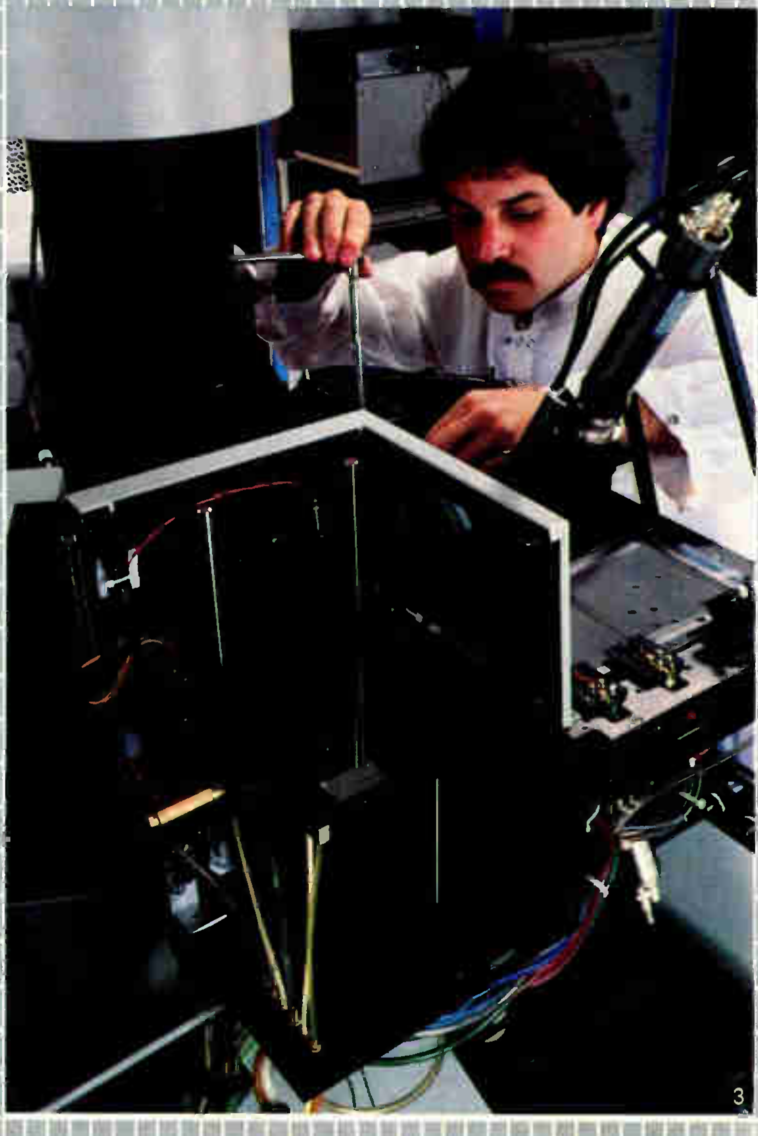
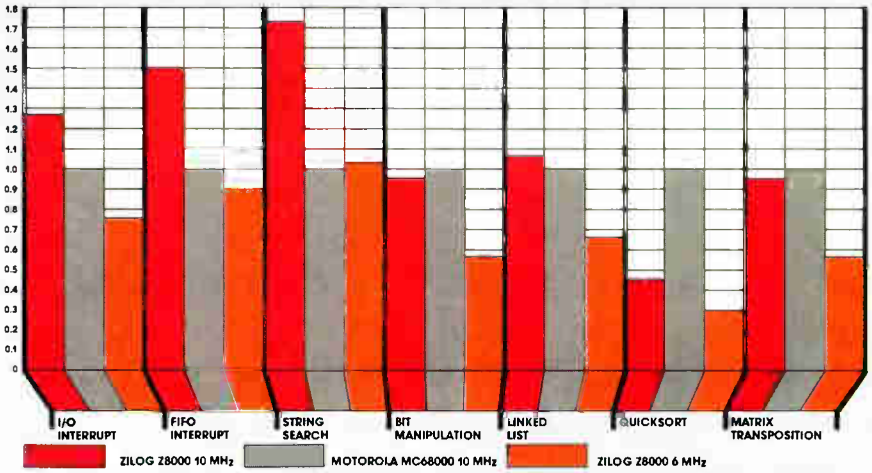

3

World Radio History

How to tell apples

In microprocessor benchmarks, comparing 10 MHz CPUs with 6 MHz CPUs is equivalent to comparing apples with oranges. Why? Because the 10 MHz units are proportionally faster—and more expensive—than their 6 MHz counterparts. To tell the apples from the oranges—and to separate the sour grapes from the top banana—be sure to check CPU clock speeds before you accept benchmark results.

For fastest execution, Zilog's Z8000.™ Megahertz for megahertz, the Z8000 has execution speeds second to none. Comparisons based on the Grappel & Hemenway benchmarks for 16-bit devices show that the new 10 MHz Z8000 is the fastest CPU available, with performance superior to the 68000's in most applications. And it performed equally well in the Blacksburg, and Nelson & Nagle benchmarks. But we're not resting on our laurels, because front runners in the megahertz race can change rapidly—and there's a lot more to



The Grappel & Hemenway benchmark—as reported in the April 1, 1981 EDN Magazine—compared a 6 MHz Z8002 with a 10 MHz 68000.

When the 10 MHz Z8002 enters the picture, the Z8000 clearly outperforms the 68000.
The Z8000's execution speed has been illustrated relative to the 68000's which is normalized to 1.0.

performance than just raw speed.

A true measure of CPU performance. While generalized benchmarks provide guidelines, performance measurement is best approached from a systems perspective, because speed is affected significantly by ancillary hardware and software.

from oranges.

Thus, the enhancements obtainable with high level languages and peripheral devices must be weighed, as well as the effects of architectural characteristics, and the memory access time requirements of faster CPUs. Since these considerations are critical to overall performance, they must be evaluated, along with speed and memory usage.

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Circle 111 on reader service card

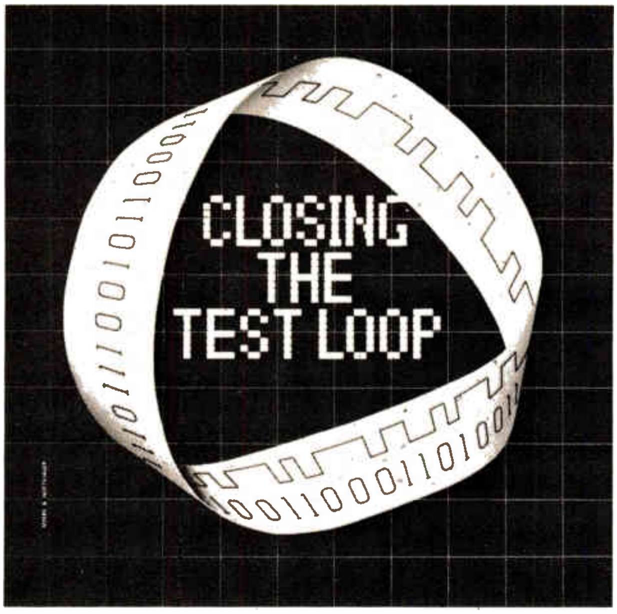
Logic analyzer delivers test patterns, too

Card-configurable instrument adds digital stimulus to data acquisition to close design checkout loop, simplifies system setup with efficient menu set

by Steve Palmquist and Gerd Hoeren, *Tektronix Inc., Beaverton, Ore.*

☐ The development of the logic analyzer seven years ago was an important step in simplifying the job of checking out a digital design. But it addressed only half the check-out problem—data capture. The designer was still faced with the task of building a test fixture that supplied the necessary stimulus—the test vectors—needed to exercise the product being designed.

With digital designs constantly becoming more complex, this task has grown to the point where some designers are spending half their time building such fixtures, rather than designing new products. Clearly, the designer now requires a better tool to be more productive.



The DAS 9100 digital analysis system (shown in Fig. 1) is an instrument that for the first time offers the designer both the stimulus source, in the form of a pattern generator, and the data-acquisition capability that is necessary in order to perform the checkout task efficiently and easily. These capabilities are so highly configurable that the instrument will be able to tackle digital problems that have yet to show up, as well as those encountered now. And despite its high modularity, the analyzer is easy to set up for any digital test task.

The DAS is more like a digital computer or intelligent terminal than a traditional instrument; it consists of a number of printed-circuit cards dedicated to various functions—overall instrument control, data acquisition, pattern generation, and digital or video communication—housed in a 24-by-43-by-60-centimeter mainframe. But whereas the complement of cards in most digital systems is reasonably fixed, the DAS is designed to be easily configured by inserting various pattern-generator or data-acquisition card modules.

This approach was taken to benefit users; it allows them to configure the system to meet their particular logic analysis needs. The table overleaf lists cards that are currently available and their capabilities. Using the data-acquisition cards, for instance, the DAS can be configured to resemble practically any logic analyzer available today and a number that are not.

Such a high degree of configurability can make an instrument difficult to operate. It was, therefore, necessary to devise a way in which the DAS could be set up without requiring a significant amount of operator instruction and time. The basic design philosophy behind this requirement was that the instrument had to allow the user to be free to concentrate on solving his problem, not operating the instrument.

Had a traditional key- or command-per-function approach been taken in the design, about 500 separate keys or commands would have been needed, violating the design philosophy. For that reason, a menuing approach—in which keys select one of seven different menus—was adopted. For the instrument designer, the nature of the menus was complicated by the fact that the choices that the menus present have to change, depending on which cards are included in the system at any given time.

The menuing approach in the DAS differs from that of other systems. In most menuing schemes, the order in which information is supplied by the user is dictated by the menu itself. An information field flashes until the user has supplied some appropriate information. Once that information is supplied, the menu lights up another field, and the process continues until the user has filled in all the blanks.

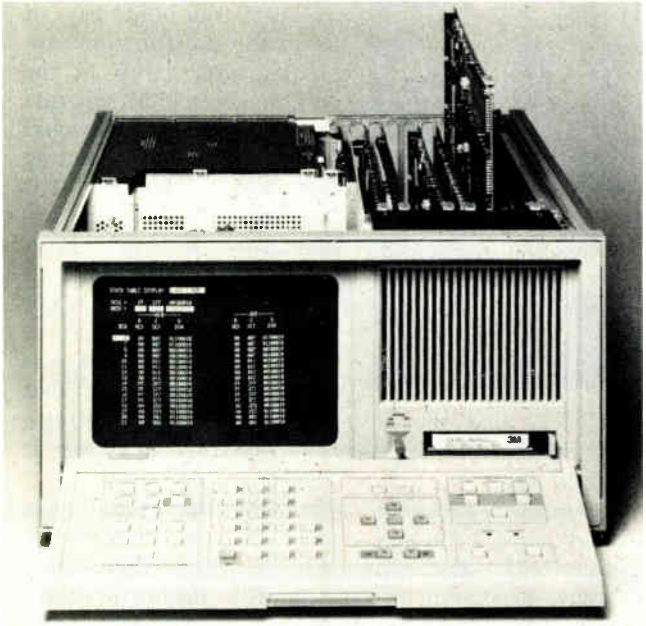
The menu and cursor scheme used in the DAS is much simpler and quicker to use. Once a menu is selected, it is displayed with the conditions that were last chosen for instrument operation or a set of default conditions. Using the cursor, the DAS operator can quickly jump through the menu to a field he wishes to change. Then, he or she can scroll through a set of fixed conditions or, where appropriate, key in the desired information.

For example, in setting up the trigger menu, the user might want to simply specify the clock as TTL. Choosing this option, the threshold level of +1.40 volts would be displayed automatically in a nonvariable field next to the legend TTL. On the other hand, if the option VARIABLE were chosen, the field next to the legend would become changeable. The user could then enter a threshold level such as −1.3 V, which would be appropriate for emitter-coupled logic. The keyboard arrangement for the DAS is shown in Fig. 2, and the menus are presented in "A menu of menus" (see p. 116).

Design decisions

The goals of modularity and ease of use drove the architectural design of the DAS. Achieving a modular yet easily configurable architecture involved making critical choices in the organization of system firmware, choice of a system language, and organization of bus structure. Since the menus and system operation are dependent on the cards resident in the system at any time, firmware that informs the central processing unit of the card's capabilities and adjusts the menu is resident on each card module.

This, however, presents another challenge: whereas an 8-bit Z80 microprocessor is sufficient to perform the system management tasks, its addressing capabilities are limited. For the system and all its cards, a total of 120-K bytes of firmware are required—much more than a 8-bit processor can directly address. Further, it is desirable to have an open-ended addressing scheme, one to which more firmware could be added when new cards are developed.



1. Card tricks. The capabilities of the DAS 9100 digital analysis system are determined by which cards the user inserts in the right part of the mainframe. The complement of cards includes two types for pattern generation, a capability not seen before in logic analyzers.

Open for business

Since the Z80 address space is not open-ended, a way of mapping a variety firmware into a fixed space was devised. A 4-bit slot-selection register on the controller card can be programmed to select the card module that is to be addressed. A second 4-bit register selects the particular 8-K bytes of read-only memory on the data-acquisition or pattern-generator card that should be accessed by the controller. This results in the memory map shown in Fig. 3.

The system language has to be able to handle complex data structures that describe whether the card is actually resident in the system, what its capabilities are, and where in the cage the card is located. Because of its ability to handle such large and sophisticated data structures with memory-efficient coding, Pascal was selected as the system language.

The nature of the information that has to be transmitted from card to card determined the bus structure of the system. In general, two types of data had to be communicated: configuration or measurement data and high-speed information, such as clock and trigger signals. The former does not have to be communicated in real time, and thus the bus structure of the controlling Z80 computer was sufficient.

The Z80 controller bus, in buffered form, goes to all the instrument's cards and serves as the primary link among the distributed system firmware. The bus carries the address and data information that the Z80 loads onto and out of the cards.

The high-speed bus is a group of 72 carefully structured paths whose impedances have been tightly specified to ensure high-quality waveform transmission. It is

PATTERN-GENERATION AND DATA-ACQUISITIONS CARDS FOR THE DAS 9100

Card type	Model No.	Description
Pattern generation (maximum 80 channels)	91P16	Microprogrammed card able to output 16 channels of data plus two strobes and two clocks at a data rate of 25 MHz
	91P32	Pattern generator expansion card with 32 channels and 4 strobes. Must be used with 91P16
Data acquisition (maximum 104 channels)	91A32	Intended for wide-bus application, can acquire 32 channels of data at a cycle rate of 25 MHz, sync or async
	91A08	Intended for hardware debug, can acquire 8 channels of data at a cycle rate of 100 MHz, sync or async
	91A04	For debugging high-speed logic, can acquire 4 channels of data at a 330-MHz cycle rate, sync or async, or 2 channels at 1.5-ns resolution
	91AE04	Adds an additional 4 330-MHz channels or 2 (1.5-ns) channels of signal acquisition. Must be used with 91A04

used, for instance, by the data-acquisition cards to transmit word recognition and qualifier signals to the trigger–time-base card. It is also used by the pattern-generator card to communicate with its expansion cards.

To let users tackle a wide range of test problem, the pattern generator was designed so that, by adding expansion cards, up to 80 channels of output data and 10 independent strobes can be generated simultaneously. Whereas stimulation of simple circuits or microprocessors can often be handled with 16 channels, stimulation of bit-slice devices, microcode memory, or large circuit boards may require in excess of 64 channels.

Pattern source

The primary pattern-generation card contains all the pattern-generation control circuitry and can generate 16 channels of data and two independent strobes. The expansion cards increase the amount of pattern-generator memory and each provides an additional 32 channels and four strobe lines. The system can contain a maximum of two expansion cards, which must be used with the primary card.

It is the job of the primary pattern-generator card to process the instructions for generating all test vectors put out on the channels, regardless of how many pattern-generator cards are in the system. When a vector storage random-access memory on the primary card is addressed, the card passes the address to the vector memories on the expansion cards using the high-speed bus.

Through the primary card, the menu is automatically updated to reflect the actual number of pattern-generation cards in the system. (The card's operation is explained in "Pipelining a test pattern," p. 118.)

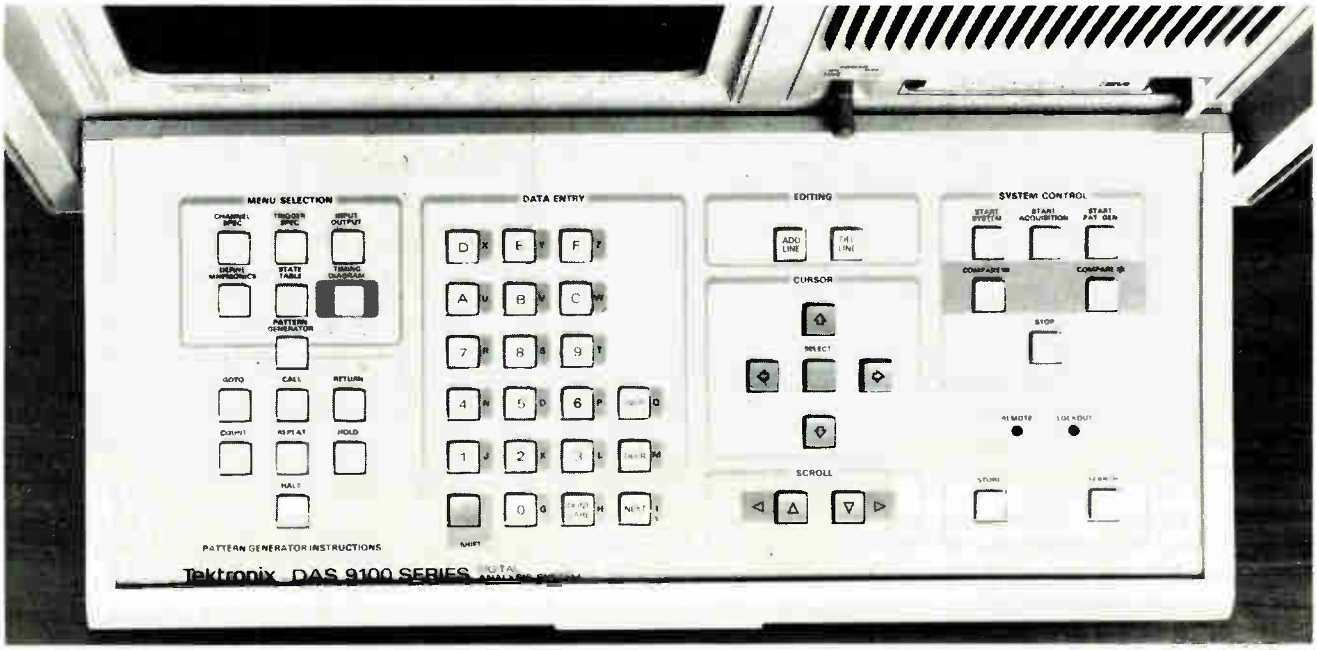
To deal with high-speed bus structures and permit stress and margin testing, the pattern generator must be able to create and output numerous vectors quickly and accurately. The pattern-generator controller selects vector-memory locations using algorithms consisting of jumps, loops, and counts, as well as subroutines for bus handshaking sequences.

The 254-word vector memory, therefore, can produce patterns that are several thousand words long and repeat indefinitely. Yet the actual programs used to generate these patterns are generally only 10 to 15 instructions long, because the pattern generator's high-speed hardware is involved in generating vectors. Thus the DAS can deliver a valid test vector every 40 nanoseconds, without requiring multiple machine cycles to compute an output.

Until now, most pattern generators have been more like computers, requiring the user to learn a special language. Further, very few of the programming statements were directly related to the test vectors to be generated. In the DAS, each program statement relates directly to the test vector because it defines the pattern-generator output for that cycle.

Strobing parameters

The pattern generator's strobe lines in conjunction with its data-output ports simulate different bus structures. For example, when designing a microprocessor-based controller, the test vectors can be organized into address and data buses while the strobes are used as control lines, to simulate external functions of the microprocessor. This is done by using an instruction set that is familiar to the designer, eliminating the need to work with various assembly languages. The leading and trail-



2. Key to simplicity. Despite its complexity, the DAS 9100 has a fairly simple keyboard, thanks to its menuing scheme. The keys in the upper left, above, call the various menus while the cursor keys, right of center, choose menu parameters. The pattern-generator programs are created using the keys at lower left, while the hexadecimal key pad permits more sophisticated use of the system.

A menu of menus

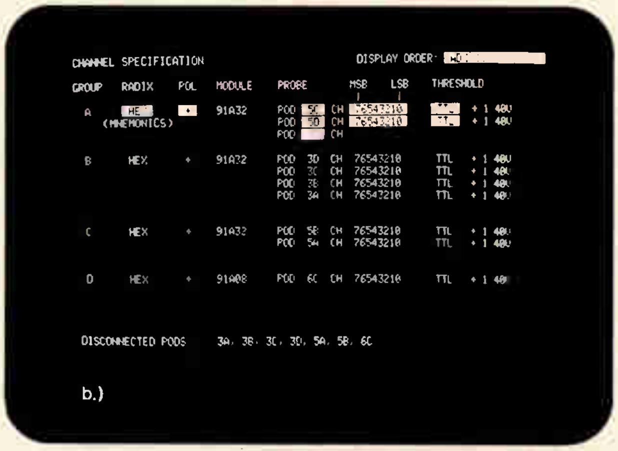
The ease with which the DAS 9100 logic analyzer can be operated, despite its configurational complexity, involves a carefully devised menuing scheme. At power-up, the user is presented with a menu (a) informing him or her what cards are in the instrument and whether they are all operational. If they are not, the user can run more complex diagnostics by pressing a button.

With the channel-specification menu (b), the sequence and format in which channel information is to be displayed, as well as the logic level for the channels, are specified. Then with the trigger menu (c), the user specifies when data is to be collected. All menus vary automatically to reflect what capabilities are in the system at any time, and the trigger menu shown here permits the slower (25-megahertz) card, the 91A32, to arm the hardware 91A08 card.

In the define-mnemonics menu (d), the user can assign to different logical combinations that appear on certain channels the mnemonics that may be associated with those combinations, such as mnemonics for various microprocessors or for the IEEE-488 interface.

The program generator menu (e) lets the operator set up simple routines that can use several loops to create varied patterns to stimulate and test the unit. Associated with that menu is the strobe menu (f) that, by letting the user define up to 10 lines as strobes, enables the DAS to simulate various bus structures, for example.

To communicate data from the DAS for display or analysis elsewhere, or to permit storage of patterns and mnemonics for later use, the DAS provides an input/output menu (g). In the menu shown, patterns and mnemonics are to be sent to a tape drive that is on the general-purpose interface bus (IEEE-488).



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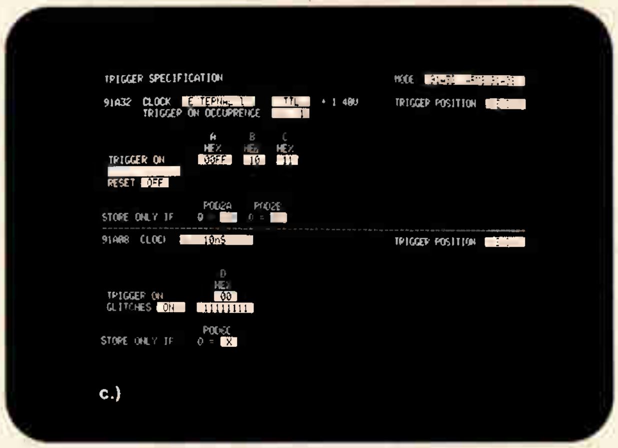

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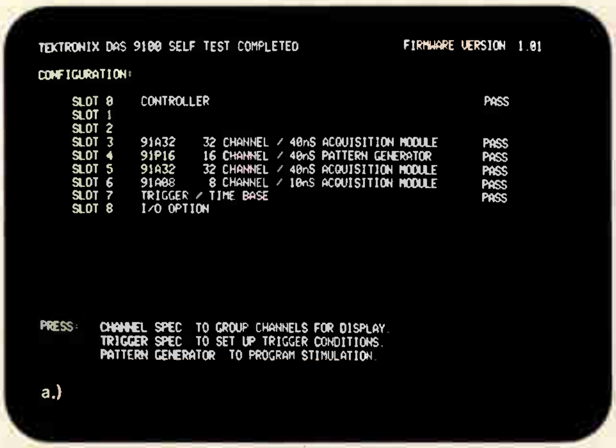
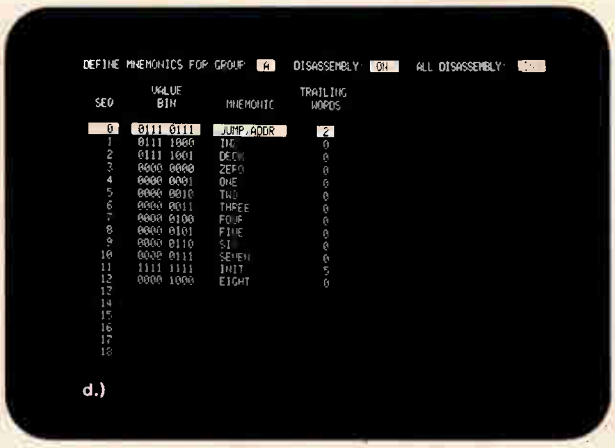


a.)



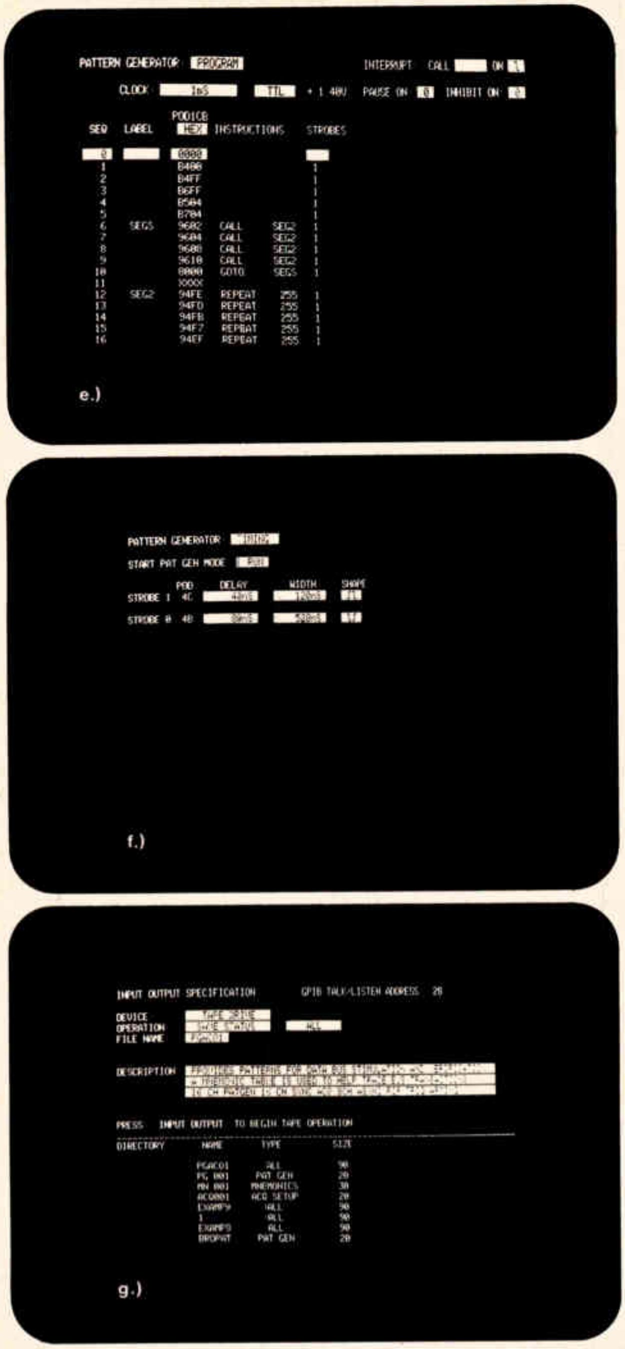
d.)

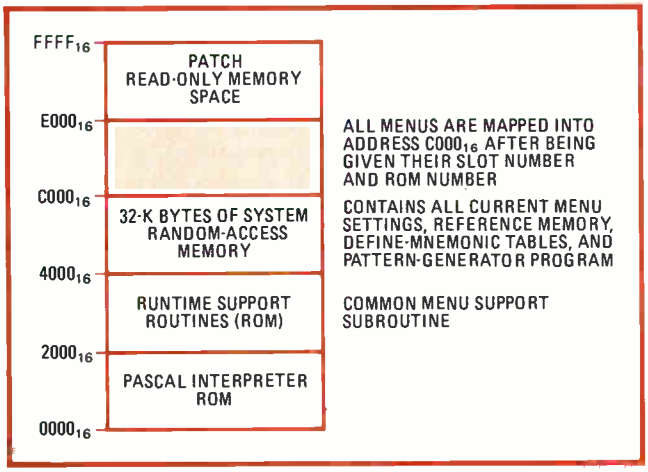
ing edges of the strobe outputs are programmable within the data cycle's limits as shown in Fig. 4, and all strobe parameters are easily set using the strobe menu.

To deliver the strobe and data signals to the circuit under test, the pattern generator comes with a special set of probe pods.

The set includes two different types of probes, each optimized for different logic families. The version intended for use with TTL and MOS devices has active pull-up and pull-down circuitry and can accommodate large swings in voltage. The ECL version, on the other hand, is designed to handle the smaller voltage swings and the faster rise and fall times associated with that high-speed logic family. It has active pull-up but passive pull-down circuitry.

Each pod has 10 outputs: eight data channels, one





3. Making room. To let the instrument's Z80 processor address all the system's present 120-K bytes of firmware, the firmware associated with the menus for the different cards is mapped into the open space shown near the top of the memory map above.

strobe line, and one clock line. In addition, the pod has two reference lines that are connected to voltage levels that serve to determine the high and low levels of the output data.

To let the DAS simulate a bus-resident device, each of the pod's output lines can be placed in the three-state condition in either of two ways—the user can put "don't care" statements in the pattern-generator program that will invoke the state on the fly, or a control line on the pod can be connected to an external device that will initiate or end the three-state condition.

Even if the DAS could not stimulate a test circuit, its logic-analysis configurability makes it an outstanding instrument. In effect, the user has not one but hundreds of different logic analyzers to choose from in the DAS.

The data-acquisition cards that configure the DAS were designed to serve the different requirements of software and hardware debugging. Software de usually requires more data-acquisition channels the 91A32 card has 32 channels that can acquir cycle times to 40 ns. Up to three of these car used in the system at any one time, so the u potential capacity to watch 96-bit-wide softw through a system—a capability that is un outgrown at all soon.

Checking out hardware

Hardware debugging, on the other h generally require a large number of chan demands that the designer be able to ob changes at speeds well above the 91A32's 25 megahertz. The DAS provides a choice of cards with which the user can watch hardware timing. One of the two major hardware-oriented cards, the 91A08, has eight data-acquisition channels that sample signals every 10 ns at maximum. The sibling of this 100-MHz card is the 91A04, which has half the number of channels but a much faster acquisition time—3 ns synchronously or asynchronously. Additionally, the card will operate with 1.5-ns timing resolution if only two channels are used. More 330-MHz channels can be added using the four-channel 91AE04, while the number of 100-MHz channels can be increased by adding more 91A08 cards. Altogether, a total of four hardware-oriented cards can be supported by the system at any one time.

Within the limit of 104 acquisition channels, users

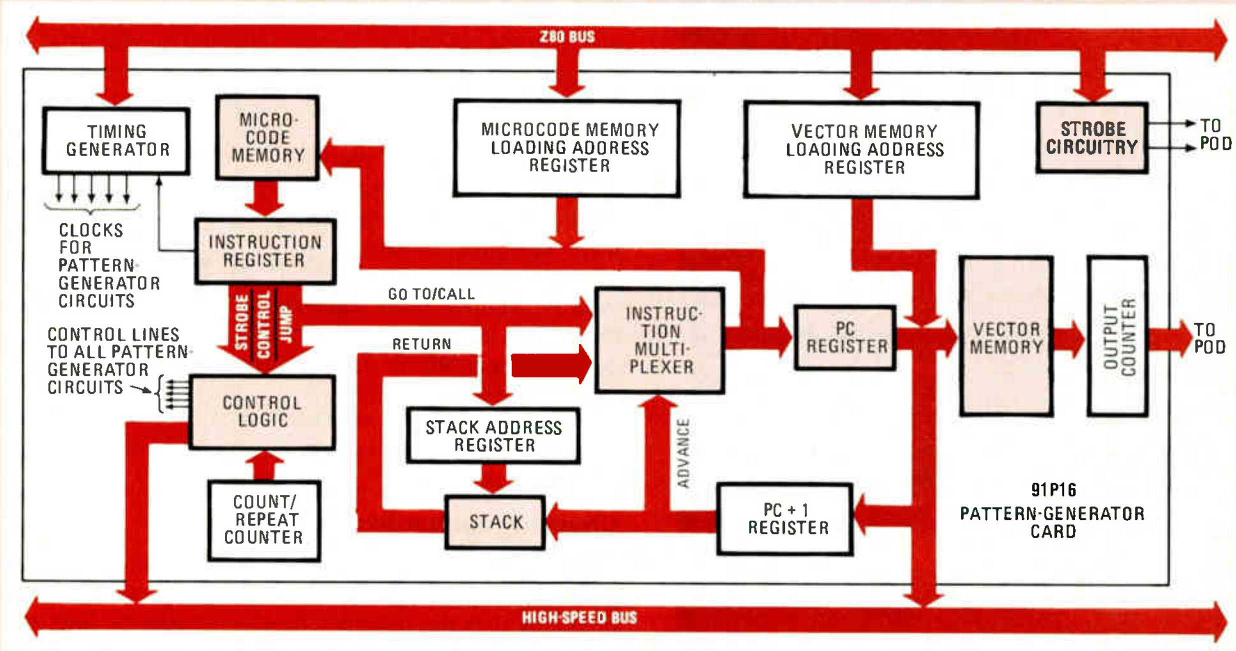
Pipelining a test pattern

The digital analysis system's pattern generator is actually a special-purpose microprogrammable computer that outputs test vectors using a triple pipelining process. The major elements of the pattern generator are the 256-by-13-bit microcode memory, the control logic, the instruction multiplexer, the 16-by-8-bit stack, the 256-by-16-bit vector memory, and the strobe circuitry. These and the supporting circuits, shown in the accompanying illustration, are all contained on the primary pattern-generator card, the 91P16; the expansion cards contain additional vector memory that is controlled from the primary card.

The process of putting out a particular set of logic states on the pattern generator's channels in a given cycle—that is, a test vector—actually takes three cycles. Thus to create the Nth cycle test vector, the process begins in cycle N−2. It is actually a triple-stage pipeline whose use results in valid outputs for every cycle.

Pattern generation begins after the microcode memory has been loaded with the instructions on how to generate a pattern and the various test vectors have been loaded into the vector memory via the Z80 bus. At the beginning of cycle N−2, an instruction is logged from the microcode memory into the instruction register. The instruction consists of three major fields: the control, jump, and strobe fields. The control field directs the control logic to pass either the contents of the jump field to the top of the stack or the contents of pc+1 to through the instruction register. If the control field specifies a call instruction, the contents of the jump field are passed through the instruction multiplexer and pc+1 is pushed onto the stack. The strobe field specifies the selected strobe and is pipelined to occur in cycle N.

At the beginning of cycle N−1, the output of the instruction multiplexer is logged onto the pc register and is used to select one of the vector memory locations. In cycle N, the contents of that location is logged into the output counter and sent out to the circuit under test.



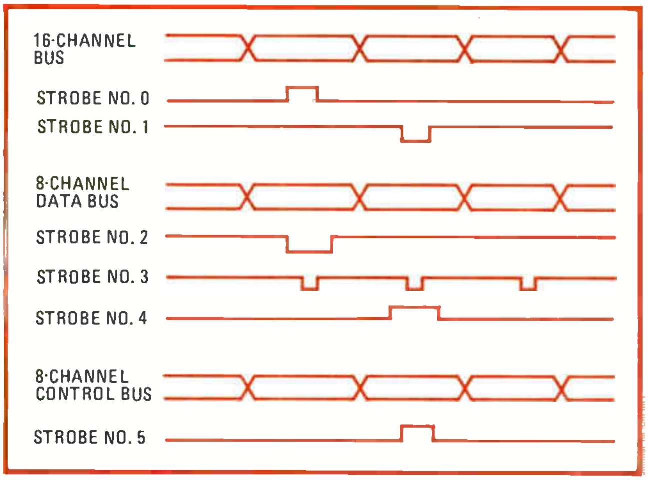
may install a variety of software- and hardware-oriented data-acquisition cards simultaneously in the DAS. The ability to combine both cards makes the logic analyzer into an extremely powerful troubleshooting tool, since hardware and software are intimately related in the majority of designs.

Staying in step

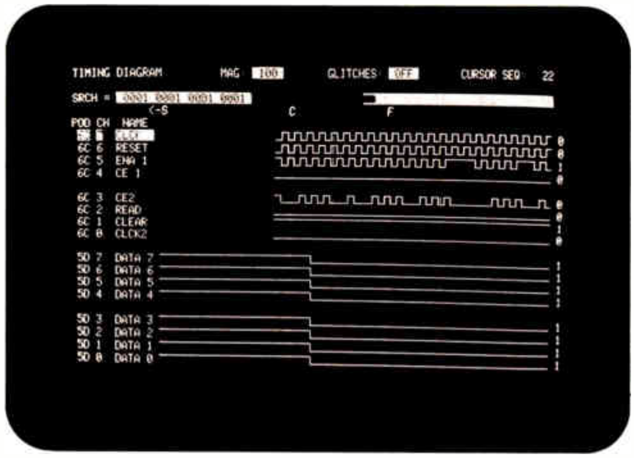
During system integration, for example, it is usually necessary to watch the software flow and then relate very fast hardware transitions to the program steps that caused them. Because the logic analyzer has a special operating mode called the arms mode, it can make a one-to-one correlation of software and hardware events and present this information to the user.

In the arms mode, the user sets up a menu so that a software event monitored by the slower software-oriented card triggers one of the higher-speed cards to gather hardware data. Once the data is trapped, the DAS can present a correlated display such as the one that is shown in Fig. 5.

For the system to match the data taken in by the two card types, the higher-speed cards were designed with an extra channel dedicated to acquiring the clock signal of the slower card. When triggered, they clock in the signal at the speed of their faster clocks and store the state of



4. Strobing simulations. The pattern generator's programmable strobe lines let the pattern generator emulate control lines for the unit under test, as shown above. Thus, buses and other schemes may be simulated. Strobes can be set within 40 ns in a clock cycle.



5. Logical match. Using the DAS's 25-MHz data-acquisition card to arm a hardware acquisition card lets the DAS present a correlated view of the firmware flow (bottom) and the affect of that flow on faster hardware events (top). Display resolution may be increased.

the slow clock in a special memory that is called the clock array.

Once all the data is acquired, the CPU reconstructs a picture of the actual events from the data in the clock array and from its knowledge of the number of cycles between triggers.

When an instrument performs as many functions as the DAS, it is important to have self-test at power-up. The user then knows that the functional blocks have been checked out and are up and running. If the DAS does not pass the start-up tests, the user may go into an extended diagnostic procedure to check out any card down to the component level.

Although the DAS functional blocks are checked at power-up, the diagnostics cannot check probes the user may have already hooked to a circuit. To test the probes, the DAS has a diagnostic lead set that connects eight channels of the pattern generator to eight channels of acquisition. A preset walking 1s pattern allows the user to test the complete path from the pattern generator through both the pattern-generator probes and the acquisition probes to the acquisition card. It also allows for testing of the triggering modes and provides a vehicle for learning how to operate the instrument.

Room to grow

The optional DC100 magnetic-tape drive provides over 160,000 bytes of storage. In this space, the test patterns used for troubleshooting the product during design can be saved for use in manufacturing test and evaluation once the product goes into production. Instrument setups can also be stored to prevent the designer from having to rethink the design problem every time he or she returns to the bench.

By combining the tape drive with the channel specification and mnemonic menus, the designer can configure the logic analyzer for the number of channels and mnemonic display required for the current application. Moreover, he can save it for future use.

General-purpose logic analyzers provide state table displays in hexadecimal, octal, or binary radixes. In most cases, the engineer must purchase a separate ROM, probes, or monolithic instrument to get microprocessor disassembly mnemonics.

Not only single-word operation codes and microprocessor mnemonics but also the address labels of the engineer's program or any other appropriate mnemonics (symbols) can be displayed simultaneously on the DAS. Up to 16 independent tables can be used. For example, simply loading a different configuration file from the tape drive will set the DAS up to disassemble the information flowing over an IEEE-488 bus.

Action at a distance

The DAS can also contain option I/O hardware for both RS-232 and IEEE-488 interfaces. Both allow the designer to run the DAS from a controller in a networked or automated test application. The remote programming language supports all operations that can be performed from the keyboard and some additional commands that are useful for automated testing.

The DAS can be connected to another DAS via phone lines using the RS-232 interface. Either one can then be operated from the other. For example, a DAS could be in place as the on-site diagnostic tool for a large minicomputer. In the event of a failure, the factory service center could use its DAS to call its on-site counterpart over an acoustic coupler, operate the on-site DAS remotely, acquire data, and analyze the problem.

Alternatively, a DAS could be used to monitor and analyze a prototype in an environmental test location like a radiation, temperature, or cycle chamber where people cannot survive. This DAS could be operated remotely from another one outside the chamber.

In these applications, the DAS plays a key role in transporting design documentation and tests out into the manufacturing and service areas. □

SAW components answer today's signal-processing needs

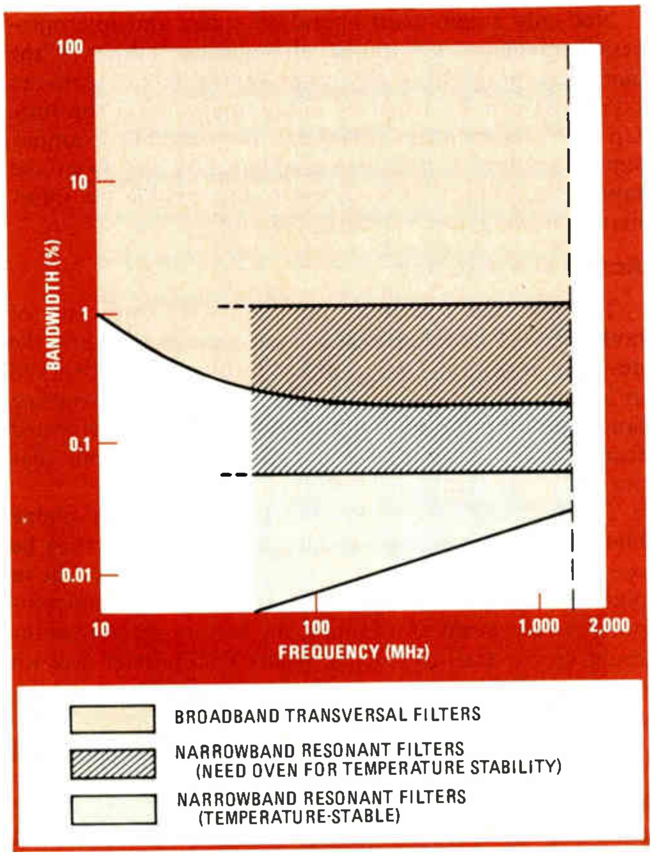
Filters, delay lines, and oscillators using surface-acoustic-wave technology are now practical

by R. J. Murray and P. D. White, *Philips Research Laboratories, Redhill, Surrey, Great Britain*

☐ Signal-processing devices that depend on surface acoustic waves are coming into their own, as more and more electrical engineers become familiar with the SAW phenomenon. Once the concept of converting an electrical signal into a surface wave is accepted, EEs soon discover the versatility of SAW devices—which now are available at commonly used frequencies and so are suited for many modern electronic systems.

For systems designers, SAW parts offer attractive features. For one, it is possible to implement certain signal-processing functions that would be impractical in other technologies: large time delays in small devices, for example. Also, the structure of photolithographic patterns on a crystal substrate yields small, light, rugged parts that require no tuning or setting up. Finally, SAW devices can meet military electrical and environmental specifications.

Bandpass filters, delay lines, and oscillators are the most common SAW components. These parts and the many specialized devices based on them depend on the same basic theory (see "Making use of surface acoustic waves," opposite). The performance limits, specifications, and applications of these three components are an important part of the system designer's knowledge.



1. Wide range. The three most common types of SAW filters can implement various combinations of bandwidth and center frequency. Above 1.5 GHz, special photolithography and construction techniques are required, and bandpass performance may be reduced.

SAW filters

There are two types of SAW bandpass filters: transversal and resonator versions. An important distinction is that they work at different bandwidths (Fig. 1).

The transversal filter, which consists of two or more interdigital transducers (IDTs), is a traveling-wave structure. Its bandwidths can be from 0.2% to 100% of the center frequency, which are in the 10-to-500-megahertz range with a projected upper limit of 1.5 gigahertz. For standard processing techniques, design procedures are similar to those used for digital filters.

The resonator filter consists of one or more IDTs in a cavity formed by two surface-wave reflectors. This structure supports a standing wave. Bandwidths of 0.01% to 1% of the center frequency are feasible, with center frequencies currently in the 50-to-500-MHz range and ultimately greater than 1.5 GHz. Design procedures are similar to those of conventional LC filters.

In the simpler form of the transversal filter (Fig. 2a), an electrical signal feeds into one transducer, is converted to a surface acoustic wave, filtered, reconverted to electrical energy at the other IDT, and emerges as a filter signal. An alternative structure (Fig. 2b) incorporates a multistrip coupler in the wave's propagation path. A series of parallel unconnected metal strips, the coupler transfers the wave from one track to another, providing discrimination against the unwanted bulk acoustic waves that are also launched by the input IDT.

SAW transversal filters usually have non-minimum phase responses, so the amplitude and phase responses may be designed virtually independently of each other. Thus, a precisely defined amplitude response with steep sides, a flat or even equiripple passband, and good stop-

Making use of surface acoustic waves

Of the different kinds of surface acoustic waves, the most commonly exploited for signal processing is an elastic wave that travels on a piezoelectric substrate. There are two reasons for this choice: usually more than 95% of the elastic SAW energy is within one wavelength of the substrate's surface, and the propagation of the wave is essentially loss-free.

Also, the surface wave's velocity is typically 3,000 meters a second, five orders of magnitude smaller than that of an electromagnetic wave. Therefore, relatively large delays can be achieved in short paths, allowing realization of compact delay lines and the many signal-processing components that employ them.

For minimum loss of energy during conversion of the electromagnetic signal into its SAW equivalent and then back after processing, the best input and output structure is the interdigital transducer. The IDT consists of two sets of interspersed electrodes, each connected to a busbar. The electrodes are photoetched onto the polished surface of the piezoelectric substrate in a thin film of metal, usually aluminum between 500 and 5,000 angstroms thick.

Applying an alternating potential difference between the two sets of electrodes produces electric fields below the substrate surface. In a piezoelectric material, these fields create a periodic mechanical distortion on and within the substrate surface: the SAW phenomenon.

This effect may be understood by assuming that each electrode launches a surface wave. These waves add in phase at the synchronous frequency f_0, given by v/d where v is the surface wave's velocity and d is the IDT's period. Thus, reinforcement occurs and a surface wave is launched from both ports of the transducer. The IDT can transmit a band of frequencies centered on f_0, where the wavelength (λ_0) of the surface wave equals d.

The transducer's geometry determines its impulse and frequency responses. The relative position of each electrode determines the time of its contribution to the impulse response and the extent to which the interdigitated electrodes interlock determines their contribution to the amplitude of the impulse response.

Now, the Fourier transform of the impulse response determines the frequency response. The uniform IDT, in which the electrodes interlock completely, has an impulse response that, to the first order of approximation, is a sampled rectangular function.

Designing a transducer with a given frequency response is a matter of working backward by performing a Fourier transform on that frequency response in order to give the associated impulse response. Then this response is then truncated to a time period that contains the bulk of the signal energy.

This impulse response is built into the IDT by the amount of interlock of the electrodes. For a linear phase response, the electrode pattern is either symmetric or antisymmetric about its geometric center. For nonlinear phase response, the pattern must be asymmetric.

Electrically, the IDT can be represented by a lumped circuit with three parallel elements. One is the static capacitance between the electrodes; another is the frequency-dependent radiation conductance, which represents the translation of electrical energy into surface waves. The third is the radiation susceptance and is given by the Hilbert transform of the radiation conductance.

Whether or not the transducer is driven directly, it usually is inadvisable to operate it with an impedance matching the power source. In wideband filters and delay lines, such a match maximizes the level of unwanted acoustic reflections. When analyzing or synthesizing the frequency response of the IDT, the effect of the terminating electrical circuit must be taken into account.

band level can be achieved while maintaining a linear phase response with a constant group delay typically in the 1-to-5-microsecond range.

Any spurious signals in the filter will arrive at the output with a time delay different from that of the main signal. They cause ripples in the amplitude, phase, and group-delay responses and can produce quite large deviations from the ideal response. So appropriate steps must be taken to minimize them.

Rejecting spurious signals

The most serious unwanted response is what is called the triple-transit signal, caused by successive reflections from the output and input transducers before detection and reconversion of the SAW signal. If the main signal delay is τ, then the triple-transit signal is delayed by 3τ, and the period of the ripples in the frequency response is half the main signal delay, or $\frac{1}{2}\tau$.

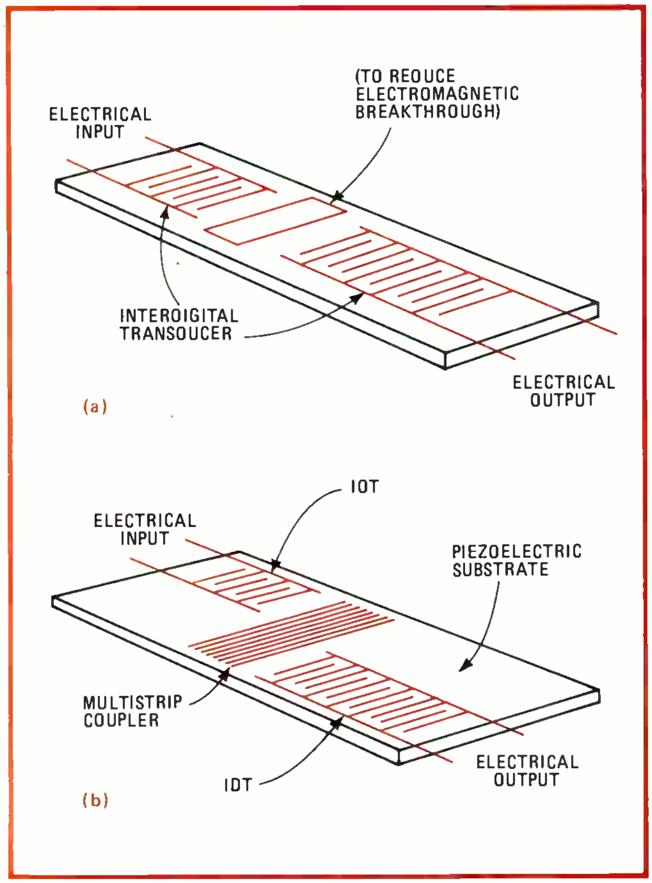
The major contribution to the reflections causing this spurious signal is electrical in nature and is a consequence of the IDT's structure: two acoustic and one electrical port (Fig. 3). During the launching of surface waves, an electrical input signal causes acoustic signals to be launched at both acoustic ports. If the electrical port is perfectly matched to the source, then half the available power is delivered to each acoustic port. If surface waves are incident on one acoustic port, half the energy is delivered at the electrical port and one quarter at each acoustic port.

For a filter consisting of two perfectly matched IDTs, the minimum theoretical insertion loss is 6 decibels, and the triple-transit signal is only 12 dB below that. The result is an amplitude ripple of about 4 dB peak to peak and a phase deviation from linear of about 25° p-p. Ripple of this magnitude usually is unacceptable.

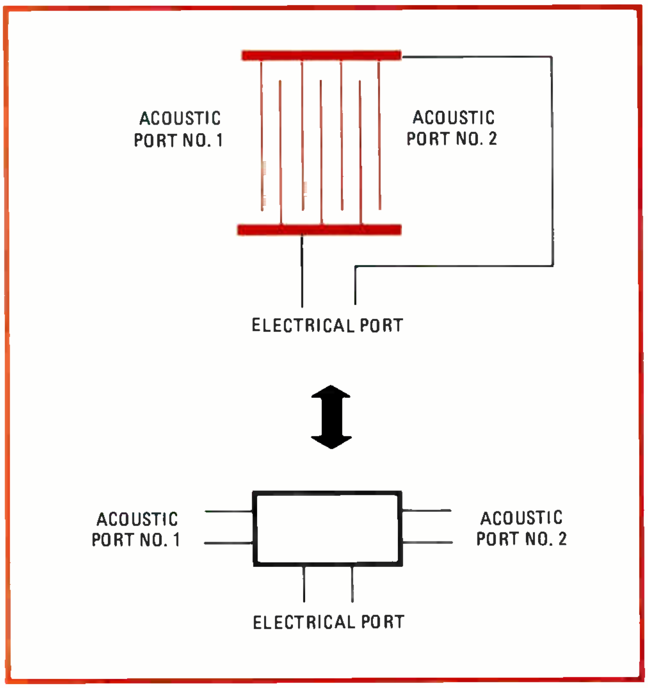
The simplest and most widely used means of reducing the triple-transit signal is to operate the filter with a mismatched source or load impedance (or with both). This tactic increases the filter's insertion loss but drastically reduces the level of the reflection signals: experience shows a typical insertion loss is 20 dB with peak-to-peak ripples of less than 0.3 dB in amplitude and less than 2° deviation from linear phase.

Unfortunately, any attempt to reduce the insertion loss by improving the match of the terminations will cause increased amplitude and phase ripple. For filters that must have the lowest possible loss, there are other, more complicated methods to use in order to suppress triple-transit responses.

There are several other spurious signals in SAW



2. Two types. The SAW transversal filter may be designed in either of two configurations (a) and (b). The multistrip coupler found in (b) filters out unwanted bulk acoustic waves. The coupler is deposited on the piezoelectric substrate much as the transducers are.



3. Three ports. A SAW filter has three ports, since the incoming electromagnetic wave is converted into an acoustic wave at the input with the conversion being reversed at the output. Both acoustic and electric ports may have to be matched for maximum power transfer.

devices, and these can be reduced substantially by suitable design of the transducers and the substrate. For example, reflections from the substrate ends can be cut by beveling them and applying an acoustic absorber behind the IDTs. Another problem can be reflections within the transducers, and these may be reduced by replacing each electrode (which are a quarter of a wavelength wide) with a pair of like-polarity electrodes that are half the width.

Resonator filters

In a surface-wave resonator (Fig. 4), the design of the reflectors is all-important. Surface waves cannot be efficiently reflected by an abrupt discontinuity, such as a substrate edge; such a reflection would convert a significant proportion of the energy into bulk acoustic waves, which are undesirable in this application.

Therefore, SAW reflectors consist of a large number of low-impedance discontinuities in the form of metal strips or grooves half a wavelength apart. They have typical peak-amplitude reflection coefficients of 99% or higher, and the resonant cavity that holds the transducers generally can support several standing waves. The required standing-wave mode is determined by the design of the reflectors and the IDTs.

The equivalent electrical circuit of a single-port SAW resonator resembles that of a quartz crystal bulk-wave resonator. It consists of an LCR resonant section for the cavity and a shunt capacitance for the transducer. Two or more of these elements may be connected to produce a coupled resonator.

By the appropriate choice of structure, various filter types like Butterworth and Chebyshev may be realized. In general, any number of resonators may be coupled to form a multipole filter. However, for very narrowband filtering at frequencies above 150 MHz, there is a severe insertion-loss penalty for fourth-order and greater filters.

Differing applications

Since surface-wave filters can be broad- or narrowband, they fit a wide range of applications. The best known example of a broadband transversal device is the television set's intermediate-frequency filter. It replaces an LC filter with five inductors and a resistor, all needing factory alignment, and assembled on a 50-cubic-centimeter printed-circuit board with several other components. The SAW replacement needs no alignment and is mounted in a TO-8 package occupying but 2 cm^3.

Transversal filters have many potential applications in communications and radar systems, which can capitalize on their small size and light weight. Table 1 lists the performance these devices can achieve—although no one unit can achieve the maximum in all specifications simultaneously. For example, it would be unreasonable to expect a filter with a very narrow bandwidth at 10 MHz to fit into a TO-8 package, since a narrow bandwidth usually means a long device.

Moreover, the values shown are typical, not necessarily outside limits. For example, bandwidths greater than 50% can be achieved only with high insertion loss. Also the size of the part and fabrication constraints limit the bandwidth and frequency range. The maximum acceptable substrate size determines the steepness of the filter's bandpass shape, and the pattern definition determines the upper frequency limit.

The absolute time delay through the filter, listed in the table as between 1 and 5 μs, may be more for filters with very steep sides. Also, the tradeoff between insertion loss and amplitude ripple holds for group-delay ripple: the typical insertion loss of 20 dB might give a group-delay ripple of less than 2%, as well as the amplitude ripple of less than 0.3 dB.

Resonator specs

Because the narrowband SAW filter is a resonant device, it has a more restricted range of parameter values than does the transversal filter. Table 2 summarizes the achievable resonator filter characteristics. Again, not all maximums can be met simultaneously: a part with a very narrow bandwidth (say, 0.02% of the center frequency) at 500 MHz with a third-order response would have more than 6 dB of insertion loss.

However, the insertion loss decreases significantly as the bandwidth increases. For example, a bandwidth of 0.03% may be accompanied with a loss of 2 dB. In parts with bandwidths greater than 0.1%, in fact, the loss is due mainly to external components and stray capacitance and is about 1 dB.

Bandwidths of up to 0.05% can be achieved with a quartz substrate and no external temperature compensation. Above that, it is necessary to use a different material and to institute control of the filter's temperature.

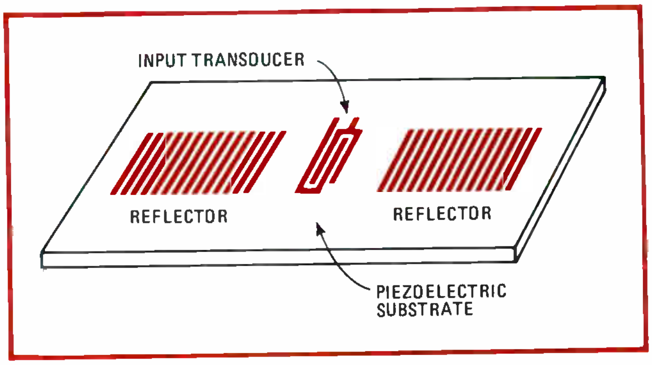
Delay lines

The second major class of signal-processing device using surface acoustic waves is the delay line, which consists of two interdigital transducers suitably placed on a piezoelectric substrate. If each IDT is symmetric or antisymmetric around its geometric center, then the frequency response is a bandpass with a linear-phase characteristic. With a suitable asymmetric design, the part can be made to be dispersive so that the delay varies as a controlled function of the frequency.

Linear-phase delay lines can be made with bandwidths of as much as 100% of the center frequency between 10 MHz and 1.5 GHz. Delays ranging from 400 nanoseconds to 30 μs or more can be achieved; shorter delays are best realized as the differential delay between two of the devices.

The most attractive feature of SAW delay lines is the small size of the part needed to achieve a relatively large delay. For example, in an ST-X quartz crystal that is temperature-compensated, a delay of 1 μs may be obtained with an acoustic path length of 3.2 millimeters.

Applications for these components include radars, electronic countermeasure systems, and target simulators. They also are useful in discriminator circuits in which a signal is fed to a double balanced mixer via two paths, one direct and the other through the delay line. If the component has a linear-phase response, the dc output voltage from the mixer is a cosine function of the input frequency and is approximately linear over a reasonable bandwidth. As is usual with discriminator circuits, linearity can be achieved over a wide bandwidth by limiting the signals at the mixer inputs to square waves.



4. Resonator. It is possible to make a single-port SAW resonator by depositing an input transducer between SAW reflectors. Multiple standing waves can be supported, with the correct one being chosen by design of the transducer fingers and the resonator shape.

Using SAW techniques, it is possible to make fixed or tapped delay lines that are accurately defined and highly reproducible. The substrate length must be on the order of 3 mm/μs, and 100% bandwidths can be achieved at center frequencies that range from 10 MHz to more than 1 GHz. A linear-phase response can then be achieved within the passband.

SAW oscillators

There are two types of surface-wave oscillators, based on the components already discussed. One type employs a conventional SAW delay line in the feedback loop of an amplifier. Typically, the frequency may be linearly modulated by 0.1%. SAW resonators may also be used: a single-port part is much like an oscillator made of a bulk-acoustic-wave crystal resonator, and a two-port version may be used in an amp feedback loop just as a SAW delay line may.

Resonator oscillators can provide only very narrowband linear frequency modulation, but they do furnish better noise performance than a delay line type can. Both types can work at fundamental frequencies of between 10 MHz and 1.5 GHz without additional multiplying circuitry. They are considerably smaller, cheaper, and lighter than conventional oscillators.

In the delay line version, any delay at a given frequency corresponds to a phase shift. Oscillation occurs when the total phase shift around the oscillator loop is equal to an integer multiple of 2π.

Suitable design of the IDTs will ensure that the frequency of interest is passed but that spurious generated frequencies are rejected. The loop's frequency may be modulated by the variable phase shifter, which may incorporate one or more Varicap diodes to do the shifting. The output signal may be taken at any point in the loop; but for maximum power, it would be immediately after the amplifier, and for minimum noise, immediately after the delay line.

As is usual with oscillators, the amplifier's gain must be greater than the loss around the loop, and the common operating mode is with the amp saturated. The delay-line loss typically will be 10 to 20 dB, depending on the electrical matching.

SAW resonators are components with high quality

TABLE 1: SURFACE-ACOUSTIC-WAVE BROADBAND TRANSVERSAL FILTER CAPABILITIES	
Center frequency range	10 MHz – 1.5 GHz
Bandwidth (–3 dB) minimum	100 kHz or 0.2% of center frequency (whichever greater)
Bandwidth (–3 dB) maximum	100%
Transition bandwidth (–50 dB to –3 dB) minimum	100 kHz or 0.2% of center frequency (whichever greater)
Typical group delay	1–5 μs
Typical group-delay ripple	<2% p-p
Typical insertion loss	15–25 dB
Typical passband amplitude ripple	<0.5 dB p-p
Typical stopband	50 dB close to passband, 70 dB further out
Package size	Small – usually TO-8 (1.5 cm in diameter)

factors that operate at frequencies of 10 MHz and above. Unloaded Qs over 20,000 can be achieved at 250 MHz, making it possible to provide stable sources at the fundamental frequencies.

If a two-port resonator is used in an amplifier feedback loop, the amp need provide only 4 to 5 dB of gain, because a resonator has a lower insertion loss than the delay-line SAW part used as an oscillator. However, the frequency response of a resonator is linear only over a very narrow range of about 0.02%, so there is less potential for linear frequency modulation.

If the resonator used is a single-port configuration, then in ultrahigh-frequency applications, the construction could be based on a cavity- or resonator-stabilized microwave oscillator. In some cases, then, a single transistor can serve as the amplifier, giving a very compact oscillator for many systems.

Application areas

For low-noise, stable oscillators operating at high frequencies, surface-wave components are rapidly becoming recognized as the best control elements available. Their operating range eliminates the need for costly multiplier chains and consequent spurious oscillation modes.

A typical SAW oscillator might have a fundamental frequency of 400 MHz, a long-term stability of better than 3 parts per million per year, and 1-part-in-10^{-9} short-term stability at less than 10 seconds. Frequency variation with temperature is small, and it is possible to improve it with temperature compensation or control. A typical noise figure at 400 MHz is –140 dB/Hz at 10 kHz from the carrier. Using a voltage-controlled element in the circuit will provide fm capability.

The small size and light weight of SAW oscillators are particularly attractive. If the oscillator is made as a module, it usually will fit into a space of 2 by 2 by 1 cm, and recent development efforts have produced a device that fits into a 1-cm^3 volume. Typical uses include local oscillators for telemetry applications, such as radiosonds, and fixed-frequency low-noise oscillators for communications purposes.

The center frequency and delay of SAW devices are temperature-dependent and are affected by the choice of

TABLE 2: SURFACE-ACOUSTIC-WAVE RESONATOR FILTER CAPABILITY	
Center frequency range	50 MHz – 1.5 GHz
Bandwidth (–3 dB) minimum at 50 MHz at 500 MHz	 0.01% of center frequency 0.02% of center frequency
Bandwidth (–3 dB) maximum temperature-stable not temperature-stable but can be put in oven	 0.05% 1.0%
Typical insertion loss	<6 dB
Typical stopband	60 dB
Typical size at 50 MHz at 500 MHz	 25 x 15 mm 10 x 5 mm

substrate material. Generally, substrate materials suitable for narrowband devices have better temperature performance than those for wideband devices. However, it is possible to have temperature-stable wideband parts if high insertion loss is acceptable.

Environmental considerations

Two of the most popular substrate materials are quartz (with good temperature stability), which is usually used for narrowband devices, and lithium niobate (with a linear temperature variation of frequency and delay), which is used for wideband devices.

Typical temperature variations of frequency and delay are:

- Transversal filters with bandwidth greater than 5%: 94 ppm/°C.
- Transversal filters with bandwidth less than 5%: less than 80 ppm over a reference temperature range (t_0) of ±50°C.
- Resonant filters with bandwidth greater than 0.05%: 94 ppm/°C.
- Resonant filters with bandwidth less than 0.05%: less than 80 ppm over a t_0 range of ±50°C.
- Oscillators: less than 80 ppm over a t_0 range of ±50°C.
- Delay lines: same as transversal filters.

Standard or custom-designed packages may be used for SAW devices. For transversal filters, size depends on the bandpass steepness, stopband level, and passband ripple. In general, the package size will be less than 25 by 12 by 6 mm, and TO-8 packages are commonly used.

For resonant filters, size depends on center frequency and bandwidth. The size is generally less than 25 by 12 by 6 mm. The total module size for oscillators is less than 20 by 20 by 10 mm. As mentioned, each microsecond of delay requires a substrate length of about 3 mm. Thus, a packaged delay line with a delay of 7 μs is approximately 25 mm long.

All these devices are made using standard photolithographic techniques. Although it is possible to make SAW devices operating at frequencies of up to 1.5 GHz, the fine geometries required may impose some restrictions on the range of achievable performances at higher frequencies.

The substrate is mounted flat on the base of a package, giving a rugged planar device. Consequently, vibration and g-sensitivity are low. Furthermore, the package types lend themselves to modern assembly methods. □

Chip trio simplifies precise position control

A microcomputer is the only other device needed to complete the interface with the motor in this low-cost servomotor loop

by Maurizio Pitalieri and Carlo Bozotti, *SGS-Ates Componenti Electronici SpA, Milan, Italy*

☐ Designers who need the quick and precise position control that a servomotor loop affords—for example, for daisy-wheel printers and robot manipulators—need no longer be bothered by the complexity of their drives. Three new bipolar integrated circuits and a microcomputer make it possible to build a complete servomotor loop that exploits to the fullest the loop's high torque, high speed, and nonoscillatory positioning, as well as its low power consumption during standby. Also, of course, because the loop uses ICs, the additional benefits of small size, low cost, and high reliability are reaped.

The chips are the L290 tachometer converter, the L291 digital-to-analog converter and position amplifier, and the L292 switch-mode driver. They form the complete interface between motor and microcomputer, integrating all the required functions in between.

A block diagram of the complete loop is shown in Fig. 1. Although each chip can be used separately by itself, they are described here in the context of a three-chip system—the most likely configuration.

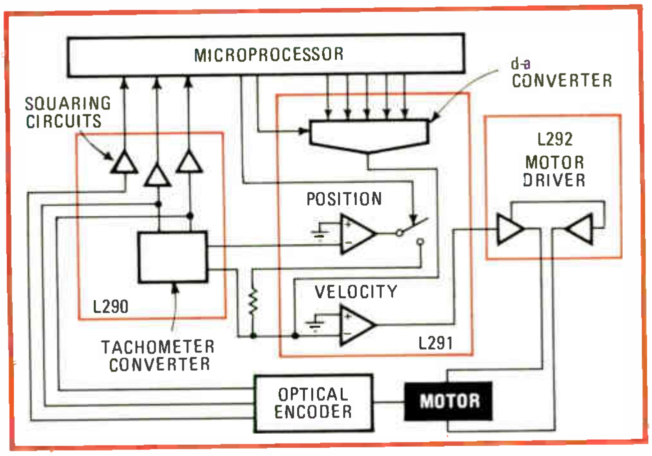
The L290 tachometer converter has two functions: it generates a reference voltage and a shaft-position voltage, both used by the L291 converter-amplifier, and it converts the pulses from a motor shaft encoder into speed information that is then used by the microcomputer to develop a 5-bit control word. The control word, along with a reference voltage and motor position information, is used by the L291 to determine the motor speed, which depends on the distance remaining for the motor to travel.

Finally, the L292 motor driver amplifies an error signal from the L291 and uses the result to pulse-width–modulate an on-board oscillator. The PWM oscillations are the driving signals for a bidirectional bridge circuit that in turn controls the current to a servomotor. Especially noteworthy about the L292 is the fact that it uses the PWM switching technique to enable it to deliver over 60 watts of drive power, the highest of any monolithic driver yet, and at an efficiency of almost 80%.

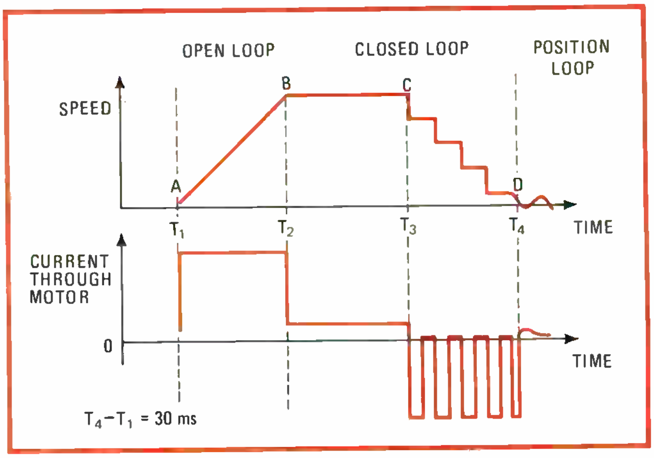
As a system, the three ICs and the microprocessor operate alternately in two modes—speed sensing and position sensing.

Two modes

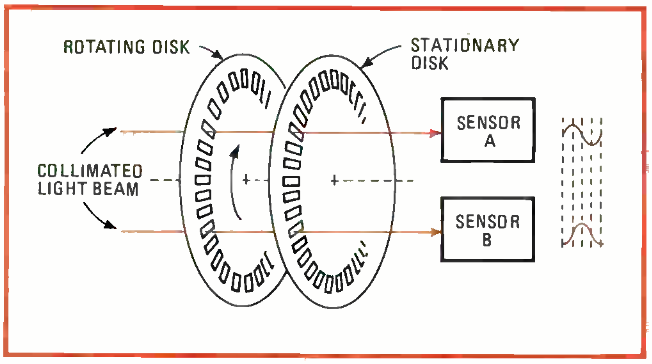
Action begins with the microprocessor sensing the motor speed. Initially, with the motor at rest and a new position ordered, there is no feedback from the L290 tachometer converter, and the system therefore operates in an open-loop mode, with the driver chip delivering maximum current to the motor. When the motor reaches maximum speed, the tachometer chip signals the processor to reduce the accelerating torque. As a result, the



1. Dynamic trio. A three-chip system interfaced with a microcomputer gives designers a head start in using closed-loop servo control. The chips include a tachometer converter, a digital-to-analog converter/position amplifier, and a switch-mode driver.



2. Fast start. The servomotor is run in an open-loop mode since in this way it will build up speed quickly until, when full motor speed is reached, the loop is closed. At the point when the final position is near, a braking current is pulsed to the motor.



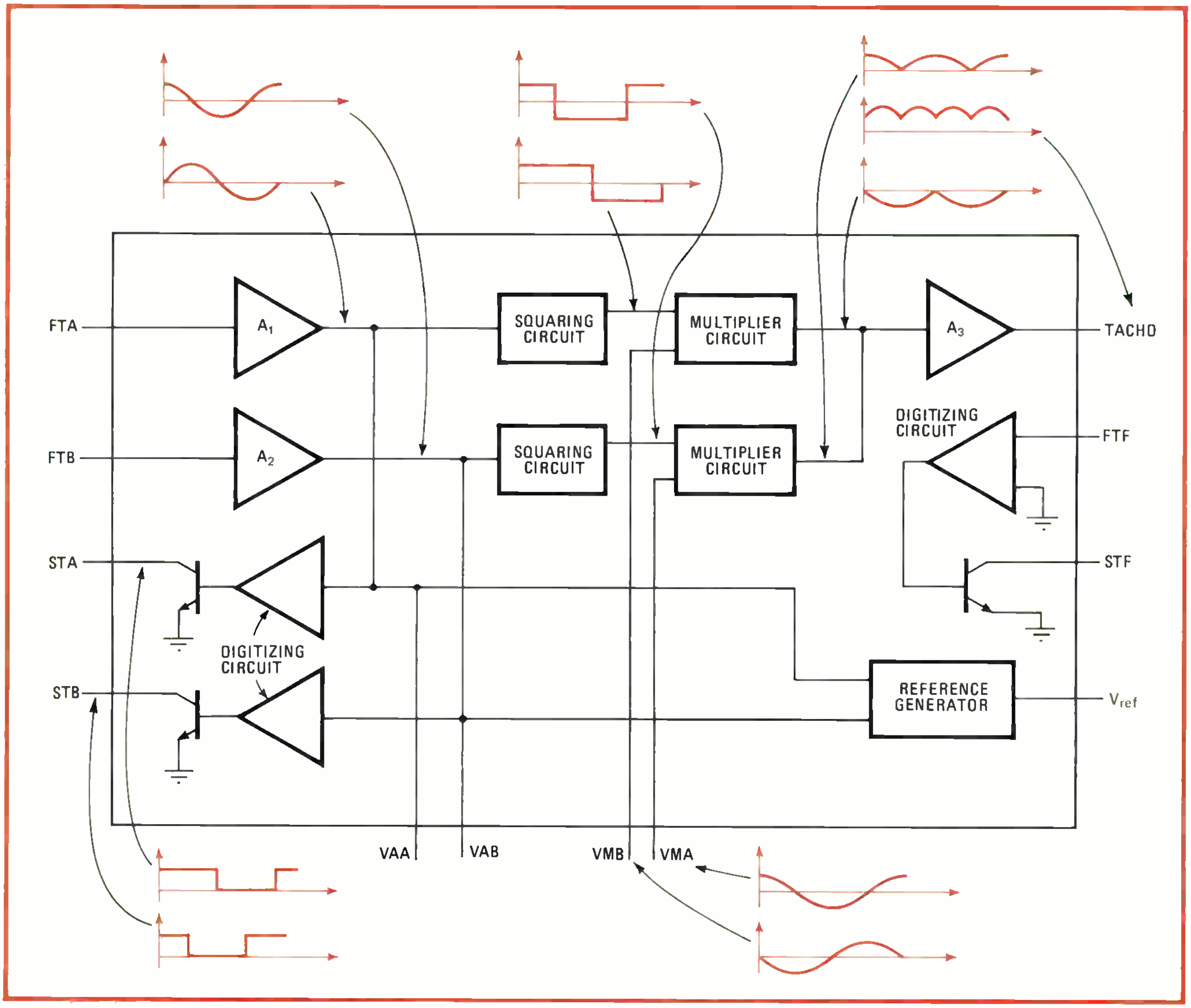
3. Motor encoder. Speed and position information is produced by the optical tachometer that is connected to the motor shaft. A stationary disk helps provide the output with its sine-like variation, while the use of a pair of sensors gives direction data.

motor continues to run at top speed, but now under closed-loop control.

When the position signal from the L290 indicates that the target position is near, the microprocessor lowers the value of the 5-bit speed word sent to the L291 chip, which in turn reduces the voltage to the L292 driver, in effect braking the motor. The braking is progressively increased until the motor is running at minimum speed, at which time the microprocessor switches to the second, or position-sensing, mode. Then within 3 to 4 milliseconds, the L291 orders the motor shaft to the desired position, where it is held by electronic detenting—an inherent quality of the high-gain feedback loop. This sequence of events is shown in Fig. 2.

A closer look

The mechanical interface to the L290 is an optical encoder. It generates two quasi-sinusoidal signals, FTA and FTB, 90° out of phase—leading or lagging according to the motor direction—and proportional in frequency to the speed of rotation. The optical encoder also provides at one point on the disk an output that is used to set the initial position. This position feedback is needed because the velocity feedback alone does not guarantee motor position with enough precision. As a result of the posi-



4. Tacho chip. The L290 tachometer converter translates encoder pulses into motor speed and position information used by the other chips in the set. In addition, it supplies a voltage reference. The phase of the waveforms indicates a clockwise rotation of the motor.

tion feedback, the final position is reached very quickly, usually in 1 ms and without ringing.

As mentioned, the optical encoder connects the motor output to the servo-loop input. The encoder generates a set of quasi–sine-wave signals whose frequency is a function of the speed of the motor. The signals depend on the movement of a disk that has a series of openings equal in width to the closed space connecting them (Fig. 3). This disk interrupts a field of light from a light-emitting diode, and a sensor on the opposite side of the disk collects the light. A system for masking the light beam, together with another sensor, produces two quasi-sinusoidal signals with a ±90° phase shift with respect to each other. The sign of the phase shift is related to the direction of motor rotation, and a third signal (not shown in the figure) gives absolute positioning information when power is applied.

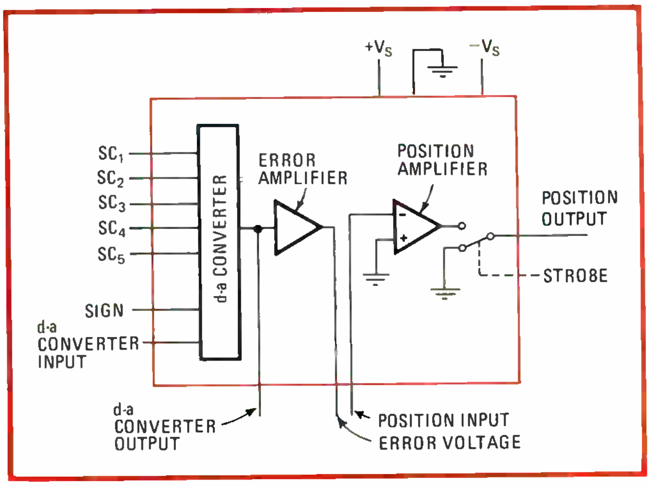
The tachometer signal

The tachometer signal is sent to the tachometer converter chip (Fig. 4). The L290's basic function is to convert the input signal frequency, which is directly proportional to the motor rotation speed, into a voltage level called the tacho signal that feeds the L291. Analytically, the function carried out by the L290 is given by:

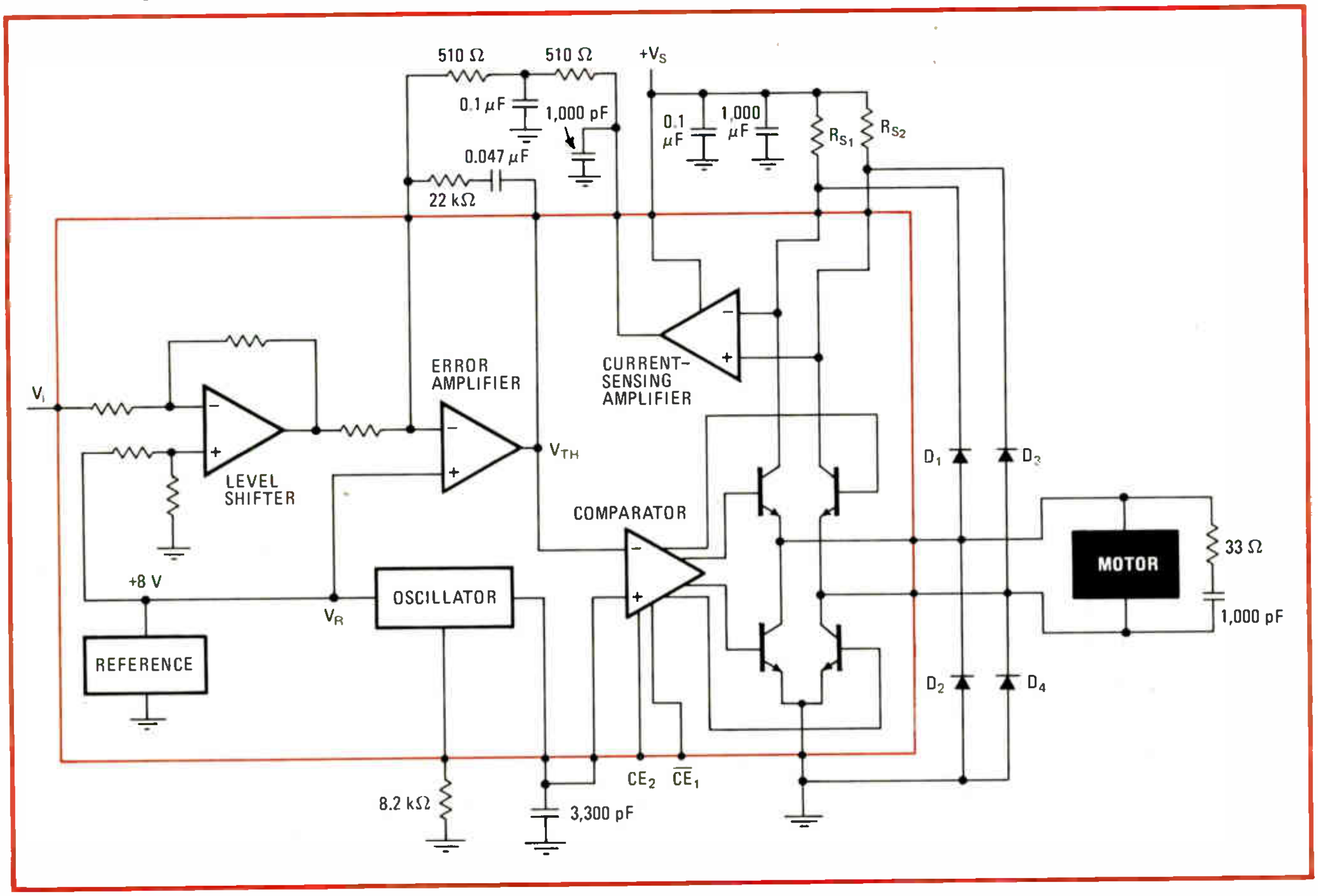
$$\text{output signal (tacho)} = \frac{dV_{AA}}{dt} \cdot \frac{FTB}{|FTB|} - \frac{dV_{AB}}{dt} \cdot \frac{FTA}{|FTA|}$$

where the input signals FTA and FTB from the tachometer are amplified on the chip by A_1 and A_2 respectively to obtain voltages V_{AA} and V_{AB}. From V_{AA} and V_{AB}, external RC differentiator networks generate signals V_{MA} and V_{MB} that feed on-chip multipliers.

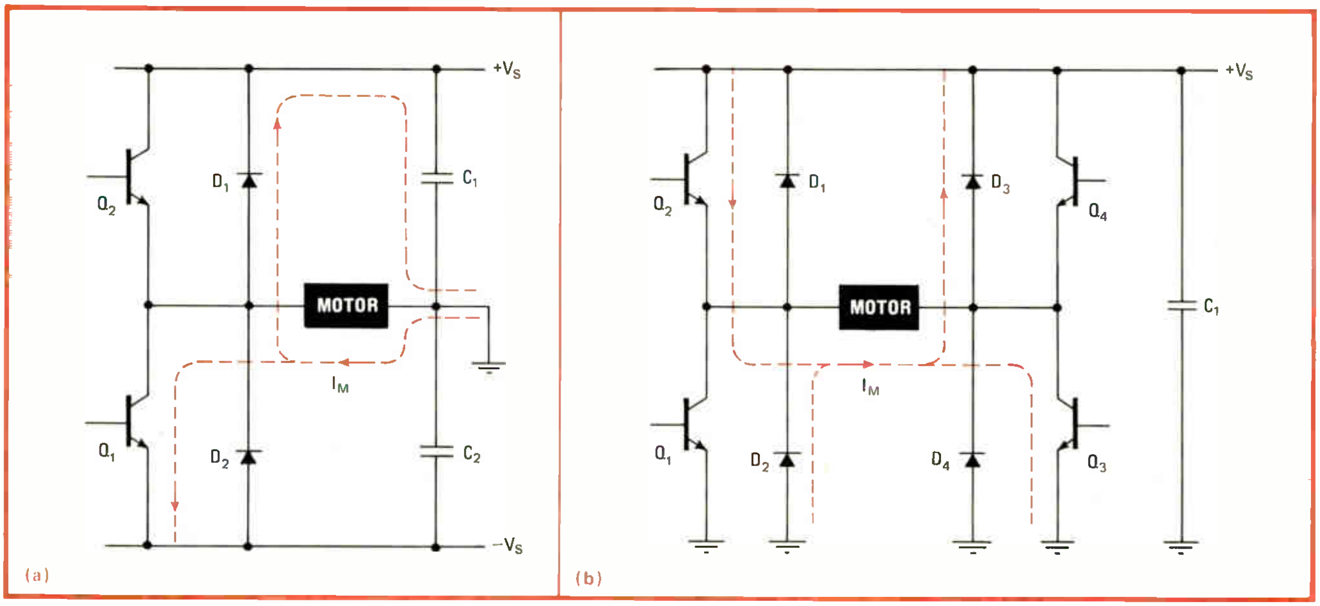
A second input to each multiplier is the sign of the first input to the other multiplier, before it is differentiated, obtained from comparators C_{S1} and C_{S2}. Then the outputs of each multiplier, called CSA and CSB, are



5. Converter. A digital-to-analog converter, error amplifier, and position amplifier make up the L291, the second chip in the system. The d-a converter gets speed-command words from a microprocessor, while position information comes from the tachometer converter.



6. Hard driver. The last chip of the trio is the L292 switch-mode driver. It compares speed commands from the microcomputer with the motor current and from the difference between them derives a pulse-width–modulated input for the (on-chip) bridge circuit to the motor.



7. Single supply. A simpler output stage than that on the L292 would require a bipolar power supply and would risk damage to associated components (a). The bridge output (b) of the L292 needs only a single output supply, avoiding excessive voltage build-up.

summed by amplifier A_3 in order to obtain the final tacho output signal.

The polarity of the tacho signal indicates the direction of rotation of the motor. The waveforms for clockwise rotation of the motor are shown in Fig. 4. For counterclockwise rotation the phase shift changes from $+90°$ to $-90°$. If the phases of the signals related to FTA are used as the reference, then for counterclockwise rotation those related to FTB are inverted from the clockwise. As a result, the two rectified sinusoids CSA and CSB change sign, as does the tacho signal itself.

There are numerous advantages to this technique of generating the tacho signal. First, a low ripple signal is obtained because the positive and negative peaks of the two rectified waves, CSA and CSB, tend to cancel out, one being added to the other. Second, the ripple frequency is a fourth harmonic of the fundamental—high enough for it to be filtered out without excessively delaying the speed loop and thus allowing wideband operation. Finally, it is possible to acquire tachometer information in real time, roughly within a quarter of a period. This is fundamental for systems that have to have good settling time characteristics.

Besides generating the tacho signal, the L290 also uses comparators C_1 and C_2 to derive logic signals STA and STB from V_{AA} and V_{AB}, respectively. These signals are counted by the microprocessor to determine the position of the motor. Also, the L290 develops an internal reference voltage V_{ref} derived from V_{AA} and V_{AB}, where $V_{ref} = V_{AA} + V_{AB}$.

This reference is used by the d-a converter in the L291 to compensate for variations in input voltage levels, temperature changes, and aging. Finally, one pulse per rotation, generated by the optical encoder and labeled FTF, is connected to an input pin of the L290 where it is squared to give the STF logic output for strobing by the microprocessor.

The L291 contains three basic sections—a d-a converter, a main error amplifier, and a position amplifier (Fig. 5). The d-a converter accepts a 5-bit code from the microprocessor and generates a bipolar output current whose polarity depends on the direction input signal, SIGN, and whose amplitude is a multiple of the reference current, I_{REF}, from the L290. For this type of d-a converter, the maximum output current is:

$$I_o = 2I_{ref}(1 - 1/2^n)$$

where n is the number of input bits. In this case, the output current for a 5-bit word is:

$$I_o = 2\ I_{ref}(1 - 1/2^5) = 1.937\ I_{ref}$$

This current is guaranteed to within ±2%.

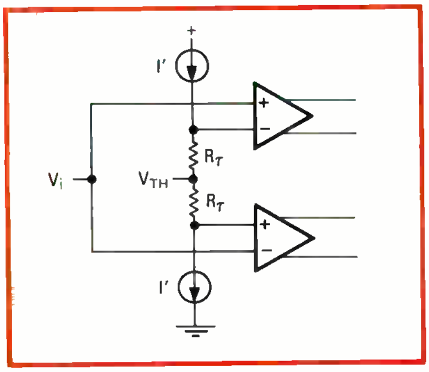
The main error amplifier of the L291 has two inputs, one from the d-a converter and one from a modified tacho output of the L290. These are summed to produce the motor drive error signal, ERRV, which feeds the V_i input of the L292 driver.

The final section of the L291 is an operational amplifier that provides additional servo-loop gain in the position mode. The position op-amp signal is added to the control loop by activating a strobe input that closes an internal switch, connecting the position amplifier's output to a pin on the L291 chip.

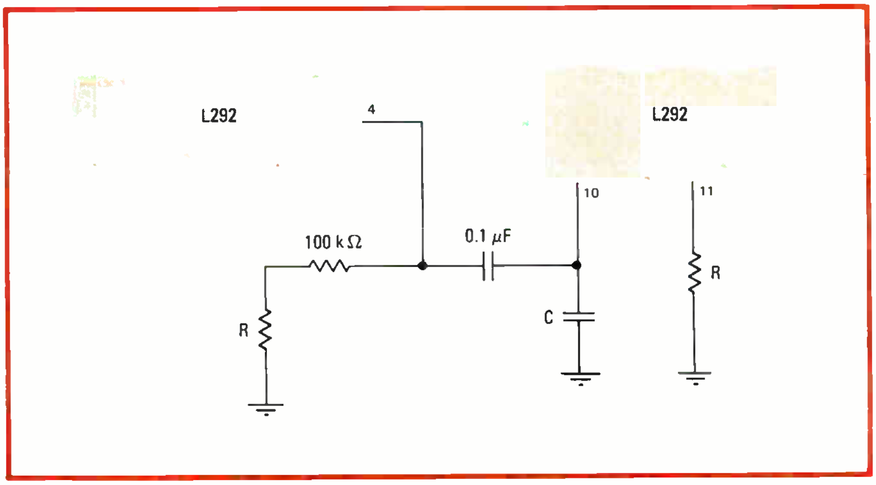
Last but not least

The last chip of the trio is the L292 switching drive. This is a complete switch-mode power amplifier with a bridge output stage. As shown in Fig. 6, it incorporates six functions altogether: an input buffer amplifier, an inverting loop-compensation amplifier, an oscillator, a comparator and drive circuit, an output stage, and a motor current detector. Since the L292 operates with a single supply and the ERRV input signal from the L291 is bipolar, the first stage is a voltage translator to change ERRV into a positive signal. Also, because the motor current is controlled by the circuit input voltage, V_i, the L292 works as a transconductance amplifier.

During motor acceleration, the L292's input voltage



8. Comparator cure. A comparator circuit in the L292 avoids turning both legs of the power bridge on simultaneously by introducing a time delay between two separate comparators. R_T, an internal resistance, and an external capacitor give the needed time lag.



9. Driver duo. The circuit shown here synchronizes two driver chips increasing the total power-handling capability beyond that of a single L292 driver.

V_i is initially at a maximum, giving maximum output current, a condition evoking maximum torque and acceleration from the motor. Signal V_i, level-shifted within the L292, is summed with the motor current feedback signal, which is derived from a feedback loop consisting of two current-sensing resistors, R_{S1} and R_{S2}, a differential current-sensing amplifier, and a lowpass filter.

The output signal of the error amplifier, V_{TH}, is therefore proportional to the difference between the input signal V_i and the motor current. V_{TH} is used as the controlling input of a comparator whose other input is a triangular waveform generated by an on-chip oscillator. The result is that the outputs of the comparator are PWM waveforms with a duty cycle dependent on the value of V_{TH}. These waveforms are the driving signals for the four-transistor bridge circuit that drives the motor.

The choice of a bridge configuration in the output stage of the L292 allows the motor supply voltage to be double that sustained by the chip itself. In addition, the choice of a single, over a bipolar, supply avoids the problems associated with pumped-back energy.

For example, with the double supply shown in Fig. 7a and the motor initially moving counterclockwise, transistor Q_1 is periodically conducting while diode D_1 recirculates the motor current. This means that current from the negative supply line, $-V_s$, during the conduction period is sent to the positive line, $+V_s$, during recirculation through D_1. Some power is thus taken from one supply and pumped back into the other. As a result, the voltage to which capacitor C_1 is charged can rise excessively, risking damage to the associated electronics.

On the other hand, in the single bridge configuration of Fig. 7b, a single supply capacitor operates in both the conduction and recirculation phase, and average motor current is such that power is always taken from the supply and never pumped back. The problem of an uncontrolled increase in capacitor voltage consequently does not arise.

Another potential problem addressed in the L292 motor driven chip is the danger of simultaneous conduction in both legs of the output bridge that could damage the output transistors. To overcome this hazard, the comparator of the L292 that drives the final stage is actually two comparators (Fig. 8). Both comparators receive the same threshold voltage, V_t, but on opposite inputs. The remaining two inputs are driven by the same V_{TH}, but shifted plus or minus a voltage produced by $R_T I$. This voltage shift results in a switching delay from one comparator to the other. The delay τ is a function of the integrated resistor R_T (1.5 kilohms) and an external capacitor C_1 connected to the L292 (which also determines the oscillator frequency). Specifically, $\tau = R_T C_1$.

In a typical application, a capacitor of 1,500 picofarads gives a switching delay of 2.25 microseconds—a more than adequate time considering that the switchoff delay of the integrated transistors is only 0.5 μs.

One reason for choosing a switching amplifier for the L292 motor driver is its high efficiency. The expression for the efficiency, independent of the losses due to the switching times and neglecting the dissipation due to the motor current ripple, is:

$$\eta = 1 - \frac{\Delta t_1}{\Delta t_1 - \Delta t_2} \times \frac{V_{sat}}{V_s} - \frac{\Delta t_1}{\Delta t_1 - \Delta t_2} \times \frac{V_{over}}{V_s}$$

where

$V_{over} = 2V(2V_{BE} + R_s.I_M)$
V_s = supply voltage
$V_{sat} = 4V(2V_{CEsat} + 3V_{BE})$
Δt_1 = transistor conduction period
Δt_2 = diode conduction period.

In practice, the efficiency will be slightly less due to the power dissipation in the signal circuits, about 1 W at 20 V and to the finite switching time, which adds about 1 W of loss. If 40 W is delivered to the motor, the bridge power dissipation is low and the total dissipation is 12 W, giving an actual efficiency of 77%. At this efficiency, since the L292 can dissipate up to 20 W, it is possible to handle continuous power greater than 60 W.

For driving more power to a servomotor, it is possible to synchronize two L292s with the network shown in Fig. 9. Finally, two enable inputs are provided on the L292 so that the output stage may be inhibited by taking one of them high or the other low. These inputs may be used to prevent motor action during reset of the logic circuits. Further, the output will automatically be inhibited if the supply voltage falls below 16 V. □

Designer's casebook

Multiplexers compress data for logarithmic conversion

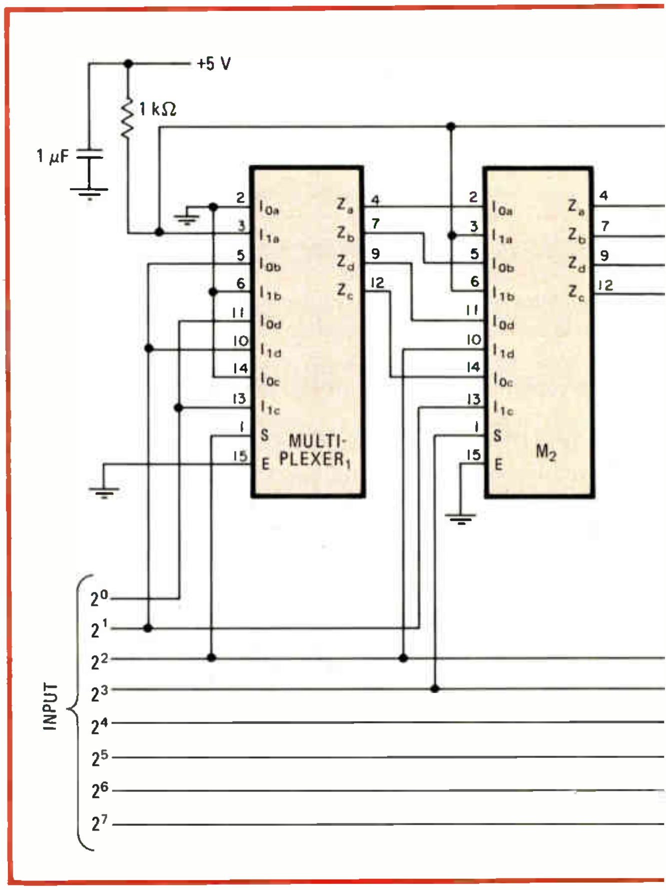
by Andrzej Piasecki
Warsaw, Poland

Cascaded multiplexers and a few gates are all that is needed to build this digital log converter, which compresses an 8-bit signal into a 5-bit number according to the transformation $2^n \rightarrow 4n$. Conversion to higher numbers is achieved by cascading additional multiplexers and appropriate gating circuitry.

As seen in the figure and the truth table for n extending from 0 to 28, the design of the circuit is simplified because each of the circuit's 74157 multiplexers can transfer without alteration 4 bits of the signal formed by a preceding multiplexer.

Alternatively, following multiplexing it can transport input bits that extend the second and third digits to the two least significant bits at the output.

As a result, the two most significant output bits of any multiplexer are fixed within a given input-number range. They are encoded by transferring the given 0 and 1 logic states into successive multiplexer inputs, with the most significant input bit (at logic 1) switching on whichever multiplexer is appropriate for transferring the desired number to the output.



Multiplexer manipulation. Using digital multiplexers, this circuit converts 8-bit input numbers into their corresponding 5-bit logarithmic equivalents, performing the operation in 100 ns. The truth table illustrates the simplicity of the design technique that performs the conversion. Multiplexers may be cascaded for extending the range over which n may be transformed into its log value.

TRUTH TABLE: DIGITAL LOG CONVERTER

Number n	Input 2^4	2^3	2^2	2^1	2^0	Number n	Input 2^4	2^3	2^2	2^1	2^0
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	1	2	0	0	0	1	0
2	0	0	0	1	0	4	0	0	1	0	0
3	0	0	0	1	1	6	0	0	1	1	0
4	0	0	1	0	0	8	0	1	0	0	0
5	0	0	1	0	1	9	0	1	0	0	1
6	0	0	1	1	0	10	0	1	0	1	0
7	0	0	1	1	1	11	0	1	0	1	1
8	0	1	0	0		12	0	1	1	0	0
10	0	1	0	1		13	0	1	1	0	1
12	0	1	1	0		14	0	1	1	1	0
14	0	1	1	1		15	0	1	1	1	1
16	1	0	0			16	1	0	0	0	0
20	1	0	1			17	1	0	0	0	1
24	1	1	0			18	1	0	0	1	0
28	1	1	1			19	1	0	0	1	1

As the input number decreases, the number of multiplexers required to transfer the desired data increases. NAND gates G_1 through G_5 derive the logic value of the most significant bit of the 5-bit number at the output. Note that the algorithm used will necessitate that the designer observe considerable care in wiring up the additional multiplexers that would be required to process larger numbers.

The propagation time of a digital logarithmic conversion is about 100 nanoseconds. The circuit draws no more than 120 milliamperes. □

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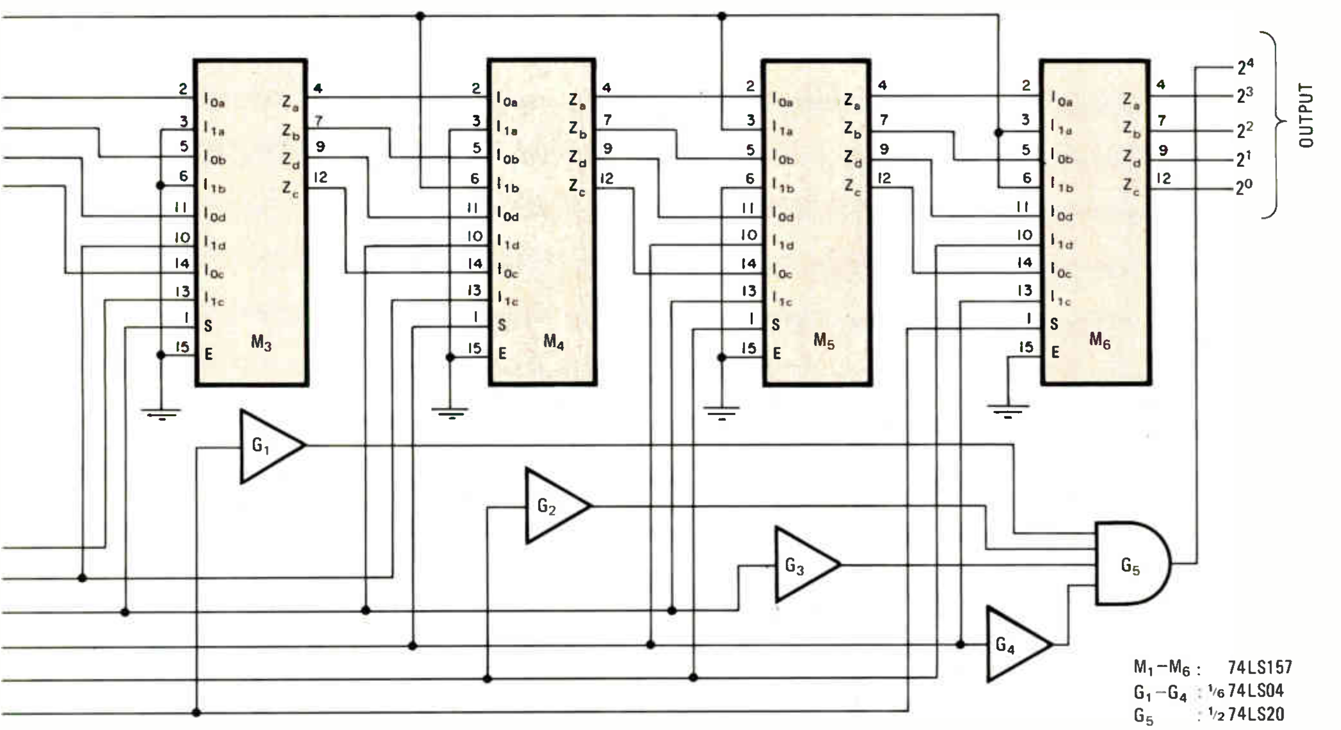

Noise-immunized annunciator sounds change-of-state alarm

by K. Soma

Singapore Electronic & Engineering Ltd., Sembawang, Singapore

To determine the status of a multichanneled telemetry receiver, relays are usually employed to activate lamps or light-emitting diodes set in the face of a remotely sited operator panel. However, if the call annunciator must sound an alarm each time a change occurs in the receiver's state, it often becomes vulnerable to noise pickup from external sources and produces false alarms. This circuit immunizes the receiver panel against the effects of that noise.

The simplest way to sense a change in status would be to link 39 capacitors at points P_1 through P_{39} in the figure and to connect their common output to the gate of a thyristor at point J. Indeed, this method is often used. But although the circuit will work, it is extremely susceptible to noise pickup from such sources as an electrical drill because all 39 capacitors form a series-parallel network that filters out most of the 12-volt pulse switchover signal when a lamp changes from green to red or *vice versa*. Thus, only about 100 millivolts of the original pulse is picked up at point J to trigger the thyristor.

A better method is to use transistor switches, as shown, for capacitor-to-thyristor storage and isolation to ensure that a sizable spike—not just a minor glitch from an external noise source—will trigger the alarm. A standard versatile transistor such as the 2N3904 may be used as a switch.

The standby current contributed by each transistor is less than 3.5 microamperes, and the peak current during switch-on is as much as 1 milliampere, which is sufficient to drive most current-gated thyristors—for example, the C103YY.

Note that each lamp in the display panel is effectively monitored by a transistor. Each capacitor is wired so that at least one transistor is momentarily energized only if there is a change in the lamp display input. The capacitors should have a fairly high value, which in this

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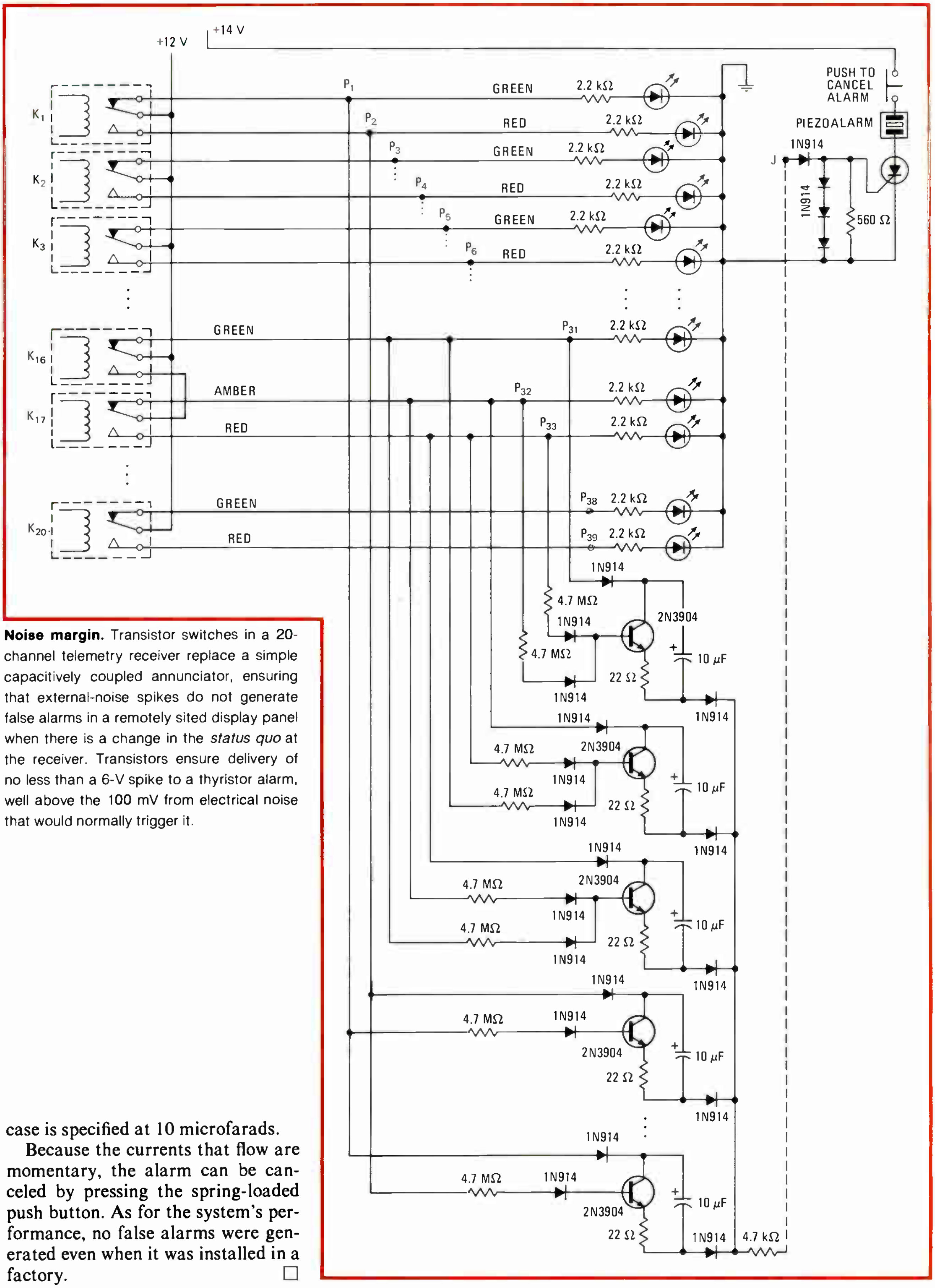

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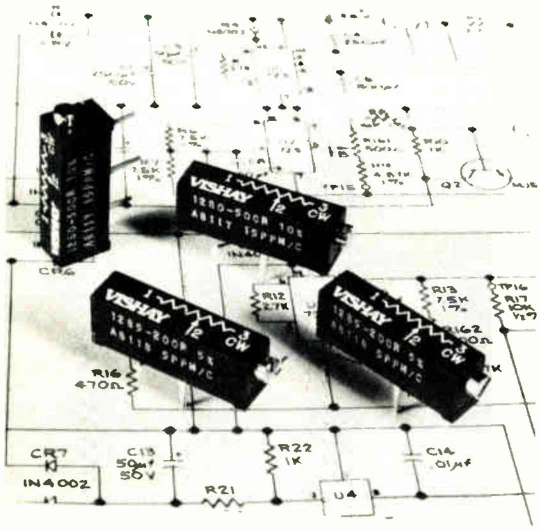

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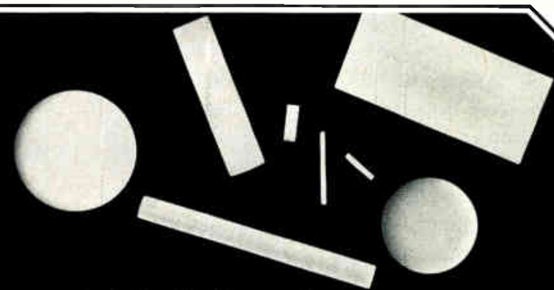

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Silicon operating system standardizes software

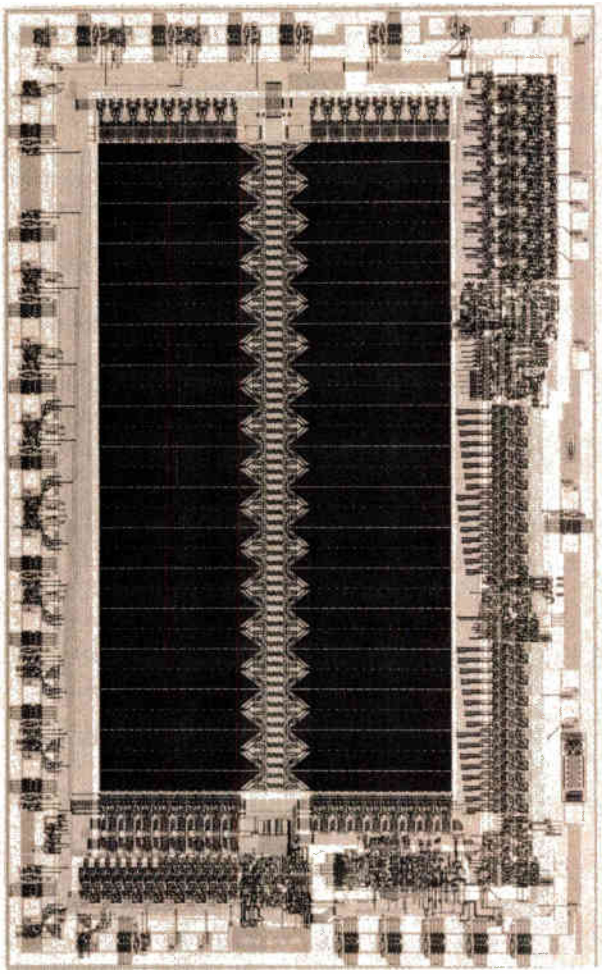
All the basic functions for real-time multitasking programs, including software subroutines and hardware timers, fit on the 80130

by C. McMinn, R. Markowitz, J. Wharton, and W. Grundmann, *Intel Corp., Santa Clara, Calif.*

☐ Silicon software, an inherently ambiguous phrase, refers to the solid-state realization of standard programs. It is the midpoint in the migration of microprocessor software into microcode and, as such, it exhibits the characteristics of both. Like software, it must be reconfigurable if it is to endure the fast-changing world of microprocessor technology, and like hardware, it must capitalize on this technology to reduce hardware and software costs and to provide increased system performance.

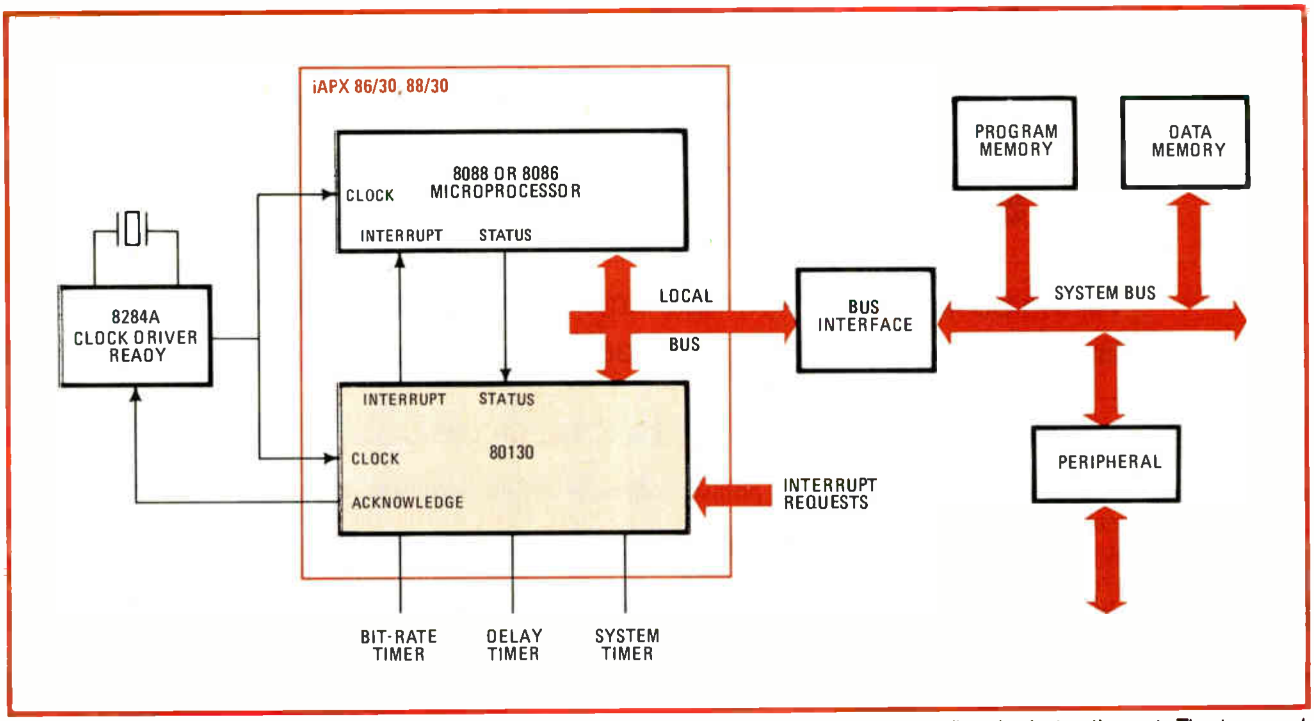
Recognizing this need, Intel Corp. has designed a set of silicon operating-system primitives that provides all of the basic building-blocks needed to write real-time multitasking software. These building blocks have been carefully chosen to include the functionality needed today as well as to allow reconfigurability for tomorrow. But the 80130 is not just software, since it also includes on chip all the other hardware components necessary to make the system work without additional external logic (Fig. 1). It is designed to be closely coupled to either the 8086 or 8088 16-bit microprocessor, creating the iAPX 86/30 and 88/30 two-chip sets.

These two-chip operating-system processors, as they are called, were specifically developed to remove the burden of designing multitasking operating-system primitives from the application programmer by providing a well-defined, fully debugged set implemented directly in the hardware. The application programmer no longer has to write the program that processes and coordinates a number of events. Instead, he or she can write several programs, each of which has only to process a single event and uses the common multitasking primitives for coordination. In essence, the handling of multiple, concurrent, asynchronous events has been localized entirely in these primitives, freeing the application programmer to concentrate on his or her own program and allowing an application to be developed faster and with reduced software costs.



1. More than memory. Though the die of the 80130 is mostly occupied by the 16-K-byte kernel control store, it also includes an interrupt controller and two 16-bit timers for operating-system use, plus a bit-rate generator for the user's convenience.

The primitives support an event-oriented design that entrusts the application to separate concurrent tasks, rather than burdening a single program with the complex dependencies inherent in random real-time events. Each event can be processed by a separate task or along with closely related events in a common task. External events and interrupts are processed by the interrupt-handling primitives directly from the on-chip interrupt controller subsystem as they occur in real time. Multiple tasks and multiple events are coordinated by the scheduler, whose preemptive, priority-based scheduling algorithm and system timers organize and monitor the processing of each task to guarantee that events are performed in their order of importance. The 80130 also provides primitives for intertask communication—by mailboxes—and for mutual exclusion—by regions—both of which are essential



2. Intimate contact. The 80130 is closely coupled to the 8086 or 8088 processor, in effect extending the instruction set. The two used together form the iAPX-86/30 or 88/30 operating-system processors. With an 8087 arithmetic processor, they form the 88/31.

functions for multitasking applications.

From the application programmer's viewpoint, the 80130 extends the base of the 8086 architecture by providing more than 30 operating-system primitive instructions (see Table 1), making the 80130 a logical and easy-to-use extension to an 8086 or 8088 system.

The 80130 replaces approximately 10 large- and small-scale integrated circuits in a system. It sits directly on the local bus of the processor and runs with both the 8086 and 8088 at an 8-megahertz clock rate. This guarantees that, regardless of the speed of the remaining memory in the system, these time-critical operating-system primitives will operate at the maximum bus bandwidth.

The chip has also been designed to be compatible with the iRMX-86 operating system and, as such, has been thoroughly tested against a wide range of text software available for this product.

The 80130 primitives were chosen after much analysis both because they are useful in many applications today and because they will continue to be useful primitives, if not standard machine instructions, in future processors. The 80130 kernel implementation is simple and efficient yet powerful enough to be a highly versatile architectural building block.

Architectural details

The 80130 is connected directly to the local bus of the 8086 and 8088 processor (it automatically detects whether the 8086 or 8088 is present), with address decoding, buffering, and bus-demultiplexing logic contained on chip (Fig. 2). The 80130's firmware is memory-mapped to any 16-K boundary in the processor's 1-megabyte address space. The control registers are mapped into the input/output space; they are aligned on any 16-byte boundary within the space.

Internally, the 80130 firmware consists of two sections: an operating-system unit and a control unit (Fig. 3). The former consists of a 16-K-byte operating-system–kernel control store complete with an operating-system timer and a delay timer; a bit-rate generator; and 8259A-compatible programmable interrupt logic.

The first timer generates the fundamental real-time clock period in the system. It is set to 10 milliseconds initially but can be modified by the system designer. The delay timer supports the kernel timing function by indicating the next event. Both these timer resources are reserved for use by the kernel.

The bit-rate generator, which has a range of 75 to 768 kilobits per second, is provided as a user resource. The 80130 interrupt logic vectors eight independent priority levels, one of which is reserved for the operating-system timers. Optional external slave interrupt controllers (8259A) can expand the number of user-programmable interrupt levels to 57.

Individual treatment

The 80130 interrupt logic goes beyond that of an 8259A interrupt controller. First, it allows the eight interrupt inputs to be individually programmed as level- or edge-sensitive (whereas the 8259A requires all to be programmed alike). Second, the 80130 has an output line that can be used in conjunction with the 8289 bus arbiter to reduce interrupt latency by localizing interrupt response to a single board in a multiboard system. An additional advantage is that the system bus remains available to other processors during an interrupt.

The 80130 supplements the 8086's basic architecture with five new objects, or system data types—jobs, tasks, segments, mailboxes, and regions.

TABLE 1: PRIMITIVES USED IN 80130 OPERATING SYSTEM FIRMWARE

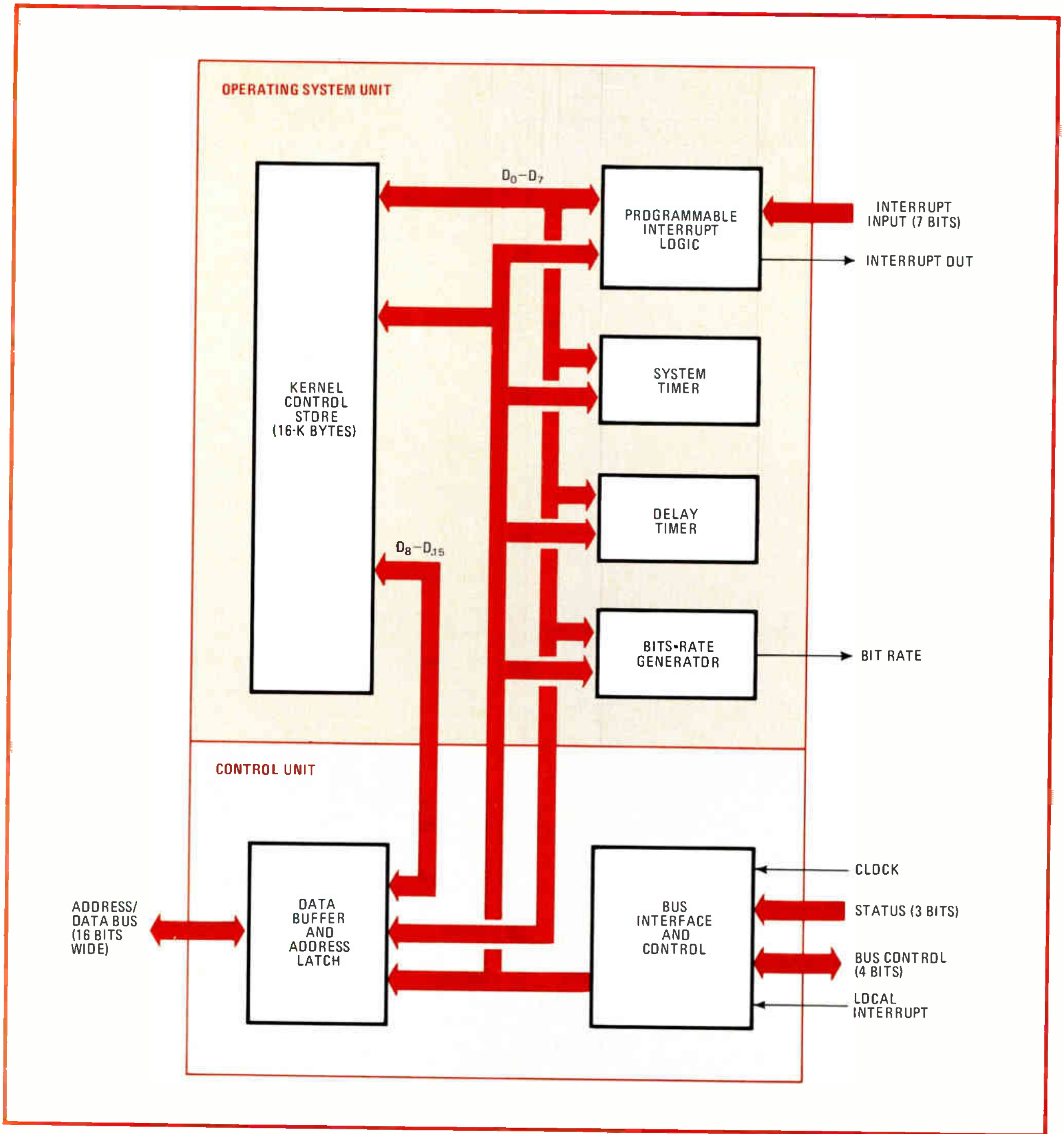
Type	Primitive	Function
Job	Create job	Creates a job partition including memory pool, task list, and stack area.
Task	Create task	Creates a task with the specified environment and priority and puts it in the ready state. Checks for insuffficent memory available within the containing job.
Task	Delete task	Deletes a task from the system as well as from any queues in which it is waiting. The task's state and stack segment are deallocated.
Task	Suspend task	Suspends a task (changes its status to suspended) or increases the task's suspension count by 1. A sleeping task may also be suspended and will then awaken suspended unless resumed.
Task	Resume task	Decreases the suspension count of a task by 1. If the count is at that point reduced to 0, the task state is made ready or if it was suspend-asleep, it is put back to asleep.
Task	Sleep	Puts the task in the asleep state, a number of 10-ms units may be specified.
Interrupt	Set priority	Changes the task's priority to the value passed in the primitive.
Interrupt	Set interrupt	Assigns an interrupt handler to a level. The task that makes this call is made the interrupt task for the same level, unless the call indicates there is no interrupt task.
Interrupt	Reset interrupt	Disables an interrupt level. Cancels the interrupt handler, deletes the interrupt task for that level if assigned.
Interrupt	Get level	Returns the number of the interrupt level for highest-priority interrupt handler currently in operation (several interrupt handlers could be operating).
Interrupt	Exit interrupt	Completes interrupt processing and sends end-of-interrupt signal to hardware.
Interrupt	Signal interrupt	Invokes the interrupt task assigned to a level from that level's interrupt handler.
Interrupt	Wait interrupt	Makes the interrupt task state suspended pending a signal interrupt from an interrupt handler. Used by an interrupt task to signal its readiness to service an interrupt.
Interrupt	Enable	Enables an external interrupt level.
Interrupt	Disable	Disables an external interrupt level.
Interrupt	Get exception handler	Reads the location- and exception-handling mode of the current operating system exception handler for a task.
Interrupt	Set exception handler	Establishes the location-and exception-handling mode of the current OSP exception handler for a task.
Segment	Create segment	Allocates dynamically an area of memory of a specified length in 16-byte paragraph units up to a maximum of 64-k bytes (for example, for use as a buffer). Returns a location token for the segment allocated.
Segment	Delete segment	De-allocates the memory segment indicated by the parameter token.
Segment	Enable deletion	Allows the system data type value indicated by the location token to be deleted.
Segment	Disable deletion	Prevents the system data type value indicated by the location token from being deleted.
Mailbox	Create mailbox	Creates a mailbox with the specified task queueing discipline. Returns a location token.
Mailbox	Delete mailbox	Deletes a mailbox, and returns its memory. If tasks are waiting for the mailbox, they are awakened (their state is made ready) with an appropriate exception condition. If messages are waiting for tasks, they are discarded.
Mailbox	Send message	Sends a message segment to a mailbox.
Mailbox	Receive message	A task is ready to receive a message at a mailbox. The task is placed on the mailbox task queue. The task may optionally wait for a response indefinitely, or a number of time intervals (generally 10 ms long), or not at all. When complete, the primitive returns to the task the location token of the message segment received.
Region	Create region	Creates a region data type value, specifying a queuing discipline. Returns a token for the region.
Region	Delete region	Deletes a region if and only if the region is not in use.
Region	Accept control	Gains control of a region if it is immediately available, but does not wait if it is not available.
Region	Receive control	Is the same primitive as accept control but the task that performs it may elect to wait.
Region	Send control	Relinquishes a region.

The 86/30 operates by creating, manipulating and deleting individual system objects. When an object is created, the 86/30 returns its name to the creating task. This name is referred to and used as an abstract data type, called a token. The token is a highly efficient way of accessing the 86/30 address space. Referring to a segment object, for example, causes a 16-bit address to be loaded into one of the processor segment registers, which can then be used to directly address a paragraph (16-byte unit) anywhere in the 1-megabyte address space. Task creation is also accomplished in this manner and requires only the specification of a priority, a task private data segment (if needed), a task stack, and a task program starting address.

To take full advantage of multiprogramming, the operating system must provide each application with a separate environment—that is, separate memory and tasks. This isolation both protects independent programs from interfering with one another and allows the application programmer to work without regard to the other application programs in the system. The 80130 supports multiprogramming with the job data type. The creation of a job requires the specification of a large number of parameters and is normally done only when the system is being initialized.

Interrupt-driven

In multitasking systems, there are two common techniques for deciding which task is to be run at any given moment. Time slicing runs tasks in rotation and is the technique used in time-sharing systems. Priority-based scheduling, on the other hand, compares assigned task priorities to decide which task is to be run next. Further, priority-based systems are usually preemptive—in other



3. Inside view. The silicon operating system is realized in the 80130 pictured here in the form of firmware containing the operating-system kernel, pl us the two timers, interrupt-handling logic, and other support hardware necessary to handle complex multitasking applications.

words, a higher-priority task is executed as soon as it is ready to run, rather than only after the current task has run to completion of a time slice.

The 86/30 supports preemptive, priority-based scheduling. The built-in scheduler performs all task-scheduling functions and controls the transition of tasks among the five possible operating states. Tasks that may be executed are in what is called the ready state. The one with the highest priority will be running, while all those of lower priority remain ready.

The 86/30 hardware timer facilities support time-outs with the asleep state. Tasks can put themselves into the asleep state in one of two ways. They can wait for a predefined number of 10-ms time periods (or for some other user-defined value if 10 ms is not appropriate for the application), or they can wait for a message that a shared resource, such as an I/O device, has by now been made available.

Tasks can also make themselves or other tasks enter the nonready state called suspended. A task may be suspended more than once, and suspensions are cumulative, requiring the task to be resumed for each suspension. A task marked asleep can also be suspended. It will then be put in the special state that requires both the time-expiration condition and the suspension condition to be met before it again becomes ready.

The 80130's preemptive-scheduling algorithm ensures that the highest-priority task that is in the ready state will receive the processor and that a task that is running will continue to do so until a higher-priority interrupt occurs (including a time-out interrupt) or until it relinquishes the resources that would allow a higher-priority task to make the transition to the ready status. Each task is given a priority-and-interrupt level relative to every other task and interrupt when it is created, but task priority may also be altered dynamically.

The 80130 maps external interrupts directly into internal task priorities, using the interrupt control logic included on the chip.

Two methods of interrupt management are supported for each level. The first is the interrupt handler. It can be used for time-critical interrupts or for interrupt processing requiring a small amount of work—for example, entering an input character into a buffer. While executing in the interrupt handler, a task will be restricted to calling a very limited set of operating-system primitive functions: enter-interrupt, get-level, signal-interrupt, and exit-interrupt.

The second method, the more general interrupt task, can be used when there is more processing work to be done. This interrupt task is an ordinary 80130 task, but one that cannot be suspended. Its processing of an interrupt begins with execution of the interrupt handler for that level. It is the handler that fields the time-critical portions of the interrupt and then optionally invokes an interrupt task.

Segments, mailboxes, and regions

The 80130 also provides a free-memory manager that allocates memory to requesting tasks dynamically. This manager operates within the pool of memory resources allocated by the create-job function of the containing job. When a system object is created, the memory manager allocates the required memory; when the value is deleted, it de-allocates it. This operation is implicit, and a separate create-segment call is not required. Two related kernel primitives are provided to enable or disable the deletion of individual system objects. When a value is deleted, its memory is automatically recovered for the job memory pool. When a value is created, the deletion function is enabled, so that the disable-deletion primitive must be executed to "lock" it in memory and remove it from the available memory list.

The technique used to facilitate communication and synchronization is a mailbox, a system data type designed to pass this information reliably and efficiently between tasks. Mailboxes support both priority and first-in, first-out queues. If the receiving task is of a higher priority than the sending task, receipt of a message can cause preemptive rescheduling of the sending and receiving tasks.

One of the most difficult problems to solve in a multitasking system is mutual exclusion. Mutual exclusion is absolutely essential to a multitasking system, for

TABLE 2: EXAMPLES OF THE PERFORMANCE OF OPERATING-SYSTEM PROCESSOR PRIMITIVES

Data-type class	Primitive	Execution speed* (μs)
Job	Create job	2,950
Task	Create task (no preemption)	1,360
Segment	Create segment	700
Mailbox	Send message (with task switch)	475
	Send message (no task switch)	265
	Receive message (task waits)	540
	Receive message (message waiting)	260
Region	Send control	170
	Receive control	205

*in the 8-MHz iAPX 86/30 configuration

it guarantees proper processing whenever two tasks require the exclusive use of a memory or I/O resource like a disk drive. Without mutual exclusion, the higher-priority task would immediately gain access to the shared resource, even if the lower-priority task is already in the process of modifying the information.

The 80130 solves the problem of mutual exclusion with the region object. It provides for both code regions and data regions, and both may be protected from simultaneous access by multiple tasks. If one task is in a region when another higher-priority task requests control (with receive-control), the task currently in the region will be run at the higher priority of the requester until it relinquishes the region via send-control. At that point a scheduling preemption will occur.

The performance of several 80130 primitives is given in Table 2. These times are shown for an iAPX 86/30 implementation at 8 MHz and rival those of similar functions in today's high-end minicomputers, being an entire order of magnitude faster than those of the previous generation of microprocessors. Indeed, many of these primitives operate faster than the basic multiply and divide operations of the last generation of machines.

Configuration plus

In addition to placing the 80130 in his system, the 86/30 user must supply a configuration and initialization area adjacent to the kernel store. A working area of approximately 1,500 bytes for use as the kernel stack will also be allocated in system random-access memory as part of the system initialization process.

The configuration process for the 80130 is simplified by the use of the iAPX 86/30 and 88/30 Operating-System–Processor Support Package. This software package, which runs on Intel development systems, includes optional user parameter validation code, system initialization software, and the 80130 interface library. This library and the 80130 design itself provide position independence for the 80130. All accesses to the 80130 are indirect, made through an on-chip jump table at an address supplied by the interface library. With this arrangement, the 80130 can be located on any 16-K-byte boundary in the user's address space. The on-chip jump table also ensures that if the primitives are changed, the user-to-program interface remains identical. □

CAD toolbox holds all gear for the design of custom logic arrays

Personalization of arrays goes quickly with computer-aided – design packages available on a timesharing basis

by William R. Blood Jr., *Motorola Inc., Mesa, Ariz.*

☐ Logic arrays are consolidating much of the random circuitry that mass-produced standard integrated circuits, for reasons of economy and performance, are simply unable to accommodate. Since array wafers are processed up to a point and stockpiled for later personalization, array chips should allow a customer to get a custom circuit out the door quickly.

That is the theory. But, without a complete set of computer-aided–design tools and an efficient means for manufacturer and customer to communicate, an array option may take an inordinately long time to develop, perhaps opening the door to the competition.

The high-performance Macrocell line of bipolar array products comes equipped with a comprehensive set of software development tools and a predefined communications interface. Besides a sophisticated program for automatic placement and routing of array functions, the CAD software includes test routines that provide the circuit simulation for error checking and fault grading.

These software packages are available on a timesharing basis, with the customer using a graphics display terminal and other on-site equipment to communicate with the computer. This setup is so efficient that simple circuits like the 4-bit counter design detailed below can easily be laid out without using the automatic placement and routing algorithms.

High performance

The high performance of Macrocell arrays is achieved by combining an advanced, oxide-isolated bipolar IC process, called Mosaic I, and series-gated emitter-coupled logic. One example in the resulting family is the MCA1200ECL, which contains 48 major, 32 interface, and 26 output cells, organized as in Fig. 1.

Each block contains transistors and resistors that may be interconnected with metal patterns to perform logic functions. For example, one major-cell metal pattern provides a multiplexer, another a dual flip-flop, another an adder, and so on. A predefined Macrocell library contains more than 100 different logic overlays.

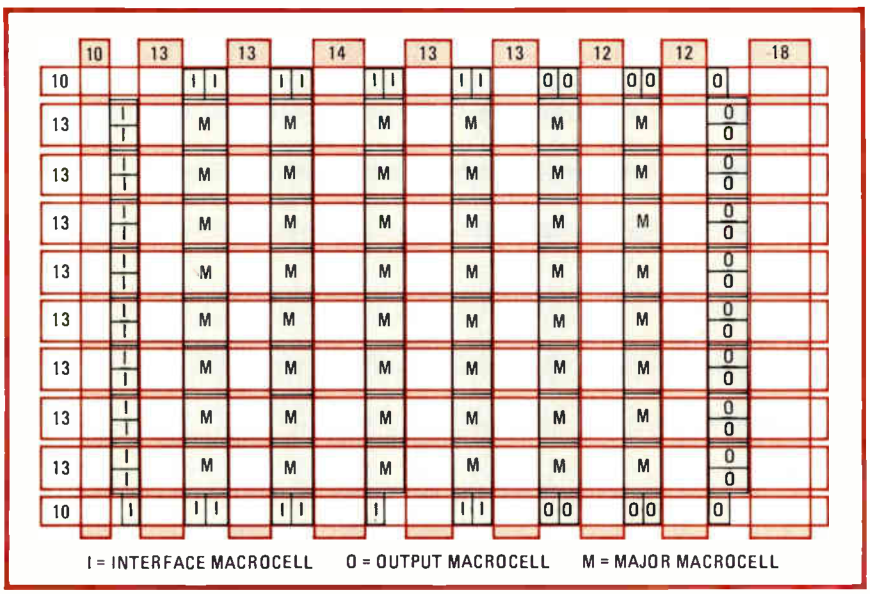
CAD software resides on IBM 370 or Amdahl 470 computer systems. Required at the user's location is a Tektronix 4014 or 4014-1 display terminal, a Tektronix 4662 or 4663 interactive digital plotter, and a 300- or 1,200-bit-per-second modem. A teletypewriter-compatible keyboard terminal with printer and a Tektronix 4952 joystick are optional.

Each array design is customized by selecting Macrocell functions from the library, placing them in cell locations on the chip, and interconnecting them to each other and to input/output pads via two metal layers. Cell placement and routing can be entered manually through the storage cathode-ray tube terminal and plotter or generated automatically with the placement-and-routing software in the CAD system. Also, a combination of manual and automatic approaches may be used to optimize a particular design.

The user's responsibilities

Although the CAD system is designed to flag design-rule violations, the accuracy of macrocell selection, placement, and routing remains the designer's responsibility.

The customer is also called upon to provide a functional test sequence. Test vectors generated during simulation are automatically converted into a format required by automated test equipment for functional checkout. The CAD system helps again by allowing the designer to exercise a potential test sequence using a simulated model of the array from routines based on Logcap from Phoenix



1. Silicon grid. Macrocell arrays use two metal interconnection layers. Vertical routing channels and logic function wiring are on the first level, whereas the second is used for horizontal paths and for connections to Macrocell input/output points. Both metal layers are used for chip I/O.

Data Systems Inc. of Albany, N. Y. It also provides a fault-grounding program that determines to what extent the array logic was tested by a given test sequence.

While using the graphics equipment, the option designer follows a sequence of steps. Initially, logic functions are defined in terms of Macrocells, and a CAD net file is constructed to describe all of the interconnections between Macrocells and I/O pads. The file gets its name from the interconnection pattern, which looks like a net.

Next, test-sequence files are built to define inputs, outputs, and logic-level forcing functions required to check the circuit. A CAD simulation program is executed to compare the interconnection net list against the test sequence, and fault grading is used to determine the test sequence's ability to verify circuit functionality.

The automatic placement-and-routing software is then called upon to lay out the option and plot the final results. Any interconnections not covered by the routing software are placed manually. The option design is completed by selecting input pulldown resistors (on ECL-compatible arrays). Macrocell current levels may also be selected, and a final check for design-rule violation is then carried out.

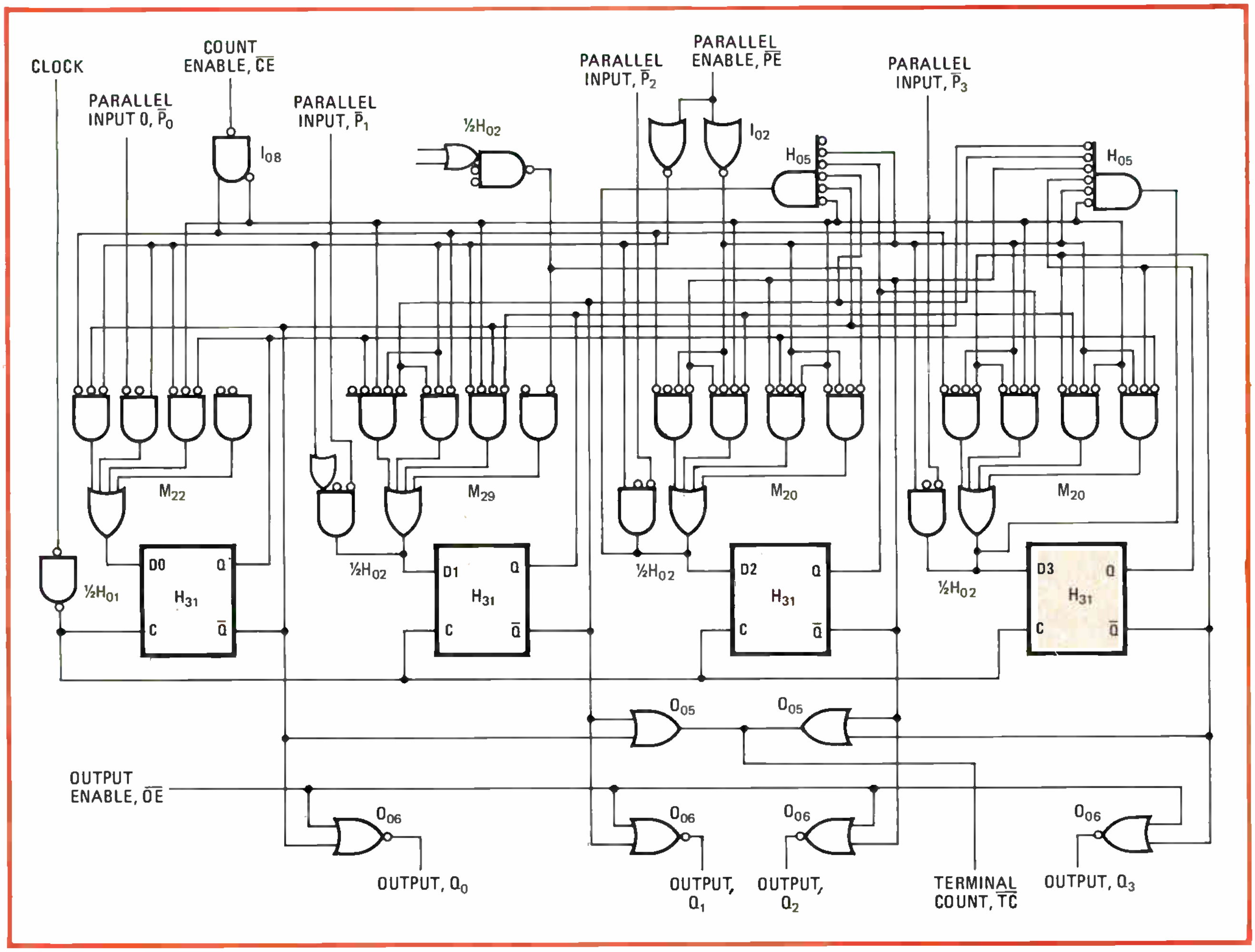
Motorola translates option data into masks for the metal layers and vias through a Calma graphics system. A composite plot is sent to the user for final design verification, after which the Calma data is sent to a pattern-generation and mask-making shop for fabrication of three top masks. Finished wafers are probe-tested using the customer's test sequence, which now incorporates features added by Motorola for parametric testing.

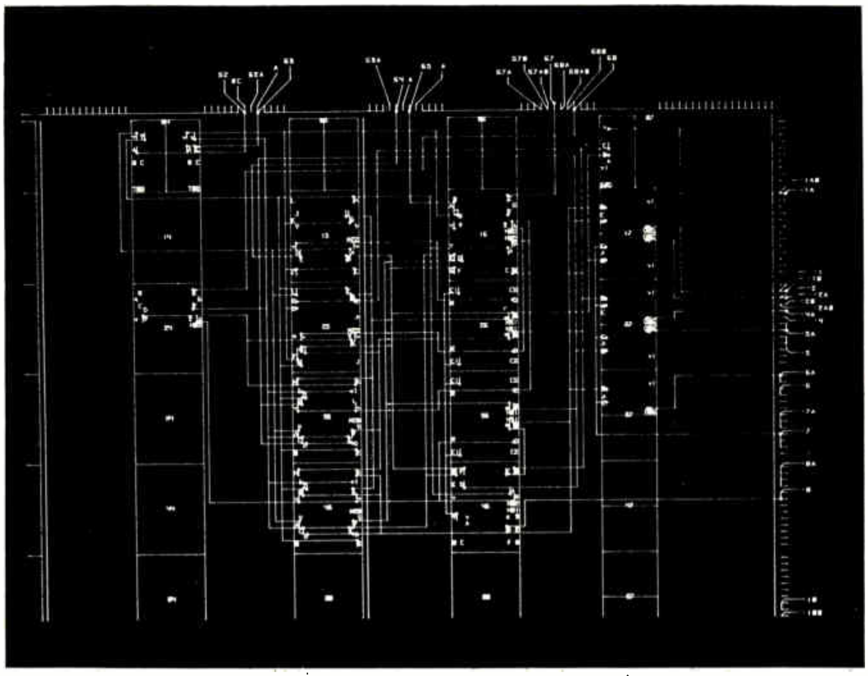
CAD design example

The 4-bit count-up programmable counter of Fig. 2 is an example of what can be constructed from a Macrocell array. In this design, controls are provided to allow cascading for larger sums. The chip accepts complemented $\overline{P}$ inputs to compensate for the count-up direction, thereby allowing modulo n − 1 counting sequences; or, with early terminal count decoding, modulo n.

Also, the count-enable ($\overline{CE}$) signal connects to the terminal count ($\overline{TC}$) output of the previous chip, or it is gated to all previous $\overline{TC}$ outputs if more than two counters are used in series. When the terminal count goes high, the output-enable ($\overline{OE}$) line forces all outputs except $\overline{TC}$ to a low level. The parallel-enable ($\overline{PE}$) signal is buffered because of its heavy fanout requirements, and the clock is buffered to comply with a design rule prohibiting external inputs from being connected to the lower-

2. Ready for routing. This 4-bit counter will be integrated in a Macrocell array. M, I, and O stand for major, interface, and output cells, respectively, with H being half an M cell and the subscript numbers corresponding to cell positions on the routing worksheet.





3. All done. This pattern would be displayed on a cathode-ray-tube screen to show how the circuit of Fig. 2 was interconnected. The counter is simulated to insure the integrity of the design, and fault grading is used to rate the testing sequence designed by the user to check out the chip functionally.

level inputs of the series-gated ECL major Macrocells.

The simplicity of the circuit permits bypassing the automatic placement-and-routing software. After developing a routing worksheet and logging on to the system, the user initializes a CAD program called Layout. This routine establishes a file name for the design option and draws an array outline on the CRT screen.

The designer uses CAD placement commands to list the required Macrocell types along the right-hand side of the screen. Additional placement commands position each cell in the selected location on chip and provide for editing, if needed. After placing cells, routing worksheets are drawn with the plotter, which also may be used to generate permanent design records and to digitize routing information for entry into the CAD system.

With a relatively simple circuit like the 4-bit programmable counter, routing can be done off line, directly on the worksheet. Placement is not critical since there are more than enough routing channels. After routing on the worksheet according to array design rules, the circuit is ready as input to the CAD system.

The designer enters routing information by redisplaying the routing worksheet on the CRT screen and drawing each path. Any necessary editing is handled with CAD commands. An alternative approach is to place the routing worksheet back on the plotter and digitize the data into the system. The result is shown in Fig. 3.

Next comes logic simulation which provides two important functions. First, it verifies that the design is logically functional: routing and logic design errors, Macrocell selection and I/O pad selection problems, and so on can be caught. Second, the test sequence developed will be used during wafer probing and final testing to determine fully functional products.

Test sequences can be formulated by examining the entire circuit and engineering a test sequence that verifies functionality according to end use. An alternative approach is to break up the circuit into individual Macrocells and set up tests that exercise all inputs and outputs. The first method was used in this design example, and it resulted in a sequence of 76 test steps.

Before running the simulation, two CAD files must be entered and edited through the operating system. One is a command file that defines the number of test steps and the circuit's I/O format. The second, called the pattern file, defines the time required for each test step in 100-picosecond increments. It also defines the logic state of each input.

Command and pattern files may be entered with either the 4014 graphics terminal or the teletypewriter-compatible terminal with printer. The printing terminal is recommended for simulation because it produces hard-copy results faster.

The logic simulator in the CAD system exercises the design using test information contained in the command and pattern files. Logic errors indicated by incorrect output states are due to logic or routing errors on the array or to an incorrect test sequence. Both can be traced using a logic diagram generated by the CAD system.

Fault grading measures the simulation test sequence by exercising every cell input and output. It sequentially forces each node to a logic 1 or 0 level while running the simulation test sequence and checking to see if a fault is detected. The output of this program lists all tested nodes and those with faults that were not detected.

A successful simulation means that the difficult part of the option design is done. Remaining CAD operations take care of circuit details and provide a final check for design-rule violations. Layout, the program initially used for Macrocell placement and array routing, also includes commands for wrapping up the design.

A final requirement is to strike all unused Macrocell I/O ports from the design. This process shorts out base-emitter junctions on input transistors and removes the 1.0-milliampere resistors from unused cell outputs.

A program called Violate generates a list of the unused I/O ports for this purpose. After the list is approved, the program automatically removes the unneeded cell ports. It also provides a final design checklist listing all modified internal emitter-follower load resistors, unused I/O ports, unnecessary interconnect vias, routing net errors, via violations, input pads with loading resistors, and untied cell ports of the same name. After correcting any design problems caught with the checklist, the option designer's job is complete. Motorola then pulls information out of the CAD system to build prototype evaluation circuits. □

Multiwire boards compete with microstrip and strip-line packaging

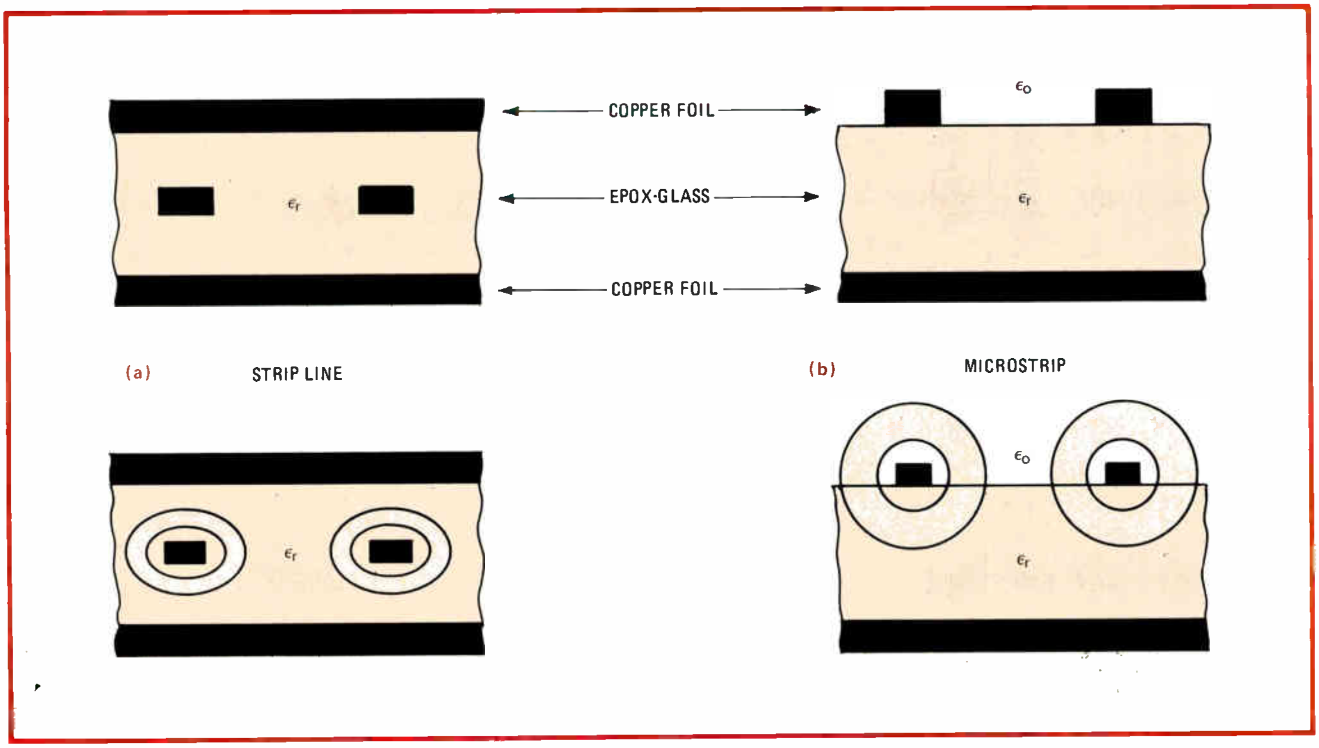
Discrete-wired technique yields controllable impedances of 50 to 100 ohms suitable for high-speed signals

by J. Philip Plonski, Tom Buck, and Sam Smookler, *Multiwire Division, Kollmorgen Corp., Glen Cove, N. Y.*

☐ As emitter-coupled and Schottky TTL logic families with rise and fall times in the 1-nanosecond range continue to gain acceptance, designers face a new challenge in designing boards that can handle these high-speed signals while preserving signal fidelity and minimizing crosstalk. Previously, most high-speed circuit boards were constructed with either strip-line or microstrip techniques, both of which use conventional printed-circuit technology to form structures like transmission lines. Now a new approach has entered the high-speed board arena—the Multiwire technique, an automatic wiring technique that lays insulated wires down onto a bed of adhesive covering a standard glass-epoxy board (see "The making of a Multiwire board," p. 144).

The Multiwire process was originally developed as a high-density competitor to the multilayer pc board in medium-speed applications, but extensive testing has verified the performance of this discrete-wiring approach in controlled impedance situations (50 to 100 ohms) where rise times approach 1 ns. In addition, a nominal impedance designed into a Multiwire-fabricated board is more predictable than a controlled impedance designed into two-sided and multilayer pc boards. The discrete-wired technique also has proven to be less costly than the other two methods.

At high speeds, signal lines must be treated as transmission lines, and controlled impedance techniques must be applied when interconnecting integrated circuits because the fast rise times of high-speed logic families require high bandwidths extending well into the ultra-high-frequency and microwave regions. Failure to establish controlled line impedances in a high-speed board can cause pulse degradation, such as ringing on the leading edge. Spurious signal levels like these can exceed the logic-level voltage thresholds of the circuits, producing data errors. Furthermore, the coupling of adjacent signal



1. High-speed board. The standard printed circuit techniques for high-speed logic functions are strip line (a) and microstrip (b). In the case of microstrip, the propagating electromagnetic field travels in two media with different dielectric constants, creating forward crosstalk.

The making of a Multiwire board

The initial step in the Multiwire discrete-wiring process is imaging and etching a copper-clad printed-circuit-board laminate (below; top left) in accordance with a format drawing provided by the customer. The format (top center) determines the ground planes for power distribution, as well as for controlled impedance.

Next, an adhesive material is applied to the board (top right). The B-stage (partially cured) epoxy-coated fabric provides a plane of adhesion for placement of the insulated wire. Finger regions, card-guide edges, and other areas are left free of adhesive.

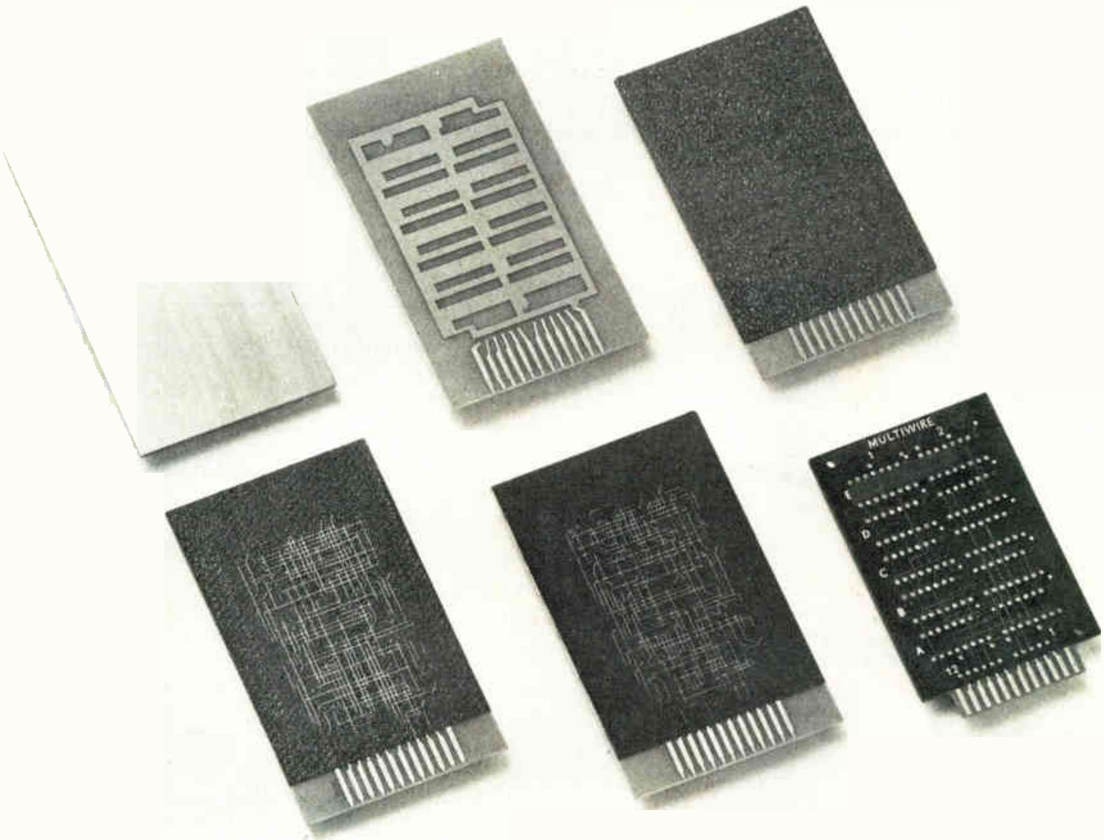
Using computer-driven, numerically-controlled wiring machines, wires are then laid down with the aid of a specially designed wiring head on the bed of adhesive in accordance with the wiring instructions and component locations supplied by the customer, as seen in the board shown at the lower left. While each wire begins and ends at a hole, a wire may intersect any number of holes and wires may cross each other.

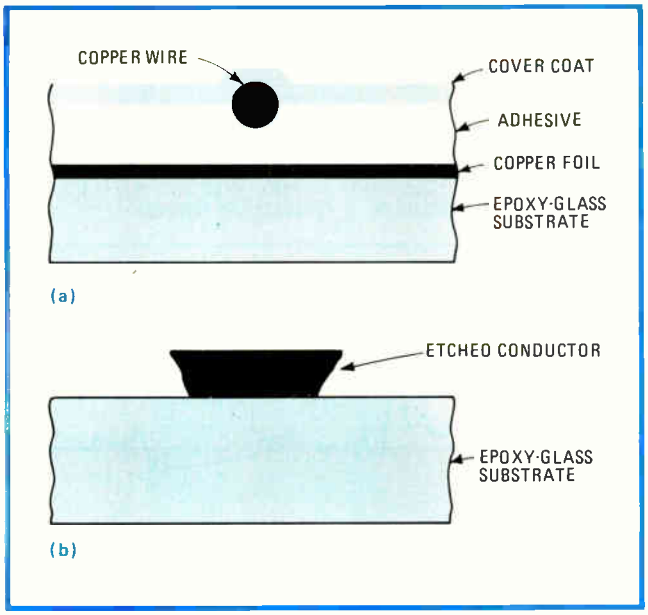
The wires are processed into the adhesive, covered by a sheet of epoxy-coated glass cloth (called prepreg) and cured (bottom center). This step locks the wires securely in place. Holes are then drilled by computer-controlled drilling machines at each plated-through location, resulting in the board shown in the lower right. As the drill bit descends, it first shears off the wire so that it ends at the wall of the hole. These holes serve a dual role, forming a junction for each wire and mounting holes for components. Tooling holes for automated insertion and holes for card ejectors or various other purposes are drilled after the hole has been plated.

After all holes are drilled, the polyimide insulation of the wires is chemically etched back from the wire ends. Then, using an electrodeless additive plating process, copper is deposited in the holes, electrically bonding each wire to the wall of the hole and affording an excellent solder surface at the same time.

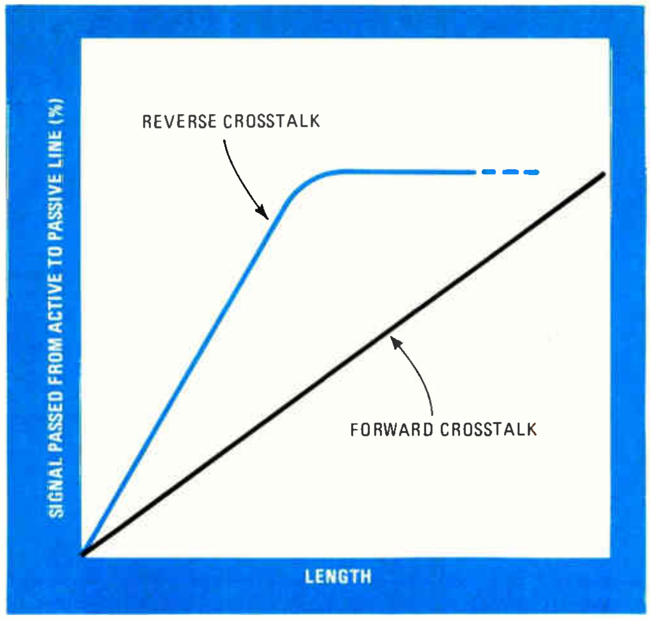
Additional steps to complete the fabrication process include applying a cover layer, gold plating of the contact fingers, routing the board perimeter to its final profile, and screening legends in place.

Finally, each Multiwire board is electrically tested to make sure that there is continuity between every hole interconnected by wire. High-potential and insulation-resistance tests are also performed to ensure the electrical integrity of the foil layers of the Multiwire board.





2. Cross-sectional geometries. Multiwire's critical geometry (a) is governed by the annular property of a wire drawn through a die. On the other hand, the etching used with printed circuit geometries tends to create an irregular trapezoidal cross-section (b).



3. Forward and reverse. Forward crosstalk is approximately a linear function of coupled length. Reverse crosstalk reaches a maximum in a finite length that is determined by the rise time of the waveform and the propagating velocity of the signal in the transmitting medium.

lines can create crosstalk and induce additional data errors. ECL is particularly susceptible to crosstalk because the rate of current change is very large and noise margins are quite low (less than 1 volt).

The distinguishing factor of any controlled impedance line is that the transverse geometry must be diametrically uniform throughout the length of the line. Coaxial cable, with each of its conductors surrounded by a separate shield and the conductor-pair spaced by a polyethylene dielectric, is familiar to almost everyone. Less familiar are two additional forms of controlled impedance lines—the strip line and the microstrip—both frequently used in wiring boards.

Microstrip versus strip line

The strip line and microstrip approaches both stem from work at the Air Force Cambridge Research Center, which in 1949 first treated the conductors on circuit boards as a transmission lines. As shown in Fig. 1, the strip-line technique (a) identifies a series of rectangular cross-sections of a foil conductor embedded in an epoxy-glass substrate. Note that foil layers above and below the conductors form ground planes. The microstrip technique (b), on the other hand, identifies a transmission line on the surface of a circuit board that employs a single copper foil layer as a ground plane.

In the strip-line process, the signal propagates solely in an epoxy-glass medium. With the microstrip approach, propagation occurs partially in the substrate and partially in surrounding air. This dual-dielectric medium contributes to forward crosstalk. Thus, in terms of performance the strip-line approach is preferable.

When cost alone is considered, the microstrip approach is more favorable because there is no need to use two ground-plane layers for each level of transmission lines. The Multiwire technique, however, can combine the advantages of both, exhibiting the performance of the strip-line approach, but at costs comparable to the microstrip process.

The Multiwire technique is based on discrete-wired circuit boards. It differs from both strip-line and microstrip printed circuits in that it employs wire rather than etched copper traces for signal interconnections.

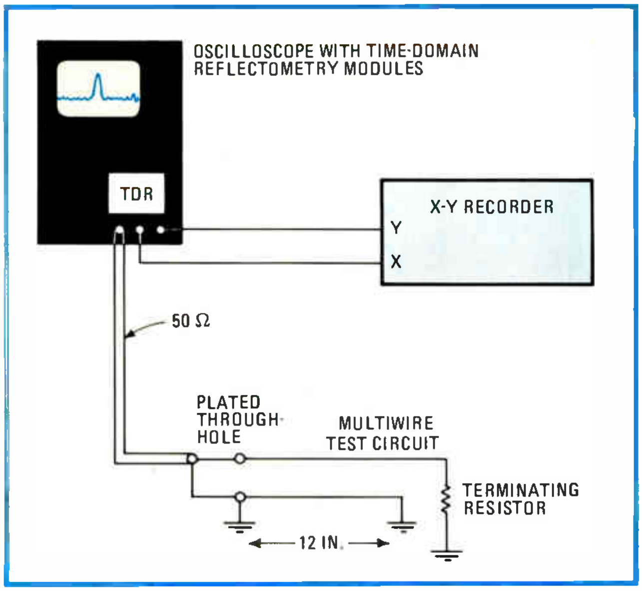
The fact that Multiwire relies on No. 34 AWG wire rather than etched traces improves control over impedances. This is because the wire employed for signal interconnections (Fig. 2a) is formed by being drawn through a die. Wire manufacturers are thus able to control diametric accuracies to within 0.002 inch. Such precision controls the wire's transverse geometry to a degree unmatched by the etching or plating techniques of pc board fabrication.

A printed circuit, for example relies on chemical etching techniques for forming a pattern on a thin copper foil sheet. Since the etchant removes copper sideways as well as downward, each trace develops an irregular cross-section that is roughly trapezoidal in shape (Fig. 2b), making it difficult to predict and control nominal impedance. Still another factor favoring the Multiwire technique in controlled-impedance applications is its better uniformity at the bend in a wire than in a corner formed by a copper foil conductor.

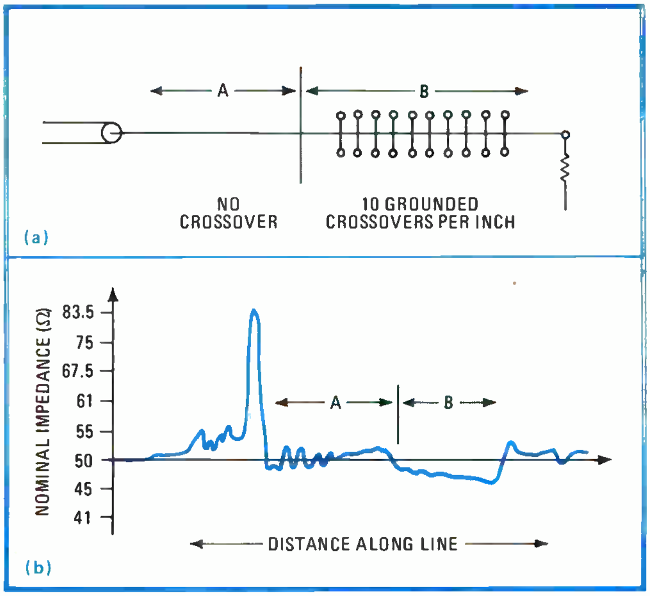
Forward and reverse crosstalk

In addition to the basic alternatives for controlling impedance, methods for combatting crosstalk must be considered as well. Crosstalk occurs whenever the electromagnetic field accompanying a moving waveform on a wire becomes sufficiently coupled to a neighboring line to induce noise in the line without actually being physically connected to it.

Crosstalk is usually expressed as the percentage of the



4. Delicate timing. In this test setup, a time-domain-reflectometry oscilloscope applies a signal to the test wire. Variations in the impedance both appear on the display screen and are plotted as a function of length on the X-Y chart recorder.



5. Reading the results. In the test wire shown, time-domain reflectometry revealed that region A has no crossovers while region B has crossovers, which reduce nominal impedance only slightly. The large peak at the cable-board interface is not in the domain of interest.

signal amplitude on the active line to that occuring on the inactive line. As Fig. 3 shows, forward crosstalk varies almost linearly with length of the coupled line, whereas reverse crosstalk reaches a maximum in a finite length and then stays bounded. Thus, any discussion of forward crosstalk must assess the impact of the various wiring techniques on transmission line characteristics.

As has been pointed out, the microstrip technique differs from that of the strip line in that the transmission line is configured on the surface rather than wholly within the board. Because of this, the resulting dielectric medium has a discontinuity at the interface between the board surface and the air dielectric, and a velocity differential develops.

Forward crosstalk in a microstrip application is created by this difference in propagation velocity. The dielectric constant of epoxy glass is 4.5, and air's dielectric constant is 1 to 1.2. Since the propagation velocity varies inversely with the square root of the relative dielectric constant, the portion of the wave traveling in air propagates faster. Consequently, forward crosstalk increases with distance.

In the case of the strip-line technique, two wires are totally embedded in a common dielectric. Thus there is no forward crosstalk, because all components of the waves are traveling through the conductive medium at the same velocity.

Homogeneous dielectric

As in the strip-line approach, forward crosstalk is very limited in the Multiwire process because its dielectric is homogeneous, since the transmission lines are discretely wired on the boards. Though the wiring is placed on the surface of a board, the cover layer gives uniformity to the dielectric medium, enabling the Multiwire technique to approach the economies of microstrip fabrication techniques, while at the same time exhibiting the electrical performance of boards using the strip-line approach.

As it turns out, forward crosstalk is seldom a problem in the short distances encountered on circuit boards, but reverse crosstalk is more severe. In addition, if the reverse crosstalk is held within acceptable limits, it is virtually assured that the forward compenent will be negligible. Fortunately, in the case of reverse crosstalk, there is a critical length that represents a worst-case condition, as explained below.

Choosing the nominal impedance

The nominal impedance of a transmission line depends on both the inductance and capacitance per unit line length. Minor changes in geometry alter the unit inductance only slightly. However, the unit capacitance is quite sensitive to changes in the dielectric constant and the size and spacing of the conductors.

The nominal, or characteristic, impedance of each controlled-impedance line laid down in the Multiwire process is a function of both the height of the center of the wire above the ground plane and the dielectric constant of the surrounding medium. The characteristic impedance of a Multiwire board can be closely approximated by:

$$Z_o = [41.2/(\epsilon_r)^{1/2}] \ln 11.8\,(h/d)$$

where

ϵ_r = the effective dielectric constant
h = height of the wire center above the foil
d = the diameter of the wire.

The standard Multiwire board is composed of a ground plane, an adhesive sheet with the wires embedded in it and a cover layer of epoxy-impregnated glass cloth called a prepreg. The ratio of height to diameter for this construction is about 1.5. Heavy crossover densities may reduce the nominal impedance by 10%.

By raising the height of the wire above the ground, higher impedances can be obtained. Raising the wire is achieved by either adding layers of prepreg between the adhesive layer and the ground plane or by constructing the core material using mass-molding techniques and burying the ground plane within the laminate.

Measurement techniques

Tests have been run on Multiwire circuit boards over a period of a year to verify theoretical calculations of nominal impedance and crosstalk. Because controlled impedance circuits built with the Multiwire technique are similar to other types of transmission lines, impedance can be measured using one of the techniques commonly employed in evaluating traditional transmission-line circuits—time-domain reflectometry (TDR).

In this technique, a high-speed pulse is applied to a transmission line. When the pulse encounters a discontinuity in the line impedance, a reflected wave occurs and is propagated back toward the source, where its amplitude and time of occurrence are monitored. If the velocity is known, then the location of an impedance discontinuity in the line is easily determined. Also, the amplitude of the reflected wave can be translated into an impedance value.

In the test setup shown in Fig. 4, the pulse travels down a cable of known delay (T_r). Any reflected signal (denoting an impedance discontinuity) arrives back at the pulse generator at $2T_r$, twice the delay time of the test line. The relationships relating line impedance at any point are governed by the following relationships:

$$I_t = E_t/Z_o = (E_i + E_r)/Z_o$$

and

$$I_i = E_i/Z_o, \; I_r = -E_r/Z_o$$

where E_i, I_i and E_r, I_r are the voltages and currents of the incident and reflected wave, respectively, Z_o is the nominal impedance of the reference line, and Z_t is the characteristic impedance at any point on the test line described by:

$$Z_t = (E_i + E_r)/(I_r + I_i)$$

Letting $\rho = E_r/E_i$, the appropriate substitution will yield:

$$Z_t = [(1+\rho)/(1-\rho)]Z_o$$

The test circuit employed groups of parallel No. 34 AWG wires on a standard Multiwire board. Wire lengths were 12 in. to ensure that measurements could be made well away from the interface between the test circuit and the Multiwire board itself and to exceed critical lengths for 1-ns pulses. The most satisfactory interface was provided by subminiature connectors soldered directly to the Multiwire board. The test circuit also required that a 50-Ω resistor terminate each line.

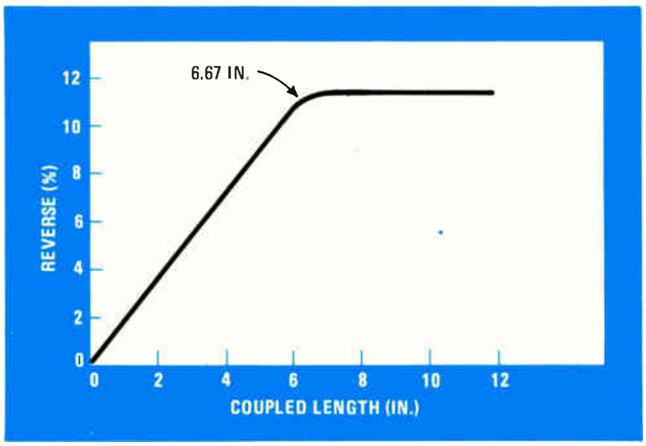
The pulse from the TDR pulse generator was fed through the coaxial cable, entered a plated through-hole, and then traveled in the board itself. As noted in the figure, it then encountered the interface to the terminator and finally the terminating resistor itself valued at Z_t for the circuit under test.

Crossovers and capacitance

The impedance along a wire path within the Multiwire board is shown in Fig. 5. It should be noted that in region A (no crossovers) and region B (packed with crossovers), the nominal impedance is within 10% of the nominal 50-Ω value. In the figure, the crossovers are grounded, demonstrating a worst-case instance and again showing that the characteristic impedance variation is nominal.

The crossover in Multiwire board construction produces a capacitive loading on the circuit. This tends to reduce the characteristic impedance and increase propagation delay. However, each crossover adds a mere 0.025 picofarad, and even with 10 crossovers per inch, the reduction in nominal impedance is less than 5%.

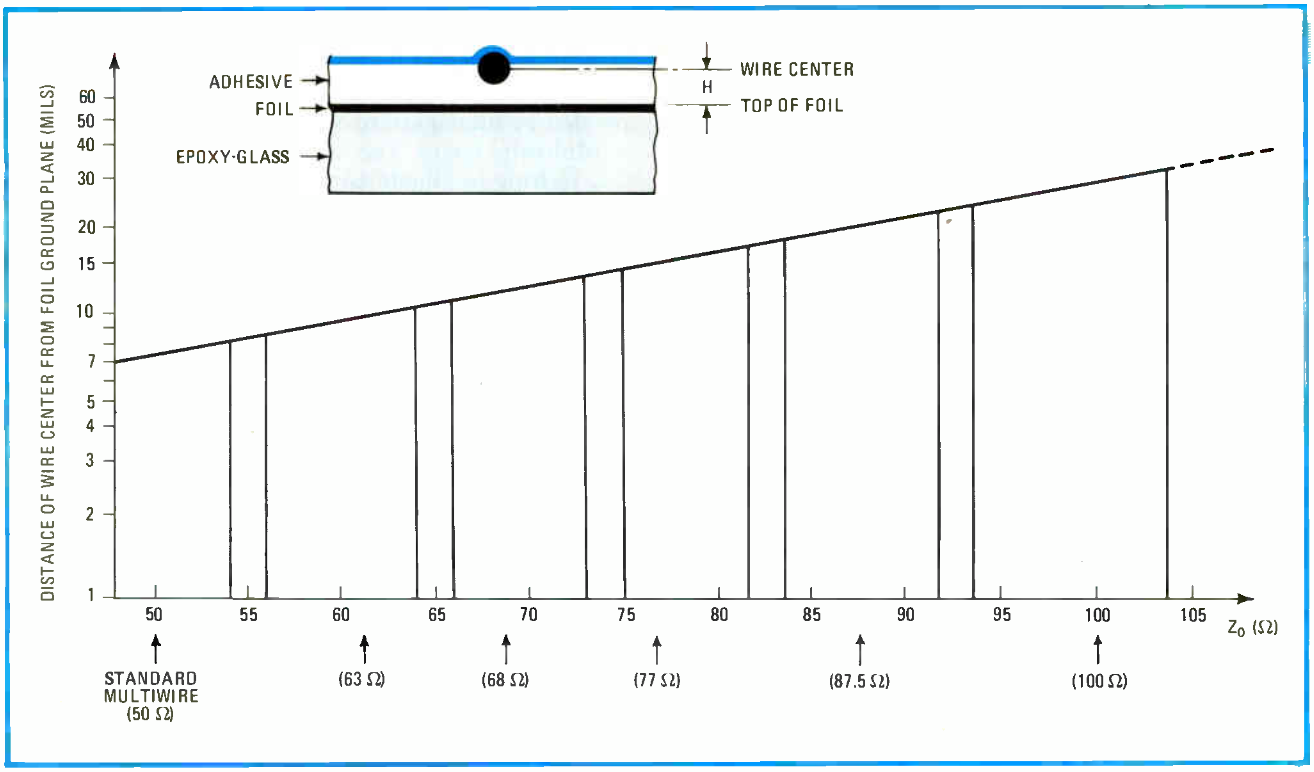
Transition through plated through-holes exhibited lit-



6. Critical length. An actual example of a reverse-crosstalk measurement for a 1-volt, 1-nanosecond signal applied to an active Multiwire signal line demonstrates that at a certain length known as the critical length—here 6.67 inches—the crosstalk is constant.

VARIATIONS IN MULTIWIRE IMPEDANCE AND CROSSTALK BASED ON WIRE SPACING

Distance of No. 34 AWG wire center to ground plane (in.)	Nominal impedance (Ω)	Reverse crosstalk (%)	
		for 0.050-in. interwire spacing	for 0.016-in. interwire spacing
0.0075	50	1.3	11.5
0.017	79.8	3.9	20.5
0.023	92.8	6.4	24.0



7. Controlled impedance. This is a plot of nominal impedance versus wire height above ground for multiwired boards using No. 34 AWG wire. The shaded areas denote nominal impedance ranges obtained by varying the distance between the foil ground and the plane of the wires.

tle change in the nominal impedance. In fact, connectors introduce greater impedance variation than does terminating directly to a plated through-hole because the latter actually resides in the dielectric medium.

In the table, reverse crosstalk values for various impedances values and for spacings of 0.05 and 0.016 in. are shown. Note that for 0.05-in. wire spacing, reverse crosstalk is always less than the values listed, as explained below.

Reverse crosstalk is a linear function of distance for lengths below a critical value. As shown in Fig. 6, if the length of the coupled line is less than this critical length, then a step signal will have insufficient time to complete the transition.

To illustrate why this occurs, assume a propagation delay of 1.8 ns per foot, which is typical in a 50-Ω Multiwire board, and a rise time of 1 ns. In this case, a length of wire 0.55 ft long is required for a 1 ns pulse to complete a transition. Thus, for a coupled length less than 0.55 ft (6.67 in.), reverse crosstalk will not exceed the worst-case value.

Reverse crosstalk—the critical length.

As it turns out, 6.67 in. is a relatively long distance on a board. So if a line is no longer, the crosstalk will never be more than 11.5%, and it will not exceed that figure, regardless of length. Shorter coupled lengths can be computed by substracting from worst-case figures. Consequently, crosstalk is less than 11.5% for coupled lengths that are less than 6.67 in.

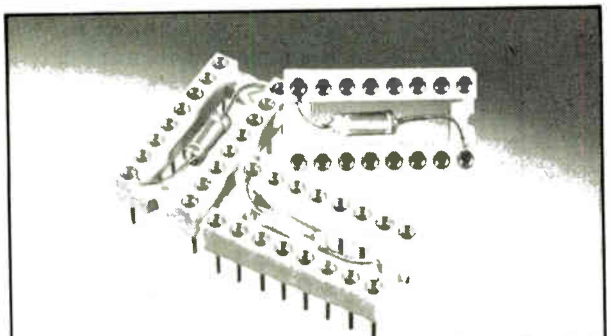
If both the density and the controlled impedance required for a design indicate a need for greater density and accuracy than is possible with two-sided circuit boards, multilayer boards are an excellent alternative in that they duplicate the performance of microstrip boards. However, Multiwire boards yield multilayer densities and performance without having to resort to interleaved power and ground layers.

In fact, with a four-layer Multiwire board, it is possible to attain controlled impedance equivalent to a 10-layer multilayer design. By placing two layers of wire on each side of a board, the attractive characteristics of both the strip line and a 10-layer multilayer board can be achieved, but at a cost much more in line with less costly four-layer multilayer design.

Minor changes

Because Multiwire uses wire, rather than etched foil traces for signal interconnection, only minor changes are necessary in standard fabrication techniques to achieve controlled impedances. Interconnections can be fabricated with impedances of between 50 to 100 Ω, letting integrated circuits be interconnected with low pulse distortion when using high-speed TTL and ECL.

As long as the dielectric constant of the propagation medium is uniform, then the nominal impedance of the wire paths in a Multiwire design becomes solely a function of the spacing of the wire relative to the ground plane. The tolerance bands for controlled impedance lines laid down on a Multiwire board are shown in Fig. 7. If a standard Multiwire board has wire embedded in a single layer of adhesive that is 0.007 to 0.008 in. thick, the nominal line impedance will be 50 Ω with a tolerance within ±10%. By adding a prepreg spacing layer ranging in thickness from .004 to .028 in., impedance values of up to 100 Ω can be established. □



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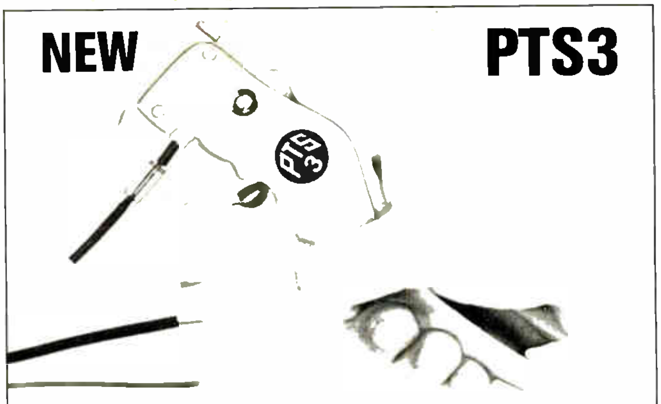

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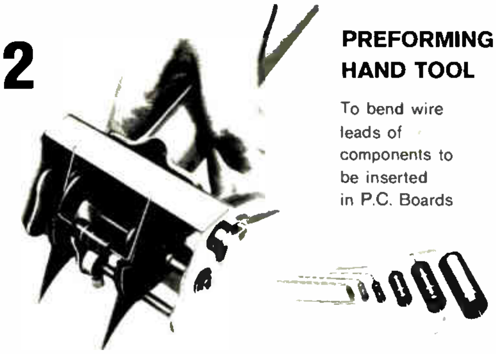

TP

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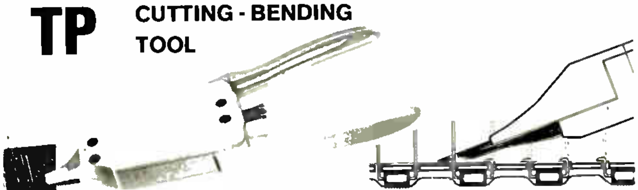

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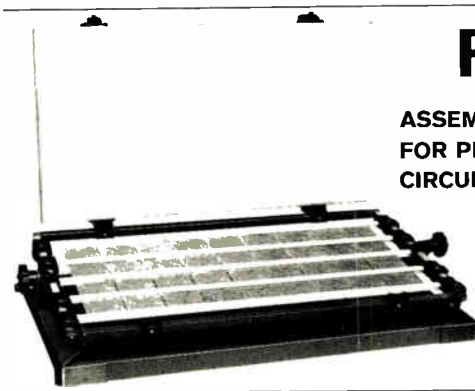

Max P.C. Board sizes:

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PCSS-1 = mm. 270 × 220 (with inserted mid rail) = mm. 270 × 110 + 270 × 110
PCSS-2 = mm. 500 × 220 (with inserted mid rail) = mm. 500 × 110 + 500 × 100
PCSS-3 = mm. 750 × 220 (with inserted mid rail) = mm. 750 × 110 + 750 × 100
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Audio-range mixer calibrates intermod-distortion analyzers

by Michael Bozoian
Electric Consulting Service, Ann Arbor, Mich.

This low-cost system generates intermodulation distortion levels in the audio band from 0% to 100% and is thus a useful test and calibration instrument. Only two integrated circuits are required for it.

The LM3600N, an operational transconductance amplifier with linearizing diodes and a buffer, is wired as a wideband amplitude modulator (Fig. 1). The modulation level and phase is set by a 741 operational amplifier that works as a scaler and inverter. The modulation waveform generated by the circuit is symmetrical. As a result, the percent modulation m becomes $100(E_{crest} - E_{trough})/(E_{crest} + E_{trough})$ (Fig. 2). The calibrated circuit generates a value for m that becomes equal to the rms value of the modulating voltage, e_m.

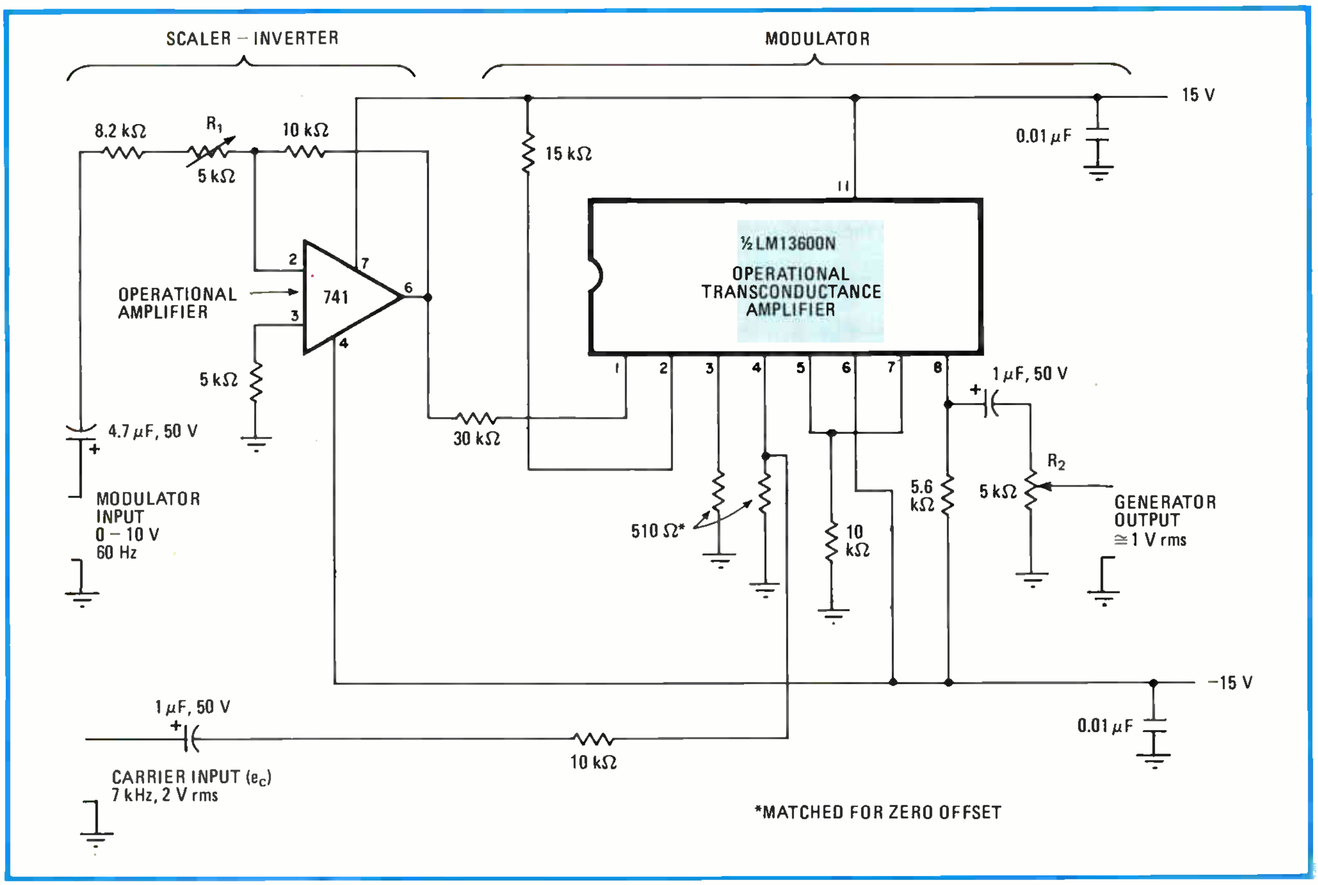
The modulating frequencies applied range from 10 to 500 hertz, with 60 Hz most common. Thus, the general capability of the 741 as a modulation source is adequate, the only requirement being that its output offset be low.

Calibrating the circuit is simple and requires only an oscilloscope. With a carrier input of 7 kilohertz at 2 volts rms and a modulating input of 10 V rms at 60 Hz, the output should appear as shown.

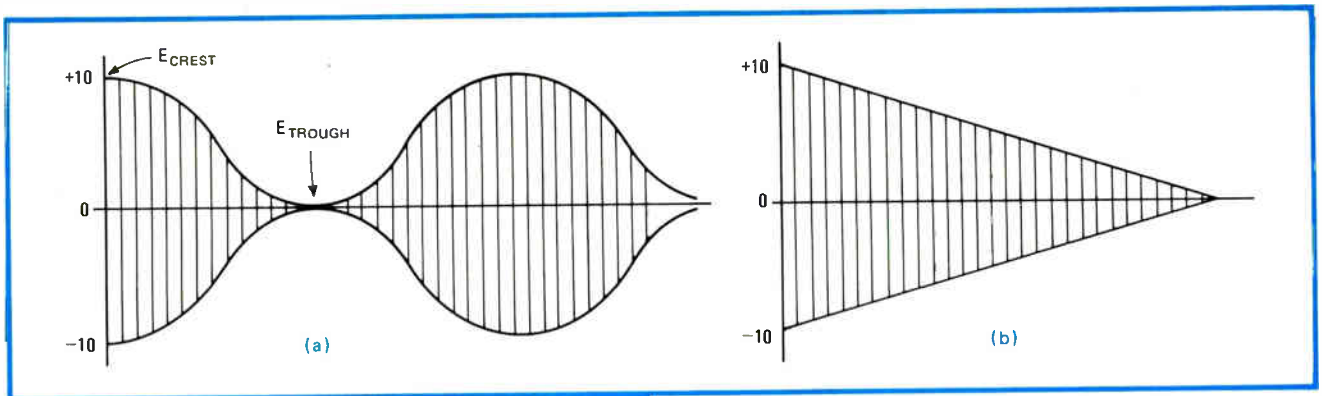
When the vertical channel of the oscilloscope is driven by the output of the system and the horizontal time base is accordingly adjusted, the waveform of Fig. 2a is displayed. The triangle of Fig. 2b will be observed if the output of the system drives the vertical channel and the horizontal input receives the 60-Hz modulating signal. The inverting function of the 741 causes the apex of the modulation triangle to appear at the right of the trace.

The scaling function of the 741 serves to calibrate the system. For (a), trimmer potentiometer R_1 is adjusted until the positive and negative troughs of the curve merge for a 10-V rms input at 60 Hz. Expanding the horizontal sweep of the scope with the 5× or 10× magnification control will help to determine the merge point. In the alternative display of Fig. 2b, the gain of the 741 op amp must be adjusted until the modulation triangle just attains its apex, holding the modulating input at 10 V rms.

With the calibration complete, a direct relationship



1. Nonlinear analysis. A two-chip audio and ultrasonic modulator generates preset levels of intermodulation distortion for a given carrier frequency suitable for testing and calibration purposes. The system is easily aligned, and the circuit's wideband modulator is flat to 120 kHz.



INTERMODULATION DISTORTION LEVELS

Modulation voltage (rms)	Intermodulation distortion (%)
10.0	100
1.0	10
0.1	1
0.01	0.1

2. Response. This system can be calibrated at 100% intermodulation for the 7-kHz carrier frequency using a standard or trapezoidal pattern much as in any amplitude-modulated network. In (a), R_1 is adjusted for a merge of positive and negative troughs, holding the modulating level at 10 V rms. In (b), R_1 is adjusted until the modulation triangle just reaches its apex.

now exists between the modulation voltage level and the percent intermodulation distortion (see table).

The 10% point is used to calibrate the analyzer. Potentiometer R_2 provides level control and aids in determining the high-frequency– input sensitivity of the analyzer; a full-scale response of 25 mV is good. □

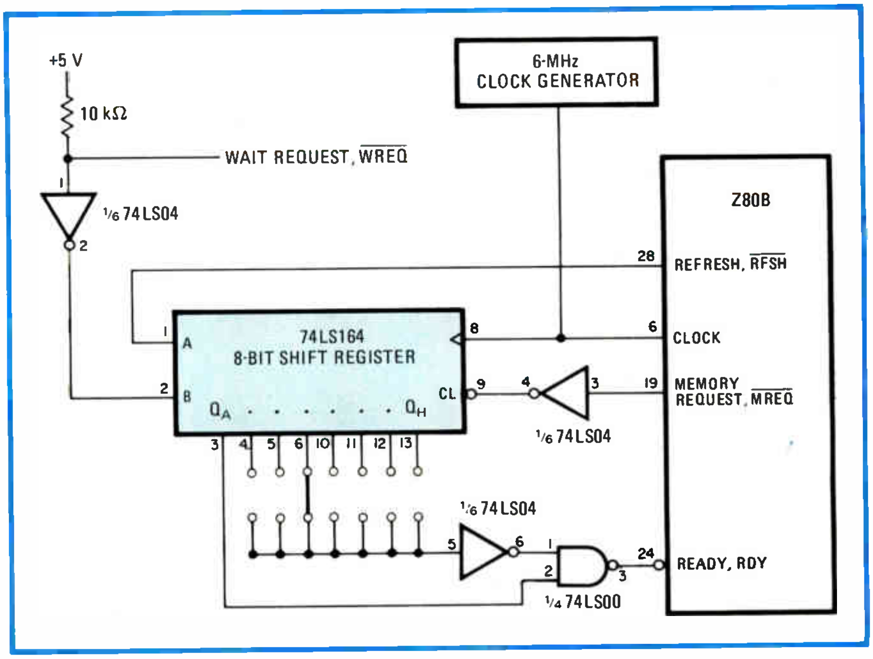
Z80B controller waits for slower memory

by Robert E. Turner
Martian Technologies, Spring Valley, Calif.

In order to run at full speed, the Z80B microprocessor requires memories that have an access time of 140 to 180 nanoseconds. However in small systems where memory costs must be kept to a minimum, problems may occur when data is pumped through during each cycle of the Z80B's 6-megahertz clock because of the system's generally slower (less costly) memories.

This programmable wait-state generator can tailor system speed to the memory type used, permitting fast and slow memories to be intermixed within the address space of the Z80. For example, a 2-K-by-8-bit random-access memory having a 120-nanosecond access time, such as the 6116, and a 2-K-by-8-bit erasable programable read-only memory having an access time of 450 ns, such as the 2716, may be used together.

Because the wait generator slows down the Z80's operation only when slower memories are addressed, a



Patience at the PROM. A programmable wait generator for the Z80B microprocessor allows intermixing of fast and slow memories for maximum throughput. Precautions are taken to avoid generating a wait state during memory refresh cycles by using the refresh line to disable the external wait input. This circuit may be used without any drawbacks with any programmable-I/O, serial-I/O, or peripheral chip in the Z80 line.

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high throughput rate can still be achieved when fast RAMs are used. The advantages to be gained in terms of speed outweigh those achieved in systems using a slow clock rate to accommodate both memory types. The most memory-intensive Z80 operations involve the stack, and the operations depend on data variables.

Subroutines are a good example. A CALL has two stack operations; a RETURN has two more. If registers are saved on the stack, even more operations will occur during the operation of the subroutines. Thus, by using fast RAMs and the Z80B, system performance may be sped up by as much as 40% when compared with the Z80A arrangement and its 4-MHz clock.

As for circuit operation, a 74LS164 shift register is used to add one to seven clock periods to a given Z80 memory cycle. This addition allows the Z80B to drive memories that have 166-ns-to-1.166-ms access times.

The shift register is held in a cleared state until the Z80's memory-request output becomes active low. Then the register clocks the wait request through, from the Q_A output toward the Q_H output on each rising clock cycle.

When slow memory is addressed by the Z80, the wait-request line is pulled low by the memory addressed. This in turn sets Q_A of the register high on the next clock. The Z80's ready input then goes low until a logic 1 is detected by the 74LS04 inverter that is connected to the 74LS164. The output of the 74LS00 gate goes low when the wait line goes low and remains there until the selected register output goes high. The number of wait clocks is selected by connecting the input of the 74LS04 to the appropriate output of the register.

This generator will not alter the RAM's refresh cycle. The Z80 address bus has all 0s for the top nine output bits during such a cycle. These 0s could create a problem in using the address bus for wait selection, so the refresh line is used to disable the external wait line. In this way, the generation of a wait state is prevented. □

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 $75 for each item published.

Optocouplers clamp spikes fast over wide range

by Alex Kisin
Digitus Corp., Baltimore, Md.

A series resistor and shunting diode are the cheapest way to protect the input stages of analog-measurement devices, at least partially, against overvoltage. But when high-voltage spikes come through, users find the large-value resistor often needed to limit surge currents may lead to an increased RC response time of the suppressor.

However, this increase cannot often be tolerated because of the propagation time of the analog data. By substituting an optocoupler for the shunting diodes, the device being protected may be isolated while ensuring a minimum delay time in eliminating glitches.

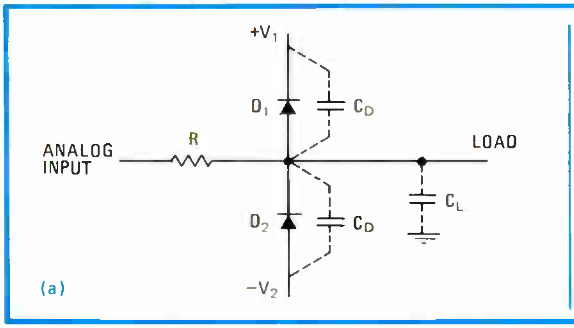
A common circuit for securing pulse protection is shown in (a). To increase protection, clamp voltages $+V_1$ and $-V_2$ may be raised, which is not always convenient. Alternatively, R may be increased but the response time of the device then becomes $\tau = R(C_L + 2C_D)$—a value that is often too high to be practical.

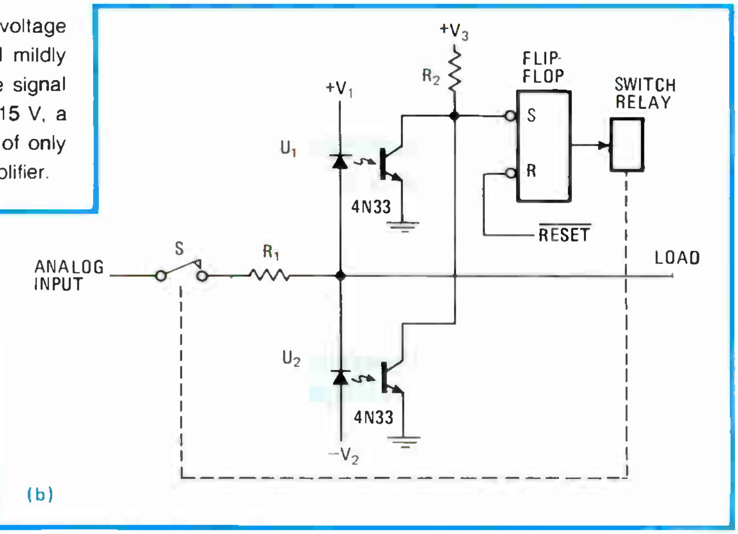
Adding opto-isolators (b) cures the problem. When the input voltage exceeds $+V_1$ or $-V_2$, the respective light-emitting diode will glow, transmitting light to the transistor optosensor. The flip-flop will be set and, in turn, the switch relay, which may be a small field-effect transistor, will be deactivated and the input signal electrically disconnected from the circuit.

The small activating and high surge current of the LEDs allow the input resistance (R_1) of the circuit to be reduced without sacrificing reliability.

This circuit, having V_1 = 15 volts, V_2 = −15 V and R_1 = 470 ohms, was used with 4N33 optocouplers to protect an LF198 sample-and-hold amplifier. The propagation delay was less than 50 nanoseconds. □

Short suppression. A rudimentary circuit (a) securing overvoltage protection for analog-signal-handling devices is simple and mildly effective, but opto-isolators, as placed in circuit (b), reduce signal propagation times drastically. With V_1 = 15 volts, V_2 = −15 V, a pair of 4N33 optocouplers permits propagation delay times of only 50 ns for signals processed by an LF198 sample-and-hold amplifier.





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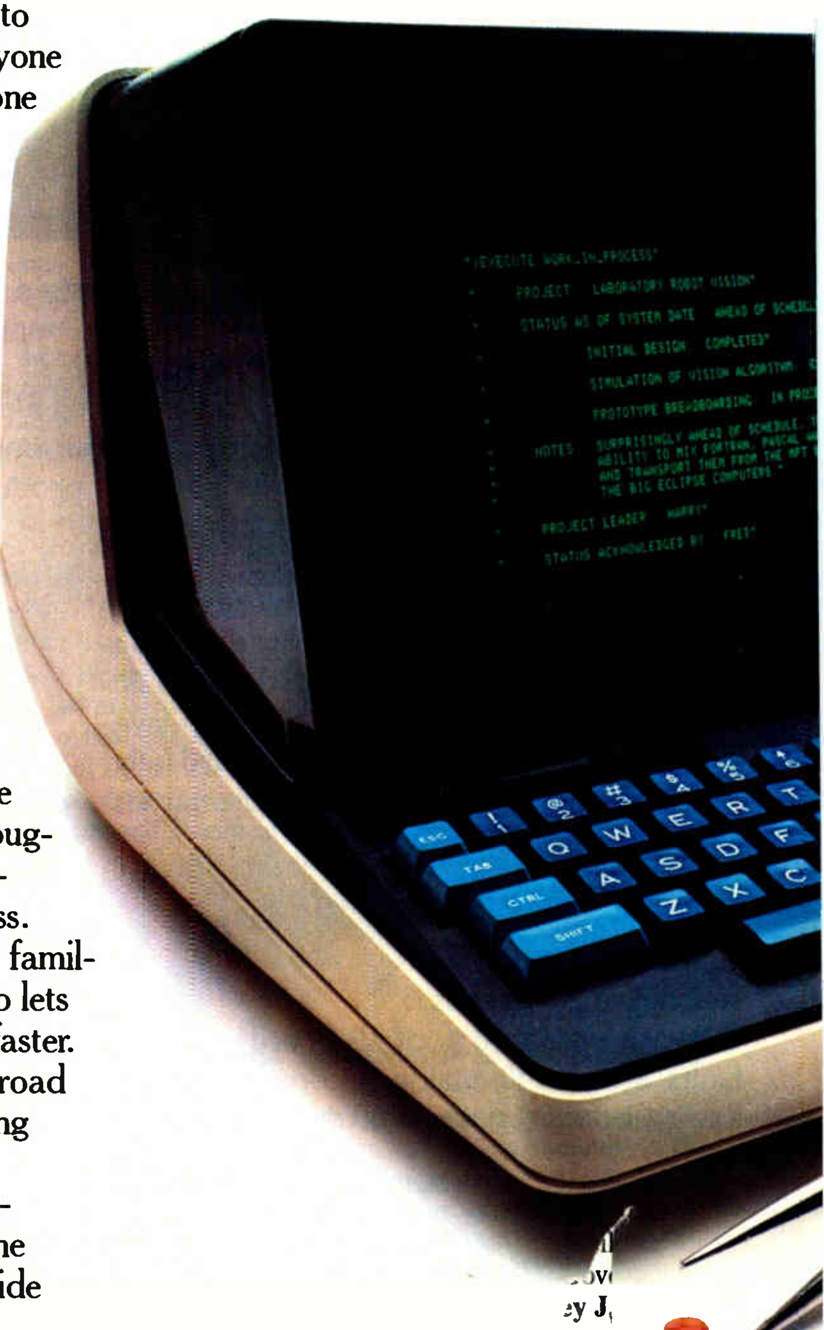

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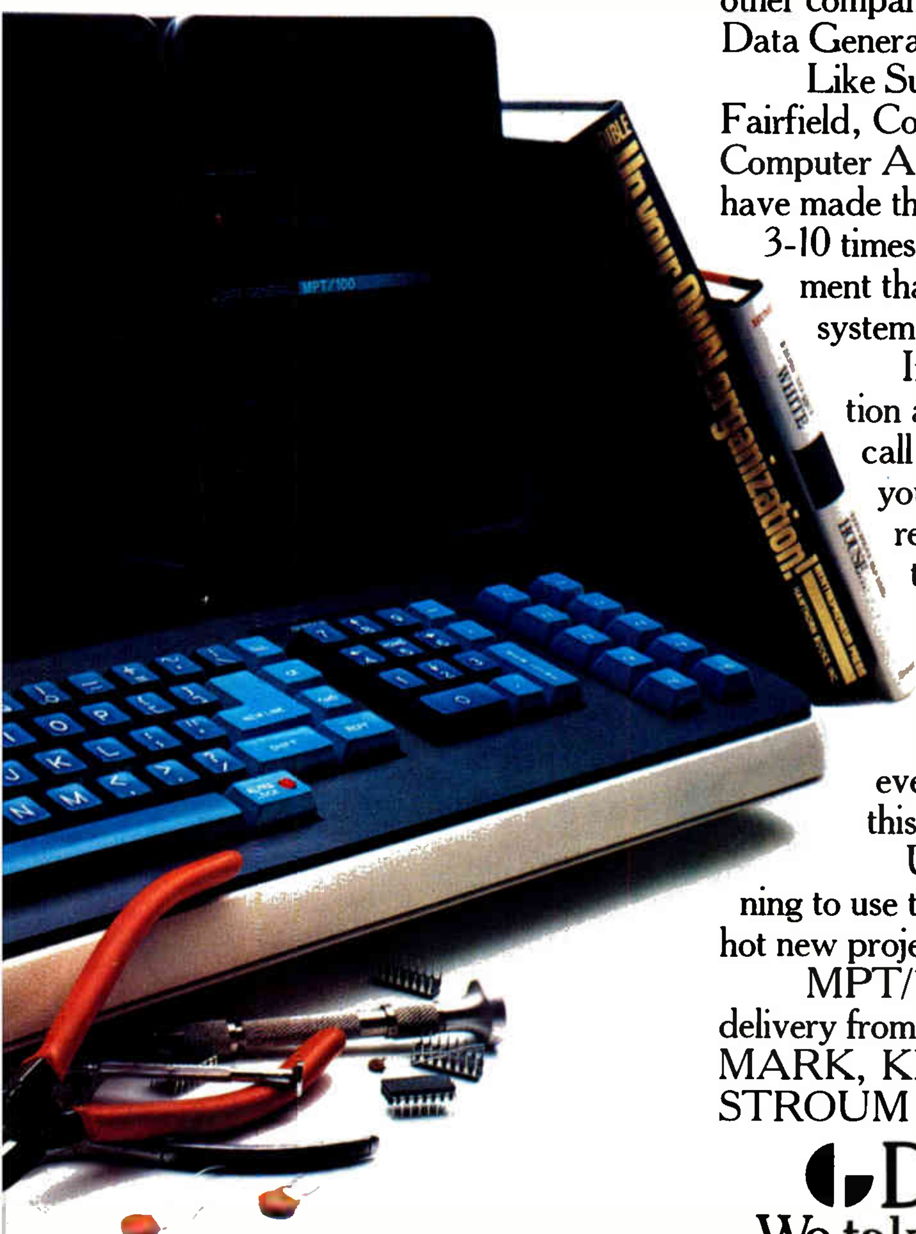

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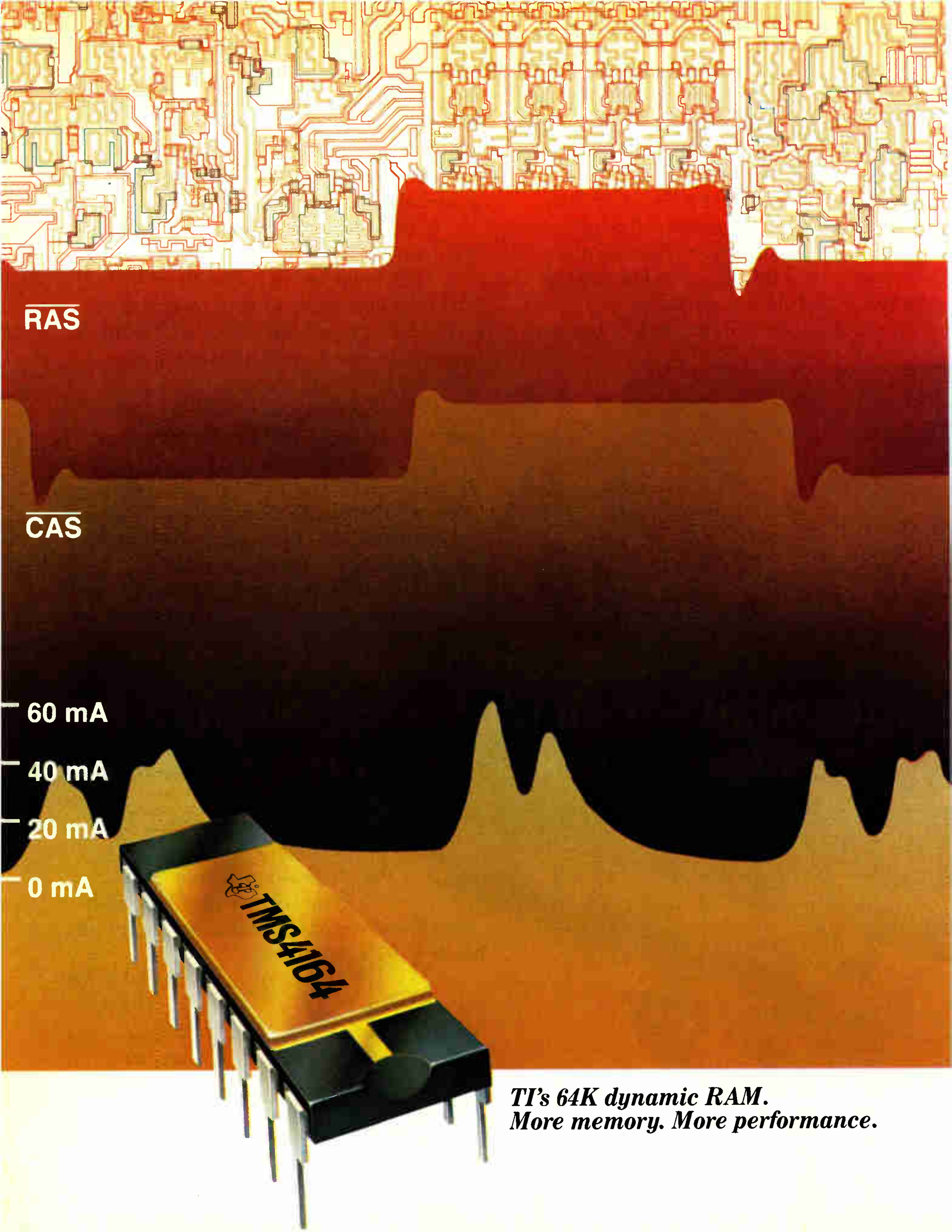

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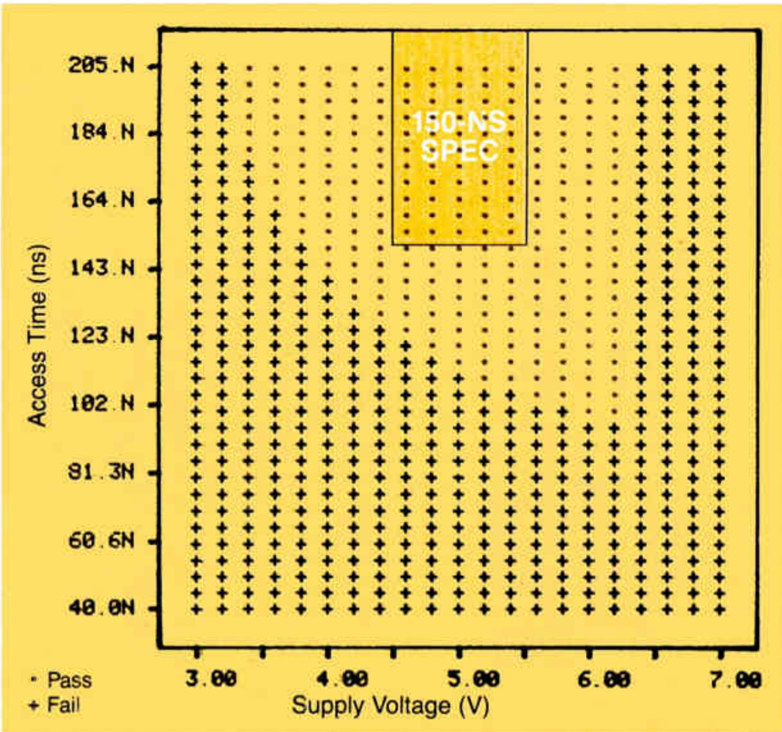

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Cycle Time Read or Write (Min)	280 ns	350 ns	410 ns
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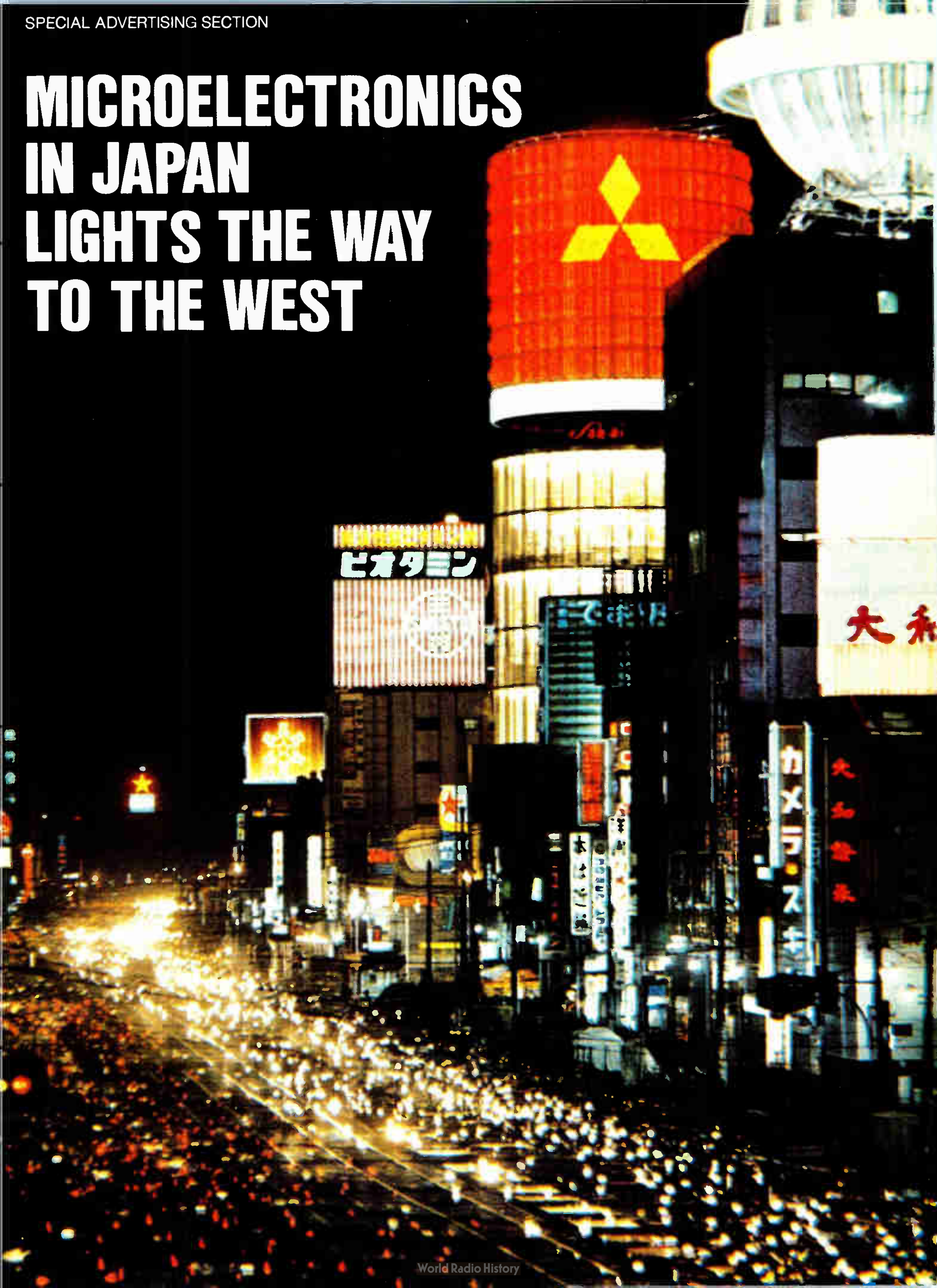

OFFICE AUTOMATION

Japanese-Language Word Processors and Facsimile Machines Lead the Parade

By Mamoru Kobaykawa

Like all industrialized nations, Japan depends upon information flow to keep its highly organized economy working—and, as in other countries, the flow is swelling into a flood. Thus office automation is a topic of keen interest and is a prime area of research and development for the nation's electronic firms.

Japanese-language word processors and facsimile terminals are major beneficiaries of the R&D efforts, representing as they do two different answers to the problem of information processing with ideograms. About 3,000 of these highly complex characters are needed: compare that to the three dozen or so with which alphanumeric systems get by.

As well as making domestic sales, Japanese word processor makers are showing an interest in overseas markets.

More Word Processors

The use of word processors has begun to grow, paralleling their progress in handling Japanese ideograms. The first Japanese-language word processor was marketed in 1978 by Toshiba Corp., and now about 20 manufacturers are competing in this burgeoning market and are beginning to eye foreign-language markets.

The development of word processors is giving impetus to the development of Japanese electronic technology. Examples are printers with high resolution (characters up to 3 by 3 millimeters) and 24-by-24 dot-matrix displays (characters up to 5 by 5 mm) at prices reasonable for general commercial use. Another is wider commercial introduction of 1-megabit read-only memories to serve in pattern generation of the Kanji ideograms.

Because of the special characteristics of the Japanese language, product development efforts are concentrating on the input subsystem. One type of input is what is called full-character lineup: a touch-sensitive keyboard of all the characters. However, the coming technique looks to be a conversion method: inputs are made on a kana (phoneme-based) keyboard and are automatically converted into kanji.

Faster is Better

Indeed, a faster conversion rate is a major R&D task. Beyond that, there is considerable research into a voice-input system by Toshiba, Nippon Electric Co., and others and into optical character recognition by Nippon Telegraph and Telephone, Fujitsu, and others.

On the output side, 24-by-24 dot-matrix impact printers are the mainstream technology. However, recent market introductions include an ink-jet system for quiet printing in the same matrix, a laser-beam system printing 32-by-32 dot-matrix characters quietly and quickly, and a transfer-type thermal printer for low-cost machines. Only time will tell if one of these approaches will overtake impact printers in sales.

Dropping the price

In order to expand the market, word-processor makers are hoping to offer compact and low-cost machines so that one office can have more than one and so that an individual can afford one. The greatest obstacles to both miniaturization and low cost will be two

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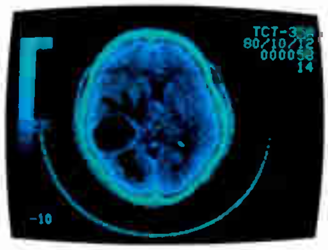

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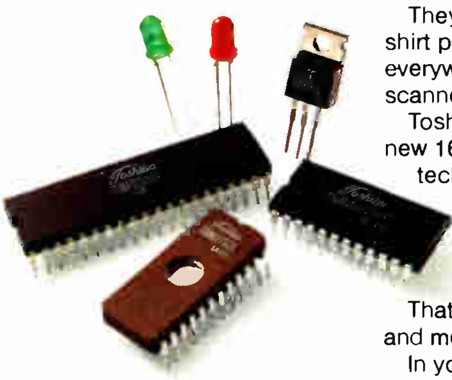

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Circle 164 on reader service card

peripherals: the printer and the cathode-ray-tube display.

The present answers are input-only models eliminating printers and equipment without a CRT. Also, Sharp Corp. has announced a field trial of an advanced personal word processor employing a liquid-crystal display—a potential use of flat-panel displays, which are another area of intensive R&D effort in Japan.

Fax Grows

Japanese production of facsimile terminals has been growing at an average annual rate of about 40%, reaching more than 100,000 units valued at $400 million in 1980. One reason is the start of telephone fax service on a commercial basis in 1973. Another is the ease with which Japanese-language documents may be transmitted—especially compared to teletypewriter machines, which are little used for that reason. So bright is the fax future that about 20 suppliers of the terminals have rushed to market.

Product development in telephone fax machines has been toward high-speed, multifunction units that offer a wider range of grey tones and even multicolor capabilities. High speed is attained with a buffer memory and transmission schemes that skip white sections on the original. As a result, fax terminals that transmit an A4 8½-by-11-inch manuscript page in 15 seconds over a telephone line are now on the market.

More Grey, More Colors

For a wider range of grey tones, a dither method has been introduced in a fax machine that uses an electrostatic pickup, and a pulse-width-modulation method has been introduced for units that use thermal recording. Products now on the market can transmit up to eight tones. In multicolor capabilities, trial products of an ink-jet color facsimile terminal and of a two-color machine with thermal recording were announced earlier this year by Japanese companies.

In the transmit function, solid-state scanners using an MOS or charge-coupled-device image sensor have been replacing mechanical scanners, giving higher performance and lower cost. Also, NTT is working on a large-area solid-state image sensor. It could eliminate the lens now necessary, thereby advancing miniaturization, simplification, and lower-cost manufacturing as well.

These goals are as important as the thrust for higher-performance machines. Right now, some intermediate and high-speed machines cost as little as $2,500 and $7,500 respectively. Later this year, NTT is to start its Telephone Mini-FAX service, sending a maximum size of half an A4 page with what is likely to be a $500 to $750 terminal.

Yet another area of fax development is coupling the terminals with other equipment—in fact, products have been available for two years. Typical examples are facsimile transmission of computer outputs, OCR computer inputs of fax transmissions, and compound terminals integrating fax machines, keyboards, and printers. □

The author of this and most succeeding chapters, Mamoru Kobayakawa, is chief of the electronics industries section in the Industrial Economics Department at the Nomura Research Institute. His staff, Shigeki Kurokawa, Masakazu Kimura, and Shiro Tanikawa, assisted in the preparation of this material.

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PRODUCTION EQUIPMENT

Makers Advance Rapidly, Spurred by Semiconductor Houses

By Mamoru Kobaykaua

Japan's semiconductor-production-equipment industry is making rapid strides today and is developing the world's most advanced equipment in certain specialized fields. It is supported by the brisk capital investment being made by the country's semiconductor manufacturers.

Currently, there are about 60 equipment manufacturers in Japan, of which about 12 are undertaking the manufacture of diffusion furnaces, chemical-vapor-depostion sputtering gear, and other equipment related to wafer processing. These firms can be grouped into enterprises affiliated to firms and independent enterprises.

Internal Efforts

Also drawing much attention lately are the activities of the internal equipment-fabrication departments and direct subsidiaries of major semiconductor manufacturers. Examples in lithography equipment are Nippon Electric Co. in laser units and Hitachi in 10:1 steppers and electron-beam equipment; and in bonding equipment, Toshiba Machine with electron-beam machines.

Most of the manufacturers of production equipment are aligned in one way or another with a particular semiconductor manufacturer. Especially in the wafer processing field, there are hardly any independent equipment manufacturers. Also, on the whole, there are very few enterprises that are exclusively dedicated to the manufacture of semiconductor production equipment.

Most specialized manufacturers are operating as one of the divisions of a large enterprise. These characteristics are mainly rooted deep in the history of the development of Japan's semiconductor industry.

From the initial period of its development to the early 1970s when it launched into IC production, Japan's semiconductor industry was far behind its U.S. counterpart in technology and production capacity. Therefore the industry had to rely on equipment imports from the U.S. for most of its major production steps, such as for wafer processing and mask generation.

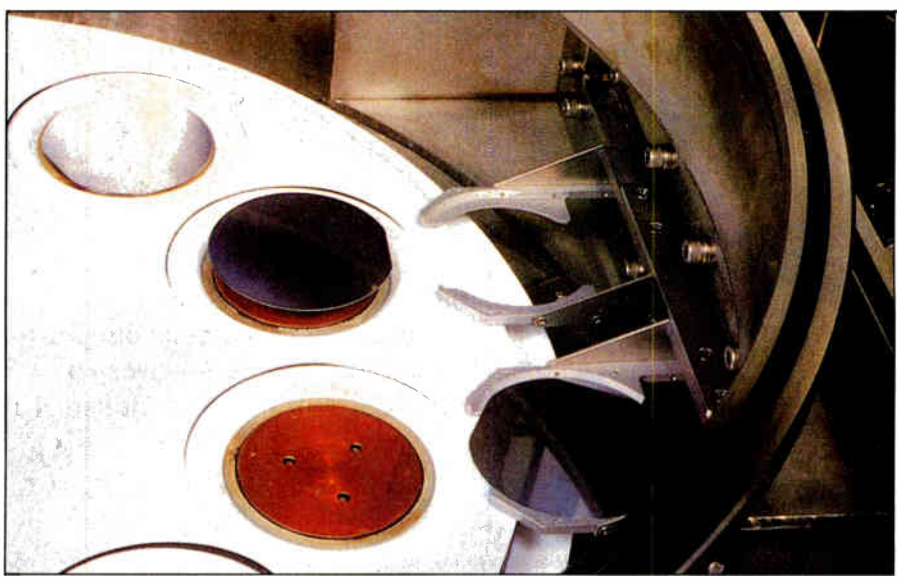
Also, because the scale of the semiconductor industry was still small, most of the indigenous equipment manufacturers were primarily engaged in fabricating assembly equipment or in improving wafer processing equipment in affiliation with their respective groups of semiconductor manufacturers.

The technological level and production capacity of Japan's semiconductor makers gradually rose after the turn of the 1970s. As a consequence of joint development efforts by the equipment suppliers and semiconductor houses, automated technology for wire bonding and similar assembly operations was developed—and it attracted the attention of semiconductor manufacturers throughout the world. In contrast to the push of U.S firms into Southeast Asia and other regions in pursuit of low costs for the labor-intensive assembly operations, the Japanese semiconductor manufacturers had rationalized the process through automation, and so they kept their factories at home.

New Entrants Appear

At this point, Japan's semiconductor industry began to advance rapidly, and enterprises so far unrelated to the field began to join the suppliers of production equipment by converting their technologies developed in other fields. In this way, they were different from those U.S. startup businesses that had originated as spinoffs from semiconductor manufacturers. Also, as these new entrants originally did not

An example of advanced Japanese production equipment is the reactive ion etcher from Anelva.



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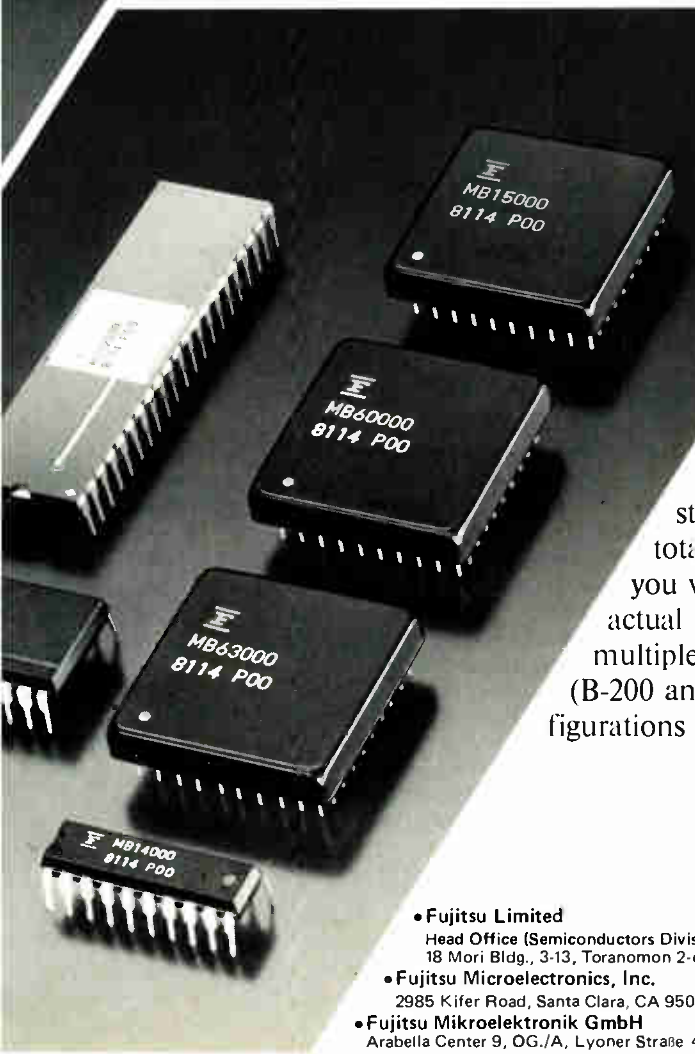

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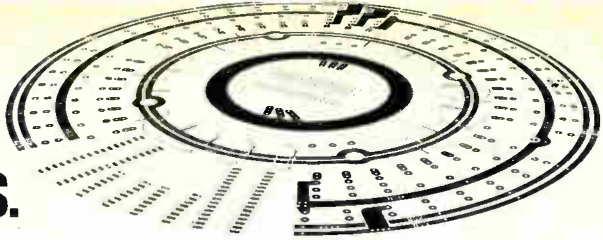

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have much to do with the semiconductor industry, many of them characteristically entered fields other than wafer processing equipment. Typical examples are Disco, a grindstone manufacturer, that has seized an almost 80% share of the world market in the dicing saws, and Canon, an optical apparatus manufacturer that now accounts for almost 70% of the world's share in proximity and contact aligners.

Big Leap Coming

The activities of the processing equipment industry have become increasingly vigorous with the support of brisk equipment by sales to Japan's semiconductor industry—whose sales continued to grow at an annual rate of around 60%, reaching $750 million in 1980. Particularly spectacular is the recent activity in the field of production systems for very large-scale integrated circuits. It has mobilized every frontier technology available.

In the past, Japan had been importing the established technologies in this field from the U.S. or merely following its footsteps. By capitalizing on the accomplishments of the 1976-79 VLSI Joint Research Group, the Japanese equipment manufacturers have been able to introduce a number of noteworthy devices in certain fields.

For example, the current accuracy required for VLSI processing equipment is 2 micrometers $\pm 0.5\ \mu m$. The 1:1 projection aligner from Canon and the 10:1 stepper from Nikon perform as well as U.S. products do.

In the field of dry etching, reactive ion-etching devices ready for line production have been announced by Anelva, Tokuda Seisakusho, and others. All of these units were exhibited at the recent Semicon West Show in Silicon Valley and were well received.

In photolithographic masks, too, Japanese technology has begun to surpass the world level. For example, two leading photomask producers of Japan, Dai Nippon Printing and Toppan Printing, are steadily supplying highly accurate 5-in. masks flat to within 3 μm, having ± 0.25-μm total pitch error and $+0.3$- to -0.15-μm line-width accuracy, and with above 98% chip yield for design rules of 2 to 3 μm.

So Japanese manufacturers have begun to develop equipment comparable to the level of the U.S. standards in some fields. However, on the whole, there is still a large gap in terms of the scale of business, accumulated research accomplishments, and quality of equipment installed in actual production lines. For instance, the sales of the top six U.S companies have already exceeded the $100 million level, whereas in Japan, equipment manufacturers with sales in excess of $50 million are just beginning to emerge (see table) ☐

Major Japanese Manufacturers of Semiconductor Production Equipment

Company	Annual Sales ($ Millions)	Profile
Canon	45	A manufacturer of optical instruments like cameras. It has almost a 70% share of the world market in contact and proximity aligners and makes projection aligners.
Kokusai Electric	39	Radio equipment manufacturer in Hitachi group. One division makes diffusion equipment, which accounts for about 30% of total sales.
Anelva	37	A joint-venture manufacturer of vacuum apparatus of NEC and Varian Associates. It makes sputtering and dry-etching equipment.
Shinkawa	34	A leading manufacturer of wire bonders. It also makes automated processing systems.
Disco	30	The world's top manufacturer of dicing saws, accounting for 80% of the market. It also makes rotary surface grinders.
Ulvac	26	Japan's foremost manufacturer of vacuum apparatus. Semiconductor gear like evaporators, ion etchers, and sputter etchers account for about 30% of total sales.
Tokyo Precision Instrument	20	An instrument manufacturer. It makes automatic wafer probers and scrubbers that account for about 30% of total sales.
Tokuda Seisakusho	14	The vacuum-apparatus manufacturer of the Toshiba group.
Kaijo Electric	14	Manufacturer of applied ultrasonic-wave equipment in the NEC group. It is a leading maker of automatic wire bonders, which account for about 30% of its sales.

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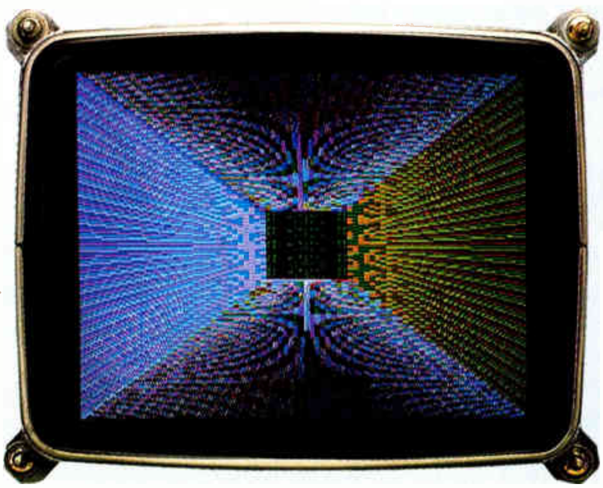

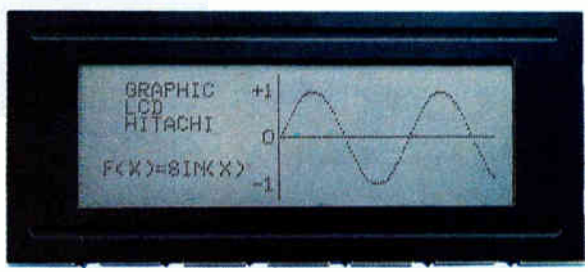

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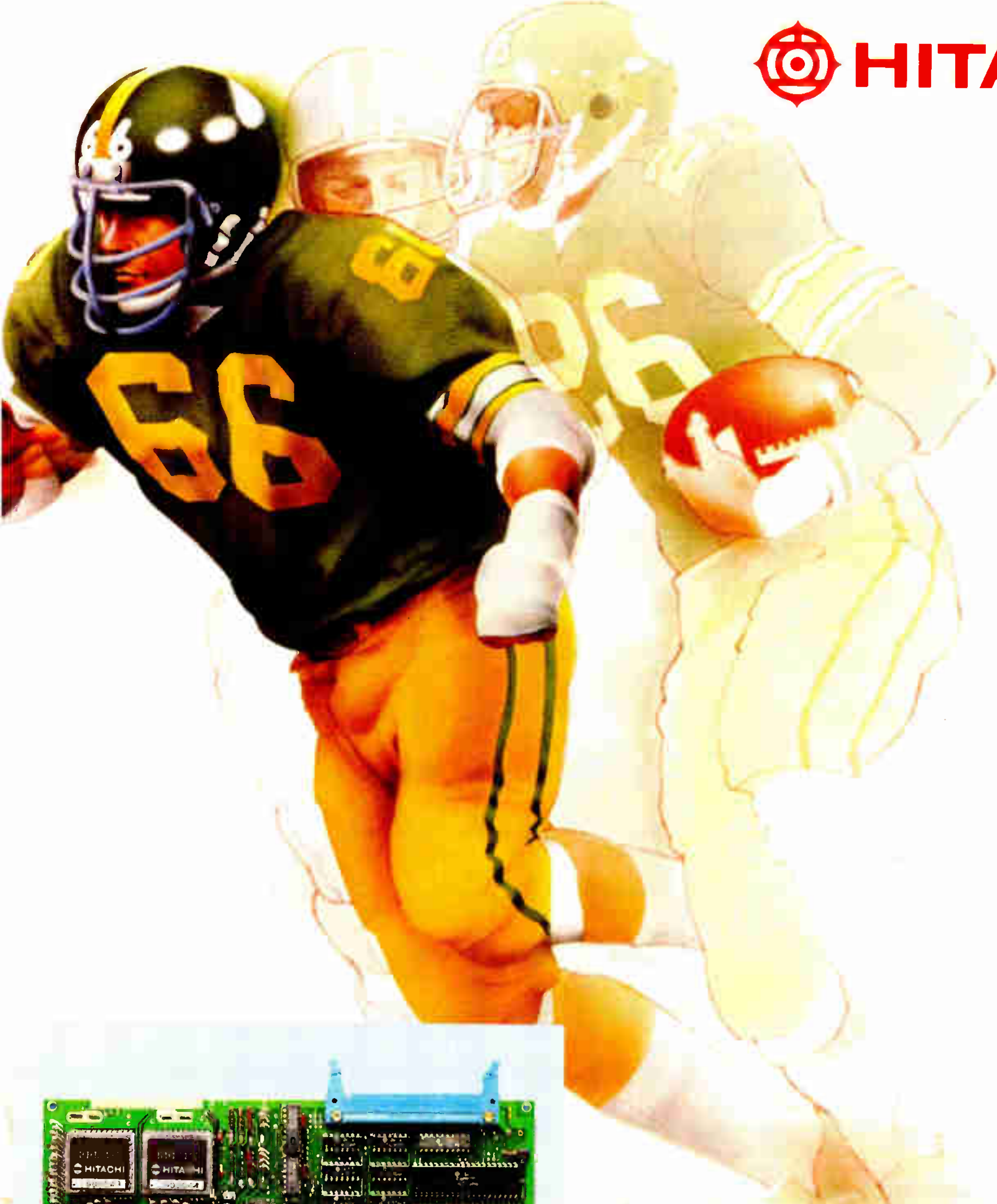

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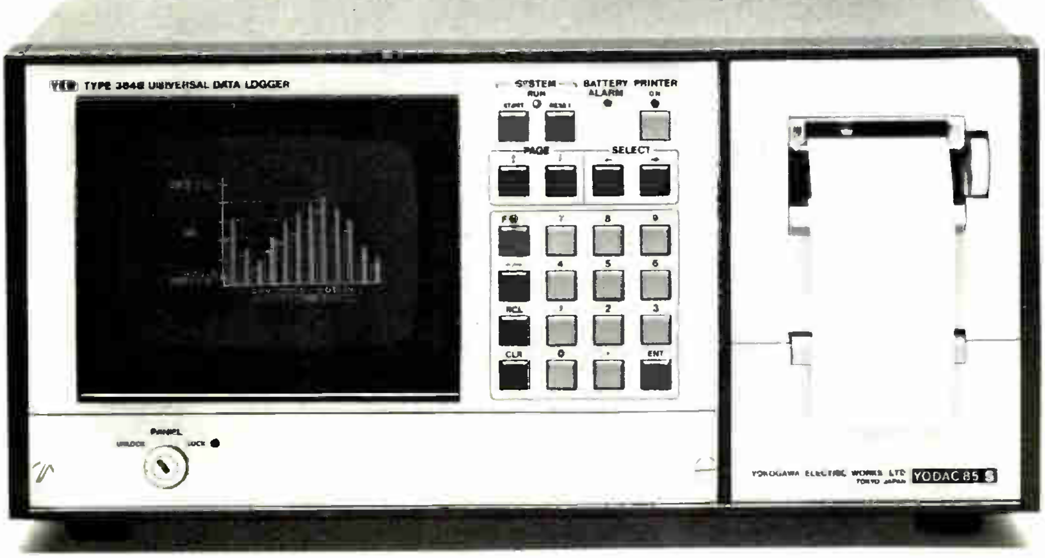

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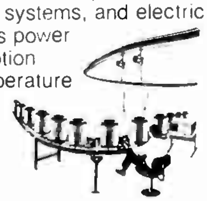
Production Line
Motor, refrigerator, battery, transformer, and temperature sensor (thermocouple, thermostat) test systems, and electric machines power consumption and temperature tests.



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TEST & MEASUREMENT GEAR

Oscilloscopes and Automatic Test Equipment Star

By Mamoro Koboykawa

In recent years, Japanese electronics manufacturers have shifted emphasis from consumer goods to industrial and commercial equipment. This shift has spurred the production of electronic test and measurement equipment, as well as of data-processing equipment; in fact, their manufacturers are emerging from the stage of manufacturing import substitutes to become aggressive exporters.

In many respects, it is difficult to attribute any technological innovation to the industry, but Japanese firms can boast some unique features in mass-produced instruments, notably in the oscilloscope, and in test systems for large-scale integrated circuits. Also, they have been introducing some advanced products ahead of their world competitors, such as optoelectronic instrumentation, network analyzers, and spectrum analyzers.

The Japanese Oscilloscope Market

		1977	1978	1979	1980
Production	Units	68,375	79,157	80,400	95,285
	Value ($ million)	63.3	67.3	73.9	87.1
	Unit price ($)	926	850	919	871
Exports	Units	45,503	57,456	60,734	79,550
	Value ($ million)	20.7	24.6	30.5	37.9
	Unit price ($)	455	429	502	537
Imports	Units	1,365	1,567	1,780	2,221
	Value ($ million)	4.6	5.1	8.4	10.5
	Unit price ($)	3,381	3,245	4,713	4,525

Source: Japanese government statistics $1 = 200 yen

Scopes Flourish

As is true of other measurement gear, American products used to have the overwhelming share of the Japanese oscilloscope market. In those days, firms like Iwatsu Electric, Hitachi Denshi, and Matsushita Communications Industrial Co. began to grow, starting out with low-bandwidth equipment for use in consumer-electronics manufacturing and in the maintenance of telecommunications equipment.

The entry of companies like Kikusui, Leader, and Trio strengthened the Japanese firms' hold on the domestic lowband market. Moreover, as production has jumped, so have exports, while imports have primarily been high-performance, high-cost models (see table).

Cost competition among the Japanese scope markers has been particularly brisk, as has been the push to develop models compatible with the GPIB bus. Now these firms are aggressively trying to develop high-performance equipment that will cost less than $2,500 for 100-megahertz four-channel units and less than $1,500 for 50-MHz models—with every intent of competing in the world market.

The trend towards active export of high-quality, low-cost, mass-produced products is likely to show up in other signal sources and in such burgeoning fields as logic analyzers and spectrum analyzers. Market size is one reason for the intense interest in exports: the size of Japan's domestic market for instruments is estimated to be about a fifth that of the U.S.

ATE Gear is Hot

Automated test equipment for semiconductor manufacturers and users also is taking breathtaking strides. Japan's semiconductor production continues to grow at an annual rate of 25% (for integrated circuits, 37%), opening up vast opportunities for ATE makers.

With the support of the prospering domestic IC industry, ATE manufacturers have capitalized on their advantages in being the "hometown" makers of semiconductor test gear. They also have begun to release products that are technologically superior to their U.S. competition.

The best example is Takeda Riken's Advantest 100-MHz tester that can handle a maximum pin count of 384 and features an overall timing accuracy of 500 picoseconds. Other Japanese manufacturers are equally aggressive in the development of high-speed models.

With such equipment as standard bearers, the makers of semiconductor test equipment are trying to make inroads into overseas markets. Maintenance is of critical importance to the international deployment of electronic test and measurement equipment. Therefore, the important task for the Japanese firms is to formulate an overall strategy for internationalization that includes product development with adequate consideration of maintainability establishment of a sales and service network, and export price competitiveness. □

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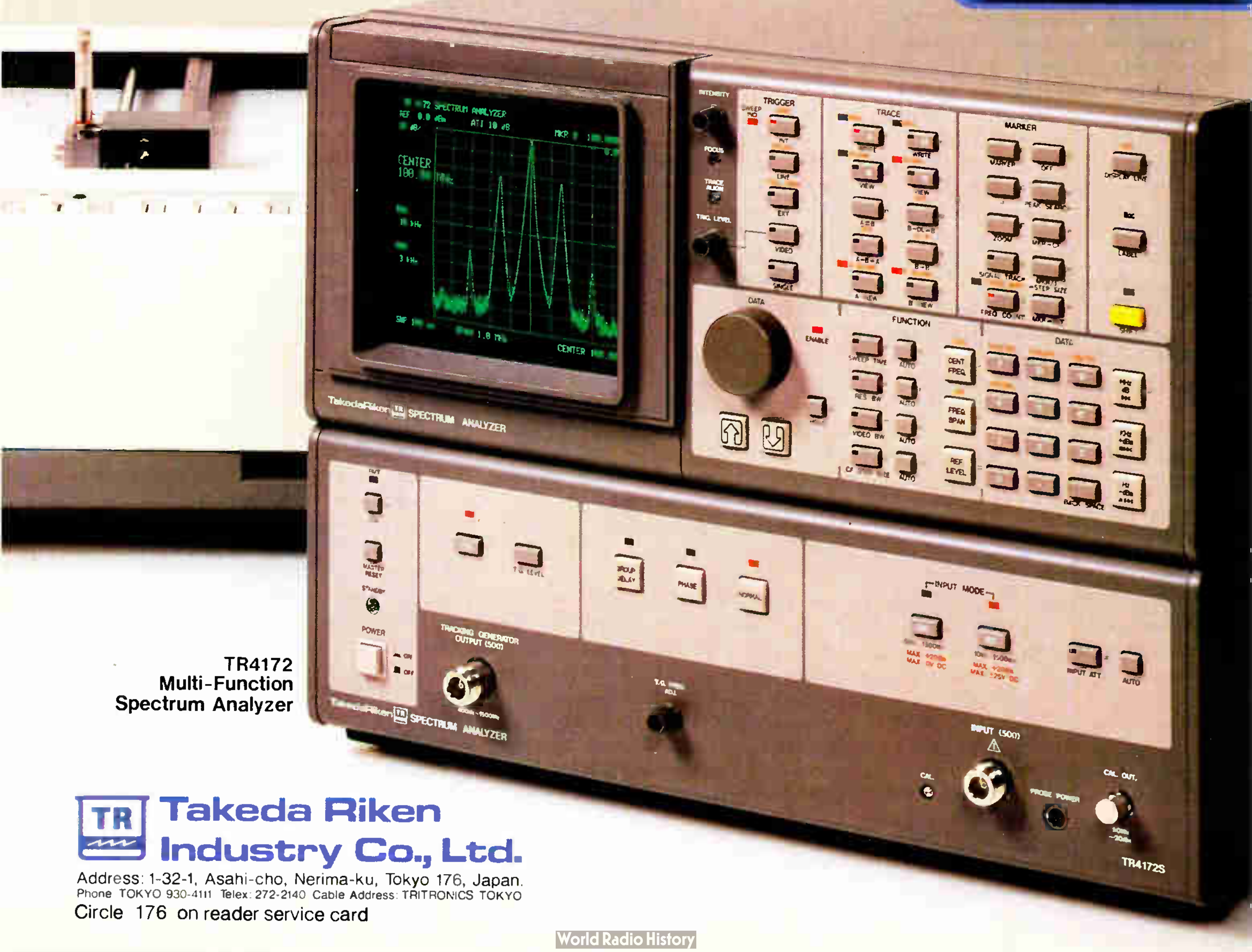

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INDUSTRIAL MICROELECTRONICS

Automated Machinery, Including Robots, Populates the Factory Floor

by H. William Tanaka

A recently developed robot installs doors on car bodies for one Japanese manufacturer, and the company is developing another one that will remove the doors after the car is painted so that the seats may be automatically installed. The doors will be routed along a conveyor belt paralleling the bodies' assembly track and will be reinstalled by another robot.

Such automation owes its existence to microelectronics, which is making possible new forms of robotics and other computerized factory equipment. Its effects are being felt especially in old-line industries like automobile and steel—giving, not only lower production costs, but also a higher quality end product.

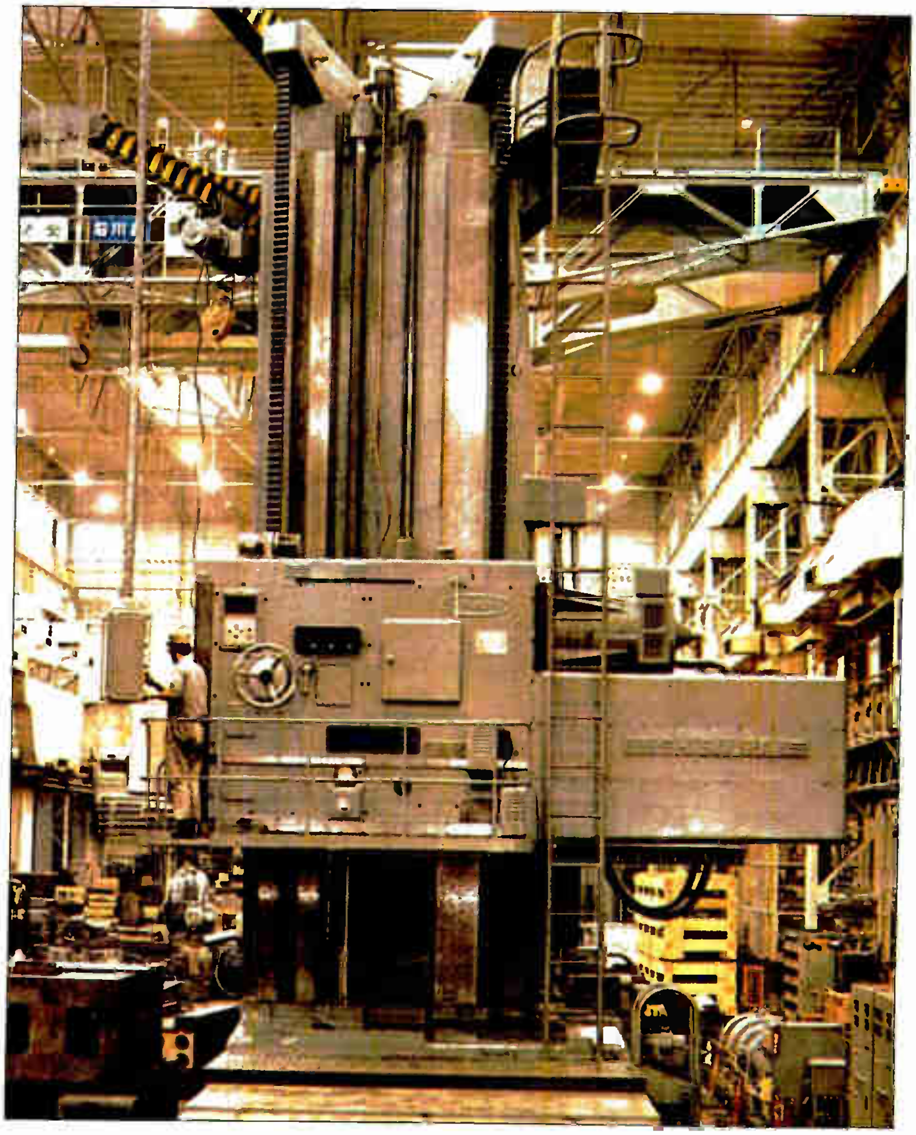
As well as robots, computerized numerically controlled equipment, and the like, more sophisticated computer-aided-design tools and test equipment are beginning to crop up in various industries. The net effect is what is being called the second industrial revolution—still only in its infancy. Like its predecessor, this industrial revolution will profoundly change the socioeconomic map of our world.

Computer-Aided Manufacturing

Robots have been on the industrial scene since the early 1960s. However, the first versions were targeted primarily to handle difficult and hazardous jobs. More recent models perform more precise tasks, and future robots will handle complex assembly jobs. Eventually, many factories will become totally automated, with large computers controlling many microprocessor-directed robots.

Sensory robots programmed to automatically respond to changing conditions on their own represent the state of the art in robotics and are used in assembly-line tasks. Future robots will have enhanced sensory capabilities, be easier to program, and be capable of making running adjustments and incremental changes in the manufacturing process.

Because of the relentless competitive drive for cost efficiencies, the auto industry has become one of the principal users of robots. One Japanese auto factory has 96% of the body-assembly work performed by



Automated factory tools had simple beginnings, with equipment like this boring machine; now robots are beginning to be commonplace in the factory.

computer-controlled machines. Other companies in Japan, the U. S., and Europe are rapidly closing the automation gap.

Appliance manufacturers, following closely behind the auto industry, are also automating their assembly lines. The industry first used robots for less complex tasks like painting and installing heavy parts. With enhanced vision capabilities, robots are expected to assemble refrigerators, stoves, and other kitchen appliances.

Consumer electronics has also been a leader in the use of innovative automated machinery. Currently, high-performance handheld calculators are being assembled by robots equipped with video cameras.

Aerospace is another industry with a potential for wider application of robots. A major military aircraft hardware program coordinated by the U. S. Air Force includes automation of the entire manufacturing process. The first integrated operational center is scheduled to be completed by 1985.

Even such traditional and labor-intensive industries as textiles are being revolutionized by robotics. Computerized equipment lays out patterns and material; microprocessor-controlled lasers cut cloth; and computerized sewing machines finish the garments. Use of high-technology machines has enabled a number of mills in industrialized nations, including the U. S., to regain their competitive edge against imported clothing from low-wage countries.

To a large extent, today's robots have been designed to do tasks previously performed by human workers. Tomorrow's robots will branch out to work in areas beyond the capabilities of man.

Deep-sea mining and nuclear power-plant operations are areas where the special talents of robots are usefully exploited. Two Japanese companies are jointly developing a giant seabed exploration robot that can lay pipelines at depths of 1,000 to 2,000 feet.

Computerized Machine Tools

Assembly and finishing operations are only one aspect of the manufacturing process invaded by computerized equipment. Upstream in the process, the product's metal and plastic parts may have been cut and shaped by computerized machine tools. In fact, microprocessors have been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incorporated into a variety of machine tools, guiding lathes, grinders, cutters, and drills.

While computerized numerically controlled units have been in existence for a number of years, demand for them has surged recently, triggered by the need to manufacture products to higher precision and closer tolerances while reducing machining costs. The largest user of CNC machine tools has been the automobile industry, but the equipment has applications in other industries such as steel, plastics, appliances, and electronics.

Advances in integrated-circuit technology now pit microprocessor-controlled machine tools against minicomputer-guided models. Widespread availability of the faster and more powerful 16-bit microprocessors account for this contest.

Although the use of microprocessors can cut computing costs by 50%, the cost of redesigning systems and software has slowed any massive changeover to the new tools. However, with greater user interest on cost reduction and through improvements in design and software, the microprocessor will assume a commanding role in future machine-tool design and production.

CAD as Test Tools

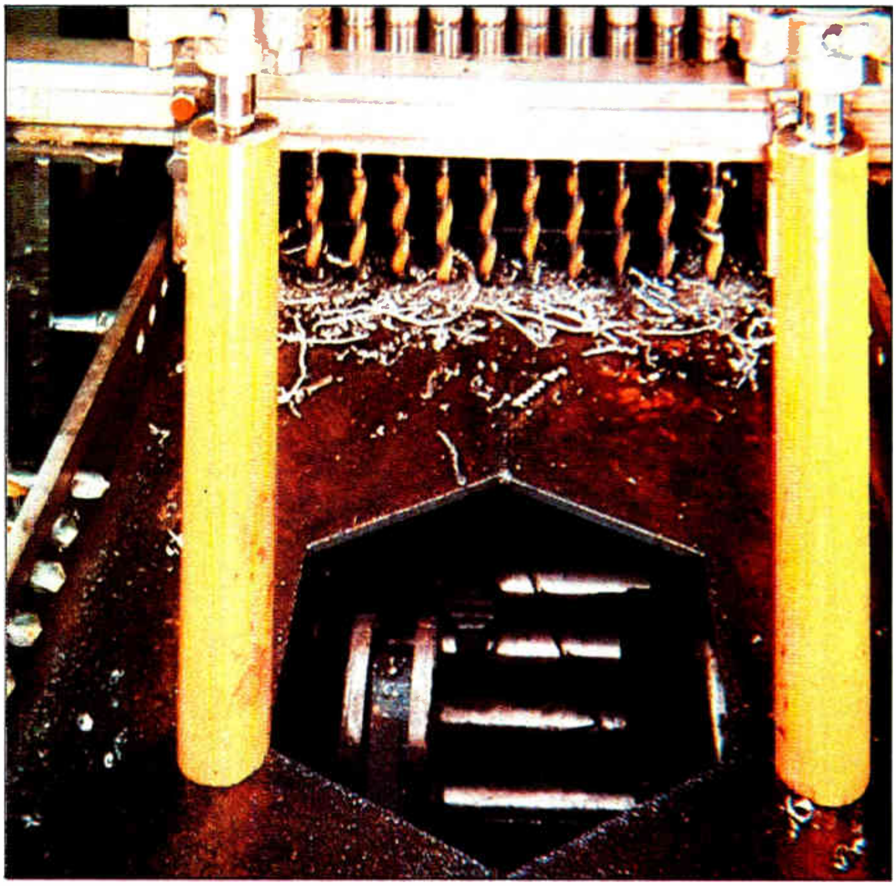
Product design is another area soon to be revolutionized by electronic devices. For many years, computer-aided design has been viewed as the ultimate tool for assisting man to shape and fashion the objects around him.

While the early expectations remain unfulfilled, optimism for a major breakthrough in the near future continues. Improvement in software to overcome difficulties in communicating the precise shape of three-dimensional solids is continuing. Increasing research and experimentation signify that computer-aided design will become widespread during the 1980s.

Industrial applications of computer-aided design are almost unlimited. Revolutionary changes are in the offing in such industries as machine tools, aircraft, and chemical processing equipment. Computer-aided design will even benefit the medical appliance industry in the designing of prosthetic devices and artificial joints.

Lastly, electronic test equipment has taken on an expanded role in reducing product defects, including component checking, as well as end-product testing. Electronic testing equipment is already at work in many industries. For example, in metal-working shops, an electronic test device examines the metal shaped by a CNC lathe to determine conformity with customer specifications.

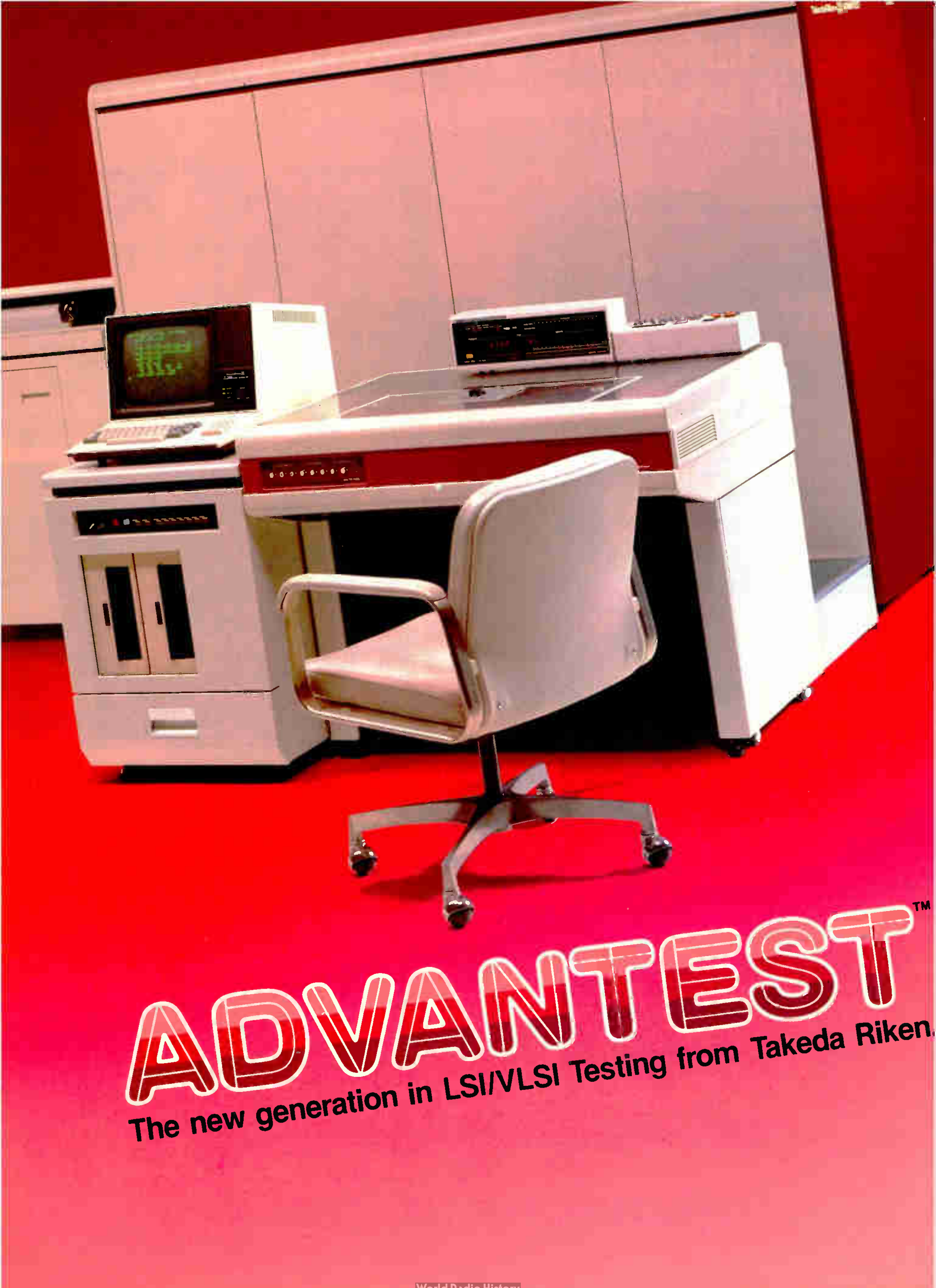
Larger, more complex equipment is used for testing in automotive factories. One Japanese plant uses a computerized machine for tracing the contours of newly stamped parts and comparing them with the desired profile. Electronic engine testing equipment now allows highly accurate diagnostic checks while the engine is run through more than a hundred complicated tests.



Drilling holes is a job that is a natural for automation, since it is highly repetitive and usually has a standardized pattern amenable to computerized control.

Tolerance Checks

One Japanese manufacturer uses a highly sophisticated electronic gauge to check the location of 24 critical surfaces and holes on the front structure of the car. Failure to meet the company's tolerance limits during any of the tests results in the entire assembly line being shut down while adjustments are made and defective pieces removed. Such testing was unknown in the industry before the mid-1970s, but it is rapidly becoming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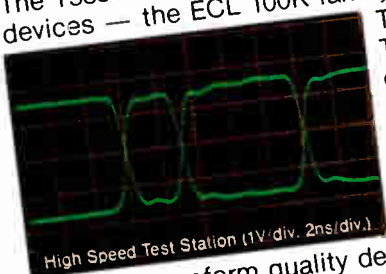
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standard procedure with the tougher competition for new car sales.

The second industrial revolution is only in its infancy. Advances are being made on various fronts to upgrade and develop machinery for designing products, cutting out parts, and assembling and finishing them. All of these developments are proceeding in piecemeal fashion. Ultimately they will link together in a fully automated factory, which itself will be operated by a computer.

Electronics will play a dominant role in this entire process. Sophisticated processing and memory units will be required as further advances are made in these industrial machines. As manufacturers step up demand for even more sophisticated electronic equipment, the electronics industry will be pushed to advance the frontiers of its knowledge and capabilities.

Cost Reductions

Sparking the second industrial revolution is the need for resource- and energy-efficient output in virtually every industrial, service, and agricultural sector. The persistent and debilitating inflation permeating the world economy, exacerbated by dramatic increases in energy costs, compelled the auto industry, the machine tool industry, and a host of others to look towards automation in order to drop costs. High-technology industrial equipment meets these criteria by boosting productivity while upgrading quality by eliminating defects, increasing useful life, and reducing maintenance costs.

The color television receiver industry is a case in point. Under the spur of competition, TV manufacturers were one of the earlier groups to automate, as design and manufacturing technology shifted from tube receivers to solid-state sets.

Use of the transistor and other solid-state devices enabled television manufacturers to eliminate labor-intensive operations with electronically controlled equipment, such as automatic insertion machinery and automatic component and circuit testing units. The larger automatic insertion machines alone reduced workforce requirements anywhere from 175 to 400 workers.

Coupled with automated assembly techniques that largely eliminated human error in component assembly, greater emphasis among workers on quality control cut factories' defect costs. For example, within two years after one Japanese manufacturer introduced highly automated assembly operations at a formerly American-owned TV plant, the cost of warranty claims dropped by almost 90%.

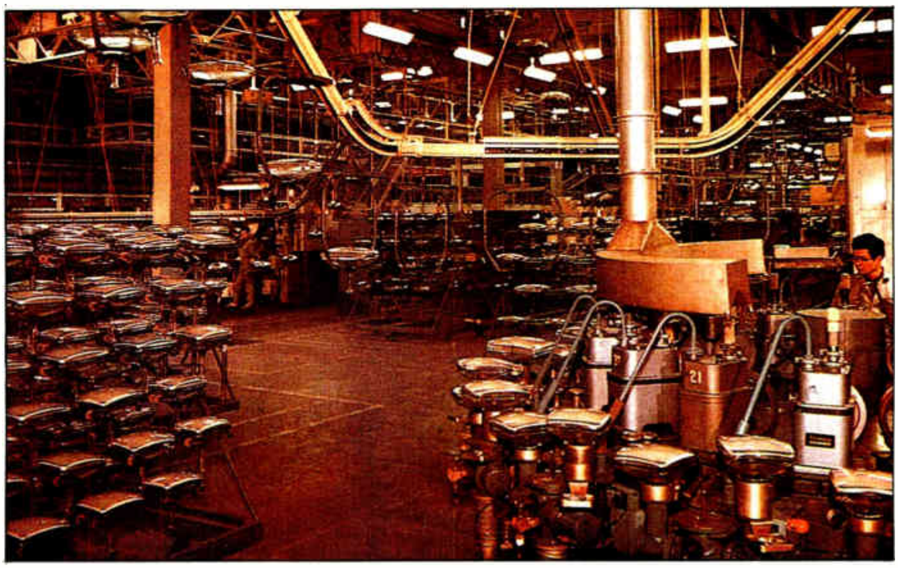
Expanded Horizons

With the development of more advanced solid-state componentry, the television industry and consumers further benefited from declining component costs. Many previously discrete components were displaced by one integrated circuit in certain television applications.

The dramatic cost savings from reduction in component count is seen from the fact that color TV sets that once used some 3,000 parts now only contain slightly over 400. Besides cost reduction, the sharply reduced component count achieves a lighter, more compact product with lower shipping costs, longer life, and reduced repair costs.

Real consumer benefits flowing from the television industry's shift to solid-state devices and automation can be best understood by reference to TV cost and price trends. Despite the recent high level of inflation, costs in TV manufacturing have remained stable as labor input in the U.S. television industry declined by about 53% between 1973 and 1980, two years with comparable sales levels. During the same time period, color television prices have remained constant, while set quality and features were upgraded: a convincing demonstration of the dramatic disinflationary effect of technology.

Historically, automated devices like robots were developed to perform difficult or hazardous tasks, rather than to achieve cost efficiencies and upgrade quality. With the persistence of inflation, most industries are putting renewed emphasis on cost-control and -reduction. This precipitated the recent



The production of television receivers took a giant step forward when manufacturers began to automate such jobs as production of TV picture tubes.

surge in demand for computer-controlled machinery, which is expected to expand along a broad front later in this decade.

Recent studies confirm that the $4.80 per hour robot cost in the U.S. auto industry provides substantial savings when compared with the skilled labor cost of more than $14 per hour. At the same time, robots usually replace more than one worker: one Japanese auto manufacturer has concluded from its extensive experience in using robots that one of these machines equals the output of 1½ workers.

Varied productivity increases are reported from the use of computerized automated equipment. A U.S. calculator manufacturer estimated that use of computerized assembly techniques for 75% of its production would increase productivity by 40%.

One American machine-tool manufacturer claims a 50% increase in productivity from the use of a robot. A Japanese machine-tool manufacturer reported doubling its production after adding 15 robots to the previous workforce of 10 workers and 10 robots. These results are consistent with the predictions of automation experts that eventually highly intelligent robots will displace between 65% and 75% of the current factory workforce.

However, the emphasis on productivity gains obscures other important savings attributable to computerized automated machinery. Topping the list of these other savings is the drop in product-repair and -replacement and warranty costs.

Automated machinery importantly promotes product quality, a much sought-after goal as product and price competition intensifies. Monotony, boredom, and fatigue, which cause human errors, are substantially reduced as a managerial concern.

Less obvious are the intangible benefits derived from the positive product identification, established through a reputation associated with a defect-free product. With the increased emphasis on defect reductions, an

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industrial manufacturer must pursue an aggressive quality control program. This, of course, will include increased automated designing and assembly.

Automated manufacturing processes have also brought unexpected cost reductions. One U.S. manufacturer achieved a 35% reduction in floor space utilization by installing a computerized robot assembly line. Another company expects the reprogramming of its computerized machinery to forestall costly retooling expenses. Reprogrammability is particularly important in the aerospace industry where production volume is limited.

The Revolution's Effects

The enormous forces unleashed by the innovative process in the electronics industry have been and will continue to be creative of new values and destructive of existing values. Spreading in ever widening circles, the ripple effect of these forces is engulfing every major industry from fisheries to home products. At the center of this technological maelstrom is the semiconductor industry, the most innovative sector in the world economy.

Although bringing enormous benefits in terms of production efficiencies, consumer convenience, and enhanced quality, the electronics revolution has also left in its wake destruction of entire industries, vitiation of highly refined skills, human trauma over job losses, and community dislocations.

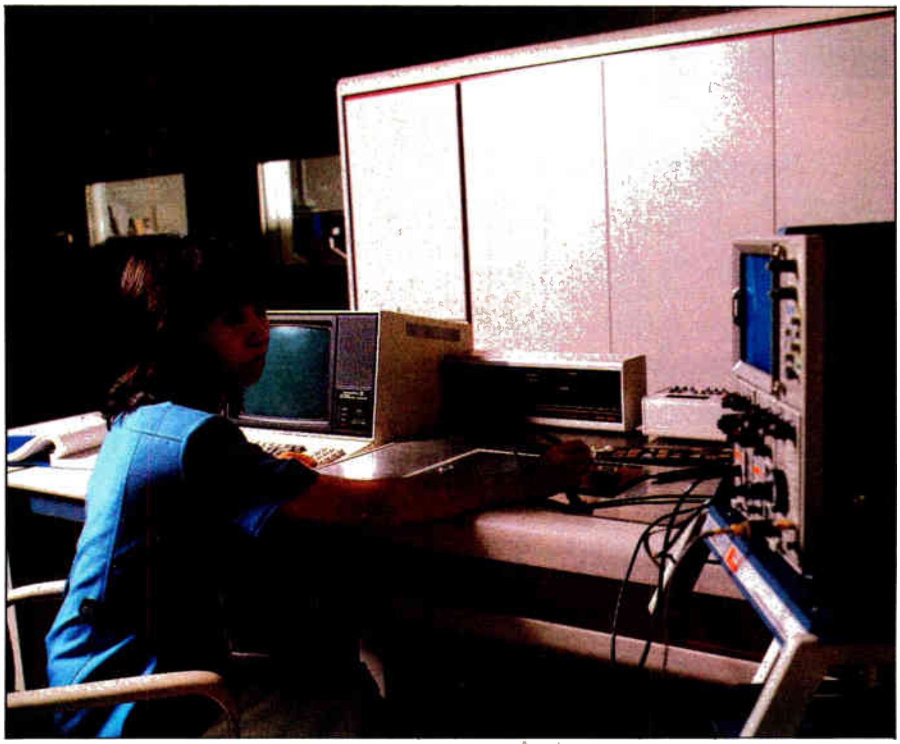
The destructive effects of this process of technology displacement were first felt in the electronics industry when the transistor rapidly displaced the vacuum tube and associated components as viable commercial products. Subsequently, end-product manufacturers, including audio equipment producers, adding machine manufacturers, and the watch industry, were victimized by the technological predation of transistors.

For example, following the introduction of the electronic watch, the well-established Swiss watch industry was hard hit, reportedly losing 46,000 jobs. It was compelled to upgrade from the watch to the jewelry business in order to survive.

Events to date mark the second industrial revolution, as semiconductor technology spreads out to revolutionize the entire economy—bringing with it, resource and energy cost-efficiencies, upgraded quality of products and services, greater convenience, and more leisure time. No industry will be spared from fundamental structural changes. In particular, mass-production manufacturing processes, interoffice communications, and retailing will, to a greater or lesser extent, be taken over by automated equipment.

At the same time, the work environment will be upgraded, freedom of choice expanded, and economic opportunity and leisure time increased, while the process of environmental degradation is offset and reversed by more cost-efficient use of energy and resources. In the competitive struggle for industrial survival, no major firm, American or otherwise, can afford the inflationary and strike-prone mode of mass production, which deskills workers and treats labor as a cost rather than a resource.

Corporate financial resources generated from reordered internal priorities and the cost efficiencies realized, expanding sales, and increases in real income will be increasingly invested in the education, training and upgrading of skills for workers. Thus, an increasing number of future workers will consist of engineers, trained technicians, and other white collar specialists and highly skilled blue collar craftsmen and operators enjoying cleaner working environments and greater employment security. □



Trailblazers for electronic test equipment were the electronics industries themselves with equipment like this Takeda Riken integrated-circuit tester.

Mr. Tanaka is a Washington, D.C.-based lawyer with a special interest in Japanese trade and economic issues.

SPECIAL ADVERTISING SECTION

Auto Electronics

Microelectronics Conquers Pollution

By Mamoru Kobaykawa

Japan's emission standards for automotive exhaust pollution are the most stringent in the world, and Japanese car makers have placed great emphasis on electronic control technology to meet these regulations. This emphasis has been a powerful impetus for the development of Japanese automotive electronics.

With about 50% of Japanese auto production slated for export, the development of automotive electronic systems in Japan is strongly influenced by overseas needs, notably those in North America and Europe. Many of the Japanese systems in use are based on imported technology, but domestic research and development efforts are beginning to lead the world in many cases.

Electronic components for American car makers are an important market for Japanese manufacturers, who have been shipping microprocessors for engine controls, display devices, and ordinary circuit components. An increasing number of Japanese component firms are building American manufacturing plants to serve the U.S. automobile industry.

Under-the-hood applications of microelectronics are flourishing, largely to control emissions. Instrument-panel and comfort and safety applications also are important.

How it Began

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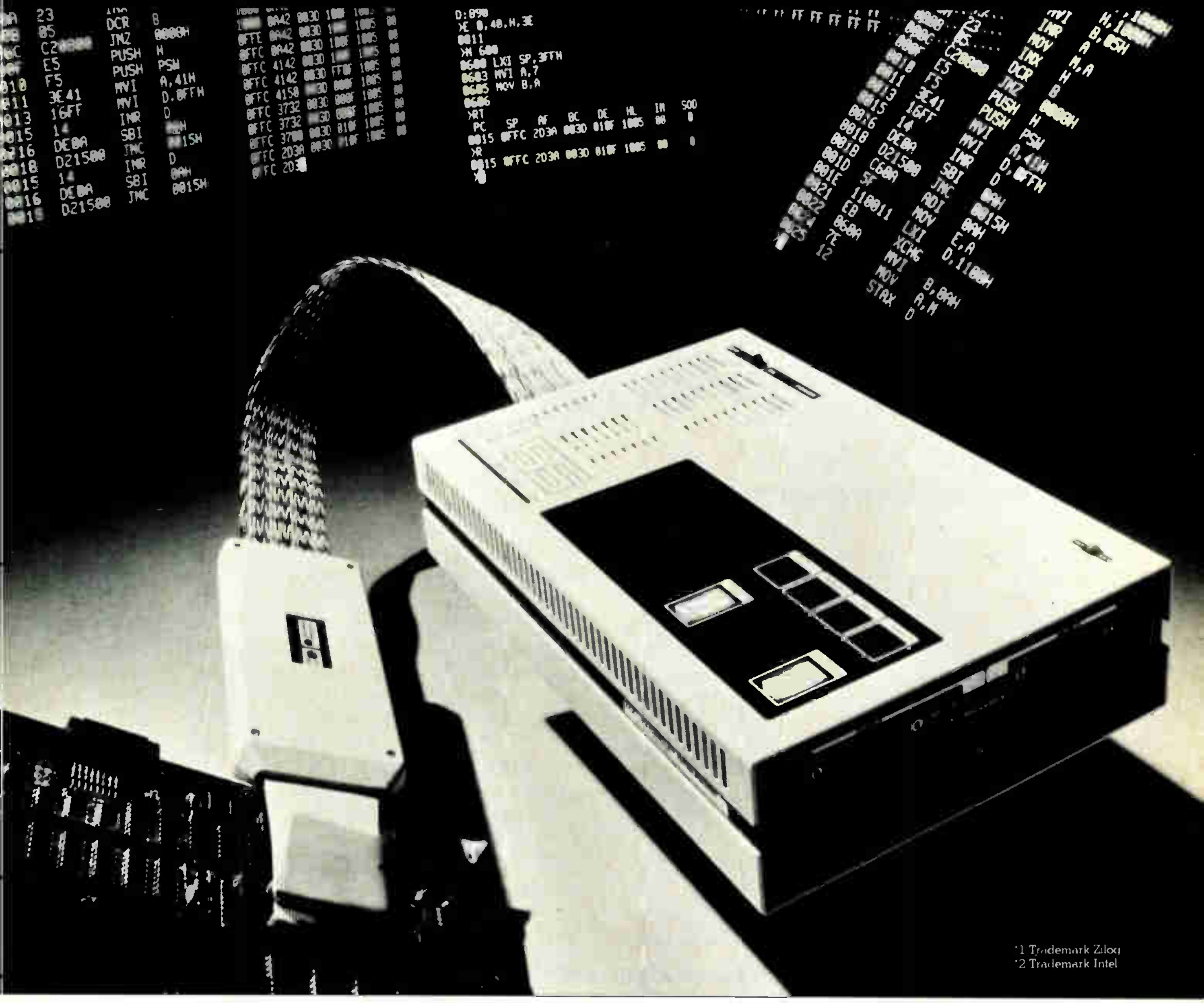

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Phones: (03) 331-5201

Brochures on request.

Circle 263 on reader service card

The Complete Analyzer

It's a network analyzer.
It's a spectrum analyzer.
It's an impedance analyzer.

Sometimes there are just too many complicated–and expensive–instruments that you absolutely need. A network analyzer for transmission and impedance parameters. A spectrum analyzer for signal distortion, spurious emissions, carrier/noise, compression. A separate monitor scope. Impedance bridge. Maybe even a microcomputer for control. You can spend more time–and money–on changing test gear and probes than on making measurements.

But that's history. Because the new MS420A from Anritsu is a highly sophisticated network analyzer that also combines the functions of a spectrum analyzer and an impedance analyzer–all in one completely self-contained unit.

Frequency range is 10 Hz to 30 MHz, to cover telephone and audio circuitry and AM broadcast and CB bands. The frequency synthesizer has the power for testing even **telephone** circuitry at levels that are close to those found in actual operation. And besides the **two traces–for simultaneous wideband and high-resolution sweeps**–the built-in CRT screen gives you digital readouts of such vital measurements as center frequency, signal level, sweep width, and more.

The MS 420A is "smart," too–you can control it from the front panel or with GP-IB interface, or you can actually program it to respond to measurement levels and to control other instruments and peripheral devices. A plug-in bubble memory module saves your front-panel settings and control programs for future use.

So before you add to your problems, have a look at the solution. Call or write Anritsu.

Be sure to see the MS420A in our booth No. 810/819 at INTELEXPO '81 in Los Angeles, September 14 through 17.

50th Anniversary

Anritsu

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Phone (03) 446-1111/Telex 0-242-2353
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128 Bauer Drive, Oakland, NJ 07436, U.S.A. Phone: (201) 337-1111 Telex: 642-141 ANRITSU OKLD
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Av. Passos, 91-8º Ander, 20.051-Rio de Janeiro-RJ, Brazil Phone: 221-6086, 224-9448 Telex: 2131704 ANBR

Circle 264 on reader service card

Partly because of the minimal development time available, the car makers developed their systems jointly with the manufacturers of auto electrical parts affiliated with them. However, as more sophisticated digital controls have come to the fore, car makers and electronic components manufacturers are participating in joint R&D efforts.

More Digital Controls

The resulting microprocessors, sensors, and other parts generally can be supplied at relatively low cost, and the range of development options they offer has expanded. As a result, automobile manufacturers in Japan have adopted a variety of digital control systems for their products.

Systematization of digital control, including the development of digital sensors, has advanced rapidly. What's more, these systems have been adopted rapidly for applications other than engine control.

Applications of automotive electronics already has begun expanding beyond engine control, notably to the instrument panel, but also to safety- and comfort-related control features. This expansion is rapidly reinforcing the R&D efforts of Japanese car makers.

Joint R&D Flourishes

Internal efforts are growing, and so are joint development projects with domestic components makers. The two giants of the auto industry—Toyota and Nissan—have blazed the trail.

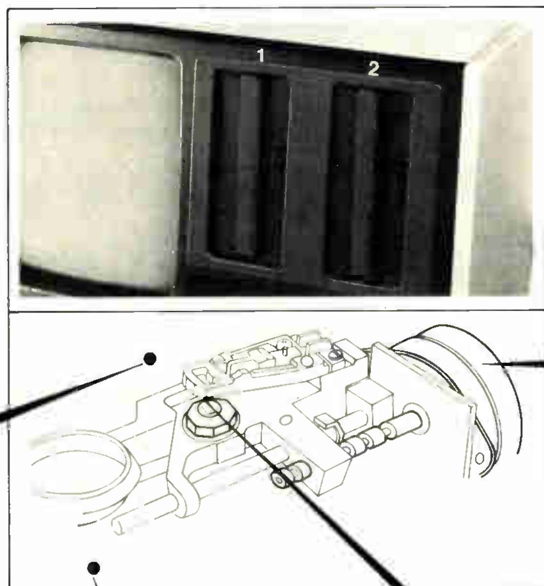
The Toyota group has established a joint development structure that includes Toshiba, Nippon Denso, and others. The Nissan group has organized a joint development effort embracing Hitachi, Nippon Denshi Kiki, Kanto Seiki, and others. Other car makers like Toyo Mazda, Mitsubishi, and Honda tend to follow similar patterns of development, relying to a considerable extent on these same manufacturers of electronic components and auto electrical parts.

Give Your Flexible Disk Drive A Heart of Gold:

Specify Sankyo "Core Parts" for quality and cost efficiency.

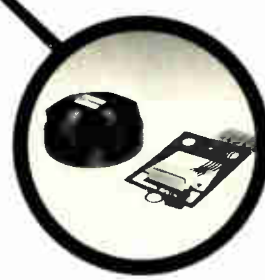
Up-to-the-second know-how gives Sankyo a reputation for quality and cost efficiency. The same strong technological base enables Sankyo to supply every part and component to help you build a truly remarkable product. We call our line "Core Parts," and you will too. They get to the core of your problems promptly.

SPECIFY SANKYO

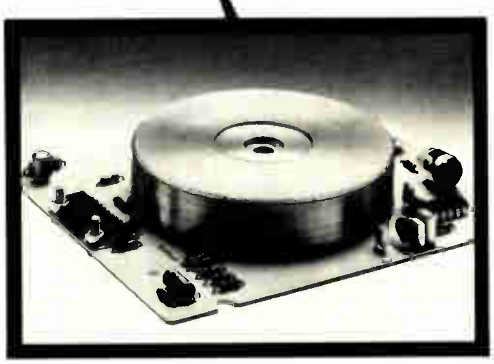


• Sankyo Plunger (Whisper-Quiet Operation/High-Speed Design).

• Sankyo Stepping Motor.



• Sankyo Read/ Write Head for Flexible Disk Drive.



• Sankyo Direct Drive Brushless Servomotor.

For more information, write to Sankyo at the address below:

Sankyo
Sankyo Seiki Mfg. Co., Ltd. **Electronic Equipment Div.**

Export Dept. 17-2, 1-chome, Shinbashi, Minato-ku, Tokyo 105, Japan,
Tel: (03) 502-1157 Telex: 29548

SPECIAL
ADVERTISING SECTION

Toshiba and Hitachi are the leaders in automotive electronics. Mitsubishi Electric is participating in a joint development with Mitsubishi Motor; and NEC, the Matsushita Electric group, Oki Electric, and others are continuing active efforts in system and component development for autos.

New Directions Afoot

In the development of control software, multifunctional dedicated digital sensors, and actuators, Japanese automotive electronic technology is lagging that of the U.S. car makers. Japanese firms are tackling this gap through the independent development of technology and technological collaboration with U.S. and European firms as well.

Further international collaborations are seemingly required. However, a number of the instrument-panel, safety, and comfort features recently introduced in some Japanese cars are in advance of car makers' efforts in the rest of the world.

As well as digital instrument displays, bar-graph displays using fluorescent vacuum tubes have surfaced. Also, panels using liquid-crystal displays are the subject of intensive R&D efforts.

Perhaps the most noticeable new electronic feature in Japanese cars are voice alarm systems in models from Toyota and Nissan. The basis is the Parcor voice-synthesis technology developed by NTT.

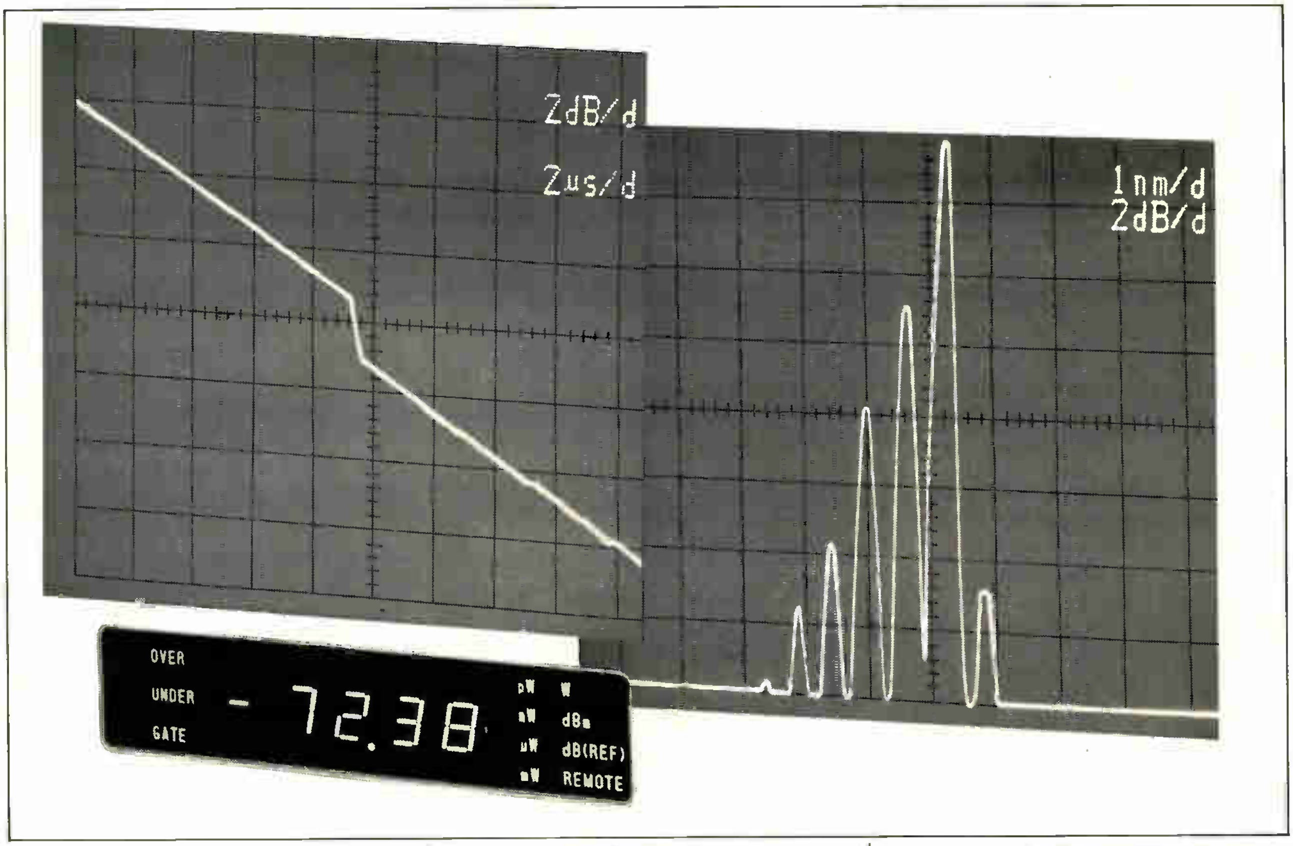
Word of Warning

Toyota uses a single-chip voice synthesizer produced by Matsushita Electric, and Nissan uses a three-chip synthesizer manufactured by Hitachi. There are four or six alarm items, including a caution that warns of a door that is ajar.

Other electronic systems offered in Japanese cars include an automatic clutch, an automatic levelizer, power window controls with a timer to lock the doors, a microcomputer-controlled air conditioner, and an electronic azimuth instrument. □

ANDO

Ando Presents a Full Line of Fiber-Optic Communication Measuring Sets



OPTICAL POWER METERS

Three models available: the AQ-1111 for small power measurement; the AQ-1112, precision type served as a standard; the AQ-1113 for extremely small power measurement.

They feature: three different display modes of watt (W), absolute level (dBm), and relative level (dB), average processings of measurements, and remote control capability.

TYPE AQ-1902 OPTICAL FIBER ANALYZER

This instrument provides a function for a fault location of an optical fiber by detecting the Fresnel reflection from a breaking points by means of an optical pulse-echo method and also a function of optical loss and connection loss of optical fibers from one end of the fiber by detecting the backscattering light.

Maximum measuring distance is 16 km (8m resolution).

TYPE AQ-1404 OPTICAL SPECTRUM ANALYZER

This optical wavelength spectrum analyzer employs a sweep-type monochromator for a wavelength selection to directly observe the spectral characteristics of a laser diode (LD) or a light-emitting diode (LED). It is composed of a mainframe and a wavelength unit. Two types of wavelength units, a short-wavelength unit and a long-wavelength unit are depending on your measurement needs.

OTHER MODELS • LED/LD Light Sources • E-O/O-E Converters • Optical Wavelength Meter • Optical Cable Pair Identifier • Optical Loss Characteristics Measuring System • Optical Fiber Baseband Characteristics Measuring System

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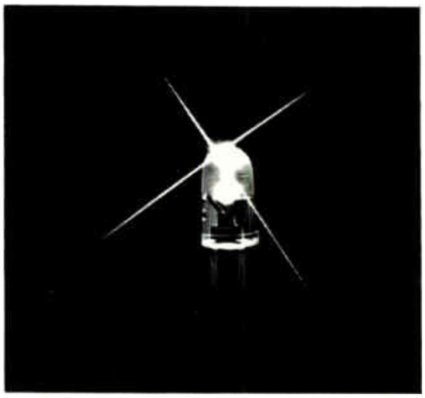
SPECIAL
ADVERTISING SECTION

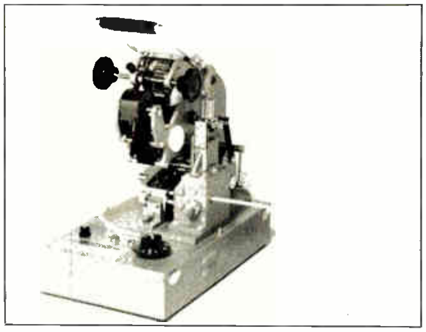
NEW PRODUCTS

Brighter LED
Stanley Electric Co. is using gallium, aluminum, and arsenic in its new light-emitting diode to produce a red light with a brightness of 500 millicandela at 1.7 V and 20 mA—at least five times better than conventional LEDs, the company says. Conversion efficiency is improved from the conventional 1.6% to around 4%. (351)

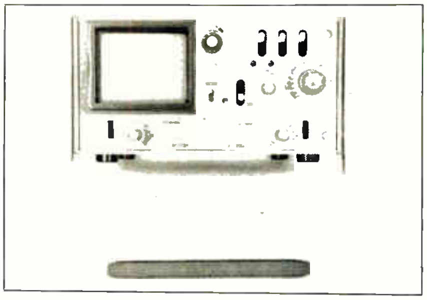


Isolated dual switchers
Elco Co. has launched the JMB line of isolated dual-output power supplies for use with floppy-disk units, CRT displays, and similar equipment. Input voltage ranges from 85 to 132 V ac or 110 or 170 V dc with 5- and 12-V or 5- and 24-V outputs. Maximum inrush current is 16.5 A at a 110-V ac input and full load. An overvoltage circuit shuts off all power if control is lost and output voltage reach 115% or more of the supply's rating. Overcurrent protection also is provided for the 5-V and +V outputs. (353)

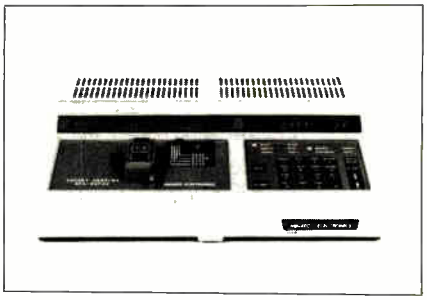
Tube stamper
Chuo Tsusho Kaisha Ltd. offers the Hotmarker H401FC for marking PVC tubes. The low-cost, bench-type, manual hot-stamping machine is equipped with automatic tube feeding and cutting attachments for 3-to-6-mm-diameter tubes. Simple cutter mechanism adjustments make possible complete or partial cuts of the tube. (352)



Miniature oscilloscope
Hitachi Denshi Ltd. has the V-509 11.1-lb. portable dual-channel oscilloscope. The 50-MHz scope offers a dual trace, delayed sweep, and a sensitivity of 1 mV/division. The vertical deflection factor is 5 mV/div to 5 V/div ±3% in 10 calibrated steps and rise time is 35 ns, both parameters applying to use of the 5× amplifier. Horizontal deflection for time-base A is 0.1 μs/div to 0.2 s/div ±3% in 20 calibrated steps, and for time-base B, 0.1 μs/div. to 2 ms/div ±3% in 14 calibrated steps. Delay time is 1 μs to 2 s. Trigger modes are: automatic, normal, single sweep, TV-V, TV-H, and delayed sweep. The 3.5-in CRT has an 8-by-10-division display area. The unit is ac-, dc-, or battery-powered. (354)



PROM programmer
Minato Electronics Inc.'s Z80-equipped model 1862 compact PROM programmer can be used with single MOS and bipolar programmable read-only memories. Blank-check, program-read, and verify functions are provided and can be operated independently. (355)



Portable datalogger
Yokogawa Electric Works Ltd. offers a portable datalogger that has a 3½-digit voltmeter and printer, a built-in a-d converter, and a quartz clock. It covers the input ranges from 20 mV (10-μV resolution) to 20 V and has a selectable decimal point. (356)

Power-factor meter
The 2524 digital power-factor meter from Yokogawa Electric Works Ltd. measures power factors by both the conventional power-ratio method and by the ratio of power to true-RMS

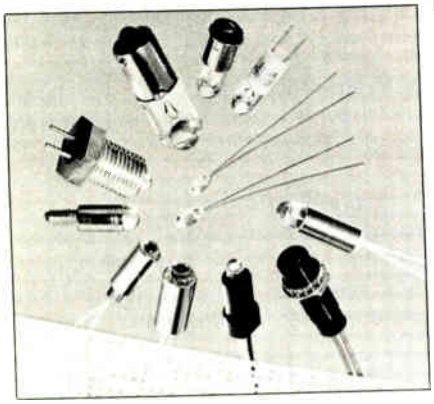
SPECIAL ADVERTISING SECTION

NEW PRODUCTS

volt-amperes. Accuracy of both methods is ±0.015. Range is from 0.5 lag to 0.5 lead. (357)

Lens-end lamps

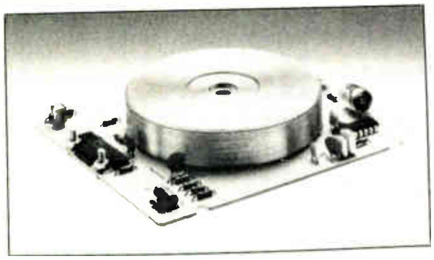
Hamai Electric Lamp Co. makes its Royal lens-end lamps with several spot shapes. A lens-end lamp has the



effect of compressing the light from the end of the lamp into a narrow beam, giving an intensity gain of up to 12 times more than an unlensed lamp does. (358)

Floppy-disk drive

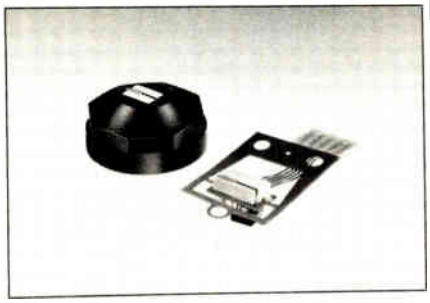
Sankyo Seiki offers its HU2-R floppy-disk drive for 5-in. disks. With a rated life of 10,000 hours, it features a



brushless dc motor with a rated speed of 300 rpm. The 12-V drive has a maximum rated current of 200 mA, and a fluctuation/load of 0.003 rpm/gr-cm. (359)

Floppy-disk head

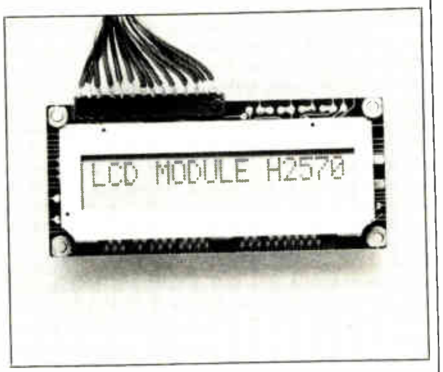
A magnetic head from Sankyo Seiki is designed for in-contact recording on oxide-coated flexible media operating



at a rotational speed of 300 rpm. Write current is 6 mA p-p, erase current is 30 mA p-p, and maximum read output voltage is 10 mV with 95% resolution. (360)

LCD modules

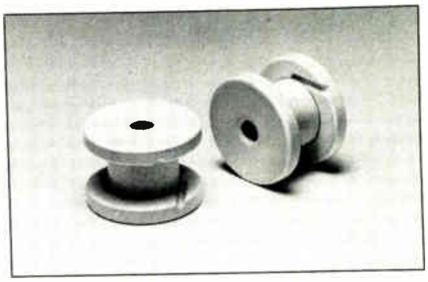
Hitachi Ltd. is introducing the H2570 series of liquid-crystal-display modules with 5-by-7 and 5-by-10 dot-



matrix characters, 3.5 mm high. All modules can display the full 150-character JIS font set, includes lower-case descenders, plus 32-character special font sets under user software control. A dedicated on-board controller executes all control, refresh, and display functions. The contrast ratio of the characters improves as ambient light increases. There are three models available, displaying 16, 32, or 40 characters in a single line. (392)

Bobbin cores

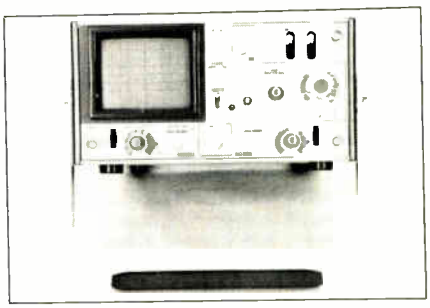
TDK's new bobbin cores for high-performance power-line choke coils are aimed at switching regulator applications. Their high Bsat. H7C2



material can be used with high currents yet has a low temperature rise, and the epoxy-coated surface gives superb insulation. (391)

Portable oscilloscope

The V-209 portable 20-MHz oscilloscope from Hitachi Denshi Ltd. weighs 10 lbs and has a dual trace and a sensitivity of 1 mV/division at 5 MHz.



The dual-channel unit has a 3.5-in. CRT with an 8-by-10-division display and operates from a dc source or a battery. (394)

Digital multimeter

Takeda Riken's TR6824 is a pocket-

SNAFU'ED*

by Real Time Data Acquisition?

Some Hidden Dangers in Many Real World Installations

After you invest hard dollars in data acquisition hardware and software, you're certainly justified in hoping that your new simulation, control, or test system will do everything you may need it to do. But then the UNTHINKABLE happens...suddenly you are:

- Awash in a sea of "software improvement" dollars
- Unable to steam along at a speed that keeps you ahead of your real-world process
- Uncertain of your position due to electrical interference
- Unable to tack quickly enough as the Requirement Winds change
- Adrift because accuracy drifts
- Unable to read the charts because documentation & support are incomplete
- Overboard as a result of inadequate reliability
- Deep-sixed by long software development times for simple tasks, like conversions to engineering units
- Or ____________________

We'd like to hear of any data acquisition SNAFU that you may have experienced. Please describe it above, then mail this page to us (addressed to T. Ellard).

The Cold, Hard Facts

It happens constantly. Whether you buy data acquisition equipment for integration with your computer, or buy an "integrated" data acquisition system, suddenly you're spending a lot of time, energy, and money improving synchronization capabilities, overcoming software limitations, and learning that the accuracy of the analog-to-digital converter at the heart of the system is degraded by the rest of the system; or worse...suddenly you're just plain sunk!

It need never happen again.

FOCUS 5000™ (FORTRAN Controllable Universal System) is the most comprehensive programmable I/O and processing system available for real world analog and digital data. It economically meets the "hidden" data acquisition needs, as well as the more easily visible needs, of many critical installations such as engine test stands, process control systems, and simulators — by integrating field proven equipment into a flexible, new architecture with unique software and timing capabilities.

Depending on the application, FOCUS 5000's easy-to-use programmability lets installations come on-stream up to 90% sooner than with other data acquisition systems. And the advanced architecture lets installations operate several times faster...at rates up to 100,000 measurements and outputs per second (with synchronization to the microsecond)!

Now any real-time installation can *perform* as though it has a custom integrated data acquisition system, at the far greater *economy* of a standard system. In fact, FOCUS 5000 is priced competitively with slower, less accurate "standard" systems.

Don't be SNAFU'ed*

FOCUS 5000 includes a high level (economical-to-use) programming language tailored to the needs of engineers and scientists, plus comprehensive software utilities and debugging aids. Its single-call access to calendar time and relative time clocks simplifies synchronization, data correlation, and time-based processing such as calculating derivatives of analog inputs with respect to time. Further, its accuracy guarantee applies to the entire *system*, not just the A/D converter!

We not only deliver a thoroughly tested system ready for immediate connection to your I/O field wiring...we also include self-test hardware and software at no extra cost so that you can easily verify system integrity. That's just the start of a comprehensive field support package tailored to put you in control of your real world.

We Look Deeper

Thousands of Analogic multichannel data acquisition and signal processing systems have been installed worldwide. FOCUS 5000 was evolved from this successful base to meet needs expressed by engineers in many different fields.

We think you'll like the result. Find out. Throw us a line (circle the reader service number) and we'll send you our free brochure. Or, if you need help now, give us a call at (617) 246-0300. On the West Coast, call (408)247-6401.

FEATURES

- Software engineering routines include thermocouple linearization to 0.2°C
- Direct connections for up to 1,000 I/O channels, with up to ±500V electrical isolation
- Analog resolution of 12 to 16 bits, with guaranteed accuracy
- Up to 10^5 measurements /sec.
- Full digital I/O including contact closures and interrupts

FOCUS 5000 is a trademark of ANALOGIC Corporation

* *For those of you who are too young to remember World War II, SNAFU was a term commonly used then, meaning: Situation Normal, All "Fouled" Up. Based on comments we receive from a broad spectrum of engineers, SNAFU seems to fit a large percentage of the real time data acquisition systems commonly used today. That's why we developed FOCUS 5000. So system engineers won't be SNAFU'ed And real time installations won't founder.*

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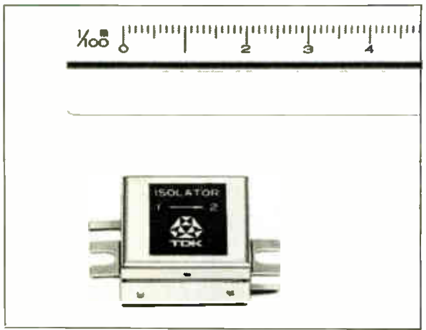
NEW PRODUCTS

able digital multimeter offering a 4½-digit display, a 10-μV resolution, and a ±0.04% accuracy, guaranteed for 6

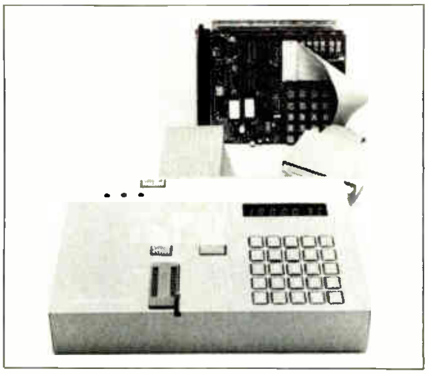
months. The autoranging unit measures ac and dc voltage and current, resistance, and temperature (with 0.1°C resolution). (393)

Miniature isolator
The VU421 miniature isolator from TDK is aimed at high-capacity mobile telephone units. Its frequency bandwidth is 821 to 841 MHz or 915 to 940 MHz. Maximum insertion loss is 0.5



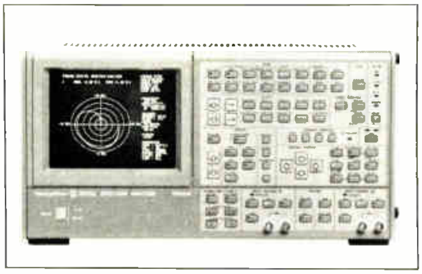
dB, minimum isolation is 20 dB, maximum voltage standing wave ratio is 1.2, and power is 10 W. (395)

E-PROM programmer
Computer Research Co. has added a debugging function to its CRC-80WA programmer for erasable programmable read-only memories. It can program six types of E-PROMs, and, with



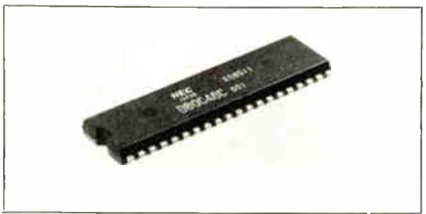
an optional probe, can emulate a Z80 or 8085 that is in the user system. (396)

Spectrum analyzer
The TR9405 dual-channel digital spectrum analyzer from Takeda Riken has a differential input, an input sensitivity of −120 dBV (1 μV RMS), a 100-kHz frequency, and a 70-dB



dynamic range. Among its 13 functions are transfer, coherence, correlation functions, impulse response, and spectrum zooming. (392)

8-bit microcomputer
Nippon Electric Co. is introducing the μPD80C48 single-chip 8-bit complementary-MOS microcomputer with 1-K byte of ROM, 64 bytes of RAM, an

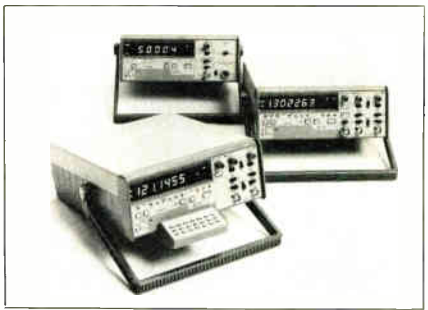


internal timer/event counter, and 27 I/O lines. The μPD80C35 version is ROM-less. The family is compatible with the industry-standard 8048, 8748, and 8035. Cycle time is 2.5 μs, and all instructions are 1 or 2 cycles; 70% of the 97 instructions are single-byte. (398)

Digital multimeter
The TR6840 series 4½-digit multimeters from Takeda Riken are intended for production-line and system test-

ing. Features of the four-model lineup include high-speed sampling, 1-μV resolution, and true-RMS ac voltage measurement. Options are the GPIB interface and BCD output. (400)

Multifunction counter
The TR5820 series multifunction counters from Takeda Riken can mea-

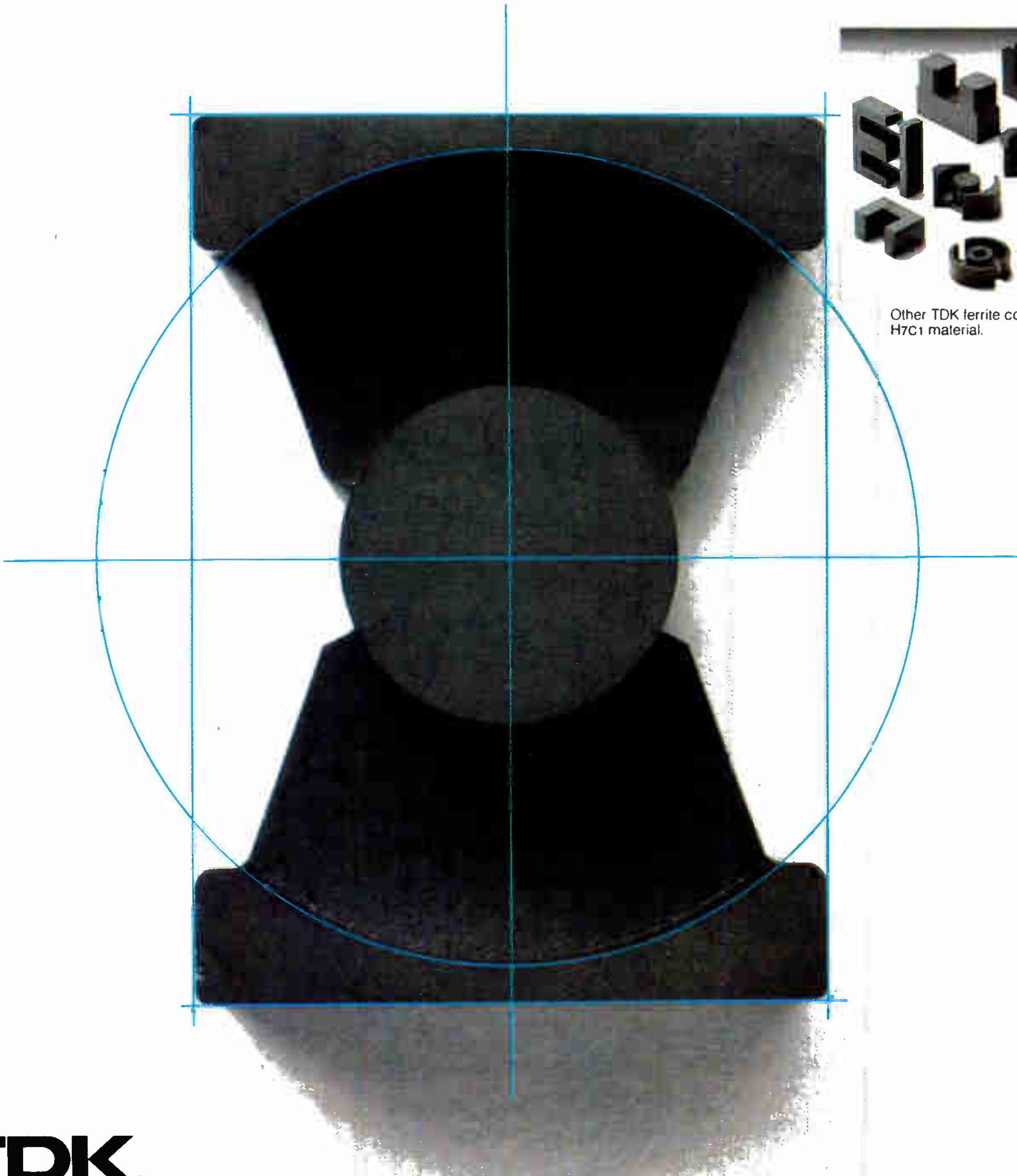


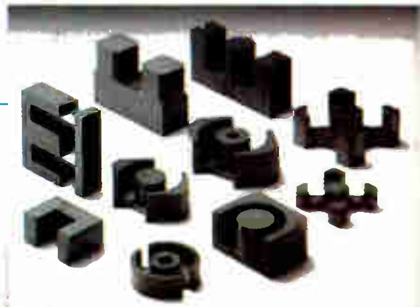
sure frequency, period, and time interval. In addition, some models can measure frequency response and total event count. The units incorporate the company's own design of microprocessors. (399)

THE "MORE POWER FOR LESS" SHAPE

TDK has some of the world's top high-performance power ferrites. They are made with the H7C1 material which displays a high saturation magnetic flux density, high permeability and low power loss characteristics. Most particularly, its uniqueness lies in the fact that the higher the temperature rises, the more the power loss is reduced. The PQ* Core makes full use of H7C1's qualities of increasing performance while saving power. It's a TDK original product, and its shape makes it ideal for designing power transformers and choke coils.

* PAT. PENDING





Other TDK ferrite cores made with the H7C1 material.

TDK

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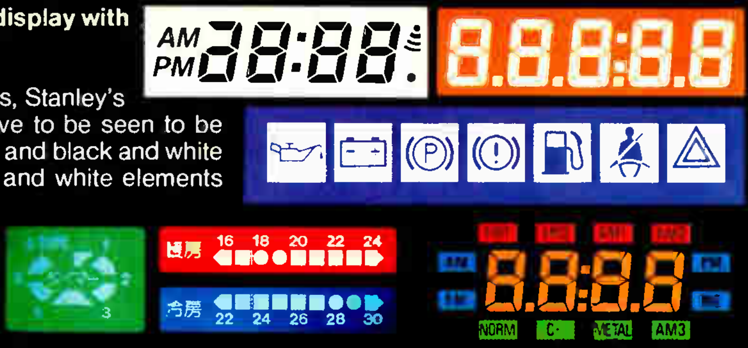

Color LCD Samples

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Circle 204 on reader service card

Computer takes on measurement tasks

Everything analog about the Data 6000 is in digitizing plug-ins; mainframe is a 16-bit computer that caters to engineers

by James B. Brinton, Boston bureau manager

Today's measurement operations often involve a complex of instruments haywired together—an oscilloscope to enable engineers to see what's being measured, a digital multimeter for quantitative measurements, a calculator for on-the-spot figuring, and in sophisticated laboratories, a computer backup for performing Fourier analyses and other less common parameters.

Now all these instruments are combined in one package base-priced below $10,000. The Data 6000 from Data Precision Corp. combines data acquisition and digitization with a 16-bit microprocessor-based computer and a digital oscilloscope. In doing so, the firm claims to be delivering one of the most comprehensive test and analysis systems ever offered to electronic engineers. Says Harold S. Goldberg, president of Data Precision, "With the 6000, you can press a few buttons or keys and get answers about waveforms almost instantly."

The unit's outward simplicity belies its capabilities. The front panel consists of a 9-in. cathode-ray-tube display with 20 value-set buttons just below it, which are set by referring to menus displayed on the lower portion of the CRT. In the center is a set of eight keys that controls the basic operating parameters of the instrument's mainframe. Below these are 45 calculator-like buttons that trigger a large number of single or multiple processing operations. On the right is a plug-in data-acquisition module with its own eight keys to control operation of multiple time bases, filters, and triggering.

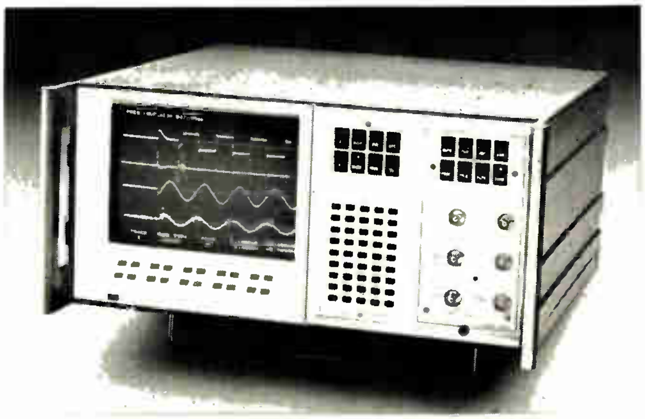
With the 6000, an engineer can sample and digitize an unknown waveform and, using only one or two basic keystrokes, rapidly determine parameters such as frequency, period, half-cycle width, pulse width, rise time, fall time, delay time, overshoot, settling time, maxima and minima, local maxima and minima, peak-to-peak value, maximum slope, area under a curve, energy described by a curve, root-mean-square and mean value, and −3-dB points.

Math. Using more processing power, an engineer can integrate, differentiate, cross-correlate, autocorrelate and compute simple and complex magnitude spectra and simple and complex magnitude-squared spectra of displayed waveforms, moving averages and simple and complex phase spectra.

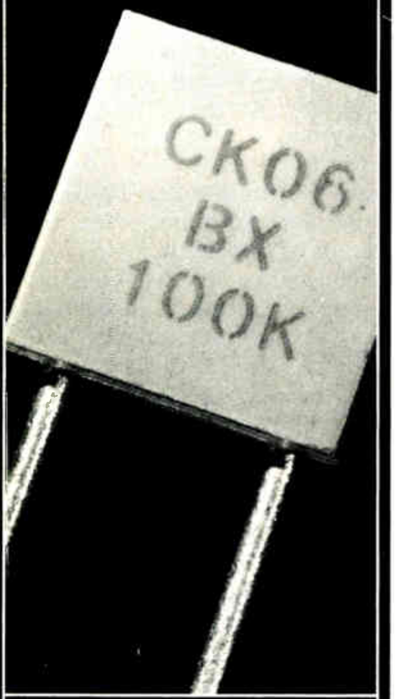
Up to eight such operations can be chained, performed in sequence, and their results displayed separately as well. In addition, the user can press one of two shift keys on the 6000's keypad and program the MC68000 in machine language to suit the application. In all cases, measured or computed values are presented on a line at the top of the CRT with resolution to five significant digits. All computations are performed using digitally stored samples of original waveforms, not with reference to displayed waveforms. Thus the computations are more accurate than those using data picked off the face of an oscilloscope.

The 6000 is bus-based with its microprocessor, a direct-memory-access controller, a display and front-panel controller appended to the bus along with options such as dual RS-232-C ports, an IEEE-488 bus controller, a plotter interface, floppy-disk controller, and a forthcoming array-processor module. The complementary-MOS memory is organized in 16-bit words and is about equally divided into random-access and read-only memory. Firmware for the system is stored in 16- to 128-K words of ROM, and 16- to 128-K words of RAM stores digitized waveform data, operands, and interim results of computation.

The 6000 will be sold with more or less mainframe memory depending on user requirements; 16-K words of RAM is enough to store 10,000 digitized data points; the 128-K-word maximum stores up to 100,000 points.



The Data 6000's computer-like bus extends into the data acquisition plug-ins. Each plug-in contains 16-K words of C-MOS ROM that characterizes it for the central processor. Thus a system



call will never be made for "input channel three" when a plug-in has only two input channels.

Each plug-in contains controllers for its front panel, inputs, trigger, twin time bases, and memory. Two plug-ins are available now—the model 610, with a frequency range to 100 kHz, and the model 620, which accepts 100-MHz signals.

The 610 has two or four channels depending on the user's need for differential on single-ended inputs. Behind each input is a defeatable anti-aliasing filter with three-pole response, cutting off signals above 40 kHz. The 610's analog-to-digital converter has 14-bit resolution, and there are three input voltage ranges: ±0.5, ±5, and ±50 V. Offset voltages are automatically nulled out by the computer once each minute, when the plug-in is not sampling.

Knobless. In both plug-ins, all operational parameters are under firmware control. There are no variable attenuators or trimpots; even trimming input gain to suit the probe in use is a pushbutton matter.

The high-frequency plug-in, model 620, has one differential or two single-ended inputs and a basic accuracy between dc and 1 MHz of ±0.5% of full scale ±0.5% of reading. The input range is ±2.5 V.

Using flash a-d converters, the 620 achieves 8-bit resolution to 50 MHz, dropping to 7 bits between 50 and 100 MHz. Minimum sampling period is 10 ns, and aperture uncertainty is ±50 ps. Differential nonlinearity is ±½ least significant bit.

Unlike its lower-frequency brother, the 620 runs too fast to use direct memory-access. Thus, it includes several levels of cascaded C-MOS RAM to temporarily store conversion results until the bus can be accessed. Although the memory chips have a basic read time of 120 ns, rippling through the memory lets the "inter-cascaded memory array" achieve the equivalent of 10-ns accesses, according to Goldberg.

In operation, digitized data from a plug-in is assigned an address in main memory and stored. Before it is displayed on the unit's CRT, it is rewritten in a second location. Thus, if the data is manipulated in any way—say, used as an operand in computation and altered—the original sample is safe and can be recalled at any time. Alternatively, waveform data may be updated periodically or on command.

The system can display one to four traces simultaneously. Display resolution is 512 by 1,024 lines. Separate traces can be superimposed for inspection or computation, with reference to a cursor, a baseline, or cross-hairs. A computer-generated grid also is available.

Any display can be expanded in the X or Y axis until the trace appears as separate points. The "blanks" between the points can be filled in in either of two ways, using a linear interpolation routine or with a (sine x)/x function.

For analysis of repeating waveforms, the user can call for sweep-to-sweep weighted averages of the input signal. The user can order that any preset number of sweeps up to 10,000 be averaged. Since the plug-ins have sampling periods as long as 600 seconds, the Data 6000 can collect information for up to 6.9 days, building a data base. This feature might be used with the unit's "max/min envelope" function to show the maximum and minimum amplitude waveforms collected during a period, and typically, the more recent waveform sampled.

For all its capabilities, the unit is compact enough for either bench or rack-mount use and, in a pinch, could even be considered portable. It is 7.75 by 19 by 15 in. deep.

Base price for the Data 6000's mainframe—display, memory, and computer—is $4,995. The low-frequency model 610 plug-in costs $1,995 and the 100-MHz 620, $3,995. Data Precision offers a dual-drive 5¼-in. floppy-disk store capable of holding 1.5 megabytes, at $3,995. Thus a user might pay as little as $6,990 for a low-frequency version of the 6000. Delivery is scheduled for 90 to 120 days.

Data Precision Corp., Electronics Ave., Danvers, Mass. 01923. Phone (800) 343-8150, or, in Massachusetts, (800) 892-0528 [338]

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Circle 209 on reader service card

DAC80 is reduced to one chip

Burr-Brown guarantees 500-ns maximum settling time for less expensive, pin-compatible monolithic 12-bit DAC800

by Roderic Beresford, Components Editor

Four years ago, the DAC80 catapulted Burr-Brown Research Corp. to prominence in the general-purpose data converter market. Now the company is ready to introduce a follow-on to that industry-standard, widely second-sourced 12-bit digital-to-analog converter—the DAC800. This d-a converter is pin-compatible with the DAC80, and prices are lower thanks to its monolithic design.

Well aware of the intense competition in low-cost converters, Steve Harward, marketing manager for data-conversion products, is seeking to capitalize on the position won by the DAC80. "What we are looking for," he says, "is a direct replacement for the DAC80 that will be well suited to high-volume production and low prices." The DAC800 incorporates thin-film resistors and voltage-reference circuits on chip, making it the first complete monolithic 12-bit d-a converter with the DAC80 pinout.

Faster. Performance improvements were not a primary goal in the DAC800 design. As Harward points out, "reducing a 13-chip hybrid to a single die is challenge enough for anyone. Nonetheless, the monolithic design does allow us to do some things that weren't possible before, and we do get some benefits, such as a faster settling time." DAC80s are available from many suppliers with typical settling times of 300 ns (for current-output operation), but with no guaranteed maximum.

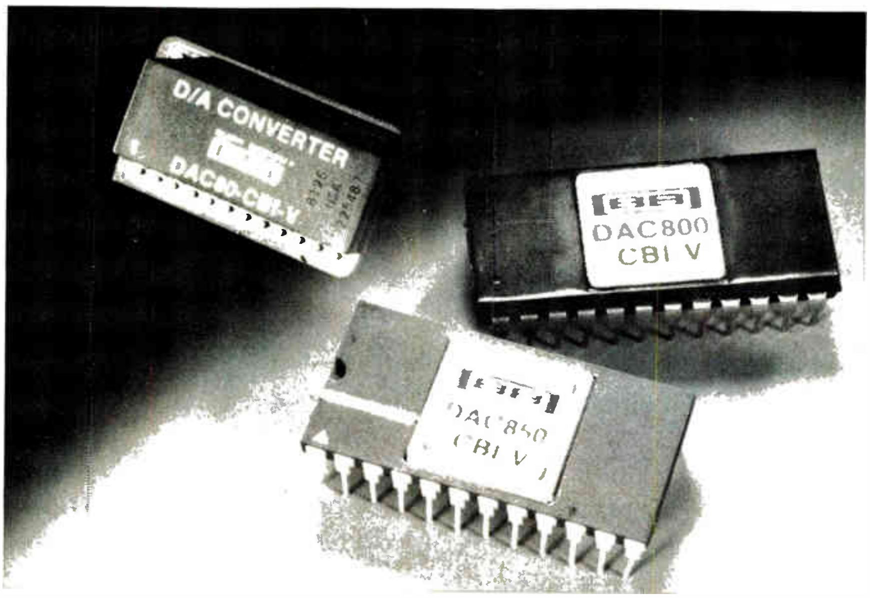
One of the limitations in many DAC80 designs, explains Harward, is the bandwidth of the closed-loop control circuit that stabilizes the base drive voltage applied to the current switches. The DAC800 uses a proprietary voltage-reference circuit, based on a buried zener diode, that operates open-loop and escapes this limitation, allowing Burr-Brown to guarantee a 500-ns maximum settling time to within 0.01% of full scale. Harward estimates this at about half of what can be expected from DAC80s. Typical settling time is still in the range of 200 to 300 ns.

To achieve 12-bit accuracy, the thin-film resistors are laser-trimmed at the wafer level. Integral and differential linearity are guaranteed within ±½ least significant bit over the range 0° to 70°C for the DAC800. The other offerings in the series are the 850 for the −25° to +85 °C range and the 851 for operation over the full military range, −55° to +125°C. Offset and gain drifts with temperature are held to ±15 and ±30 ppm/°C respectively, for the DAC800; ±10 and ±20 ppm/°C for the 850.

Voltage-output models are also available, with a guaranteed settling time to 0.01% of 3 μs, compared with 5 μs in Burr-Brown's DAC80. These devices contain an operational amplifier on a second chip that performs the current-to-voltage conversion.

Prices for the DAC800 start at $18.90 in lots of 100, compared with $22.40 for the DAC80 from Burr-Brown and about the same catalog prices from other DAC80 suppliers. As Harward notes, "most suppliers can offer significant reductions over listed prices for high-volume orders, and we are no exception." The booming market in low-cost converters will no doubt welcome the cost advantages of the DAC800. Delivery is from stock to four weeks.

Burr-Brown Research Corp., International Airport Industrial Park, P. O. Box 11400 Tucson, Ariz. 85734. Phone (602) 756-1111 [339]



Facts from th

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VLSI tester runs at 50 MHz

Supporting one or two 128-pin heads, system tests memories, logic arrays, and emitter-coupled logic

by Linda Lowe, Boston bureau

Set for formal introduction at the International (formerly Cherry Hill) Test Conference in October, a general-purpose test system for large- and very large-scale integrated circuits will give systems like GenRad Inc.'s GR 16 and GR 18 a run for the money. Although Accutest Corp.'s system 7900 has slightly fewer pins than its competition—it can handle two 128-pin devices, and the GR 18 boasts two 144-pin heads—the 7900 can test at rates 25% higher (50 MHz) and is accurate to within 500 ps after autocalibration, double that of the other systems.

"The 7900 can handle everything from random-logic VLSI devices to structured-array parts like random-access memories, read-only memories, and programmable logic arrays, and it accommodates high-speed emitter-coupled-logic technologies as well as more conventional circuitry," Halper notes. He says the 7900 will aim at both merchant and captive markets, with applications in engineering characterization, production testing, and quality control.

Based on a Digital Equipment Corp. PDP-11/23 central processing unit with 128-K words of memory space, the system 7900 has a high-speed tester backup memory that can store up to 128-K 16-bit words (512-K-word capacity is planned). It also includes a parametric test subsystem, a functional test subsystem, and either one or two test heads. System peripherals include a 10-megabyte Winchester disk drive, 500-K-byte floppy drive, line printer, keyboard console, and disk and tape storage subsystems.

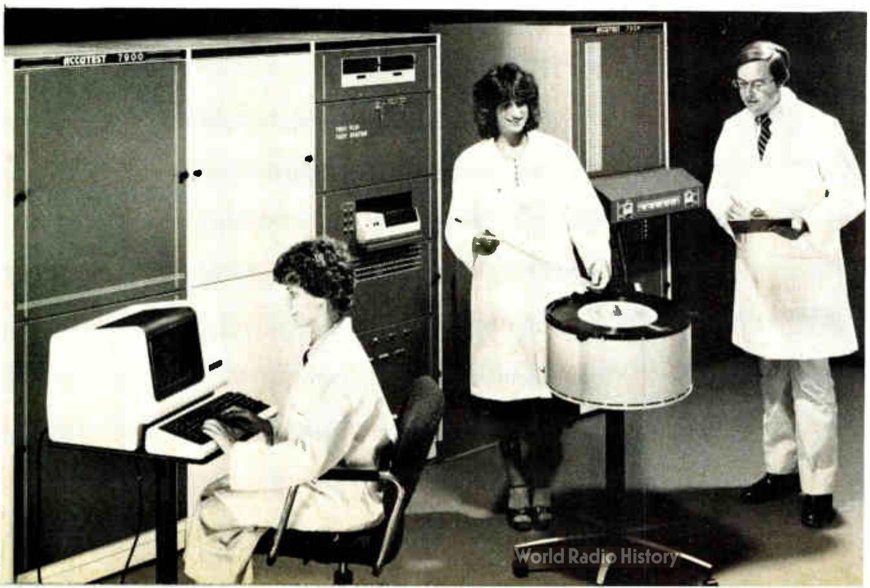
The 7900's three-bus architecture uses a computer bus that interfaces the operator's console with the system CPU and peripherals, a high-speed ECL bus along which various sections of the functional test subsystem communicate, and a test bus controlling parametric subsystems, test and bias supplies, and probers and handlers. As the test bus also interfaces with the back-up memory, the CPU can download programs into the functional test system and the 7900's two test heads can run separate test plans.

Each 7900 has one or two system-level parametric measurement units, which can connect to any pin of the device under test and quantitatively measure voltage and current levels. The system PMU is programmable in three voltage ranges; depending on range, its resolution is 1 to 100 mV. It also measures seven current ranges, with resolutions of 1 nA to 1 mA.

The system PMUs can be switched to any pin by relays for either single-ended or differential measurement, or a field-effect-transistor matrix can supplement the switching relays, allowing high-speed measurements at low currents. Each pin on the test head is equipped with a reduced-function monolithic PMU that is somewhat less accurate than the system PMU. Thus all pins of a device can be measured simultaneously, a useful capability for leakage tests, for instance.

The system 7900 test head contains 64 pins, each backed up by 4-K of local memory and each software-configurable into a separate driver and receiver connecting to separate pins, or to a single pin, of a device under test. Two types of pin electronic cards—one tailored to ECL circuitry, and one for more conventional TTL and MOS technologies—can be intermixed in the test head's circular-card configuration. Both types of drivers have ECL-compatible 50-Ω outputs, and a device-load board maintains that impedance at the test socket. Rise time of the ECL driver is 950 ns.

The 7900 uses cylindrical elastomer contacts that lie lengthwise between the test head's pin electronics and the device-load board. In a mounting arrangement that Accutest is patenting, the elastomer contacts rotate to present a new contact



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face each time the load board is changed. More wear-resistant than the more commonly used pogo-pin interface, elastomer contacts also permit minimal, 0.25-in. separation of driver-receiver electronics and the load board, making for an uninterrupted high-frequency transmission path. The test head incorporates a manipulator unit that makes positioning the head easy.

Sequencer. The 7900's functional test subsystem operates under the direction of a sequence processor built with 10-K and 100-K ECL devices. This unit selects test data and controls data flow to the device under test. The data may come from one of two pattern-storage RAMs; the main RAM, which is 256 bits deep, stores variable test data, and a RAM 4-K words deep stores only the patterns, such as read and write cycle subroutines, that apply to any tested device. This scheme, says Halper, eliminates redundant data in the main RAM and makes possible the compression of test patterns.

An optional algorithmic pattern generator produces independent 16-bit X and Y addresses and 16-bit data patterns, which the sequence processor selects and interleaves with the RAM-stored patterns for test programs. These programs can be run at the 50-MHz maximum rate.

The 7900's master system clock has an 8-ns period; customized hybrid circuitry also can synthesize shorter timing intervals, down to 125 ps. Test cycle time ranges from 40 ns to 32 ns in 1-ns increments. Strobe resolution is 125 ps; clock and drive resolution are 1 ns.

The system 7900 software is supported by DEC's RSX-11M operating system, and includes a user-interface language called Accutest command language (ACL), in either a menu-driver or command format.

First shipment of the system 7900 will take place at the end of this month. Accutest's Halper estimates the system will sell for between $500,000 and $700,000. Delivery takes four months.

Accutest Corp., 25 Industrial Ave., Chelmsford, Mass. 01824. Phone (617) 256-8124 [340]

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Communications

Ethernet kit speeds evaluation

Three transceivers, cables, connectors, terminators, and technical answers are included

An Ethernet transceiver starter package from 3Com Corp. is aimed at helping designers evaluate and implement an Ethernet local network for their computer system. The kit includes a designer's guide and a set of three transceivers with enough cable and terminators to implement a network up to 30 meters long from the first transceiver to the third. The package also contains a two-page summary of Ethernet specifications and the full Digital Equipment Corp.-Intel Corp.-Xerox Corp. Ethernet specification.

According to Lawrence Hartge, 3Com's vice president of product marketing, "questions abound about the design for the line driver-line receiver circuits for the link between Ethernet transceivers and controllers. For example, designers want to know what they should look like and how they should interface the controller with the transceiver." The designer's guide addresses these questions, identifies the other parts and functions of an Ethernet system, and describes the shape of 10-Mb/s waveforms as they propagate through the network.

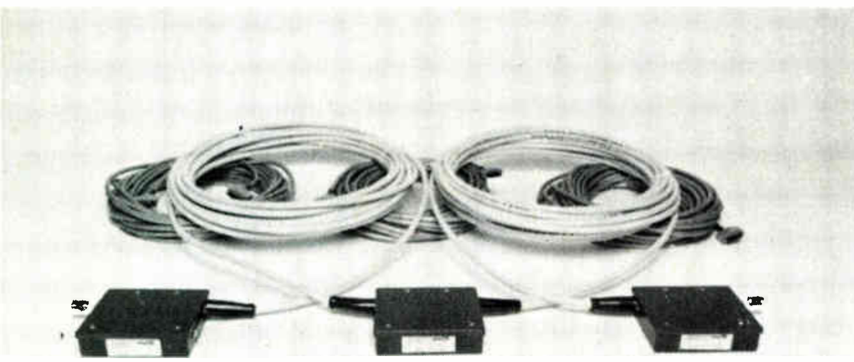
The guide also points out the most important operating factors in each part of the Ethernet system. According to Ron Crane, designer of 3Com's Ethernet transceiver, "the most important transceiver transmission factors are the average dc level, symmetry, and rise time. For reception, the key factor is the extent of phase jitter in the presence of noise and signal attenuation."

To aid designers in examining these factors for their networks, 3Com engineers have developed a fast test procedure for determining the health of the network and its subsystems. This procedure also is described as part of the package's documentation.

The three model 3C100 Ethernet transceivers carry data between the data-link controller and the 50-Ω coaxial cable after specified transmission-signal conversions. They equal or exceed Ethernet specifications as established in version 1.0 issued a year ago.

The transceivers are compact—approximately 5 by 4 by 1.5 in. They are housed in rugged and electrically insulated enclosures and are suitable for installation above ceilings, under false floors and in cable trays.

All parts needed to build a complete transmission subsystem are in the package. The three transceivers are connected with two sections of 50-Ω coaxial cable, and the remaining two transceiver connectors are terminated using 50-Ω resistive terminators. The transceivers can be interfaced with a data-link controller subsystem using three cables that are included in the package.



Networking software. While Ethernet users are trying out their ideas with the 3Com starter kit, the company has also come to the aid of small-computer–system users who use an operating system like Bell Laboratories' Unix. They can now enjoy networking privileges formerly available only on large systems. Using the Unet networking software from 3Com, Unix-based systems from small to large may be joined in a common network. And Unet's newest enhancements extend communication rates up to 100 kb/s for DEC computers and up to 200 kb/s for the Cyber series from Control Data Corp. via Hyperchannel.

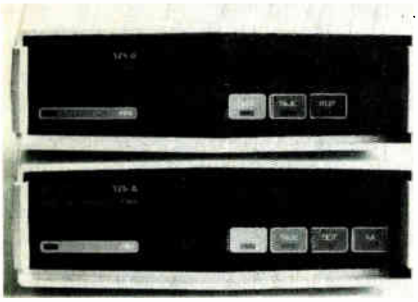
3Com's Unet software and its enhancements inplement internet- and transmission-control–protocol standards adopted by the Department of Defense in January 1980, which were developed by the U. S. Advanced Research Projects Agency. Unet, like Unix, is written in C. According to Hartge, using Unet, computers running Unix Version 7—including Xenix, Onix, IS/1, and VMUNIX—may all be linked in common networks. Unet has an automatic pass-through capability that uses store-and-forward procedures and supports remote transfer of ASCII and binary files, queued or immediate-delivery electronic mail, program-to-program communication, and a datagram service for implementing user-defined protocols.

The $2,600 Ethernet starter kit is available from stock. At the one-to-three-user level, the Unet license fee is $7,500 and copies are $4,000.

3Com Corp., 1390 Shorebird Way, Mountain View, Calif. 94043 [401]

Dial modem supports Telidon videotex system

The CDS 125 dial modem is designed for the specialized requirements of the Canadian Telidon videotex system, as well as other high-



performance low-cost dial applications, operating at assymmetric data rates of 150 b/s in one direction and 1,200 b/s in the other direction in full duplex mode.

The unit improves terminal response time for interactive dial-in users of Bell 103-type modems and reduces connect charges for data collection applications. It takes advantage of higher data loads in one direction. Since the path is full duplex, no complicated polling and line turnaround delays are encountered as would occur with Bell 202-type dial modems, and the end result is a fourfold performance improvement over 103-type modems, without the need to resort to the more costly Bell 212 unit. An optional buffered speed converter suits the modem to terminals that cannot support the asymmetrical data rates; with it, equipment at both ends transmits at 1,200 b/s.

Available now, the CDS 125 is $235 each in a stand-alone configuration and $250 as an originate-and-answer unit when ordered in small quantities.

Concord Data Systems Inc., 442 Marrett Rd., Lexington, Mass. 02173 [403]

Measurement front ends aid radar work at 35 and 94 GHz

A series of instrumentation radar front ends makes the measurements required when developing new millimeter-wave radars. Incorporating solid-state components, the new subsystems enable an instrumentation radar to provide a real-world data base for subsequent weapon sensor development.

Basic configurations include a transmitter module (pulsed or cw), a receiver module, an antenna assembly, and temperature-stabilized oscillators that operate over a baseplate range of 25°C ±10°C.

Models are available at both Ka-band (35 GHz) and W-band (94 GHz) frequencies, with power outputs of 150 mW and 100 mW, respectively, for cw-mode units and 5 W and 10 W and 3 W and 5 W, respectively, for pulsed-mode units.

Pricing varies with options and configurations, but a transceiver rated at 5 W at 94 GHz with two 12-in. antennas sells for $46,815. Delivery takes 120 days.

Hughes Aircraft Co., Electron Dynamics Division, 3100 West Lomita Blvd., Torrance, Calif. 90509. Phone (213) 517-6400 [404]

Digital communication system transmits voice, data

The ISC-100 digital internal communications system is an electronic direct-speech system that can transmit data as well as voice simultaneously. It is based on microprocessor-controlled stations—up to 100 per system—with no central switch or mechanical switching. Individual stations are connected to a standard television-type coaxial cable at any point along the cable.

The system has seven channels, permitting up to seven two-way conversations or data transmissions, 11 functions in addition to data transmission, and various audible tones to signify system functions. Each station console has a keyboard with 10 numeric keys and eight function keys. A four-digit liquid-crystal display shows the time of day when the station is idle and system information, such as the number of the station being called or a rolling data display, when in use.

The power distribution unit with the time clock is priced at $475; each station is $475 plus $25 for each handset. Delivery takes six weeks.

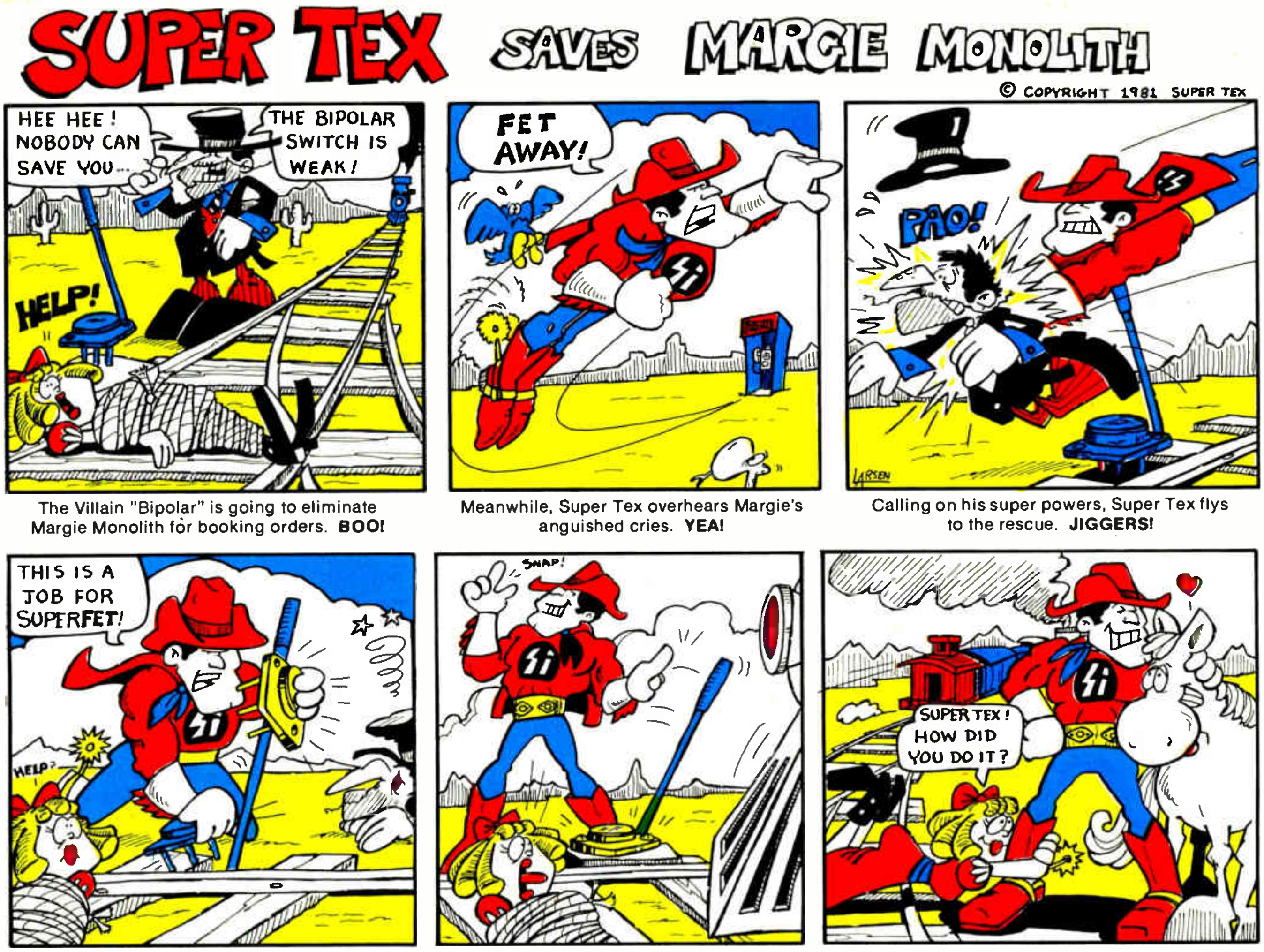
Multitone Electronics Inc., 1 Cornell Parkway, Springfield, N. J. 07081. Phone (201) 467-1800 [406]

Modems have various rates and functions

The LSI multicapability modem communicates on a variety of networks and operates at rates of 0 to 1,200 b/s in various functional modes. Seven modules with LSI-based receiver and transmitter functions are available.

The low-speed 300-b/s modem is compatible with the CCITT V.21 standard in full- or half-duplex, answer or originate, and self-test modes. The phone-line interface has auto- or manual-answer modes, pulse-dialing control, a multitiming function, and a line-busy indicator with solid-state holding circuits but no bulky transformers or coils. The 1,200-b/s module meets Bell 202 specifications for full duplex transmission in four-wire, and half duplex operation in two-wire installations. The Viewdata module has CCITT V.23 compatibility with a 1,200-b/s speed in receive mode and a 75-b/s reverse channel. A 1,200- or 300-b/s selectable module is dual-speed modem compatible with Bell 103 and 202 specifications. The deaf modem module interfaces with the deaf teletypewriter network, as well as the Bell 103 answer-originate unit. Single unit pricing ranges from $99 to $150, with delivery from stock.

Novation Inc., 18664 Oxnard St., Tarzana, Calif. 91356. Phone (213) 996-5060 [405]



The Villain "Bipolar" is going to eliminate Margie Monolith for booking orders. **BOO!**

Meanwhile, Super Tex overhears Margie's anguished cries. **YEA!**

Calling on his super powers, Super Tex flys to the rescue. **JIGGERS!**

Alertly, Super Tex identifies the situation and snapping a SuperFET from his belt, replaces Bipolar's switch. **REJOICE!**

Super Tex, with his snappy action, saves the day and Margie Monolith. **HUZZA!**

"It was a snap, mam. I use SuperFETs for all high power, high speed switching applications." **APPLAUSE**

(To find out how Super Tex solved the problem, read the specifications.)

SUPERFETS™

Two Technologies Combined — Monolithic Fet-Bipolar High Power Switching Devices

Supertex has combined the best features of two technologies to produce a family of monolithic devices that are ideal for high-speed, high power switching applications such as power supplies and motor speed controls.

SuperFETs combine the high input impedance characteristics of a power MOS transistor with the low on-voltage and high current-carrying capability of a bipolar transistor in a monolithic structure, therefore providing better power handling at a lower cost.

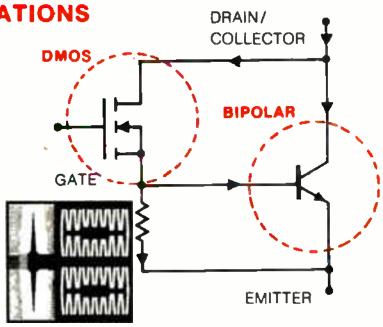
Constructed in a manner similar to a Darlington, the schematic and photo show the structure used to achieve this outstanding performance with a DMOS FET input and Bipolar output.

SUPERFET SPECIFICATIONS

Switching Frequency	250KHz
T_{OFF}	305nS
T_{ON}	115nS
V_{SAT}	6V max @ 20A 40A Pulsed

Packaged in TO-3 metal cans, SuperFETs are available at these voltages:

VOLTAGE	PART NO.
300V	SN0130N1
350V	SN0135N1
400V	SN0140N1
450V	SN0145N1



Call, clip the coupon, or circle the bingo, but start today on your evaluation of SuperFETs. We will send you a catalog by return mail.

☐ Send me a Super Tex poster ☐ Have a salesman call me

☐ My application is ______

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Supertex

1225 Bordeaux Drive, Sunnyvale, CA 94086
(408) 744-0100 TWX 910-339-9388

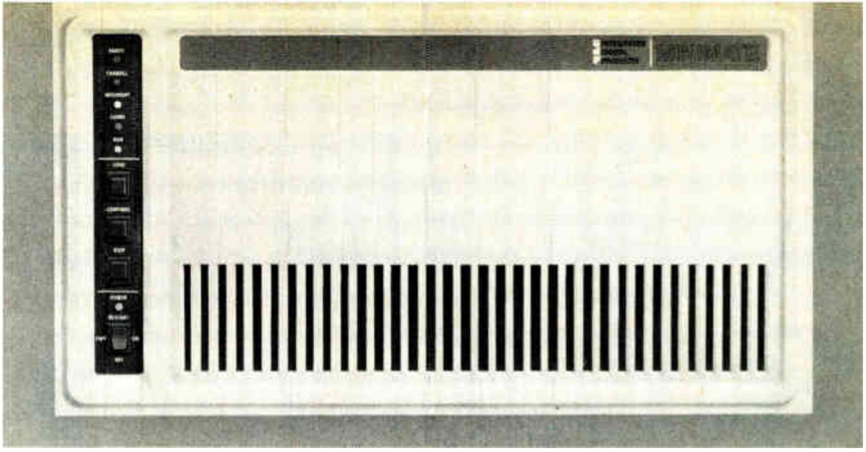
Circle 219 on reader service card

New products

Computers & peripherals

100-ns CPU is Nova-compatible

C-MOS static RAMs are key to ECL-based computer's speed; solid-state cache also helps



Successor after successor has significantly out-performed the original Nova and Eclipse central processing units, with design iterations by Data General and its many emulators sometimes doubling the best existing speed. But Integrated Data Products Corp.'s MiniMate board set increases speed fourfold with its 100-ns execution time.

The MiniMate uses existing technology in making the leap, with a key to the product's swiftness being Hitachi's complementary-MOS HM 6147-3 4-K static random-access memories. "The technology was there, but the price was not. Memory was too high," says Dennis Peattie, president of the two-year-old firm.

Once Hitachi C-MOS RAM prices fell low enough for the firm to attempt to halve the 400-ns cycle time of Point 4 Data Corp.'s fastest Nova-compatible product, Integrated Data Products determined it could make a fourfold jump by using emitter-coupled logic rather than TTL. Communications are still carried out in TTL, however, by converting both input and output.

The company incorporated a discrete translator, designed in-house, that performs ECL-to-TTL conversion in less than 10 ns and TTL-to-ECL conversions in only 1 ns. "It would take 200 ns instead of 100 if it were all done in TTL," says Pat Goodrich, engineering vice president.

Access time for the 128-K-byte memory is 55 ns, and load-and-store time is 200 ns. Direct-memory-access transfer time is 800 ns, and execution time drops by only 25% during memory access.

Although the unit is much faster, its speed cannot be fully utilized without the firm's recently introduced MiniMeg, solid-state cache system. With most disk systems, the CPU is often idle while waiting for information being retrieved from the disk; this idle time tends to minimize the CPU's speed advantage.

MiniMeg shortens this idle time, operating at 2.5 megabytes/s, the top speed of the Nova data channel. The solid-state memory is not essential for computation-bound users in the scientific community or for users of some cache disk systems marketed by emulators of Data General products, according to Goodrich.

Power consumption for the 64-K-byte CPU board is low, thanks to C-MOS static RAMs; it consumes 8 A at 5 V. An on-board battery backup not only secures the system against power shortages or brownouts, but also makes it possible for a user to program the board, pull it out of the chassis and transfer it to another site without the loss of bits for three days, Peattie notes.

The board-level system comes in two configurations: a dual-board 64-K-byte version priced at $5,025 in single quantities and a three-board, 128-K set for $7,125. Deliveries are set for the fourth quarter.

The manufacturer also offers its own chassis, which measures 10.5 by 19 by 19 in. Single units cost $7,875 with the 64-K-byte CPU, and $9,975 for 128-K-byte version. With the 512-K-byte MiniMeg and without the chassis, the 64-K-byte CPU costs $13,175; the 128-K-byte version lists for $15,275. The MiniMate operates with the IRIS, RDOS, VMOS and Bliss/Cobol operating systems.

Integrated Digital Products Corp., 3156 E. La Palma Ave., Suite A, Anaheim, Calif. 92806. Phone (714) 632-6972 [361]

Cartridge system takes knocks

Tape machine loads or stores data under harsh conditions, heating itself when cold

The model 2765 tape-cartridge system is a complete data storage, loading, and transfer system designed for use in harsh environments. The stand-alone system, housed in a case measuring 16.47 by 9.56 by 11 in., meets MIL-T-21200 and -810C requirements for shock and vibration.

The 30-lb unit has a built-in heater for operation at temperatures as low as −10°C, and all manual controls are designed to be easily accessed with gloves in extreme weather conditions. A specially designed door prevents dirt and other foreign particles from entering the unit, making it suitable for use on airfields for commercial and military flight-line operations, in quasi-military areas, and in airborne and land-based geophysical applications.

The system consists of a cartridge-tape drive, a power supply, and a microprocessor-based formatting and interface unit. The formatting and interface components are mounted on a single printed-circuit board. Formatting capabilities include error checking and automatic retry if the initial transmission of data is not valid.

The drive is the Qantex model 660 militarized cartridge-tape unit, a descendant of a transport design

A variety of recording options with flexible data analysis later

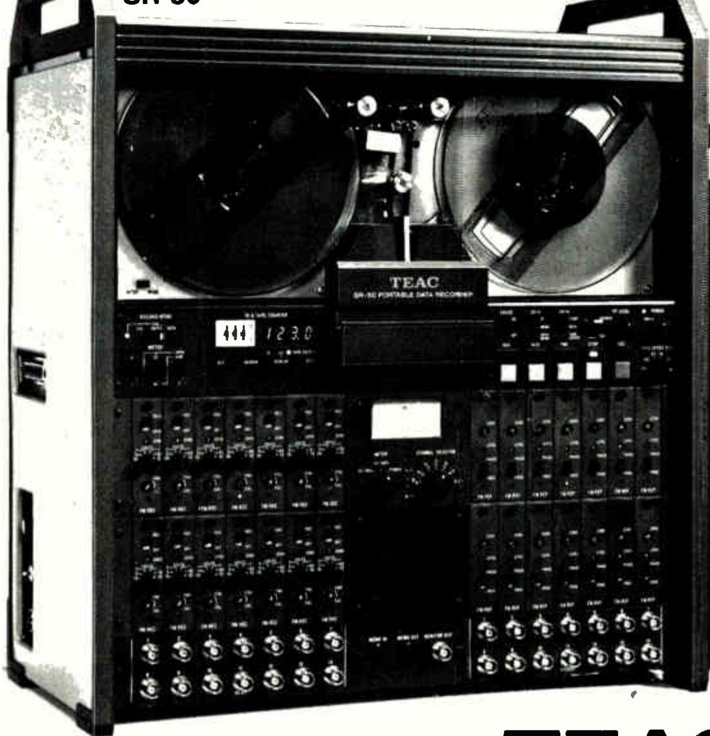
The TEAC SR-50 and SR-30 are among the most flexible data recorders available, with an incredible ability to match themselves to your particular application.

When recording, choose between wide-bandwidth FM, intermediate-bandwidth FM, and optional DR formats. Then choose one of seven switchable speeds. You'll be able to select the optimum tradeoff between signal-to-noise ratio, frequency response and recording time per reel. A full 14 channels (7 with the SR-30), bi-directional recording, auto calibration and a whole range of optional, plug-in modules and accessories including a transport sequencer and a track sequencer further increase the possibilities.

When it comes time to analyze your data, take advantage of the sophisticated search-for-ID and search-by-tape-counter functions to easily locate and process selected portions of the tape. Using the optional GPIB interface, you can connect the SR-50 or SR-30 to your computer system, allowing analysis of recorded data by the computer with full computer control of all transport functions.

The powerful SR-50 and SR-30. Flexibility to handle any job you can come up with.

SR-50



SR-30

TEAC

TEAC CORPORATION: 3-7-3 Naka-cho, Musashino, Tokyo, Japan Tel: (0422) 53-1111

• **Hongkong** Dah Chong Hong Ltd., Tel: 5-261111, 5-226258 • **Australia** Jacoby Mitchell Pty Ltd, Tel: (02) 26 2675 • **South Africa** Mayfair Sales (Pty) Ltd, Tel (011) 29-2921 • **Belgium & Luxemburg** Simac Electronics, Tel: 02-219.24.53 • **Denmark** Danbit, Tel: (03) 141515 • **France** Tekelec Airtronic S.A. Tel. (1) 534-75-35 • **Holland** Simac Electronics B.V., Tel 40-533725 • **Italy** A.E.S.S.E. S.P.A., Tel. 54.64 741-2-3 • **Spain** Ataio Ingenieros S.A., Tel 733 0542, 733 3700 • **Sweden** teleinstrument ab, Tel: 08-380 370 • **United Kingdom** International Recorders Ltd., Tel: 04427 5959 • **West Germany** nbn Electronik GmbH, Tel 08152/390 • **U.S.A.** B.J. Wolfe Enterprise Inc., Tel. (213) 877-5518 • **Canada** R.H. Nichols Co., Ltd., Tel (416) 661-3190

Circle 221 on reader service card

Neohm's Law

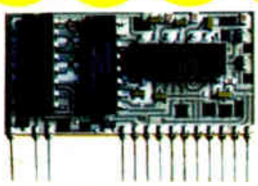
listen propose
ask design
explore fabricate

basic principles lie behind Neohm's law: a sound technical background, and continuous interchange of information with the customer. With our technical expertise and manufacturing capability we can easily customise the product.
And Neohm's own technical staff will provide useful application proposals.
Our applications laboratory and design office have available all the equipment and experience necessary to appreciate customer requirement and quickly to develop its implications.
Close collaboration with the customer's own designers is mantained throughout the entire project, from the original concept to the finished product. At every step, Neohm sets out to understand, and to mach, the customer's needs.

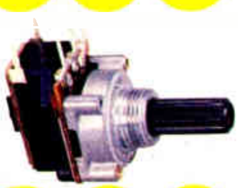
NEOHM s.p.a.
Via Torino 177
10040 Leinì TORINO - Italy
Tel. (011) 9989553/664
Telex 210577

LESA NEOHM

NEOHM UK Ltd
Italia House - 99 Windsor Road - Oldham
Greater Manchester - OL81RP England
Tel. (061) 6240261
Telex 666060



Thick film technology solves the problems of reliability, of repeatability within high quality device fabrication, of extreme miniaturisation. Functional calibration by laser avoids electromechanical adjustments.



The traditional characteristics of potentiometers and resistors can also be modified, depending on the particular requirements of the user - eg. potentiometer tracks with empirical laws of variation, very high voltage resistors.

BELGIUM • Regulation Mesure Sprl - tel. 7712020 - BRUXELLES
DENMARK • Tage Olsen A/S - tel. 02-658111 - BALLERUP
FINLAND • Oy E. Friis - Mikkelsen AB - tel. 90-327722 - HELSINKJ
FRANCE • Futur Ids - tel. 7494305 - RUEIL MALMAISON
Mateleco - tel. 6577055 - MALAKOFF (Paris)
IRELAND • Neltronic Ltd. - tel. 01-501845 - DUBLIN
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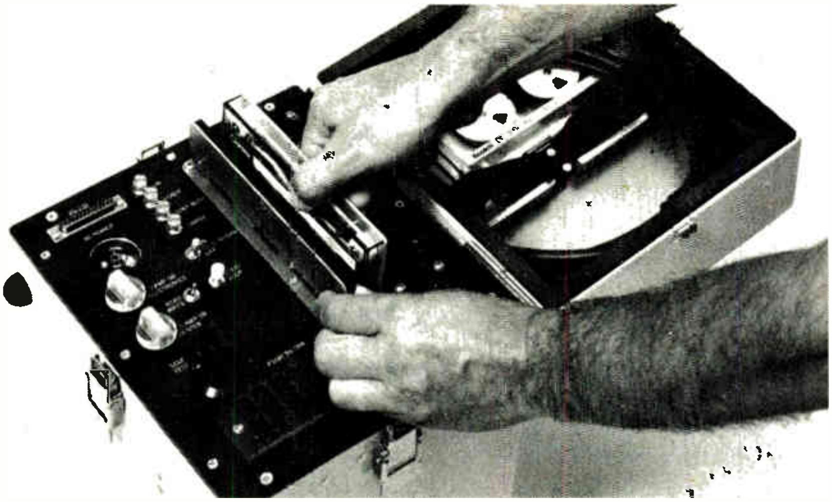
SPAIN • Hispano Elettronica - tel. 6194108 - MADRID
SWEDEN • Abemi AB - tel. 08-7300790 - SOLNA
SWITZERLAND • Omni Ray AG - tel. 01/478200 - ZÜRICH

Circle 223 on reader service card



used in the Navy AN/USH-26 data storage unit. The DC-300XL data cartridge holds up to 4.3 megabytes.

Automatic operation. Communications between the model 2765 and a host computer occur through a doubly buffered RS-232-C interface. The host computer initiates all commands and the unit's microprocessor executes them; automatic operation reduces the danger of operator-induced errors. Readouts on the front panel enable the operator to monitor all data-transfer functions as they occur. Bit rates range from 110 to 19,200 b/s, and the system writes blocks of 1- to 2-K bytes, reading one block at a time.

Upon start-up, the 2765 performs a self-test routine, including a programmable read-only memory check, a random-access memory check, and a front-panel indicator test. At power-up, it adjusts the tape tension to assure that the cartridge is ready for recording or reading.

The unit requires 115 V ac (104 to 122 V root mean square) at 48 to 400 Hz, consuming only 300 W with the heater on and 150 W without the heater. It can operate continuously at temperatures of −10° to +55°C and intermittently for 20-minute periods at 71°C. The DC-300 cartridge is rated for operation between 5° and 45°C.

The $10,365-unit takes 10 to 12 weeks for delivery.

North Atlantic Industries Inc., Qantek Division, 60 Plant Ave., Hauppauge, N.Y. 11787. Phone (516) 582-6060 [362]

Firmware instructions improve Mark VIII throughput

An expanded firmware instruction set gives the Mark VIII computer twice the throughput of its predecessor, the Mark V computer. Its high-speed central processing unit, 128-K bytes of main memory, and all its options are contained on a single printed-circuit board residing in a seven-slot chassis. The other slots accommodate peripheral controllers like the Mighty MUX multiplexer and the Lotus disk controller.

The new set of firmware instructions, which replace numerous functions previously performed by the IRIS operating system, increase speed and efficiency. The time required to fetch an instruction is reduced from 400 ns to just 100 ns, and when a routine is directly executed in firmware, an instruction rate of 7.5 million instructions per second is achieved. In addition, each firmware instruction is 80 bits wide, whereas a standard software instruction is 16 bits wide.

A subset of two-word instructions

lets the CPU perform many functions as 32-bit instructions although the address to the bus memory is only 16 bits wide. Firmware instructions implemented on the Mark VIII include literal byte compare and access, stack instructions, decimal add and subtract, extended load and store, byte-access instructions, byte-access sequential mode, block move, and extended translation.

In addition, the Mark VIII can use Point 4's high-speed interprocessor bus to communicate with a second Point 4 computer at a speed of 400 ns per word, resulting in communication transfer rate of 5 megabytes/s. The Mark VIII is listed at $10,700, but original-equipment-manufacturer discounts are available. Deliveries are scheduled to begin in mid-November and will be 60 days after receipt of order.

Point 4 Data Corp., 2569 McCabe Way, Irvine, Calif. 92714. Phone (714) 754-4114 [363]

Digital display modules offer 2,048-by-2,048 resolution

The HP 1345A digital display module produces vector graphics and alphanumerics on its 6-in. cathode-ray tube in response to digital commands from an external processor. Also, a built-in binary interface provides an easy connection to the user's external 16-bit TTL-level data bus.

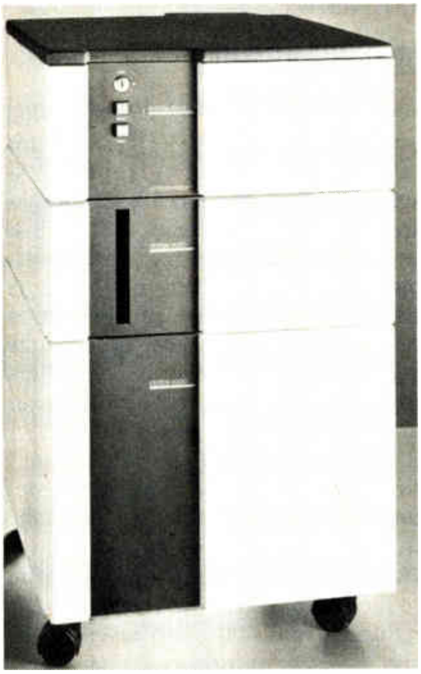
Vector end points may be defined anywhere on the CRT screen with a 2,048-by-2,048 point resolution. Additional display flexibility is assured by three programmable intensities plus off, four programmable line types, and four programmable writing speeds. An optional 4-K word-vector memory saves memory and eliminates the refresh requirements of the user's processor.

The HP 1345A is integrated into most instrument or system designs by the 16-bit binary interface that enables connection to 8-bit or 16-bit microprocessors, the self-contained character read-only memory, and the built-in test and calibration system. The unit is priced at $3,350, with delivery taking 12 weeks. Quantity discounts are available to original-equipment manufacturers.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. Phone (415) 857-1501 [364]

Zilog introduces a 16-bit commercial system

Zilog's System 8000, based on its Z8000 16-bit microprocessor and the Zeus operating system, gives businesses minicomputer-level performance in a small package for under $30,000. The system can handle eight users with a 24-megabyte Winchester disk drive and Zeus software.



The Zeus operating system has all the benefits of Unix, plus a number of enhancements developed by Zilog. Included is a visual editor for word processing and other text-oriented applications. In addition, Zeus handles random records in large files of up to 1 gigabyte, retains regular parameters, and enables users to create customized loops and control variables.

Also, Zeus has a higher degree of access control than that originally found in the Unix operating system. Because these enhancements do not affect the Unix kernel, Unix programs developed on other systems may be easily transported to the System 8000.

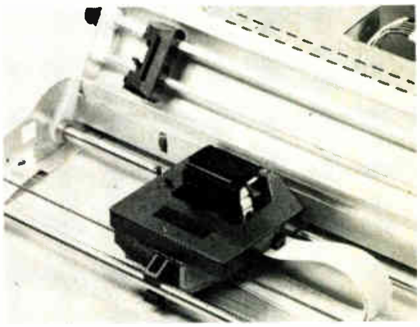
The central-processing-unit card is based on the 6-MHz segmented Z8001A processor and has three on-board Zilog Z8010A memory management units. The basic system includes a CPU board, two intelligent controllers, 256-K-bytes of error-checking-and-correcting memory, one 24-megabyte Winchester disk drive, one 17-megabyte cartridge tape drive, eight serial input/output ports, and the Zeus software.

Zilog, 10304 Bubb Rd., Cupertino, Calif. 95014. Phone (408) 446-4666 [365]

Low-cost printers run at 340 characters/s

Printek's 900 series of printers may be used for data processing, graphics, and correspondence. The 910 has bidirectional printing up to 170 characters/s and up to 140 lines/min; the 920 offers printing up to 340 characters/s and 270 lines/min. In producing graphics, the 910 prints 2,000 dots/s; the 920 produces 4,000 dots/s.

Both units offer a 9-by-9-dot format, a graph density of 144 by 144 dots/in., a set of 96 ASCII characters with optional fonts, underlining, superscript and subscript, descenders, double-width characters, and a downloadable set. Their line length is 136 columns at 10 characters/in. and line spacing is 6, 8, 12, and 16 lines/in. Four character sizes are offered: 10, 12, 13.3, and 16.7 characters/in.



Both models have 1,800 character buffers for concurrent data receipt during printing, option slots for future needs, and parallel and serial interfaces. The two models are in the evaluation stage of production, but will be on the market by year end. The 910 will sell for $1,650, and the 920 is listed at $2,345, both with original-equipment–manufacturer quantity discounts available.

Printek Inc., 1517 Townline Rd., Benton Harbor, Mich. 49022. Phone (616) 925-3200 [366]

Multiple capabilities are put into a desktop unit

Data-processing, word-processing, and communications capabilities are combined into a desktop distributed data-processing system called the model 503. The $6,490 unit includes a cathode-ray tube, a detachable 78-key typewriter, a 10-key numeric-pad keyboard, 64-K characters of random-access memory, a 15-in. 2,000-character display, and a cabinet that contains two 5¼-in. diskettes (four diskettes is optional), each capable of storing more than 800,000 characters of data.

For data-processing applications, the 503 supports Cobol, Basic, and TAL 2000. For word-processing applications, it uses an Omniword software package for letter writing and document handling and a Striker printer to produce letter-quality copies. As a communication device, it supports protocols in asynchronous, binary synchronous, or synchronous data-link control modes at speeds of up to 9,600 b/s.

The 503 operates as a stand-alone unit or in a small-computer environment and is compatible with the company's more sophisticated systems. It can be connected to the model 504, 435, 445, 585, and other 503 systems through Omnilink, Northern Telecom's local network. Deliveries of the system begin this month.

Northern Telecom Inc., Data Park, P. O. Box 1222, Minneapolis, Minn. 55440. Phone (612) 932-8153 [367]

Components

One-chip buffer slews at 300 V/μs

Design eliminates closed loop for speed; dc characteristics lean on zener-diode trimming

Precision Monolithics has added to its line of analog buffers the BUF-03/883, a high-speed monolithic buffer and voltage follower that is processed to MIL STD-883 B specifications. The open-loop circuit design gives it a slew rate of 300 V/μs for the model BUF-03AJ/883 and 200 V/μs for the BUF-03BJ/883.

The high slew rate and 60-MHz bandwidth are achieved by eliminating the capacitive feedback loop used in previous monolithic designs. In a closed-loop design, the compensating capacitors needed for stability ultimately limit circuit bandwidth and slew rate. In PMI's open-loop circuit design, zener diode trimming serves to maintain accurate dc specifications. A matched pair of junction field-effect transistors at the input give the units an input offset voltage figure of 6 mV maximum and 2 mV, typically.

The 150-pA input bias current will keep source impedance errors to a minimum. The device's gain is 0.997 with a 0.015% nonlinearity over the full input voltage range of ±11.5 V. The FET-input stage provides an input resistance of 5×10^{11} Ω. The buffers' output impedance is 2 Ω, and their output current drive is 70 mA peak. The overall gain error of 0.3%, due to mismatches in the internal level-shifting circuits, can be corrected externally.

Their specifications make the buffers suitable for high-speed sample-and-hold amplifiers, line drivers, high-speed active filters, and data-conversion circuits. The open-loop design allows large capacitive loads to be driven without instability.

Housed in TO-99 packages, the buffers operate over a temperature range of −55° to +125°C. In 100-piece lots, the BUF-03AJ/883 sells for $28.20, and the BUF-03BJ/883 is priced at $15. Both are available from stock.

Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, Calif. 95050. Phone (408) 727-9222 [341]

75-W MOS FETs operate at 1 kV

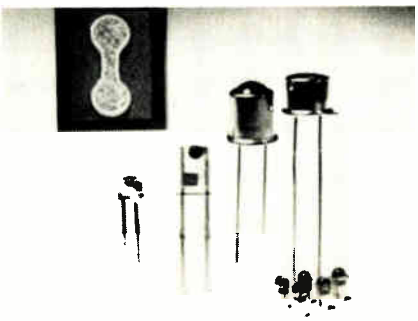
Aiming at high-voltage power supplies and line-operated switches, Motorola is extending its TMOS line of power MOS field-effect transistors with devices capable of 1-kV operation. The transistors are double-diffused n-channel enhancement-mode MOS types with silicon gates. Rated at 1 A continuous drain current (6 A peak), they are able to dissipate 75 W at 25°C and have a maximum on-resistance of 10 Ω.

The maximum drive voltage required is 4.0 V, and the maximum switching times are 200 ns (on) and 300 ns (off). Priced at $12.42 in 100s, the MTM1N100 comes in a TO-3 metal package, and the MTP1N100 in a TO-220 plastic housing. Equivalent devices rated at 950 V can be had for $11.29. Delivery is 6 to 8 weeks.

Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Ariz. 85036 [350]

GaAlAs doubles the power output of GaAs LEDs

TRW Optron's light-emitting diodes made from gallium-aluminum-arsenide have twice the power output at



the same forward current level and significantly improved coupling efficiency with silicon phototransistors over gallium arsenide versions.

The line includes a hermetic pill series, the OP223 and -224, with a power output of 3.0 mW/cm² at a forward current of 50 mA and a forward voltage of 1.8 V maximum and a hermetic TO-46 series, the OP230 to -233 and -230W to -233W, with a power output of 10 mW/cm² at a forward current of 100 mA and forward voltage of 2.0 V maximum.

In addition, the line has a plastic end-looking series and a plastic side-looking series, the OP260 to -260SLA and OP240 to -240SLA, respectively. These units have typical power outputs of 50 mW/cm² and 1.0 mW/cm² respectively at a forward current of 20 mA and a forward voltage of 1.8 V, maximum.

The aperture can be reduced with these units to obtain high resolution. Photosensor gain can be reduced for a better signal-to-noise ratio and a favorable gain-to-bandwidth relationship. All devices are available from stock and in 1,000 piece lots are priced at $1.36 for the 223, $1.23 for the 230, $0.51 for the 260, and $0.48 for the 240.

TRW Inc., TRW Optron, 1201 Tappan Cir., Carrollton, Texas 75006. Phone (214) 323-2200 [344]

Oscillator is programmable to 13 frequencies

The PCXO-116 crystal-controlled oscillator can be programmed using binary-encoded signals to 13 different frequencies extending from 1 MHz (base frequency) to 0.01 Hz in decades. In addition, 1 cycle/min, 0.1 cycle/min, 1 cycle/h, 50 Hz, and nonstandard base frequencies and time periods are also available.

The 24-pin dual-in-line-packaged unit has TTL- and diode-transistor-logic-compatible inputs and outputs and an edge jitter of less than 20 ns. It exhibits a frequency tolerance of ±0.001%, a frequency stability of ±10 ppm/°C, and a rise and fall time of 100 ns. The PCXO-116

74LS. CMOS. SPI.

SPI's 74LS Devices In CMOS

SPI gives you 20 new reasons to celebrate.

If you're a system designer, you know that CMOS is the process of the 80s. And SPI is the CMOS innovator. We've taken 20 of the most popular 74LS devices and manufactured them in CMOS — to give you low power and increased system performance.

Our 74SC components are pin-for-pin compatible, direct plug-in replacements for low power Schottky devices. But you also get the advantages of CMOS: significantly lower power, higher noise immunity, full TTL compatibility (input and output) and the same high speed.

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SPI CMOS Makes It Possible

Our 74SC devices are fabricated using a proprietary selective oxidation silicon gate process we call SPI CMOS. It's the same advanced technology that we use in our 500- and 1000-gate uncommitted logic arrays, so you know it's been proven where it counts — in the field.

SPI's new family of 74SC components covers the range of the most widely used devices. Decoders. Multiplexers. Octal drivers. Transceivers. Flip-Flops. Latches. All are direct plug-in replacements designed to solve marginal performance problems in existing designs. Or, with an eye on the future, you can design in the building blocks for tomorrow's high-speed, low-power CMOS systems.

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On The Shelf Now

You can start using SPI's CMOS 74SC products today because they're available now.

74SC in CMOS from SPI — don't settle for anything less. Put more into your system right now and stay ahead with SPI CMOS — the process of the 80s.

Call or write SPI for more information, before your competition does.

• SP74SC137	1 of 8 Inverting Decoder with Input Latches
• SP74SC138	1 of 8 Inverting Decoder
• SP74SC139	Dual 1 of 4 Inverting Decoder
• SP74SC237	1 of 8 Decoder with Input Latches
• SP74SC238	1 of 8 Decoder
• SP74SC239	Dual 1 of 4 Decoder
• SP74SC240	Octal Inverting Buffer
• SP74SC241	Octal Buffer
• SP74SC244	Octal Buffer
• SP74SC245	Octal Transceiver
• SP74SC373	Octal Transparent Latch
• SP74SC374	Octal D-Type Flip-Flop
• SP74SC533	Octal Inverted Output, Transparent Latch
• SP74SC534	Octal Inverted Output, D-Type Flip-Flop
• SP74SC540	Octal Buffer
• SP74SC541	Octal Buffer
• SP74SC563	Octal Inverted Output, Transparent Latch
• SP74SC564	Octal Inverted Output, D-Type Flip-Flop
• SP74SC573	Octal Transparent Latch
• SP74SC574	Octal D-Type Flip-Flop

SPI SEMI PROCESSES INC.

1885 Norman Avenue, Santa Clara, CA 95050, Tel: (408) 988-4004
TWX: 910-338-0025 SPI SNTA

SPI in Europe: Semi Processes Inc., Austin House, South Bar, Banbury, Oxfordshire, England, Tel: (44)-295-61138 Telex: 837594

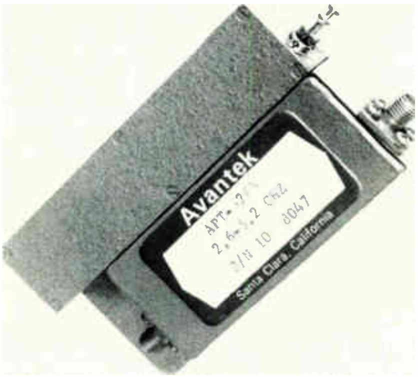
Circle 227 on reader service card

operates over the 0° to 70°C temperature range from a 5-V dc power supply. It is intended for aerospace, military, and industrial applications. In lots of 100, the oscillator costs $98, with delivery taking six weeks.

Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343. Phone (213) 894-2271 [345]

GaAs FET amplifiers cover 2 to 4, 4 to 8 GHz

Three series of hybrid intermediate-power amplifiers made from gallium arsenide field-effect transistors provide up to +30-dBm power in the 2-to-4-GHz (APT-4060) and 4-to-8-GHz (APT-5260) frequency ranges and +26 dBm in the 2.6-to-5.2-GHz band (APT-8060). The three versions offer a choice of moderate (28, 30, and 30 dB) or high (40, 38, and 40 dB) gain levels.



They have a 4.0-to-6.0-dB maximum noise, ±1.5-dB full-band gain flatness, and a 2:1 maximum input and output voltage standing wave ratio. Packaged in a hermetically welded 8-oz aluminum package, they are powered with a +15-V dc power supply and operate from 0° to 50°C, with a ±1.0% typical gain variation and ±0.5 dB typical output-power variation over the full temperature range.

The APT series uses balanced amplification, in which all stages have a pair of identical amplifier channels with quadrature hybrid couplers at the inputs and outputs. The amplifiers are built with thin-film gold conductors and thin-film tantalum nitrate resistors deposited on precision ceramic substrates.

The devices meet MIL-Q-9858A requirements, and their specifications make them suitable as drivers for high-power traveling-wave tubes in electronic-warfare equipment. The units range in price from $2,950 to $4,250 for quantities of 1 to 9. Delivery is approximately 120 days after receipt of order.

Avantek Inc., 3175 Bowers Ave., Santa Clara, Calif. 95051. Phone (408) 496-6710 [346]

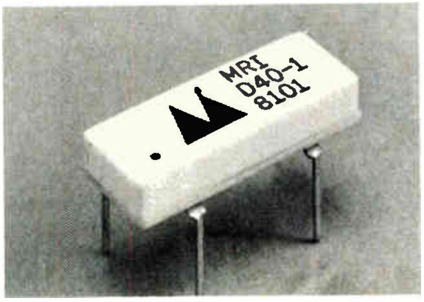
D40-1 relay switches dc or ac loads up to 80 mA

Microelectronics Relays' model D40-1 solid-state relay is a form, fit, and function alternative for the Teledyne 640-1. The D40-1 will switch either dc or ac loads up to 80 mA and 50 V. Its input voltage ranges from 3.8 to 10 V dc.

Transformer coupling provides high input/output isolation, a turn-on time of 1 μs maximum, and a turn-off time of 10 μs maximum, making it a suitable interface switch for current-loop applications in cathode-ray-tube terminals and a low–to–medium-level driver-isolator in industrial-control and instrumentation systems.

The relays use hybrid microelectronic circuitry in sealed ceramic packages in a modified TO-116 configuration. In 5,000-piece quantities the D40-1 runs $6.20, with delivery from stock.

Microelectronic Relays International Inc., 2566 Via Tejon, Palos Verdes, Calif. 90274. Phone (213) 373-0721 [348]



THE OPTICS ALONE ARE WORTH THE PRICE

Now get more room to work, high power, and exciting new optics with the AO Series 1860 Industrial Microscope. ☐ Here's the ultimate in image quality, contrast and resolution. And unlike other scopes that depend on vertical stage movement for focusing, the 1860 utilizes an exclusive focusing nosepiece principal that revolutionizes the ease and speed of wafer inspection. ☐ And the fixed stage height provides excellent stability and easier use of the ancillary equipment, such as microprobes, micromanipulators, carousels, and other stage hardware. Result: masks, wafers and other components are moved on and off the stage faster. ☐ Only AO offers built-in halogen lamps with 10,000 hours of life and a full 20 mm. field of view... no other scope even comes close. ☐ The unique AO Series 1860 - another American idea in human engineering for the technologies of the 1980's. For a demonstration see your AO dealer or representative, or write for our brochure: American Optical, Instrument Division, P.O. Box 123, Buffalo, NY 14240.

The versatile 1860 accepts cameras for documentation and is available with attachments to accommodate several viewers simultaneously.

ANOTHER AMERICAN IDEA

Circle 230 on reader service card

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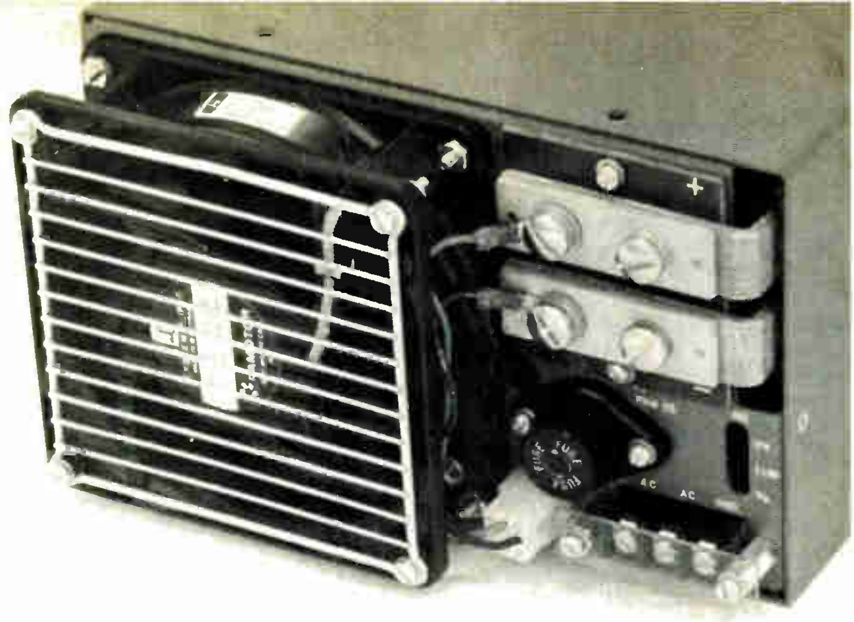
American Optical

New products

Power supplies

5-V switcher carries 300-A load

1,500-W switching supply has output adjustable from 4.6 to 5.25 V, $1,120 price



The 1,500-w AQS5-300 switching power supply will interest designers of mainframe computers, large add-on memory systems, and other users of the standard 5-by-8-in. package who find that present products do not satisfy reserve power requirements. The supply, with an output adjustable to 5.25 V dc at 300 A, will reduce the overall number of power supplies required in large systems that typically use several supplies paralleled to a common bus, decreasing costs and increasing reliability. Replacing 150- or 200-A units presently installed increases the margin of safety and provides power for later add-on capability.

The AQS5-300 gives full rated power at up to 50°C ambient temperatures and will operate at up to 70°C with power derating. Its output is adjustable from 4.6 to 5.25 V dc, making available a voltage margin to offset load and line drops that can be critical at high current levels.

Input need. The unit's ac input requirement is 208 to 230 V ac at 47 to 63 Hz, maintaining full rated power and output-voltage regulation to within ±0.2% over an input range of 166 to 264 V ac. Load regulation is within ±0.4% for 100% load changes. Output filtering attenuates ripple and noise to a maximum of 50 mW peak to peak measured in a dc-to-50-MHz bandwidth.

Other features include built-in adjustable overvoltage and overload protection, input turn-on surge limiting, parallel or series operation, and Underwriters Laboratories recognition under Standard 478. Ball bearings give the self-contained cooling fan twice the mean time before failure of fans using standard sleeve bearings. The unit has a Molex connector for system interface, an ac power fail signal, a margin signal, remote sensing connections, and output-inhibit input. Burned-in MIL-STD-883 pulse-width-modulation chips and computer-grade components are used, and all units undergo a 72-hour burn-in at full load before testing and inspection. The 14-in.-long unit has mounting holes compatible with smaller 1,000-W supplies.

Options available on the supply include a 2-V dc output at 300 A adjustable from 1.8 to 2.5 V, load-sharing capability, and an internal filter to reduce conducted electromagnetic interference to meet Federal Communications Commission and Verband Deutscher Electrotechniker limits.

In single quantities, the AQS5-300 is priced at $1,120. Discounts are available for original-equipment–manufacturer quantities. The units are available from stock.

Acme Electric Corp., Cuba, N.Y. 14727. Phone (716) 968-2400 [381]

Switching power supply has outputs with 90% efficiency

All outputs are individually and independently regulated to within 0.05% for both line and load variations on Efflo's four-output switching power supplies, which also have a cross regulation of 0.025%. Two standard power supplies are available, covering 200 to 450 W and 450 to 750 W. Units covering the kilowatt range with six outputs will soon be available.

The 5-V outputs have efficiencies of 85% and over 90% for all other outputs. The hold-up time is over 75 ms, permitting masking of longer ac power interruptions. The response time from a 20% to 100% load change on any output is under 20 ms. The units have a 15% overvoltage protection and 20% overcurrent protection. They have a temperature coefficient of 0.0075% per °C and a noise and ripple figure of 10 mV.

Models with four outputs cost $420; versions with three outputs retail for $375. Delivery takes two months.

Efflo Inc., 455 Los Gatos Blvd., Suite 103, Los Gatos, Calif. 95030. Phone (408) 356-2325 [383]

500-W uninterruptible power system bears $875 price tag

Wilmore's 500-W model 1408 uninterruptible power supply has been designed for point-of-sale terminals, small computers, communications equipment, and security systems. It consists of a dc-to-ac inverter, battery charger, and sensing and line-to-inverter transfer circuitry.

The $875 unit is connected to a battery and plugged into a power outlet. If ac power is interrupted, the user's load is powered by the inverter. When power is restored, the load is automatically transferred back to commercial power and the charger

automatically recharges the user-provided back-up battery.

The inverter efficiency is 80%. It has a 2:1 power-surge capability, a frequency stability of ±0.15 Hz, and a response time of 16 ms. The standard model provides a single-phase output of 115 V ac, 60 Hz; versions are available for use with either 24- or 12-V back-up batteries. Delivery is from stock.

Wilmore Electronics Co., P. O. Box 1329, Hillsborough, N. C. 27278. Phone (919) 732-9351 [384]

Bipolar power supply is digitally programmable

The model DPSV 20-1 is a digitally programmable power source for automatic test equipment, exercisers, measurement systems, and diagnostic equipment. It provides a bipolar, constant-voltage output of −20 V to +20 V at 0.05 A to 1 A, and it has an accuracy within 0.05% and response time of 500 µs from minus to plus full scale.

The digital-to-analog converter, power supply, and binary-interface circuitry for the 20-1 are enclosed in a single package, thereby eliminating the hybrid-system approach of mixing and matching two or more black boxes.

The 20-1 may be programmed to respond to control signals such as polarity, strobe, data clear, range, direct zero, address, standby, set, direct standby, and output voltage. The DPSV 20-1 is priced at $1,990, with delivery from stock; 14 other models priced at $490 to $3,250 are available.

Kikusui International Corp., 17121 South Central Ave., Carson, Calif. 90746 [385]

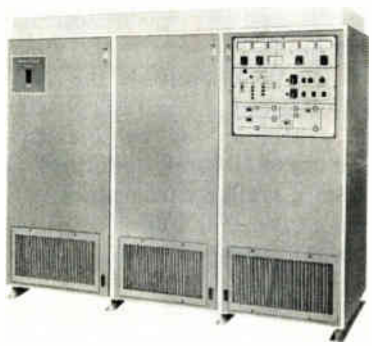
325-kilowatt unit is 92% efficient

Sola's line of uninterruptible power supplies with ratings of 225, 275, and 325 kW, which complement the firm's existing 1.5–to–150-kW line, are available in single, parallel, and parallel-redundant configurations, all three of which have operating efficiencies of 92%.

The supplies are intended to protect mainframe computers; industrial process controls; security, medical, and communications systems; and other large-scale electronic and electrical equipment requiring no-break power protection.

The units use Sola's 12-step, pulse-width–controlled inverter technology to improve output characteristics. The inverter produces an ac voltage regulated to ±1% of rated voltage, while holding the output's total harmonic distortion to less than 5% of the maximum root-mean-square voltage. Even if voltage were to drop as low as 15% below nominal, the supply will maintain regulated output without discharging its battery bank.

The standard units have outputs of 277 to 480 V ac at 60 Hz with



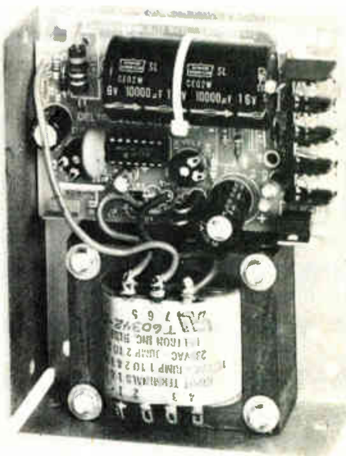
three-phase inputs or outputs of the three- or four-wire type. Models with 120–to–208–V ac output ratings are also available. The systems also contain Sola's expanded operator control panel that includes a status indicator providing a visual representation of system power flow for performance monitoring. An internal panel gives complete monitoring for easier servicing, says the firm.

Without batteries, units are priced at approximately $80,000 each.

Sola Electric, 1717 Busse Rd., Elk Grove Village, Ill. 60007 [386]

Inexpensive power supply has 100,000-hour MTBF

The HVQ series of high-volume power supplies offers a shielded transformer, socketed semiconductors, dual ac input, barrier block terminals, and a mean time between failures of up to 100,000 hours. The



linear open-frame power supplies have input ratings of 105 to 125 V ac and 210 to 250 V ac, at 47 to 440 Hz. Their outputs are 5 V at 3 A, 12 V at 1.7 A, and 24 V at 1.2 A, all adjustable to within ±5%.

Line and load regulation for the supplies is ±0.1%, and ripple-and-noise factor is 1.0 mV root mean square, 5 mV peak to peak. All units have remote sensing built in, reverse voltage protection on output, a ±0.1% stability for 8 hours after warm up, and a temperature coefficient of 0.03% ppm/°C. All 5-V at 3-A units have a built-in silicon controlled rectifier that is used as a shunt for overvoltage protection and cost $21 with a three-year warranty. Delivery is from stock.

Deltron Inc., P. O. Box 1369, Wissahickon Ave., North Wales, Pa. 19454. Phone (215) 699-9261 [387]

More than just another Spectrum Analyser.

Solartron
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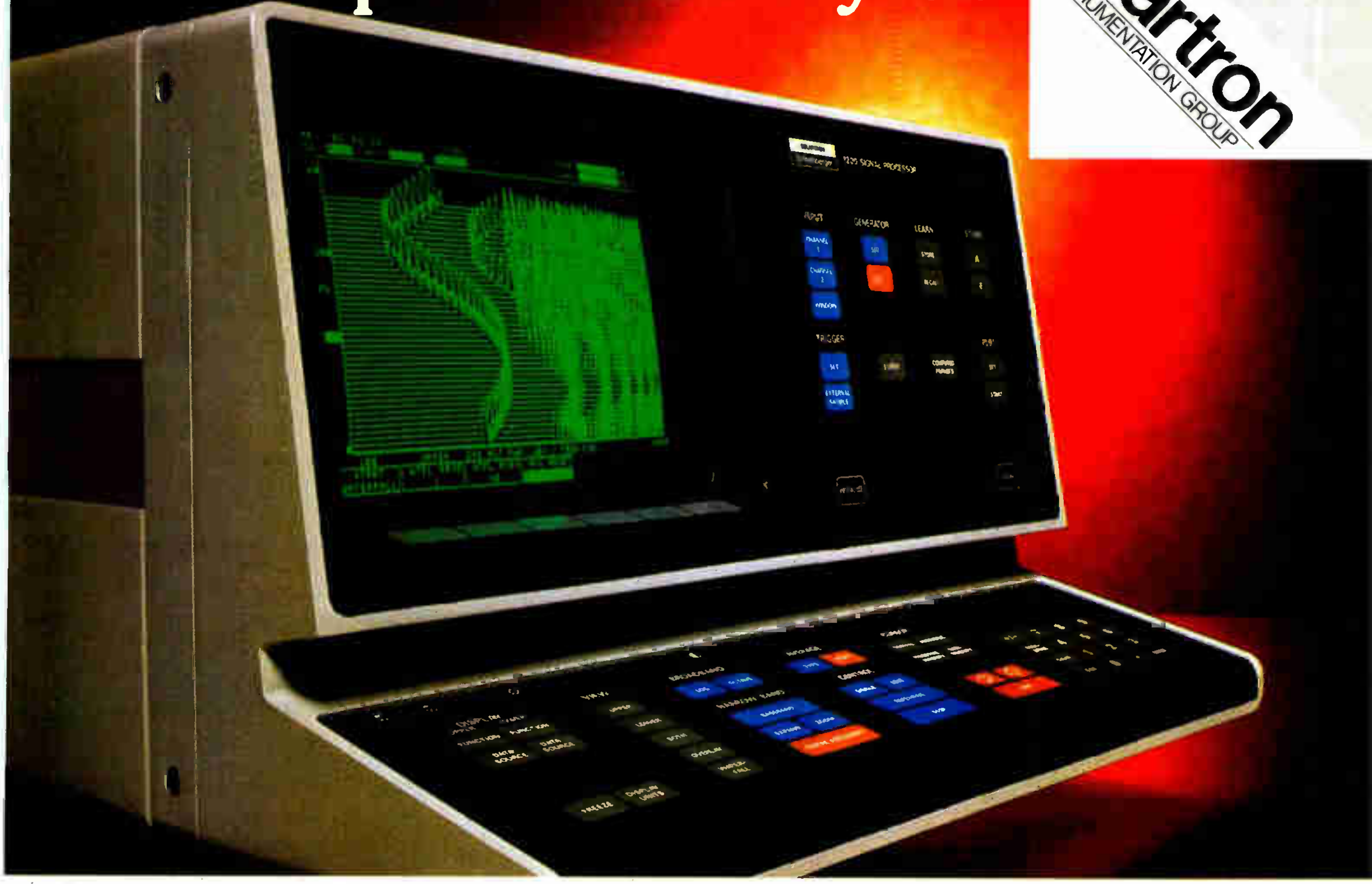

The Solartron 1200 Signal Processor.

MEASUREMENT

Two channel, floating.
Autoranging: 10mV to 300V.
Resolution: 11 bits.
Windows: rectangular, flat-top, Hanning.
Integration, differentiation.
Engineering units.
Acoustic weightings.
Triggers, pre-triggers.
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Resolution: 500 lines, 2mHz.
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Zoom: x2, x5. Expand: 4 decades.
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Auto- and cross-power and correlation.
Transfer function. Coherence.
Cepstrum. Synchronous spectrum.
Computed power and noise bandwidth.

DISPLAY

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Single: any function, waterfall, two functions overlaid.
Dual: two independent functions.
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Full cursor control. Variable resolution.

INTERFACES

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Quite a list – and all features are standard. No need for add-on options; this is how the 1200 gives you more. A product designed with the engineer in mind and which has unrivalled ability to take maximum advantage of dynamic measurements, whether in the time or frequency domain.

Brilliant ergonomic design enables simple operation. A minimum of main controls supplemented by 'soft-keys' guide you to just the settings you need.

The 1200 provides a capability which gives unrivalled analysis of dynamic performance.

No other unit can offer such features as standard and at such a realistic price.

Please phone and find out how the 1200 Signal Processor can benefit you.

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Circle 232 on reader service card

Industrial

Boards jacketed for duty at sea

Silicone-resin coating and gold-plated socket contacts toughen microcomputer cards

Drawing on experiences from its geophysical exploration business, Texas Instruments Inc. is introducing a new line of microcomputer boards that are conformally coated to protect them in harsh operating environments. The MOS boards are industrial-grade versions of TI's current TM990 16-bit microcomputer boards.

In addition to a protective coating of transparent silicone resin, the new TM990/C series features low-power complementary-MOS memories and gold-plated integrated-circuit sockets for high reliability. Overall, the industrial-grade models cost 25% to 30% more than the standard TM990 boards. Initially, TI's microcomputer-board operation in Houston will offer coated versions of five boards in the series.

"This is just the minimum that you need to start a system. It's what we've come up with after talking with some of our customers," explains Mike Hulme, product marketing manager for TM990 boards. "We will expand that range as it becomes necessary." Already, TI is planning to add three additional members to the series in the fourth quarter—a thermocouple-interface board, a pulse counter and accumulator, and a central-processing-unit board with extended (1-megabyte) addressing capabilities.

TI's conformal-coating process, developed by its geophysical exploration operation in Houston, uses boards that are electronically complete except for their erasable programmable read-only memories, which are dipped in a silicone resin manufactured by Owens-Corning Corp. After the resin is cured, the E-PROMs are placed in the board's gold-plated sockets—the resin will not adhere to the gold deposited on the sockets or the board's connectors. A corrosion-resistant lubricant is also placed on the sockets to protect the connections. TI uses C-MOS static random-access memories in its industrial-grade CPU and memory-expansion boards instead of the usual n-channel MOS devices.

The Dallas firm is making a move to address what it sees as a surge in industrial-control applications for MOS-microcomputer boards in remote and harsh environments—particularly in the oil-exploration business. Hulme estimates that industrial automation and control processing will eventually account for 48% of the total available microcomputer-board market.

"It's not only the operating environment that we are protecting against. Many times you have to consider that customers will have replacement boards sitting on the shelf—and that could be as harsh as some operating environments," he notes. "And you must consider the people that will be using them—if you've got some guy with big boots and gloves on an oil rig in the ocean, say, you don't want something that's delicate like a standard computer board sitting around."

Specifically, the conformal coating is designed to ward off corrosion due to acid, chemicals, salt, or moisture, "which obviously causes other problems, like fungus in the tropics, for instance, when dust settles on it," Hulme notes. The seal also guards the boards against abrasions. However, if the need arises, repairs can be made on the boards by cutting through the coating.

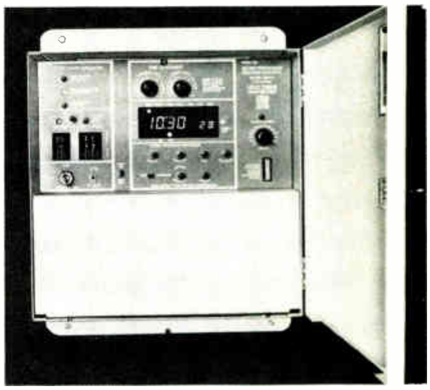
After 400,000 hours of testing, TI says the conformally coated boards have had only one failure in four and a half years at 65°C.

The boards and their single-quantity prices are: TM990/C101 CPU-controller, $1,187; TM990/C201 C-MOS static RAM expansion module, $1,844; and three communications boards—the TM990/C310 programmable input/output module, $594; the TM990/C307 RS-232C serial expander, $844; and the TM990/C308 industrial communications module with High-level Data-Link Control, $1,187. Deliveries are expected within eight weeks of order.

Texas Instruments Inc., P. O. Box 202129 S. C. 315, Dallas, Texas 75220. Phone (713) 778-6584 [371]

Heating control unit cuts building fuel costs

The MPC-7 heat timer controls the heating system of a building, cutting energy consumption by lowering temperatures when appropriate. According to the company, it is



expected to compete in the replacement of more than 350,000 nonelectronic mechanical heat-timer controls currently in use.

The heat timer is equipped with a computer and electronic clock. It maintains comfortable heat levels and lowers them to an energy-saving level for the portion of the day it is programmed to. The normal and low heat levels are determined by setting a number of controls that respond to the temperatures outside and inside a building, both of which are shown on a digital display.

The MPC-7 can be custom-made for each building by adjusting it to compensate for the variables in characteristics of the buildings and heating systems. In case of power failure, the unit can be used with a rechargeable nickel cadmium battery. It also has a locking control on the panel that prevents tampering by unautho-

rized personnel. It can be installed in less than a day and sells for approximately $1,600.

Heat-Timer Corp., 115 Fifth Ave., New York, N. Y. 10003. Phone (212) 673-3200 [373]

Hand-held digital thermometer has two thermocouple inputs

Omega's model 870 hand-held digital thermometer has a dual input and uses low-power large-scale integrated circuits and a 15-mm-high liquid-crystal display. Equipped with

an analog output, it can be interfaced with chart recorders or with data-acquisition systems.

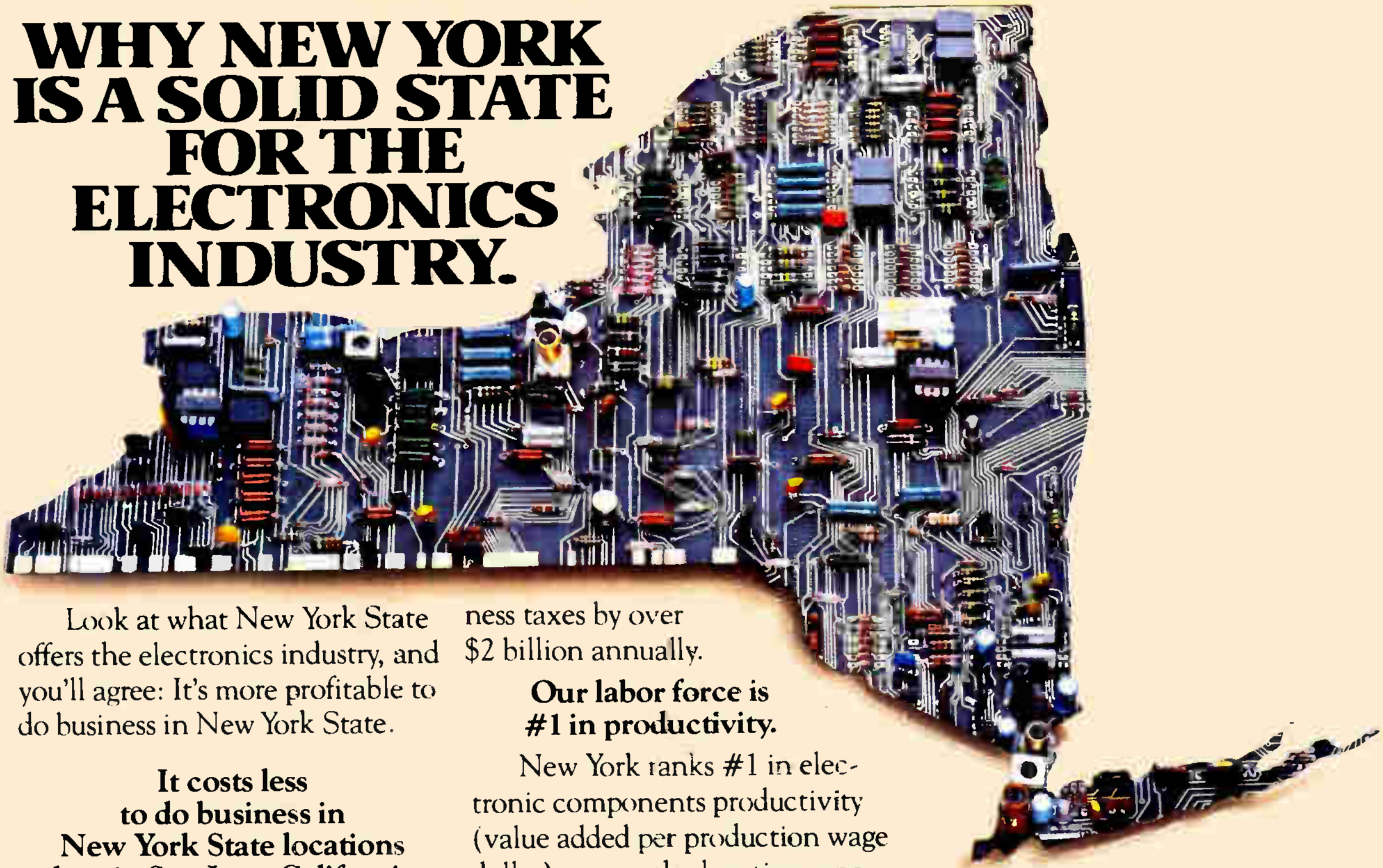
The model 870 thermometer comes with the 8701 adaptor, which converts the input from banana-plug jacks to the firm's subminiature thermocouple connectors. Purchase price also includes a model 8702 Chromel-Alumel thermocouple sensor with a banana-plug input.

The manufacturer also offers a number of additional probes that are equipped with the subminiature compensated connectors for the 8701 input adaptor.

The 870 measures temperatures from −40° to 1,999°F or −40° to 1,370°C to within 0.25% accuracy. It has a 0.1° resolution up to 200°C or F. Available from stock, the model 870 sells for $234.

Omega Engineering Inc., One Omega Drive, Box 4047, Stamford, Conn. 06907. Phone (203) 359-1660 [376]

WHY NEW YORK IS A SOLID STATE FOR THE ELECTRONICS INDUSTRY.



Look at what New York State offers the electronics industry, and you'll agree: It's more profitable to do business in New York State.

It costs less to do business in New York State locations than in San Jose, California. And we can prove it.

An independent study analyzed the four critical costs of taxes, wages, power and construction for a model new electronics firm. It showed that New York State offers locations where these costs are less than they are for choice electronics industry locations around the country.

For example, these costs would total $7.6 million annually in San Jose, versus only $6.4 million in, say, Brookhaven, New York.

New York has the best business advantages in America.

New York State is committed to a big, broad business-boosting program to create private sector jobs.

Our costs are lower because we have the best tax incentives and credits. We have on-the-job training and job incentive programs. Long-term, low-cost financing. And, we've cut personal and business taxes by over $2 billion annually.

Our labor force is #1 in productivity.

New York ranks #1 in electronic components productivity (value added per production wage dollar) among the locations analyzed. And in the past five years, New York's number of idle man-days due to work stoppages was half that of the national average.

We graduate more electronics engineers than any other state.

Thanks to universities like RPI and Cornell–and dozens of other fine colleges and universities–more electronics engineers are graduated each year in New York State than in any other state including California or Massachusetts. And since many of the largest electronics firms are already doing business here–GE, IBM, to name only a couple–our graduates are quickly turned into seasoned professionals.

When you look into New York, you'll love New York.

We have an abundance of electric power. Lots of affordable housing for your employees. And our 30 million acres include thousands of available plant sites. And some of the most magnificent outdoors and year-round recreation on the American continent.

Tell me more about why New York is a solid state for business. I am particularly interested in information on:

- ☐ Electronic Components
- ☐ Small Computers
- ☐ Semiconductors

George G. Dempster, Acting Commissioner
New York State Dept. of Commerce
99 Washington Avenue
Albany, New York 12245

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Company Name____________________

Product/Service____________________

Employees____________________

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NEW YORK STATE VOTES "YES" FOR BUSINESS.

Circle 237 on reader service card

Mallory tantalum capacitors earn top MIL reliability ratings.

In solid tantalums, Mallory is now qualified to provide Level S, the highest reliability rating, for styles CSR 13 and CSR 91. Level S, under MIL-C-39003, means a life failure rate of only 0.001% per 1,000 hours. Here is our current QPL line-up in solids:

MIL Style	Mallory Type	Life Failure Rates
CSR13	TER	M, P, R, **S**
CSR23	TXE	M, P, R
CSR33	TXR	M, P
CSR91	TNR	M, P, R, **S**

In wet slug tantalums, we have become the first source qualified at Level R, under MIL-C-39006, for style CLR69 — the extended capacity range wet tantalum, which makes our wet QPL list look like this:

MIL Style	Mallory Type	Life Failure Rates
CLR10	XTM-XTK	L, M, P
CLR14	XTL-XTH	L, M, P
CLR17	XTV	L, M, P
CLR65	TLX	L, M, P, R
CLR69	TXX	L, M, P, **R**

They're all available from authorized Mallory Distributors. Send for our latest QPL bulletins. Mallory Capacitor Division, Mallory Components Group, P.O. Box 372, Indianapolis, Indiana 46206. (317) 636-5353.

MALLORY

ELECTRICAL / ELECTRONIC GROUP

EMHART

Circle 238 on reader service card

Products Newsletter

D-a converter interfaces with microprocessors

Later this month, Analog Devices will introduce the AD7527 monolithic 10-bit digital-to-analog converter that interfaces directly with 8- and 16-bit microprocessor buses. It accepts either right- or left-justified data words and includes data-readback and data-override features, the former for error detection and the latter for calibration. **The unit is double-buffered, includes an up-down counter, and requires only a single 5-V supply.** Targeted by the Norwood, Mass., firm at process control applications, the 7527 will be priced at about $13 in lots of 100.

Mostek's 64-K dynamic RAMs go to market in quantity

Now that Mostek Corp. has begun volume deliveries of 64-K dynamic random-access memory chips, it anticipates monthly production of more than 100,000 devices at year's end. Although MK4164 prices are being negotiated by Mostek's distributors, **most large-order devices are being sold in the $13-to-$14 range.** These prices are expected to drop below $10 in the final quarter as the Carrollton, Texas, firm speeds up production. A lower-cost plastic dual in-line package version of the 4164 will be introduced in the fourth quarter.

DIP adds 10-line buffer to printer

The DIP-81A 100-character/s bidirectional dot-matrix impact printer interfaces directly with mini- and micro-computers. An updated successor to DIP Inc.'s model DIP-81 [*Electronics*, July 31, 1980, p. 137], **the new unit prints both 40- and 80-character lines, and it comes with a standard 10-line buffer, with a 24-line buffer optional.** It can accept data from dumb cathode-ray-tube terminals, modems, and teletypewriter-replacement equipment during printout. The unit uses a full 96-character ASCII set and a 7-by-7-dot matrix that can expand to a 14-by-7 matrix. The DIP-81A can include an optional RS-232-C line or 20-mA current loop, as well as the standard Centronics-compatible parallel interface. Priced at $379 in 100-unit quantities, the DIP-81A sells for $499 in single units. Delivery from the Boston, Mass., firm takes 30 to 60 days.

Findex offers added storage, full CRT

The first full-screen desktop computer from Findex of Torrance, Calif., maker of portable microcomputers with plasma displays, is to be announced later this month. **The Z80-based system consists of a 12-in. cathode-ray-tube terminal, dual 5¼-in. Winchester drives with capacities of up to 20 megabytes,** and two floppies with either 400- or 800-K-byte capacity. Two dot-matrix printers are offered, a 150-character/s unit or a nearly letter-quality model. The as yet unnamed system will be delivered in November for between $6,000 and $12,000 with CP/M.

National reprices processor series

As a result of significant manufacturing yields, National Semiconductor Corp. of Santa Clara, Calif., is making its NSC800 microprocessor family available in molded packages with a price tag of $29 for the 1-MHz NSC800N-1 in 100-piece quantities. Introduced earlier this year in a ceramic package for $87, **the NSC800N-1 uses 5 mA and an up-to-1-MHz system clock and executes the Z80 instruction set.** The firm is also reducing the price of its standard 8040 and low-power 8040L XMOS microcomputers. In quantities of 10,000, the INS8040N-6 will sell for $5 each, down from $10, and the INS8040LN-6 is $6 each, reduced from the previous $12.

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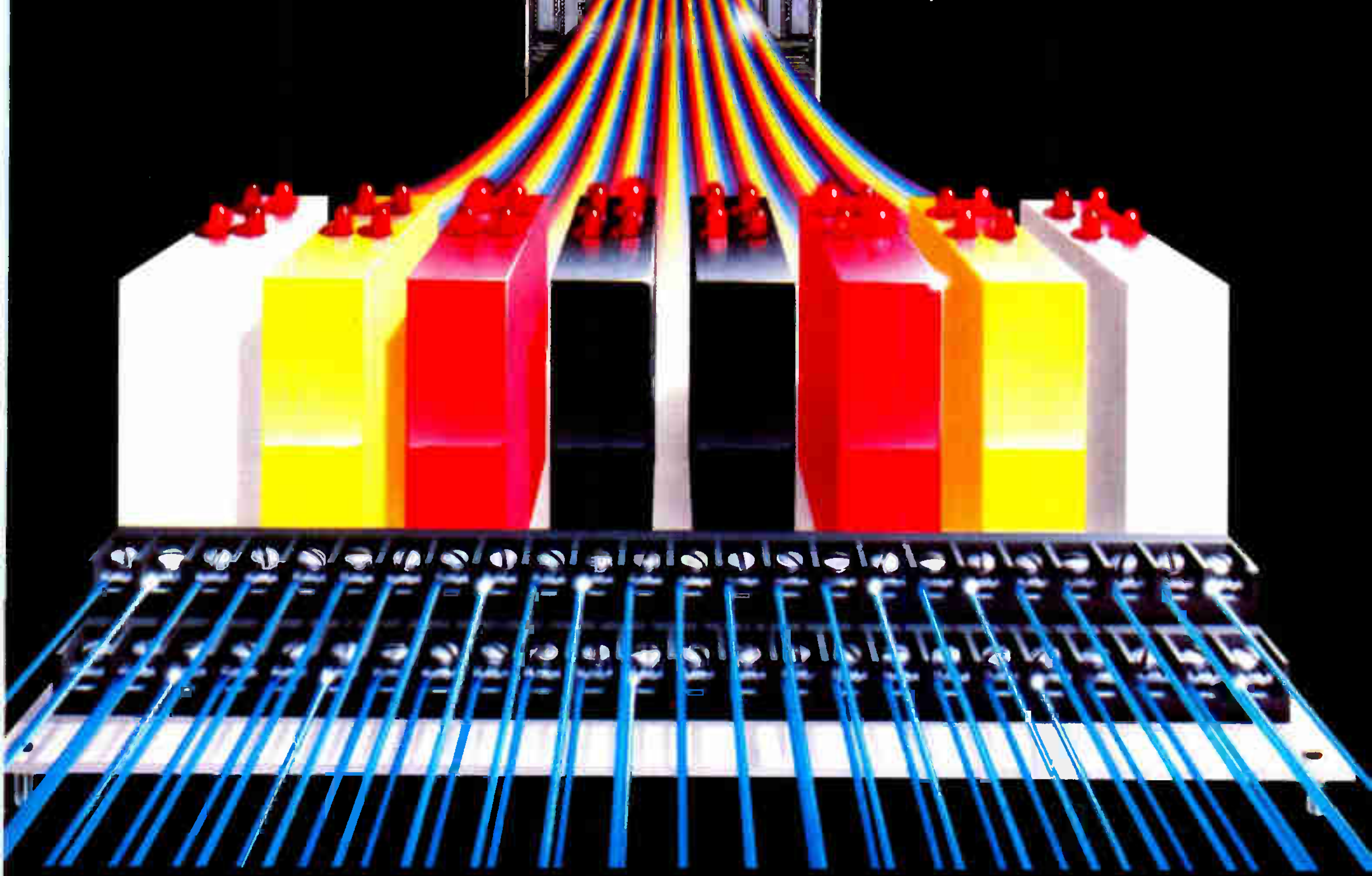

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