JUNE 21, 1979

CLEANING UP SPACE JUNK TO MAKE ROOM FOR SATELLITES/96

Microprogramming made easier with a writable control store/121

How design innovation achieved a 1-GHz oscilloscope/131

50 YEARS

Electronics

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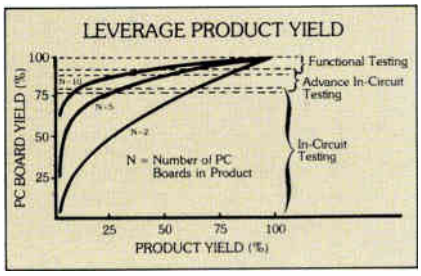
ACCEPTABLE PRODUCT YIELD IN FINAL TEST—THE BOTTOM LINE FOR A COMBINATION OF IN-CIRCUIT AND FUNCTIONAL TESTING.

In-circuit testing is a powerful test approach. But today's complex products require more than in-circuit testing. Higher and higher PC board yields are required to maintain an acceptable product yield in final testing.

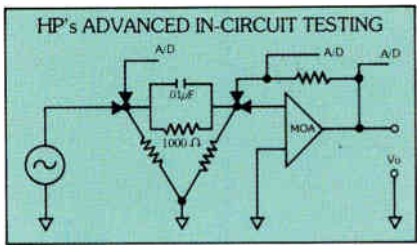
Leverage product yield.
The addition of advanced in-circuit test techniques, together with functional testing, adds that extra increment to your PC board yield as shown below.



For example, in a five PC board product, increasing the PC board yield from 75% to 98% will leverage product yield from 23% to 90%. This can result in substantial savings, since the cost of fault detection increases dramatically with each production step.

What is advanced in-circuit testing?
In-circuit testers contact each PC board node through a bed-of-nails fixture. The system switches from component to component and "inspects" for value, placement, etc. Today, the wide diversity of component values, tolerances, components, and interconnections, means that conventional in-circuit techniques often leave some parameters untested.

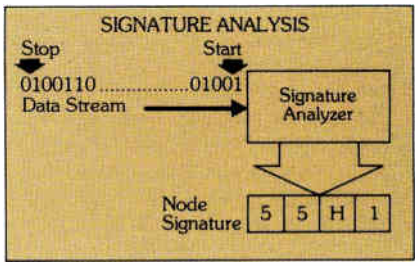
On the other hand, the HP 3060A Board Test System ($74,000* for standard operational system) utilizes advanced techniques that allow component isolation in commonly found but difficult circuit configurations. For example, a .01 μF



capacitor can be measured to an accuracy of 4% even when it is shunted by a 1000 Ohm resistor. The key to this measurement is a phase synchronous detector. This is a valuable tool for measuring components and circuits with significant real and reactive characteristics.

Functional testing makes the difference.
The standard HP 3060A also has a useful set of analog and digital testing tools. It incorporates board level stimulus/response testing in order that components such as operational amplifiers, DACs and optoelectric devices can be tested. This functional testing permits circuit parameters, such as frequency and period, to be measured and circuit adjustments made. The 3060A's functional testing capability extends to digital pattern, analog and combined circuits. For example, the 3060A can be used to test a D/A converter by applying digital patterns and then monitoring the analog output voltage.

At-speed testing of microprocessor boards.
The big news in PC board testing is the microprocessor. Conventional digital testers do not have the massive data storage required to test microprocessors. But the HP 3060A uses an HP developed technique called Signature Analysis to test these microprocessor boards at operating speed. The 3060A collects lengthy bit streams at circuit nodes and converts them to short, four-character hexadecimal signatures. Under test, the bit stream signature at each circuit node is compared to the expected value, making it easy to locate nodes with faulty signatures. This data compression technique makes microprocessor-board testing manageable. Company after company is becoming convinced that HP's signature analysis technique is the right solution to testing microprocessor boards.



For complete details.
There are other benefits to PC board testing with the HP 3060A. To get complete details, send for our HP 3060A data sheet, or contact your HP field engineer.

* Domestic U.S.A. price only

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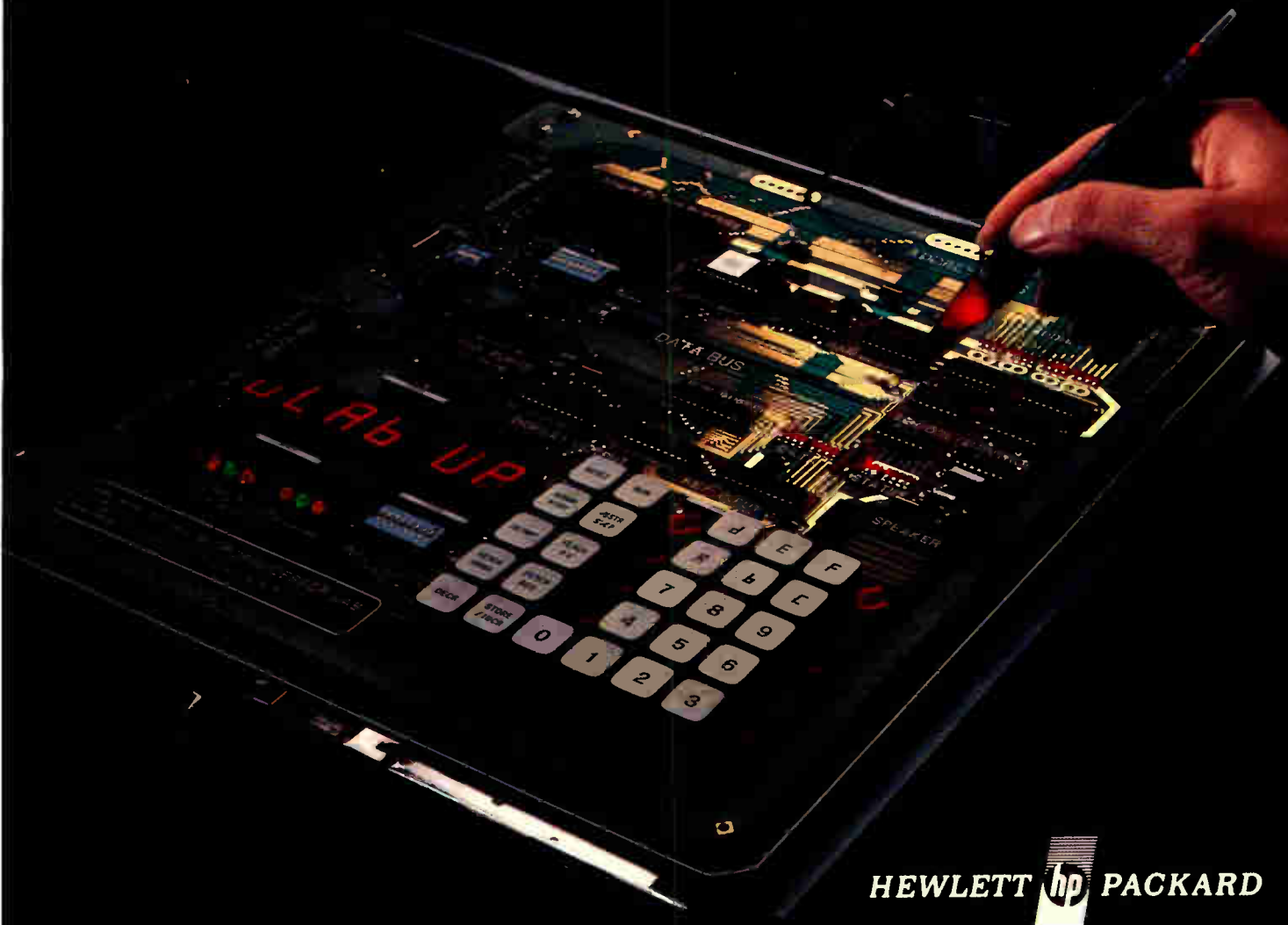

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Circle 2 on reader service card

Electronics
The International Magazine of Electronics Technology
Vol. 52, No. 13 • June 21, 1979

Highlights

Cover: Discouraging the data thief, 107
Large-scale integrated circuitry is the best way of implementing the IBM-developed and Government-sponsored data encryption standard. Commercial users like its reasonable cost, and even critics concede the code is reasonably hard to break.

Cover is by Ann Dalton.

Thin-film heads double disk density, 86
Ferrite heads seem likely to follow core memories into obscurity, as IBM Corp. and other manufacturers of disk drives switch over to smaller, thin-film types.

How to cut microprogramming time, 121
Build a writable control store—a development tool consisting of microprocessor-controlled random-access memories and capable of communicating with any software development system.

The news inside a real-time 1-GHz scope, 131
An upgraded monolithic process, special packages linked by unique connections, and ingenious linear circuit design are all needed to display subnanosecond events without sampling.

. . . and in the next issue
First part of a two-part article on field-programmable logic . . . SAW technology surveyed . . . parallel processing in minicomputers: first of two parts.

Electronics

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50 YEARS

Publisher's letter

Computer crime, in which a clever thief rips off banks and other institutions by getting the machines to steal, often emerges in the news media as an amusing scam pulled off by an electronics age Robin Hood. But breaking into data files is not a laughing matter—this form of crime is costing millions.

A solution to this problem is data encryption now made possible by the preparation of a national Data Encryption Standard (DES) and the development of data communications equipment to implement the standard. As a result, the market for this equipment and the digital integrated circuits crucial for making data encryption possible is about to explode.

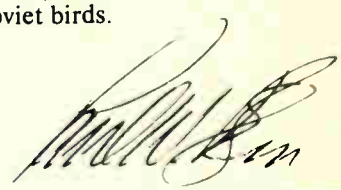
The special report on data encryption in this issue (p. 107) discusses the new standard and how it is being realized. It also describes how the National Bureau of Standards determines that equipment meets the standard before certifying it. Although the chip makers and the hardware producers are off and running, there's still some controversy surrounding the potential for cracking the DES algorithm, according to communications and microwave editor Harvey Hindin.

"The DES appears to be secure for now, but technology will catch up and eventually it may be cost-effective to break the code. It depends on how much the code breaker wants to spend," Harvey explains.

The national campaign to stop litter bugs may have to move into space as well. "The simple fact is we have been slovenly in our satellite programs," Harvey Hindin comments. His probing the news story about space junk (p. 96) underscores that the Skylab crash expected shortly is only one part of the problem.

The junk accumulated over the years and still floating around in space is the main problem. The chances of a newly launched satellite running into the litter are increasing.

Even one of the solutions—sending a space craft to sweep up—has touchy ramifications, says Harvey. It seems the Russians are concerned that a U. S. garbage collector could be used as a cover for a satellite destroyer that would knock out Soviet birds.



June 21, 1979 Volume 52, Number 13 102,593 copies of this issue printed

Electronics (ISSN 0013-5070). Published every other Thursday by McGraw-Hill, Inc. Founder: James H. McGraw 1860-1948. Publication office 1221 Avenue of the Americas, N.Y., N.Y. 10020; second class postage paid at New York, N.Y. and additional mailing offices.

Executive, editorial, circulation and advertising addresses: Electronics, McGraw-Hill Building, 1221 Avenue of the Americas, New York, N.Y. 10020. Telephone (212) 997-1221. Teletype 12-7960 TWX 710-581-4879. Cable address: MCGRAWHILL NEWYORK.

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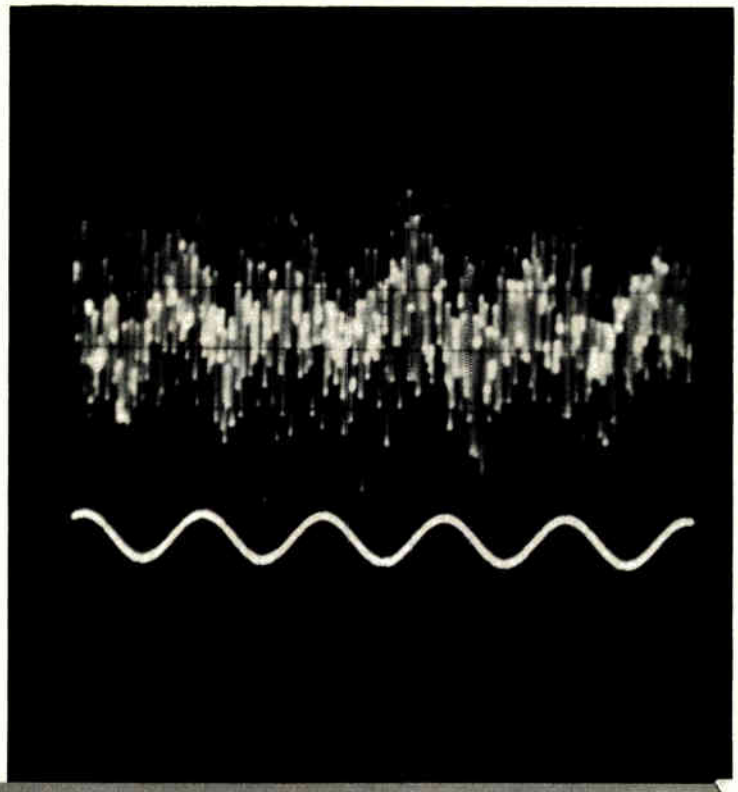

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Readers' comments

Dangerous but useful

To the Editor: With respect to "Unspecified 8085 op codes enhance programming" by Dehnhardt and Sorensen [Jan. 18, p. 144] and the subsequent letter by Reich [Readers' Comments, March 15, p. 6], I agree that it is dangerous to use operating codes that are not fully supported by the manufacturer. Nevertheless, some of the codes discovered by Dehnhardt and Sorensen rectify some long-standing weaknesses of the 8080 and 8085, particularly with respect to 2's complement numbers, and perhaps should be supported by the manufacturer.

In the article, the authors suggest no useful function for the flag bit designated X5. It does, however, provide a very useful function—namely, the true sign of the result when the operands of an addition, subtraction, or comparison are 2's complement numbers.

The current 8085 instructions, such as JP (jump on positive) and JM (jump on minus), test the apparent sign of the result and not the true sign. This can lead to serious programming errors, since the branch may be opposite to what is expected.

The true sign of the result is given by V ⊕ S, where V is the 2's complement overflow indicator and S is the apparent sign of the result.

In addition, the V flag is not available in the standard 8085 and would be difficult to compute. Also, the trap on overflow instruction (RSTV) discovered by Dehnhardt and Sorensen is clearly very useful. Finally, the instructions JX5 and JNX5 perform the functions "jump on less than zero" and "jump on greater than or equal to zero," respectively.

M. R. Ito
Vancouver, Canada

Correction

The photograph printed along with the story on Irwin Federman, president of Monolithic Memories Inc., Sunnyvale, Calif. (May 24, p. 14) was not that of Mr. Federman. Instead, it was that of Charles L. Wood, president of Electronic Arrays Inc., Mountain View, Calif. (see p. 14 of the June 7 issue).

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MWS5101EL-8	500	450	5	0 to +70	2.84

RCA

Circle 7 on reader service card

News update

■ It is clear that one of the more important lithography systems of the 1980s for integrated circuits will be the step-and-repeat reduction-projection mask-to-wafer aligner. Still, when a company that is based in the tiny central-European nation of Liechtenstein announced a very advanced wafer stepper [*Electronics* April 12, p. 110], some skeptical eyebrows were raised, particularly those of that firm's competitors.

The company is Censor Inc. and its $450,000 machine is called the SRA-100. The specifications of the 10:1 stepper include resolution of 1 micrometer, autofocus, and autoalignment. Also, the SRA-100 boasts through-the-lens alignment at each step to give a registration accuracy to within ± 0.2 μm at a 2-sigma probability. Throughput is 60 4-inch wafers per hour. The company also said that the first SRA-100 will be assembled at its Reno, Nev., plant in time to be demonstrated at Semicon West in 1980.

It appears that, for the time being at least, Censor is confounding its doubters. Werner Tabarelli, president, says, "We already have firm orders for two machines and options on six more. We plan to assemble the first five machines in Europe and then shift to assembly in the new Reno plant."

On the road. Tabarelli's firm has now passed several important milestones in the assembly of its first machine. For instance, an autoalignment accuracy to within less than 0.1 μm has been demonstrated. Also reached, he says, is the 60-wafers-an-hour throughput total. Finally, a temperature stabilized (± 1°F) reticle storage system capable of holding 15 units and a precision wafer chuck also have been constructed and demonstrated. Life tests are currently being run on all the drive motors for positioning the various components of the system.

Two important milestones are due to be reached at the end of the year. In October, Carl Zeiss and Co. is scheduled to deliver a 436-nanometer light source and, in December, an ultraprecise lens system for the SRA-100. **-Jerry Lyman**

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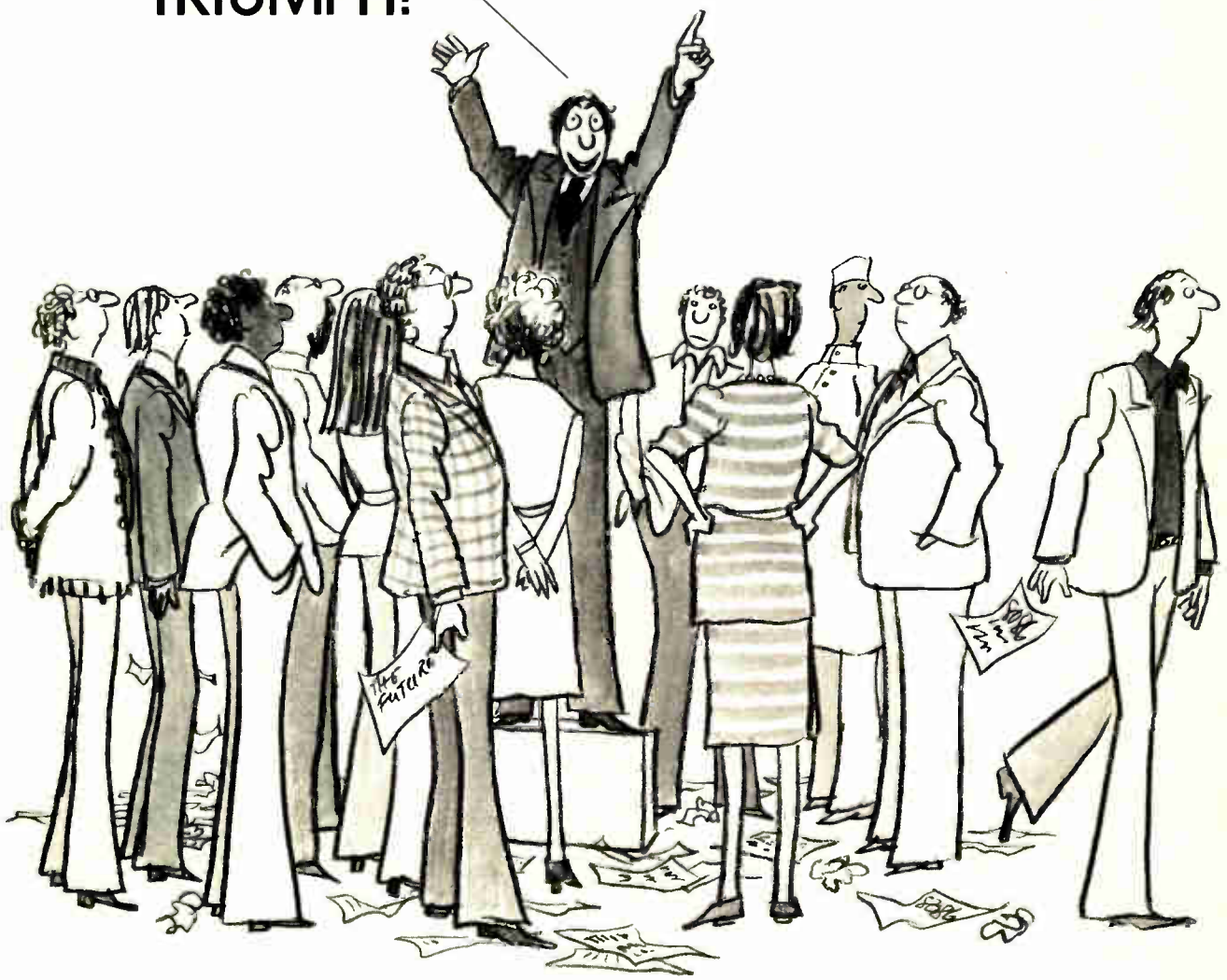

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The 8086 isn't the best 16-bit CPU.

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

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What makes the 5582 so revolutionary is the fact that it's really an evolution. It's the latest in a long line of Xincom memory test systems. Like all Xincom systems, it's based on proven distributed architecture. And unlike most new systems, it won't make you suffer through long, expensive software development. That's because it's fully compatible with the existing Xincom III software base. This is part of Fairchild's commitment to protect your software investment. That's a big savings when you consider that 75% of your total testing cost is software-related.

The 5582 can handle functional and parametric testing and can be used in both engineering and production. It can test up to four devices in parallel or can be used with one or two test heads in a time-multiplexed mode.

The Xincom model 5582 gives you a true 25 MHz. It has no limitations or compromises that reduce test speed. Its fully digital timing system gives you inherently stable and accurate pulse definition. The 5582 is the solution to your high-speed testing needs for today and for tomorrow.

The Xincom 5582 is backed by the largest service and support team in the industry. Worldwide training. Over 20 major field service centers in the U.S., Europe and Asia. And a global network of applications specialists to help you get the most from your Fairchild system.

No one else has such an evolutionary 25 MHz memory test system. And no one else can offer as thorough support. But then, no one else has such a good reputation to maintain.

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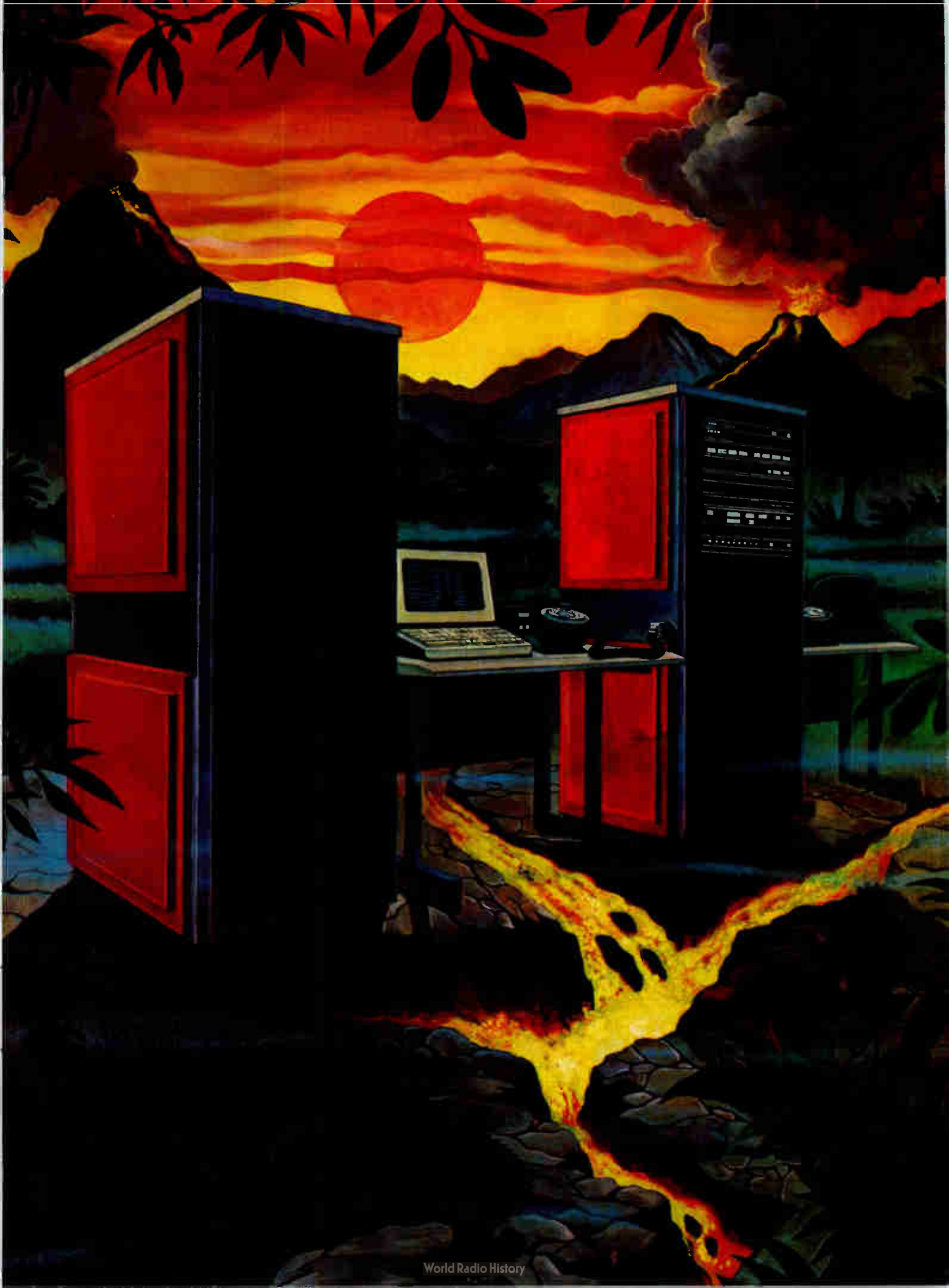

People

O'Donnell heads Litton division handling program for Saudis

Even in the middle of today's boom, a near-$300-million-a-year electronics operation that springs up overnight receives attention. And Litton Industries' new Data Command Systems division in Calabasas, Calif., created just last month to handle a $1.64 billion program for Saudi Arabia, is already attracting equipment suppliers on the scent of $600 million in contracts.

"Our procurement group is very popular," drily observes Thomas M. O'Donnell, the veteran military electronics executive tapped to be the division's president. With nearly 20 years spent marketing Litton's command and control systems, he is one of the best-known (and best-liked) figures in a particularly tough field, where R&D bugs and spiraling costs conspire to chew up managers.

Five years. But O'Donnell denies the "instant nature" of his division, pointing out that five years of preparation and selling to the Saudis went into getting the contract. A turn-key project for command, control, and communications, it is intended to automate all Saudi air defense, making it into a single countrywide net, and to serve civilian purposes as well. "This means we design, buy, integrate, install, and test it, besides training Saudi nationals to run it," says O'Donnell.

What pleases him and the corporate brass is that the new division does not have to manufacture a thing. Instead, it will buy state-of-the-art hardware. The only Litton equipment slated for use is a sister division's AN/TSO-73 missile controller. Other major pieces are radar, a troposcatter long-range communications system, and radio gear for each of six regional centers to cover all of Saudi Arabia, an area as big as the United States east of the Mississippi River. "It will not only serve air force needs, but those of the entire government," O'Donnell says. "We're putting in 72 channels and can also handle television."

Most of the design work is done.

Contractor. With $600 million in contracts, Thomas O'Donnell's division is popular.

"Staffing is the initial hurdle," he says. He will hire key deputies from other Litton divisions, but with 100 engineers and technicians needed by July 1, and 400 at the peak of the six-year program, he has to attract more people quickly. About 300 will be sent to Saudi Arabia, to which O'Donnell expects to travel 6 to 10 times a year.

At Bell, Penzias seeks new computer interfaces

The typewriter is an outmoded machine that many find difficult to use, says Arno A. Penzias, newly appointed executive director of the Research, Communications Sciences division of Bell Laboratories. Thus, one of the important tasks undertaken by the computer systems research laboratory, one of four division laboratories Penzias oversees from his office in Crawford Hills, N. J., is to find a better way of communicating with computers.

"It takes no genius to know that everything is going digital, so we must get closer to computers," says the 46-year-old 1978 Nobel laureate. "The problem is the human-to-machine interface—it's a bottleneck."

Penzias has a message here that is applicable to almost all electronics research: simply improving technology in a vacuum is not enough. "We have to start studying human beings," he says.

Verbal communication with com-

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People

New factor. Electronics will change the keyboard-display boundary, says Penzias.

puters is far from reaching the desired level of precision, he says. One division at Bell is working on such problems as speech recognition and speech synthesis by computers. But despite the extremely complex work the researchers are doing, computers remain capable of only the simplest recognition tasks, according to Penzias.

This comes as no surprise, given the complexities of speech recognition. "If *people* can't get my name right . . . ," says the Hungarian-born scientist, leaving the hazards it poses for a voice-recognition system to the listener's imagination. "So for a long time we'll be 'typing' to communicate with computers—but it doesn't have to be on typewriters."

And what will replace the typewriter? The key, Penzias thinks, may be to blur the "distinction between keyboard and display. The boundary is one that electronics will change." Something along the lines of the flat display and the flat keyboard of the latest hand-held calculators may be an answer, he conjectures.

Besides the computer systems lab, the 18-year Bell veteran oversees the radio, guided-wave, and electronics labs, which have about 200 researchers. He will combine his own research in radio astronomy with administrative duties. His Nobel prize was for his 1964 discovery, with co-worker Robert Wilson, of residual microwave radiation from the cosmic explosion that formed the universe. □

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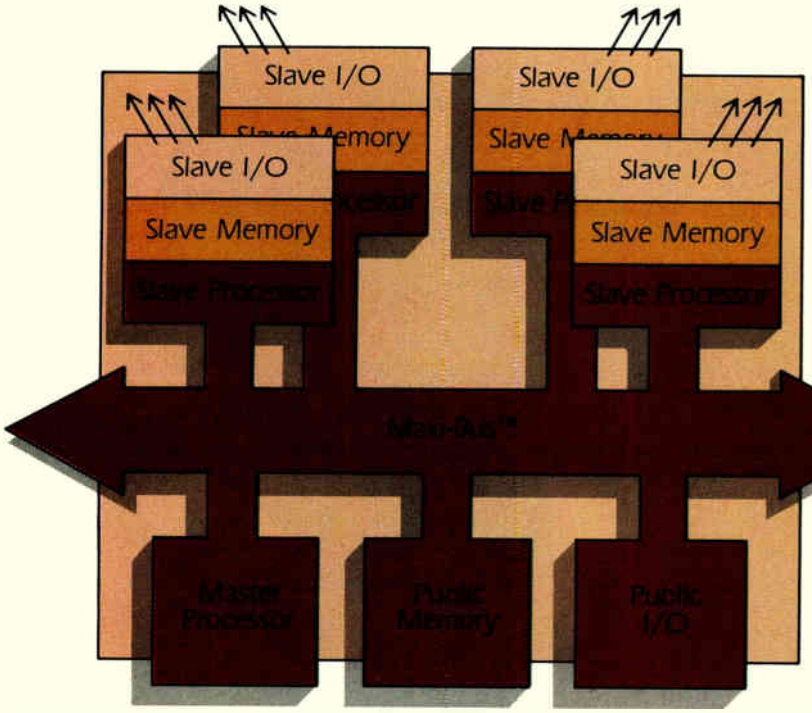

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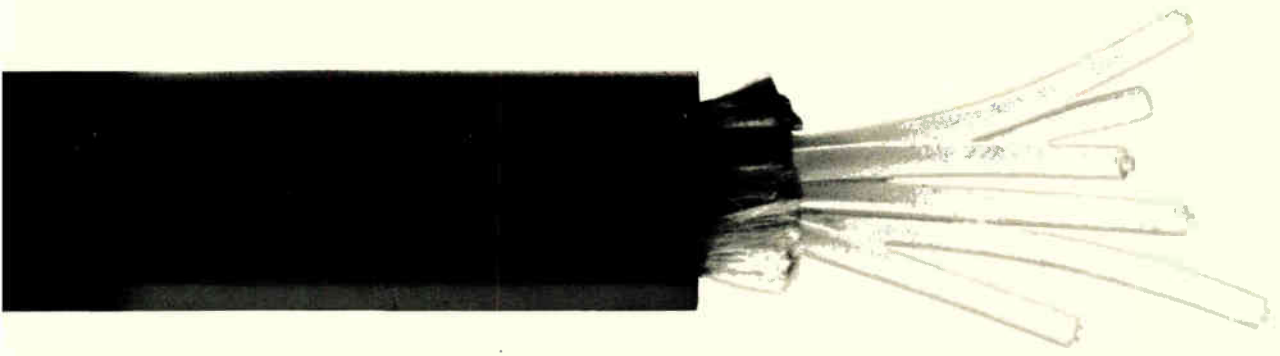

As our Quality Control Engineer, Mr. Armstrong is responsible for checking the quality of not only our fiber and cable, but of every optical component we make. Like so many before it, that milestone 3,000th mile went into the completion of another of the numerous complete systems built by ITT. To meet our standards, it had been proof tested over its entire length at 100,000 psi or greater to ensure high strength for ease of handling and assured long term durability.

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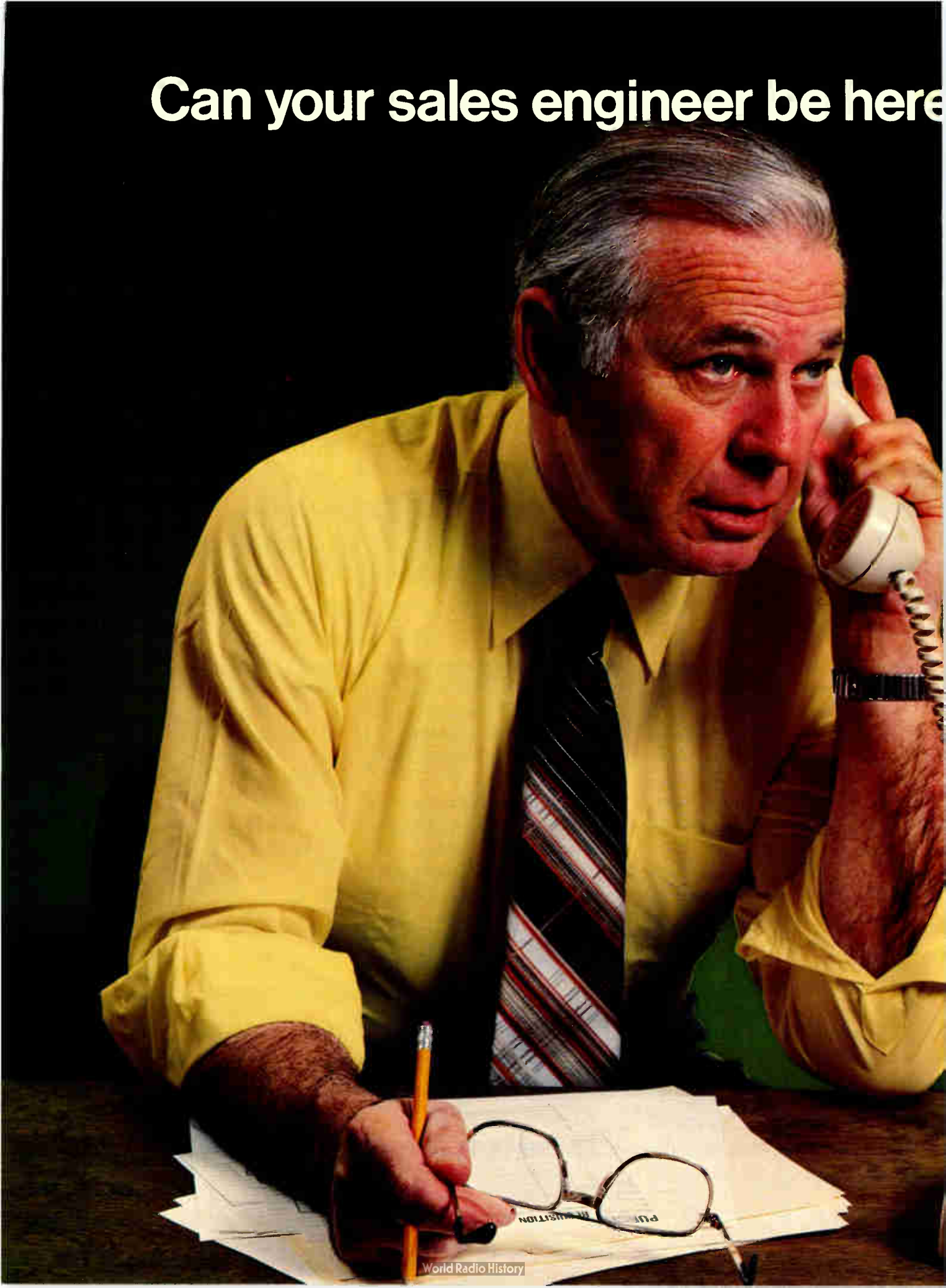

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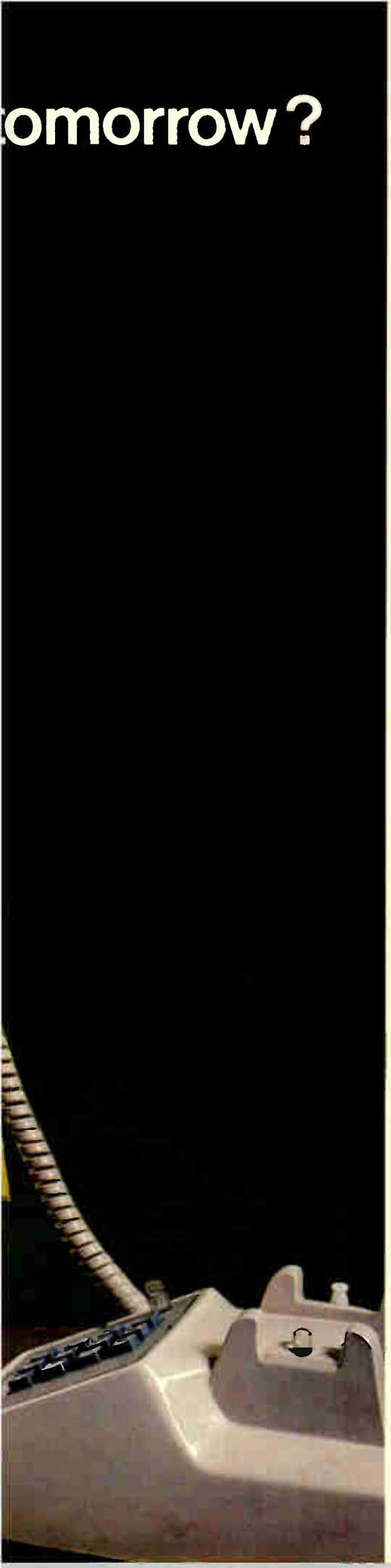

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Editorial

Privacy: the undoing of computers?

At the National Computer Conference held recently in New York, it was easy to sense the robust nature of the business and the feeling that this is where it's at these days—"it" being the leading edge of technology, the powerful determining force in electronics.

But now is a good time, before the glow wears off, to take a look at what society thinks of computers. Like it or not, computers have become so pervasive that the public in general and law makers in particular have become concerned and even alarmed about the misuse of computing power, with its attendant invasion of privacy.

There is a good reason for this concern. In fact, according to Alan F. Westin, professor of public law and government at Columbia University, computer company executives seem even more worried about the abuses of computer power than the public. A nationwide survey conducted by Louis Harris and Associates of New York for Sentry Insurance Co. showed them to be—though more willing than the public to accept the need of organizations to collect information—more convinced than the public that Americans surrender their privacy when they apply for credit or open a charge account. What's more, computer executives strongly reject the notion that those who complain about invasion of privacy have something to hide.

In short, the Sentry survey indicates that computer executives are ahead of the public in recognizing the dangers of unchecked use of computers. They are also more willing than the public to insist, at least verbally, on new policies or laws to protect privacy in the private sector—many want detailed and comprehensive legislation now. But very few of them are willing to guarantee immediate privacy protection—against outside credit checks, for instance—for their own employees, before legislation requires it. This last point suggests a disturbing dichotomy.

For if the computer producers who have done such an impressive job of developing and marketing data processing are ahead of the public in recognizing the social dangers, why are they not in the forefront of devising protection? Though they understand the computer data base better than the general public or the Congress, they seem reluctant to act on their better instincts.

There are good reasons for the computer industry to take the lead in privacy protection. For one, no one knows what kind of legislation lawyers in Washington might get into the books if they do not have some kind of technical guidance from the industry.

But the most significant revelation of the survey is that public attitudes toward computer technology are a direct reflection of attitudes toward the institutions making use of this technology. This should be a warning to the computer industry, as well as to computer users and would-be policy makers. In this day of general distrust—of the Federal Government, the oil industry, and so on—hostility toward institutions is being directed at the computers they operate. Many feel that technology is out of hand and that Orwell's 1984 has already come to pass.

It is in the best interests of the leaders of the computer industry to take this fact into account and to do their best to clarify these overlapping issues. Otherwise, public reaction may well demand restrictions on computers. As Westin points out, "such orientations will not be easily changed by better communications campaigns or patchwork privacy laws."

Westin suggests the need for "new mechanisms of individual participation and protection in the use of organizational data systems, especially the automated ones and the large networks." No one yet knows what these steps might be. But it behooves the computer makers to continue discussing the problems and to seek the solutions.

OHIO SCIENTIFIC DOES IT AGAIN

Ohio Scientific has taken its standard Challenger III computer and married it to the new Shugart 29 Megabyte Winchester Drive. The result is the C3-C. This new microcomputer now fills the vacuum that existed for computer users who need more mass storage capability than floppies can offer – yet until now, could not justify the additional cost of a larger capacity hard disk computer such as our C3-B 74 Megabyte disk system.

Winchester Technology

Winchester hard disk drives offer small business and professional computer users the logical solution to mass storage problems that are beyond the capability of floppy disks. In addition, Winchester disks feature a track seek-time that is much better than floppies and because they spin at eight times the rate of floppies, Winchesters have a shorter latency. Both of these points reflect one remarkable speed advantage Winchester disks have over floppies.

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Ohio Scientific's award winning Challenger III computer is a classic. It is the only computer series that utilizes the three most popular microprocessors – 6502A, 68B00 and Z-80. This tremendous processor versatility enables one to utilize a seemingly endless selection of quality programs available from Ohio Scientific's software library as well as from many independent suppliers.

And Advanced Software

For instance, there are single user, multi-user and network operating systems. A complete turnkey small business package, OS-AMCAP provides accounts receivable, accounts payable, disbursements, cash receipts, general ledger, etc. OS-CP/M offers a complete FORTRAN and COBOL package. And there is WP-2, a complete word processing system. For information management, OS-DMS, features an advanced file handling system and program library that simplifies information storage and recall and routinely performs tasks which usually require special programming on other systems.

Yields the Microcomputer of the Future

With an eye toward the future, the C3-C, like all other Challenger III's was designed with provisions for future generation 16 bit microprocessors via plug-in options.

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Meetings

ence, IEEE, Capital Hilton Hotel, Washington, D. C., Sept. 4–7.

Second International Fiber Optics and Communications Exposition, Information Gatekeepers Inc. (Brookline, Mass.), Hyatt Regency O'Hare Hotel, Chicago, Sept. 5–7.

25th Annual Holm Conference on Electrical Contacts, Illinois Institute of Technology (Chicago), Palmer House, Chicago, Sept. 10–12.

Dielectric Materials, Measurement and Applications Conference, Institution of Electrical Engineers (London), University of Aston, Birmingham, England, Sept. 10–13.

Fall Conference of USE Inc., USE Inc. (the organization for those who use Sperry Univac's series 1100 computers, Bladensburg, Md), Diplomat Hotel, Miami, Fla., Sept. 10–14.

Ninth European Microwave Conference, Institution of Electrical Engineers (London), The Brighton Centre, Brighton, Sussex, England, Sept. 17–21.

Wescon/79 Show and Convention, IEEE and Electronic Conventions Inc. (El Segundo, Calif.), Brooks Hall and St. Francis Hotel, San Francisco, Sept. 18–20.

Autotestcon—Automatic Support System for Advanced Maintainability Conference, IEEE, Radisson Hotel, Minneapolis, Sept. 19–21.

Telecom '79—Third World Telecommunications Exhibition, International Telecommunications Union, Palais des Expositions, Geneva, Sept. 20–26.

Short courses

Pascal Programming for Mini and Microcomputers, The Ramada Inn, Woburn, Mass., Aug. 13–17 and Oct. 22–26. For information, contact Prof. Donald D. French, Institute for Advanced Professional Studies, One Gateway Center, Newton, Mass. 02158, or telephone (617) 964-1412.

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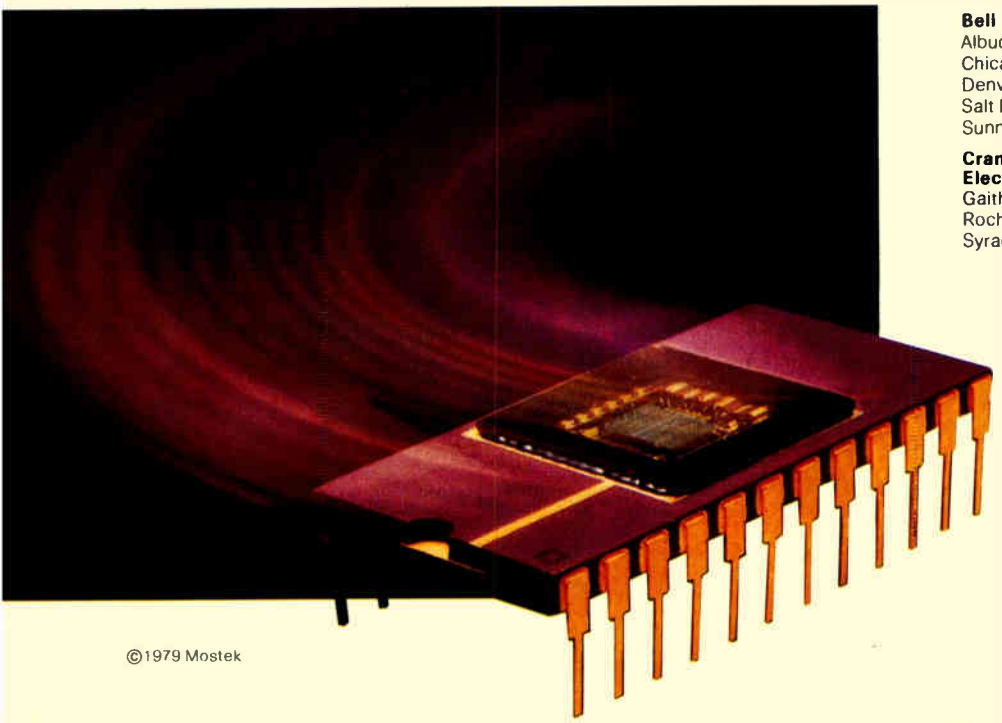

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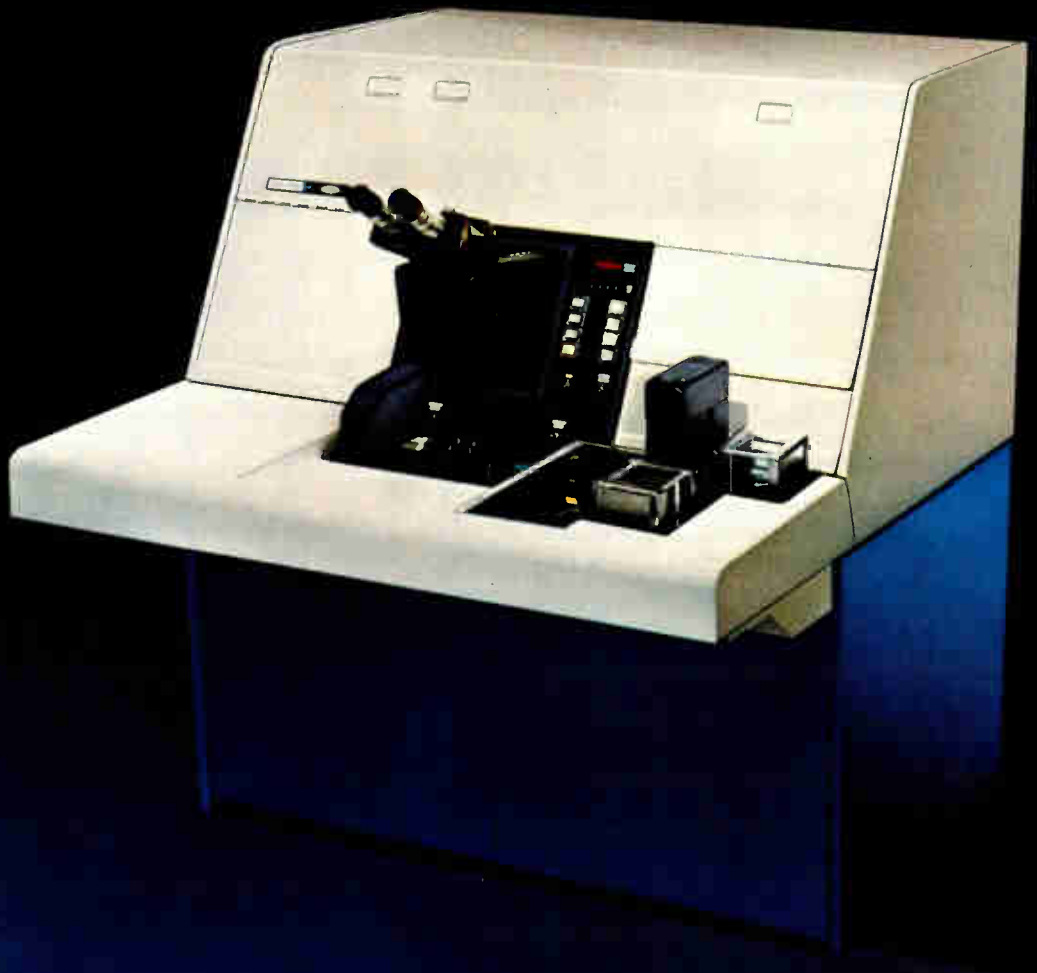

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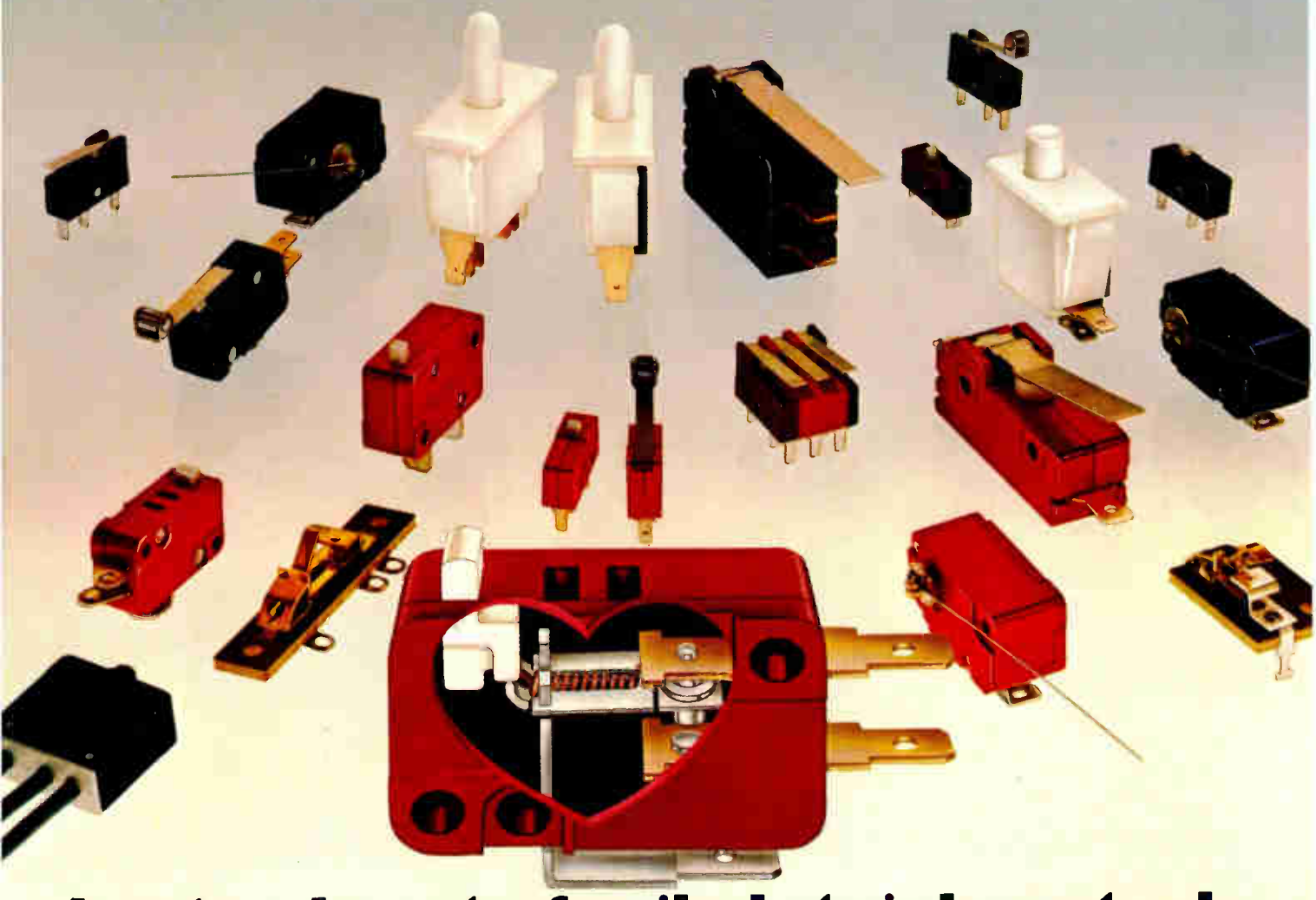

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Electronics newsletter

RCA passes Zenith to become No. 1 in color TV sales

The historic rivalry between color television assemblers RCA Consumer Electronics and Zenith Radio Corp. may shift dramatically in 1979: observers say industry leader Zenith has lost market share while RCA has gained to take over first place. **Total industry shipments to dealers in 1979 are down slightly from last year's rate** (see p. 57), but RCA's division general manager, Jack K. Sauter, says his unit sales are up a whopping 14%. Zenith concedes that its shipments have declined and that it may have lost position earlier this year because of some quality-control problems with its smaller units. But Zenith Sales Co. president Walter Fisher says, "I have no doubt we'll regain our position as No. 1."

Merrill Lynch sees 1980s shakeout for semiconductors

A just-published forecast for the semiconductor industry in the 1980s paints a sobering scenario for many companies. Among the prognostications in the $150-a-copy study by Merrill Lynch Pierce Fenner & Smith Inc.: stabilization of chip prices marked by a gradual departure from "learning curve" price reductions, and a trend toward more proprietary products for greater profit margins. In other words, **the semiconductor houses will begin looking like today's computer companies.**

The Wall Street firm's most extreme prediction is for a shakeout, with the ultimate emergence of **an oligopoly comprising Advanced Micro Devices, American Microsystems, Intel, Mostek, Motorola, National Semiconductor, and Texas Instruments.** Regarding Japan, Merrill Lynch expects Japanese penetration of the U. S. market to be more than compensated for by the easier access of U. S. chip makers to the Japanese market.

Motorola, Rockwell to sign deal on bubbles and 68000

Motorola Inc.'s Semiconductor Group will be the domestic second source for Rockwell International Corp.'s 256-K bubble memory devices. The companies confirm that they are negotiating, and it is believed that an agreement is all but signed, with only details on support devices to be worked out. In return, Rockwell's Microelectronic Devices division **is expected to build Motorola's forthcoming 16-bit microprocessor, the 68000.** The agreement will follow Rockwell deals with Siemens AG of West Germany, covering worldwide production and marketing, and with Burroughs Corp., which will build the bubble devices for its own use.

IBM disk details surface; 'Whitney' coming

Disk drive manufacturers, preparing for the next generation of peripherals (see p. 83), spent time at the National Computer Conference piecing together some of the technical details of IBM's upcoming offerings in the field. They say its new top-of-the-line 571-megabyte model 3370 drive, to be delivered in the last quarter of this year, has dual actuators that allow data at two different locations to be accessed simultaneously. **A drive code-named Whitney is expected to follow; it will use a two-stage positioning mechanism to achieve 1,000 tracks per inch and store 1 billion bytes.**

E-PROM houses seek to catch TI, Intel at 64-K level

As manufacturers scramble to cash in on the profitable market for single-supply erasable programmable read-only-memory parts, many are looking to the 64-K level as a place to catch or leapfrog 32-K leaders Intel Corp. and Texas Instruments Inc. While most are expected to go with a 28-pin package at the 64-K level based on one of two competing standards, Motorola's strategy will be different. Engineers at the company's Austin,

Electronics newsletter

Texas, Integrated Circuit operation are working on a 64-K E-PROM **to be housed in a 24-pin package that is plug-compatible with many present generation 64-K ROMs.** Despite the fact that Motorola is not yet shipping fully specified 16-K E-PROMs, officials indicate that the firm expects to have both the 16-K and 64-K parts available before year-end, with a compatible 32-K E-PROM to follow in early 1980.

CCD shortage helps RAMs gain ground

Although both Storage Technology Corp. and Memorex Corp. have shipped the first units of their peripheral memory systems based on charge-coupled devices, a shortage of the CCD parts has forced both to plan random-access-memory versions as well. Jessie Aweida, president of STC in Louisville, Colo., says a RAM version of its 4305 fixed-disk replacement will be ready later this year. **But since there will be no difference in price or performance, customers probably won't know which one they'll have been given.**

Exxon says it backs Zilog despite problems

Is money-losing Zilog Inc. for sale? No way, says Donald L. Spalinger, contact executive between the Cupertino, Calif., microcomputer maker and parent Exxon Enterprises. "There is no intention by Exxon Enterprises of selling Zilog off," Spalinger emphasizes. He adds that **"Exxon is very high on Zilog; the company has a tremendous future."** However, Spalinger says that Zilog lost "under $6 million" last year on sales of either $15 million–plus or $18 million–plus, depending on which accounting system is used. The company's losses since 1975 total under $10 million, less than those of any other Exxon Enterprises venture, he states.

Zilog's problems have been in management, morale, manufacturing, and mix of products, all of which Spalinger waves off as normal for a rapidly expanding company. But Charlie Bass, Systems division general manager [*Electronics,* Jan. 4, p. 14], this month became the latest in a string of executives who have left the company this year. Also not helping is a recent $5 million damage suit by National Semiconductor Corp. alleging that Zilog has confidential information on National's upcoming 16-bit microcomputer. Zilog lost the first round June 8 when a Santa Clara County, Calif., Superior Court temporarily enjoined it from disseminating any of the information. Zilog plans to appeal.

Addenda

Joining the data-encryption-standard chip race (see p. 107), American Microsystems Inc. of Santa Clara, Calif., **is scheduled to introduce its version—the S6894—within 30 to 60 days.** . . . A new line of $12,000 solid-state chart recorders using a direct-writing polarized-light technique **will be price-competitive with galvanometer units, says Bell & Howell Co.'s CEC division.** . . . Hewlett-Packard Co.'s first-half orders came to $1.22 billion, up 39%, says president John Young, while net earnings were up 37% to $94.7 million. However, he told a group of New York securities analysts that he expected a second-half slowdown in the U. S. economy that could continue well into 1980. **This slowdown could enable HP to reduce its order backlog, which grew another $60 million in the first half** despite an aggressive shipping program. A major contribution to the backlog was production stymied by shortages of components such as low-power Schottky parts, but HP's semiconductor suppliers are already seeing an order slowdown, which they feel could relieve the pinch.

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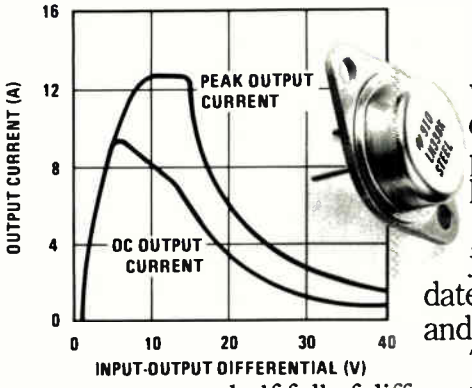

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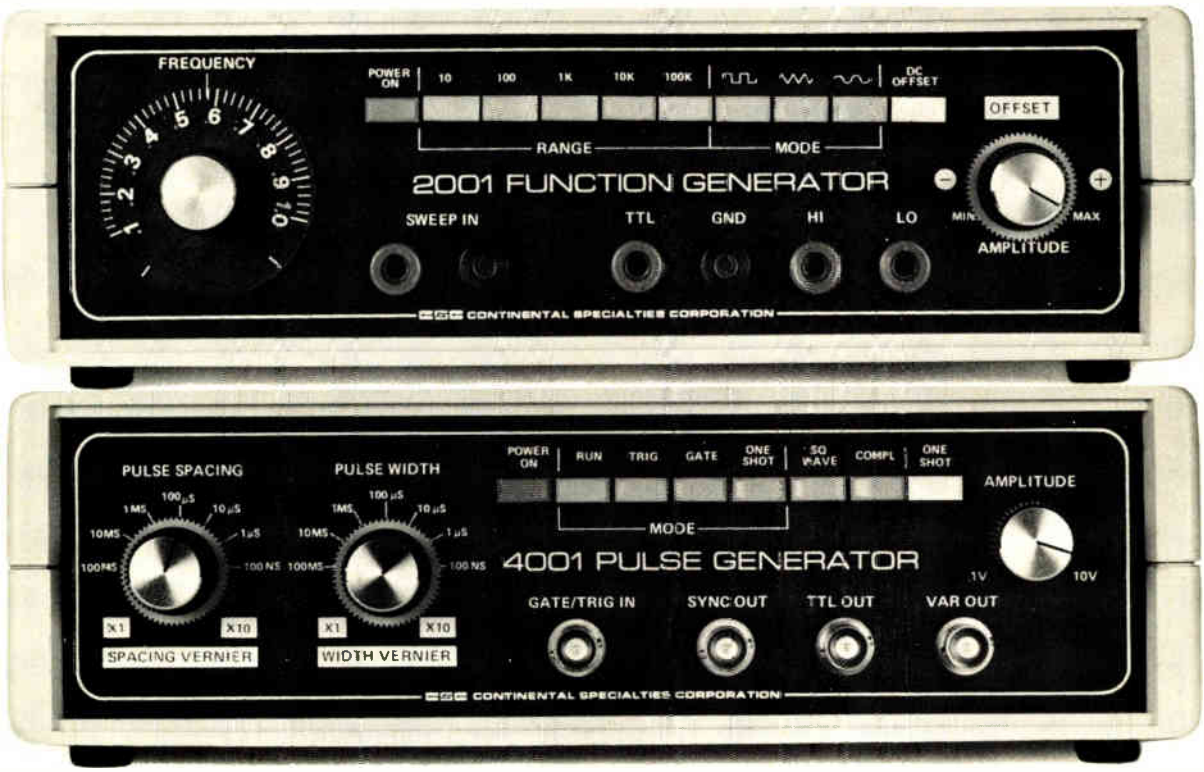

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Winchester drive comes equipped with its own tape backup

by Anthony Durniak, Computers Editor

Tape capacity surpasses fixed disk's in combination unit about the size of a floppy disk from Microcomputer Systems

How to use removable recording media to back up the fixed-in-place disks of the Winchester drive may pose the biggest obstacle to the drive's general acceptance by small computer users. For though the Winchester records more in less space than removable drives, that advantage is quickly dissipated when it must be supported by bulky and expensive equipment.

Enter Microcomputer Systems Corp. with an unusual solution: a Winchester disk drive that comes equipped with its own tape backup. And in one model of its new equipment, the Sunnyvale, Calif., peripherals controller maker even uses the same mechanical drive for the disk and tape. The result in the MSC-8000 is a compact, high-capacity unit with a ½-inch tape drive on the same motor spindle that spins three 8-in. disks. Forty megabytes of fixed disk with 25 milliseconds average access time and 80 megabytes of removable tape occupy as little space as a standard 8-in. floppy-disk drive.

This prototype unit was certainly the most unusual of the half-dozen 8-in. disks shown at this month's National Computer Conference in New York (see p. 83). Microcomputer Systems combines tape and disk drives in its larger MSC-5900, also brought to the show [*Electronics*, May 24, p. 197]. This unit, which uses separate mechanical drives, weds a 17.1-megabyte tape cartridge drive to a 14-in. Winchester drive that holds between 12.5 megabytes and 87.8 megabytes.

Reliability. With nonremovable disks, the IBM-developed Winchester drives have had considerable success applied to large-scale computer systems; because they are sealed they offer higher reliability than removable disk drives. Some 18 months ago they began to be scaled down in size and price for small-computer users. But backing them up with units to copy and remove important information for safe keeping has been a problem solved until now with either removable disks or tape.

James Toreson, president of Microcomputer Systems, points to another advantage of his combination MSC-8000 unit: "The removable [tape] media stores more than the disk [it is backing up]." Most other backup schemes for fixed disk, such as cartridge tapes or floppy disks or even that in Toreson's own MSC-5900, hold only a fraction of the information that the fixed disks hold, so that several packages of media must back up one disk drive, which increases backup time.

In addition, Toreson explains that his tape drive can record data at 750 kilobytes per second, almost matching the 1.2-megabyte-per-second

Togetherness. To achieve backup, the prototype Microcomputer Systems MSC 8000 drive is designed to place a rotary tape head (center) on the same spindle as three 8-inch disks.

transfer rate of the disks and thereby reducing the amount of buffering needed and further speeding up the backup procedure. To accomplish this, Microcomputer Systems uses a rotating read/write head similar to those used in video tape recorders. The tape is held still while the rotating head (which is attached to the disk spindle) writes 50 longitudinal tracks on a tape section. When the section is full, a small motor advances the tape in what Toreson calls a paging operation. Holding the tape still while recording also eliminates mechanical phase jitter, Toreson says, allowing tape recording densities of 6,400 bits per inch.

Although the hybrid tape/disk drive is the most intriguing device in the MSC-8000 series, Toreson also unveiled a high-capacity 8-in. six-platter, disk-only drive that stores up to 110 megabytes and has the same transfer rates, average access time, and recording densities of 8,500 bits and 510 tracks per in. And his plans call for a tape-only system that uses the same rotating head technique with cartridges of 2-in.-wide tape and a storage mechanism to hold multiple tape cartridges. Such a system could store as much as 11 billion bytes in a unit about twice the size of a portable microwave oven, he estimates.

Toreson, a former computer designer from Hewlett Packard, founded Microcomputer Systems almost five years ago to sell to original-equipment manufacturers. The privately held company is expected to achieve revenues between $14 million and $16 million for its current fiscal year.

It is currently looking to license its new drive to OEMs for manufacture. Prices are not yet firm, but Toreson hopes to market the device in OEM quantities for under $3,000—a savings of $1,000 to $2,000 over the prices now being quoted for separate 8-in. disks and tape units. Toreson also has plans for building the drive in house starting this fall, with volume production by early 1980. He has especially big plans for the hybrid tape/disk drive. "We feel we'll get at least 50% of the 8-inch market," he says.

Solid state

Fast RAMs aimed at bit slice processors arrive with 1-K-by-4-bit organization

The plot of very fast static random-access memories is thickening. Intel Corp. has made the latest move with the introduction of a 4-K RAM that is organized as 1,024 by 4 bits [*Electronics*, May 24, p. 33]. It is called the 2148—to play off the Santa Clara, Calif., company's popular 2147 RAM that is in a 4-K-by-1-bit arrangement—but there is more to the new device than meets the eye.

The new RAM with a 55-nanosecond maximum access, may have the widest appeal yet of any high-speed memory part. The reason is that, in addition to the minicomputer and mainframe builders who need fast RAMs for cache memories and control stores, there is a new customer—the bit-slice processor maker.

Also aiding quick acceptance of the part is a standard pinout: the 1-K-by-4-bit arrangement has been around for a long time in the form of the 2114, a static RAM originally aimed at microprocessors and slower computers, whose pinout is accorded a standard by the Joint Electron Device Engineering Council (Jedec).

Thus Intel is widening its market for high-speed RAMs. "The 2148 is not a main memory part," explains Barry Cox, marketing manager for Intel's memory components division in Aloha, Ore., "but it can be used for cache memories as well as or better than the 2147. In fact, many customers for the 2148 will be new."

Other contenders. The 1-K-by-4-bit market will get even more interesting in a few months, as other entries appear. Fairchild Camera and Instrument Corp., for example, which makes the 93471, a 4-K-by-1-bit bipolar RAM, will soon bring out a part with the same reverse organization as the 2148.

"It is a natural upgrade from our 256-by-4-bit RAM," explains Stephen Jasper, marketing manager for the Mountain View, Calif., company's bipolar group. "Judging from the orders we've had for the 1-K part, the new 4-K could be the most pervasive part ever—especially since it won't have pinout problems.

What Jasper is referring to is the difference in pinouts between Intel's 2147 and Fairchild's 93471. But although users will not have to decide on pinouts, they will have several other decisions to make when selecting a 1-K-by-4-bit part.

In addition to the choice between bipolar and MOS, there is another issue. The 2148 has an automatic power-down feature—the same one that is on the 2147—which cuts its power automatically when the chip is idle. But this feature can hinder overall system speed.

Though Intel denies any plans to build a non-powered-down version, another company already has: American Microsystems Inc. is in the competition with the 2114H, a part with an access time currently rated at 70 ns; it will soon be improved to 55 ns to match Intel's.

"We've found that users don't want to pay the penalty of a long chip-select access time that power-down parts have," explains T. J. Rodgers, manager of development at AMI's Memory division. "That's why we've considered offering a non-powered-down version of the 2147 as well," he adds.

Buried. The main argument against powered-down parts is that they offer little savings in power dissipation unless used in large arrays, which are not the target of the 2148. Four-bit-wide RAMs are more often found buried in a computer's control architecture or in bit-slice processors. "In those situations, the memory parts are often the limiting factors in a system's speed," says Fairchild's Jasper, "and the designers have little concern for

power dissipation." Still, Intel's Cox counters that users who do not want the power-down feature can just keep the part selected all the time.

Will Intel build a faster 2148 with the scaled-down H-MOS II process used in the 35-ns 2147H? "It would be a natural evolution for the 2148," says Cox. **-Raymond P. Capece**

NCC

More new wares on view at the big show

No doubt about it: this year's National Computer Conference at the beginning of the month was an overwhelming success. An unaudited audience tally indicates that 78,843 showgoers crowded the 521 exhibits in New York City's Coliseum and in spillover space at both the Rockefeller Center Hilton and the Personal Computer Conference in the Sheraton Centre. (That figure includes about 17,000 exhibiting personnel and members of the press.)

Moreover, the American Federation of Information Processing Societies, sponsor of the NCC, reports that the accompanying technical sessions drew well, although a breakdown was not immediately available. While there were no startling announcements at those sessions or the exhibits, showgoers did find a number of new products that received little preshow publicity. Among them:

- Pixnet, an advanced network for distributed data processing, provides what is called a virtual link between an IBM mainframe and remote peripherals by performing device identification that otherwise requires an IBM 370X front-end processor and teleprocessing software. The networking system, from modem maker Paradyne Corp., Largo, Fla., permits any system terminal to address any mainframe in the net.
- The 6520 front-end processor can support four host computers and single-ended multiplexed lines, either asynchronous or bisynchronous, and is directly compatible with IBM's 3704/5 and 2703 front-end units. With higher-level products to come, it marks the entry into the communications processor market by modem and multiplexer maker Codex Corp., Mansfield, Mass.
- Source, a telecomputing network, will give owners of personal computers and small businesses access to more than 2,000 programs and data bases, ranging from TV show reruns and consumer information banks to airline reservations and sophisticated business application packages. The net, a service of Telecomputing Corp. of America, McLean, Va., is open to any machine with a 300-word-per-minute telephone interface and offers electronic mail facilities.
- The 1000/4 and 1000/8 small business computer systems provide multiuser capability for four or eight terminals, which may be dumb or smart. The new models are extensions of the 1000 line introduced at least year's NCC by Lear Siegler Inc.'s Data Products division, Anaheim, Calif.
- ADDS/Vantage, a small business system, is aimed at the user with no computing expertise. It marks the debut of terminal maker Applied Digital Data Systems Inc., Hauppauge, N. Y., in the end-user market.
- Comm-Storr II Communications Storage Unit, a single- or dual-drive diskette system, fits between an asynchronous terminal and a data set to permit storage of received or locally generated messages for future use, editing, or transmission. Marketed by American Telephone & Telegraph Co., it was developed and is made by Sykes Datatronics Inc., Rochester, N. Y.
- The Basic-86 interpreter extends to 16-bit 8086 microcomputer installations the Basic-80 interpreter widely used in 8080 and Z80 applications. Also introduced by Microsoft, Bellevue, Wash., was a compiled version of Basic-80.

With old and new products crowding the stands and the hordes of showgoers crowding the aisles, the

The Japanese have landed

Japanese electronics companies have made it clear for some time that they intend to participate in the U. S. computer market. Judging from the exhibits by more than a dozen Japanese firms at the National Computer Conference and the number of Japanese nationals staffing the booths, they're well on their way.

Leading the list were a number of state-of-the-art peripherals vendors. Canon U. S. A. Inc., Lake Success, N. Y., unveiled its laser beam printer, which prints 10 pages per minute (about 880 lines) on plain paper using semiconductor lasers and an electrophotographic technique. Although U. S. prices are not set yet, Canon is looking for an original-equipment manufacturer to buy the unit. OEM prices in Japan are about $10,000, and a 20-page/min version is in the works.

At a nearby hotel, Konishiroku Photo Industry Co., perhaps best known for its Konica cameras, was showing its U-Bix 30-page/min xerographic printer. Based on a combination of fiber optics and a cathode-ray tube, the nonimpact unit is expected to sell to U. S. OEMs for $7,000. A 15-page/min version that also does convenience copying was also shown.

Fujitsu America, the Santa Clara, Calif.–based subsidiary of Fujitsu Ltd., introduced 66-, 132-, and 165-megabyte Winchester disk drives to OEMs at the NCC. Hitachi Ltd.'s Hitachi America subsidiary and Nippon Peripherals Ltd. both showed top-of-the-line IBM 3350–type disk drives and tape cartridge systems compatible with IBM's 3850.

Among others at the show were NEC Information Systems Inc., Lexington, Mass., Epson America Inc., Torrance, Calif., Panasonic, Arlington Heights, Ill., and Toshiba International Corp., San Francisco.

Perhaps summing up the increased activity best are the words of Hitachi America's corporate song, copies of which were distributed at the NCC in the Japanese company's product brochure: "Hitachi America in the U. S. A., Hitachi America is here to stay."

NCC came close to bursting at the seams. Moreover, the scene is likely to be repeated at next year's show in Anaheim, Calif., and at the 1981 edition in Chicago. The space at Anaheim is already entirely booked even though maximum booth size was further reduced to 2,000 square feet, with the NCC organizers promising that the parking garage used for spillover exhibits will be air-conditioned next year.

If the organizers feel that the NCC has grown too big to be manageable, they are not letting on. They acknowledge that they are considering alternatives—perhaps the encouragement of offshoots, like the concurrent Personal Computer Conference—but are not considering a return to the two-shows-a-year format. **-Benjamin A. Mason and Anthony Durniak**

Consumer

Electronic games tripling sales

There is no such thing as a recession or a slowdown this year, so far as the maufacturers of hand-held electronic games are concerned. By the end of the Summer Consumer Electronics Show in Chicago, held earlier this month, almost all of this year's production had been sold, according to officials from some of the biggest game makers like Mattel Electronics, Milton Bradley, Coleco Industries, and Parker Brothers.

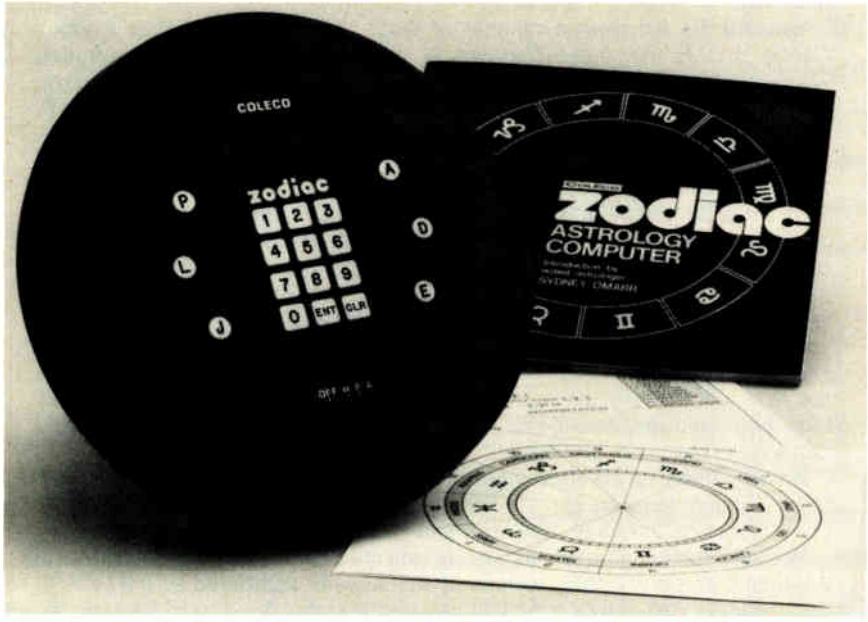
Total retail sales in 1979 could hit $400 million, more than triple last year's record. Michael J. Moone, vice president of Milton Bradley in Springfield, Mass., for example, says, "Our dollar sales are 40% to 42% ahead of last year."

Once again, game assemblers say their production will be limited by what chip manufacturers can send them. Several companies, among them Mattel, received fewer chips this year than expected, because normal yield problems took a heavier toll of production volumes than expected, says Edward M. Krakauer, senior vice president and general manager of Mattel, which is based in Hawthorne, Calif.

Branching out. The game designers are also branching out beyond the traditional hand-held units that duplicate athletic games like baseball and football and are moving into other areas. Coleco has an astrology computer, and Milton Bradley introduced a $60 space game, "Space Rider," that includes a plastic seat with a control panel. Complete with a viewing screen and sound effects, it lets a child simulate the piloting of a space craft.

Despite the strong showing expected by home computers in the marketplace, video-game makers also say that sales are better than ever. Atari Inc., Sunnyvale, Calif., reports that sales of its programmable video game this year are at almost double the rate of last year.

There is more good news for retailers and manufacturers alike—a trend away from seasonal sales peaks at Christmas. Peter N. Rosenthal, marketing manager at Atari, says, "The selling window has broadened substantially." **-Larry Marion**



Good signs. It doesn't take an electronic astrologer to predict the solid success of hand-held games. One popular entry was Coleco's Zodiac, in which a microprocessor reads the stars.

Computers

Two heads better than one for Univac

The Univac 1100 series, one of the oldest computer families in the industry, received a new member earlier this month. But the grandfather, model 1107, may not recognize its most recent descendant, which has two heads.

Dubbed the 1100/60, the new computer was unveiled by the Blue Bell, Pa.–based division of Sperry Rand Corp. at the National Computer Conference. Its multimicroprocessor hardware architecture is unique among general-purpose mainframe computers but nevertheless reflects a trend toward the use of standard large-scale integrated circuits to improve the price and performance of an established computer architecture. The 1100/60, as expected, uses some 68 of Motorola's 10800 emitter-coupled-logic bit-slice microprocessors [*Electronics*, May 24, pp. 34 and 111].

The 1100/60 is available in six field-upgradable models. All of these are based on the same central processing unit.

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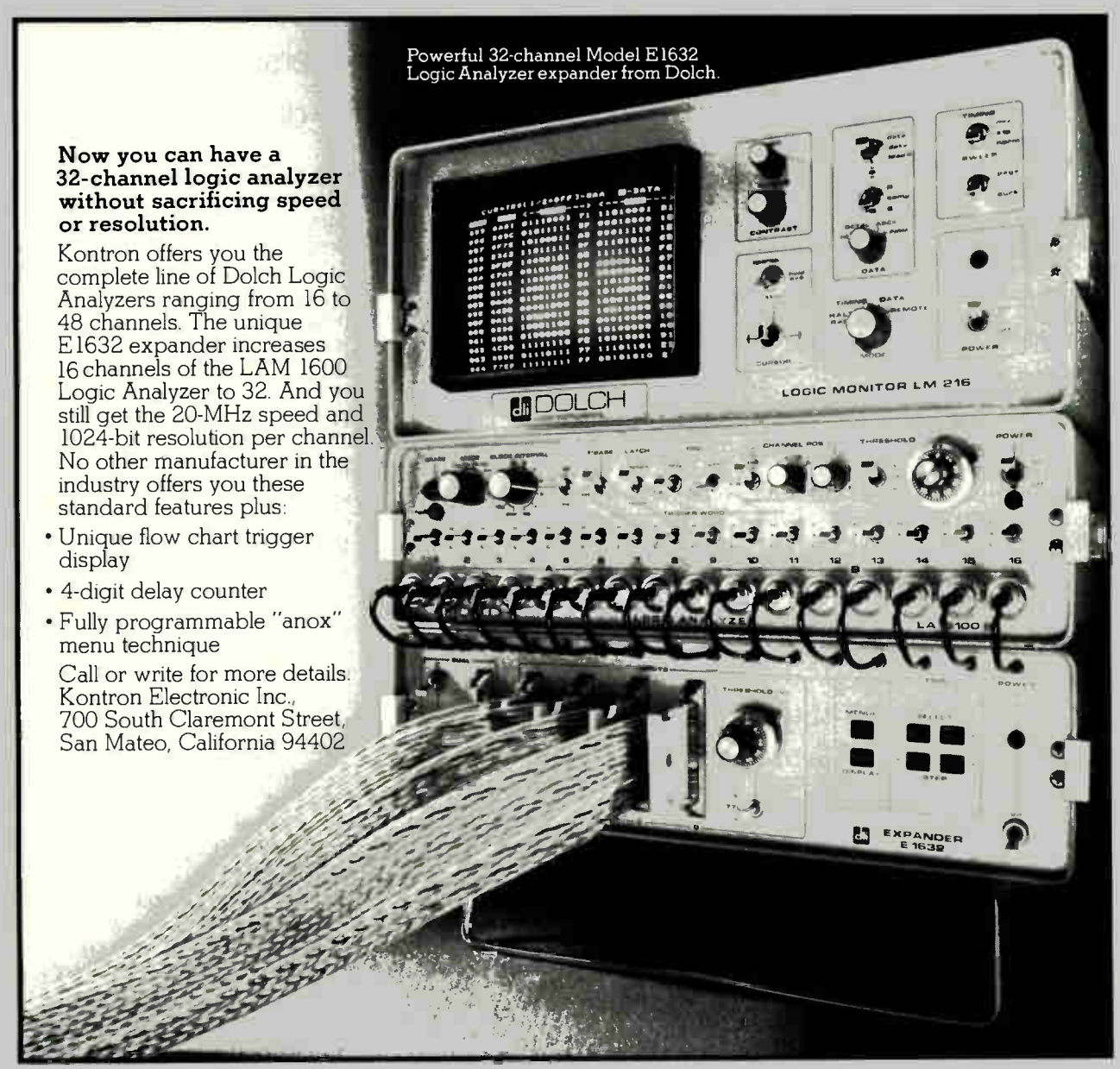

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hardware architecture based on a CPU composed of four microprogrammed microinstruction-execution units. Each of these comprises nine of the 4-bit-wide 10800 bit-slice microprocessors.

These microinstruction-execution units are paired to create two instruction processors—in essence, two heads. Macroinstructions are then executed by a series of microinstructions read from control storage.

Operating in parallel, the paired microinstruction-execution units each perform parts of up to four microinstructions at the same time in an overlapped, or pipelined, manner. This means that while the results of one instruction are being stored, a second instruction is already being executed, the data for a third instruction is being fetched, and the addresses for a fourth instruction are being generated.

Apparently proving that two heads are better than one, Univac says the dual units are the key to the 1100/60's increased reliability. Although each operates in an overlapped manner within itself, the two instruction processors operate redundantly, performing the same operations on the same data in synchronism and comparing answers.

Should the answers fail to match, the hardware automatically repeats the instruction. This prevents transient errors from interrupting the machine, Univac explains. Should the answers disagree a second time, the operator is signaled that a failure has occurred.

When a failure occurs, according to Ronald H. Wandersee, director of 1100-series worldwide marketing and services, Univac will use a "completely different maintenance philosophy." The customer calls a toll-free telephone number, allowing the CPU to be diagnosed remotely via an attachment to the 1100/60's separate microprocessor-based System Support Processor.

Using a scan-set technique, Univac can remotely read in a set of data, capture the contents of various registers in the microinstruction execution units, and compare them with a set of expected results.

Because there is so much logic on the bit-slice microprocessor chips, "it is easy to diagnose the problem down to the chip level," adds B. J. Walker, program director for 1100 series systems development at Univac's Roseville, Minn., facility.

To increase operating times, portions of the hardware can be disconnected should they fail, allowing the rest of the machine to continue operation, albeit at a degraded performance level.

The 1100/60 also uses new technology in its main memory, which comprises 16-K MOS chips and operates with an average access time of 575 nanoseconds. Basic memory in all models, is 524,288 words (36 bits each)—approximately 2.4 megabytes—expandable in 262,144-word increments to a maximum in the H2 model of 1,098,576 words—about 4.9 megabytes.

Holding all this semiconductor technology together is new packaging technology based on a 10-layer printed-circuit board. Up to 72 of these boards are plugged into a 16-layer backplane. **-Anthony Durniak**

How the 1100/60 stacks up

The 1100/60 is seen by most industry observers as Univac's answer to IBM's 4300 small mainframe computers. The smallest Univac unit, the 1100/60 model C1, has a basic purchase price of $318,975 and is comparable in price and performance to IBM's 4331, including operating-system software.

The 1100/60 model C2, with its extended instruction set, is said to have about 1.2 times the performance of a C1 and is priced at $355,365. Adding cache memory to the C1 doubles its performance and produces the model H1, which is priced starting at $657,040. The 1100/60 model H2 includes cache and the extended instruction set. It has about 2.4 times the performance of the C1 and sells for $693,610.

Further performance improvements are achieved by tightly coupling two of the H models, producing the 1100/62 model H1 or H2. The top-of-the-line multiprocessor H2 has 5 times the performance of the C1; its power is comparable, Univac feels, to that of an IBM high-end 3032 mainframe. With prices starting at $1,442,075, Univac estimates it has about a 10% advantage in price/performance ratio over the IBM offering.

Companies

Intersil looks hard at data acquisition

For a company to compete effectively in the expanding data-acquisition computer interface marketplace, it needs strong capabilities in monolithic technology as well as the traditional hybrid and module approaches. With this competence in place, Intersil Inc. reasons it is now the new contender among leading market heavyweights like Analog Devices and Burr-Brown.

With fiscal 1978 sales of $102 million, Intersil recently added strength in hybrid and module technology by acquiring Datel Systems Inc., a $21.4 million Mansfield, Mass., leader in data-acquisition devices using these technologies. Together they total some $19 million in computer interface converters, it is estimated.

Intersil's bent has long been towards data-acquisition components—it introduced a 12-bit microprocessor several years ago that is still in demand by the 12-bit–oriented data-acquisition market—and the Cupertino, Calif., company is currently expanding its digital and linear product lines, both built primarily with complementary metal oxide semiconductors. Intersil is building a version of Intel Corp.'s 8748 single-chip microcomputer in C-MOS, and has introduced a line of C-MOS operational amplifiers [*Electronics*, May 10, p. 44].

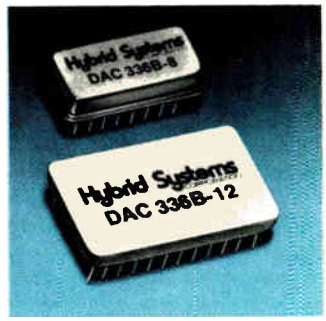
What the Intersil-Datel combination is after is the dominant slot in a $300 million-a-year or better market

Hybrid Systems DACs: Fastest, Lowest Power, Most Accurate, μP Compatible

Fastest output IC DAC.
DAC392-12's voltage output can be updated at 1.3mHz. It's the fastest 12 bit IC DAC anywhere. Faster than most 12-bit modules, too. Provides 2 quadrant multiplication for today's high speed graphic displays.

Lowest power 12-bit DAC.
DAC356LP-12 uses just 75mW to operate switches, ladder network, internal reference and output amplifier. In applications where many DACs are used, such as flight simulators, the savings can add up to watts.

First IC M-DAC with true 14-bit accuracy.
Perfect for high-resolution data displays. DAC331-14 features $\pm$½ LSB maximum linearity error and 2- and 4-quadrant multiplication. Operates from single +5 or +15V power supply.



Low-cost, μP-compatible latched DACs.
Easiest to use because they're so complete. DAC336-8 and -12 are ideal for microprocessor applications. Each includes reference, ladder network, switches, output amplifier and input register.

These new hybrid IC DACs are available in commercial and MIL-STD-883 versions. Backed by more than a decade of leadership in data conversion, they expand our already comprehensive DAC product line.

Incorporating our own proprietary thin-film networks into our products assures superior characteristics. And to guarantee the finest quality data converters available, nearly one-third of our manufacturing labor is devoted to inspection and testing at various stages of production.

Whatever the application — satellite systems, navigation and guidance equipment, or demanding industrial and commercial applications — our products meet the highest standards for reliability and performance.

For fast results, call or write. Or circle the number(s) on the reader service card.

When the chips are down . . .

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(TWX 710-326-7584
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61 Darmstadt, Luisenplatz 4, Germany
Tel. 6151-291595
(TELEX 419390 HYSY D)

In the United Kingdom:
Hybrid (Component) Systems U.K. Ltd.
12A Park Street, Camberley, Surrey
Tel. (0276) 28128
(TELEX 858720 HYBRID G)

Circle 45 on reader service card

that is growing at least 30% a year in such products as analog-to-digital and digital-to-analog converters, analog multiplexers, amplifiers, power operational amplifiers, and the like. "We plan to make everything in the signal chain for data acquisition and process control," director of analog product marketing Jerry Zis declares. "We have all the capabilities. As we go along, we'll see what vertical integration we'll do."

Impressive. The breadth of capabilities brought together by the combination certainly impressed Datel. "We had many offers from other companies, but we never gave them serious thought," says Michael G. Tagaris, former Datel president, now a senior vice president at Intersil. "It's a perfect match, complementing our product line," he says. Adds Intersil's Zis, "We've filled in virtually all the gaps [in data acquisition] except for gates and flip-flops."

Pointing to Intersil's strong suits in linear and C-MOS, Zis says the strategy is "to make better, cheaper devices than they [the competitors] do." An example out this month is a two-chip, 16-bit microprocessor-compatible a-d converter for process control applications where a signal may have to be sampled only once a second. The ICL 8068-7104 pair converts up to three times a second but sells for a very low $29 in quantities of 100. The idea here, Zis says, is that a user could multiplex a number of these, instead of using a faster but very expensive converter.

Next quarter, Intersil will introduce a data-acquisition subsystem aimed at process control and energy management, Zis says, adding that it will have a "unique" data protocol and raise eyebrows in terms of price and performance. He also expects to expand into other areas such as vertical-groove MOS power field-effect transistors. Though not true data-acquisition products, these will be very big in switching power supplies, he says. Other power supply and power management-oriented products will be small- and large-scale voltage references.

Intersil will also soon introduce a

News briefs

New Josephson-junction logic is IBM's fastest

Breaking its own records for superspeed logic, International Business Machines Corp. has fabricated simple AND and OR gates that are the fastest yet. Including propagation delays, a two-input OR gate switches in 13 picoseconds, and an AND circuit with four inputs and two outputs takes 41 ps. Researchers at the Thomas J. Watson Research Center, Yorktown Heights, N. Y., say the average power of the gates is about 6 microwatts. What's more, a new configuration that IBM is calling current-injection logic triples the speed, but like earlier Josephson-junction designs, the circuits must be cooled nearly to absolute zero.

Philips shows tiny player for digital audio disks

Laser-based players for digital audio disks can be much smaller than conventional analog units, and they can offer superior sound, says North American Philips Corp. of New York, which is showing a prototype playing 1-hour disks only 4½ inches in diameter. However, to shrink the machine size to about that of an audio tape cassette player, the associated company, N. V. Philips Gloeilampenfabrieken of the Netherlands, has abandoned compatibility with its video players, which use 12-in. disks moving at speeds up to 12,000 revolutions per minute. The audio player's solid-state laser reads and decodes 14-bit pulse-code–modulated music from the disk, which slows from 500 to 250 revolutions per minute as the laser scans from its center to its circumference. North American Philips says Magnavox Consumer Electronics Co., its Fort Wayne, Ind., subsidiary, which already offers a video-disk system, will produce and market the laser-based digital audio disk unit within a few years.

Monsanto doubling silicon wafer production

A major new source of silicon wafers will go on line next summer when Monsanto Co. opens what it is calling the world's largest such plant, with an ultimate annual capacity of 150 million square inches of silicon. The facility will make 4-in. wafers, with a 5-in.-wafer production line starting up later. It will effectively double Monsanto's worldwide production of polished slices, says James E. Springgate, general manager of the Electronics division, noting that the company is expanding its St. Peters, Mo., plant 25% and its Kuala Lumpur, Malaysia, plant 60%.

U. S. semiconductor shipments to jump over 15% in 1979 . . .

Led by a 20.2% surge in integrated circuit shipments, total semiconductor sales by American companies in the world market should increase by 15.3% this year, according to figures released recently by the Semiconductor Industry Association. Total dollar value, SIA estimates, will be just under $5.6 billion in 1979 compared to $4.85 billion in 1978. ICs should grow from under $3.3 billion to over $3.9 billion.

Digital MOS devices should hit $1.92 billion this year, well ahead of digital bipolar shipments of $1.15 billion. Moreover, MOS devices will boast a 24.9% growth rate, according to the report. While the U. S. domestic market will continue to show the largest dollar-value market for ICs, Japan, with a 26.4% increase, shows the largest percentage growth rate. As for discretes, the SIA expects a 5.2 growth rate this year, and again the Japanese market promises the highest increase.

. . . while Japanese said to hold a third of U. S. 16-K market

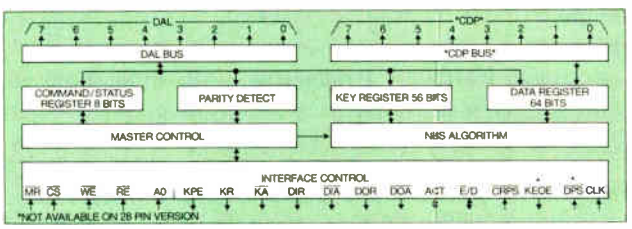
Japanese semiconductor makers now hold a 35% share of the $200 million to $250 million U. S. domestic market for 16-K dynamic random-access memories, say members of the Semiconductor Industry Association. The firms—principally Nippon Electric Co. and Fujitsu Ltd.—have moved in to fill a demand that American companies cannot meet, but apparently do not figure in the well-supplied 4-K RAM market in the U. S. The SIA members allege that the Japanese firms are meeting the U. S. price of $6 apiece, although it is half the price at which they sell in Japan.

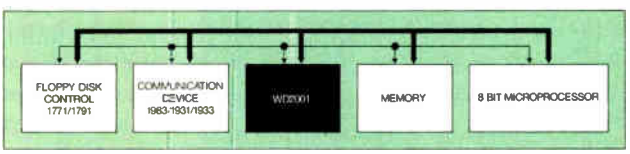
THE WORLD'S FIRST HIGH-SPEED ENCRYPTION PRODUCTS HAVE ARRIVED!

...AND MORE ARE ON THE WAY!

The Data Encryption Standard (DES) is a MOS/LSI device which implements the NBS Data Encryption Algorithm. DES is implemented in N-Channel, silicon gate technology and all inputs and outputs are TTL compatible. Two configurations (WD2001E/F and WD2002A/B) are available ***now*** for preliminary sampling; a third (WD2003), which performs NBS Algorithms with high-speed cipher feedback and complies with Federal Standard 1026/1027, will be available for preliminary sampling by August.

The DES interfaces with a wide variety of processors and mini-computers. A typical system implementation and the DES block diagram are shown below.





FEATURES:

- Guaranteed minimum data rate of 167K bytes/sec.
- Higher speed versions available
- WD2001 has a Common Clear Data and Encrypted Data I/O Bus
- WD2002 has 2 separate and independent I/O Buses: one for Clear Data, one for Encrypted Data
- Implements NBS Data Encryption Algorithm
- Single Key
- Encrypt in the block mode

Western Digital is always in the forefront of TOMORROW'S TECHNOLOGY TODAY. That is why we are the first company to offer high-speed ENCRYPTION. And it doesn't stop there: A whole family of Encryption Products are being developed to meet the ever changing needs of a dynamic industry.

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C-MOS version of the 8048 microprocessor. On the bipolar side, the company is developing a 12-bit a-d converter with a targeted conversion time of less than 10 microseconds.

Nor is the other half standing idle. In April Datel launched a $3190 data-acquisition system boasting an acquisition rate of 250,000 samples/s and 12-bit resolution [*Electronics*, Apr. 12, p. 180]. **-William F. Arnold**

RCA Solid State at the crossroads

Though the semiconductor industry generally has proven too tough a nut for established companies to crack, RCA Corp. has been a notable exception to that rule. However, its Solid State division, once an industry leader in the complementary-MOS field, has not managed to vault into the front ranks of the industry.

Now, in the wake of the sudden resignation of division vice president and general manager Bernard V. Vonderschmitt, observers are wondering what RCA will do with the Somerville, N. J.–based division. Executive vice president Roy H. Pollock has been appointed acting general manager.

Sales for the division are healthy, with outsiders estimating 1978 totals at $111 million for discrete and $126 million for integrated circuits. Yet RCA president Edgar H. Griffiths has intimated that the division is not living up to corporate expectations. With a background in the financial side of the company, Griffiths emphasizes the bottom line.

SOS. For many, the problems can be summed up in a single word: sapphire. The division has devoted much of its developmental effort to putting its C-MOS technology on sapphire, combining its demonstrated low-power advantage with the smaller, faster chips possible on the precious-mineral substrate. In spite of all the work, silicon on sapphire is far from challenging bulk-silicon technologies, nor has RCA taken a leadership position in any semiconductor technology.

As much as the SOS technology, its market share in ICs is a question for the division. Its 1802 8-bit C-MOS microprocessor and related ICs are an example: they sell, but the 1802 has only 10% of the 8-bit market, according to one outside survey. "I certainly don't hear about them as a strong factor in MOS," says Kent A. Logan, vice president of investment research at Goldman Sachs & Co.

Still, the division does have some impressive strengths, especially in the consumer, instrumentation and control, military, and automotive markets. Among the strong points are power transistors: "They've always been very good and probably always will be," says Hans Severiens, vice president of investment banking at Merrill Lynch Pierce Fenner & Smith Inc.

The electro-optics operation is a well-respected outfit, especially for its work on charge-coupled-device imagers. On the IC side of the house, the 4000 series sets the pace in C-MOS logic, although competitors like Motorola have moved in. Motorola now claims to be number one in C-MOS.

Yet the SOS program is lagging, and results have been spotty. Back when RCA signed an agreement to produce C-MOS-on-sapphire versions of Intel's 8-bit 8085A and related parts [*Electronics*, April 13, 1978, p. 41] the Solid State division reported it would have its own single-chip 1804 out by year's end. Now it is targeting the end of this year for introduction of the microcomputer, the Intel parts, and some new SOS products of its own, including a 2,048-bit erasable programmable random-access memory.

Production. All indications are that RCA simply does not have the recipe for C-MOS on sapphire as a production process. Its 4,096-bit static random-access memories are in production and have proved denser than the C-MOS RAMs from Harris and Intersil—24,000 square mils against more than 30,000 mil². While specified at a 450-nanosecond access time, the upper end of the range of the competing ICs, the SOS part is coming through mostly at 600

PROMs

ECL PROMs

Organization	Part Number	Access Time (ns max)	Output	No. of Pins
32 x 8	MCM10139▲	25	ECL output	16
256 x 4	MCM10149▲	30	ECL output	16

TTL PROMs

Organization	Part Number	Access Time (ns max)	Output	No. of Pins
64 x 8	MCM5503/5303▲	125	Open collector	24
64 x 8	MCM5504/5304▲	125	2K pull-up	24
512 x 4	MCM7620▲	70	Open collector	16
512 x 4	MCM7621▲	70	3-state	16
512 x 8	MCM7640▲	70	Open collector	24
512 x 8	MCM7641▲	70	3-state	24
1024 x 4	MCM7642▲	70	Open collector	18
1024 x 4	MCM7643▲	70	3-state	18
1024 x 8	MCM7680▲	70	Open collector	24
1024 x 8	MCM7681▲	70	3-state	24
2048 x 4	MCM7684*▲	70	Open collector	18
2048 x 4	MCM7685*▲	70	3-state	18
2048 x 4	MCM7686*▲	70	Open collector with latches	20
2048 x 4	MCM7687*▲	70	3-state with latches	20
2048 x 4	MCM7688*▲	----	Open collector with registers	20
2048 x 4	MCM7689*▲	----	3-state with registers	20

EPROMs

MOS EPROMs

Organization	Part Number	Access Time (ns max)	No. of Power Supplies[1]	No. of Pins
1024 x 8	MCM2708C▲	450	3	24
1024 x 8	MCM27A08C▲	300	3	24
1024 x 8	MCM68708C▲	450	3	24
1024 x 8	MCM68A708C	300	3	24
2048 x 8	TMS2716C▲	450	3	24
2048 x 8	TMS27A16C▲	300	3	24
2048 x 8	MCM2716C*▲	450	1	24
2048 x 8	MCM27A16C▲	350	1	24
8192 x 8	MCM68764C*	450	1	24

MOTOROLA MEMORIES

Motorola has developed a very broad range of MOS and bipolar memories for virtually any digital data processing system application. And for those whose requirements go beyond individual components, Motorola also supplies Memory Systems and Micromodules.

New Motorola memories are being introduced continually. **This selector guide lists all those available as of June,1979.** For later releases, additional technical information or pricing, contact your nearest authorized Motorola distributor or Motorola sales office.

Data sheets may be obtained from your in-plant VSMF Data Center, distributors, Motorola sales offices or by writing to:

Literature Distribution Center
Motorola Semiconductor Products, Inc.
P.O. Box 20912
Phoenix, AZ 85036.

MOTOROLA INC.

MOTOROLA MEMORIES Selector Guide

RAMs
ROMs
PROMs
EPROMs

June 1979

MOTOROLA INC.

MOTOROLA INC.

RAMs

MOS DYNAMIC RAMs

Organization	Part Number	Access Time (ns max)	No. of Power Supplies[1]	No. of Pins
4096 x 1	MCM4096C-6▲	250	3	16
4096 x 1	MCM4096C-16▲	300	3	16
4096 x 1	MCM4096C-11▲	350	3	16
4096 x 1	MCM4027AC-2▲	150	3	16
4096 x 1	MCM4027AC-3▲	200	3	16
4096 x 1	MCM4027AC-4▲	250	3	16
4096 x 1	MCM6604AC	350	3	16
4096 x 1	MCM6604AC-2	250	3	16
4096 x 1	MCM6604AC-4	300	3	16
4096 x 1	MCM6605AL	300	3	22
4096 x 1	MCM6605AL-2	200	3	22
16,384 x 1	MCM4116AC-15▲	150	3	16
16,384 x 1	MCM4116AC-20▲	200	3	16
16,384 x 1	MCM4116AC-25▲	250	3	16
16,384 x 1	MCM4116AC-30▲	300	3	16

TTL BIPOLAR RAMs

Organization	Part Number	Access Time (ns max)	Output	No. of Pins
256 x 4	MCM93412*▲	45	Open collector	22
256 x 4	MCM93422*▲	45	3-state	22
1024 x 1	MCM93415▲	45	Open collector	16
1024 x 1	MCM93425▲	45	3-state	16

*To be introduced.
▲Second source.
Heavy black type denotes industry standard part numbers.
Operating temperature ranges:
MOS 0°C to 70°C
CMOS −40°C to +85°C and −55°C to +125°C
ECL Consult individual data sheets.
TTL Military −55°C to +125°C, Commercial 0°C to 70°C

[1] MOS power supplies:
3 +12, ±5 V
1 +5 V
All MOS outputs are 3-state except the 6570 and 6580 Series which are open-collector.

[2] Character generators include shifted and unshifted characters, ASCII, alpha-numeric control, math, Japanese, British, German, European and French symbols.

MOS STATIC RAMs

Organization	Part Number	Access Time (ns max)	No. of Power Supplies[1]	No. of Pins
128 x 8	MCM6810	450	1	24
128 x 8	MCM68A10	360	1	24
128 x 8	MCM68B10	250	1	24
1024 x 4	MCM2114P-20▲	200	1	18
1024 x 4	MCM2114P-25▲	250	1	18
1024 x 4	MCM2114P-30▲	300	1	18
1024 x 4	MCM2114P-45▲	450	1	18
1024 x 4	MCM21L14P-20▲	200	1	18
1024 x 4	MCM21L14P-25▲	250	1	18
1024 x 4	MCM21L14P-30▲	300	1	18
1024 x 4	MCM21L14P-45▲	450	1	18
4096 x 1	MCM6641P-20▲	200	1	18
4096 x 1	MCM6641P-25▲	250	1	18
4096 x 1	MCM6641P-30▲	300	1	18
4096 x 1	MCM6641P-45▲	450	1	18
4096 x 1	MCM66L41P-20▲	200	1	18
4096 x 1	MCM66L41P-25▲	250	1	18
4096 x 1	MCM66L41P-30▲	300	1	18
4096 x 1	MCM66L41P-45▲	450	1	18
4096 x 1	MCM2147C-55*▲	55	1	18
4096 x 1	MCM2147C-70*▲	70	1	18
4096 x 1	MCM2147C-85*▲	85	1	18

CMOS STATIC RAMs

Organization	Part Number	Access Time (ns max)	No. of Power Supplies	No. of Pins
256 x 4	MCM145101-1▲	450	1	22
256 x 4	MCM145101-3▲	650	1	22
256 x 4	MCM145101-8▲	800	1	22
4096 x 1	MCM146504▲	450	1	18
1024 x 1	MCM146508*▲	460	1	16
1024 x 1	MCM146508-1*▲	300	1	16
1024 x 1	MCM146518*▲	460	1	18
1024 x 1	MCM146518-1*▲	300	1	18

ECL BIPOLAR RAMs

Organization	Part Number	Access Time (ns max)	Output	No. of Pins
8 x 2	MCM10143	15	ECL output	24
256 x 1	MCM10144▲	26	ECL output	16
16 x 4	MCM10145▲	15	ECL output	16
1024 x 1	MCM10146▲	29	ECL output	16
128 x 1	MCM10147▲	15	ECL output	16
256 x 1	MCM10152▲	15	ECL output	16

ROMs

MOS STATIC ROMs

Character Generators[2]

Organization	Part Number	Access Time (ns max)	No. of Power Supplies	No. of Pins
128 x (7 x 5)	MCM6670P	350	1	18
128 x (7 x 5)	MCM6674P	350	1	18
128 x (9 x 7)	MCM66700P▲	350	1	24
128 x (9 x 7)	MCM66710P▲	350	1	24
128 x (9 x 7)	MCM66714P▲	350	1	24
128 x (9 x 7)	MCM66720P▲	350	1	24
128 x (9 x 7)	MCM66730P▲	350	1	24
128 x (9 x 7)	MCM66734P	350	1	24
128 x (9 x 7)	MCM66740P▲	350	1	24
128 x (9 x 7)	MCM66750P▲	350	1	24
128 x (9 x 7)	MCM66760P▲	350	1	24
128 x (9 x 7)	MCM66770P	350	1	24
128 x (9 x 7)	MCM66780P	350	1	24
128 x (9 x 7)	MCM66790P	350	1	24

Binary ROMs

Organization	Part Number	Access Time (ns max)	No. of Power Supplies	No. of Pins
1024 x 8	MCM68A30P8	350	1	24
1024 x 8	MCM68A308P7	350	1	24
2048 x 8	MCM68A316P91	350	1	24
1024 x 8	MCM68B30AP▲	250	1	24
1024 x 8	MCM68A30AP▲	350	1	24
1024 x 8	MCM68B308P▲	250	1	24
1024 x 8	MCM68A308P▲	350	1	24
2048 x 8	MCM68A316EP▲	350	1	24
2048 x 8	MCM68A316AP▲	350	1	24
4096 x 8	MCM68A332P▲	350	1	24
4096 x 8	MCM68A332P2*	350	1	24
8192 x 8	MCM68A364P*▲	350	1	24
8192 x 8	MCM68A364P3*	350	1	24
8192 x 8	MCM68B364P3*	250	1	24

CMOS ROM

Organization	Part Number	Access Time (ns max)	No. of Power Supplies	No. of Pins
256 x 4	MCM14524	1200	1	16

Electronics review

ns and above. The division claims a 250-ns version is on its way.

The Solid State division had devoted considerable effort to developing inexpensive sapphire substrates. Yet the cost still runs 20% above comparable silicon substrates.

No matter what the outcome of the SOS effort, the IC operation has a tough row to hoe in competing with other technologies. "Its main problem is that it is betting heavily on C-MOS, and that has not become a major computer technology or a major microprocessor technology," says Merrill Lynch's Severiens.

So the departure of Vonderschmitt leaves the Solid State division at a crossroads. The former general manager refuses to discuss his resignation, although he has referred to the personal strain he experienced in running the division. Moreover, Pollack refuses to comment on the future. But it is a safe bet that RCA is looking hard at the division and its operations, not just looking hard for another general manager. **-Benjamin A. Mason and Raymond P. Capece**

Distributed processing

Multi-routes mapped in IBM's software

Now that practically every major computer manufacturer has a distributed-processing architecture, it is the communications management software that increasingly differentiates the offerings. International Business Machines Corp. apparently intends to spotlight its Systems Network Architecture with a set of new software products that significantly increase network configuration flexibility and diagnostic capabilities. Three new microprocessor-based modems were also added.

The basis of the new software is Release 3 of IBM's Advanced Communications Function Virtual Telecommunications Access Method (ACF/VTAM) and Version 2, Release 3, of the Telecommunications Access Method (ACF/TCAM). Running on

System/370 mainframe computers, this software handles communications between computers and the data-communications network.

To work with the new releases, IBM added Release 3 of ACF/Network Control Program Virtual Storage software that runs in IBM's 3705 communications controller.

The new configuration flexibility made possible by this software comes from its provisions for multiple data routes between computers, parallel links between 3705 controllers, and extensions to the number of remote 3705s that can be connected to a computer. In addition, free-standing 3705s can now be remotely connected to a host computer's 3705 and interconnected to each other. This broadens configuration rules that previously required each 3705 to be locally connected to a computer and allowed only one remote 3705 connection.

Fail safe. A major function not previously available from IBM—nor from most of its current competition—is network reconfiguration in event of a hardware failure. Up to eight host computers can now share one 3705. Thus if one computer fails, another can take over control of the 3705 and drive the communications network. The new software also notifies operators when such a reconfiguration takes place.

Further increasing reliability are the new modems and the Network Problem Determination Application (NPDA) software. The new Model 3863, 3864, and 3865 modems operate at data rates of 2,400, 4,800 and 9,600 bits per second, respectively. Based on microprocessors, they can diagnose themselves upon command from the NPDA software, which can then isolate the problem to the modem, transmission line, or terminal involved.

The new modem models, which range in price from $2,135 to $5,300, are scheduled for their first deliveries in the first quarter of 1980. The software, which has license fees from $32 to $800 per month, will be available to users starting in mid-1980 and stretching into 1981. **-Anthony Durniak**

SYNERTEK PERFORMS

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WE'VE MADE IT SIMPLE.

Our 6551 Asynchronous Communications Interface Adapter is the world's most comprehensive ACIA. We made it that way by designing-in simplicity. It interfaces directly with 6500/6800 microprocessor families. And we've kept it small by eliminating unneeded synchronous protocols and conventions.

ON-BOARD BAUD RATE GENERATOR.

The 6551's on-chip programmable baud rate generator eliminates the need for external components and features 15 programmable rates up to 19.2 kilobaud. For non-standard baud rates (up to 125 kilobaud) the 6551 allows the use of an external 16X clock. This wide-ranging programmability allows accommodation of a variety of applications—from point-of-sale, financial and intelligent terminals to front-end processors, remote data concentrators, computer-to-computer links and more. Whatever your communications application, the 6551's built-in versatility delivers.

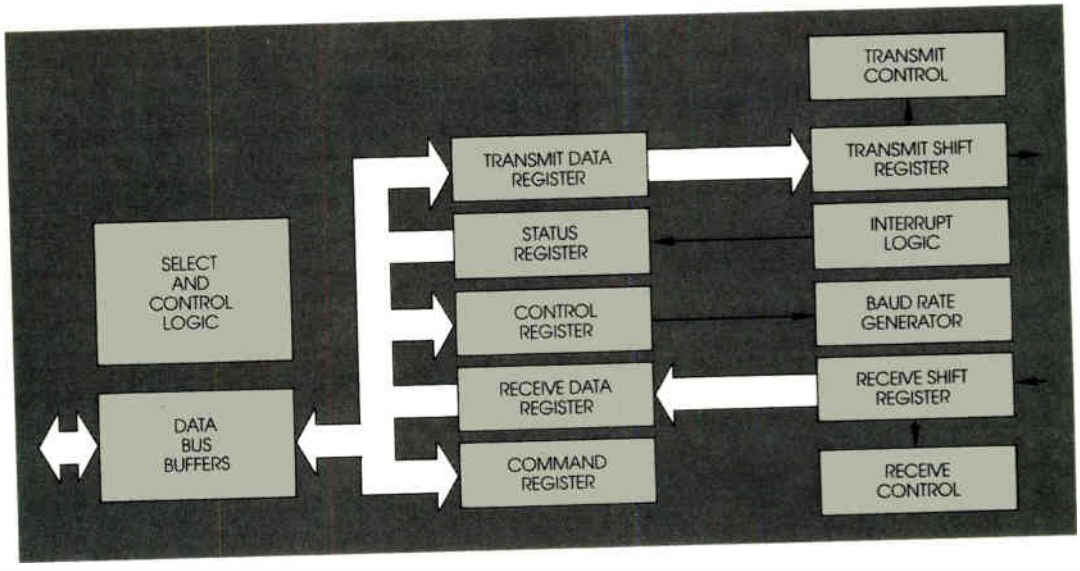
BENEFITS, PLUS SOME.

It all adds up to higher reliability, lower manufacturing cost and lower system cost. Among the features that make it this way are:

- Single +5 volt power supply
- Requires only a standard 1.8432 MHz external crystal
- Non-standard user-provided baud rates at 16X external clock frequency (up to 125 kilobaud)
- Stop bits: 1, 1.5 (5-bit word) or 2
- Independently selectable transmit and receive baud rates
- Parity (odd, even, none, mark parity, space parity)
- Double-buffered transmitter and receiver
- Half or full-duplex operation
- Serial echo mode
- Interrupt feature and status register

Find out how we can help you meet your needs. For information on the SY6551 ACIA, contact Clement Lee, Microprocessor Group, Synertek, Inc., 3001 Stender Way, Santa Clara, California 95051. (408) 988-5614.

We've made it in production. We're making it in high technology.



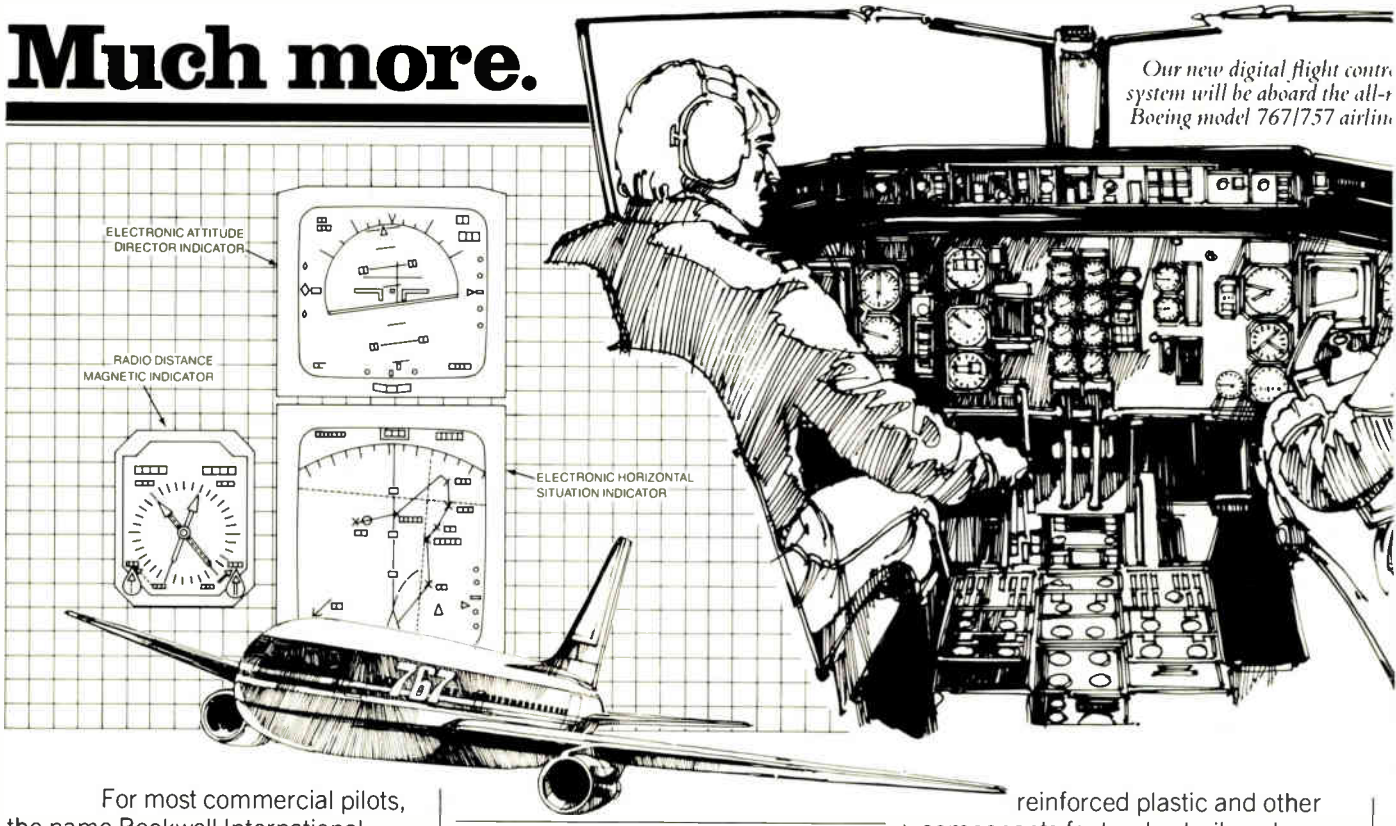
SYNERTEK, INC.

3001 Stender Way, Santa Clara, California 95051
(408) 988-5600. TWX: 910-338-0135.

Circle 53 on reader service card

Rockwell is more than a builder of avionics for most of America's airliners.

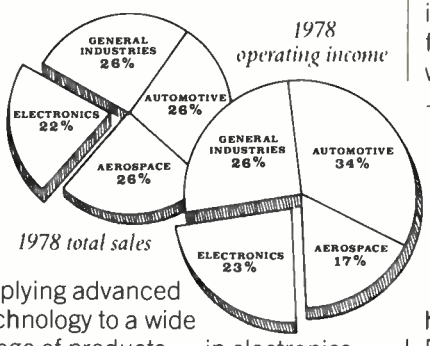
Much more.



Our new digital flight contr system will be aboard the all-r Boeing model 767/757 airlin

For most commercial pilots, the name Rockwell International stands for aviation electronics. Understandably so: Rockwell-Collins avionics equipment is on board nearly every U.S.-built airliner. And our Collins Air Transport Avionics Division has contracts to build avionics for Boeing model 767/757 airliners — programs planned to extend into the next century.

But avionics is only one of our strengths. Rockwell International is a major multi-industry company applying advanced technology to a wide range of products — in electronics, automotive, aerospace and general industries. Following are some examples of our balanced diversification.



Electronics.

(Sales, fiscal 1978: $1.3 billion.)

As one of the world's leading suppliers of avionics, we provide communications, navigation and flight control equipment, not only for airliners, but for general aviation and government aircraft as well.

We also make microelectronic systems and devices, broadcast equipment, and guidance and control systems. And we manufacture and install telecommunications systems for businesses and governments worldwide.

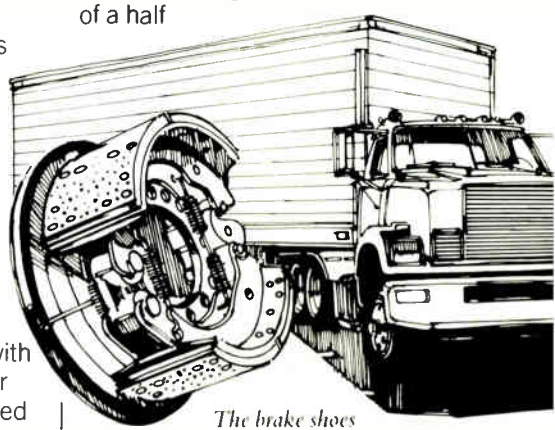
Automotive.

(Sales, fiscal 1978: $1.5 billion.)

One-half of the highway tandem tractors in North America are equipped with Rockwell axles — and more than half of the heavy-duty trucks stop with Rockwell brakes. We're also a major supplier of drivelines, steel and styled aluminum wheels, mechanical devices, castings, stainless steel wheel covers, reinforced plastic and other components for trucks, trailers, buses, vans and passenger cars.

Our new Cam-Master® "Q"™ is the latest in the most widely used series of heavy-duty air brakes in the trucking industry. The "Q" is known as "the no-sweat, no-tools brake," because its special design permits changing brake shoes without tools, in less than two minutes.

Rockwell's extensive product line of air, mechanical and hydraulic cam and wedge brakes is the result of a half



The brake shoes in this Cam-Master "Q" brake can be changed in less than two minutes – without using tools.

Also aboard is our new Electronic Flight Instrument System which displays attitude and navigation data.

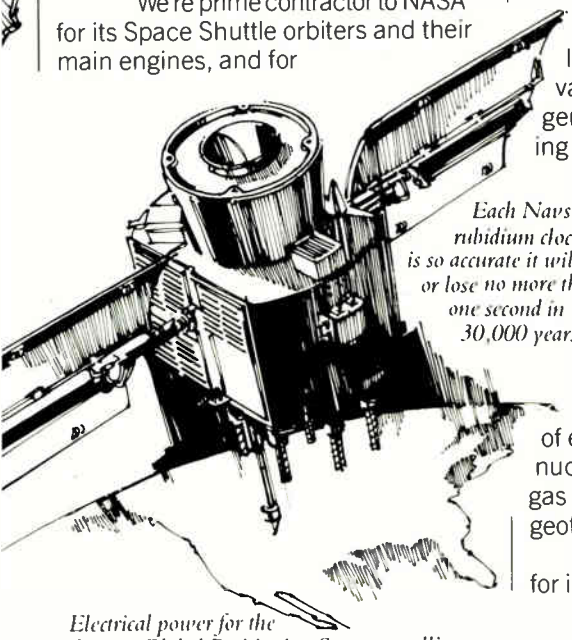
century of design, engineering and manufacturing experience. Our most popular brake designs have been proved on and off the highway in literally billions of miles on the job.

Aerospace.

(Sales, fiscal 1978: $1.4 billion.)

We're prime contractor to NASA for its Space Shuttle orbiters and their main engines, and for integrating the entire Space Shuttle system including selected payloads. We also build rocket engines for many other applications, and several types of Earth-orbiting satellites. We also have a long, proud history as a designer and builder of business and U.S. military aircraft.

Our current satellite projects include "the brightest star in navigation history" — Navstar — designed and built by Rockwell for the U.S. Defense Department's Global Positioning System (GPS). When fully operational in the mid-1980s, GPS will utilize 24 Navstar satellites orbiting 11,000 miles above the Earth. Beaming a continuous stream of signals, the system will enable land, sea, air and space navigators to determine their positions to within 30 feet, their speed to within a fraction of a mile per hour — and the correct time to within a millionth of a second.



Each Navstar's rubidium clock is so accurate it will gain or lose no more than one second in 30,000 years.

Electrical power for the Navstar Global Positioning System satellites is provided by solar arrays which swivel to track and capture the sun's light.

General Industries.

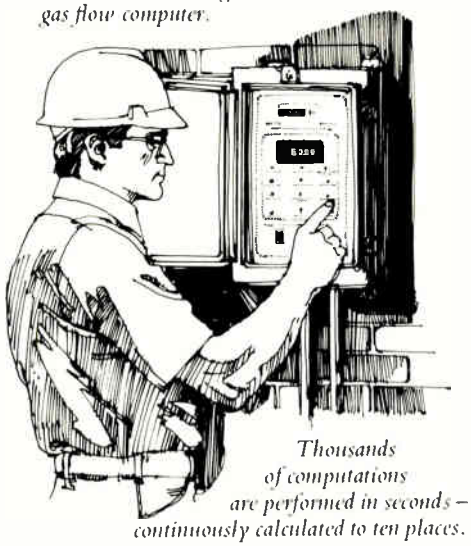
(Sales, fiscal 1978: $1.5 billion.)

Rockwell is one of the world's largest suppliers of high-technology valves for the energy market and for general industry. We also make printing presses, textile equipment, power tools, industrial sewing machines, and products for utilities, including over one-fourth of all the meters purchased by America's municipal water departments.

Our extensive technology is also being applied to the world's growing need for alternate sources of energy. We're involved in projects for nuclear energy, coal gasification, flue gas desulfurization, and solar, wind and geothermal power.

We also manufacture gas meters for industrial applications.

Rockwell's new digital gas flow computer.



Thousands of computations are performed in seconds — continuously calculated to ten places.

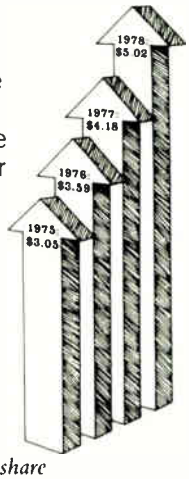
And our brand-new MPB Gas Flow Computer, the product of "computer on a chip" technology, can be connected directly to our meters to provide extensive, highly accurate flow data at the push of a button.

Over 14,300 scientists and engineers.

Of our 114,000 employees, one in eight is either a scientist or an engineer. They constitute about one percent of America's total scientific-engineering community. This technological base positions us for leadership in each of our product areas. It also makes our corporate slogan, ". . . where science gets down to business," a fact.

Business is good.

Rockwell International's total sales for 1978 were $5.67 billion. Fiscal 1978 was the most profitable year in Rockwell's history. Net income, up 23% over fiscal 1977, was $176.6 million, generating a record $5.02 per share.



Earnings per share

For more of the Rockwell story, please write us: Rockwell International, Dept. 815G, 600 Grant Street, Pittsburgh, PA 15219.

Rockwell International

...where science gets down to business

The TEAC Super Performers

TEAC has a complete line of cassette data recorders to answer all your data acquisition needs. For field work there's the ever-popular R-61. Ruggedly built to stand up under demanding conditions, it is fully portable and easy to handle. It provides four channels of precision recording capability, two of which can be switched from the standard FM recording mode to DR (direct recording) operation for use with high frequency data.

For precision lab work consider the full-feature R-81. Its seven channels and four speeds provide you with a great deal of operation flexibility.

Choose either the R-61 or the R-81 and you can be sure of getting the performance and reliability that TEAC is famous for.

TEAC

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Circle 56 on reader service card

Washington newsletter

DOE picks nine for photovoltaic system projects

Nine new photovoltaic demonstration projects worth $21.5 million were selected by the Department of Energy in mid-June for contract negotiation. Topping the list of industrial contractors, **General Electric Co.'s Philadelphia-based Advanced Energy Programs operation gets $3.4 million** to build a 110-kW concentrator system for Orlando, Fla.'s Sea World. A Phoenix public utility, the Arizona Public Service Co., pulled down the biggest award—$6.5 million—for a 283-kW concentrator system to power that city's Sky Harbor International Airport.

Two 15-kW projects, each worth $2.7 million, are also on the list: Solar Power Corp., Woburn, Mass., which will produce a flat-panel array to power the Beverly, Mass., High School, and New Mexico's Lea County Electric Cooperative, which will employ similar technology to power a shopping center at Lovington. Science Applications Inc. of McLean, Va., got $2.5 million for a 150-kW flat-panel array at Oklahoma City's Center for Science and Arts.

Other contractors also selected for negotiation from the 29 proposals were (with proposed cost and output): E-Systems Inc., Dallas ($650,000/27 kW); DBM Corp., Albuquerque, N. M. ($1.1 million/47 kW); Acurex Corp., Mountain View, Calif. ($1.4 million/85 kW), and New Mexico State University, Las Cruces ($480,000/17.5 kW). All systems have a 1986 break-even cost goal.

Recession signs in May downturn of consumer sales

Recession? Not yet, but May home-entertainment electronics sales to dealers show that retailers are getting ready by reducing inventories. **Color TV sales, an economic bellwether, slipped 3.3% in May from last year's 673,632 units,** cutting volume in 1979's first 21 weeks by 0.7% from 1978's nearly 3.66 million. TV sales figures for the first June week, however, are up 5% from 1978, suggesting a firm trend has yet to be established. Home video cassette recorders, another high-dollar item for consumers, recorded their second consecutive monthly sales drop in May, off 6.2% from the nearly 28,000 units sold by dealers last year, following a 21% decline in April, according to data gathered by the Electronic Industries Association.

FCC's Darby quits as bureau chief; others to follow

Dissatisfaction with the reign of Federal Communications Commission Chairman Charles D. Ferris and a group of his close advisers has led to the resignation of Larry F. Darby from his position as chief of the common carrier bureau, effective June 30, along with Darby's chief economist, Walter Bolter. Other key staff departures are expected to follow. Darby cites only "personal reasons" for his departure from the job he held just 10 months. He will be succeeded by Philip Verveer, broadcast bureau chief. However, other senior FCC personnel say **staff morale and effectiveness are the lowest in memory** as a result of Ferris and his close-knit staff's issuance of directives directly to bureau workers that often counter those of their immediate superiors.

Meanwhile, the FCC has modified its May restrictions on General Telephone & Electronics Corp.'s acquisition of financially troubled Telenet Corp., Vienna, Va., so that GTE may compete with AT&T's Advanced Communications Service in the high-speed data packet transmission market. In an exchange of stock worth about $65 million, GTE would acquire Telenet provided it remains a separate entity with separate books.

Washington commentary

The war over electronic mail

The board of governors of the U. S. Postal Service appears to be backing away from Postmaster General William Bolger's proposal to compete with private services in electronic mail [*Electronics*, Dec. 7, 1978, p. 58]. The post office "will not seek to become a telecommunications common carrier" and "will not duplicate facilities available to it in the private sector," the governors said in a policy statement published this month. For many in the data-communications industry, however, this is not good enough in view of what the governors are saying that the USPS will do.

"Electronic mail services offered by the postal service will involve acceptance of messages in hard copy, magnetic tape, or electronic forms; transmitting the messages [under contract with private sector communications companies] to destination postal stations; and printing and enveloping the message for delivery," the governors of the postal service said. "Any telecommunications company desiring to offer an electronic mail service can connect with our delivery system for hard-copy delivery."

Opposing the post office

The reactions of the telecommunications industry to those statements are strong. "Dealing with the post office will be like dealing with the Bureau of Customs," complains one lobbyist. "They will set the law, interpret the law, and adjudicate the law. It won't work." Another argues that "letting a tax-free Government entity with enormous resources into the private marketplace is absurd." The Computer and Communications Industry Association contends that even the prospect, much less the reality, of postal entry into electronic message service "has a chilling effect on competitive firms and their ability to attract capital."

The effort by the postal governors to assuage industry and congressional opposition to its electronic message service plans is not being swallowed by anyone. The fact that USPS says it will get into electronic mail at all "is a camel's nose in the tent if I ever saw one," says John Sodolski, vice president for the Electronic Industries Association's communications division.

Industry's criticisms of the plans have considerable congressional support [*Electronics*, June 7, p. 63]. Chairman Harley Staggers (D., W. Va.), whose House Interstate and Foreign Commerce Committee is responsible for telecommunications issues, has joined leading Senate opponents. He wrote to President Carter expressing concern about "action that might be taken that would overturn years of governmental policy and legislative history that have prohibited the postal service from providing telecommunications services and left such services to private enterprise." He cited the USPS tax-free status, its "ever-growing monopoly," and "the potential for cross-subsidization" of electronic mail by monopoly services as "unfair advantages."

White House reaction

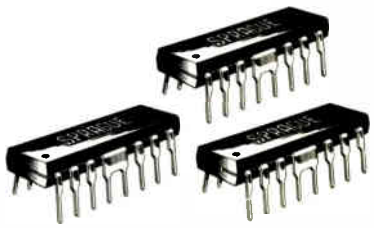
The nearly unanimous opposition to USPS entry into electronic mail clearly has caught the White House by surprise. President Carter delayed issuing a policy review memorandum beyond the mid-June deadline that White House staff members had themselves imposed. "He's in a box on this one," notes one telecommunications specialist somewhat smugly. "Congress has to legislate on postal policy, and with every responsible committee chairman on the record as opposed to USPS plans, does the President have any choice? Carter has alienated so much of the Congress on so many issues, he can't afford to lose another."

Nevertheless, the President does have a choice. And anyone who has tracked Jimmy Carter's record of contrary responses knows that this is not the time to assume the war between the post office and the private competitive sector has been won. Postmaster General Bolger is still pushing his plans for electronic mail despite the USPS governors' most recent proposal to cut private industry in for a piece of the action.

What was said in this space last December is worth recalling: if the electronic message service system and its supporting technology are to develop successfully, they must do so in a free and open competitive market in which USPS participation is limited to those unique services that cannot be duplicated by industry.

-Ray Connolly

THINK NEGATIVE



Solve design problems simply with 1.5 Amp Interface ICs for Negative Supply Applications.

You can use Sprague Electric's new Series UDN-2840B 1.5 amp monolithic quad power drivers in three basic versions to solve your circuit needs for (1) sinking applications, (2) source applications, and (3) combination sink-and-source applications.

You can get this versatile IC family with either 5V logic compatibility or 12-15V MOS compatibility. Make your choice from these six types:

TYPE	I_{OUT}	$V_{OUT(OFF)}$	OUTPUTS	$V_{SUPPLY\ (TYP)}$	COMPATIBILITY	TYPICAL APPLICATIONS
UDN-2841B	1.5 A	−50 V	Sink (4)	0 V to 5 V	5 V Logic	electrosensitive printer interface
UDN-2842B	1.5 A	−50 V	Sink (4)	0 V to 12 V	PMOS, CMOS	
UDN-2843B	−1.5 A	−50 V	Source (4)	5 V	5 V Logic	solenoid, LED, or relay drive
UDN-2844B	−1.5 A	−50 V	Source (4)	5 V to 12 V	PMOS, CMOS	
UDN-2845B	1.5 A/−1.5 A	−50 V	Sink (2) Source (2)	5 V	5 V Logic	bridge motor drives
UDN-2846B	1.5 A/−1.5 A	−50 V	Sink (2) Source (2)	5 V	PMOS, CMOS	

All Series UDN-2840B power driver ICs include input current limiting, level translation, and sufficient amplification to operate high current Darlington outputs. The Sprague-originated 16-lead webbed dual in-line package is used for maximum power dissipation.

For application engineering assistance on these or other interface circuits, standard or custom, write or call George Tully or Paul Emerald, Semiconductor Division, Sprague Electric Co., 115 Northeast Cutoff, Worcester, Mass. 01606. Telephone 617/853-5000.

For Engineering Bulletin 29314 and a 'Quick Guide to Interface Circuits', write to: Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Mass. 01247.

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

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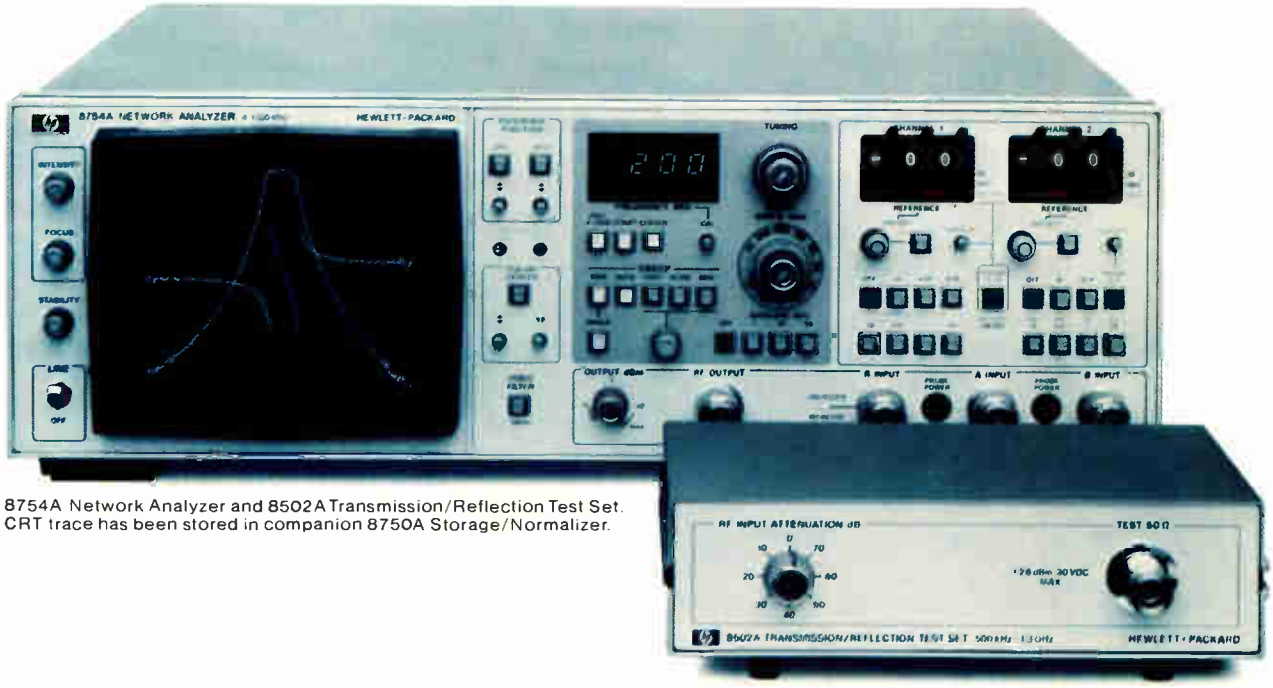
... and you thought we only make great capacitors.

Circle 58 on reader service card

HP's New 1300 MHz Network Analyzer:



8754A Network Analyzer and 8502A Transmission/Reflection Test Set. CRT trace has been stored in companion 8750A Storage/Normalizer.

When your RF network measurement needs are large, but your budget isn't.

45902

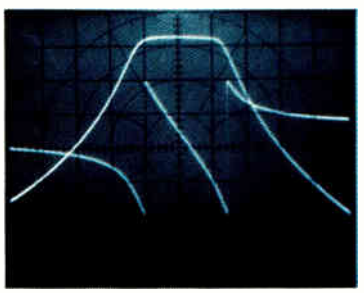
For assistance call: Washington (301) 258-2000, Chicago (312) 255-9800, Atlanta (404) 955-1500, Los Angeles (213) 877-1282

HP's new 8754A Network Analyzer brings speed, convenience and economy to RF measurements. It costs only $11,500 and consists of:

- Built-in 4-1300 MHz swept source with +10 dBm leveled output, calibrated sweeps and crystal markers.
- Three channel receiver to measure any two transmission or reflection parameters simultaneously with > 80 dB dynamic range.
- CRT display for fully calibrated rectilinear and polar plots with resolution to 0.25 dB and 2.5° per major division.

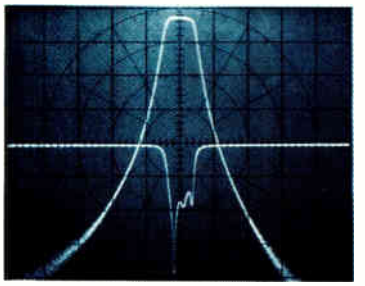
Just add the test set appropriate for your application and you're prepared to make thorough and accurate measurements quickly and easily. Here are just a few of the things you can do with the 8754A:

Transmission Magnitude and Phase



It's easy to measure loss, gain and phase shift using just the 11850 Power Splitter ($525). You can completely identify filter passbands and skirt characteristics without misleading harmonic or spurious responses.

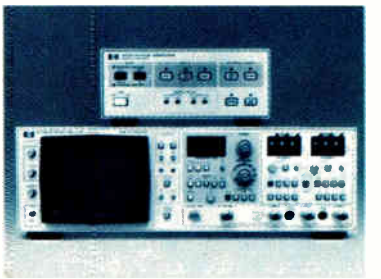
Simultaneous Transmission and Reflection



Using the 8502 Test Set ($1850) you can see the trade offs between transmission gain or loss and input match in a single test setup. For complete two-port characteristics of networks, including devices like transistors, an S-parameter test set is available.

Impedance

Measure and display impedance in polar form with convenient Smith Chart overlays. Test sets are available for both 50 and 75 ohm systems. The 8754A's crystal markers give precise frequency data. In addition, probes are available for in-circuit measurements.



Add a storage/ normalizer and increase the 8754A's capabilities even more!

The HP 8750A Storage/Normalizer can automatically remove system frequency response variations. And you can make comparison measurements easily because normalization directly displays the difference between two responses. The 8750A's digital storage permits flicker-free displays, even for measurements requiring slow sweep rates.

Best yet, all this capability is offered at an affordable price. A call to your nearby HP field sales office is all you have to do to get more information, or write.

Domestic US prices only.

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Circle 61 on reader service card

King Carl XVI Gustav of Sweden—on the right in these photos—presents the 1978 Nobel Prize in Physics to Bell Laboratories scientists Robert Wilson (top photo) and Arno Penzias.

What does the Nobel Prize have to do with your telephone?

The two scientists on the opposite page are receiving the highest honor a scientist can earn—the Nobel Prize. They are the sixth and seventh laureates who did their prize-winning research at Bell Telephone Laboratories. These scientists shared a common goal—the search for new knowledge to further advance the art of telecommunications.

Clinton Davisson shared the Nobel Prize in 1937 for demonstrating the wave nature of matter. In 1956, John Bardeen, Walter Brattain and William Shockley were honored for their invention of the transistor. Philip Anderson's theoretical work on amorphous materials (such as glass) and on magnetism led to a Nobel Prize in 1977. And in 1978, Arno Penzias and Robert Wilson received the Prize for detecting the faint radiation from the "big bang" explosion that gave birth to the universe some 18 billion years ago.

The search for knowledge

These scientists and their colleagues at Bell Labs, given the freedom to explore, have proved time and again the value of investment in research—not only for telecommunications but for society in general. The transistor, for example, revolutionized communications and brought into being entire new industries—indeed, a new industrial society—based on solid-state electronics.

Other Bell Labs advances—products of this same research environment—have included high-fidelity recording, sound motion pictures, long-distance television transmission in the United States, the electrical digital computer, information theory, the silicon solar cell, and the laser. The impact of this work—on almost every field of commerce, industry, education and even medicine—has been incalculable.

The innovation process

Research done at Bell Labs in the past is the basis for the products and services the Bell System offers its customers today, just as the research going on now is the foundation for tomorrow's telecommunications.

Bell Labs scientists—specialists in physics, chemistry, mathematics and many other disciplines—team their efforts with those of our systems, development and design engineers. They, in turn, work closely with Western Electric manufacturing engineers and with the people of the Bell System operating telephone companies.

This technical integration is the foundation for true innovation. One idea feeds another. A basic scientific discovery can make possible entire new technologies and products for telecommunications, and a concept for a new product or system can stimulate the research to find even more new knowledge. That interaction, that teamwork, has been extremely productive: Bell Labs people have received 18,645 patents between our founding in 1925 and the end of 1978.

Sometimes, the search for knowledge may lead to a Nobel Prize. Often, it benefits all of society. And always, its ultimate aim is better service for Bell System customers.

Bell Laboratories
600 Mountain Avenue
Murray Hill, N.J. 07974

Bell Laboratories

Keeping your communications system the best in the world.

RCA

A report on electro optics: Low cost GaAs IR emitters.

RCA offers a line of standard IR emitters that cost under $1.00 for volume orders.

No matter what the price, every electro optic product RCA makes must meet our high standard for reliability.

In gallium-arsenide IR emitters, that standard results in a mean time before failure far greater than 100,000 hours.

Variety of applications.

Sealed in a rugged hermetic package, RCA IR emitters are interchangeable with most standard types.

They're compatible with silicon phototransistors or photodiode detectors. And designed for a wide range of industrial applications.

Including: card and paper tape readers, shaft encoders, intrusion alarms, high speed sorting and counting, smoke detection, and optical switches.

Pulsed or continuous.

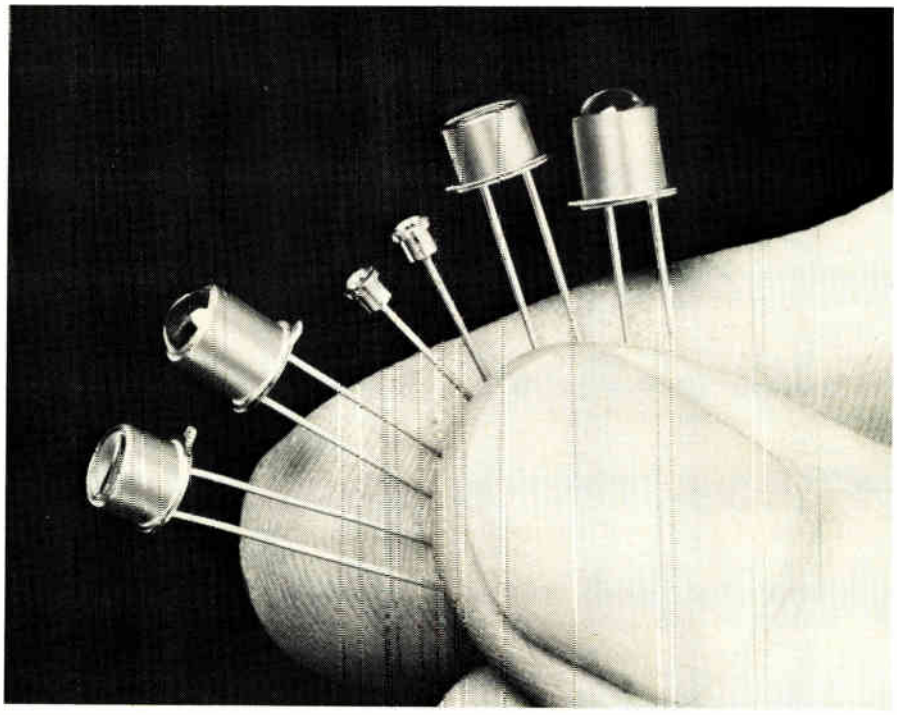
For continuous DC or low-current pulsed operation, you can choose the SG1009 series. Or for high-current pulsed operation, the SG1010 series.

Power outputs are 4 mW minimum, 7 mW typical for continuous wave operation. Up to 200 mW for pulsed power output.

Both types are available with glass lenses for a narrow beam pattern, 8° half angle beam spread at 50 percent intensity points, or with simple flat glass windows for 30° beams.

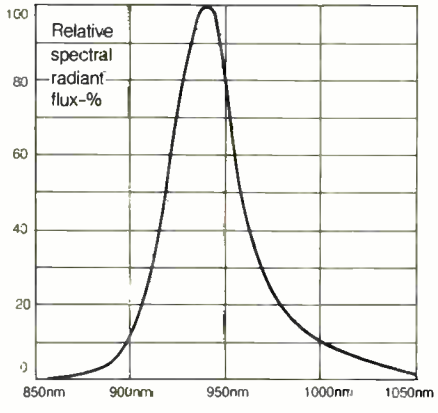
Minis for close mounting.

If space is a problem, consider our minis (SG1002, SG1003, SG1004). They exhibit the same wavelength characteristics as the above types.



Yet the extremely small size of these devices (.095 inches, overall diameter) permits close mounting dimensions with a minimum of cross coupling.

Typical spectral radiant flux (percent).



Power outputs range from 1 mW to 2.4 mW minimum for continuous operation. And from 24 mW to 40 mW typical for pulsed operation.

An integral reflector in the OP-10 package used for these devices focuses output to a 15° half angle at 50 percent intensity points.

Large quantities available.

No matter what your application, RCA can probably provide an emitter to meet your needs.

And we can deliver as many as you need from stock.

For further information on the RCA line of IR emitters, contact RCA Electro Optics and Devices, Lancaster, PA. Buenos Aires, Argentina. Brussels, Belgium. Sao Paulo, Brazil. Ste. Anne-de-Bellevue, Quebec, Canada. Sunbury-on-Thames, Middlesex, England. Stuttgart, W. Germany. Mexico 16 D.F., Mexico.

International newsletter

Will RAMs replace scan tubes in radar displays?

Scan converter tubes, long used to transform radar images into bright television displays, may become yet another victim of low-cost semiconductor memory. At the Paris air show that ended earlier this week, Thomson-CSF showed the prototype of a digital scan converter based on a 4-megabit picture-element store of 16-K random-access memories. Controlled by a fast microprocessor, **the converter reads digitized radar video signals into the 1,024-by-1,024-pixel store** and then reads them out as a high-resolution TV raster display—875 lines or more per frame. Thomson says the digital converter will be more expensive at the outset than tube converters, but the difference in cost will be more than offset over the equipment's life because there is no tube to change every 20,000 hours or so. Furthermore, synthetic displays of alphanumerics and symbols can be added easily on the raster display.

Hitachi weighs in against 4300 series with three models . . .

The latest Japanese response to IBM's 4300 series of medium-sized mainframes comes from Hitachi Ltd., which promises January deliveries of three additions to its Hitac M series. **The new models use dual disk drives with a capacity of 635 megabytes per spindle and a data transfer rate of 1.198 megabytes/s.** The new M-140H has a main memory of 0.5 to 2 megabytes and a 5-megabyte/s channel transfer rate. It uses firmware to replace the main portions of the virtual operating system, thereby reducing running time of the control program by 15% to 20%. The M-150H has a main memory of 1 to 4 megabytes and a 5.5-megabyte/s channel transfer rate; the M-160H boosts these specs to 2 to 6 megabytes and 7 megabytes/s. For the 140 and 150, optional high-speed execution units can double performance.

. . . that use 64-K RAMs, to be sold commercially

Hitachi's three new computers will use 64-K single-power-supply random-access-memory chips, which are also being employed to boost capacity in the Hitac L series of smaller mainframes. The company will supply samples of its HM4864-3 64-K dynamic RAM by the third quarter. The chip operates from a single +5-V power supply and has a 200-ns maximum access time and a 375-ns minimum cycle time. Power dissipation is 300 mW, and the 128 refresh cycles each take 2 ms. **Hitachi says it will deliver the new memory to Nippon Telegraph and Telephone Public Corp. in December** for use in file-control equipment; but the company will be pursuing sales worldwide, especially in the U. S. The chip comes with pin 1 unconnected, as does Texas Instruments' 64-K RAM.

Microcontroller uses self-optimization to regulate building heat

A 20% to 40% slash in building heating costs is the promise held out by a microprocessor controller with self-adaptive software now being launched in Europe by Honeywell Inc. Developed by the firm's Dörnigheim, West Germany, unit, the Micronic 100 is intended for such uses as office buildings, where optimum turn-on and -off times for the heat can realize important fuel savings. The software, which runs on an Intel 8085, learns from experience, automatically adjusting for outdoor temperature, length of time the building has been vacated, and differences in thermal performance in different buildings. **It is probably the first commercial product to use a self-optimized microcontroller.** Elsewhere, an Oxford University laboratory is working on applying the technique to nonlinear processes and those with long time-constant controls [*Electronics*, June 22, 1978, p. 67].

International newsletter

Diode laser offers 1.3-μm wavelength, 5-mW output

Long-distance, high-capacity optical transmission systems will get a boost with Hitachi Ltd.'s new indium-gallium-arsenide-phosphide laser operating at a 1.3-μm wavelength and an output of 5 mW. The new devices make possible **data rates of more than 1 gigabit per second over distances between repeaters of up to 50 km.** Two models will be available in September, initially in small quantities: the HLP 5400 (U), for experimental use, and the HLP 5500 (U), which has a short length of optical cable for splicing to a transmission line. The company will say only that single-quantity prices will range from $1,800 to $2,700.

GaAs wafers slated for mass production for FET applications

Sumitomo Electric Industries Ltd. says it will now mass-produce gallium-arsenide wafers for field-effect transistors with a thin active epitaxial layer on a semi-insulating substrate. The epitaxial layer is grown on a buffer layer in a vertical tube (furnace), **so the firm can process batches of 3 to 10 times as many wafers** as can be handled with conventional, horizontal tubes. The characteristics of the final devices are highly dependent on those of the epitaxial layer. By careful process control, the impurity level of the epi layer is down to 1 part in 10 billion, and the variation in thickness is held to between 200 and 300 angstrom units. Current price is almost $1,000/in.^{2}, but the company expects it to be at most $100/in.^{2} by 1982.

FETs slash resistance with molybdenum gates

Molybdenum gates are featured on the high-frequency n-MOS power field-effect transistors, samples of which are just now coming from Hitachi Ltd. Two devices with a 100-W dissipation and 160- and 200-V ratings are available. They are similar to Hitachi's earlier polysilicon-gate power MOS FETs [*Electronics*, May 12, 1977, p. 56 or 6E] but **the molybdenum gates have one tenth the resistance, thus decreasing the RC time constant.** Transconductance is substantially flat out to 30 MHz, and amplifiers have been built with a gain fallout of only 3 dB at 100 MHz. The devices, which do not suffer from current hogging, are especially suited to parallel operation at very high frequencies. They are also suited to high-frequency switching applications, including switching regulators, since they are immune to current storage effects. Hitachi expects to supply samples of complementary p-channel devices in September.

Addenda

Bankruptcy proceedings for Denmark TV maker 3-F have begun, marking the final blow to the plant's employees, who have been struggling to maintain production. **They had already ceded majority control to a Hungarian-controlled group,** which simply stopped pouring money into the operation. Reorganization attempts are likely. . . . Digital Equipment Corp., Maynard, Mass., is setting up a **European technical assistance center in Valbonne, the French Riviera electronics center** [*Electronics*, July 6, 1978, p. 92]. Thirty specialists are to be on hand when the center opens in October. . . . Marconi Instruments Ltd. is stressing an enhanced digital test circuit capability for its new Autotest System 80, which can check out a board's components through a 512-pin bed of nails. **The company cuts the cost of the in-circuit tester by using an LSI-11 microprocessor instead of a minicomputer** and boosts its speed by shifting from interpreter- to compiler-driven software.

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The PM3214 25MHz/2mV dual trace alternate time base oscilloscope has all the triggering facilities found on the latest, most expensive scopes, but the price is only $1,445* And it's portable. That's more for less!

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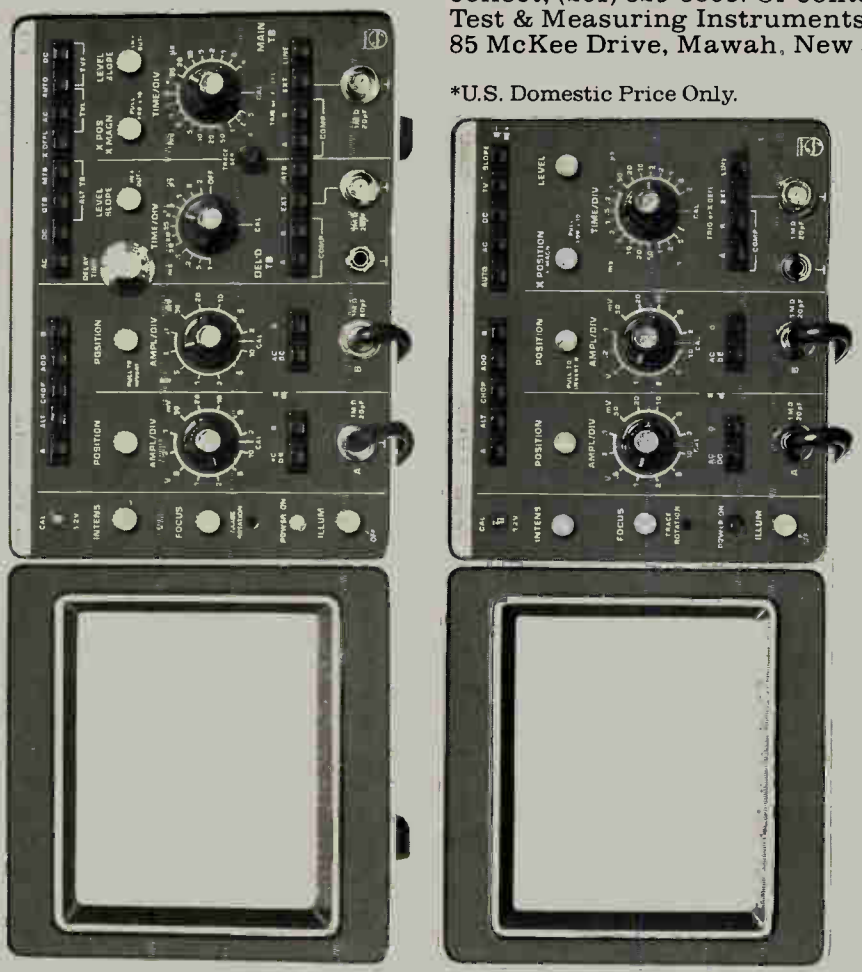
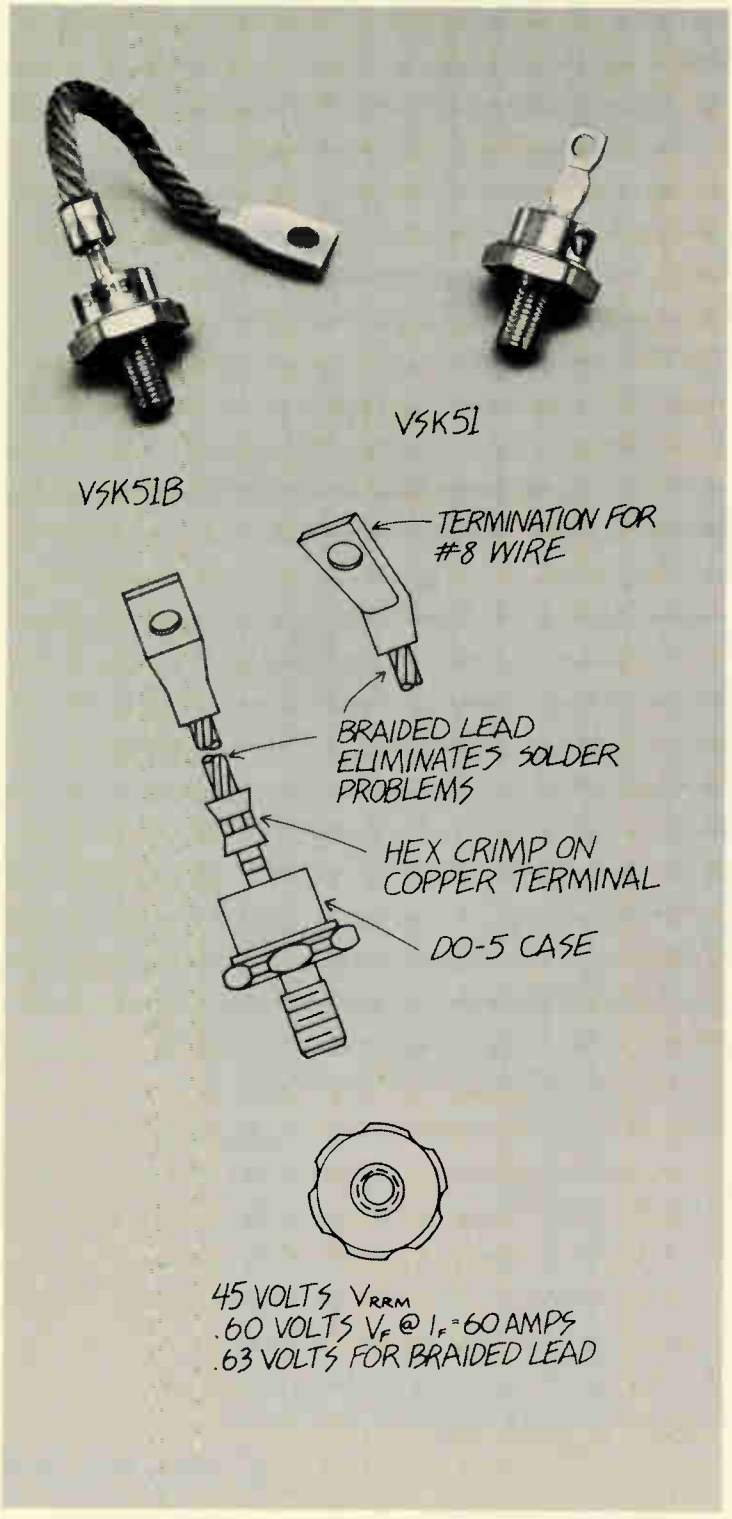
*U.S. Domestic Price Only.



PHILIPS Test & Measuring Instruments

PHILIPS

Varo's 60 amp Schottky rectifier adds a new twist for long term performance and reliability.



Look to Varo for the most complete line of Schottky power rectifiers: an on-the-shelf product line of fast recovery, low forward drop devices from 1 to 40 amps in a variety of case styles. Look to Varo for a new twist in a 60 amp Schottky rectifier: a standard DO-5 case with a braided lead.

Varo's new VSK51B (braided lead) is an economical package offering long term reliability by eliminating potential terminal seal breakage, internal solder reflow and cold solder joints. Its one step assembly with #8 wire assures minimum power loss.

In quantities of 100: the VSK51 costs $5.50; the VSK51B (braided lead) costs $7.40.

For specs or pricing on any Varo device, call: (214) 271-8511 VARO Semiconductor, Inc.; Box 40676; Garland, Texas 75040.

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Amorphous silicon shows promise for flat-panel TV display

by Kevin Smith, London bureau manager

Thin-film insulated-gate field-effect transistors seem to meet the needs for controlling liquid crystals

An idea for a flat-screen liquid-crystal TV display first proposed by Westinghouse Research Laboratories, Pittsburgh, in 1973 is being resurrected by research workers at Dundee University's Carnegie Laboratory of Physics, but with a new twist. In an experimental project now getting under way, a research team headed by Prof. Walter E. Spear hopes to solve some of the problems that brought the earlier project to a stop by using amorphous silicon.

The Westinghouse team under T. P. Brody aimed to produce an experimental flat-screen display for low-resolution TV pictures using a combination of thin-film transistors and nematic liquid crystals. They designed a 6-by-6-inch display with 20 lines per inch and 14,000 picture elements, each driven by a thin-film cadmium-selenide transistor.

But, says Spear, "the difficulties of controlling a two-component thin-film material are very considerable. It may well be simpler to control an elementary material such as silicon." In fact, Spear has recently reported in the literature on amorphous-silicon insulated-gate field-effect transistors (IG FETs) that have encouraging electrical characteristics.

Requirements. To drive their liquid-crystal elements, the Westinghouse team needed a thin-film transistor with an on-to-off-current ratio of 300, an on-resistance of less than 9 megohms to allow sufficiently rapid charging of the element, and an off-resistance of greater than 3,000 MΩ to prevent excessive charge decay between scans. Says Spear, "amorphous-silicon IG FETs readily satisfy those requirements."

His team is now working to scale up their process, determine reproducibility, and establish likely yields.

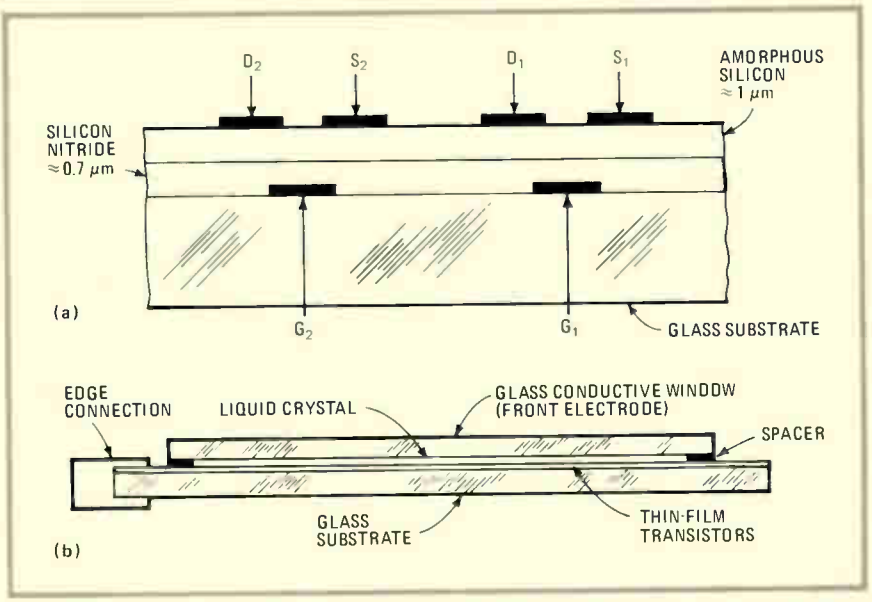
The process starts by evaporating a series of thin aluminum-gate electrodes about 100 micrometers wide onto a glass substrate (see part a of diagram). An insulating silicon-nitride layer 0.5 to 1 μm thick is then deposited by the decomposition of a mixture of silane and ammonia in radio-frequency glow discharge.

Next, an amorphous-silicon layer about 1 μm thick is deposited on the silicon nitride, also by a glow-discharge technique. Finally, the required pattern of source and drain contacts is evaporated onto the amorphous-silicon surface. So far, source-to-drain separations have been from 30 to 66 μm.

Display. In an assembled LCD, the liquid crystal would be sandwiched between the amorphous-silicon surface and a conducting glass window (see part b of diagram).

Moves to scale the process up have gone well, according to P. G. Le Comber, one of the researchers. Adds Spear, "Long-term device stability may be better than the group III–V compounds used previously." Specimens have been stored at room temperature for several years without showing any significant change. Both controllability and reproducibility look good, he says.

If the group succeeds in producing



TO KUM. A Dundee University research group is working on amorphous-silicon IG FETs (a) and thinks it may be possible to use them to make a flat-panel LCD (b).

suitable matrix arrays, they will probably work with another laboratory that has the skills needed to develop a full display complete with driver electronics. In an integrated display, the IG FET is connected at each junction of the X-Y matrix. In operation, amplitude information, possibly stored in a charge-coupled-device buffer, is discharged onto each column in turn. Meanwhile a scanner turns on all transistors in an addressed row.

As a result, a voltage proportional to brightness would be applied to each liquid-crystal element in that row. The applied voltage rotates the plane of polarization of the element, altering the light transmitted through it.

Japan

Hitachi, VLSI coop lab readying E-beam units to print 0.5-μm lines

As part of its efforts toward very large-scale integration, Japan's VLSI Cooperative Laboratory has worked with Hitachi Ltd. on two electron-beam exposure units capable of producing lines as thin as 0.5 micrometer.

One is an electron-beam pattern generator with a spot size of only 0.1 μm for direct lithography on wafers, designed by the lab and built by Hitachi. With this type of machine, minimum line widths of the pattern should be at least four spot diameters and corners should be reasonably sharp. Thus the minimum line width of the new system is on the order of 0.5 μm.

Making the small spot size possible is a newly developed field-emission electron gun, or cathode. The size of the spot from which it emits electrons is only 0.01 μm across—a lens system magnifies the beam to yield the final spot size.

The high beam current produced plus vector scanning of the beam make the machine extremely fast. For example, in a demonstration of the unit's capabilities, the lithography for the aluminum metalization of a 1/8 linear scale replica of a 16-K dynamic random-access memory chip measuring 0.83 by 0.42 millimeter was completed in 15 seconds.

Most advantages the new system has over previous electron-beam units depend on the new electron source. Rather than the heated tungsten hairpin or lanthanum-hexaboride thermal cathodes of previous systems, the unit uses an unheated tungsten-chip cathode from which an electron field of 10 megavolts per centimeter literally pulls out electrons.

Operation of the cathode at room temperature means that the system reaches thermal equilibrium almost immediately, eliminating the need for warmup. Still, the beam current of 40 nanoamperes is some 10 times larger than that of thermal cathodes and more than 100 times larger than the field-emission cathodes used in electron microscopes.

More benefits. A field-emission electron source yields at least three other advantages. For one, all electrons in the beam have the same energy, eliminating the chromatic aberrations encountered with conventional cathodes. In addition, magnification of the beam, instead of reducing it as with a physically larger, thermal cathode, permits the use of a much smaller column with two rather than the usual three magnetic electron lenses. Furthermore, essentially all the beam starting toward the target reaches it.

The tungsten chip has a small rounded tip. Although the voltage applied to the electrostatic accelerating lens is only 3 to 5 kilovolts, it causes a field of 10 MV at the pointed end of the chip. A current of 100 microamperes flows, of which 40 nA is available as the electron beam. This current can be increased severalfold by moderate heating, even though the temperature is still far lower than that needed for thermal emission. The noise component of the beam is typically less than 5%.

The system is designed for writing directly on wafers up to 3 inches in diameter. The area over which the beam can be deflected is variable between 2 and 5 mm square, and the stage is moved to expose the remainder of the wafer.

Performance. Use of a 16-bit digital-to-analog converter gives a resolution of 0.03 μm for a 2-μm-square field; it is correspondingly coarser for larger fields. The writing speed is adjustable between 1 mm and 1 meter per second, depending on the sensitivity of the resist.

The resolution capability in sensing alignment, using back-scattered electrons, is 0.01 μm. A laser senses table position, also to within 0.01 μm, and maximum error for the overlay registration at 1 σ is again 0.1 μm.

Hitachi has said it will take orders for this system if an agreement can be reached on price and other terms. The company refuses to discuss a figure, though, saying that it has not yet decided on the price.

Projection. The VLSI lab and Hitachi are also developing a projection step-and-repeat electron-beam lithography machine similarly capable of producing lines 0.5 μm wide, or even thinner. This system uses a stencil-like pattern cut into a 3-μm-thick nickel mask and projects a shower of electrons having the same pattern with linear dimensions reduced to one fourth.

The nominal size of the masks used is 12 by 12 mm, yielding a field size of 3 mm square after reduction. Resolution is 0.2 μm, and alignment is accurate to within 0.2 μm. The speed is said to be about 3 seconds per chip for polymethyl methacrylate (PMMA) resist, including the shift of the table for the next chip.

The innovative use of a relatively small beam of parallel electrons plus a raster scan to cover the entire mask, rather than a large flood beam, permits the design of a dramatically smaller machine.

Systems built with a flood beam require electron lenses with diame-

ters many times that of the beam in order to reduce distortion through the beam's cross section. In general, the height of the system must be scaled up along with the diameter, and the resulting system becomes so large that, in a factory building, it extends through the ceiling into the floor above.

With a smaller beam and smaller optics, distortion varies with the position of the beam, but it can be dynamically corrected as the beam is scanned across the mask because the distortion is essentially constant across the beam's relatively small diameter. Thus the Japanese group was able to build a unit with a column diameter of only 250 mm and the reasonable height of 2.1 m.

Only one major problem remains Closed-loop patterns are not possible, because the center falls out of the mask.

Lenses. The system uses a three-stage magnetic lens for illumination of the metal mask and a two-stage magnetic lens for projection of the pattern onto the mask. The illumination-lens system operates in different modes during alignment and exposure; the projection lens system works in the same mode for both operations. During exposure, dynamic correction of the angle at which the beam illuminates the mask preserves alignment across the mask's area, and dynamic correction of the projection lens preserves image sharpness. **-Charles Cohen**

Great Britain

CAP-CPP writes Microcobol software for small-business applications

Microprocessor-based business systems have brought cheap computing power within reach of the smallest businesses, but the development of this new and potentially enormous market has been slowed by the lack of professional business software, according to the British software company Computer Analysts and Programmers (UK) Ltd.

To fill this need, it formed a new subsidiary, CAP-CPP Microproducts Ltd., in 1975 and has invested considerable programming resources over the past four years in the development of a high-level portable business language, called Microcobol.

The London firm seems to be on the right track. It is signing up vendors of small-business systems at the rate of one a week. Twenty are already on board, including two in the United States and one in the Netherlands.

Advantages. Portability means that a language can run on any microcomputer system for which a small interpreter program has been written. "You can take a diskette holding a compiled Microcobol program from an IBM Series/1 and run it on a Mostek AID-80F immediately," emphasizes Ian Jacks, marketing manager at CAP-CCP Microproducts. Manufacturers of small-business systems can therefore cash in on a library of ready-made business software.

Also, customers who develop their own Microcobol programs know their software investment will not be made obsolete by changes in hardware. Says Jacks, "This is particularly significant for large companies that wish to develop programs for operation on different hardware at several different sites."

CAP-CPP has already written enough software to put a first-time user into business. It has a multiuser transaction-oriented business operating system called BOS and a number of standard business-application packages. Recently, it launched two packages—Autoindex and Autoclerk—that allow a user to prepare his own business programs. The first is a data-base enquiry and retrieval package; the other is a file-management package that is also capable of generating reports.

Interpretation. The interpreter, resident in main memory, recomposes compiled Microcobol statements into the microprocessor's machine code, executing each statement line by line. So far, CAP-CPP has written interpreters for six different machine architectures: the Intel

They mean business. At its development center in London, CAP-CPP Microproducts writes all of its Microcobol software, which is portable and designed for small businesses.

8080, Motorola 6800, Zilog Z80, Digital Equipment Corp. PDP-11, IBM Series/1, and Texas Instruments 9900.

Says Jacks, "We completed an interpreter for Digital Micro Systems Inc.'s Z80-based DSC/2 in just two weeks," though one to two months is more usual. The company has now written interpreters for 13 different small-business computers, including Applied Digital Data Systems' System 70 and Siemens' 6.610.

CAP-CPP bypasses the need for a compiler for each different microprocessor by writing a compiler, an operating system, and applications software for a virtual machine. High-level Microcobol statements are then compiled to produce intermediate-machine code, each statement of which corresponds to one instruction for the virtual machine. The interpreter operates on this intermediate-machine code.

Machine-code instructions for real and virtual machines are at a similar level of complexity. Therefore the Microcobol interpreter needs only 4 kilobytes of code. "The only penalty," says Blandford, "is a slower operating time, which scarcely matters in interactive computing."

In addition to the resident interpreter, CAP-CPP also prepares a compiler so that user-developed programs can be both compiled and run on the same machine.

Making software portable is the only way that high-quality software can be produced at the prices needed to match low hardware costs, the firms says. Autoclerk costs $2,000, and Autoindex $1,000. **-Kevin Smith**

West Germany

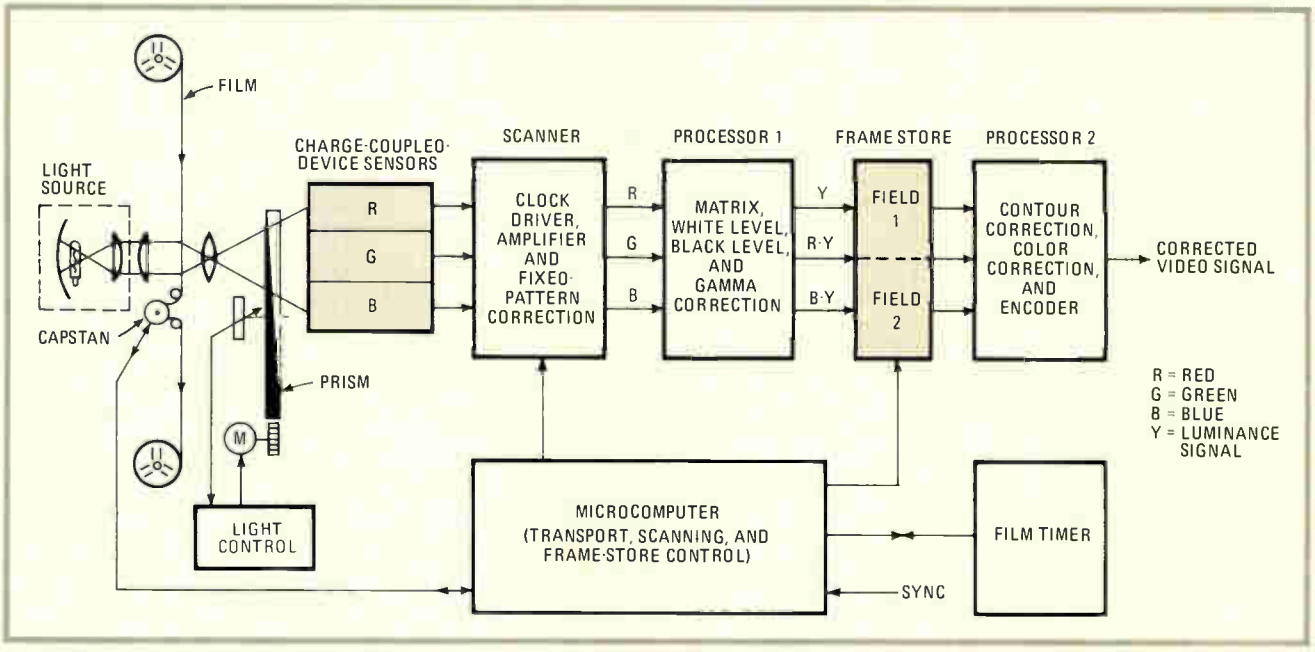
Telecine gains from the use of CCD sensors and digital storage

Broadcasters nowadays work whenever they can with television cameras and video tape recorders, but there is plenty of programming still based on motion-picture film. Thus no one yet foresees the demise of the telecine, the equipment that generates video signals as film is run through it. Quite the contrary, in fact: a new generation of telecines with solid-state image pickups and digital field stores is in the offing.

The first such unit to make it into the marketplace most likely will be from Robert Bosch GmbH. The West German company's Television Systems division showed the prototype of its FDL 60, using charge-coupled devices (CCDs) as image sensors, at the 11th Biennial International Television Symposium held from May 27 to June 1 at Montreux, Switzerland. Deliveries will start early next year, reports Dieter Poetsch, telecine products research manager for the Darmstadt-based division.

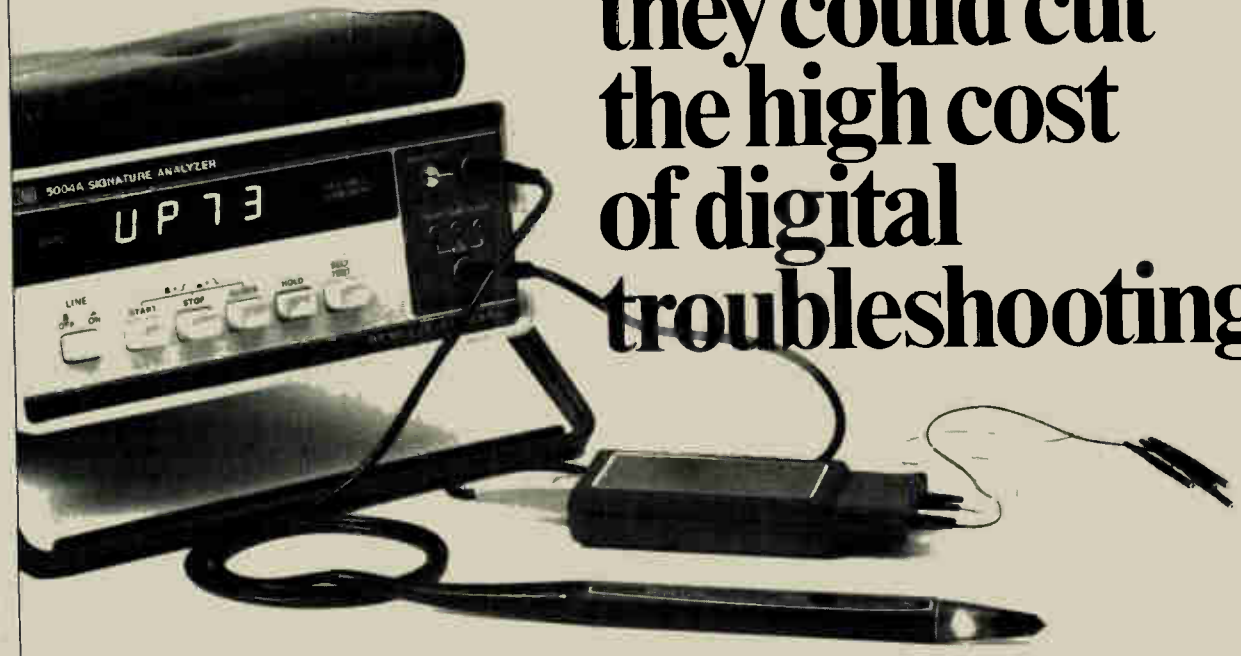
Bosch has priced the basic machine at some $165,000. That puts it roughly in the same bracket as the widely used Mark III flying-spot telecine (when fitted with a digital store) from the UK's Rank Cintel, part of the Rank Organization.

Gains. Several advantages accrue from scanning a film image line by line with CCDs and then storing it in a digital memory before processing it into composite color video signals for two interlaced television fields. A major one is that the technique eliminates the painstaking precision adjustments required for conventional



Film to video. Bosch telecine uses CCD sensors to effect line-by-line scanning of a film image. After processing, the signals are digitized and placed in a RAM field store. Odd lines are read out for the first interlaced field, even lines are read out for the second.

Last year, this $1000 device convinced over 300 companies they could cut the high cost of digital troubleshooting.



Company after company is becoming convinced that it can significantly reduce the huge costs involved in microprocessor troubleshooting by using HP's signature analysis technique. The savings on board inventories alone can run into hundreds of thousands of dollars. In brief, it is now possible for a modestly trained technician to accurately troubleshoot microprocessor boards right down to the component level in the field or on the production line.

A simple concept.
Subtle errors in the lengthy bit streams of microprocessor-based products are definitive clues to component failures which cause them. But lengthy bit streams are very tedious and costly to examine by traditional means.

HP's 5004A Signature Analyzer solves this problem by compressing lengthy bit streams into short, four-digit, hexa-decimal signatures that quickly and accurately lead right to the failed component.

Just activate a digital exercise routine in the circuit under test and compare the bit stream signature at each data node with the known good signatures previously written into your service manual. Digital signal tracing now becomes as simple as analog tracing used to be. But more accurate. So accurate that it catches almost every possible fault, including many that can be detected in no other way. It once again becomes realistic to think of field or production troubleshooting to the component level by technicians.

Design it in or retrofit.
The savings in service costs and spare circuit board inventory are well worth the effort of designing with signature analysis in mind. It could possibly eliminate the need to partition your product for modular service. In some cases, it could even pay you to "retrofit" by developing exercise circuitry and a signature manual for your existing equipment. It's a fascinating—and very workable—concept. Amazingly the price of the HP 5004A Signature Analyzer that makes all this possible is a low $990*

To help you make the most of this breakthrough we've prepared Application Note 222—"A Designer's Guide to Signature Analysis." Contact your nearest HP field sales office or write for your copy today. *price, domestic U.S.A. only

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flying-spot scanners: to save bandwidth they scan each frame twice and thus need near-perfect registration to interlace the two fields (Rank Cintel's Digiscan storage option also does away with double scanning). The CCDs also eliminate some drawbacks inherent in image-pickup tubes—the need for high-voltage power supplies, distortions caused by beam deflection, and comparatively short life, for example.

In the FDL 60, the film runs continuously, its capstan-driven transport controlled by an 8080-based microcomputer that also has charge of the scanner electronics and the frame-store circuitry. Light passes through the film and is split by a prism into red, green, and blue components. Each component is imaged on its own 1,024-element sensor, a buried-channel CCD array, type FCD 131, from Fairchild Camera and Instrument.

The three imaged signals are then amplified and corrected in the scanner before undergoing conventional processing—matrixing, gamma correction, and setting of white and black levels—to obtain the luminance signal and two color-difference signals.

After the processing, the luminance and color-difference signals are converted into 8-bit digital signals having a signal-to-noise ratio of 50 decibels. The luminance signal is stored line by line and the two color-difference signals multiplexed and stored separately line by line in the memory, which is built of 16-K dynamic random-access memories, some 290 of them.

Odd and even. When the full frame has been stored, the odd lines are read out to get the first field and then the even lines to get the second interlaced field. After read-out the three signals are converted back into analog form and then encoded to get a standard composite color video signal—PAL, Secam, or NTSC.

All the read-in and read-out operations are controlled by the microcomputer. At read-in, each line gets a specific address so that the computer can be programmed to read out lines to obtain effects like stop action, reverse action, and slow motion. Of course, the new telecine offers the conventional features of its flying-spot predecessors—like 16- and 35-millimeter film formats and magnetic and optical sound playback. **-Arthur Erikson**

France

4-km optic TV cable links camera to van

Field-production equipment for color television is part of the fast-growing list of hardware being bettered by fiber optics, and it has a new addition from Thomson-CSF, a major European producer of broadcast and studio equipment. At the May 27–June 1 International Television Symposium at Montreux, Switzerland, the Paris-based firm demonstrated the prototype of a two-way optical link that lets a camera operate as far as 4 kilometers from a van handling on-location production of a TV broadcast.

Longer. In contrast, when the link from camera to van is a multiconductor cable, the limit is just 250 meters. For triaxial cable—a coaxial cable for the video with added conductors for power—the limit goes up to 1.5 km; but the cable is some 2½ times heavier than the new fiber-optic link.

Thomson-CSF still has not set a price for its hardware but insists it will be competitive for links over 3 km long and will get cheaper if demand is strong.

Although there are many bare-bones optical links on the market that can handle a single video channel, none had the transmission characteristics that Thomson-CSF's Radiodiffusion-Télévision division wanted. So it turned to the company's electronic laboratories at Rennes. "We had to maintain broadcast quality," says the labs' assistant director, Jean-Claude Bellamy. "The weighted signal-to-noise ratio is 65 decibels, the phase differential less than 1°, and the gain differential less than 1%," he explains.

"From what some competitors and potential customers have told us, we are ahead with this link," Bellamy maintains. Instead of the usual one-way video cable, Thomson-CSF's has two. One fiber carries an encoded color video signal (PAL, Secam, or NTSC) and two audio channels from the camera to the control unit in the van. The other carries a black-and-white video signal for the camera's viewfinder, two audio channels, as well as up to 15 analog control signals and 12 logic signals, from the van to the camera. In addition, eight copper wires carry power for the camera.

The watertight, dustproof cable connector snaps shut automatically when disconnected. The optical attenuation is less than 1.5 dB.

In the transmitting head for each channel is a gallium-arsenide laser diode operating at a wavelength of 830 nanometers. The diode's output is pulse-frequency–modulated and couples between 2 and 2.5 milliwatts of useful light power into the associated step-index fiber. Each has a 65-micrometer core and an outside diameter of 125 μm, with attenuation less than 5 dB/km.

The audio and control signals are encoded into 12-bit digital format and multiplexed into a pulse-code–modulated signal at a rate of 512 megabits per second. This signal modulates a 7-megahertz subcarrier that is combined with the video signal, which has a bandwidth of 6.5 MHz, and fed to the pulse-frequency modulator. It operates at a 15-MHz carrier frequency with a swing of 3 MHz for a 1-volt change in the video signal.

At the receiver, the optical signal is picked up by a GaAs avalanche photodiode. The photodiode's output is amplified and then processed to extract the video and PCM signals for the multiplexed audio and control signals. The bias of the photodiode comes from a dc-dc converter controlled by a comparator's error signal that is the difference between the diode's output and a reference current. Thus no system adjustment is needed if the cable length is less than 4 km. **-A. E.**

The hot little idea that's spreading like wildfire.

Last year, Fairchild silently slipped over the silicon border into the 16-bit microcomputer systems business.

Our first product was the 9440 MICROFLAME™ microprocessor. We introduced it as "the microprocessor that thinks it's a minicomputer." But it looked like a component. So most people assumed it was just a component.

It wasn't.

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It was the heart of a microcomputer system.

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Please turn the page.

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minicomputer CPU on one chip, packaged in a 40-pin DIP. It is supported by other family members:

The 9441 memory and DMA controller.

And the 9442 I/O bus controller. These three LSI chips, plus our performance-matched dynamic bipolar RAM, are all that is needed to build a full microcomputer.

Major applications for the 9440 MICROFLAME include OEM data processing systems used in a variety of computing control and instrumentation environments. Telecommunications PBX and PABX switching installations. And distributed intelligence, distributed multiprocessing and front-end (terminal) processing.

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For more information on our hot little family, please write the FIRE Microcomputer Group, Fairchild Camera and Instrument Corporation, P.O. Box 880A, Mountain View, California 94042.

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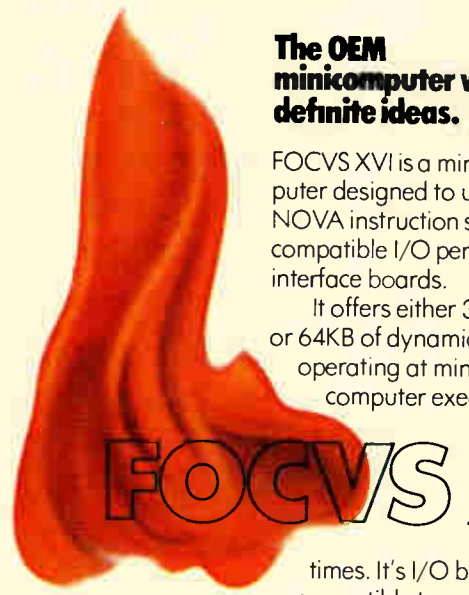
Circle 236 on reader service card



The OEM minicomputer with definite ideas.

FOCVS XVI is a minicomputer designed to use the NOVA instruction set and compatible I/O peripheral interface boards.

It offers either 32KB or 64KB of dynamic RAM operating at minicomputer execution

FOCVS XVI

times. It's I/O bus-compatible to accommodate a wide range of peripherals. And it's supported by FIRE System software, allowing it to run millions of lines of applications software you've already developed.

The FOCVS XVI 9-slot chassis gives you up to eight extra slots so you can plug in other 15" x 15" boards. And it has front-panel controls for latch and display of data addresses, and examining memory or register contents.

Depending upon the minicomputer performance required, the FOCVS XVI may be equipped with either the GLOW-16 or BLAZE-16 15" x 15" boards. The boards may also be purchased for use without the FOCVS XVI enclosure for integration into your chassis.

For more information on the FOCVS XVI minicomputer, write the FIRE Microcomputer Group, Fairchild Camera and Instrument Corporation, P.O. Box 880A, Mountain View, California 94042.

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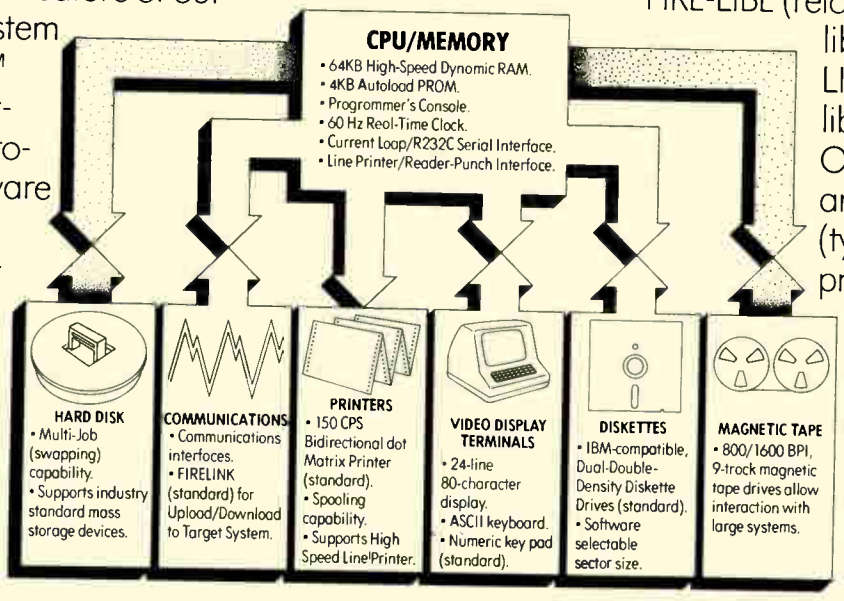

FIRELINK has the additional capability of communicating with remote target systems or other MICROFLAME Development Systems via a modem/acoustic coupler over telephone lines if necessary.

Software with FIRE power.

The integrated hardware is fully supported by the Fairchild Integrated Realtime Executive (FIRE) System software.

The Interactive Multitasking Disk Operating System (FIRE-IMDOS) supports extended file management, timesharing and device-independent I/O on the development system.

With user-supplied high-performance peripherals, FIRE-IMDOS supports timesharing for a number of users, limited only by performance of the swapping device. Additional features include password protection and version number contrc for automatic tracking and backup during the debug phase of development. Spooling capabilities allow printing to proceed concurrently with other interactive activity, thereby increasing the throughput of the system.

The system includes, as standard, system processors such as FIRE-EDIT (text editor), FIRE-MACRO (macroassembler), FIRE-SYMBUG (symbolic debugger), FIRE-LIBE (relocatable utility library), FIRE-LIBEDIT (relocatable library editor), FIRE-OEDIT (octal editor) and FIRE-TYPESET (typesetting program).

The software for PROM formatting and burning is standard on our system using either an attached user-supplied PROM programmer or a detached paper tape.

Optional high-level languages under the development system software include BASIC, FORTRAN and PASCAL.

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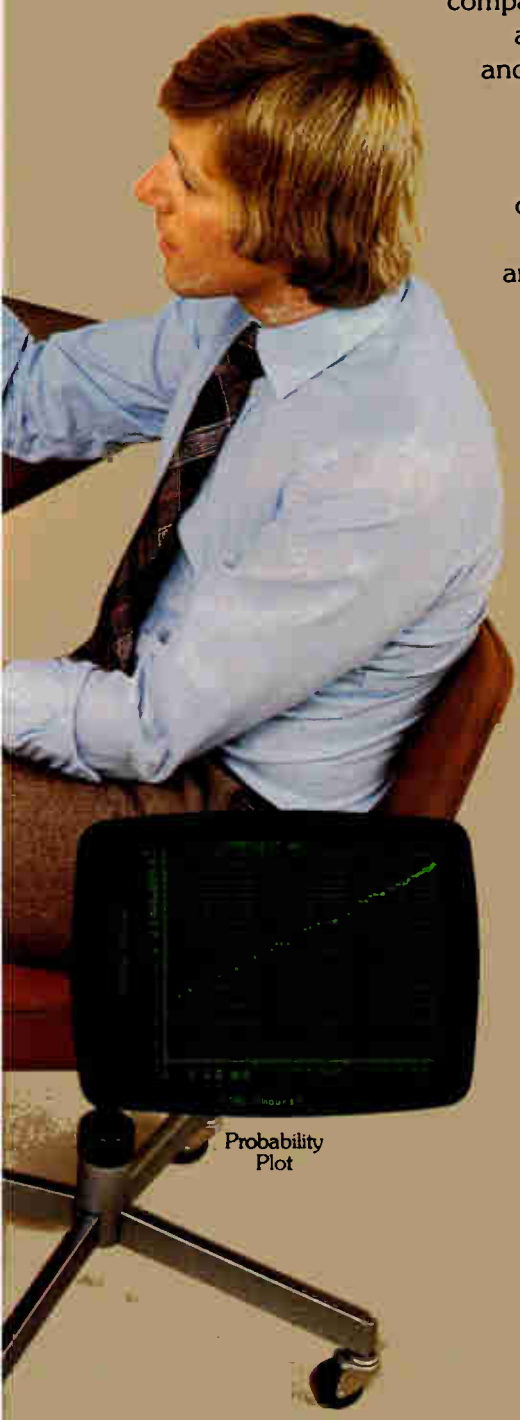
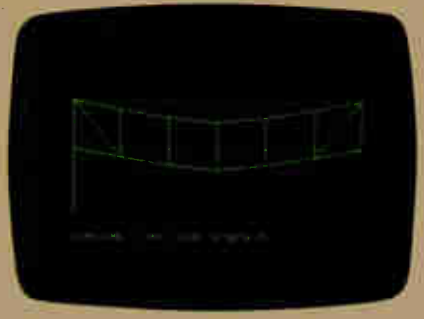


Probability Plot



Structural Analysis

GANTT Chart

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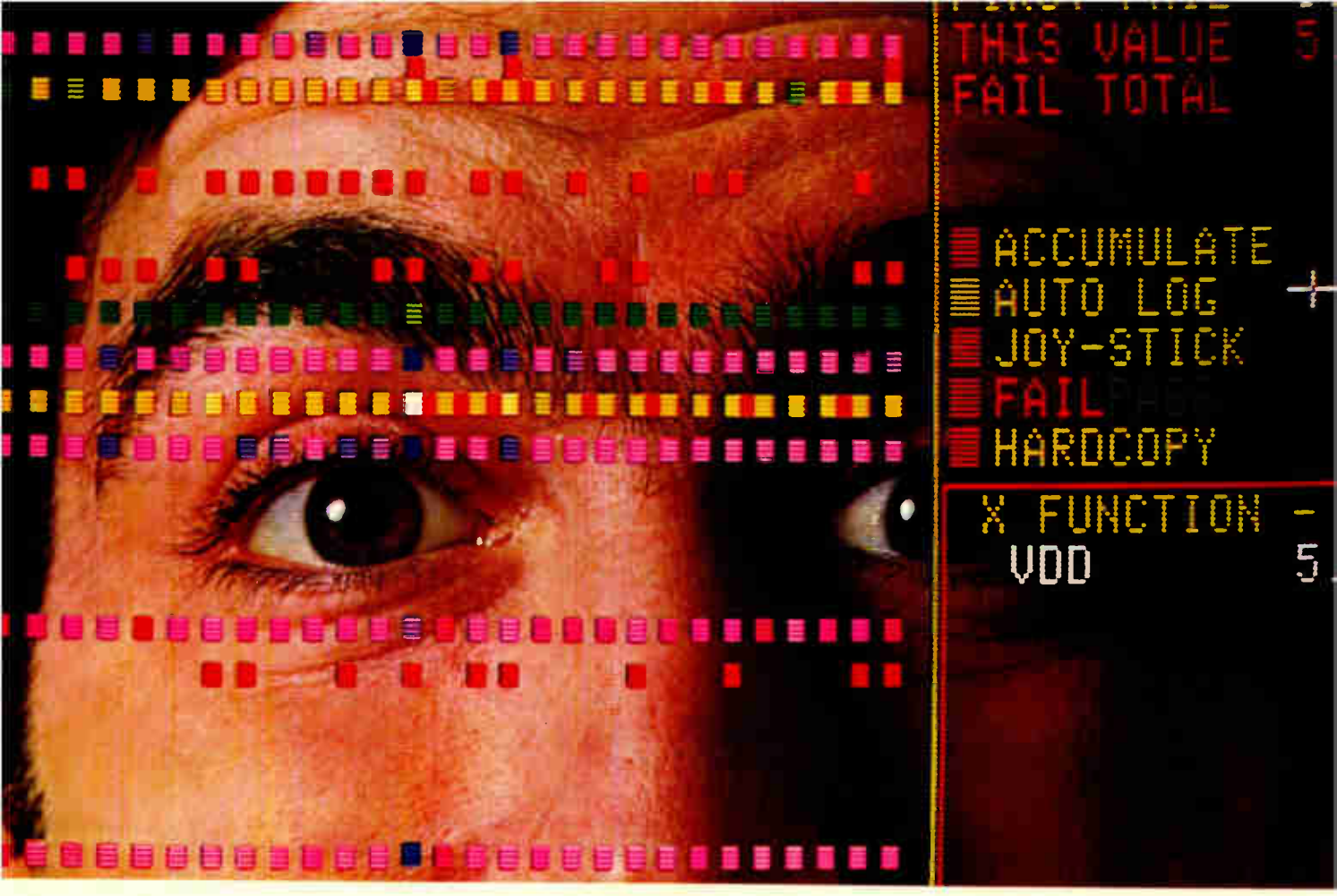

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TERADYNE

8-inch hard disks set to go

Despite lack of a standard medium, Winchester drives could be hottest peripheral since floppies arrived

by Anthony Durniak, Computers Editor

The makers of 8-inch Winchester disk drives left the starting gate as scheduled at the National Computer Conference and are racing after what may be the hottest peripheral technology since the floppy disk was introduced some six years ago. More than a half-dozen manufacturers introduced 8-in. drives the first week of June [*Electronics*, May 10, 1979, p. 40], making them the talk of the NCC in New York. But the lack of a standard medium and some vague packaging and interfacing details will probably slow the contenders' progress for at least a year.

The new drives are all based on the so-called Winchester sealed-medium technology that was originally designed for mainframe computers and has become popular over the past 18 months in drives aimed at the small computer systems market [*Electronics*, July 6, 1978, p. 90]. Instead of the standard 14-in.-diameter disks, however, the new units use media measuring roughly 8 in. across and thus fit the same cabinet opening as a standard floppy-disk drive. But where a floppy can store a maximum of 1.6 megabytes, the new drives hold as much as 60 megabytes.

With access times four times faster than those of floppy disk drives and price tags ranging from $1,300 to $2,100 each in large quantities, the drives appear perfect for small computer-system builders who want additional capacity and performance but not the traditional 14-in. disk's size or price.

"There are compelling reasons to look at 8-in. drives," explains one potential user, David Seigle, vice

THE 8-INCH DISK LINEUP

Company and model number	Capacity (megabytes)	Number of platters	Outside diameter of media (mm)	Recording densities	Positioning mechanism	Average access time (ms)	Motor type	Electronics included	OEM price
BASF 6170 series	8 24	1 2	210	6,542 b/in. 500 t/in.*	servo-controlled linear motor	50	direct drive brushless dc	drive and controller	$2,100† $3,100†
IBM model 62 PC	29 64.5	3 6	210	8,530 b/in. 450 t/in.	servo-controlled rotary actuator	27	–	–	–
International Memories Inc. model 7710	11	2	220	5,868 b/in. 300 t/in.	servo-controlled linear actuator	50	direct drive brushless dc	drive plus controller	$1,500†
Kennedy series 7000	4 12	1 2	210	–	–	50	ac belt drive	drive	about $2,000 –
Memorex model 101	11.7	2	200	6,100 b/in. 195 t/in.	open-loop stepper-motor band-actuator	70	direct drive brushless dc	drive	$1,400 – 1,500
Micropolis Micro Disk 1200	9 27 45	1 2 3	200	6,640 b/in. 478 t/in.	servo-controlled rotary actuator	34	direct drive brushless dc	drive and controller	– $1,350† –
Microcomputer Systems Corp. 8000 series	50 110	3 6	–	8,500 b/in. 510 t/in.	servo-controlled rotary actuator	25	direct drive brushless dc	amplifies only	–
New World Computer Mikro-Disc 211	2.1	1	200	8,000 b/in. 100 t/in.	stepper motor, open-loop	18.8	ac direct drive	drive plus interface	$900
Pertec D8000	20	2	210	6,000 b/in. 476 t/in.	servo-controlled rotary actuator	50	direct drive brushless dc	drive plus interface	$1,800†

*t/in. = tracks per inch †without controller

SOURCE: *ELECTRONICS*

president of Basic Four Corp.'s Distributed Data Processing division, Tustin, Calif. "The smaller size of the drive gives you less skin and framing to worry about, and the drives use less power. This results in a lower overall cost and a more compact system."

And there were many drives to be seen at the computer show. Of recently announced units, there was the D5000 from the Peripherals division of Pertec Computer Corp., Chatsworth, Calif., while Micropolis Corp. of Canoga Park, Calif., gave private showings of its MicroDisk 1200 in a nearby hotel [*Electronics*, May 24, 1979, pp. 194, 264], Microcomputer Systems Corp. of Sunnyvale, Calif. brought a virtual parade of original equipment manufacturers, potential customers all, to its suite in the Hilton to see its unique entry (p. 39), while BASF Systems of Bedford, Mass., Memorex Corp. of Santa Clara, Calif., Kennedy Co. of Altadena, Calif., and New World Computer Company Inc. of Costa Mesa, Calif., unveiled entries at their booths.

Shipping. International Memories Inc., the Sunnyvale, Calif., company that pioneered in this area last year [*Electronics*, April 27, 1978, p. 40] and did not exhibit at the NCC, is the only independent maker to say it is now shipping 8-in. drives. IBM, credited with encouraging the current activity with its own model 62 PC drive (known in industry circles as "piccolo"), is delivering it to customers for its System/34 small business system.

But others wanting to buy the drives will find them mostly unavailable until the end of the year at the earliest, and will have to choose among a wide range of performance specifications (see chart). Even pricing is not yet firm.

According to James S. Toreson, president of Microcomputer Systems Corp., the lack of a standard medium "is a serious problem. Until media is standardized there will be no market." As the chart shows, the makers are almost evenly divided between use of the 200- and 210-millimeter outside diameters. And unless a single size is used, the volumes may not be high enough for the drives to be economical.

Those companies that make both media and drives, such as BASF and Memorex, are likely to supply their own needs before they ship to competitors—which could leave independents out in the cold.

Differences. Users will also find that, though all the makers advertise their drives as fitting the same 4.6-by-8.5-in. opening as the standard floppy-disk drive, a floppy cannot literally be pulled out and replaced by an 8-in. drive. To begin with, the packages contain different electronics. Most, though, have the basic drive electronics, including the signal amplifiers, read/write electronics, and motor and servo control circuitry, configured into the basic drive package.

But International Memories, BASF, and Micropolis also have room to add a separately priced controller to handle the error checking and correction, data formatting, and interfacing to the computer. Memorex says the design of a controller is under way, but because it uses more platters than the others, Microcomputer Systems' drive has room only for the signal amplifiers.

Although Control Data Corp. of Minneapolis has not yet announced an 8-in. drive, Gordon Brown, senior vice president for planning and marketing of peripheral products, says that the one under development uses custom circuitry to pack more electronics into the drive. "We think that the use of custom LSI is critical to maintaining the small physical dimensions."

In addition, though most floppy disks currently use ac motors to rotate the media, many of the new 8-in. drives are using brushless dc motors. Designed as part of the spindle, these motors are compact, measuring no higher than 1 in., and are said to maintain a more accurate speed—importance for a consistent data-transfer rate. But a new power supply will be needed.

Finally, as Basic Four's Seigle says, "The real question is backup." With removable disks such as traditional cartridge disks or even floppy disks, a systems user with two drives can make a copy of important programs or data and remove it for safe keeping. Fixed disk drives therefore require a second device with a removable medium for back-up purposes.

Streaming tape. IBM's answer to the problem has been its 8809 tape drive. Dubbed a streaming tape drive, the unit operates at a high data-transfer rate to accept data being copied, or dumped, from the fixed 62PC disk drive. Cipher Data Products Inc. of San Diego, Calif., attracted lots of NCC attention with its streaming drive [*Electronics*, May 24, p. 208] and Data Electronics Inc. of Pasadena, Calif., promoted its high-capacity tape cartridge system at the show (p. 204).

But Ralph Gabai, general manager of Pertec's Peripherals division, says the streaming tape drive is not the perfect solution. "For small systems, such drives are still far too expensive, especially when you realize that two different controllers are required." So another backup device is needed, but Gabai will not say what Pertec is working on.

Although CDC's Brown says the company "is actively developing a streaming tape drive," its yet-to-come offering will include "a family of products with a combination of fixed and removable media including a small disk pack."

Still, even with all the details to be worked out, most industry observers see the drives as the most promising future peripheral product. Microcomputer Systems Corp.'s Toreson points out that the more sophisticated multiprogramming and file management software currently being added to small computer systems requires so much use of disks that the higher performance and durability of the hard disks is essential. "They wear out floppy media too fast," he says.

And the new 8-in. hard disks will lengthen the life of disk-drive technology in the face of predicted encroachments by semiconductor devices such as bubble memories. Micropolis president Stuart Mabon estimates that bubble chips would have to achieve densities of 16 million bits per chip and a price of $25 per chip in order to match the 8-in. disks' price and storage capacity per volume. □

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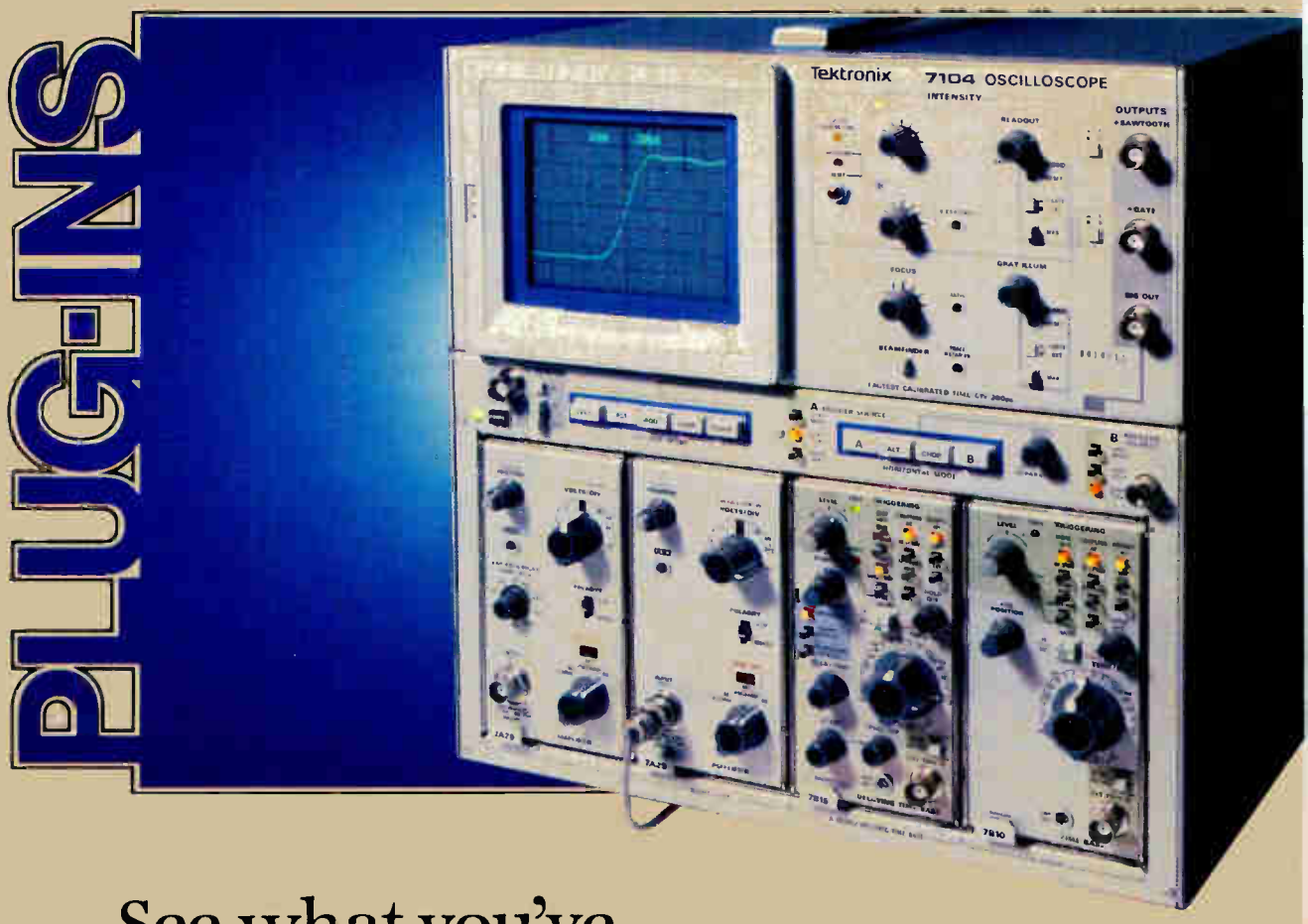

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Peripherals

Denser disk drives poised for surge

Thin-film production technology permits smaller recording heads, meaning narrower track gaps and more density, capacity, and speed

by William F. Arnold, San Francisco regional bureau manager, and Anthony Durniak, Computers Editor

Disk drives, which have been vital computer peripherals for more than 20 years, are about to take another leap forward in memory density, storage capacity, and data-transfer rates. Manufacturers are bringing out of development into commercial production a much smaller type of recording head made with a semiconductorlike thin-film technology.

One of the advantages of a smaller head is simply that the spacing between the tracks on which digital data is recorded can be narrowed and, consequently, the number of tracks on each side of the disk increased. Further, because the size of the head's recording gap can be more precisely controlled during the semiconductor manufacturing process than in the currently used handmade ferrite heads, thin-film head technology paves the way for great increases in memory density.

In hard numbers, IBM's recently announced 3370 disk drive, which apparently incorporates thin-film head technology [*Electronics*, Feb. 15, 1979, p. 85], has 571 megabytes of memory, compared with 317.5 megabytes for the previous top-of-the-line 3350 model that employs conventional ferrite heads. The 3350 has 478 tracks per inch and a recording density of 6,425 bits per inch. Because IBM will take the wraps off the 3370 only after it has shipped its first product, expected to be as early as this October, industry experts can only estimate that its specifications are 600 to 700 tracks and around 12,000 bits per inch.

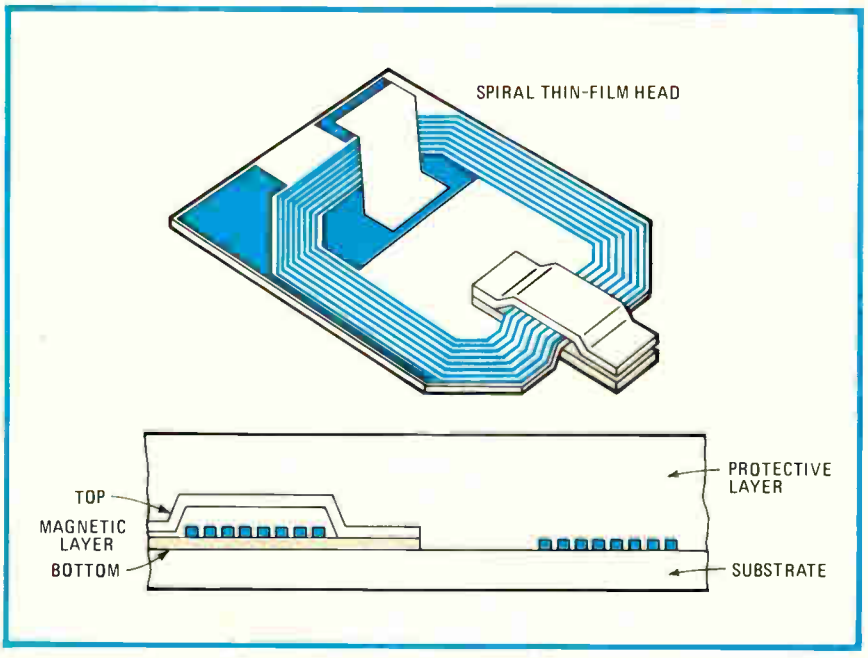
When new coating techniques are also applied to the manufacture of the recording medium on the surfaces of the disks, those specifications should soar to 2,000 tracks per inch and 25,000 bits per inch by 1985, or 16 times the present storage density, estimates Frank J. Sordello, manager of the Recording Technology Center that Memorex Corp., Santa Clara, Calif., set up to develop such advanced technologies.

Need details. Naturally, this bright promise stirs a lot of industry interest. But companies pursuing the IBM-plug–compatible market say thin-film heads will not really take off until they find out details of IBM's 3370. In addition to Memorex, IBM-compatible vendors Storage Technology Inc. of Louisville, Colo.; Sperry Univac's ISS division in Cupertino, Calif.; and Magnetic Peripherals Inc., the Minneapolis joint venture of Control Data Corp. and Honeywell Information Systems Inc., are all working on the new technology.

Others, though, are not waiting for IBM, believing that thin-film technology is one whose time has come, regardless. Independent disk maker Ampex Corp. of Redwood City, Calif., and CII–Honeywell Bull in France [*Electronics*, June 7, p. 76] are both working on thin-film heads.

Also preparing for what is expected to be a boom in new head technology are the independent head manufacturers who supply many of the disk makers as well as the smaller in-house disk-drive manufacturing efforts of minicomputer companies. These include established

Magnetic coil. This inductive thin-film head from Memorex resembles a ferrite head because of its coil winding. The other approach to thin-film technology is called magnetoresistive.



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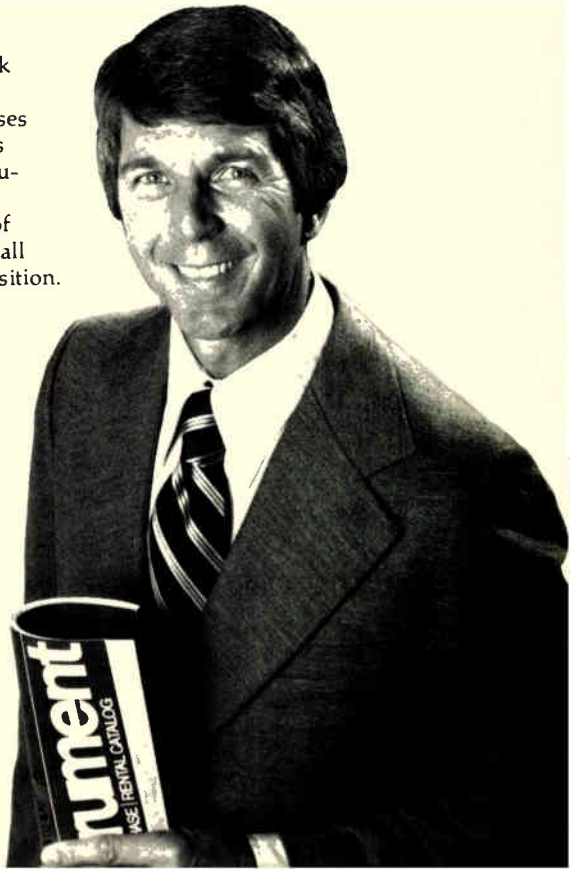

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disk-head makers such as Applied Magnetics Corp. and Information Magnetics, both of Goleta, Calif., and National Micronetics Inc.'s Pacific division in San Diego, Calif., as well as newcomers IBM-spinoff Dastek Corp. of San Jose, Calif., which is working with Santa Clara, Calif., media-maker Dysan Corp.; Magnex Corp., an Oklahoma City subsidiary of Exxon Enterprises; and Nortronics Inc. of Minneapolis.

One fact prodding thin-film head development, of course, is that "we've pushed ferrite to its limits," states Joe Levine, Magnex Corp.'s director of marketing, who thinks thin film will result in lower cost in the long term. Thin-film production leads to large and highly controllable mass production, Memorex's Sordello states, adding that it is possible to make 2,500 heads per 3-inch wafer.

Fear of flying. The smaller size and lower mass of the thin-film heads are extremely important when improving the mechanisms of the flying heads used in current state-of-the-art disk drives. The heads used in drives such as IBM's 3350 fly about 20 microinches over the disk's surface, which Sordello compares to "flying a jumbo jet 500 miles an hour a quarter of an inch off the surface of a lake."

Ferrite heads must be manually ground down to a size of about 4 micrometers each side and about 25 μm high with a recording gap of 1 μm. Thin-film heads, on the other hand, measure only 38 μm on a side and are about 6 μm high, with a recording gap of only 0.3 to 1.5 μm. Moreover, because they are smaller and lighter, thin-film heads "fly" 0.2 μm from the surface, five times closer than ferrite heads.

Such scaling down brings problems, as the many years and millions of dollars spent by industry leaders testify [*Electronics,* March 3, 1977, p. 97]. Process control is critical at these close tolerances. Moreover, "as the tracks get narrower, the amount of signal goes down," explains Thomas A. Rescamp, vice president of Applied Magnetics' Research and Advanced Technology division. In addition, the head-positioning

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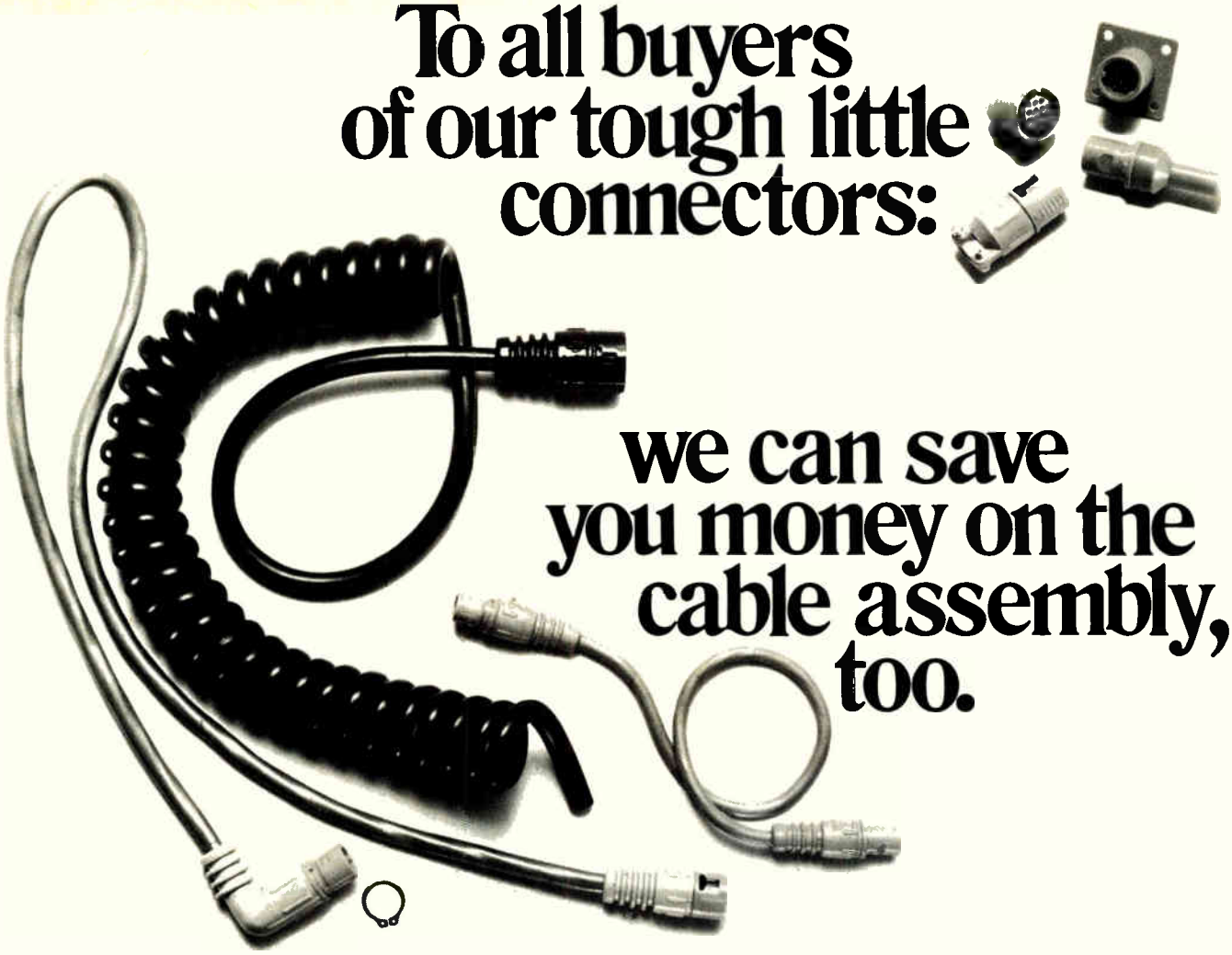

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mechanisms must be refined to operate to tighter tolerances.

Two routes. There are two approaches to thin-film heads. One is magnetoresistive, in which a current-driven resistive network is modulated when it is near a magnetic field. The other is inductive, sensing the rate of change of a magnetic field generated by a moving medium. The first approach has an advantage in that it can read independently of the speed of the medium and can yield a signal two to six times stronger than an inductive head of similar size, but it cannot write. Inductive approaches are dependent on a moving medium, but can both read and write.

First, thin-film disk drives are most likely to use inductive techniques because of the read-write feature, whereas magnetoresistive approaches are likely to show up on tape drives, industry executives surmise. Later on, however, some believe that both technologies will be combined in one head.

But Rescamp links magnetoresistive heads with noise, thermal, biasing, and other problems. Besides, they are nonlinear detectors, unlike linear inductive sensors, which "have none of these problems," he says. The magnetoresistive head "has more potential, in theory, but it's a question of when," he says. Also, sensitivity in inductive heads can be heightened by increasing the number of turns in the coils of conducting material, states Sordello.

The thin-film head technology also promises to spawn further advances in mass memory storage. Some developers talk of using many heads on each side of a disk (a maximum of two is now used) to reduce head-positioning movement and also increase data-transfer rates. Others see logic being integrated onto the same chip as the thin-film head to provide error checking and correction or content-addressable memories, freeing the central processing unit to perform other tasks. Because of these and other advanced peripheral research, Rescamp speculates that the industry could see disk drives out to the year 2000. □

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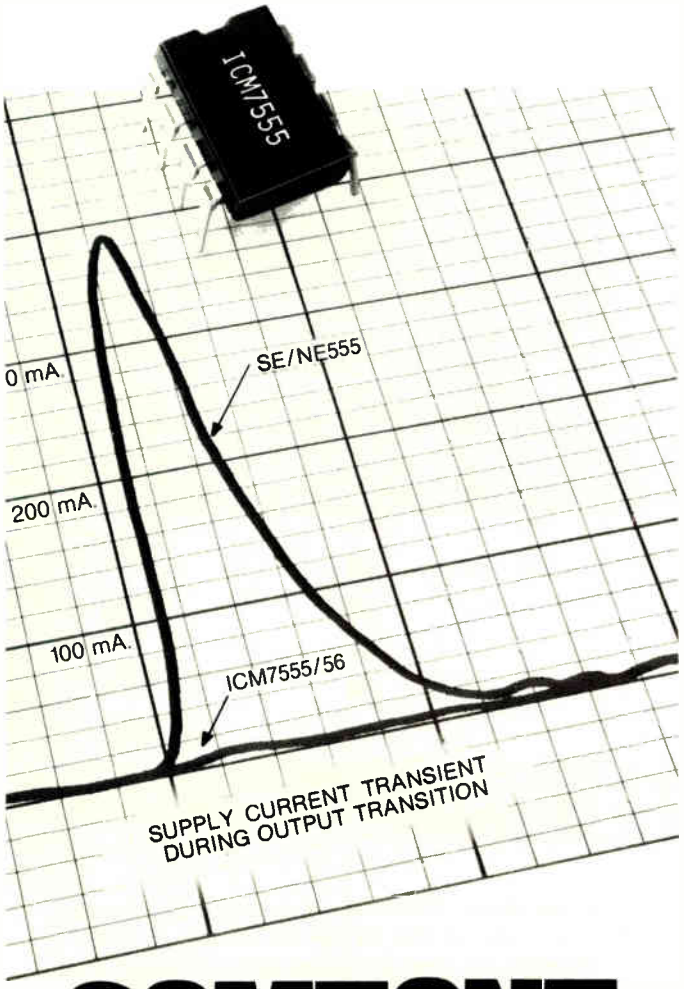

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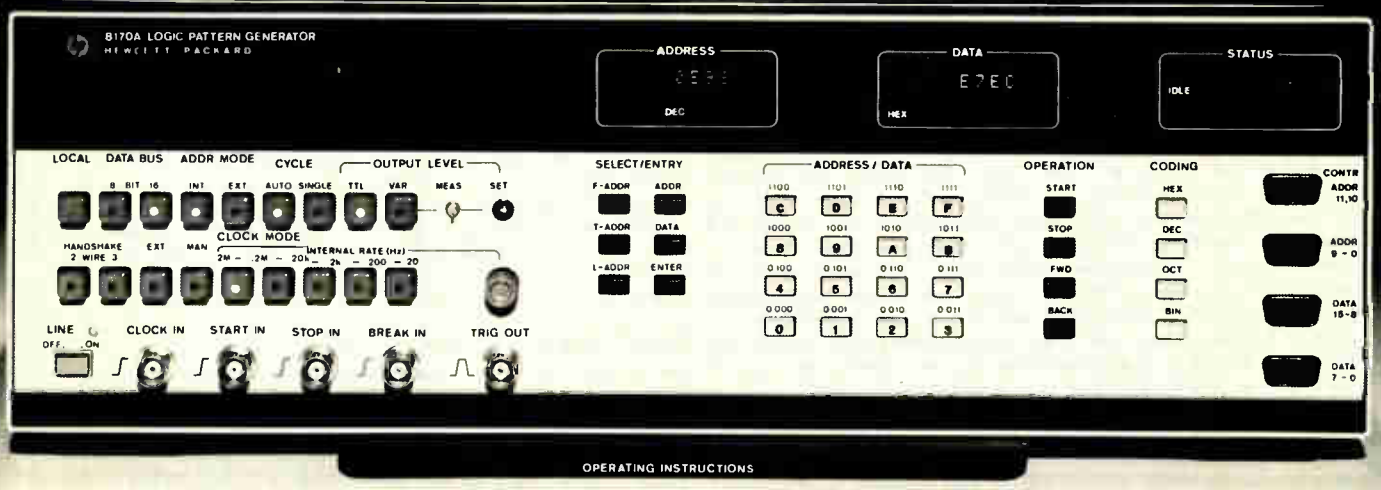

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Personal computers

There's life after TI

Relieved that the Texas Instruments home computer was not a crusher, producers are girding for a market spurt

by Larry Marion, Chicago bureau

The long-awaited entry of Texas Instruments into the home or personal computer market, expected to cause consternation among competitors, did not. At both the Summer Consumer Electronics Show in Chicago and the Personal Computing Festival held in conjunction with the National Computer Conference in New York, the reaction was a mixture of relief and surprise.

Computer exhibitors at Chicago's McCormick Place were glad to find a product priced at a level they could tolerate. But they were even more delighted to find long-hoped-for buyers from the mass merchandisers such as Sears and Montgomery Ward getting ready to set up computer counters in their stores.

The first thing most companies wanted to know about TI's new 99/4 home computer was the price—$1,150 for the basic computer, keyboard, and 13-inch color monitor from Zenith Radio Corp., Chicago [*Electronics*, June 7, p. 87]. "They're smiling with good reason—genuine relief over the price of the TI product," remarks industry analyst Benjamin N. Rosen, vice president at Morgan Stanley & Co., New York.

"It doesn't take too long a memory to recall what TI did to the consumer markets, first with its low-cost calculators and second with its cheap digital watches," another consumer electronics observer adds. "The computer companies had good cause to be scared about the price."

Despite the buildup, which has lasted about a year, the TI home computer arrived unexpectedly just days before CES opened. Controlled by TI's 9900 16-bit microprocessor, the 99/4 has 16 kilobytes of random-access memory. Software selling for $19.95 to $69.95 will come in cartridges composed of read-only memories, a technique TI pioneered with one of its programmable calculator lines. Milton Bradley Co., Springfield, Mass., will also market some of the lower-priced TI software cartridges.

A variety of peripherals, including a solid-state voice synthesizer module costing $150, a printer, and a floppy-disk drive, will be available later this year or next through independent specialty shops, such as Computerland, and a few major department stores.

Some yawns. Meanwhile, the reaction over at the Personal Computing Festival was similar to that at CES. Most exhibitors and onlookers, though excited that TI had finally broken the ice, wound up yawning at the result. The primary disappointment was that TI opted not to show its cheaper version with an rf modulator, which has been held up pending approval from the Federal Communications Commission. Some complained about an inability on the part of the user to manipulate the monitor and graphics programs. The $150 speech synthesizer, however, got excellent grades.

Says Thomas Whitney, executive vice president of engineering at Apple Computer Inc., Cupertino, Calif., "We were pleasantly disappointed. But if they had introduced the same machine in June of 1978, it wouldn't have been such a letdown."

Of course, many of the participants are migrating away from home or personal computers anyway, to concentrate on small businesses. It is obvious, too, which companies are

Entry. To make programming easy for the consumer, TI's 99/4 home computer features ROM-based cartridges that load into the console. The keyboard includes 47 keys.

Probing the news

after which markets by the conference they chose to attend. "TI is definitely home- and consumer-oriented," says Whitney, "but Apple is at NCC."

As a consumer product, TI's entry is viewed as a plus and a minus. On the one hand, it will expand the market because retailers will gain confidence in the concept now that a major electronics firm with an established name has arrived in consumer products. "It will add legitimacy to the market," says Peter N. Rosenthal, marketing manager for personal computers at Atari Inc. of Sunnyvale, Calif., part of Warner Communications Inc. Concurring, Gene Carter, sales vice president for Apple, estimates that TI's presence in the market could expand sales volume by 25%. Optimists see total sales of 650,000 units in 1979, while more conservative marketers estimate a modest 40,000-unit year.

Criticism. On the negative side, competitors and buyers were surprised at the high cost of the first unit and at the limited amount of software initially available. "You can't sell a computer for the home at that price," snaps analyst Rosen. Mattel Inc. of Hawthorne, Calif., and APF Electronics of New York, for example, have entry level units for $500 that retailers say is the upper price threshold for mass merchandising. Each Mattel module—a controller with program cartridge port and a standard keyboard—contains a 16-bit microprocessor supplied by General Instrument Corp.

Critics also noted that TI's 47-key keyboard is nonstandard and the color monitor adds too much to the cost. Replies Peter L. Bonfield, division manager at TI for personal computers, "Separate monitors are an advantage in the home because users do not want to tie up their TV set." To which Atari's Rosenthal retorts, "If consumers wanted another video output, they'd prefer to buy a receiver, not a dedicated monitor."

As for the keyboard, TI says that, because of its previous experience with it, the type chosen is cost-effective and that in any case it is more suitable for consumer use than the large standard types (see photo). And although the software library may be skimpy at present, TI promises a wide selection later.

Applause. Drawing praise is TI's market planning. "It's a very powerful instrument for the market segment—you can't beat that price for something in between a real computer and a game," comments H. R. Kauffman, president of Exidy Inc., Mountain View, Calif.

One retailer likened TI's sales strategy to audio giant Pioneer's entry into the car stereo aftermarket—a lot of demonstration equipment requiring a minimum of dealer personnel to make the sale. TI's Ralph Olivia explains, "We want to make the computer sell itself at the point of purchase." □

Software for the living room

What will consumers program into their home computers? Makers such as Atari Inc. and Texas Instruments Inc. emphasize "self-improvement" software—education aids for both children and adults, plus programs to exercise the computers. The competitors are promoting their software like breakfast cereal. Atari has its programming endorsed by tax experts, while TI's education software was developed with the assistance of the Children's Television Workshop, creators of the long-running television show, "Sesame Street." Other companies, such as APF Electronics and Mattel Electronics, focus on games.

APF's line of games includes "Meltdown," a simulation in which players pretend to operate a nuclear power reactor and are responsible for preventing a meltdown within a limited time. TI and Atari, on the other hand, promote programs for adult use in everyday life—investment and estate planning, household budgeting, and income tax preparation. Foreign language training aids will be "very important," and voice synthesis chip modules like TI's will be marketed by most of the manufacturers, though they do not reveal who will supply the chips.

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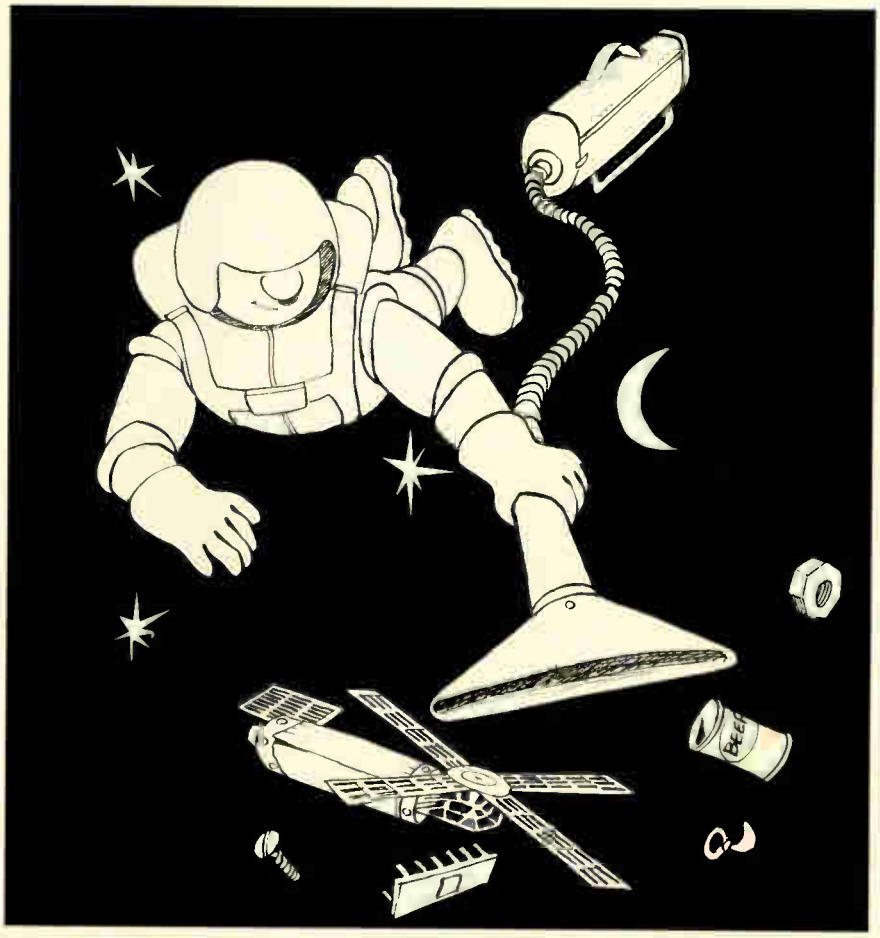
Satellites

Is it time to clean up space?

Skylab's fall underscores a growing concern over satellite junk, with the real threat possible collisions with debris still aloft

by Harvey J. Hindin, Communications & Microwave Editor



It started with random bits of metal falling in places all around the world, continued with the alleged killing of a cow in Cuba, and last year hit a peak with a barrage of pieces from a radioactive Soviet satellite peppering western Canada. This year the ultimate disaster everyone is worrying about may occur when the 85-ton U. S. satellite, Skylab, comes down—someplace.

Pieces of space junk—many very large—remain from the more than 11,000 man-made objects that have been orbited, mostly by the U. S. and Russia, since the Space Age began in 1957. There is no counting how many sensor covers, clamps, and broken or destroyed satellite parts jettisoned after launch, broken off by accident, or simply abandoned after use are out there.

Loose belts. According to Donald Kessler of the National Aeronautics and Space Administration's Johnson Space Center in Houston, Texas, "If we don't change the way we do business in space, it is inevitable that a broad belt of debris from collisions between orbiting satellites will form." What's more, he and coworker Burton Cour-Palais predict that the first major collision will occur within the next 10 to 20 years and a belt of fragments—much like the natural asteroid belts that exist in our solar system—will form within 50 years.

It may therefore be necessary to mount a cleanup operation, and NASA is currently studying the problem, according to Kessler. Though the space shuttle could be used for this task, reusable satellite systems would go a long way toward solving the problem. In fact, the Aerospace Corp. of Los Angeles did a study that has been cited as a justification for use of returnable satellite systems. Scientists for the company say that by 1985 the probability of collisions could be as high as an unacceptable 10%, with 10,000 trackable items in space. (All objects, including debris, that are large enough or low enough to monitor, are followed by Norad, the North American Air Defense radar and computer system in Colorado Springs, Colo.) This figure could go up to 20% by 1995, when there could be 20,000 items.

Smashup kills study. Probably the worst case of mission impairment in space so far, and likely caused by a collision, involved the Geos 2 magnetospheric observatory satellite launched by the European Space Agency. While much of the payload still continues on its merry way performing experiments, an accident to one solar panel has almost wiped out the entire low-energy plasma

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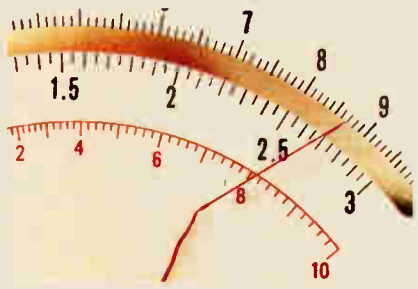

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Probing the news

study it was performing.

Some kind of physical damage to Geos 2 appears to have occurred after three days of successful telemetry. The stoppage was traced to the solar panel, which seems to have its output physically shorted to the metal satellite structure. Whenever the panel is illuminated by the sun, at regular intervals in the satellite's spin cycle, the electrical reference potential of the spacecraft jumps by 12 volts.

Because spacecraft voltage reference jumps caused by anomalous electrical charge variations in the space environment are not uncommon, Geos 2's solar cells were provided with a conducting indium-oxide coating that does not let charge accumulate. Unfortunately, this coating could also provide a shorting path if a collision brought the panel and the body of the craft into contact It seems clear that spacecraft designers will have to become litter-conscious or risk the consequences.

Meanwhile, the North American Air Defense Command, in its latest computer-based prediction, says that Skylab—all 170,000 pounds of it—will come down in 50,000 pieces over a 400,000-square-mile area. There is a 95% probability that that will happen between June 27 and July 21 of this year. Though much of the eight-story-high device will burn up or land in the ocean or unpopulated areas, there are several big pieces, including a lead-lined, 4,000-lb film vault and a 5,000-lb fixed airlock shroud, that could land almost intact. The thought of that much junk raining down from space makes people more than a little nervous.

Skylab's orbit is decaying rapidly at an uncertain rate. It was to have been rescued by the space shuttle using a special motor and control unit called the Teleoperator. But the contract for the rescue system made by the Martin Marietta Corp. in Denver, Colo., was canceled when the shuttle delivery slipped.

It is of some small comfort to know that the Government feels that it is generally liable for damages and, according to NASA assistant general counsel Richard Wieland, will give prompt consideration to claims on "a case-by-case basis." NASA's latest prediction is that there is only 1 chance in 150 of anyone being hit. The agency has, however, set up contingency plans with the Defense, State, and Justice Departments to "cope with any problems that may arise." □

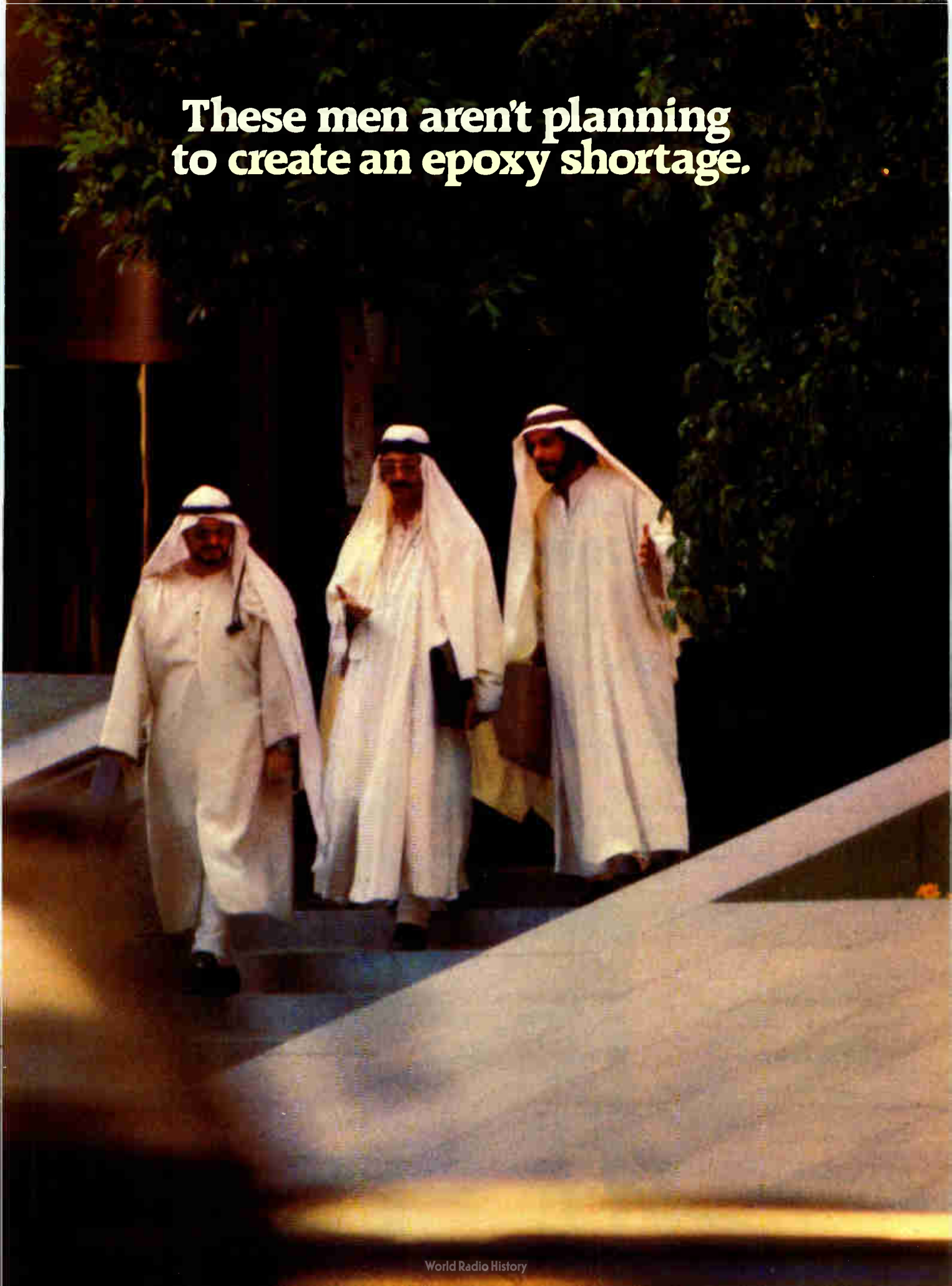
Mind over matter in Skylab

It's his first attempt to rescue a satellite, but that inexperience doesn't bother Buryl Payne. The director of the Institute for Psycho Energetics in Brookline, Mass., says he will lead thousands of people in an attempt to harness their mutual psychokinetic energy in an effort to prevent Skylab from falling on anyone's head.

Trained in physics and psychology and normally a designer of biofeedback equipment, Payne will use radio station WFTL in Fort Lauderdale, Fla., for a broadcast to coordinate the effort. The National Aeronautics and Space Administration is not impressed with this approach. In any case it appears that some rival practitioners of psychokinetics plan to make an effort to help Skylab fall during the time that Payne's group is holding it up. Whether Skylab comes down or not, one group will be able to claim success for psychokinetic techniques.

At the same time, if NASA's predictions of when and where the big pieces will fall are not enough for restful sleep, Chicken Little Associates of Washington, D. C., is offering custom-tailored prognoses for a fee. They will sell the odds for a customer's special place of interest, whereas NASA's computer capability, alas, is only capable of more general statements. In fact, Alex Fraser of the Chicken operation says that NASA really has far less control over the reentry than it claims.

For its part, NASA is no doubt unhappy that—unlike the evil organization Spectre in the James Bond epic film "You Only Live Twice"—it cannot send up a satellite-eating satellite.



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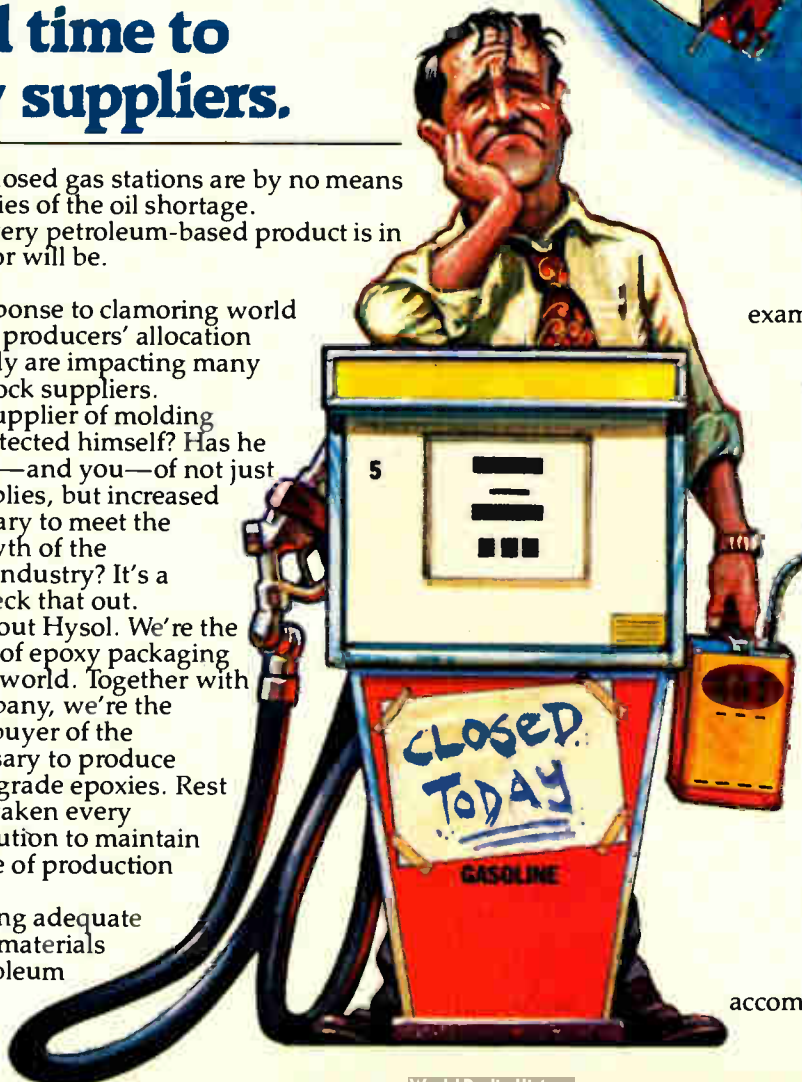

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Hysol has three separate manufacturing plants in the United States. Another in Munich. Still another in Tokyo.

Besides enabling us to service international customers quickly, the five plants provide an important production failsafe: We're not dependent on any *one* facility to maintain our delivery commitments.

In addition, our multiple plant design provides inherent capacity benefits. Our facilities are able to accommodate surges in production easily.

Growing as fast as the semiconductor industry itself.

A look at Hysol's past provides further evidence of our commitment to the semiconductor industry.

In terms of dollars, Hysol's growth rate has equalled or exceeded that of the semiconductor industry. In terms of production volume, we're obliged to maintain even faster growth because the semiconductor industry grows at a greater rate in unit volume than in dollar volume.

The $400 million Dexter Corporation, Hysol's parent company, has pledged its resources to assure this growth.

Hysol is the largest compounder of electronic and electrical grade epoxies in the world. We intend to hold that position.

70 72 74 76 78 80

Hysol's production of molding compounds has increased, in terms of dollars, even faster than the semiconductor industry. The yellow line indicates the industry's dollar sales worldwide for the decade. The orange line shows Hysol's dollar sales growth rate worldwide in molding compounds.

Quality. Reliability. Productivity.

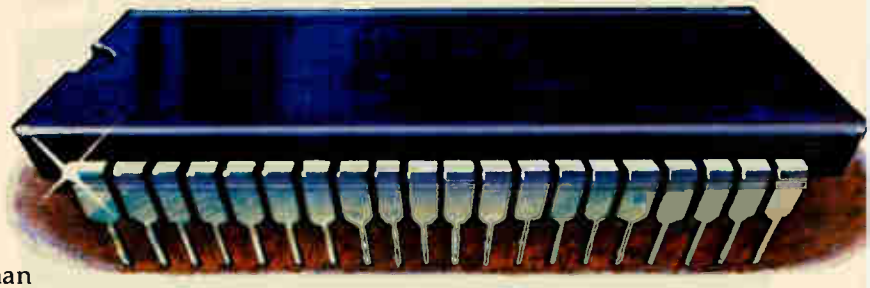
We're better than we have to be.
Our quality and reliability exceed the requirements of the most demanding users.

The productivity attainable with our products is greater than any competitive products on the market.

How do we know this?

We've set up our own miniature semiconductor production facility for study. We even produce our own test chips. We encapsulate them in various configurations on our own production lines.

This capability accounts for part of our unusually high expenditure for research and development. And it explains our unusual level of understanding of our customers' problems.



Why bother?

Understanding the problems of our own production is only half of our job.

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Get to know Hysol.

Secured supplies of raw materials. Increased capacities made possible by multiple plants. Commitment to the semiconductor industry. Quality and reliability standards unique in that industry, aimed at boosting your productivity.

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We'd like to tell you more. Why not give us a call at (213) 968-6511. Ask for Ron Benham, Products Marketing Manager, Semiconductor Molding Compounds.

Or write Hysol Division, The Dexter Corporation, 15051 East Don Julian Road, Industry, California 91749.

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THE DEXTER CORPORATION

Circle 101 on reader service card

How Litronix' opens a new world

Norand® Sprint 100™ Order entry terminal

Now designers have a communications peripheral perfectly matched in size and cost to the world of microcomputers.
Litronix invented the Intelligent Display* to give microcomputers a new way of "talking" to users in words, numbers or even sentences. And not surprisingly, these displays are already beginning to create a new class of microcomputer-based products.

Part Number	Features	Character Height	Horizontal Row Spacing	Vertical Row Spacing	Viewing Angle	Character Positions	Character Segments
DL-1416	Standard General Purpose Display	.160"	.250"	1.200"	±25°	4	16
DL-1414	Compact Display For Hand Held Equipment	.112"	.175"	.800"	±50°	4	16
DL-2416	Premium Display New Rugged Package	.160"	.250"	.800"	±50°	4	17

*Intelligent Display is a trademark of Litronix, Inc.

The Intelligent Display is an alphanumeric LED readout that incorporates ASCII decoder, multiplexer, memory and LED driver in a built-in CMOS IC. It interfaces simply and directly to any microprocessor bus, much like a RAM. Power is from a single +5V supply, and operating current is low enough for any battery powered device.

Litronix puts intelligent communications in the palm of your hand or anywhere panel space is limited. Three versions of the Intelligent Display are already available to fit a wide variety of applications. The smallest lets you fit 20 characters side by side in a space of only 3.5 inches.

Litronix' Intelligent Displays are already being used in the portable terminal, the low cost microcomputer and electronic translator above. They're also ideally suited for applications like control panel readouts. Handheld computer

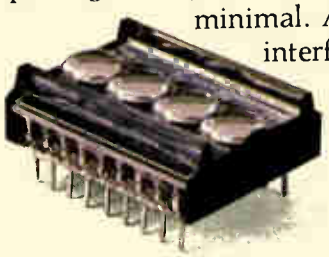
Intelligent Display™ of microcomputer applications.

Lexicon LK-3000™ Electronic translator

terminals. "Smart" games and appliances. Educational products, and more.

Use Intelligent Displays in any product that calls for alphanumerics. They'll reduce component count and cut costs dramatically. Since everything is encapsulated in a single package, design and production costs are minimal. And because no display interface PC board is needed, component costs are typically reduced by 25%. Typical OEM volume pricing per digit will range from $2 to $5 per digit, depending on display type. For easy breadboarding with Intelligent Displays, ask about our inexpensive, prewired Evaluation Kit. To get data sheets and a copy of our applications note

on Intelligent Displays, or for a demonstration, phone or write Litronix, Inc., 19000 Homestead Road, Cupertino, CA 95014. Telephone (408) 257-7910.



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Our Intellec® Microcomputer Development System makes it possible and profitable for companies like yours to take full advantage of the promise and potential of the microcomputer. For example, the world's most advanced microcomputer, our new 16-bit 8086, is the first and only 16-bit microcomputer supported by a high-level programming language—PL/M, part of the total 8086 software development package available for the Intellec system.

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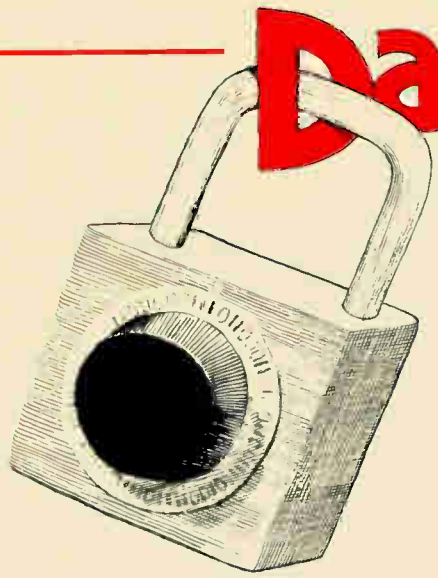


LSI-based data encryption discourages the data thief

Commercial gear for secure transmission and storage emerges in response to Government standard

by Harvey J. Hindin, *Communications & Microwave Editor*

☐ Communications security has been the subject of much thrilling fiction, associated in the public imagination with military secrets, James Bondian undercover maneuvering, guards, locks, and midnight shootouts. But the age of electronic communication is changing all that; the only exotica remaining in the field are the increasingly sophisticated algorithms that govern the electronic scrambling of data.

Codes and secret ciphers existed long before the National Bureau of Standards decided to publish a data encryption standard (see "Codes throughout the ages," p. 110). Throughout recorded history, whether for reasons honorable or dishonorable, people have been developing and using new codes (as the old ones were broken and rendered useless) with all the ingenuity they could muster. And of course for every motive to encipher, there is an equal and opposite motive to break the cipher. A coding system's life expectancy is not a long one: that, at least, has not changed.

But the technological means are being revolutionized by computers and large-scale integrated circuits. The military and intelligence communities, of course, must stay right on top of the problem. Their insatiable need for information—not to mention the imperative to maintain military secrets—has long been met with brute force and budgetary power. Immediate cost-effectiveness is seldom the primary concern in this sphere.

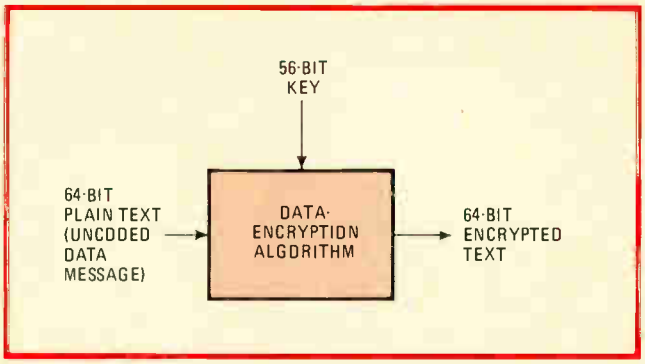
But the commercial sector has its secrets, too. They may not be as sensitive as military ones, but they often revolve around important marketing strategies, contract bids, and the disposition of large sums of money. Those are subjects that businessmen take very seriously. Engineers also find themselves dealing with sensitive information about designs and construction decisions.

Corporate secrets

There certainly is a market for secure voice transmission for telephone use; a tremendous amount of business is conducted by phone these days. Monitoring equipment that allows phone lines to be tapped with relatively little effort on the part of the eavesdropper is readily available. And with business offices becoming increasingly electronic in operation, their managers are looking for better ways to protect their dealings from competitors and disloyal employees.

The banking and financial communities are another prime encryption market. Fortunes are handled by means of electronic transmission and computer manipulation, and reports appear regularly of the clever new ways people have devised to get money by electronic fraud. Other obvious security markets include common carriers and service bureaus.

Individuals, too, are expressing increasing concern over their right to privacy. Insurance and tax records and



1. Data conversion. There are 2^{56} or 70 quadrillion possible keys that can be chosen by the data-encryption standard (DES) algorithm user. If he picks simple, easily remembered keys, he forfeits the full security potential of this large number.

files kept by numerous other organizations are potentially subject to unauthorized electronic access. A citizen does not have to be a crook to want this access prevented.

Data-communications security hardware has been available for some time, much of it from European suppliers. But as the dependence on electronic communication grows heavier, the need for economical encryption grows with it. More and more users are looking for a coding system with what Sir Francis Bacon defined as "the virtues of a perfect cipher." He said that "it should not be laborious to write and read," and, more importantly, it should "be impossible to decipher."

In fact no known code is impossible to break. But a practical coding technique can be hoped for that requires so much time and computer power to break that it is not worthwhile to do so.

Defining a standard

The National Bureau of Standards (NBS) has provided a strong stimulus for manufacturers of encryption equipment in developing its data encryption standard (DES). The nature of this standard is the subject of some controversy; in order to understand the controversy, the standard itself must be understood.

The Federal Information Processing Data Encryption Standard, originally published in January 1977, is a complex ciphering algorithm or defined set of rules. It is based on both substitution and transposition techniques, neither of which are at all new in concept. Substitution codes involve, simply enough, the substitution of one character or symbol for another. Transposition techniques involve rearranging the order of the characters or symbols according to some control pattern or key known only to the sender and the intended recipient.

In 1973, the NBS asked industry for proposals for an algorithm that would be suitable for data encryption in the commercial sector of the market. Not exactly overwhelmed with suitable replies, it asked again over a year later. The response from International Business Machines Corp. was considered to be the most suitable suggestion and the NBS published it in 1975, noting that it was being considered as a Federal Information Processing Standard.

It became a standard in 1977 for Federal agencies not involved in national security. However, it is clear that the commercial market is picking it up also.

The DES defines a set of operations to be performed on a 64-bit block of information (the plain text) to encrypt it into a 64-bit block of scrambled information (or encrypted text). This is done under the control of a 56-bit key block chosen by the sender with the knowledge of the recipient. (Eight parity bits used for internal checking make the actual entered key word 64 bits long; these 8 bits are removed before the key is used.) In this manner it is possible to convert one 64-bit piece of plain text into any of 2^{56} or about 70 quadrillion possible versions of 64-bit encrypted text (Fig.1).

The DES algorithm is available to all—indeed all the details have been published. The idea is that the security lies in the secret key just as the security of a lock lies in its combination. The extra degree of security that results when an algorithm is kept secret was not deemed to be important for the DES since it is intended "merely" for sensitive or critical commercial or civilian applications, rather than classified military or espionage ventures.

For the commercial sector, the advantage of having the algorithm known is that it establishes a standard for manufacture and comparison and allows products to be manufactured at a reasonable price. Previously available data-encryption equipment was hard to evaluate since no standards were available.

The algorithm is most efficiently implemented in hardware since the operations required can be performed by known microprocessors and peripherals as well as dedicated chips. However, software implementations are also available.

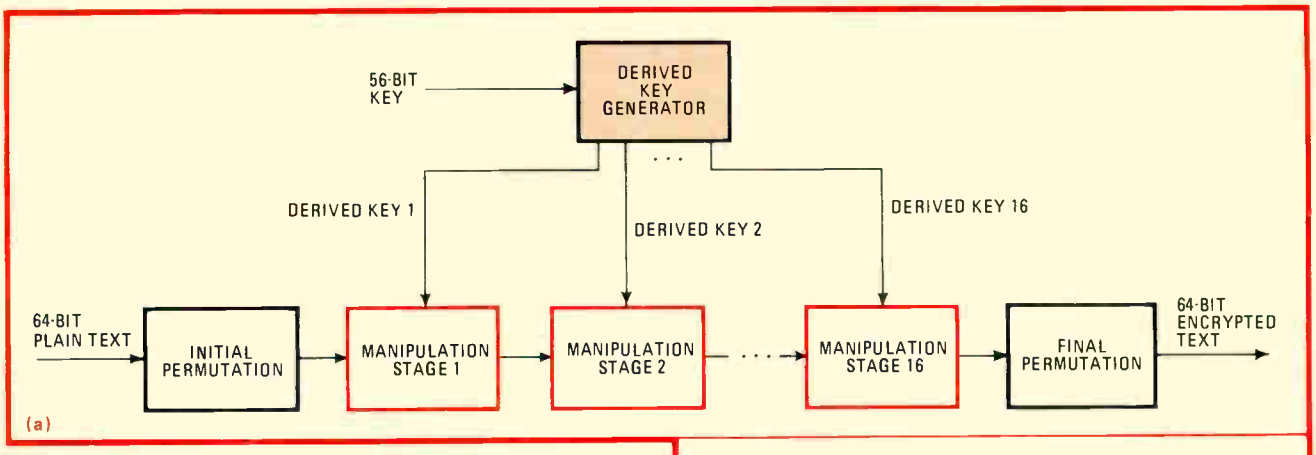
In essence, the algorithm takes a data block through 18 data-manipulation stages. Sixteen of these are identical except that they use 16 different internal coding keys derived from the 56-bit main key (Fig. 2a). The two others—the initial and final permutations—are fixed and do not require any key.

Shuffle it around

In the initial permutation, bit 58 of the 64-bit input block becomes bit 1 of the output, bit 50 of the input becomes bit 2 and so on as defined in the standard. This is a simple transposition. The last step of the algorithm (after the 16 key-controlled manipulations take place) is the inverse of the initial permutation.

Between the initial and final permutations, the 16 identical data-manipulation stages are connected in series (Fig. 2b). Each of these stages performs a complex series of manipulations on the data (Fig. 3). The 64 input bits are first divided into a 32-bit left-hand and a 32-bit right-hand block. Then the 32-bit right-hand block is expanded into a 48-bit block by a defined procedure, the so-called E-box. The result is added (based on modulus two arithmetic) to a derived key that is a separate input to the data-manipulation stage in question.

The 48-bit block that results is then divided into eight 6-bit blocks, each of which determines an entry into eight data manipulations called nonlinear substitutions, or S-boxes. Each S-box output has only 4 bits. This yields a 32-bit result that is added again (based on modulus two arithmetic) to the previously untouched left



half of the original data block. The two 32-bit halves are then interchanged and another 64-bit block is produced that becomes the input to the next manipulation stage.

Why so complicated?

If all this seems very complex, it has a specific purpose: the fundamental security of the DES lies in its internally complex structure. The role of the permutations is to so thoroughly mix the data bits that they cannot be traced back through the S-boxes. For further safety, the permutations in the derived key mix up the key bits to insure that they are all used equally, thus minimizing the probability of pattern detection. No key bit is ever used more than 15 times or less than 12 times.

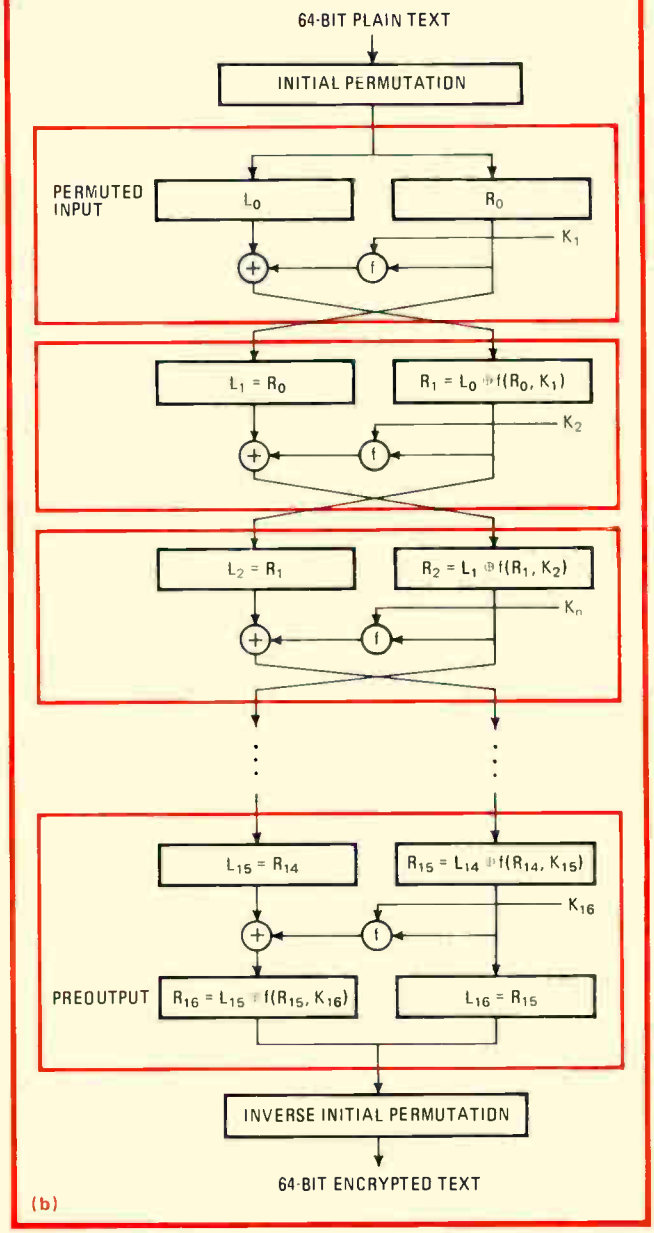
The S-boxes insure that the algorithm is not linear. (Linear algorithms are more readily attacked than nonlinear ones.) Each S-box output is related to the input by a nonlinear transformation that adds orders of magnitude to the decoding problem. The essence of this nonlinearity is data compression: each entry to an S-box has 6 bits but each output has only 4.

This is done by having 4 of the input bits determine a column and 2 determine a row in an S-box look-up table. The output is then the 4-bit S-box entry found in the location indicated by the row and column. The S-boxes are paralleled (Fig. 3).

The scrambling of the major governing key into the so-called key schedule is also important to DES security (Fig. 4). In this procedure, the 8 parity bits are removed from the 64-bit entered key to produce a 56-bit active key. This in turn is fed into two 28-bit registers whose contents are rotated by 1 or 2 bits for each of the 16 separate iterations. Another transposition operation called permuted choice 2 produces the 48-bit final key after the bits have been rotated in the registers.

It has been shown that similar algorithms without key schedules are weaker even if they have larger major keys. Yet the subject of larger keys is one that has caused controversy in the encryption community: there are people who say that the DES key length should have been greater than 56 bits. On the other hand, it is always possible to encrypt the same data word twice, in effect doubling the key size.

Critics of the DES are concerned about the motives of the standard's developers. Some of them also feel that the DES is not complex enough. At best, they say, it will



2. Multiple choice. Each of 16 keys derived from the main key is generated by a fixed, published algorithm (a). But the key and the sheer complexity of the 16-data manipulation stages (b) insure that the DES is in effect secure, at least for the immediate future.

Codes throughout the ages

Ever since man learned to communicate by means of some permanent record such as a printed text, he has been interested in doing it in secret for reasons both honorable and dishonorable. In fact, one of the earliest forms of writing—Egyptian hieroglyphics—developed two distinct forms. These were the hieratic or priestly writing and the domestic form, which was for the common people. Priests were prohibited from giving away the secrets of the hieratic symbols.

Strangely enough—for reasons unknown—cryptography even occurs in the Old Testament. In the Book of Jeremiah there are two references to both the king and city of Sheshach. This was written off as an unknown place until it was noticed that the name of the well-known city of Babylon could be transformed by a simple substitution cipher of the Hebrew alphabet to read Sheshach.

To do this, all that has to be done is to write the first half of the alphabet on a piece of paper from left to right. Underneath this, the second half of the alphabet is written from right to left. The procedure is to replace the first letter by the last, the second letter by the next-to-last, and so on through the alphabet.

According to some authorities, this was the basis for other forms of substitution encryptions that were in turn the basis for secret writing by the monks of the Middle Ages. This gave rise to the complicated codes the Renaissance city-states used to conduct their wars and businesses. And of course the impact of all kinds of complex codes on modern warfare is well documented.

The most recent of these codes are so complex that they require digital computers for any attempt to crack them. Handling the massive amounts of data and looking for the subtle and infrequently recurring patterns which help the code-breaker in his art are way beyond the capability of an individual, even with the help of mechanical or electromechanical devices.

only be useful for the next 5 to 10 years; by then decryption technology and advances in large-scale integration and computer science will likely make it possible to break a DES encryption easily. This is the viewpoint of Whitfield Diffie of Bell Northern Research in Palo Alto, Calif. Diffie and his colleague, Martin Hellman of Stanford University, have advocated researching the so-called public-key system (see p. 115).

Controversy

Though the better security of public keys is a matter upon which opinions differ widely, Diffie readily admits that "DES is the only system which at the present time can be implemented because hardware is available. So it has to be used now."

Much of the controversy may be attributed to legitimate disagreement on the merits and shortcomings of the new concept and just how they will affect the implementation of practical systems. It may be that the controversy's fires are also being stoked by the typically human problem of different originators of different ideas believing strongly in their own work.

Recognizing this, a reasoned attempt to address the problems that have grown up around the DES algorithm was mounted by the United States Senate Select Committee on Intelligence. Chaired by Senator Birch Bayh (Dem., Ind.), this committee released an unclassified version of its classified study of, among other things, "improper" involvement of the National Security Agency (NSA) in the development of the DES. It was released to the Institute of Electrical and Electronic Engineers' director of technical activities, Neil Pundit.

The committee concluded that in the development of the DES, NSA did convince IBM that a reduced key size was sufficient—the IBM-developed Lucifer algorithm that was the basis for DES used a 128-bit key. The committee also found that the NSA assisted indirectly in the development of the S-box structures. The NSA was also involved in certifying that to its knowledge, DES was free of any statistical or mathematical weaknesses. But the NSA says that the DES is an IBM invention, that it got into the act after the fact and only classified some design principles.

The Senate committee agrees that the NSA did not tamper with the design of the algorithm in any way. IBM had invented and designed the algorithm and concurred that the key size was more than adequate for any commercial applications that DES might be used for.

As to the technical arguments on how long it might take to decrypt a DES message, the committee said it lacked the expertise to comment. But it did say that the overwhelming majority of scientists consulted felt that the security offered by the DES was more than adequate for five to ten years for the unclassified data for which it will be used.

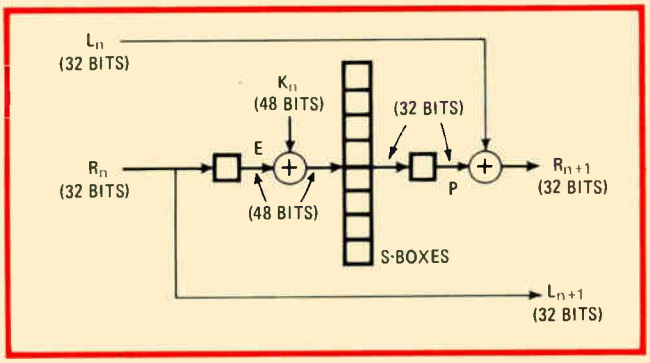
The DES standards have now been discussed in public and one of the cardinal principles of the cryptographer's art has been upheld. The system has been under attack by experts in the field and they have not been able to show how to break it—even if they have raised many questions. It may be that the system is *de facto* secure if not *de jure*.

IBM has had faith in DES from the beginning. The DES development work was done by Walter Tuchman and Carl Meyers of the Communications Systems Development Laboratory in Kingston, N. Y. It took six years; the project's original objective was a cash-dispensing scheme for a London bank.

Tuchman and Meyers feel that the DES is secure for the foreseeable future—again, about 5 to 10 years. What is more, they say, even if a computer could break a DES encryption in a reasonable time (a big if, they think), it would cost so much and use so much power that it would not be practical.

Validation procedures

Considering that a DES device has 2^{56} or 70 quadrillion possible ways of coding a 64-bit data word, verification that everything is working well is no small task. It has been clear for several years that the application of some standard validation procedure by an acceptable testing agency would be very useful for all concerned.



3. Base two. The 16 data-manipulation stages are all the same; they are connected in series, with left and right block halves (32 bits each) reversed after each stage. The two addition operations call for exclusive-OR circuits, for addition in base two arithmetic.

With this in mind, the National Bureau of Standards built a hardware testbed facility to validate manufacturers' hardware implementations of the DES. Built in transistor-transistor logic, the NBS unit can perform an encryption or decryption in 6 microseconds.

The NBS system (Fig. 5) is microcomputer-controlled and makes its decision as to whether a submitted unit is functioning correctly on the basis of comparison tests with an NBS DES unit known to be functioning correctly. The microcomputer is loaded downstream with the test program by a time-shared program running on a PDP-11/45. For the validation test the unit under test is interfaced with the microcomputer in parallel with the NBS unit. All procedures are controlled by an operator through a CRT terminal.

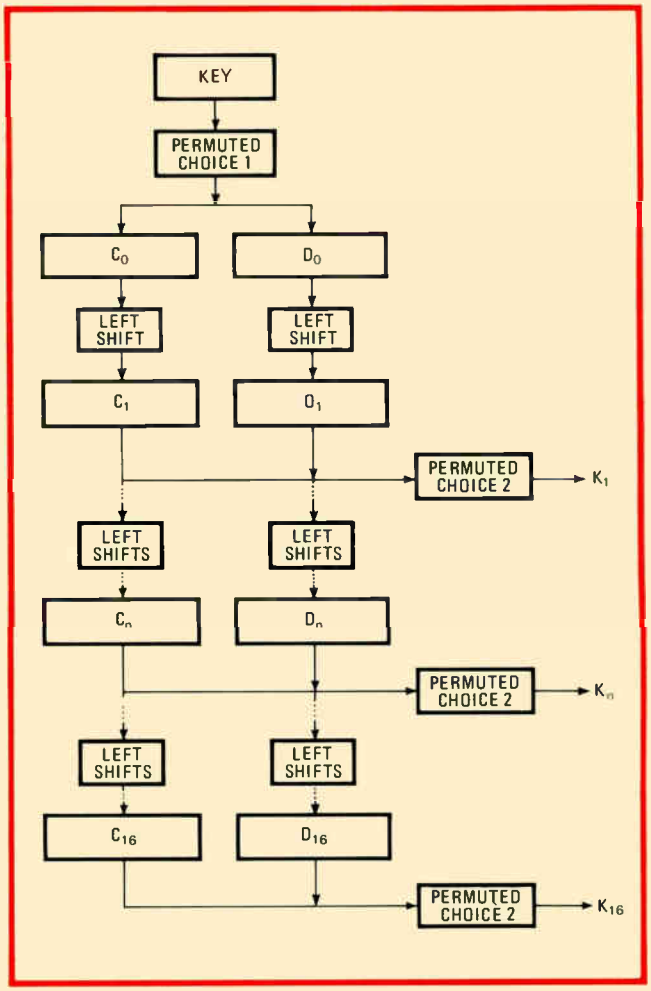
In an actual test, the device under test and the NBS unit are run simultaneously and synchronously as the various test cases are exercised. The interface between the proprietary DES unit and the microcomputer port differs for each manufacturer and may be furnished by the manufacturer or constructed by the NBS.

The NBS testbed is only for hardware implementations of the DES algorithm since the DES is "a complex nonlinear algorithm that was designed with a view to efficient hardware implementation," according to Jason Gait of NBS's Systems and Software Division. He notes that software implementations are generally quite inefficient compared to hardware versions.

Fast in hardware

Despite its complexity, a DES implementation can operate at high speeds in hardware. The NBS DES unit takes about 6 microseconds to encrypt or decrypt one 64-bit data block; it takes about 26 microseconds to load a key or load or unload either plain or encrypted text. In contrast, typical software execution times are 30 to 100 milliseconds.

The nonlinear substitutions or S-boxes are the most important part of the encryption. Unlike the other parts of the algorithm such as the various data permutations, NBS researchers could not calculate a simple small number of inputs that would completely verify that the S-boxes work correctly. They were forced to use a statistical procedure—a Monte-Carlo routine—to come up with 19 device inputs which tested each S-box entry.

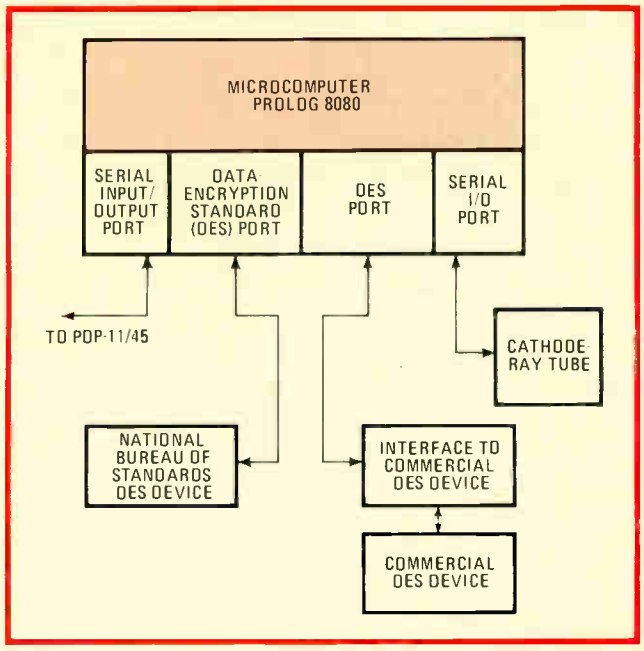


4. Key derivation. After 8 parity bits are removed from the user's 64-bit key word, the remaining 56 bits are split into two 28-bit registers. Multiple permutation operations produce the sixteen 48-bit derived keys used in the 16 data-manipulation blocks.

Fortunately other parts of the DES algorithm are analyzed more readily. For example, the keys are completely tested by using 56 specific data words for both encryption and decryption—a total of 112 tests. The initial and final permutations are tested by 128 more specific data words. These words, as a bonus, automatically verify the expansion operator E. Finally, the permutation operation P is checked with 32 more encryptions. A total of 235 encryptions and 56 decryptions do the whole job.

Any vendor of DES hardware to the Federal government must have his products validated by the NBS. The validation, however, only states that the product operates properly; no mention is made of reliability or quality control, which is left to the manufacturer. However, there is one more thing that the NBS does. With a test that may take up to eight hours, the NBS subjects the device to another Monte-Carlo procedure consisting of 8 million encryptions and 6 million decryptions.

These tests help to insure that there are no internal flaws in the device design. For example, they determine whether or not some combination of inputs causes the device to malfunction in some way that has nothing to do



5. Validation. The NBS certifies a commercial DES device by comparing its output to that of a proven, Government-built DES device. The maker may supply an interface for the hardware to be tested, or, given complete specifications, the NBS will build one.

with its implementation of the DES algorithm. They also insure that the device has not been designed just to pass the test that NBS gives it. "It's not a reliability test but it does check for operational error," says Gait. He adds that another thing the test does is insure that the device will never cause the key or plain text to appear at the output instead of the encrypted text—an obvious disaster from the security viewpoint.

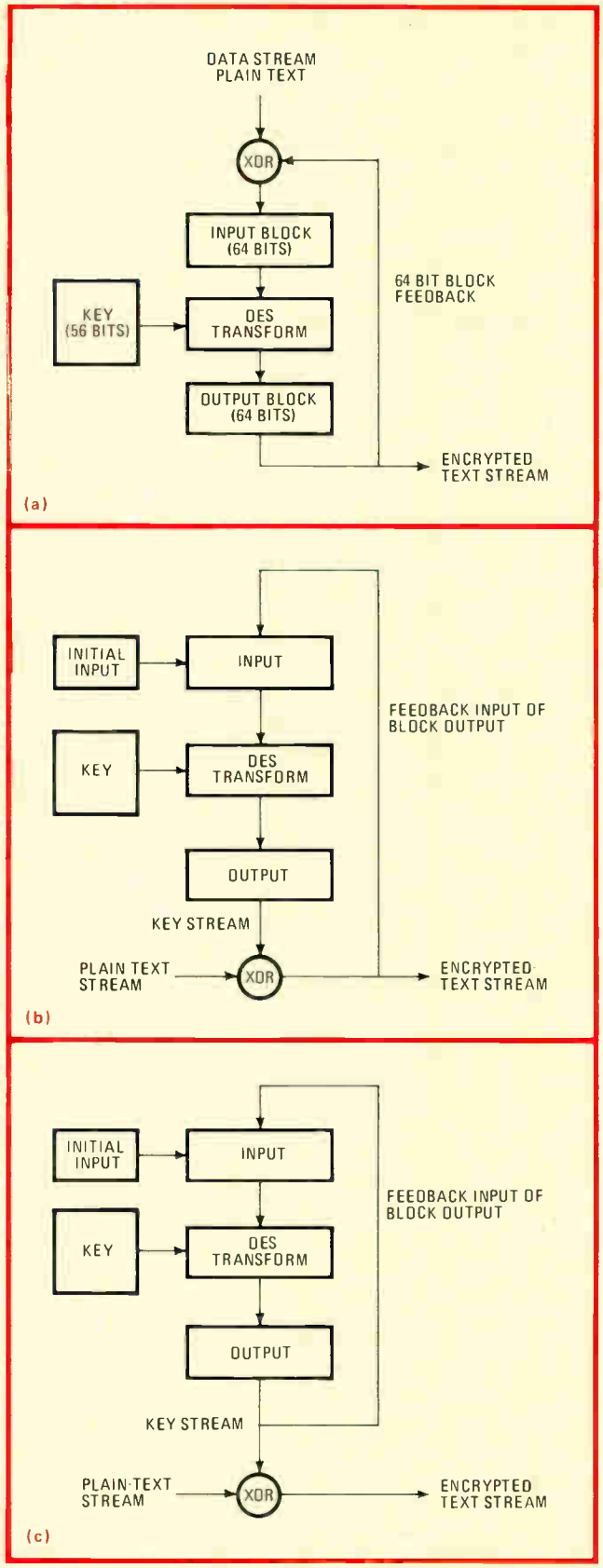
DES formats

DES describes the algorithm by which a 64-bit block of data should be transformed into another coded 64-bit block of data under the control of a 56-bit key. DES does not specify how the algorithm should be formatted and configured in a system, although this is suggested by other documents. In fact, there are several different ways to configure a DES system.

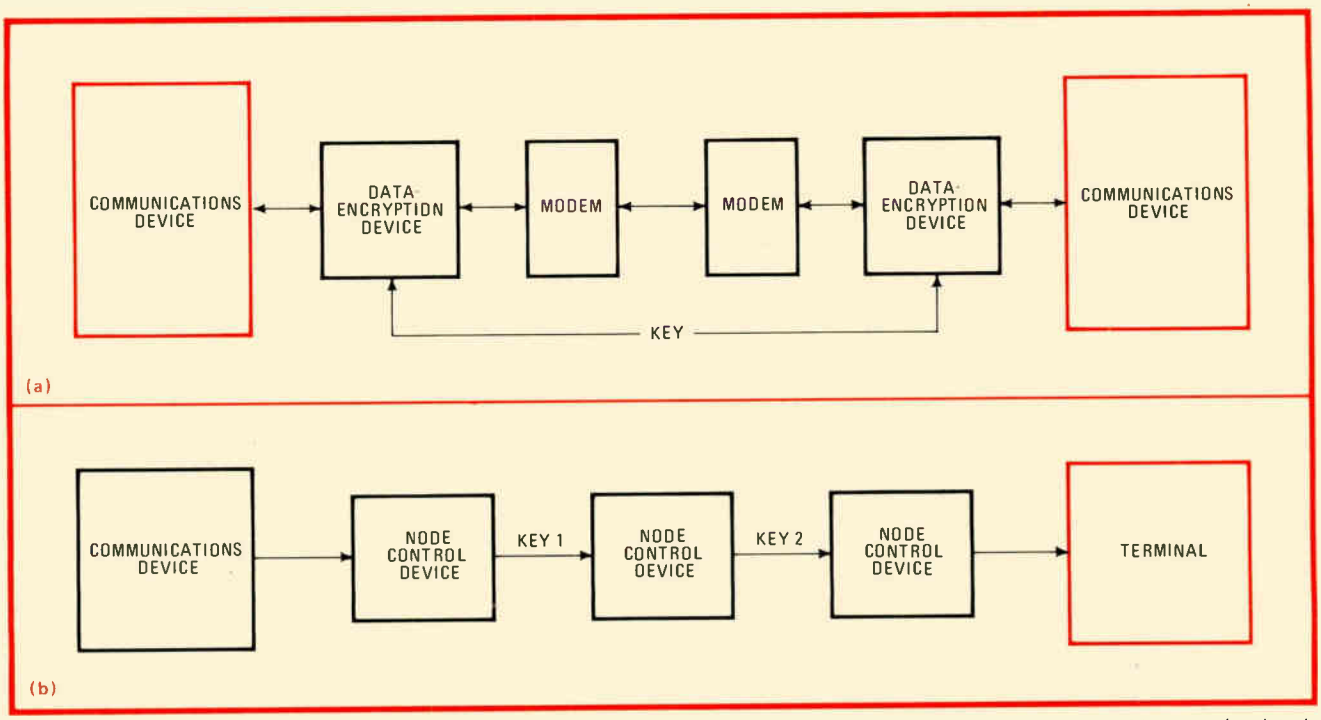
Perhaps the simplest is the block-cipher format. This is an example of data-dependent encryption. In this procedure, each output bit is a function of all the input data bits. To do it, an input data stream is divided into 64-bit blocks that are successively DES-transformed into 64-bit output blocks. Unfortunately, an error in only 1 bit of the input can cause as many as 64 bits to be in error in the coded output.

The block-cipher implementation has the further weakness that identical blocks of input data appear, after encryption, as identical blocks of encrypted text. This violates one of the basic encryption security laws: never encrypt the same message the same way twice; it's easier for an adversary to break the code. But this problem is overcome with the block-chaining feedback approach (Fig. 6a).

In this mode, the 64-bit encrypted output is combined with the next input block by the exclusive OR (modulus



6. Feedback. Three basic DES implementation schemes are used, although many variations are possible. Block-chaining feedback (a) and stream encryption with encrypted-text feedback (b) are data-dependent techniques; stream encryption (c) is data-independent.



7. Connections. Link-by-link encryption (a) is readily achieved with stand-alone equipment. A node-by-node hookup (b) keeps the data in encrypted form everywhere in the transmission path, including the intermediate nodes. It is more secure than the link-by-link system.

two arithmetic addition) operation. An initialization signal is required to start the whole process. Unfortunately, in this system, the same error problems exist as in the block-cipher mode.

Still another data-dependent encryption technique is stream enciphering with feedback of encrypted text (Fig. 6b). Here, some bits of the data stream are exclusive-OR combined with a number of output bits. This is fed back into the DES input. Again, an initialization signal is required and a 1-bit input error can expand to cause all 64 bits in a block to be in error.

Occasional error-propagation problems may be tolerable in communications systems. Yet under some circumstances, such as a noisy narrowband digital signal in an encrypted-speech application, it is best to use a data-independent stream cipher (Fig. 6c).

In a data-independent system, the DES is only a random bit stream generator. Its outputs are bit-for-bit exclusive-ORed with 64-bit blocks of the data input stream. To decipher, it is necessary to exclusive-OR the DES output keystream with the encrypted input stream. Since the keystream output is fed back on itself, this system is called a key-autokey mode. In this approach there is only one error if one input error occurs. One of the many variations of this key-autokey approach is used in the GTE Sylvania secure voice system, which operates under DES control.

There are three approaches to incorporating encryption in a communications system. Which one is most appropriate depends on the particular application at hand. Variations of the basic three are required in certain specific applications.

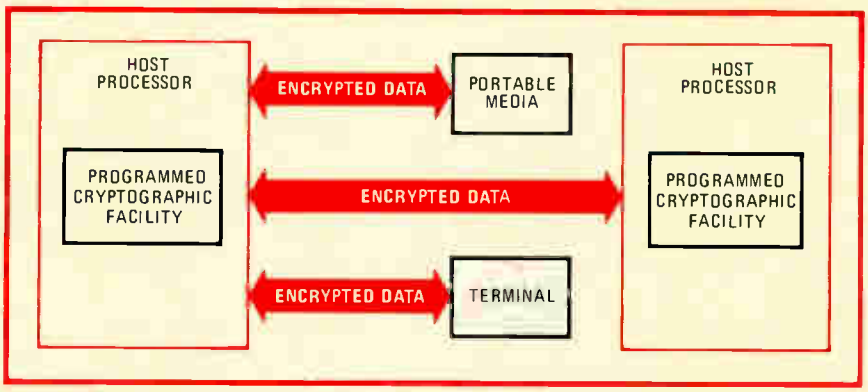
Link-by-link encryption, perhaps the simplest technique, is readily implemented so that it is transparent—in other words, it has no apparent effect on the data stream. In this approach (Fig. 7a), the encryption devices are placed in series with the circuit between data terminal equipment and data communications equipment. Its disadvantage is that all traffic has to pass through the central processing unit of any node in the uncoded state. At these points the data is susceptible to unauthorized access.

It is possible to modify the link-by-link approach to overcome the plain-text-CPU disadvantage. This approach is called node-by-node encryption (Fig. 7b). Each node uses a unique key and the conversion from one key to the other occurs within a security module. This is implemented as a peripheral to the CPU in question. At no time does plain text traverse the node.

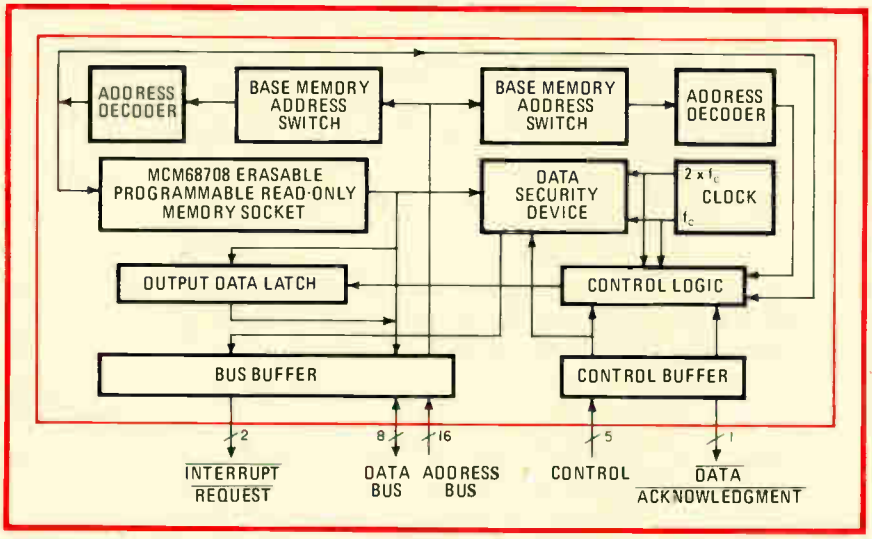
Network requirements

When complex switching networks are used to route information between a large number of senders and receivers, end-to-end encryption is required. This approach involves setting up a key-control center somewhere within the communication system. Each end point in the system is assigned a unique long-term key and only the center has a copy of all of these. When one end point user wishes to communicate with another, a request is sent to the key-control center. A temporary conversation key is generated at the center; this is then transmitted to the potential sender and receiver, encrypted using the long-term keys of both the sender and the recipient. Each decrypts the just-received temporary key by using his long-term key and the two parties are able to converse using end-to-end encryption with the temporary key.

The DES algorithm is being implemented with large-scale-integration techniques using various process technologies. Many of these physical realizations—in hard-



8. In the system. To provide centralized encryption control, IBM supplies a subsystem that is incorporated directly into operating-system architecture. All key management is done by the machine unless the operator explicitly overrides the control system.



9. Modules. Plug-in boards occupy the middle ground between DES chips and stand-alone systems. The TTL-compatible Motorola boards have the DES implemented with a single n-channel MOS chip; room is left for the addition of user-defined functions.

ware—have been submitted to the National Bureau of Standards for validation.

All of the validated devices produce identical results given the same input data and key. However, NBS Computer Security project leader Dennis Branstad points out that "each manufacturer has provided various control functions for the devices, optimized various features such as speed, cost, size, and power consumption, and built them to fill an anticipated need in the marketplace."

Technical variety

A summary of the key specifications of the validated devices—and several that have not yet been validated—shows that a great variety of functions may be satisfied and that, in the tradition of new semiconductor products, there is no general agreement among the manufacturers as to just which features the products should have and how they should be made.

Making matters more complicated, additional standards are required to make sure that the encryption devices in a communications system can communicate with each other. Communications standards and protocols do exist for computers and communications systems. This has minimized the number of codes, speeds, interfaces, and protocols that exist—or at least placed them under some control. But this has taken a great deal of effort. It is necessary to do the same thing for the efficient application of the DES standard and DES devices; both Federal and American National Standards Institute standards are being developed.

IBM has made a major commitment to DES because, in the company's words, "it is estimated that by 1980, the volume of data traffic—much of it sensitive or proprietary—will exceed that of voice traffic over common carrier lines."

Typical examples of the IBM offerings are the 3845 and 3846 data-encryption devices. These are both meant to be attached at each end of a communications line between the modem and the computer or data terminal. Both units are essentially the same except that the 46 is rack-mountable and the 45 is meant for desktop use. A hand-held key entry unit is used to enter the keys and such pertinent information as protocol, speed, and so on.

Both units are extremely flexible, although the flexibility in some cases is provided by different models of the same device. Depending on the mode of operation, they can accept up to 19,100 input bits per second. Point-to-point as well as multipoint operation is possible as is half- or full-duplex operation. Most common codes such as the ASCII and common protocols such as binary synchronous and asynchronous data-link can be accommodated.

IBM's units operate in the encrypted-text-feedback mode. Encrypted data not only enters the communications channel but is fed back to play a part in the coding of subsequent data.

For those system users who are looking for central

Public-key systems

Much of the controversy about and objections to the DES algorithm have been based on work by Martin Hellman of Stanford University. Hellman is a proponent of an alternate encryption scheme—the public-key system. In this approach, both sender and receiver use their own different-but-related keys; key transmission is eliminated.

In the public-key system, all encryption keys are published in a public directory with the user names. With each encryption key there is an associated but unpublished decryption key.

This latter key is derived by a complex mathematical relationship. Proponents of the system claim it is unbreakable since it requires the ability to factor very large numbers, something that is beyond even projected computer capabilities.

It is only necessary for a sender to look up his recipient's code and send an appropriate message. Only the recipient can decode it and all is well. As a side benefit, the electronic equivalent of a handwritten signature can be provided by a public-key system, eliminating questions as to the authenticity of transmitted information.

There is no hardware available to implement a public-key system at the present time. There have, however, been rumors in the industry that some interested parties are looking into this. Certainly the Government has not pushed it like the DES and no standards exist as yet.

Hellman's dislike for DES is based on what he feels are weaknesses in the system. These include certain symmetries which would allow for reduction in the brute force required to break a DES code. Moreover he says that there are some "questionable quasi-linear structures which might lead to substantial reduction in the required search effort." Both the NSA and the NBS say they are not aware of any methods of exploiting these effects.

Hellman has also estimated (on the basis of extrapolations of the growth of computer technology) the cost and time required for a determined adversary to break a DES encryption. For instance, he estimates that a $20 million machine might search through all 70 quadrillion possible DES keys in a single day at a cost of about $10,000. But even he admits that "this estimate has not met with universal agreement."

Tuchman and Meyers of IBM, the developers of DES, allow that the public-key algorithm has merits. But they say it must be researched, tested, and validated before it can be seriously considered for general use. Standards must be established and products and implementation procedures developed. It appears that Tuchman and Meyers aren't really knocking a public-key system—only pointing out that it doesn't really exist yet.

control of encryption procedures without the need for individual key entry by a key entry unit, IBM has a subsystem that operates under the control of system network architecture. This automates key management—a major security concern—in a manner that is transparent to the system user.

Automatic key management

Basic to this approach is the so-called Cryptographic Facility Program Product. This provides support for encryption, decryption, and key generation (Fig. 8). Also important is the encrypt/decrypt feature that can be installed on the 3276 control Unit Display Station. This implements and controls the encryption operations through the system network architecture.

IBM also offers various software versions of DES for implementation on the System/370 computer series. Thus the do-it-yourselfer can selectively encrypt certain data and handle the encrypted information in some manner appropriate to the problem at hand.

Motorola Semiconductor has jumped into the DES market with both feet and come up with a line of gear for end users and original-equipment manufacturers. For the end users, the stand-alone DES4100NSM can be used with asynchronous, synchronous, or synchronous data-link control (SDLC) protocols in any data format and is system-transparent. It operates in any of the usual DES modes such as cipher feedback or block cipher and is controlled by an M6800 microprocessor.

The 4100 can encrypt data at up to 56 kilobits per second, depending on the mode of operation it is set up for—full or half duplex. One of the most important features, according to Motorola, is the fact that "not only can the encryption key be entered manually by the user but it can also be entered by the Info-guard Key Manager, which is available as optional equipment."

In the key-guard system, the user is relieved from the problem of key selection because the key-management system provides random key selection. Key distribution is simplified by the key loader and a built-in feature that automatically takes care of working key changes. This unit uses a photodiode and transistor to receive keys from the 4100KGM key generator.

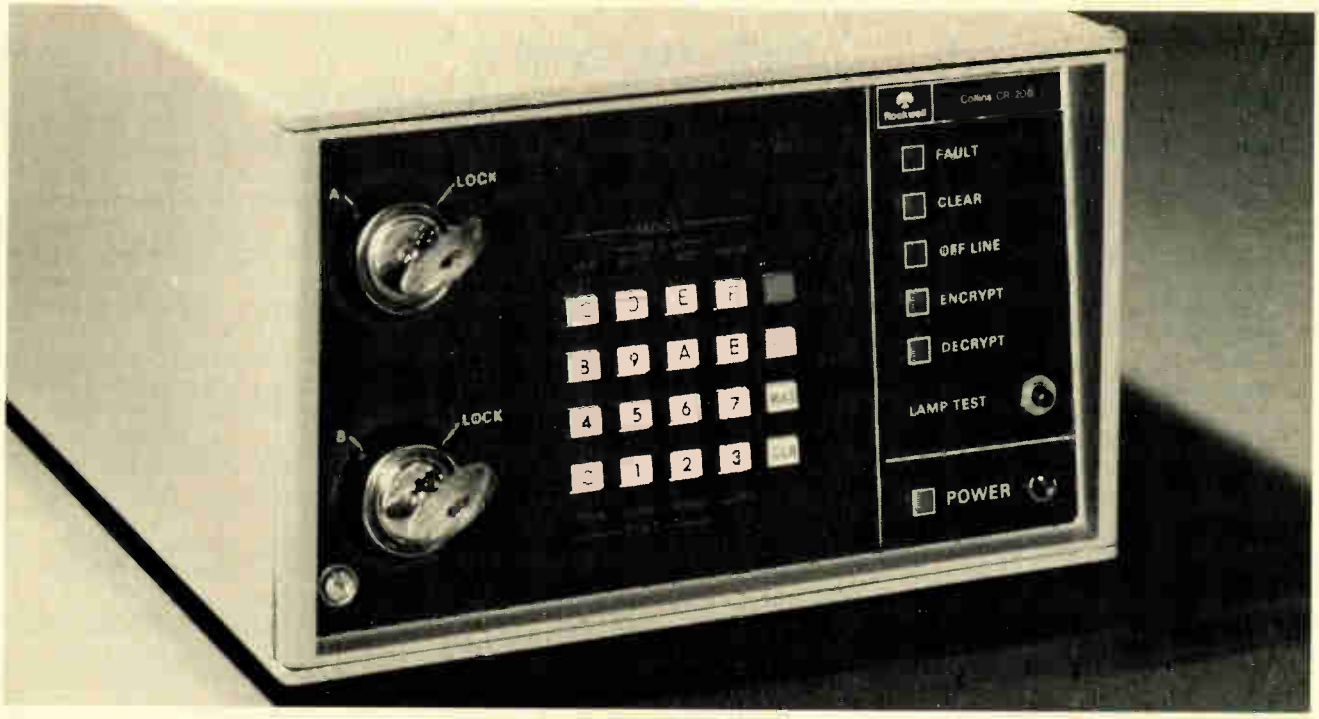
For original-equipment manufacturers who may want to buy data encryption boards to insert in their equipment, Motorola offers both the DES1100DSM and the MGD6800DSM data-security modules. These are both plug-in boards with the DES algorithm implemented with a single n-channel MOS device (Fig. 9).

Plug-in boards

The 1100DSM is geared to users of Digital Equipment Corp.'s PDP-11 and allows for direct-memory-access (DMA) control with its on-board M6800 microprocessor. The purpose of the 1100DSM is to relieve the PDP-11 from time-consuming tasks by minimizing software impact. The unit is specifically designed for the encrypted-text-feedback mode.

In contrast with the 1100, the MGD6800DSM is designed to implement the DES in either the block- or cipher-feedback mode. It is set up to interface the Motorola M6800 EXORciser or Micromodule system. Moreover, it is TTL-compatible and can run at a 400-kilobit-per-second rate. It has room for optional erasable programmable read-only memory for control program or encryption key storage.

Just to make sure that no one is left out, Motorola's MGD8080DSM is compatible with the Intel MDS development system or SBC module family in either the block-cipher or cipher-feedback mode. It is also TTL-compati-



10. Stand-alone. Self-contained units such as this one from Collins allow the user to encrypt or decrypt data on a desk top; he may enter a new key at any time. The unit has physical security features and a number of key-management functions.

ble, with optional E-PROM and space for user-defined functions.

Unlike the vendors in the data-encryption market who plan to sell implementation chips to the DES do-it-yourselfer, Rockwell International Corp.'s Collins Telecommunications Products Division in Cedar Rapids, Iowa, is going after the end user who wants to buy a ready-to-go box. And for those who want the bulk of the DES work done for them, it is offering a data-encryption board that original-equipment manufacturers can put in their gear to do the DES job.

This card uses MOS logic under microprocessor control to achieve data rates up to 45 kilobits per second in either a simplex or half-duplex mode. It is capable, says Collins' Bruce Bjorseth, manager of data products, of either the block- or cipher-feedback modes. The card, dubbed the CR-300, interfaces with Intel 8080, Motorola 6800, and Rockwell 6500 microprocessors.

Desktop boxes

Complementing the CR-300 is the CR200/220 data security unit. Either of these stand-alone devices (Fig. 10) uses MOS implementation to encrypt 2,400 bits per second for the CR-200 and 9,600 bits per second for the 220. The units are otherwise identical.

According to Bjorseth, "The user has a choice of full- or half-duplex and asynchronous or synchronous operation with either of these units. They can be used in either the single-link mode of encryption, the multipoint-link mode or the message-switch mode." In the first case, the unit is inserted between the host and its associated modem and a second unit is inserted between the data terminal and its associated modem. The second case—an extension of the first—encrypts the output of a host processor with a multiterminal link. A CR-200, for example, is used between each receiving modem and its associated data terminal.

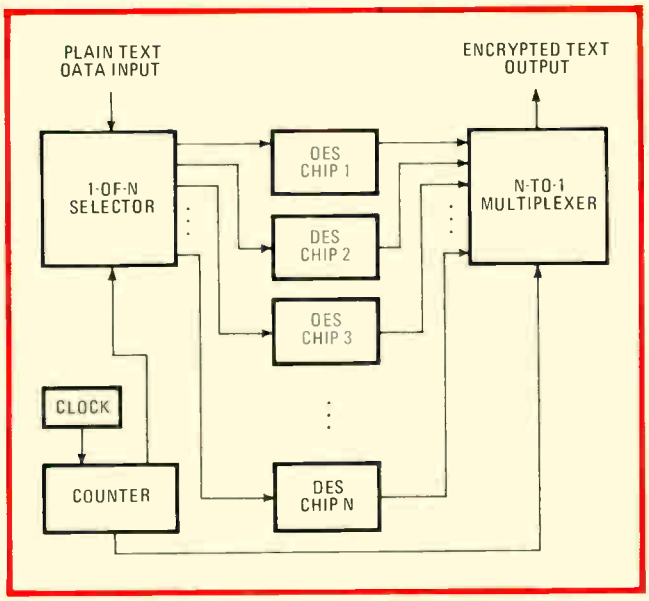
For message-switching applications, the unit is inserted between each data terminal and the switched data network (Fig. 7a). Since some of the transmitted bits in such a setup are utilized to control the switching network for message routing, the CR200/220 has provision for removing such characters from the encryption procedure.

The units can handle asynchronous, bisync and bit-oriented protocols [*Electronics*, Sept. 14, 1978, p. 175], according to Bjorseth. Just what data rate is achievable depends on the protocol and mode of operation.

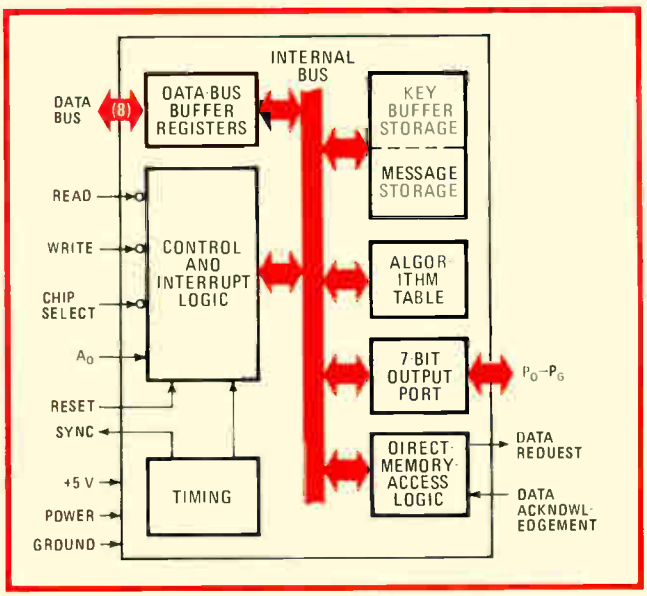
A key-management system is built in so the user is somewhat freed from the key security problem. Keys are handled by a Rockwell-designed 40-pin key-generation chip built with p-type depletion-MOS technology. Feeling that the greatest need for DES is in the banking community, and since the American Banking Association has endorsed the DES standard, Rockwell has geared its initial marketing efforts toward that segment—at least for the stand-alone devices.

Burroughs Corp. has also had a data-encryption device certified by the NBS testing facility. But whatever the company is intending to do with it, executives are keeping it to themselves and "are not yet ready to discuss a product," according to a company spokesman. While it's not clear what they intend to do, it is doubtful they will offer chips for sale like Intel, Fairchild, Texas Instruments or Western Digital. They are most likely developing devices for end users of Burroughs data-handling equipment.

Users of satellite data services [*Electronics*, March 28, 1979, p. 91] are not being ignored. The Cryptoline service offered by American Satellite Corp.'s Satellite



11. High rates. It is possible to multiply the data-handling rates of DES chips by hooking them up as part of a parallel processing circuit. If n chips are used, the effective rate is multiplied by n, but synchronization and timing become critical factors.



12. Peripheral. Intel's 5-volt device is a microprocessor peripheral with a direct-memory-access interface. Designed for banking applications, this device is byte-oriented, capable of handling up to 80 bytes per second or multiples thereof when paralleled with others.

Data Exchange Service is typical. It has been used in the earth stations operated by Western Bancorp since late 1978.

The American Satellite units provide DES encryption in a full-duplex mode at rates up to 112 kilobits per second for either synchronous point-to-point or multipoint operation. They are typically placed between the earth-station electronics and the user's data terminal.

Satellite security

Other satellite data handlers have looked into encryption and their reactions vary as to its importance. For most data handlers, no decision has been made. Either their customers have not asked for the service or they will "provide it if it is needed," as RCA claims. The claim to such a quick reaction supports the theory that they will buy a stand-alone unit rather than build it themselves.

There are also many consultants and companies that offer software implementations of DES. Computation Planning of Bethesda, Md., has emulation programs for a variety of computers and is typical of the suppliers of this service.

Texas Instruments Inc.'s bid to capture a portion of the data encryption market is embodied in the TMS 9940 chip. This microcomputer can achieve a 4.8-kilobit-per-second continuous coding rate, according to Robert L. Budzinski at TI's Dallas facility. What is more, he says, "the TMS implementation is stand-alone, requiring only a data stream and a data strobe. No external memory is required and the implementation can easily be interfaced to a microprocessor bus using transistor-transistor logic."

The 9940 is a 5-volt device. Like Intel's chip, it is geared to the relatively slow terminals such as are used in banking transactions. It was readily adapted for this function from TI's 9940 microprocessor family, says Budzinski. Its instruction set is the same as that of the 9900 and the 9980 with the exception of three additional instructions. It typically works in conjunction with a 5-MHz clock.

The TMS 9940 can be operated in either the buffer or pipeline mode. In the buffer mode, data is transferred into the chip, the encryption or decryption is performed, and the data is transferred out, leaving the chip ready for a new cycle.

In the pipeline mode, new data is fed into the chip as previously encrypted or decrypted data is read out; the output rate is equal to the input rate. This allows the maximum 4.8-kilobit-per-second continuous rate to be achieved.

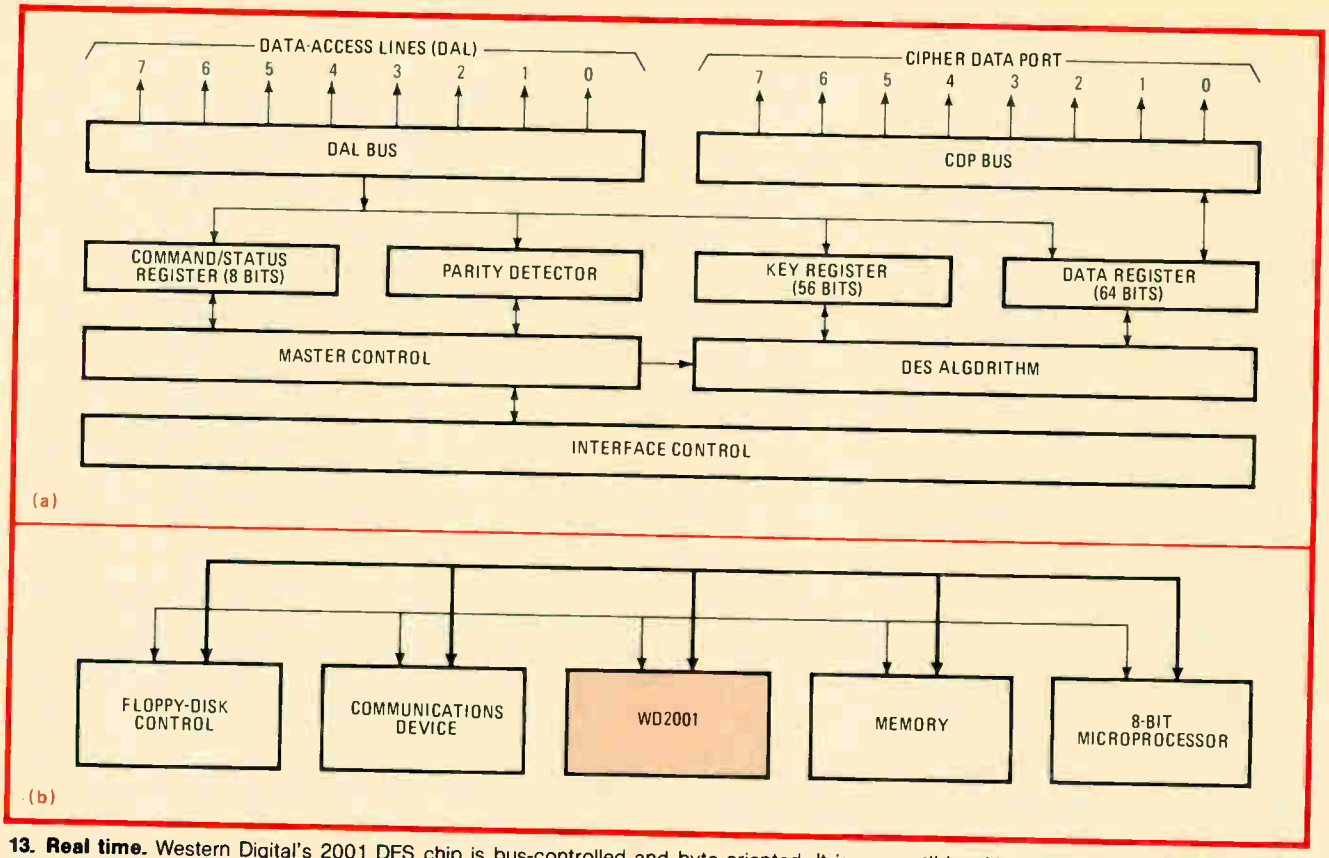
As with the Intel chip, paralleling the chips can deliver a much higher effective data rate. In fact, the use of n chips multiplies the rate by n (Fig. 11). In this scheme, each chip merely receives every nth block of data and chip coordination is furnished by chip-select inputs.

The Intel 8294 data-encryption chip is a microprocessor peripheral specifically designed to implement the DES for slow devices, according to Daniel Shafer, the company's microcomputer marketing manager. The 5-volt device (Fig. 12) may be used with the MCS-58, -48 or -80 processors and has a DMA interface to facilitate information transfer without having to go through the microprocessor.

The chip is byte-oriented and has a fundamental information-transfer rate of 80 bytes per second. Since the DMA interface is available, if necessary the 8294 can be paralleled to achieve information rates that are multiples of 80.

Different jobs, different speeds

"The 8294 data-encryption chip, while not fast enough for real-time voice encoding and decoding like the Motorola Infoguard line, is nonetheless fast enough for



13. Real time. Western Digital's 2001 DES chip is bus-controlled and byte-oriented. It is compatible with many microprocessors and can operate at 176 kilobytes per second when driven by a 2-MHz clock. This is fast enough for most real-time applications.

virtually any computer application and is significantly less expensive than other products presently available," marketing manager Shafer points out.

Taking the n-channel silicon-gate approach, Western Digital Corp. of Newport Beach, Calif. has announced three DES chips with DMA and all inputs and outputs compatible with transistor-transistor logic. The WD2001E/F and the WD20002A/B are available as samples now; the WD2003 will be available in the last quarter of 1979.

The Western approach is a high-speed one geared to capture markets other than the banking institutions that will perhaps be the first volume customers. According to division vice president Charles Von Urff, the WD2001 can code at a 167-kilobyte-per-second rate when driven by a 2-MHz clock. Faster rates are available when the clock frequency is increased, he says, although 167 kilobytes per second is probably fast enough for most real-time applications.

Bit-slice chips

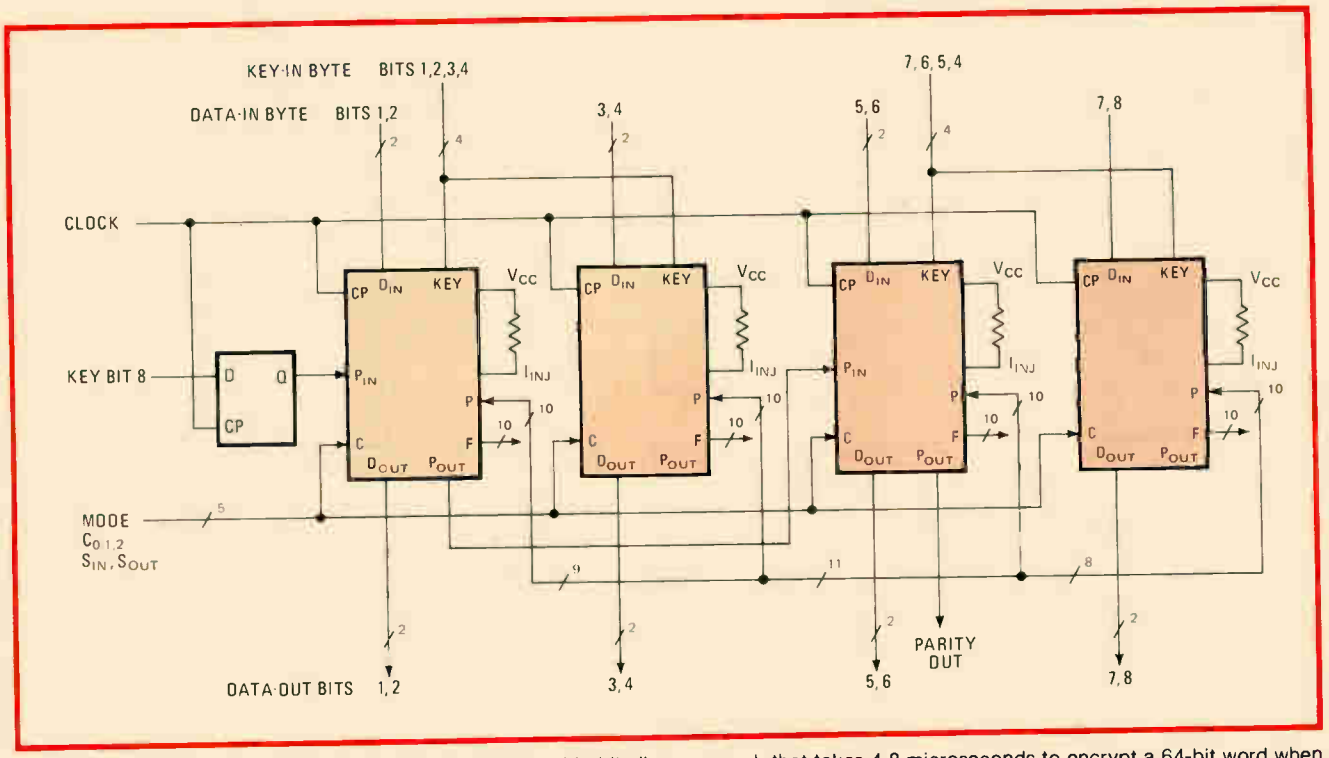
The 28-pin 2001 is compatible with many microprocessors but is tailored to the 8080. It is bus-controlled and, like the Intel chip, byte-oriented. (The 64-bit input word may be viewed as 8 bytes.) The Fairchild 4-chip set is not byte-oriented; so far only Fairchild has gone to the bit-slice procedure to attain high speeds.

Western's 40-pin 2002 handles plain and enciphered messages on separate bus lines rather than multiplexing them on one as the 2001 does. This should appeal to military people who do not like to mix secret and non-secret information (Fig. 13). The 2003 will be capable of performing in the cipher-feedback mode, but final specifications have yet to be announced.

In order to gain high-speed encryption and decryption, Fairchild Camera and Instrument Corp. engineers decided to implement the equivalent of parallel processing in their bit-slice four-chip set (Fig. 14). Two bits of each input byte are distributed to each of the four chips. Each chip has a separate input and output so that input and output can go on simultaneously. Chuck Erikson, manager of LSI logic design at Fairchild's Mountain View, Calif., facility, says this overlap procedure makes it possible to "get a data throughput of 4.8 microseconds per 64-bit word" at a 5-MHz clock frequency.

The four chips, 9414-1, -2, -3, and -4, are 40-pin integrated-injection-logic devices that must each be independently supplied with 100 milliamperes of injection current. Each chip has a pair of data registers, four 8-bit shift registers, control logic, and two 64-word-by-4-bit read-only-memory sections. They can be used in the cipher-feedback or the cipher-block-chaining mode to make the encryptions depend on past messages as well as the key word.

Fairchild's entry into the encryption sweepstakes is geared to capturing as much of the market as possible—it is fast enough to handle just about any device with output that needs to be encrypted. "It was clear," says Erickson, "that the data terminal market, which uses much lower speeds, is only a small percentage of the total market. We wanted a bigger piece of the action than that."



14. Lots of bits. The Fairchild DES implementation is a 4-chip bit-slice approach that takes 4.8 microseconds to encrypt a 64-bit word when driven by a 5-MHz clock. The integrated injection logic on each chip requires 100 milliamperes of injection current.

Fairchild sees a big market for its devices not only in communications but in the protection of stored data. Erickson says disk storage, for example, is a prime candidate for computer crime, and the need to protect it is great.

Racal-Milgo Inc. of Miami, Fla., is the latest entrant in the data-encryption market. Introduced last month, the stand-alone Datacryptor handles 9.6 kilobits per second in link-by-link or any other type of network configuration, using synchronous, binary synchronous, and other protocols. It is set up to operate in the encrypted-text-feedback mode.

Company president Edward Bleckner Jr. feels that the Datacryptor is a natural addition to the firm's line of data-communications equipment. Customers include banks, insurance companies, and commodities organizations, all of which have an interest in secure data handling.

Racal is making a master encryption device intended for installation at a central computer site, a remote unit for outlying points in a system, and a key transport module that stores DES keys for use at the remote sites. Up to 32 remote stations may be accommodated, and up to 32 different keys may be used at once. Allowance is made for transmission of both encrypted and unencrypted data on the same line.

What did you say?

Right on the heels of the telephone's invention, a patent was filed for a speech scrambler—the need for secure telephone communications was recognized at a very early stage. Today the problem is acute.

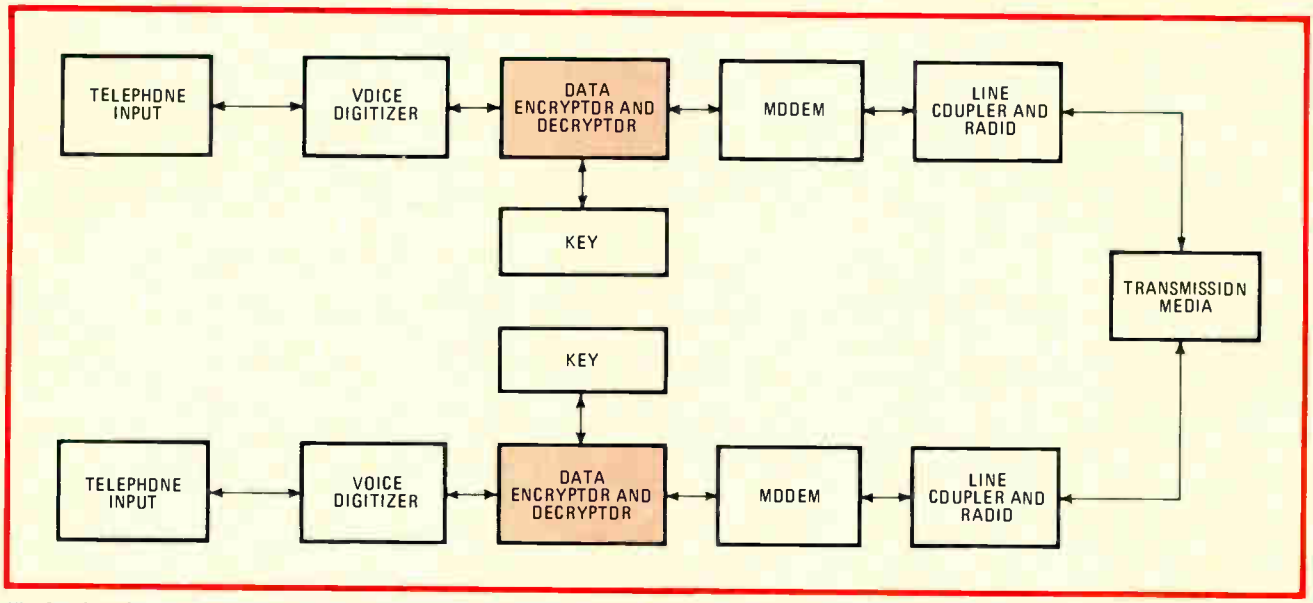
A commercial voice security terminal designed by GTE Sylvania uses the DES algorithm to protect speech transmitted over standard telephone lines. It consists of a voice digitizer, an encryption/decryption device and a modem (Fig. 15). Why has it been necessary to use such sophisticated technology?

The problem with telephone speech security has been to provide acceptable voice quality with high security over standard telephone lines. Early devices based on analog technology were relatively simple and provided moderate speech intelligibility by scrambling either voice amplitude or frequency. However, the security they provided was minimal and they certainly did not comply with the DES.

According to Joseph LeLellis of GTE Sylvania's Needham Heights, Mass., facility, its device "has a speech digitizer which uses adaptive-predictive decoding—a technique for removing the inherent redundancy in the speech waveform—to minimize the data rate required for intelligible voice transmission in a digital mode." Its 6,400-bit-per-second rate is low enough to go on a standard voice-grade line, yet the voice quality is quite satisfactory. LeLellis says a simple analog-to-digital conversion of a voice signal requires a data-transmission rate of from 48 to 56 kilobits per second. This is too high for conventional telephone line transmission.

While the a-d converter determines voice quality and the data rate that is required to go out over the telephone lines, the DES encryption device in the terminal provides the usual 2^{56} possible encodings of the digital voice signal. Users of the system simply select an encryption key with thumbwheel switches on the voice-security terminal itself.

Most industry observers and participants agree that because of the tremendous potential for electronic crime, integrated security procedures using everything from



15. On the phone. Sylvania's stand-alone unit lets the telephone user encrypt his conversation with the DES algorithm whenever he wants to do so. The analog voice signal must first be converted into a digital data stream without excessive loss of voice quality.

armed guards to DES encryption will become commonplace. While no one yet knows the final size of the market, the evolution of DES products and markets is following classic patterns.

The concept has been introduced—although not without controversy—and in the words of one Rockwell International engineer, "the industry is in an evaluation phase. That's when a company that is a potential user buys two to five or so modules to get hands-on experience." This contrasts, he says, to the last two years or so when "interest was more literary than in applications." Rockwell expects the market to explode in 1981.

Optimistic projections

Industry consultants are now getting into the act with their high-priced reports. Strategic Business Systems of San Jose, Calif., headed up by Michael Killen, has issued a study authored by public key advocate Whitfield Diffie. This study examines data-security questions from both the short- and long-term views. There are many problems, Diffie points out—export controls, patent laws, legal and security restrictions and the very newness of the market. But the study nonetheless estimates the market size as over $243 million for general-purpose terminals in 1979 and about $4 million for special-purpose secure terminals.

Another report, put out by Ken Bosomworth of International Resource Development in New Canaan, Conn., expects the current market—which the report estimates to be $240 million in both the military and commercial sectors—to show a tenfold increase over the next five years. However, he does not expect U. S. shipments to increase tenfold because of the relatively low prices of the new LSI DES chips that are on the way.

In one study, IRD found that 30% of the large computer-communications users had set up study groups to look at data encryption. This tends to support Rockwell's view that the industry is in the evaluation phase.

Of course, the greatest stimulus to the use of DES equipment will come as the algorithm is accepted as a standard by those organizations directly involved with data-security problems. A major step in this direction was taken when the American Bankers Association endorsed DES as "a significant step forward towards the encryption of electronic funds-transfer networks." It also seems that even the most outspoken opponents of DES (on a security basis) are agreed that it will be useful for at least the next few years. And the investment of the various semiconductor houses and computer companies would certainly seem to support that view.

Since the Federal DES is showing signs of becoming the U. S. commercial standard, many potential manufacturers and users of equipment complying with the algorithm want to try it out. For some of them, the software approach is easiest since general-purpose microprocessors or computers are readily available.

In theory, the National Technical Information Service document FIPS-PUB-46 tells all that is required. Yet, in practice, says G. Yuvel of the Wisundig Seminarium of Vrije Universiteit in Amsterdam, the Netherlands, "since the document contains no worked examples, not only is it hard to debug an encryption program, there is no way to discover that there even is a bug in it."

To help solve this practical problem, Yuval has published his software program (report IR 46) and compared his results for worked examples with the results of other people's work. Since the results agree—except for some mistakes that were determined to be typographical errors—and it is unlikely that different programmers working separately will make the same programming mistakes—Yuval has concluded that the published programs are bug-free.

Report 46 also has a printout of all the stages of the encryption for 10 specific examples. By following these results, a programmer should be able to localize the source of any troubles he may have. □

Writable control store saves microprogramming time and expense

Microprocessor controls the transfer of assembled microcode from a development system to a user's prototype

by Joseph A. Oberzeir, *National Semiconductor Corp., Santa Clara, Calif.*

☐ The growing number of uses of microprogrammed, bit-slice architectures has highlighted the need for a more efficient way to develop and test microprograms. The usual technique for testing and transferring assembled microcode to the host machine is to fill programmable read-only memories (PROMs) with test routines, but this wastes expensive devices as well as considerable programming time.

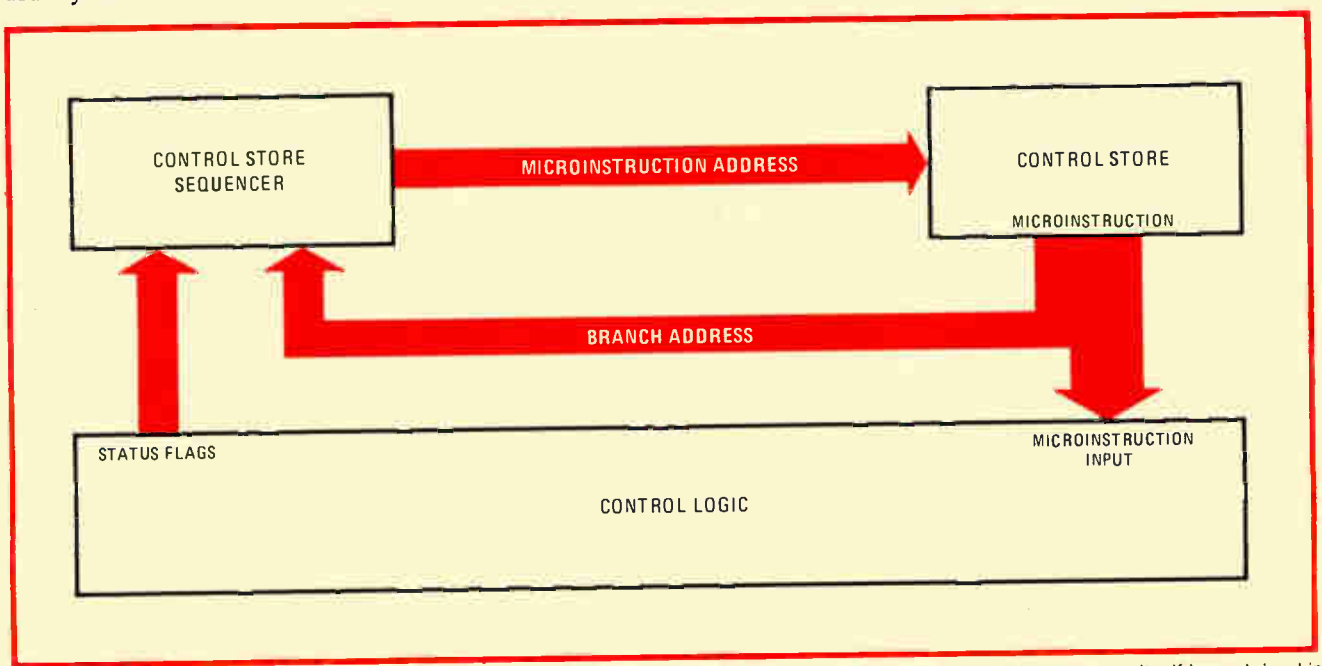
In most cases, though, test microprograms are short and therefore relatively easy to debug. Hence, a small writable control store (WCS), on line to a software development system, would considerably expedite the development of microprograms and save PROMs.

Microprograms may range in size from 256 32-bit words to 4 kilowords by 64 bits or even larger. They are usually developed via a microassembler, reducing syntactical errors and generating a binary image of the microcode. The machine that hosts the microassembler may be either a time-sharing network or an on-site development system. Development time for the latter is usually shorter than for the former because PROM-burning hardware is on hand and because there are few transmission and turnaround delays.

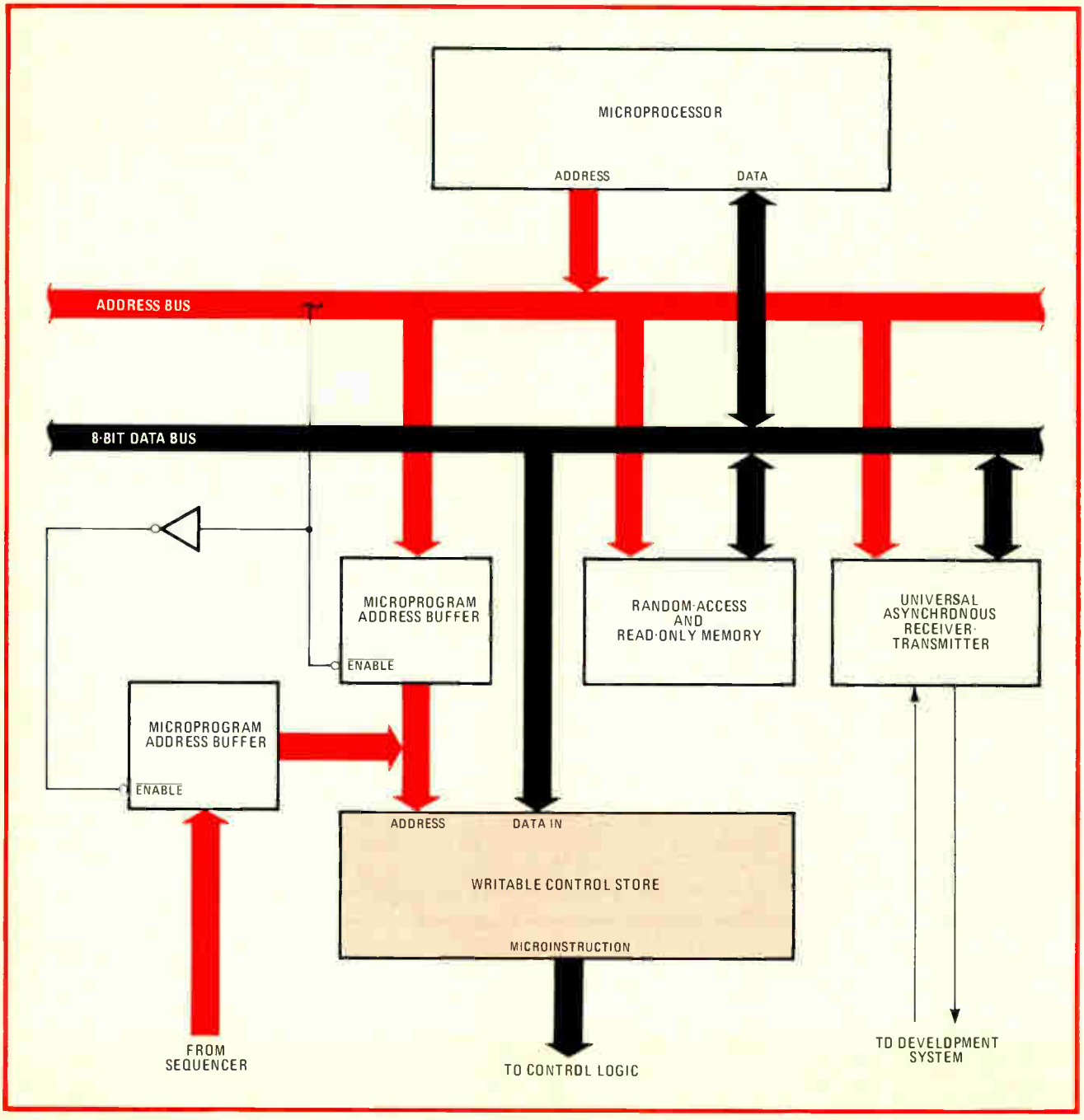
Microprogramming is a powerful technique for designing fast, complex, or special-purpose processing systems such as disk controllers, signal processors, and flight computers. Such systems are generally computation-bound; that is, the execution speed of the processor limits the overall performance of the system. In most cases, these demanding applications rule out the use of readily available microprocessors whose instruction execution times range from 1 to 15 microseconds. The large number of general-purpose instructions required to perform a given function also restricts their use.

A microprogrammed controller, on the other hand, because of both its custom instruction set and its architecture, is extremely fast. Such high speeds in a microprogrammed system are attained primarily by paralleling as many operations as possible and, of course, by using bipolar components instead of MOS devices.

As seen in Fig. 1, a microprogrammed controller can be divided into three main blocks: a control store within



1. Microcoded controller. A microprogrammed controller can be divided into three functional units. The microprogram itself is contained in the control-store memory while the sequencer steps through the memory's addresses. The logic carries out the current microinstruction.

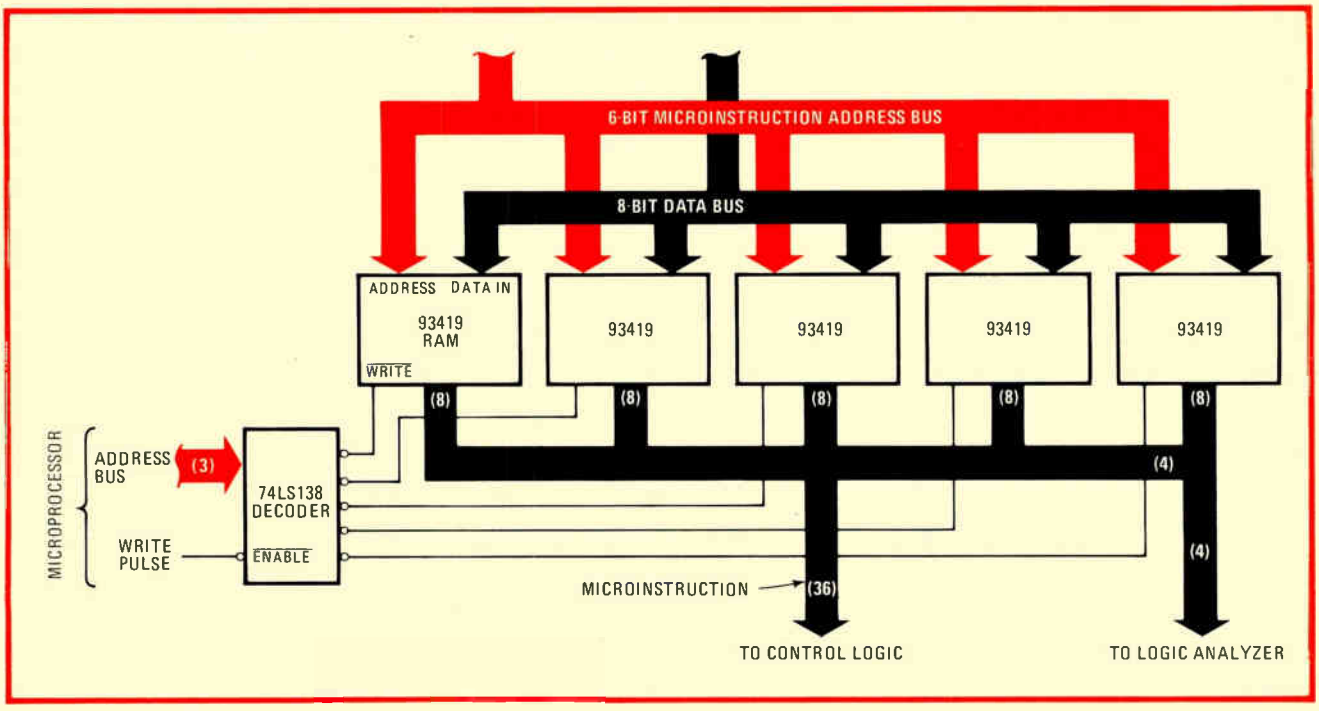


2. Microprocessor-controlled. Microprograms are downloaded into this development tool via a serial link. The microprocessor addresses the WCS (see Fig. 3) to load the microcode. To test the code, another buffer is enabled so that the sequencer can access the RAM.

which resides the microprogram, a sequencer that addresses this control-store memory by stepping through the microprogram, and the logic block that implements the current microinstruction.

This system operates by sequencing through a memory that contains microinstructions, which in turn direct the various functional units tied to the data bus. A microinstruction, or word of microcode, is divided into ranges of bits called fields that control a particular section of the processor. Sometimes all that is controlled by a field is the input to a single gate or the address to a multiplexer. Other controlled functions may include bus-driver enables, the source and destination of registers, the arithmetic and logic unit's operation, the address of the next microinstruction, and conditional jump data. Since for each microinstruction many functions are performed in parallel, the word length of the control store can get very long, often topping 32 bits. For high speed, the control store is usually built with bipolar PROMs.

Clearly, the microprogrammer must attend to many details to ensure that all program development aids are considered. Unfortunately, although great attention has been given to microprocessor emulators for software development and hardware debugging, few tools are available for the development of microprograms. Yet the writing of the microprogram is one of the most impor-



3. Writable store. The 64-word-by-40-bit writable control store shown above uses five 93419 bipolar random-access memories. Thirty-six of the bits are actually used by the microprogram, and the remaining four are routed off, in this case, to a logic analyzer for debugging.

tant phases of the design cycle, and care must be taken to see that this firmware is developed efficiently.

A microprocessor-controlled writable control store is shown in Fig. 2. This development tool communicates with any software development system over a serial link conforming to the appropriate Electronic Industries Association standard, to accept test microprograms. Most debugging sessions require small microprograms, so that a relatively small microstore is needed. However, should it be necessary to test an entire microprogram, more random-access memory can be added. Also, some interconnection has been omitted from the figure: a minor amount of logic—to enable the memories, for example—is excluded because it depends on the central processing unit selected.

Figures 3 shows a 64-word-by-40-bit writable control store with 93419/N82S09 RAMs used individually in a 64-by-8-bit configuration. Thirty-six bits are required by the microprogram, and the 4 extra bits are used as flags—to trigger an oscilloscope or logic analyzer, for instance—facilitating both hardware and software development.

The worst-case access time for a 93419 is 45 nanoseconds; when combined with the delays added by the address buffers, capacitance effects, and line-interconnection delays, this value can exceed 65 ns. Should the latter figure be excessive, other TTL RAM configurations can be considered before resorting to emitter-coupled-logic RAMs (and associated TTL interface components) for the WCS.

A data-transmission format is shown on p. 124, and an accompanying structured control program on p. 125. Just about any microprocessor may be used, as the execution time is not critical. Similarly, any transmission format may be used. The one employed here was chosen because it is perhaps the least complicated to implement and shows the general program flow. Also, should spurious noise be a problem in transmission, a check sum for error detection may be implemented.

Development

In a typical development session, the user first edits, assembles, and links a test microprogram on the development system and resets the writable control store's microprocessor. Then a loader program on the development system is called to transfer the assembled microcode into the WCS. The microprogram is executed using a logic analyzer as a debugging tool. As always, specialized test microprograms are helpful in reducing microprogram debugging time.

The actual work that must be done to construct the WCS is threefold. First, hardware for the development tool (microprocessor, WCS RAM, input/output interface, and so on) must be designed and constructed. As seen in Figs. 2 and 3, the hardware outlay is not very substantial and should take roughly about two man-weeks to design and build.

Second, the software for the microprocessor must be written. As indicated in the program shown, it is not very complex; about two to three weeks should be sufficient. Additional software must be written to enable the development system to transfer the microprograms; for most systems, that will take about one to two weeks.

Although allowing considerable improvement in turnaround time, a WCS is not the whole answer. If microprogramming is a considerable part of the product-development cycle, it may be advantageous to place the control inputs of the target system under control of the development system. This allows greater control of conditions in the target system from the programmer's console. Also,

a close look must be given to the available software packages suitable for microprogramming.

Microprogram software packages range from time-shared services to full-blown development systems that include computers, disks, printers, and development boards already having a writable control store. Ascertaining what is absolutely necessary for the user is difficult but essential.

Choosing development software

Consider the designer who wants to use an existing in-house minicomputer to develop microprograms. First, a microassembler must be acquired, and it must be written in a language that the minicomputer can compile. Also, the I/O and file-handling routines will have to be customized for the particular installation. Next, the user has to develop the capability to download the microcode into a writable control store for execution on the target system. A solution to this problem has already been discussed above.

A method of programming PROMs must subsequently be provided. This can be done by generating either a paper-tape load module suitable for PROM programming or a mask list for fabricating ROMs.

This programming burden—that is, the need to write all that software even before starting to write the microprogram—may be eliminated by calling in a consultant firm or by buying the whole system, including hardware, from one supplier. The former merely transfers and amplifies the cost and guarantees little. The latter ensures data compatibility—an operable system—at the risk of locking the purchaser into one vendor. This possibility can be highly undesirable, given that there are few of these vendors and their after-purchase support may be limited, at best.

If the user wants optimal software capability and is willing to face the burden of modifying an off-the-shelf software package, he needs some criteria in order to make a selection.

Primary programs

Three primary programs are used in the development of microprograms: an editor to create and modify, on disk, the microprogram; a microassembler that processes the definitions, symbols, and mnemonics that make up the microprogram to produce binary microcode and to save it on disk; and a binary loader that reads the microcode file and loads it into the development system memory or a WCS for execution.

In the past 10 years, editors have improved considerably, but there are still many that are difficult to use and waste a lot of time. The editor should be well documented, with an easy-to-use manual showing disk and memory data formats, as well as source program requirements. It should be disk-based and have a paging capability. A user developing a microprogram text file that will not completely fit into memory should still be able to list and edit microprograms.

A search-on-string capability is helpful for editing, as it makes it possible to find any particular character string within the body of the text file. Insertion and deletion of characters and lines in the body of the file should also be possible: plenty of mistakes will be made, so why retype an entire line of code just to change one misspelled word? Finally, tabs are handy for making the program easy to read and write.

ASCII TRANSMISSION FORMAT

The microprogram data format will be made of n data blocks, where n is the number of used microinstruction locations and each block is composed of an address and microinstruction in the form:

|<spaces>|<address><space>|<spaces>|<microcode><EOT>

where: <address> : : microcode load address in hexadecimal ASCII

<microcode> : : microcode to be loaded into WCS left justified (toward MSB) in hexadecimal ASCII

<EOT> : : carriage return

The microassembler, too, should be well documented. Ideally, it should be based on a language that the user is already familiar with, and it should be easily modifiable. A structured Algol-like language is best, but software written in languages such as Basic and Fortran is still most easily transported from system to system, since many compatible compilers already exist for them. Also, programs written in languages that do not lend themselves readily to structured programming techniques (such as Fortran and Basic) may be well designed in a top-down manner and be easy to modify. If software is purchased for an existing development system, either the programs have been written for the specific machine and operating system or they must be modified.

The microassembler

A disk-based microassembler is a must—microprograms and their load modules get too large to reside in available memory concurrently. If a microprogram is encountered that will not fit completely into available memory, it should still be assembled, so, once again, a paging capability is desirable.

The assembler needs an easy-to-use syntax. It should not be verbose or require many specialized delimiters: many different, special characters to separate symbols and mnemonics—for example, /)($#&''!@—make the microassembler difficult to use and can hide poor program design. A free-format text input is useful so that time is not wasted learning complicated spacing or tabbing requirements.

The assembler should recognize reserved words for a particular ALU and sequencer. For example, for all 2901 microassemblers, the mnemonics ADD, PASS, DECREMENT, and INVERT are reserved and should have defined meanings. However, the capability to redefine and add reserved words lets the user update the microassembler easily to include new bit-slice chips and sequencers that may have the same mnemonics as earlier units. An additional convenience is the ability to change reserved words by means of a data file on disk.

Symbolic and operational field assignments should

CONTROL PROGRAM FOR MICROPROCESSOR

```
/*  this program outlines the steps needed to implement
    the preceding data transmission format */
/*  subroutines used are:
          gets characters from serial s link
          ascii s hexadecimal s to s binary s conversion
          transfers microcodes buffers to s WCS
          errors process  */

Enters afters reset : PROCEDURE
/*  get microcode  – nibble at a time      */
/*                 – load it into a buffer as wide as the microword */
/*                 – transfer it if no errors into WCS  */
      microwords nibbles pointer = 0;
      DO WHILE inputs character < > SPACE;
        CALL ascii s hexadecimal s to s to s binary s conversion;
        IF not s hexadecimal THEN
          CALL errors process;
        ENDIF;
        microwords bytes pointer = microwords nibbles pointer / 2;
        IF (microwords nibbles pointer – 2 * microwords$bytes pointer);
          /* right justified nibble */
          microcodes buffer (microwords bytes pointer,3:0) = hexs digit;
        ELSE
          /* left justified nibble  */
          microcodes buffer(microwords bytes pointer, 7:4) = hexs digit;
        ENDIF;
        /* get another microcode nibble  */
        CALL gets characters froms serials link;
      ENDDO;

      CALL transfers microcodes buffers to s WCS
/*  wait for carriage return   */
      DO WHILE inputs character < > CARRIAGEs RETURN;
        CALL gets characters froms serials link;
      ENDDO

  DO WHILE  0 = 0;                    /*   continuous loop  */
/*  get leading spaces   */
      CALL gets characters from serials link;
      DO WHILE inputs character = SPACE;
        CALL gets characters froms serials link;
      ENDDO;

/*  get microcode load address  */
      DO WHILE inputs character < > SPACE;
        CALL ascii s hexadecimal s to s binary s conversion;
        IF not s hexadecimal THEN
          CALL errors process;
        ENDIF;
        microcodes address=microcodes$address * 16 + hexs digit;
      ENDDO;

/*  get delimiter spaces between address and microcode   */
      DO WHILE inputs character = SPACE;
        CALL gets characters froms serials link;
      ENDDO;
    ENDDO;
ENDPROC;
```

depend on the physical layout of the control-store PROM's data outputs. An individual operation field may not be contiguous from least to most significant bit—pieces of the field may be separated physically by several bits—and this must be reflected in the assembled code.

A good expression analyzer will save a lot of time otherwise spent calculating constants and branch addresses. The use of this feature depends on the application of the microcode.

Complete control of the microcode is also a must—every bit must be under program control. Conditional assembly is important, too, for should one microprogram be written to support more than one similar architecture, conditional testing may be essential.

A macro capability saves a lot of time writing programs with instructions that have common internal microinstruction sequences. A relocation capability, too, is handy for a microassembler. This allows modules of a microprogram to be developed and tested independently of the rest of the program. Also, comments should be insertable anywhere in the program that is appropriate, and several output formats should be provided to make the job of reading and debugging easier—a particular microassembler should not force the programmer to use a particular editor or loader. Furthermore, the host machine should be powerful enough for fast compilation: waiting half an hour or more for a program to be compiled is tedious and costly.

The loader

Although a WCS unit greatly enhances the programming process, it does need to be supported by a dedicated loader to transfer microcode into the WCS from the disk file. Like the editor and the microassembler, the loader should be well documented and easy to use. In particular, disk and memory data formats should be well explained, and adequate source-program documentation should be provided.

Modification is also significant for the loader. Again, the language the loader itself is written in is important, as is its ability to implement structured, readable programs in a top-down manner. Finally, if the microassembler is equipped with relocation capability, the loader, too, must have it.

Unfortunately, continued software support by the vendor after bugs are discovered or modifications are required is always a headache. The service contract or warranty on the software should be scrutinized carefully before selecting a supplier. The cautious buyer will find out who the vendor's satisfied customers are and talk to them about the service they have received.

Often the purchase of a microassembler software package is done with little thought of future usefulness (inclusion of new bit-slice devices, sequencers, unusual word lengths or depths, and so on). Perhaps this approach is still economically viable, given the added cost of software flexibility, but it will always cost considerably more in the learning of each new microassembler.

Since software always needs modification, it cannot be stressed too strongly that documentation—both manuals and source-code comments—is one of the most important factors in selecting a software package. □

Designer's casebook

Switching converter raises linear regulator's efficiency

by Sadeddin Kulturel
Istanbul, Turkey

The low ripple and fast recovery of a series-pass voltage regulator can be attained at the high efficiency of a switching regulator if both are combined. In this circuit, the performance is achieved by using the switching circuit as a preregulator for the linear element.

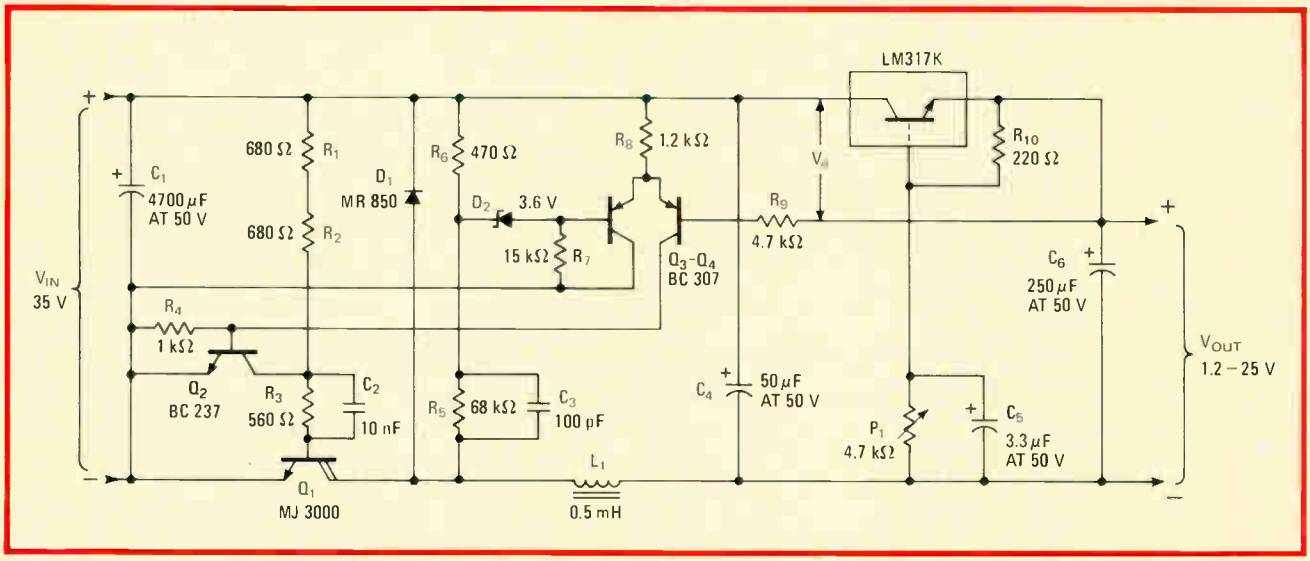
As shown in the illustration of the general circuit, which is designed to transform the 35-volt raw input into a well-regulated output, heat dissipation across the LM317K series element can be reduced if it is made to handle a switched, rather than a continuous, input. Here, the switching regulator is formed by transistors Q_1–Q_4, D_1, and L_1. During power up, Q_1, driven through R_1–R_3, is brought into saturation. Q_2 remains off and Q_3 is turned on.

Switching occurs when V_d equals 3.6 volts, which is D_2's zener voltage. Q_4 then turns on, as does Q_2, and Q_3 is turned off.

As Q_2 turns on, Q_1 switches off, and because of the positive voltage spike created by L_1, load current is momentarily forced through D_1 as V_d decreases. When V_d reaches the lower hysteresis threshold of Q_3 as established by R_5 and R_6, Q_2 and Q_4 turn off, and Q_1 turns on, completing the switching cycle. With the supply's negative path restored, V_d rises until it reaches V_2, and the process is repeated.

The linear regulator can be of any type, including a three-terminal, nonadjustable device. Note that a switching current regulator can be formed if the regulator is replaced by a resistor. In that case, the switching current will be $I_S = V_Z/R$. □

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



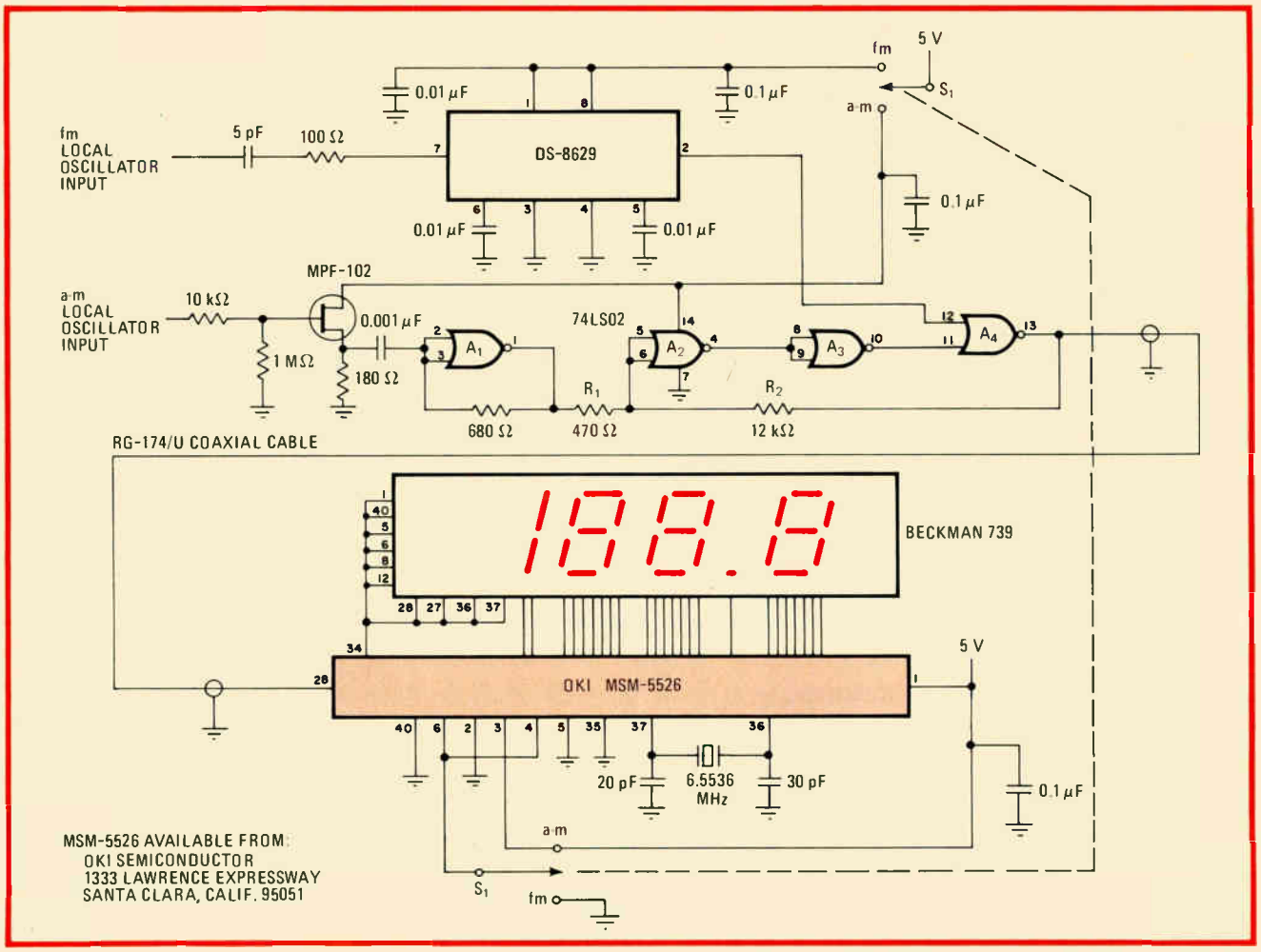
Mixed mode. Switched and linear regulators are combined to form a unit that has the advantages of both—low ripple, fast response, and high efficiency. Here a switched circuit serves as a preregulator for the linear series-pass element, the LM317K.

LSI counter simplifies display for a-m/fm radio

by Gary McClellan
Beckman Instruments Inc., Fullerton, Calif.

The design of a display providing a direct readout of any frequency tuned by an a-m/fm radio is made simple with this circuit, which uses a large-scale integrated counter-driver to determine the frequency of the receiver's local oscillator. The counter is unique in that it contains circuitry that subtracts the receiver's intermediate frequency from the local oscillator frequency in order that the true channel frequency may be found. The combination of this counter, a one-chip prescaler, and a 3½-digit liquid-crystal display makes for a compact and relatively low-cost unit.

The circuit is housed in two separate modules, one containing the preamplifier, prescaler, and logic, and the



I-f compensation. MSI and LSI chips reduce cost and complexity of display for a-m/fm radio. MSM-5526 counter has circuitry for subtracting receiver's i-f frequency (see table) from radio's local oscillator input so that the true channel frequency may be displayed.

other the counter and LCD components. In this way, the first module can be mounted on the receiver's radio frequency assembly (keeping unwanted pickup to a minimum), and the other may be placed at any convenient spot for viewing.

In the a-m mode, signals are applied to the MPF-102 field-effect transistor. The input impedance of this stage is high, and consequently loading of the local oscillator is minimal. A_1 operates in its linear region and thus serves to amplify the local oscillator signal.

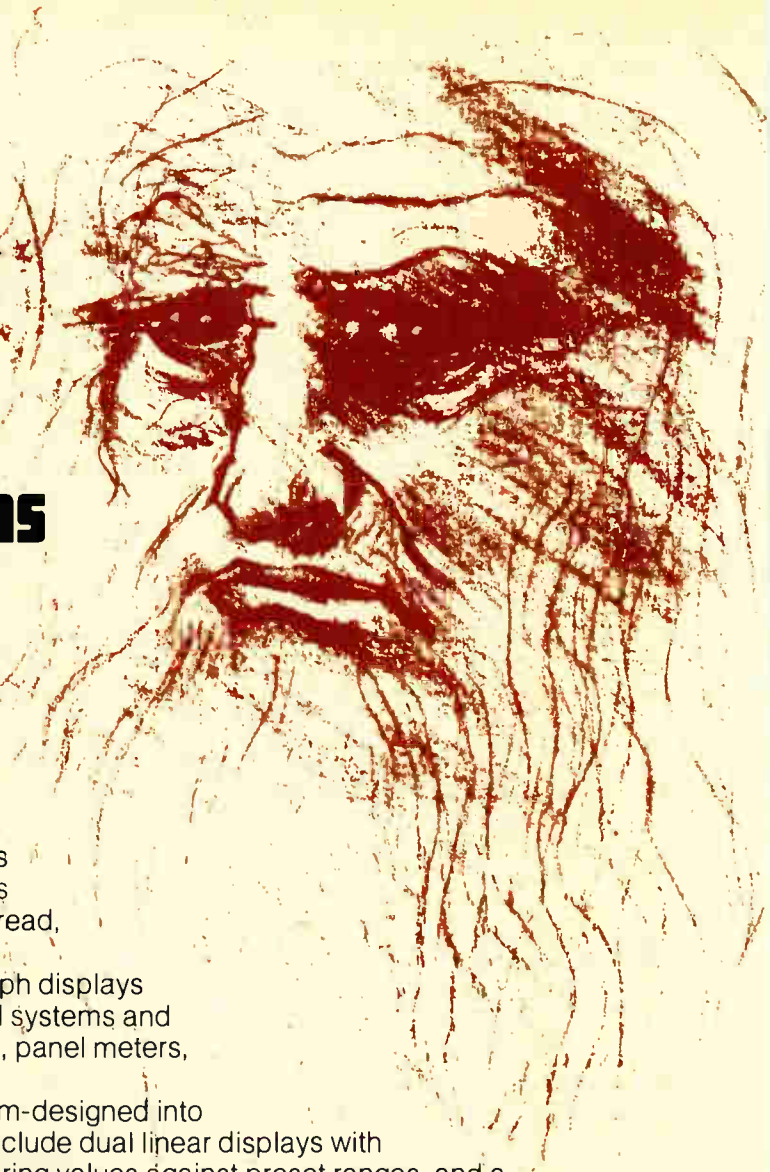
Schmitt trigger A_2–A_4 squares up the signal to transistor-transistor–logic levels, then applies it to the MSM-5526 counter. R_1 and R_2 set the hysteresis of the trigger.

The MSM-5526 contains a read-only memory that may be programmed with any i-f value (see table). Also contained is the subtraction circuitry discussed previously, and the necessary decoders/drivers for presenting the 3½-digit Beckman LCD with the difference frequency in kilohertz. Generally, the local oscillator will always lie above the incoming frequency in the modern a-m receiver, as reflected in the table. The same condition holds true most of the time in fm receivers, but there is a provision for achieving a positive offset if one of the older receivers is being used. Note that if all programmable pins are set at logic 0, an i-f of 455 kHz for a-m

MSM-5526 INTERMEDIATE-FREQUENCY OFFSET

Display mode	Input-pin state				Offset (a-m in kHz, fm in MHz)
	2	3	4	5	
a-m (pin 6 high)	H	H	H	X	−452.5
	L	H	H	X	−454.5
	H	L	H	X	−456.5
	L	L	H	X	−465.5
	H	H	L	X	−467.5
	L	H	L	X	−469.5
fm (pin 6 low)	H	H	H	H	10.68
	L	H	H	H	10.71
	H	L	H	H	10.75
	L	L	H	H	10.79
	H	H	L	H	10.82
	L	H	L	H	−10.58
	H	L	L	H	−10.60
	L	L	L	H	−10.61
	H	H	H	L	−10.62
	L	H	H	L	−10.63
	H	L	H	L	−10.65
	L	L	H	L	−10.66
	H	H	L	L	−10.69
	L	H	L	L	−10.70
	H	L	L	L	−10.72
	L	L	L	L	−10.73

If Leonardo da Vinci designed a visual indicator today... he'd use a Burroughs SELF-SCAN® bar graph display



Leonardo da Vinci would have considered Burroughs SELF-SCAN bar graph displays a designer's dream. These compact, flat panel, gas plasma indicators present instant analog displays with digital accuracy. They're bright and easy-to-read, even in high ambient light.

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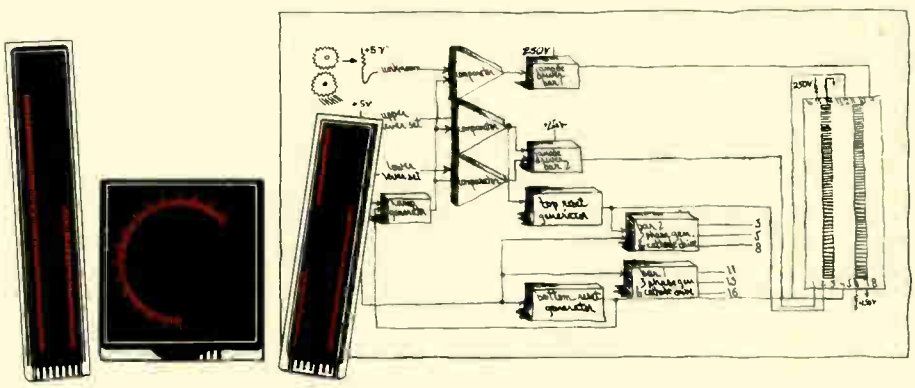


Burroughs

Circle #128 for General Information

Circle #129 for Detailed Specifications

and 10.7 MHz for fm will be subtracted.

In the fm mode, the receiver's local oscillator is applied to the DS-8629 prescaler. This prescaler has high sensitivity, and the local oscillator need only be capable of supplying a minimum of 12 mV at 100 MHz.

The DS-8629 divides the incoming frequency by 100. Then the signal is gated through to the counter via A_4. In this configuration, an i-f equal to 1/100 the fm receiver's nominal value (10.7 MHz) is subtracted from the input frequency to the counter, and the result is displayed in megahertz.

A number of practical considerations must be taken into account when building this display. Specifically, the presence of the prescaler will introduce a typical shift of 500 Hz in the read-out frequency. The error may be eliminated entirely by simple adjustment of the 30-picofarad air-variable trimming capacitor, located at pin 36 of the counter.

The first module should be shielded from the receiver's tuner if noise in the fm mode is to be held to a minimum. Housing the module in an aluminum enclosure will suffice in most cases. And although the liquid-crystal display will tend to generate less noise than many light-emitting-diode displays now available, shielding it may also be necessary in extreme cases.

Both modules should be coupled via a coaxial cable. Otherwise a broadband hiss may be heard when the unit is placed in the a-m mode. □

Balanced modulator chip multiplies three signals

by Henrique Sarmento Malvar
Department of Electrical Engineering, University of Brazilia, Brazil

Three signals can be multiplied by a one-chip double-balanced modulator, a device normally capable of mixing only two. In this case, the third input is introduced at the bias port of Fairchild's μA796, enabling the unit's transconductance to be varied at an audio rate, which effects modulation. Although the technique reduces the bandwidth and dynamic range over which the device can operate, the three-input mixer will still be useful in many applications, notably for generating discrete sidebands and synthesizing music.

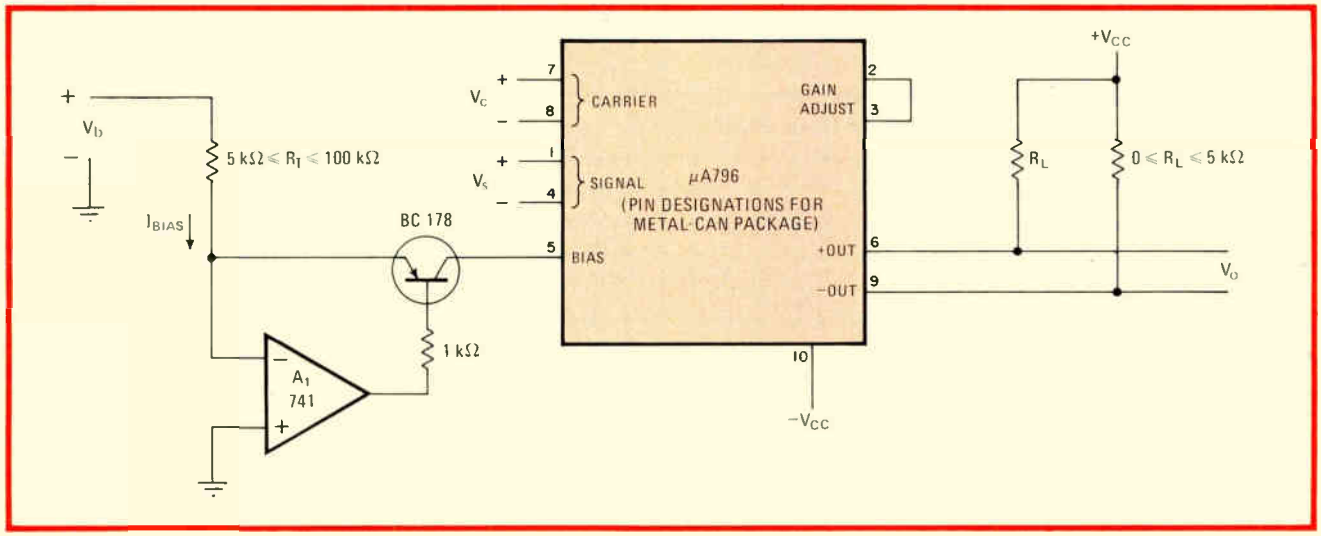
The output voltage from the mixer, V_o, is the product of a carrier switching function, V_c, and a modulated signal, V_s. Because the bias signal, V_b, controls the conductivity of transistors that are effectively in series with the usual modulating signal, it is simply regarded as a second modulating signal such that $V_o = kV_bV_cV_s$, where $k = 0.00064R_L/R_1$ over a small dynamic range and the voltages are in millivolts.

Note that V_c and V_s may be positive or negative but that V_b must always be positive to prevent the reverse-biasing of the internal transistors connected to pin 5. When V_b is negative, A_1 blocks the application of negative voltage by turning off the BC 178 transistor.

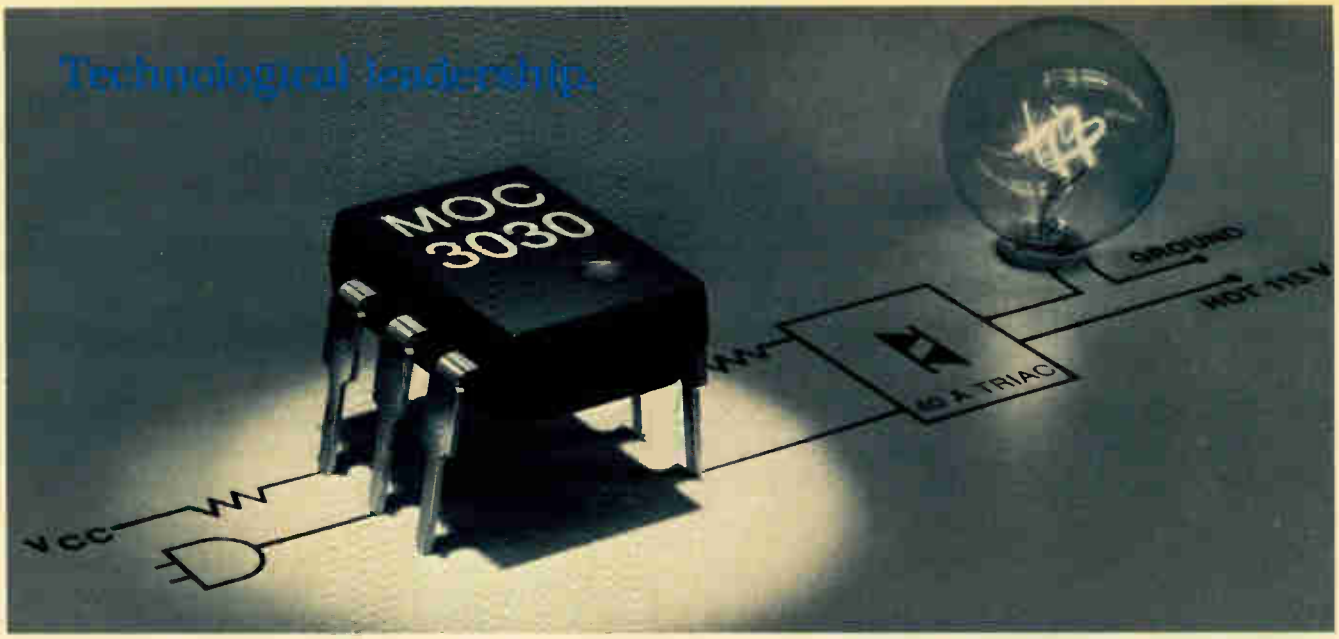
Note also that k will vary nonlinearly with the amplitude of V_c and V_s, and in order to keep k within 1% of its given value, both voltages must not exceed 8 millivolts root mean square. V_b will not affect k if $I_{bias} << 1$ milliampere. Unfortunately, k also is sensitive to temperature changes (−0.67%/°C), and this factor can limit the circuit's effectiveness in high-accuracy applications.

The output frequencies generated by the mixing process will be $|f_c \pm f_s|$, and $|f_c \pm f_s \pm f_b|$, where the f subscripts correspond to their voltage counterparts. There will be no output if any of the driving signals are disconnected.

Signal inputs V_c and V_s may have an f_c or f_s of one megahertz at the maximum. The third input, V_b, will be band-limited to 20 kilohertz, however, because of the relatively poor frequency response of the 741. □



Biased mixer. A balanced modulator can be configured to multiply three signals by introducing the third signal to the bias port. The bias current, which normally sets the dc operating point of device, is varied at an audio rate to effect linear modulation over a small dynamic range.



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Now it's here: the MOC3030, a single-chip bidirectional, optical coupler with full zero-crossing capability and the answer to your AC power control prayers.

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Elimination of electromagnetic interference generated by high inrush currents when Triacs are triggered at near-peak AC voltages is highly desirable where you're designing around sensitive and expensive loads. In the MOC3030 it's done with a pair of on-chip, N-channel enhancement-mode FETs. Whenever applied voltage to the coupler becomes greater than FET threshold, the FETs so decrease Triac gain that the LED photons are unable to turn it on. The Triac driver can therefore be triggered only when line voltage is less than FET V_{GS}, typically 20 V.

The FETs also act as an active snubber network, banishing a passel of passives. No extra parts, no external hookups, no forest primeval of componentry. Connect four leads and that's it.

Better dv/dt for better designs

Superior, 100 V/μs dv/dt is one of the keys to MOC3030 top performance, achieved through ion-implanted resistors. These raise coupler breakdown voltage to 250 V, further reducing sensitivity to false turn-on and EMI and enabling it to drive highly inductive loads whose size is dependent only on Triac capability. Nothing happens in a MOC3030-designed circuit unless you design it in.

Applications unlimited

The most natural use of the '3030 is interfacing logic/MPU to peripheral equipment directly from AC lines . . . CRTs, teleprinters, incandescents, etc. But its simplicity, adaptability and 1,000-up, $1.45 price makes a whole new ballgame possible in traffic light controls, SSRs, electronic scoreboards, home appliances, TV remotes and industrial control and lighting. And you can use it as a plug-in upgrade for existing MOC3011 designs. Naturally, it's tested to 7,500 V peak, a Motorola SOP.

For new data sheets on the MOC3030 and the MAC223 25 A plastic Triac series, another volume-produced Motorola exclusive, write Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036, or circle the reader service number.

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Design and process innovation converge in 1-GHz oscilloscope

Getting the bandwidth to display subnanosecond events without sampling called for unique circuits, connectors, and semiconductor processes

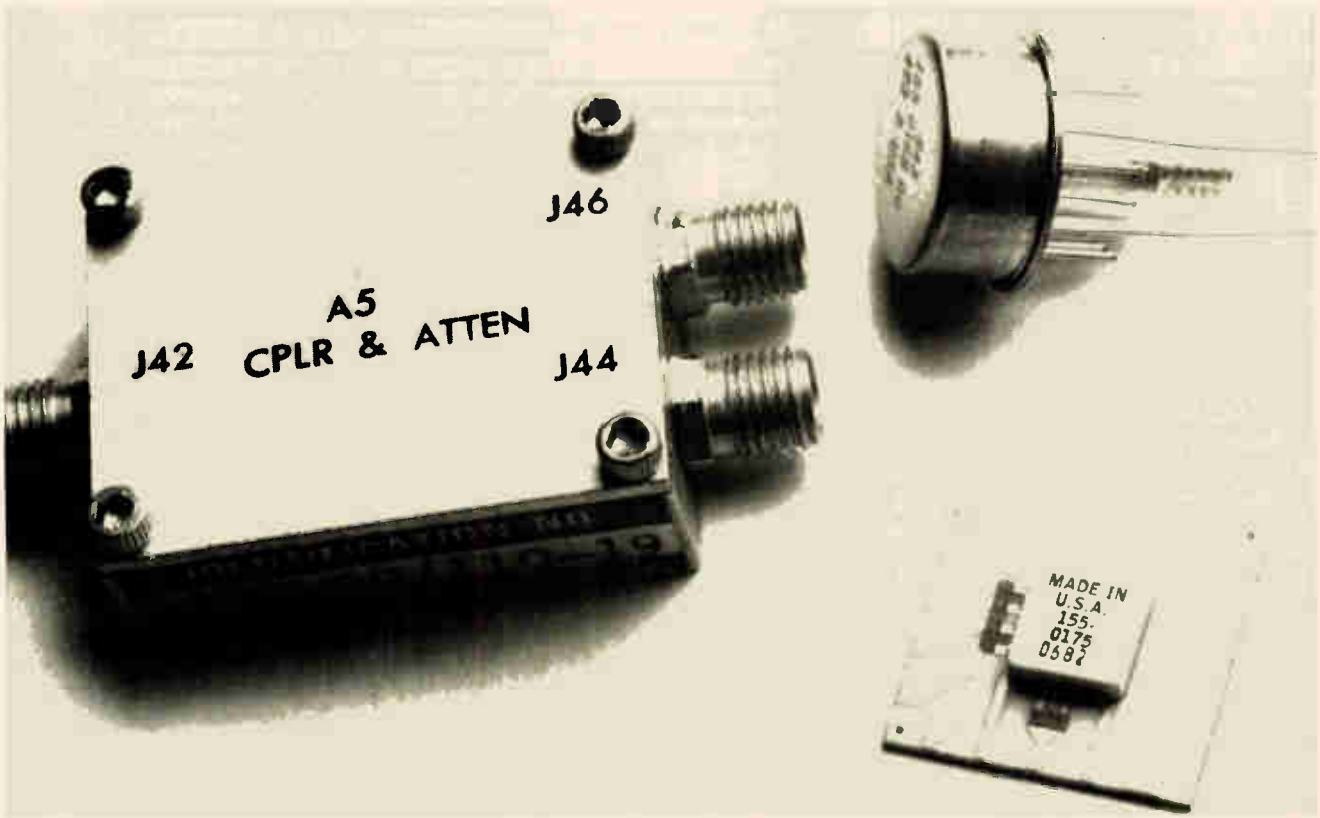
by John Addis, *Tektronix Inc., Beaverton, Ore.*

☐ Extremely high-frequency linear integrated circuits, made with a special monolithic process, packaged as thin-film hybrid devices, and interconnected with a novel high-frequency connection system, are some results of unique design techniques that have made it possible to build the world's first conventional (nonsampling) 1-gigahertz oscilloscope. As a result, the Tektronix 7104 system has a sensitivity of 10 millivolts per division, an input impedance of 50 ohms, and a maximum sweep speed of 200 picoseconds per division.

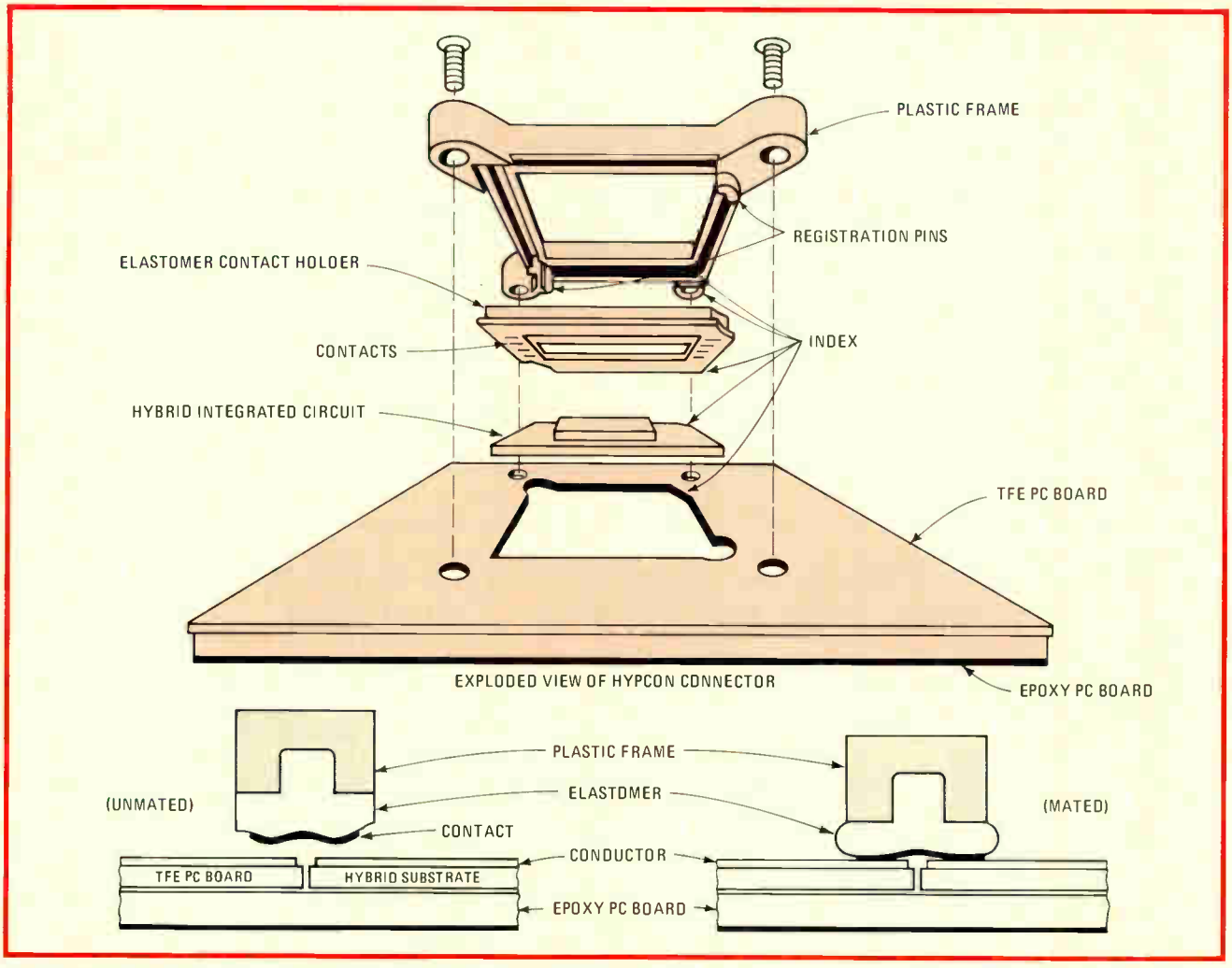
State-of-the-art designs

To achieve the required performance, the 7104 uses three different passive and seven different active hybrids—all state-of-the-art designs. For instance, one single-stage hybrid amplifier (used nine times) has a gain/bandwidth product greater than 12 GHz. The hybrids are connected to printed-circuit boards with a novel, elastomeric high-frequency connector system that allows individual hybrids to be removed and replaced quickly with only a screwdriver.

These innovations solve the problems that Tektronix engineers faced at the start of the project. Perhaps the most obvious lack they had to confront was the fact that none of the then-existing hybrid circuit packages for individual amplifier stages would be suitable at 1 GHz. The commonly used package seen at the left in Fig. 1 is barely adequate for amplifiers with half the bandwidth of the 7104, such as the vertical amplifier of the Tektronix 7904, an earlier 500-megahertz scope.



1. Hybrid packages. At the left is an aluminum box typical of those used in spectrum analyzers and other microwave systems. Upper right is a package typical of those used in the 7904 500-MHz oscilloscope. Below is a new hybrid package basic to the 7104 1-GHz scope.



2. Hybrid connection. A Hypcon consists of a glass-impregnated plastic frame that holds a silicone elastomer onto which are bonded gold contacts. These contacts touch both the hybrid package and the printed-circuit conductors without adding appreciable reactance.

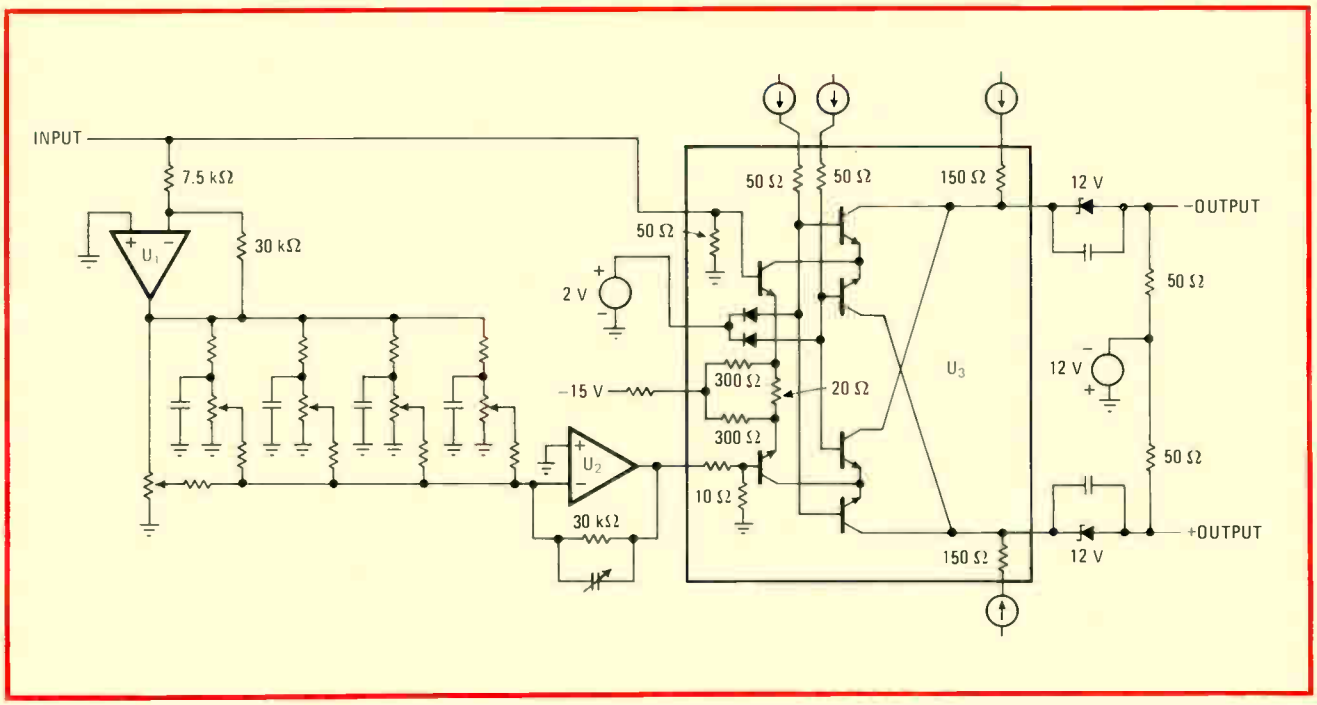
The 1-GHz amplifier requires a rise time of 140 ps. Tests showed that existing sockets produced unacceptable reflections on the transmission lines needed to interconnect amplifiers at this frequency. Other packages used in spectrum analyzers and microwave amplifiers required expensive coaxial-cable connectors. Yet the ability to replace a single high-frequency amplifier without breaking wire bonds or struggling with high-frequency connectors was essential for design ease, calibration, and serviceability. Therefore, a new interconnection technology was needed, as well as new amplifiers.

Another difficulty was achieving the flat transient response so necessary to making a precisely calibrated oscilloscope. The multiple adjustments by which a flat transient response is achieved are usually made with networks connected between the emitters of a common-emitter pair. But in a 1-GHz oscilloscope, lead length from these emitters to a network of six or eight potentiometers would be too long, so an entirely new compensation technique was called for.

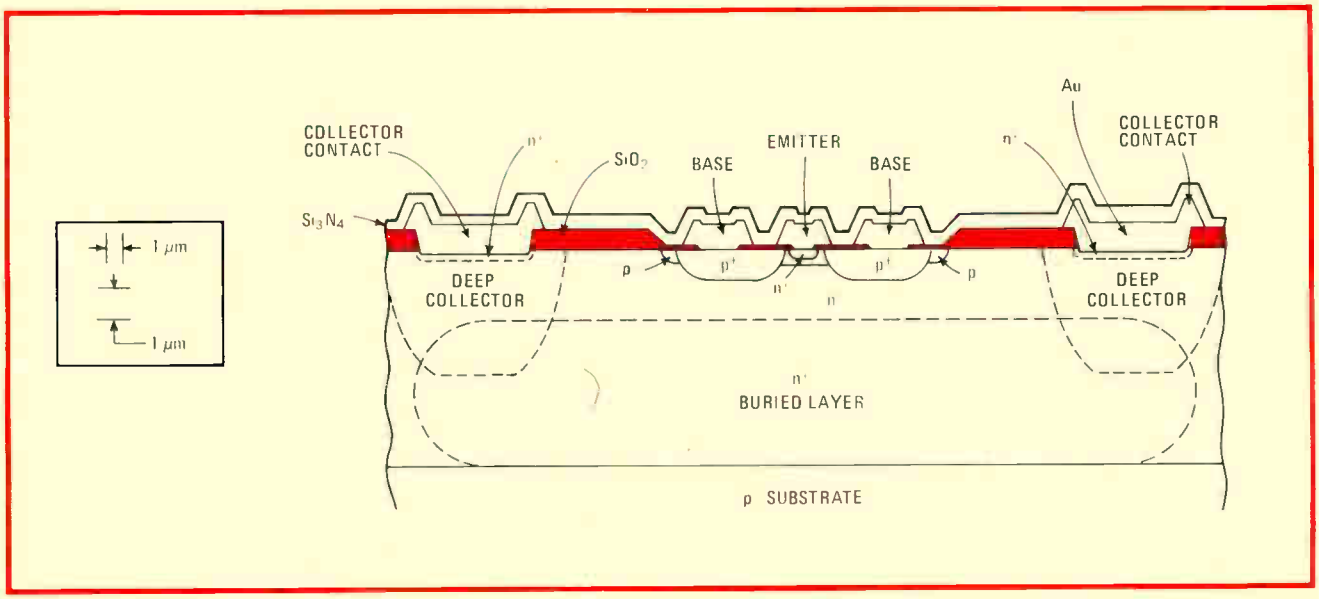
The third, and most fundamental, difficulty was the need for a great deal of high-frequency current gain. Advances in the cathode-ray tube employed in the 7104, such as the image intensifier (micro-channel plate) and a new meshless scan expansion lens, were instrumental in boosting the tube's vertical voltage-deflection sensitivity. The radically new CRT used in this instrument achieves a vertical deflection factor of only 0.9 volt per division, compared with 3.0 V/div for the 7904. So at first glance, doubling bandwidth appears easy. However, the increased CRT bandwidth necessitated lowering the vertical deflection structure impedance from 365 to 200 ohms. Also, it was considered desirable to back-terminate (impedance-match) the amplifier driving the CRT to eliminate the effects of signal reflections from imperfections in the CRTs vertical-deflection structure.

With the back termination, which the 7904 does not have, and the lower impedance, the current gain is actually required to be 10% higher in the 7104 than in the 500-MHz 7904. This current gain requirement in turn determines the necessary transition frequency (F_T) of the transistors. To get the needed current gain at high frequencies, it proved necessary to advance existing IC technology by designing a new IC process.

The complete vertical system includes a plug-in amplifier, the 7A29, that provides about 40% of the amplifica-



3. Feedbeside. In this technique, low-frequency signals are amplified by operational amplifier U_1. Different amounts of this signal are selected by five pots and filtered; this voltage is then amplified by U_2 and subtracted from the wideband input by U_3.



4. SHFIII Geometry. Tektronix SHFIII process, characterized by transistors with a 6.5-GHz transition frequency, produces some of the fastest ICs in production. A 2:1 step-and-repeat aligner projection-prints emitter widths of only 1.7 micrometers.

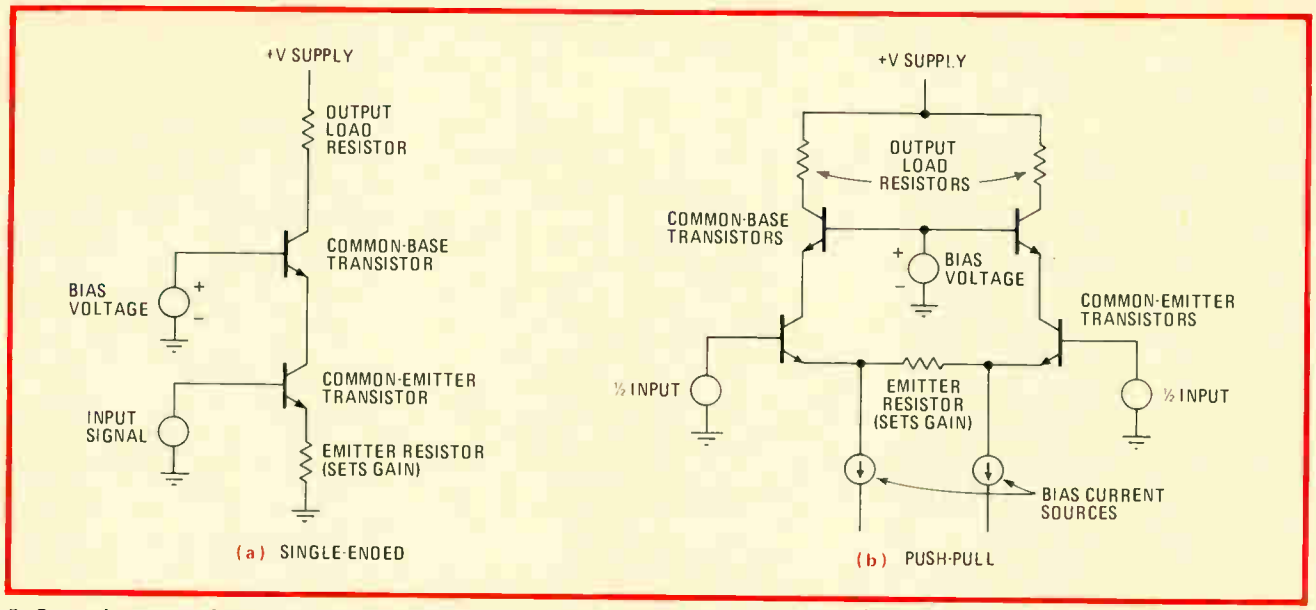
tion necessary to achieve 10-mV-per-division sensitivity. The 7A29 needs a back termination not used in the 7904 system. Overall, therefore, the 7104 system with its 7A29 plug-in vertical amplifier has 2.2 times the current gain of the 7904 system and twice the bandwidth—that is, 4.4 times the gain-bandwidth product.

The connection

Packaging was among the first of the difficulties noted. A typical amplifier stage needed one or more monolithic integrated circuits, conductors, laser-trimmed resistors, and a few small capacitors. The substrate of a thin-film hybrid circuit, to which ICs, nichrome resistors, and conductors can be attached or deposited, makes an ideal package.

Although sapphire is the substrate material commonly used at microwave frequencies, it is both fragile and far more expensive than alumina. Conductors can be easily controlled on alumina to within 25 micrometers (0.001 inch), so that 50-ohm transmission lines can carry signals from the substrate edge to the desired location near the integrated circuit.

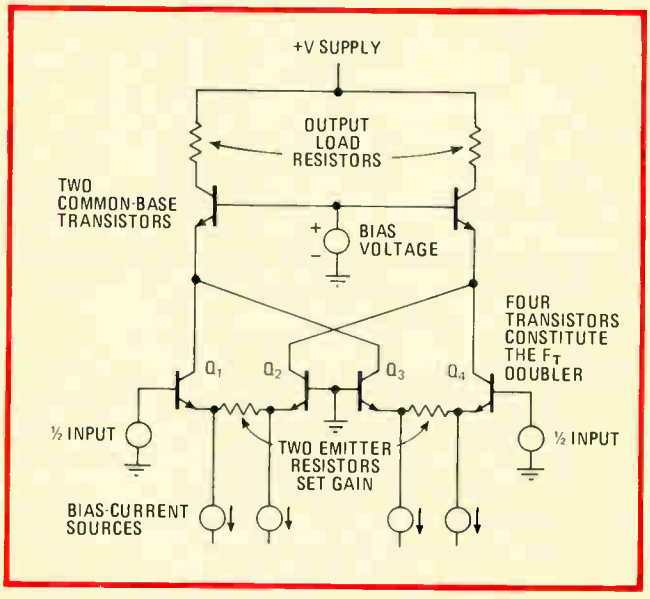
Thin-film nichrome resistors require a very smooth substrate material, and tests indicate that high-grade



5. Cascode connection. Conventional transistor cascode (a) uses a common-emitter transistor driving a common-base transistor. The push-pull cascode (b) has greater immunity to supply variations when dc coupling is required and always has a zero inductance ground.

alumina with a surface finish of 0.05 micrometer (2 microinches) is as good as sapphire. It is less than one tenth as costly as sapphire, and this saving is magnified by another advantage. Alumina is available in large enough sheets to allow the 16 circuit-sized substrates (1.75 centimeters on a side) to be processed simultaneously before being laser-scribed and separated. Two hybrids that require increased power dissipation are fabricated on beryllium oxide in exactly the same fashion. In this way the complete hybrid package became composed of an alumina or beryllium oxide substrate and a protective cover (Fig. 1, bottom right), but that left the problem of interconnecting the hybrids.

Conventional high-frequency packaging puts each substrate in a separate machined aluminum box that acts as a combined shield and cover (Fig. 1, top left and right). External high-frequency signal connections are usually made through subminiature A series connectors to semirigid coaxial cable. However, SMA connectors are both extremely expensive and labor-intensive. Furthermore, the transition from planar to coaxial transmission lines is virtually impossible to make without introducing some signal-reflecting discontinuity. A means of connecting planar circuit-board transmission lines (microstrip) to the hybrid's microstrip transmission lines was evidently needed.



6. Doubling up. The F_T-doubler cascode improves on the standard cascode by replacing the common-emitter pair with the F_T doubler. At F_T, where beta is unity, Q_2 and Q_3 add their collector currents to that of Q_1 and Q_4 for a total beta of 2, hence the name F_T doubler.

The hybrid-to-pc-board connector (Hypcon) shown in Fig. 2 consists of a glass-impregnated plastic frame holding a silicone elastomer that has small gold contacts bonded to it. The gold contacts touch both the hybrid and the circuit board conductors without adding appreciable inductance or capacitance. The reflected discontinuity at the hybrid edge is almost invisible to a 5-GHz time-domain reflectometer and is perhaps an order of magnitude better than an SMA-to-planar transition.

For the cost of a few plastic parts, the Hypcon connector not only makes all high-frequency contacts (typically four) but also all power-supply and control connections. When power dissipation is high, an excellent heat sink is obtained by placing a solid aluminum pedestal between the hybrid and chassis. Yet, with the Hypcon, it takes only minutes to remove and replace any hybrid. With a package and interconnection method decided on, it was now possible to concentrate on circuitry and device problems.

Feedbeside and flatness

A new circuit technique called feedbeside was invented to overcome the difficulty of adjusting the trace for a flat transient response. After very high-frequency effects (reflections), the second most serious source of transient response problems is the inherent thermal sensitivity of the transistor base-emitter junction.

The shortest moments on screen today

Only a few instruments at present are capable of displaying single electrical events at high frequencies. Sampling oscilloscopes have high sensitivity (2 millivolts per division is typical) but by their very nature are incapable of displaying single events. Direct-access oscilloscopes provide high bandwidth by applying signals directly to the deflection plates of the cathode-ray tube. They can therefore display single events but usually suffer from poor sensitivity.

Scan converters also display single events. They use a CRT with an electronic target such as an array of diodes or charge-coupled devices instead of a phosphor for readout. By some means, such as a second electron beam, the target is scanned at a slower rate to retrieve the recorded high-speed information.

In order of decreasing bandwidth these are the fastest instruments capable of observing single electrical events:

- Thomson-CSF of France makes a 4-gigahertz direct-access oscilloscope, the TSN 660, which has a microchannel-plate CRT. Sensitivity is 0.4 volt per division and sweep speed is 70 picoseconds per division.
- Ray Smith and his colleagues at the Lockheed Palo Alto Research Laboratories have modified a Tektronix R7912 scan converter for direct access using a small portion of the diode array target. The LM7912A achieves a sensitivity of 8.2 V full scale with 12-bit resolution and 3.5-GHz bandwidth. The diode array is capable of writing single events at full bandwidth. The instrument is at present available on a prototype basis from LPARL.
- Los Alamos Scientific Laboratories has built a 2.5-GHz direct-access oscilloscope with a slightly modified version of the CRT used in the Tektronix 7104. Sensitivity of this custom-made instrument is about 0.7 V/div.
- B&H Electronics Co. of Chester, N. Y., also modifies the Tektronix R7912 scan converter. Using discrete 15-GHz transistors, B&H has built its own amplifiers for the R7912. The M1000 is essentially hand-built but achieves 1-mV/div sensitivity and 1-GHz bandwidth. The unit has poorer transient response than most oscilloscopes but does have low noise. Since it, too, uses the R7912 diode array target, the writing rate is very high. The cost is about $32,000, including the R7912.
- The Soviets make a 1.2-GHz direct-access oscilloscope with 1-volt-per-cm sensitivity. The C7-10A is not available in the U. S. and is rare even in the USSR.
- The Tektronix 7104 system described in the accompanying article has 1-GHz bandwidth and 10-mV/div sensitivity. It costs about $21,400 with a full complement of plug-ins. Also from Tektronix are the R7912 and 7904, which both can have a 1-GHz or 500-MHz bandwidth when equipped with the appropriate plug-in. Sensitivity is about 4 V/div in the 1-GHz case, 10 mV/div otherwise. The cost is between $9,000 and $26,000. The fastest portable oscilloscope is the 21-lb Tektronix 485 with 350-MHz bandwidth and 5-mV/div sensitivity. Input impedance is switchable between 50 ohms and 1 megohm (with 250-MHz bandwidth). The 485 is priced in the region of $5,700.
- The French company Schlumberger Ltd. markets the 5246, a portable 33-lb, 300-MHz oscilloscope with 50-ohm input impedance and 10-mV/div sensitivity. The 5246 costs about $7,900 in the U. S.
- Hewlett-Packard Co., Palo Alto, Calif., makes a 275-MHz portable oscilloscope with a switchable input impedance of 50 ohms to 1 megohm. Cost of the 1725A is approximately $3,500.
- The author has also seen a 250-MHz Soviet oscilloscope, the C1-75, which has a sensitivity of 10 mV/div and a 50-ohm input impedance, weighs 51 lb, and is apparently not available in the U. S.

A signal current change in a transistor also changes its power dissipation, which in turn causes a temperature change that alters the transistor's base-emitter junction voltage. Unfortunately, the base-emitter junction voltage is in series with the input signal of a common-emitter amplifier, and as the transistor does not distinguish between the real signal input and the thermally generated one, the result is usually an up-to-8% increase in the low-frequency gain. This is unacceptable in an amplifier used in an oscilloscope, where calibration must be accurate over a broad range of frequencies to better than 1%.

Discrete transistor amplifiers show thermal effects from below 1 hertz to approximately 1 MHz unless they use thermal balancing. With this technique, two resistors are added to bias discrete transistors in pairs so as to cancel the thermal effects. However, the high-frequency response is destroyed by these added resistors unless they are bypassed with a capacitor—a capacitor so large that it makes thermal balancing an inappropriate technique for very wideband monolithic amplifiers.

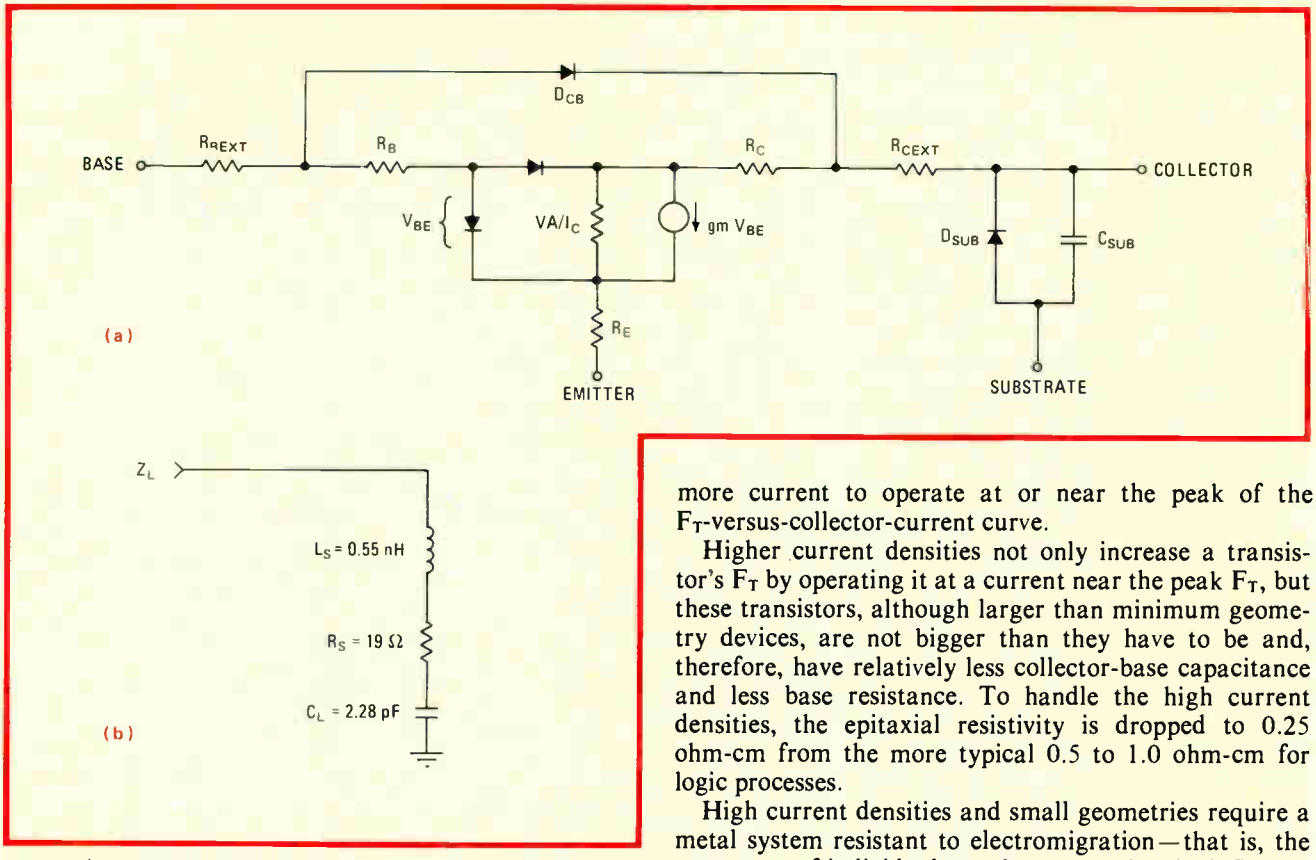
Fortunately, because of their close thermal coupling, monolithic amplifiers suffer much less than discrete versions from thermal effects, rarely showing them below 100 Hz. Their close thermal coupling is the basis for the traditional solution for monolithic amplifiers—namely, to connect six to eight RC networks between the emitters of a common-emitter pair and to select or adjust these networks in order to bring the high-frequency gain up to match the dc gain. All of the compensation circuitry for a multistage amplifier may be put in one stage, if desired, and the results can be quite good. Even a multistage amplifier that has an accumulated thermal error of 10% can be made flat to within approximately 0.5% with five networks.

Another obstacle

One limitation of this traditional solution is the need to boost the gain at all high frequencies to match the dc gain. At some high frequencies it becomes impossible to get the RC networks close enough to the transistor emitters to avoid the effects of lead inductance. The problem is barely manageable with the TO-8 packages in the 500-MHz 7904. For the 1-GHz 7104, a whole new approach was needed.

It was decided to decrease low-frequency gain until it matched high-frequency gain. The advantage of this is that only a low-frequency correction signal is required. And a low-frequency signal may be easily processed with operational amplifiers and high-impedance circuitry.

In this method the input signal is sensed and filtered in



7. Modeled. When the extended bipolar junction transistor model for a typical SHFIII transistor (a) and appropriate parasitic impedances are combined in an F_T-doubler cascode, the simple three-element input impedance model (b) is accurate up to 5 GHz.

a circuit that is separate from the main (broadband) signal path. The filtered voltage becomes a correction signal that is subtracted from the broadband signal so that it will provide a flat transient response.

Because it is neither feedback nor feedforward, this technique came to be called feedbeside. Figure 3 shows one implementation of feedbeside, the 7A29 input stage. Here, the input signal is amplified and then filtered with several adjustable RC networks (lower left); the resulting low-frequency signal is amplified again and then subtracted from the input signal within the hybrid.

Even with feedbeside, the major problem of creating a family of ICs with a large amount of current gain from dc to beyond 1 GHz remained.

Getting up to speed

This particular problem required more work than any other. The solution was to design a reproducible IC process with the highest transition frequency, F_T, possible, model the process, and design the hybrids. Accordingly, Tektronix developed a new high-frequency linear IC process called Super High Frequency III (SHFIII) specifically for the 7104.

Despite their minimum geometry, logic ICs are actually too large, in the sense that they typically operate at voltage and current levels below that for peak F_T in order to minimize power dissipation. But devices built with a linear process such as SHFIII handle more voltage and more current to operate at or near the peak of the F_T-versus-collector-current curve.

Higher current densities not only increase a transistor's F_T by operating it at a current near the peak F_T, but these transistors, although larger than minimum geometry devices, are not bigger than they have to be and, therefore, have relatively less collector-base capacitance and less base resistance. To handle the high current densities, the epitaxial resistivity is dropped to 0.25 ohm-cm from the more typical 0.5 to 1.0 ohm-cm for logic processes.

High current densities and small geometries require a metal system resistant to electromigration—that is, the movement of individual metal atoms under the influence of an electric field (flowing current), which eventually results in an open conductor. Gold was chosen for SHFIII metalization as it is highly resistant to electromigration. Unfortunately, gold dissolves in silicon, so a multilayered metal barrier is placed between the silicon and the gold. The result is an exceptionally stable and readily patterned metal system.

(To go off chip for the moment, gold bonding wires are also used, partly for their ductility and chemical inertness but additionally because use of the same metal for both the IC and bonding wires eliminates the formation of intermetallic compounds that can cause early failure. For many of the same reasons, the hybrid metal system is also best made of gold. Finally, the etched circuit boards and the Hypcon metalizations are made of gold for an electrolysis-free interconnection system, leading one wag to quip about "the all-gold oscilloscope.")

A cross section of the IC is shown in Fig. 4. Shallow, repeatable junctions are essential for intrinsically high F_T, so the base and arsenic-doped emitter are both ion-implanted for superior control of doping profiles.

High-frequency gain strongly depends on keeping emitter lead inductance to a minimum; therefore, an on-chip emitter-gain–setting resistor is essential. However, a diffused resistor is not only difficult to make accurately but has an unacceptably high temperature coefficient. To keep gain stable with temperature and time, a 10-Ω/square nichrome deposition on the IC chip is used for emitter resistors. A parallel nichrome resistor on the hybrid is laser-trimmed to adjust the amplifier's gain to the correct value.

A computer generates all the masks needed for this

monolithic process, and a Canon projection aligner prints the circuit patterns with a 2:1 reduction. This yields emitter widths of only 1.7 μm. Also, SHFIII is built on a 50-ohm-cm substrate, instead of the more usual 10-ohm-cm material, to reduce the effects of parasitic capacitances. With a 6.5-7-GHz F_T, SHFIII is one of the fastest IC processes in production and probably the fastest designed for linear applications.

But making wideband dc amplifiers successfully involves more than developing a fast IC process. It is also necessary to use the process efficiently by choosing an inherently broadband transistor configuration and an optimum peaking network. These two choices are not independent. Some broadband configurations have such ill-defined or complicated input impedances as to prevent design of an efficient peaking network.

Hitting a new peak

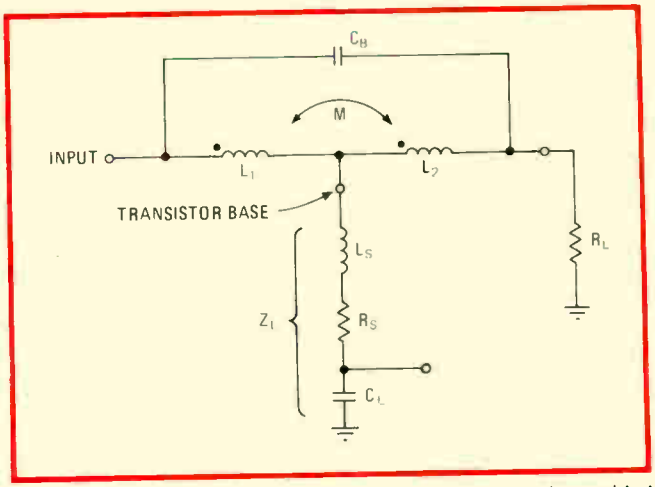
As in the case of the 7904, a transistor configuration known as the F_T-doubler cascode and a peaking network known as the bridged-T coil were chosen. Individually they are highly efficient; they are compatible; and, in the author's opinion, they are unbeatable in combination.

The standard cascode is simply a common-emitter stage followed by a common-base stage. It can be seen in Fig. 5 that low impedance at the emitter of the common-base stage keeps the common-emitter voltage gain low. This in turn prevents Miller multiplication of the common-emitter's collector-base capacitance. The common-base stage passes the signal current to the output and provides voltage gain with practically no high-frequency attenuation. In fact, the judicious use of base and collector lead inductance can improve bandwidth still further.

The F_T-doubler cascode is an advance on the standard cascode. In Fig. 6, the F_T doubler replaces the common-emitter pair. Essentially, it puts two common-emitter stage inputs in series while combining their outputs in parallel. Placing their inputs in series lowers the input capacitance and therefore improves bandwidth. Placing the outputs in parallel adds the collector currents of all four transistors and thus keeps the gain from being halved as a result of putting the inputs in series.

In practice, the F_T-doubler cascode offers an improvement of something closer to 1.5 times, but it is still a way of getting a 10-GHz transistor pair out of a 6.5-GHz IC process. In addition to its high current gain, the F_T-doubler has a very simple input impedance. An SHFIII transistor model for Spice (the Berkeley computer-aided circuit design program) is shown in Fig. 7. When this model and appropriate parasitics such as bond-pad impedances and IC run inductances are put together in an F_T-doubler cascode, the input impedance calculated by Spice is that shown at the top in Fig. 7. A close approximation to this impedance is provided by the simple three-element network also shown in Fig. 7. These three elements form the load for a bridged-T–coil peaking network, and once their values are known, it becomes possible to design the network for the input to the F_T-doubler circuit.

The bridged-T network, shown in Fig. 8, has two advantages as a broadband peaking network. First, for



8. Bridged-T coil. Broadband peaking at reduced cost is provided by this bridged-T network. L_1 and L_2 are mutually coupled inductances and C_B is a bridging capacitor. L_S, R_S, and C_L are the equivalent of the F_T-doubler cascode's input impedance, The voltage developed across C_L is peaked by choosing L_1, L_2, and C_B.

the same overshoot, it provides exactly twice the bandwidth as simple series peaking. Second, it presents an input impedance that is real and equal to the load resistance, R_L, at all frequencies.

The second advantage is at least as important as the first, but it may not be as obvious. If every stage has a real input impedance, then each may be located in a separate package and connected to the others with a transmission line. Because the bridged-T coil is such a good termination, the prior stage need not be back-terminated—and to back-terminate would halve precious current gain.

Specified peaking

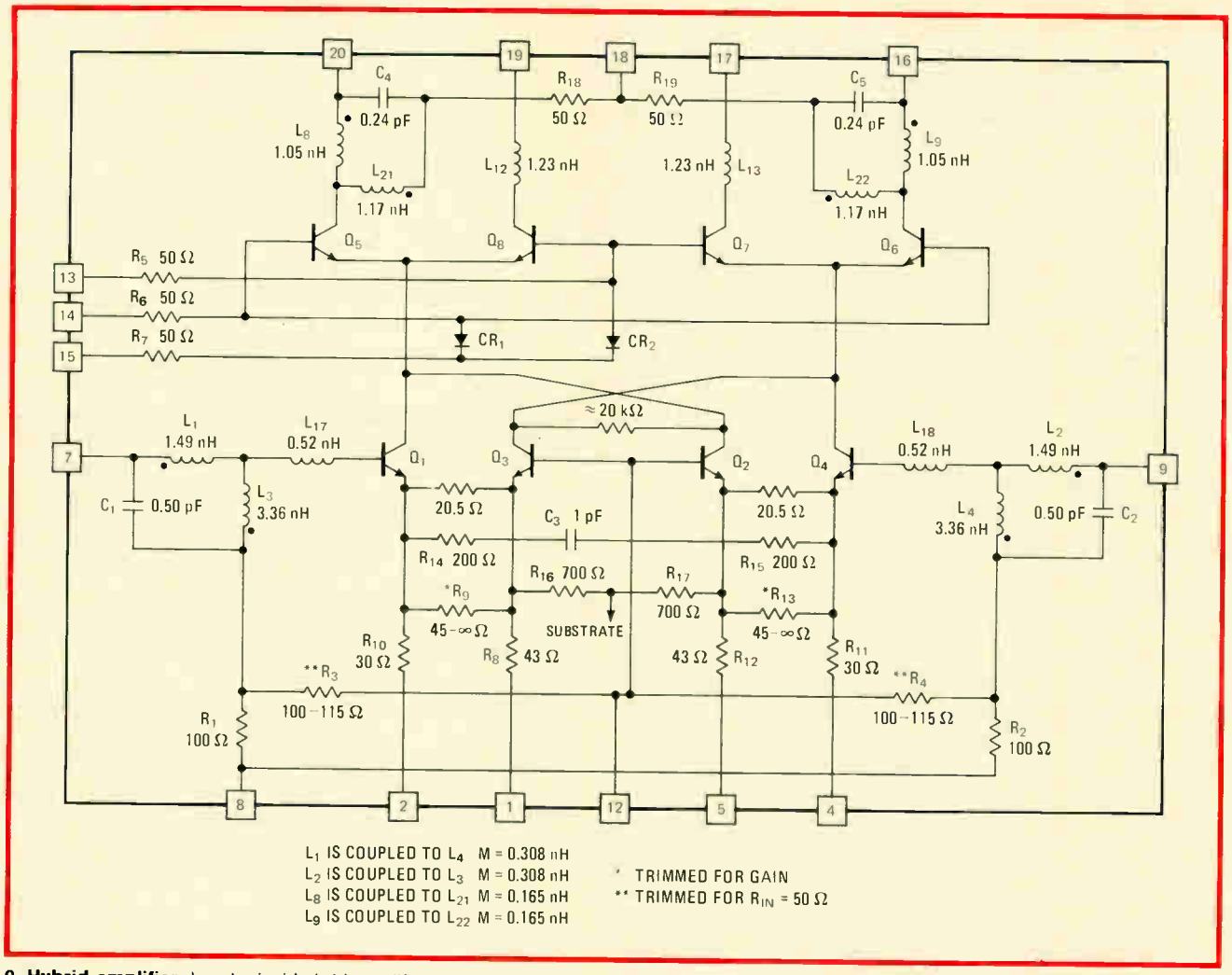
From the three-element input impedance, it is possible to calculate all four components (L_1, L_2, M, and C_B) of a bridged-T coil using formulas calculated by Robert I. Ross of Tektronix in 1969. The exact amount of peaking (i. e. pole location) desired may also be specified as a fourth input variable.

Once the T-coil values had been calculated, it was still a problem to realize them. The inductances were obtained in two different ways, depending upon the particular hybrid. Wink Gross of Tektronix wrote programs to calculate the self- and mutual inductances of both multisegment bond wires and multiturn spirals. Directional coupler effects make high mutual inductances harder to obtain with straight bond wires than with spirals. However, the higher mutual inductance of multiturn spirals can be nullified in some configurations by the bond wire needed to connect the spiral to the IC.

Bridged capacitance C_B was attained with an interdigitated structure of 25-μm-wide lines and spaces on the hybrid substrate. The multiturn spiral and the bond-wire methods are similar to the input T-coil in result.

A high-frequency hybrid

One hybrid amplifier is used nine times in a typical 7104 system and has some features worth mentioning in detail. Figure 9 shows the schematic diagram for this versatile amplifier and a drawing of the layout. There



9. Hybrid amplifier. In a typical hybrid amplifier used on the 7104 (a), pins 7 and 9 are the inputs to the amplifier from the bridged-T coil network. The circuit has a 12.6-GHz gain-bandwidth product that is exceptional in a single-stage amplifier.

are actually three usable signal outputs (all signal processing is push/pull, so that each input and each output consists of a pair of transmission lines).

Referring to the schematic, the output from pins 17 and 19 is selected by biasing pin 13 positive with respect to pin 14. In this biasing configuration the gain into a 50-ohm (per side) load is 4.6 or 13.25 decibels. The amplifier rise time is typically 145 ps in a 70-ps measuring system with very little overshoot or ringing; this gives a calculated rise time of 127 ps and a bandwidth of 2.75 GHz. The 12.6-GHz gain-bandwidth product is exceptional for a single-stage silicon amplifier.

By way of comparison, the 7904 amplifiers attain rise times of 300 ps to 400 ps with essentially the same gain. A single-stage gallium-arsenide amplifier that was reported in the literature last year had 3.0-GHz bandwidth and a gain of 12 dB but was unable to attain that gain when operated into a 50-ohm load.

By biasing pin 14 positive with respect to pin 13, output may be obtained from pins 16 and 20. The gain from this output is only 2.3 (7.25 dB). Using a second T coil in this output gives a virtually perfect 50-ohm output impedance or back termination with only a 10-ps loss in rise time. This output is used when a clean transmission line to the next stage cannot be relied upon (for example, to drive the plug-in-to-mainframe interface).

The third output is available at pins 2 and 4. This output has a gain of 0.5 and is not reverse-terminated very well, yet it is useful as a signal pickoff and has a bandwidth in excess of 3 GHz. Normally, pins 2 and 4 are terminated outside the hybrid in 50 ohms and then tied to a negative power supply along with pins 2 and 5.

The self-biasing scheme for the F_T-doubler cascode using part of the input termination, R_3 and R_4, makes the amplifier no harder to bias than a common emitter pair. A fourth output, the average dc common-mode input voltage, is available at pin 12. This voltage may be used to establish bias on a previous stage, but no external connection is needed at this terminal.

All control-base leads (pins 13, 14, and 15) are buffered on the hybrid with 50 ohms. This eliminates the most common source of oscillations associated with cascodes: common-mode capacitance at the common-base stage's base. Thus, even during the development program, this amplifier never oscillated.

Patents for feedbeside, the F_T-doubler circuit, and the Hypcon connector have either been granted to Tektronix or are still pending. □

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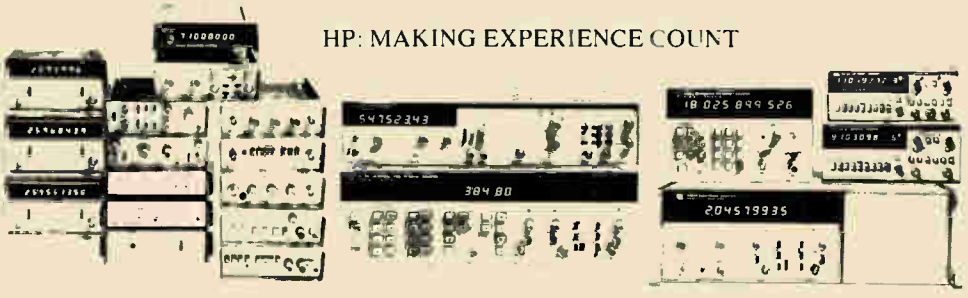


Circle 139 on reader service card

One-chip controller simplifies switched-mode supplies

by Robert C. Frostholm, *Signetics Corp., Sunnyvale, Calif.*

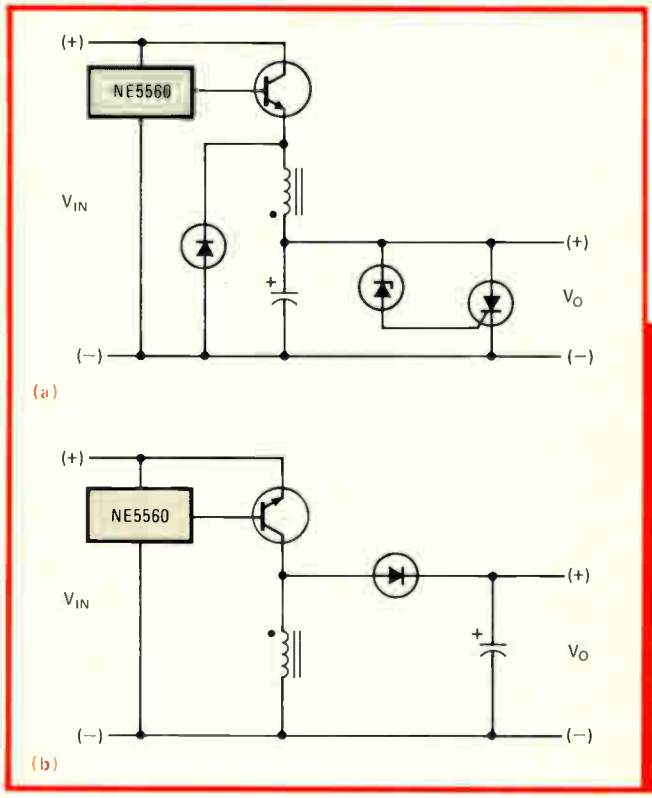
☐ Over the past few years industrial users of high-power regulators have been in search of effective energy-conversion techniques, and this has speeded the evolution from the conventional linear series-pass regulator to the more efficient switching regulator. But work to improve the switching regulator has so far been slowed by the inability of existing technology to integrate the necessary additional housekeeping—or control—and protection circuits on one chip. Recent developments have added to the switcher's other advantages, however, and it will be smaller, lighter, still more efficient, and less expensive now that one-chip controllers like the Signetics NE5560 discussed here are available.

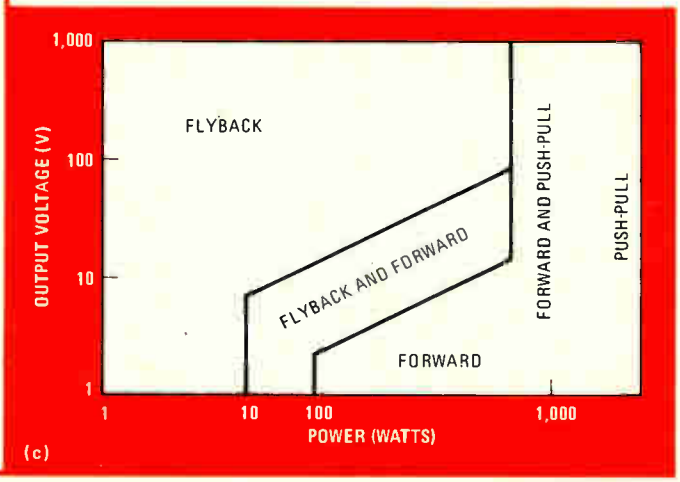
Series and shunt-pass, or linear, regulators using integrated circuits have been available for almost a decade. In both types, a dc output voltage is sensed and then compared to an internal reference. The resulting error voltage is amplified and used to control the internal resistance of the active-pass element, thus keeping the output voltage constant despite changes in line voltage and load current.

The major disadvantage of the linear regulator is that large amounts of energy are wasted. This is caused by the high currents that flow through the series resistance of the active device and the series-sensing resistance. The energy is radiated as heat, so the pass element often requires expensive heat sinks.

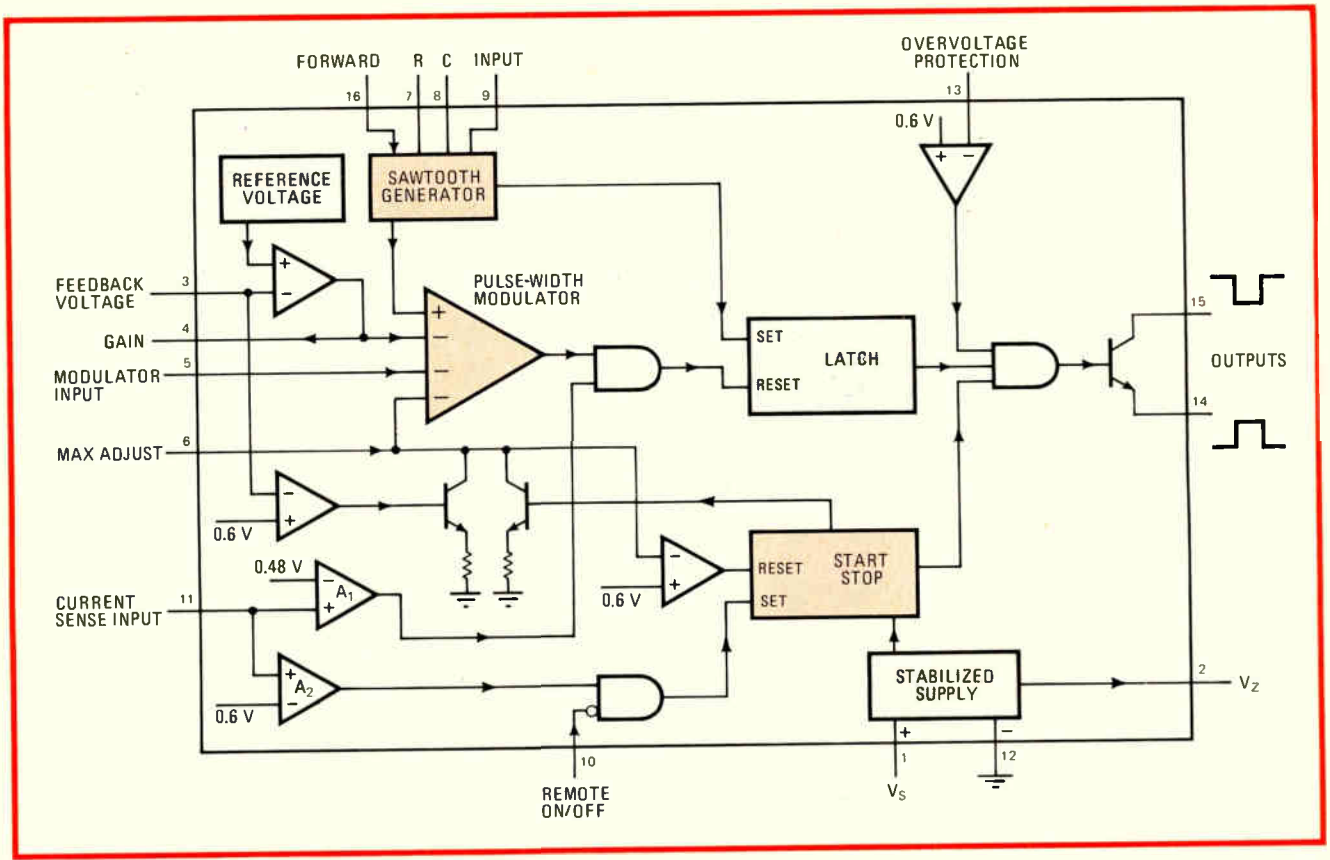
Cooler approach

The switching-mode type of regulator, on the other hand, is a dc-dc converter that operates at a high efficiency. The input dc voltage is applied to a chopper that generally works at 20 kilohertz or above, to minimize the size of the circuit's inductive elements. The chopped dc is then transformed into a higher or lower voltage, whichever is required, and rectified and filtered with the aid of the regulator's control circuitry. The controller senses the output voltage and, to keep it constant, adjusts the duty cycle of the chopper's switching transistor as needed. But the primary disadvantage of the switching converter is that it requires a greater





1. Switching family. Switching regulators may be of the forward (a) or flyback (b) type, or logical extensions of them. All may be driven by the NE5560 one-chip controller. A design guide (c) sets general voltage-power limits within which each converter is most efficient and that are therefore recommended.



2. Squeezing functions. NE5560 controller provides regulator's switching transistor with frequency-stable output signal having adjustable duty cycle. Maximum duty cycle is programmable. Also included are overload protection, automatic startup after cause for overload is removed, and microprocessor-compatible port for sequential or individual startup of supplies in multiple-output arrangement.

number of components than its linear counterpart does.

The NE5560 is designed to drive the switching transistor in either of the two basic switching configurations—the forward (series) converter or the flyback (parallel) converter. In both types (Fig. 1), a choke is used for energy storage.

Flyback and forward

In the forward converter (a), the choke is connected in series with the load. Thus energy is transferred to the load and coil while the chopper is on. In the flyback converter (b), the coil is connected in parallel with the load. Energy is stored in the coil during the chopper's on period and transferred to the load during its off period.

The advantages of the forward converter include switching that is limited to the on period, a peak collector-emitter voltage (V_{ce}) that can be no greater than the dc input voltage, a smaller choke than its flyback counterpart, and a smaller output ripple current. The disadvantages include difficulty in achieving isolation and the possibility that full input voltage may appear across the load if a switching transistor shorts. A selection guide outlining the general limits within which each is most efficient is shown in (c) for both types of converters and their offshoots.

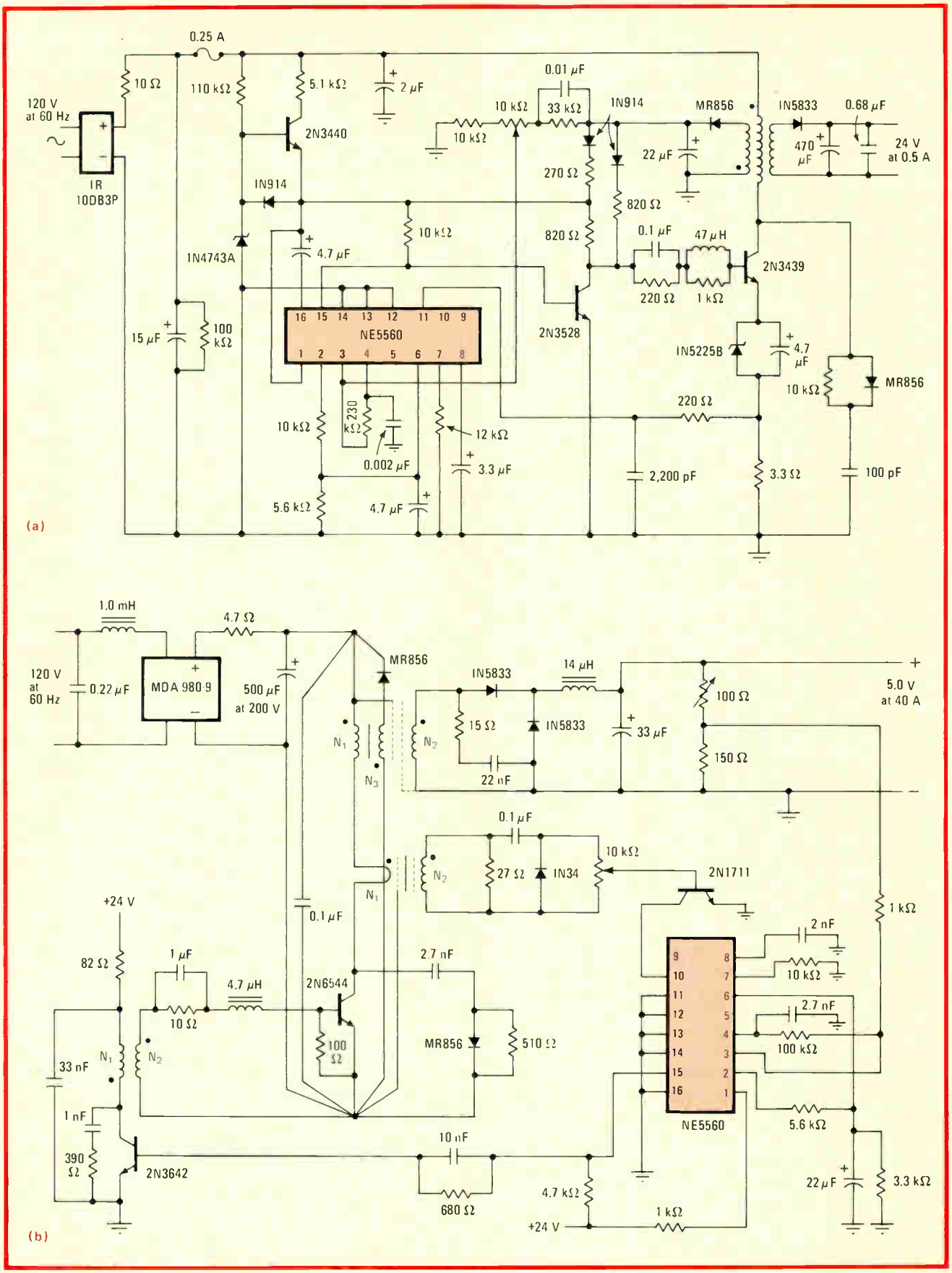
The output stage of the NE5560 monolithic controller (Fig. 2) provides a minimum current of 40 milliamperes for driving the switching transistor of either type of regulator. Not only does the controller deliver a frequency-stable output signal at an adjustable duty cycle, it also prevents overloading, initiates automatic starting when the fault causing the overload is removed, and can be controlled remotely.

The unit's sawtooth oscillator is programmed by a single RC network. The oscillator can be varied over 50 hertz to 100 kilohertz at a duty cycle of 0 to 98%.

During normal operation, the output of the generator (of which the oscillator is one part) and a pulse-width modulator set and reset the output latch, respectively. Thus the duration of the pulse appearing at the output of the single-ended, open-collector stage at pins 14 and 15 may be controlled by applying suitable driving signals to the modulator. An external synchronization port, pin 9, will override the setting of the latch, if desired. Under these conditions, the synchronizing frequency must be lower than the free-running frequency of the sawtooth generator.

Limiting pulse width

A duty cycle of 50% is considered the maximum for switchers operating in the forward-converter configuration, and provision has been made to limit it as desired. The adjusting port (pin 6), in conjunction with the V_Z output of the controller, can be used to set the maximum. Note that the modulation input (pin 5) to the pulse-width modulator affects the duty cycle in much the same way, although it has no influence on the operation of the start/stop fault circuits. Different stages in the



3. Implementation. In typical applications, NE5560 serves as controller for low-power flyback converter (a) or high-power forward converter (b). The size, cost, and number of interconnections in these already complex units are drastically reduced by the one-chip controller.

Small but competitive controller market grows

Switched-mode controllers have been available since late 1976, when Silicon General released the SG1524, and many companies now vie for a share of the market. Exar, Fairchild, Hitachi, National, Signetics, and Texas Instruments manufacture pin-compatible equivalents of the device, now called the 3524. Silicon General has two improved versions (3525 and 3526), both of which have soft-start and adjustable dead-time capability. Motorola's 3520 (no relation to SG's 3524), introduced in 1977, has no error amplifier on chip and the emitters of its output transistors are inaccessible. This limits the circuit configurations to which it may be applied, but the duty cycle can be varied over the entire 0–100% range. TI's competitive entry, the 494, is also available, and has many of the features of the controllers previously discussed. This controller is second-sourced by Motorola. Motorola also makes the 3521, which is equivalent to the 494. Ferranti (ZN1066) and Plessey (SL442) are also in the field.

The availability of an adjustable oscillator and an internal voltage reference are standard controller features, but other items—such as on-chip protection against double-pulsing of a given output during transient conditions—vary from device to device (see table of the more popular controllers).

-Vincent Biancomano

SWITCHED-MODE CONTROLLER CHARACTERISTICS

	Output configuration	Accessible emitter and collector output leads	On-chip error op amp	On-chip overvoltage or overcurrent sense op amps	Double-pulse protection	On-chip soft-start stage	Inhibit/slaving	Current-limited output stage	Dead-time adjustment range
494	push-pull	yes	yes	yes	yes	no	yes	no	0–45% each output
3520	push-pull	collectors only	no	no	yes	no	yes	no	0–50% each output
3524	push-pull	yes	yes	yes	no	no	yes	no	not available
5560	single-ended	yes	yes	yes	no	yes	yes	yes	0–98%

NE5560 provide compensation for variations that occur in the line voltage, provide protection from overload, and generate a startup sequence as soon as the overload condition has been removed.

The feed-forward port (pin 16) is instrumental in minimizing output variations due to changes in line voltage. If a control voltage applied to pin 16 should exceed V_Z, the charging current for the timing capacitor on pin 8 is increases. The larger the voltage on pin 16, the larger the charging current and consequently the shorter the duty cycle. Thus the output voltage tends to remain constant.

Sensitive

A pair of comparators, A_1 and A_2, monitors the output current with an external sensing resistor. When the voltage on pin 11 exceeds 480 millivolts, the pulse-width modulator circuit shuts down, reducing the duty cycle for one period. If the condition persists, the process is repeated. However, as the duty cycle becomes smaller, the storage time of the regulator's power transistor becomes a factor; consequently, the current may increase until the voltage at pin 11 exceeds 600 mV. A_2 then comes into play and completely shuts off the pulse modulator via the start/stop circuit.

The start/stop circuit initiates a soft-start action when the fault condition is corrected to bring the circuit back up gradually. When the 600-millivolt comparator, A_2, toggles, an external capacitor normally connected to pin 6 discharges through an internal 100-Ω resistor. As the voltage on pin 6 drops to 600 mV, the stop circuit resets, allowing the soft-start action to begin.

During soft start, the external capacitor begins to charge to V_Z via a resistor divider normally connected to pin 2. As the capacitor charges, the voltage on pin 6 increases. This increase is detected by the pulse-width modulator, which begins to provide pulses to the output, but with a greatly reduced duty cycle. The duty cycle increases gradually as the voltage on pin 6 increases, until normal operation is restored.

Microprocessor-compatible

A remote-control port (pin 10) enables sequential or individual power-up and power-down of systems containing multiple switchers. The remote-command pin is compatible with transistor-transistor logic, as are all the other input pins. When left floating or tied to a voltage greater than 2 V, the IC functions normally. When pulled below 0.8 V, the output of the NE5560 will be inhibited.

The NE5560 is readily integrated into forward and flyback converters. Despite the complexity of these circuits, a minimum of external components is required for the controller.

In Fig. 3a, a flyback converter using the NE5560 transforms a 120-V, 60-Hz input to a 24-V, ½-ampere dc output. Feedback and current-sensing signals (pins 3 and 11, respectively) are derived from the various output stages in the power-transistor chain. Remote on/off commands, sync, and overvoltage protection may be easily implemented, but to keep the number of interconnections in an already crowded schematic to a minimum, the required wiring is not shown here.

The forward converter in Fig. 3b delivers low voltage at high current and so is useful in applications where a great deal of logic must be driven. Although the regulator is still complex, the number of its interconnections and its cost are both substantially decreased by the use of the one-chip controller. □

Avoiding latchup in foldback current supplies

by Karl Karash
GenRad Inc., Test Systems Division, Concord, Mass.

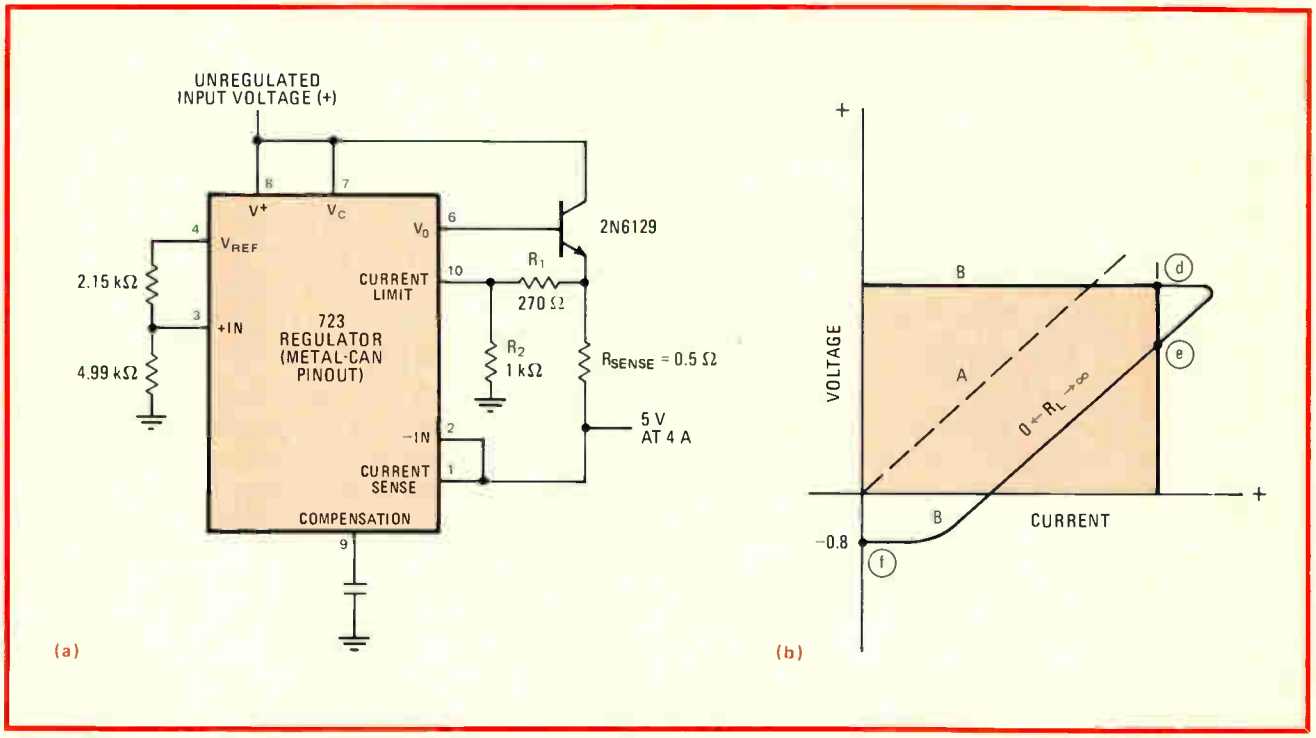
Most open-frame power supplies operate with a foldback-current–limiting circuit, which holds output power within limits as a function of the load. But if these regulators are used in a multiple output-voltage scheme, start-up and latch-up problems often occur because the user fails to examine the current-load characteristics of the supplies. When these are considered in view of the general guidelines presented here, the difficulties may be overcome.

In order to understand the origin of start-up and latch-up problems, observe the standard current-foldback regulator circuit shown in (a). The typical volt-ampere characteristics of this regulator are shown in curves A and B in (b). Note that the load current is held to some maximum value that depends on the load, decreasing as the value of the load decreases. When the supply is operated over curve B, its power dissipation is held equal to or less than the maximum normal power dissipation—indicating that the regulator is protected by virtue of foldback-current limiting.

If the load is a resistor (curve A), there is no problem in delivering power at any specified voltage. However, loads that appear to the regulator to be a current source (vertical line d-e), such as linear integrated circuits, have two operating states (points d and e) where the output current is identical for two different output voltages. This is due to the supply's foldback characteristic.

Thus, if the power supply assumes either state during a power-up with the current-source load, it will remain there. And if the regulator is in a multiple-supply configuration that makes no provision for turning on all supplies simultaneously, one or more regulators may be back-biased and will assume the state at point f permanently. This problem will occur with multiple inductor-type converters that are operating from one main transformer-type inverter. If the load should source the current from the main positive supply into a negative supply on power-up, the negative supply will be forced into the back-biased condition and may not start.

To avoid the start-up or latch-up condition, it is necessary to force the regulator into the straight current-limiting region (shaded area) on power-up. It is not easy or inexpensive to turn on all regulators simultaneously, especially after a momentary power outage, so a given regulator must be made to see a load with a defined resistive component. Adding a time constant to the foldback-determining components, however, will allow its



Boxed in. Typical supply (a) with foldback-limited characteristic (b) is subject to numerous startup difficulties that cause it to regulate at undesired voltage or not at all when used in a multiple output voltage scheme or with current-source loads. The trick is to bring regulator's characteristic within straight current-limit region (shaded area) on power-up, so operating point will be at other than d, e, or f.

transient turn-on characteristic to approach straight current limiting.

Straight current limiting can also be specified in the design. The latter is not usually done, because the current maximum will be independent of the load resistance. Consequently, a short circuit will, on the average, quadruple the normal maximum power dissipation in a typical 15-v supply, so the supply must be able to handle the increased requirement. Thus the cost, weight, and volume of an already expensive, heavy, and large supply must be increased by a considerable factor.

A simple way to approach straight current limiting with a small foldback-current supply, while avoiding the increased power dissipation caused by a short circuit, is to defeat its current-limiting characteristic and to provide external protection at the output with a 4-ampere fuse. Here, shorting pins 1 and 10 eliminates the circuit's ability to limit current on its own.

A reverse-biased Schottky diode such as the 1N5821 should be placed across the output as insurance against back-biasing of the supply. This is true whether or not the supply's current-limiting feature is used. □

Board continuity tester senses only dead shorts

by Andrew R. Morris
The Boeing Co., Wichita, Kan.

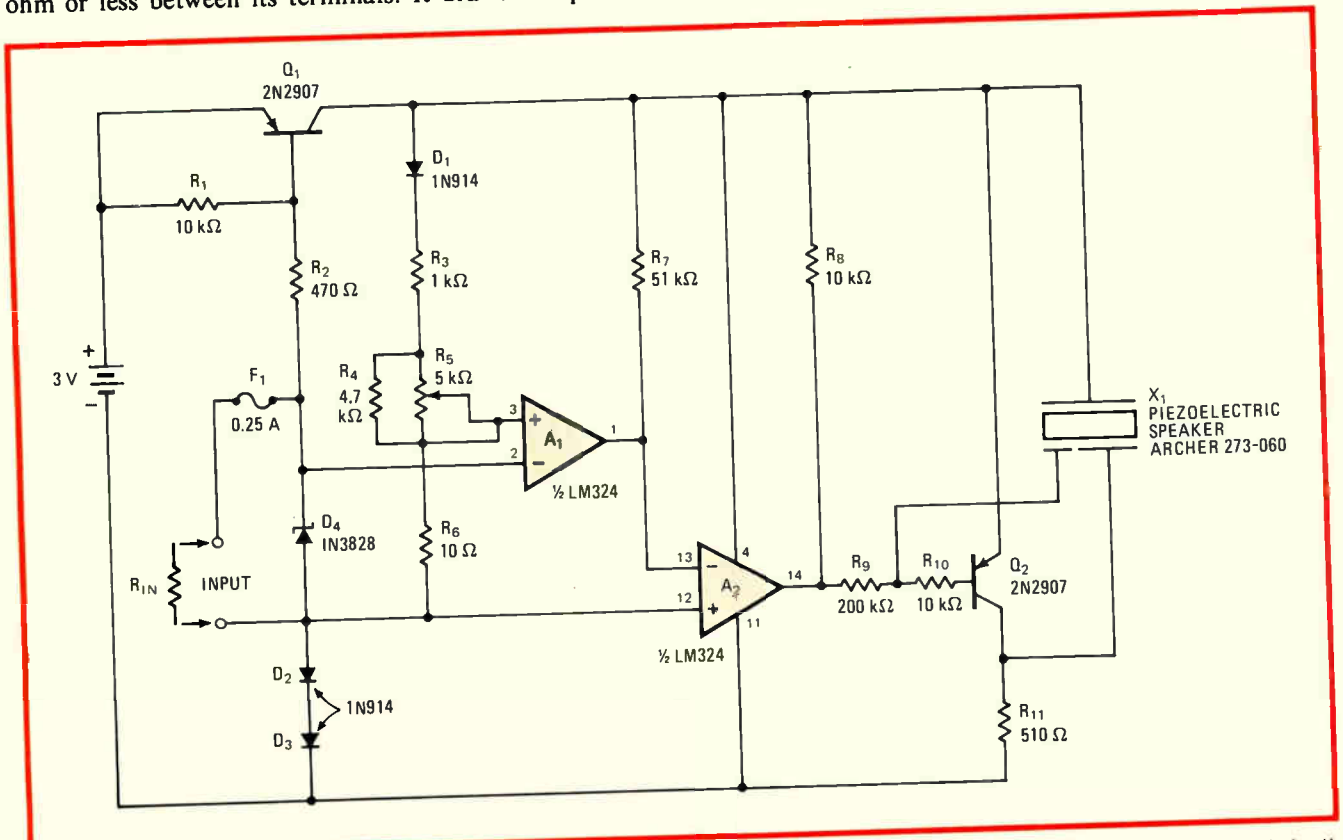
The average continuity tester is of limited usefulness in checking boards with a full complement of integrated circuits. The unit cannot differentiate between the true continuity of two test points and the low resistance (typically 5 to 20 ohms) of internal parts of any IC that may shunt the test points. In contrast, this tester triggers its audio oscillator when it detects a resistance of one ohm or less between its terminals. It draws low power, too—typically 100 nanoamperes in the standby mode and 5 milliamperes maximum.

When a resistance of 1 kilohm or less is placed across the tester's input, Q_1 turns on and applies power to the unit. Comparator A_1 and resistance bridge R_2–R_6 then determine if the resistance across the input is 1 ohm or less, taking the 2.5-ohm resistance of fuse F_1 into account. Assuming the probe is not placed across a coil winding or resistor having a resistance of 1 ohm or less, the tester will provide accurate indications.

F_1 and D_4 protect the tester from voltages that may be inadvertently applied. D_1 compensates for the base-to-emitter drop of Q_1, in order to minimize bridge imbalance caused by variations in battery voltage.

A_1 moves high if $R_{in} \leq 1$ ohm. A_2 provides gain for oscillator X_1–Q_2, which works at 4 kilohertz.

Transducer X_1 is a modified piezoelectric buzzer, the



Zeroing in. Bridge R_2–R_6 and comparator A_1 detect if R_{in} is 1 ohm or below, thus performing test for true continuity (virtual dead short) between two test points on IC-filled circuit boards. Modified transducer X_1 and transistor Q_2 comprise 4-kHz audio-output indicator.

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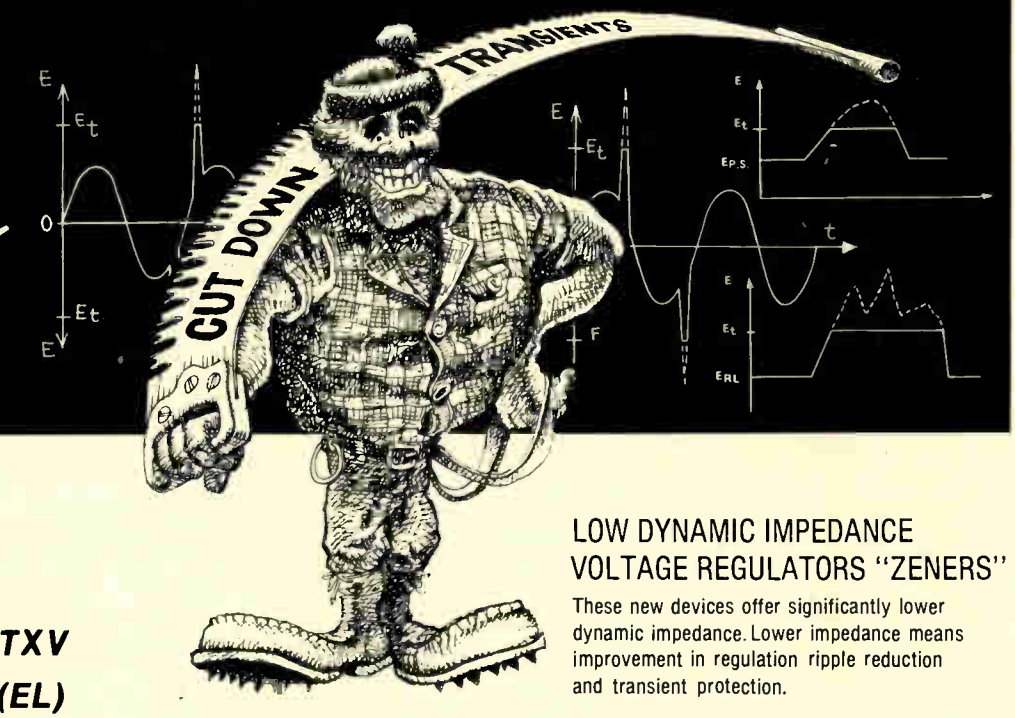

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Temperature Coefficient of (VBR): .05 to.11%/°C
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Peak Surge Voltage (Vsm): 11.0 to 286.0V
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Archer 273-060: The transducer is removed from its original casing, mounted in the tester, and driven by a transistor, Q_2, in order to minimize size and power consumption in the oscillator circuit. Alternatively, the unused sections of the LM324 device and a transistor can be used to drive a small speaker if greater audio output is desired. □

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

Data-block transfer program is efficient and flexible

by Chris Lusby Taylor
Intel International, Brussels, Belgium

Although the program described by Prakash Dandekar[1] will indeed transfer data blocks quickly, practical difficulties await users attempting to implement it in any but a dedicated-processing environment. This version of the routine is suitably modified so that the program may be used as a subroutine in any system.

Any program that modifies the stack pointer, such as Dandekar's, must afterward restore its previous value if the program is to be used as a subroutine. The program given here provides for saving and restoring the stack pointer. Note that the system interrupts are disabled when the stack pointer calls for the appropriate data and are re-enabled after the old stack pointer location has been retrieved.

The 16-bit loop counter (locations 2019–2020) has been implemented as illustrated to increase program efficiency. Although simple, very few users seem to be aware of this technique.

Also note that the word count, not the byte count, is transferred to register pair D-E. Implementing the word count transfer is logical, since the routine transfers data in pairs of bytes, not bytes. □

References
1. Prakash Dandekar, "8080's stack pointer transfers data blocks fast," *Electronics*, Dec. 21, 1978, p. 118.

8080 BLOCK-TRANSFER PROGRAM

LOC	OBJ CODE	SOURCE STATEMENT			COMMENTS
2000			ORG	2000H	
3000		SSTAD	EQU	3000H	
3002		DSTAD	EQU	3002H	
3004		WRDCNT	EQU	3004H	
3006		SPSAVE	EQU	3006H	
2000	210000	PREP1:	LXI	H, 0	
2003	39		DAD	SP	;GET OLD SP
2004	220630		SHLD	SPSAVE	;IN SAVE LOCATION
2007	2A0030		LHLD	SSTAD	;START OF SOURCE
200A	F3		DI		;MUST DISABLE INTERRUPTS
200B	F9		SPHL		
200C	2A0430		LHLD	WRDCNT	
200F	EB		XCHG		;GET WORDCOUNT IN DE
2010	14		INR	D	;ADJUST FOR DECREMENT SCHEME
2011	2A0230		LHLD	DSTAD	;HL=START OF DESTINATION
2014	C1	LOOP1:	POP	B	;GET NEXT BYTES
2015	71		MOV	M, C	
2016	23		INX	H	
2017	70		MOV	M, B	
2018	23		INX	H	
2019	1D		DCR	E	
201A	C21420		JNZ	LOOP1	
201D	15		DCR	D	
201E	C21420		JNZ	LOOP1	
2021	2A0630		LHLD	SPSAVE	;RESTORE OLD SP
2024	F9		SPHL		
2025	FB		EI		;RE-ENABLE INTERRUPTS
2026	C9		RET		;RETURN
2000			END	PREP1	

Engineer's newsletter

EIA modifies interface standard

Now that the popular RS-232-C serial binary data-communications interface is being phased out, the Electronic Industries Association is modifying the associated RS-366 interface between data terminals and automatic telephone-calling equipment. **The new RS-366-A is compatible with the RS-423 electrical characteristics and the RS-449 interface.** RS-422 and -423 were unveiled in April 1975 to gradually replace RS-232-C as the interface between data terminals and data-circuit-terminating equipment; RS-449 was adopted in November 1977 to specify the necessary new 37- and 9-connector plugs. The RS-366-A standard is available for $14.00 from the Standards Sales Office, Electronic Industries Association, 2001 Eye Street, N. W., Washington, D. C. 20006.

Photodiodes respond in tens of picoseconds

Currently available photodetectors just can't handle the picosecond response time needed to display the short optical pulse outputs of mode-locked lasers. So to improve their sensitivity, Lloyd L. Steinmetz, who is an electrical engineer with the chemistry department at the University of California's Lawrence Livermore Laboratory, modified the insides of commercially available diode chips by selective etching of the active areas. He was able to do this inexpensively with both the Hewlett-Packard HP 5082-0024 Schottky-barrier switching diode and HP 5082-0001 p-i-n diodes. Now the devices easily respond to light pulses tens of picoseconds long, in the 257-nm-to-1-μm region. What's more, they have already stimulated some commercial interest, since **the use of picosecond-pulse lasers has grown rapidly.** For information, get in touch with Steinmetz at the laboratory, Livermore, Calif. 94550, or at (415) 422-6897.

Comsat offers index to R&D reprints

Research and development in communications satellite technology has resulted in many advances in the electrical engineering art. This work, much of which has been done by the Communications Satellite Corp. and its Comsat Laboratories, appears in diverse publications and places around the world and retrieving such scattered information is difficult. Worse yet, some of it is not widely known.

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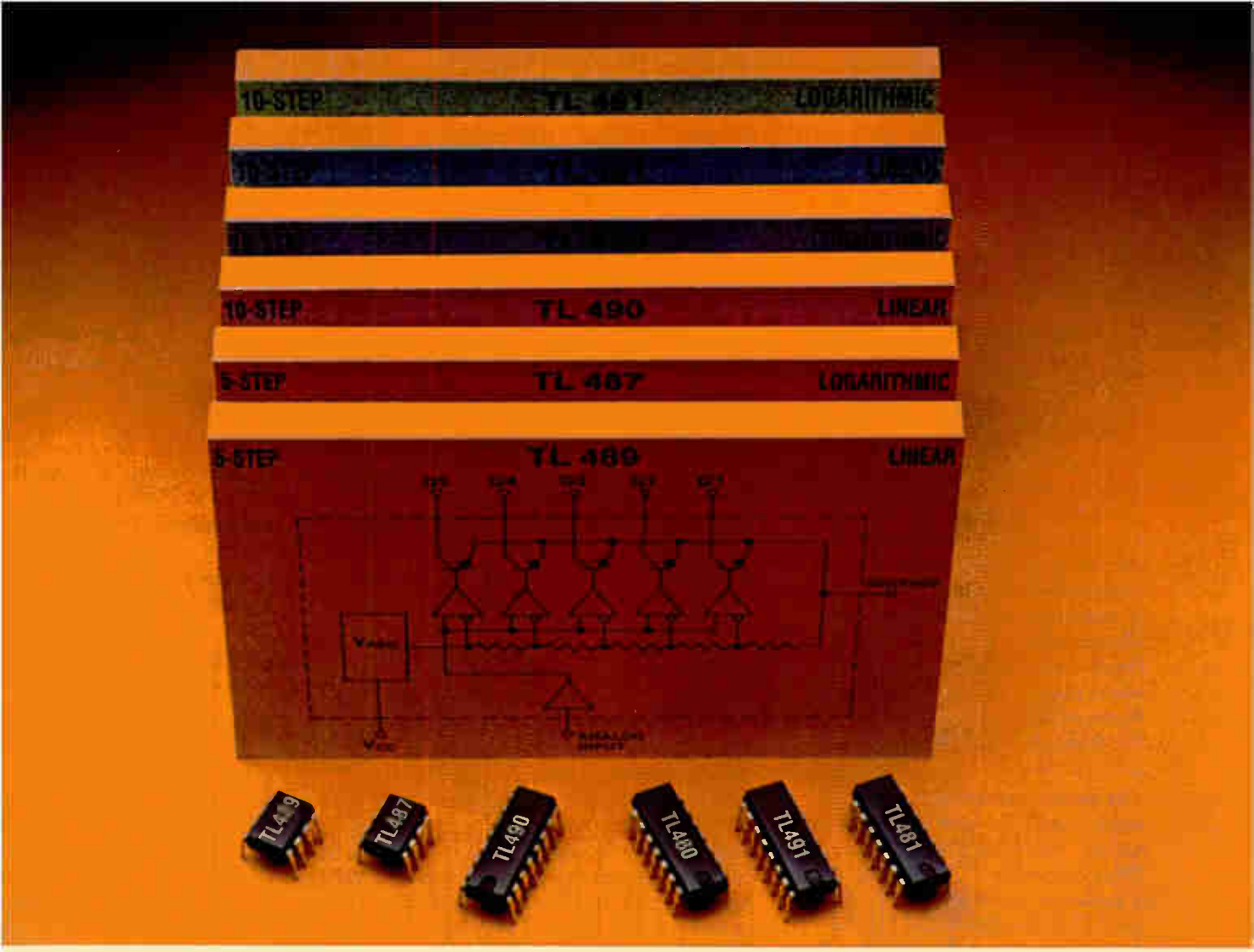
Palladium can cut plating costs by a factor of 6

With the price of gold going up almost daily, it is well worth investigating the feasibility of replacing it with palladium in plating operations. Not only is palladium a quarter as expensive but often it need be only about two thirds as thick. Engineers at GTE Sylvania Inc.'s wire and bonded components plant in Warren, Pa., say they can deposit **thicknesses of 10 to 200 microinches** on a base material. Such a range is wide enough to take care of most of the literally billions of small pins, wires, and other parts that must be kept free of oxidation.

-Harvey J. Hindin



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Device	Input	Steps	Display Type	Price* 100 Pcs.
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TL487	Logarithmic	5	LED	0.65
TL490	Linear	10	LED	1.08
TL491	Linear	10	VF	1.22

*Prices effective March, 1979.
Commercial temperature (0°C to 70°C) operating range versions in plastic dual-in-line packages.

Analog level detectors from Texas Instruments. A simple, cost-effective solution to all your level-sensing applications.

Free brochure

A new 12-page brochure (CL-410) gives full information on TI's line of monolithic analog level detectors and typical applications. Call your nearest authorized TI distributor, or write Texas Instruments Incorporated, P.O. Box 225012, M/S 308, Dallas, Texas 75265

TEXAS INSTRUMENTS
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Circle 149 on reader service card

For a professional like John Bartlett, there exists a vast wealth of opportunities. To him, finding the challenge has never been the question. It's where that challenge exists. So very much depends on where a family lives; everything that makes up the quality of the lifestyle. When John accepted an offer to manage the Energy & Environment Group of The Analytic Sciences Corporation, it meant a cross-country move to Massachusetts. John and his wife, Helen, have lived in many interesting places. They are both people of remarkable personal resources. What did they find here?

Just ask them.

The electric enthusiasm in Helen's voice sparks the tone of the conversation. "How can I begin?" she says, "Massachusetts . . . the many ways it provides for its people . . . the culture! Our daughters, Tanya and Larah, love the study of dance. Now they can go to classes every week at the Boston School of Ballet. Recreation? You name it! From the Cape Cod beaches to the Berkshires. And the shopping! Boston's Quincy Market, for example! It's a whole world in itself. A whole outdoor marketplace of colorful flowers, music, and so much more! You know, out-of-staters don't realize that so many really attractive suburban areas like our own town of Lynnfield are no more than a half hour away from Boston!"

John Bartlett speaks of how the move to Massachusetts has enriched his life. "You could put people into any location in the same job, within four walls — it would be the same. It's what's OUT THERE that's different. For me, the mind-enriching climate of Massachusetts is very real. There's just a mental sharpness that comes into every aspect of living and working here."

"As a living environment, I can't imagine anything better!" Helen continues, "You can grow or you can vegetate. In Massachusetts, you *can't* vegetate, because everywhere you go there is stimulus. I have a degree in math and used to teach full-time. When the children are grown, I can resume my teaching career here, and because of the many excellent educational facilities, I feel I'll have a better opportunity."

"Theater, art, every major league sport and recreational activity you can imagine is available here," John remarks. "And the sense of history here is just pervasive! I don't think you could find a more exciting place for a family to live."

"Massachusetts? It's kind of like looking for fine antiques. There's always life and magic in what you uncover," comments Helen.

John Bartlett and his family have found the life they've been looking for. They've found Massachusetts to be a remarkable blend of tradition and a vigorous contemporary spirit . . . a vintage of the old and state-of-the-art new.

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Circle 153 on reader service card

US Department of Commerce statistics for the period '74-77 show a 28% average annual return on investment for US manufacturers located in the Republic of Ireland-more than twice the European average.

IDA Ireland
INDUSTRIAL DEVELOPMENT AUTHORITY

The Irish government's industrial development agency has offices in New York, Tel (212) 972-1000; Chicago, Tel (312) 644-7474; Houston, Tel (713) 658-0055; Los Angeles, Tel (213) 624-1024. Overseas offices also in Toronto, Amsterdam, London, Paris, Cologne, Stuttgart, Copenhagen, Milan, Madrid, Tokyo and Sydney.

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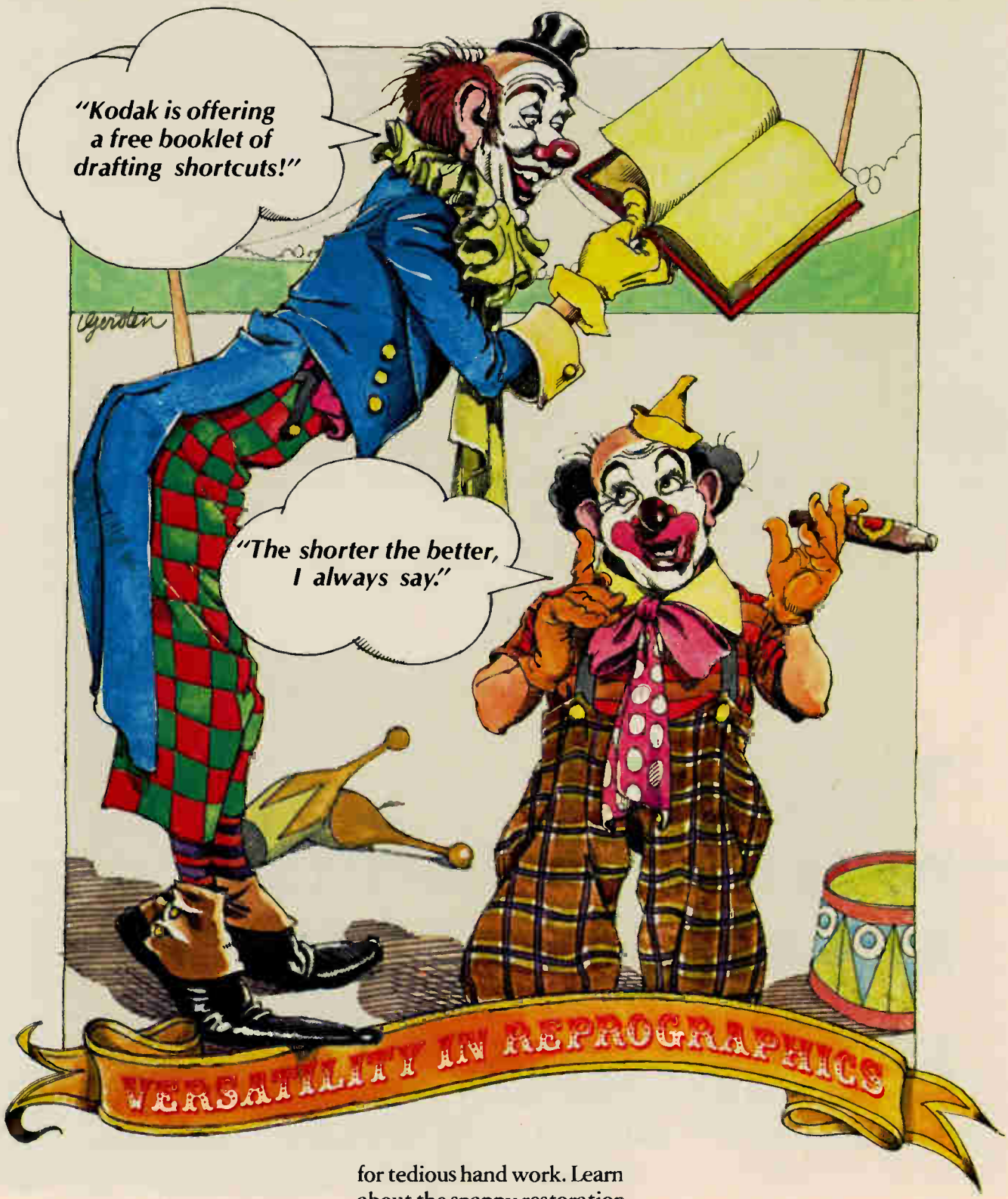

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Kodak

S-d converter has three-state latches

Offered in 10- and 12-bit models, microprocessor-compatible module delivers output data without interrupting its conversion process

by Pamela Hamilton, Boston bureau

For an engineer trying to design a tracking synchro-to-digital converter into a microprocessor-based control system, life can be difficult. First, existing s-d converters cannot be directly attached to a microprocessor bus. Second, getting digital data out of a converter is not as easy as it sounds. Grabbing it on the fly is not a good idea because the data may be changing just as it is being sampled—a situation that can lead to very large errors. Inhibiting the converter to freeze the output works well enough in applications that do not require fast repetitive sampling, but not in high-speed systems because the converter must be given time to catch up with the changing input data after being inhibited. Using the converter's BUSY output to identify points in time when the output is stable does work, but it requires a fair amount of design time and external componentry.

Analog Devices Inc.'s latest s-d converter has solved both of these problems by including a set of latches and three-state outputs in the converter package. Not only does this scheme make microprocessor interfacing a snap, "but with tri-state latches, the loop is always closed and the internal data is always valid," explains Edward H. Friedman, product line manager for synchro converters.

Both the SDC1725 12-bit converter and the SDC1726 10-bit module are continuous tracking units built around a type 2 servo loop. Their input signals may be either three-wire synchro plus reference or four-wire resolver plus reference. Internal Scott T and reference microtransformers for frequencies of 60, 400, and 2,600 Hz are available.

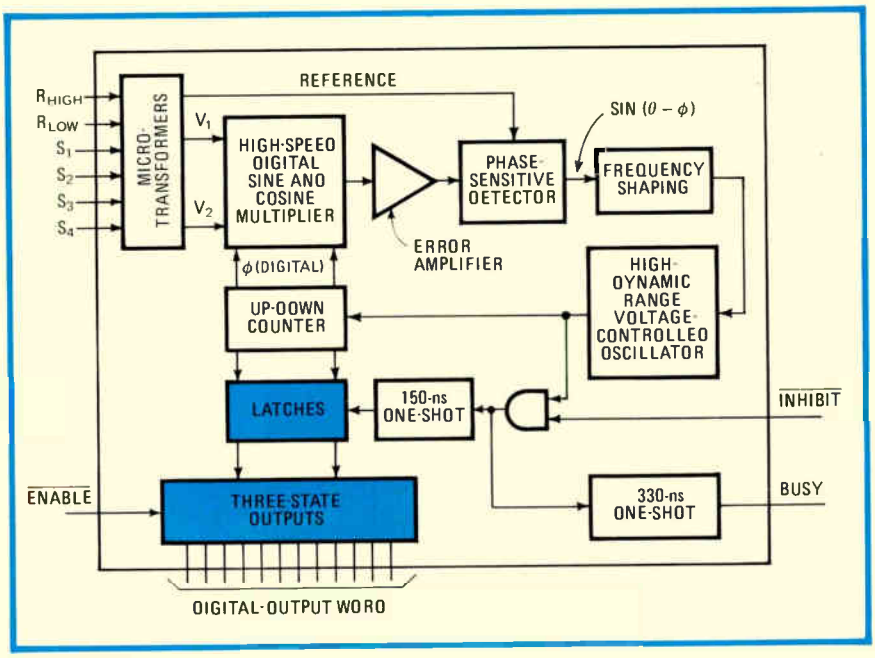
The 12-bit SDC1725 is accurate to within ±3.2 arc-minutes ±1 least significant bit. For the 10-bit SDC1726, the first figure becomes 22 arc-minutes. Both converters can work with line-to-line signal voltages of 11.8 and 90 V rms and have minimum tracking rates of 5 revolutions per second (60 Hz), 36 rps (400 Hz), and 75 rps (2.6 kHz). For the same three reference frequencies, the response times to within 1 LSB for a 179° input step are 1,500, 125, and 50 ms.

The converters draw ±25 mA at ±15 V and 120 mA at 5 V. They work from 0° to 70°C, with operation from −55° to +105°C available as an extra-cost option. The modules measure 3.125 by 2.625 by 0.35 inches and weigh 3.5 oz. Friedman notes that the 0.35-in. height will be particularly attractive to engineers designing systems in which printed-circuit boards are spaced 0.5 in. apart.

Applications for both converters include servomechanisms, antenna monitoring, simulators, and industrial controls. The three-state outputs also simplify multiplexing more than one converter onto a data bus, according to Friedman, who notes that one customer already has plans to use these converters on a robot arm to control machine tools.

The 12-bit converter will sell for $355 in quantities of one to nine; for the 10-bit unit, the corresponding price will be $295. Delivery is from stock to eight weeks.

Analog Devices Inc., Route 1 Industrial Park, P. O. Box 280, Norwood, Mass. 02062. Phone Edward Friedman at (617) 329-4700 [338]



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Used to attach cable permanently to PCB, Has rugged single piece design for fast assembly and high reliability. Cover latch swivels for easy cable insertion.

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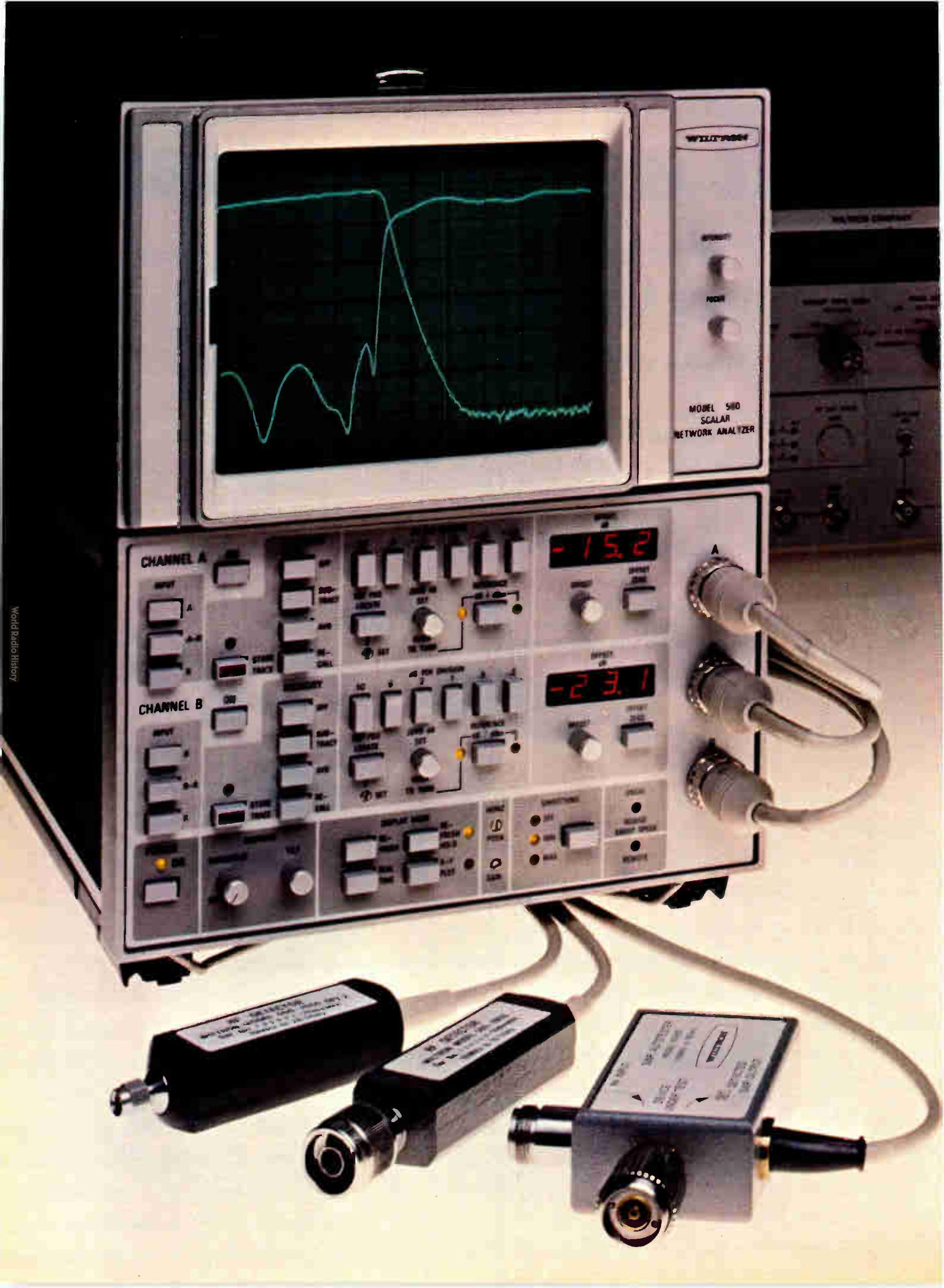
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No other network analyzer has all these features.

GPIB programmability with 0.01 dB resolution. · 66 dB (+16 dBm to −50 dBm) dynamic range. · Better than 40 dB directivity from 10 MHz to 18 GHz. · New WSMA Detector with 10 MHz to 34 GHz range. · Automatic power measurement calibration. · LED readouts — no mechanical type readout controls. · Sweeper marker display with TILT Control. · Memory-corrected output data. · Refreshed non-flickering display. · Broadband components that make uninterrupted transmission measurements from 10 MHz to 34 GHz and return loss from 10 MHz to 18 GHz. · Makes measurements with wave guide components. · No modulation required.

40 dB directivity.

For high accuracy, the 560 offers 40 dB directivity with reference calibration enhanced by memory that stores the average of reflections from a short and an open. System residuals are subtracted from test data leaving only the test device characteristics for display. For a permanent record, use a CRT camera or X-Y plotter or under GPIB control, drive an X-Y plotter or printer.

Prices begin at $5900.

For an instrument with so many applications, prices are remarkably low — $7250 with GPIB or $5900 without. A fully automated turnkey system, the Model 5610 which includes all necessary hardware and software is also offered.

For an early demo or full data on the 560 or 5610, phone Walt Baxter, (415) 969-6500 or address Wiltron, 825 East Middlefield Road, Mountain View, CA 94043.

WILTRON

Circle 161 on reader service card

Components

Hybrids match switcher parts

Optimized diode-transistor circuits provide high switching speeds

Like many other engineering activities, switching-regulator design has its less enjoyable side. Matching switching transistors and commutating diodes is probably about as unenjoyable a part of switcher fabrication as one is likely to run across, so the designers of such power supplies should welcome a new power circuit that guarantees the compatibility of the Schottky rectifiers and the transistor chips. "Our focus is on the power components," notes Harvey F. Hodsdon, market manager for industrial electronics. "We've combined them in one package, we've specified the parts properly, and we've taken the hassle out of the design process by providing both devices in one package."

Two main series of power circuits are offered: the high-current PIC700 series and the high-voltage PIC800 family. Between them, the families comprise a total of six hybrid power integrated circuits (PICs).

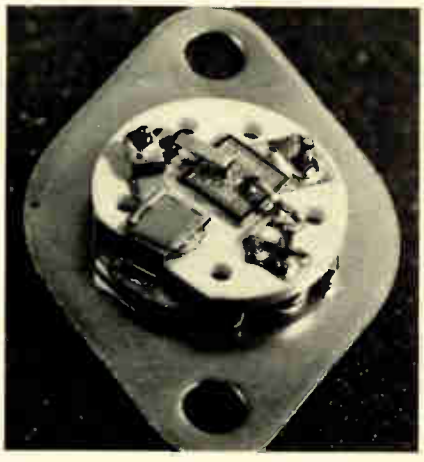
High current. The PIC700 series has two members, both of which can deliver a peak output current of 30 A. The PIC730 accepts 30 V, whereas the PIC740 can handle input voltages up to 40 V. Both units have a continuous output-current rating of 20 A and a drive-current rating of 5 A. Designed to be driven by standard IC voltage regulators, the 730 and 740 both have maximum instantaneous forward-voltage drops of 0.6 V at 20 A. Their careful matching of diode and transistor keeps inductive switching times to 300 ns maximum for current, and 350 ns maximum for voltage.

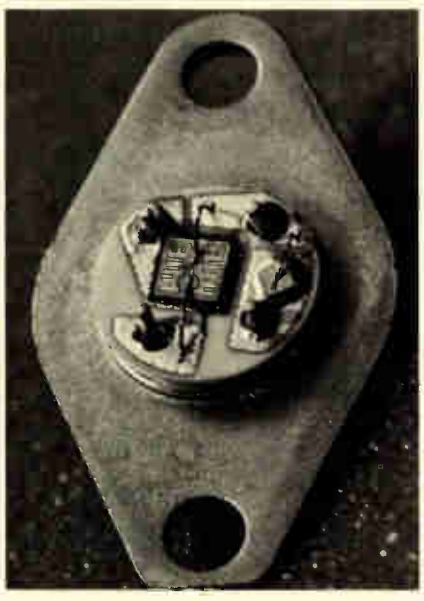
Packaged in a three-pin TO-3 case, the 730 and 740 will operate from −55° to +125°C. They will find application in high-efficiency buck- and flyback-type switching regulators.

High voltage. For designers who need a low-current, high-voltage device, the PIC800 family offers four units. The PIC800 and PIC810 operate at 350 V input, where the PIC801 and PIC811 can go up to 400 V. All four units can deliver a continuous output current of 8 A with a 2-A drive.

The difference between the 800/801 and 810/811 devices is that the Schottky diode is reversed in the latter devices, allowing the engineer to design high-voltage buck or

Matched. The high-current PIC700 device (below) and the high-voltage PIC800 (right) contain carefully matched transistors and diodes for fast switching and low noise.





Big winners: four jacks.

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Electronics review

flyback regulators with the 800 or 801 and single-ended half bridges, full bridges, deflection circuits, or dc motor drives with the 810 or 811. Hodsdon points out that two 810s or 811s are needed for a half-wave bridge, but four are required for a full-wave bridge for a switching power supply.

Like the PIC700 series, the 800 family devices each contain a power transistor and a catch diode in a single package. Like the two 700-series units, the four 800-series circuits are hybrid devices built on beryllia substrates for low thermal impedance. Units in the 800 family are housed in four-pin TO-66 cases and operate from −55° to +125°C.

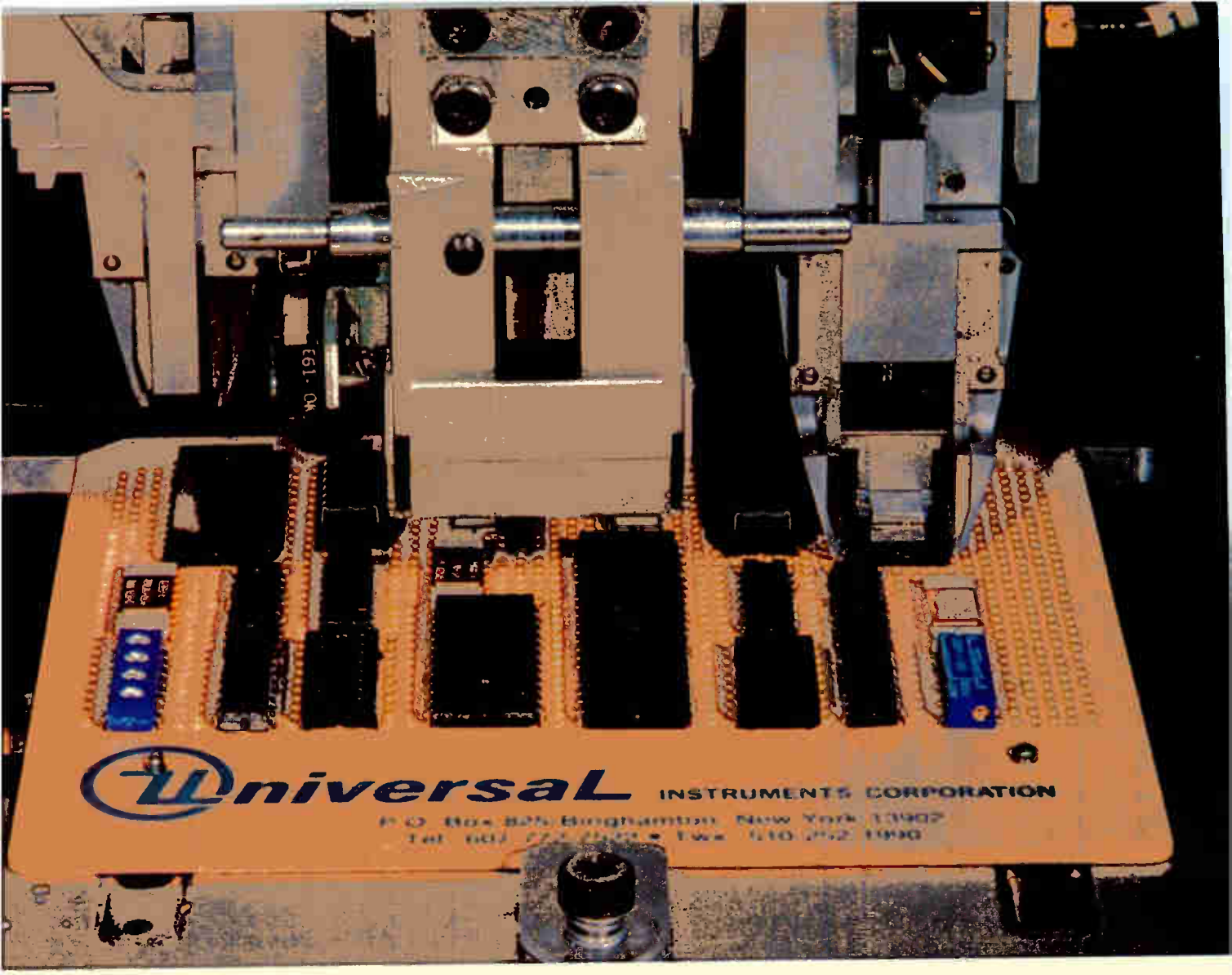
Prices for the PIC700 family start at $12 each for the 730, while those for the PIC800 series begin at $8 each for the 810. Shipments are scheduled to commence in July with delivery times of about six weeks.

Unitrode Corp., 80 Pleasant St., Watertown, Mass. 02172. Phone Harvey Hodsdon at (617) 926-0404 [341]

Adjustable state-variable filters pass or reject audio signals

Housed in packages measuring 1.35 by 2.35 by 0.6 in., the model APN-6 and APB-6 are stagger-tuned band-pass and band-reject filters, respectively. By adjusting potentiometers built into the active state-variable filters, users can position each of three pairs of poles to set the bandwidth of the desired pass band or notch or to create three separate

Circle 164 on reader service card



"Multi-Module" can insert all these DIPs and sockets in a single high speed sequence.

Universal's family of "Multi-Module" machines opens the door to new, far higher levels of productivity. Now a single machine can automatically insert DIPs with two different lead spans in a single high speed sequence. You can combine .300" lead span DIPs and sockets with .400" or .600" DIPs. Another member of the family combines inserting 2 and 4 lead types with conventional DIPs. Up to 72 input magazines. Plastic, ceramic or side brazed. Automatic inward/outward cut and clinch.

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pass bands or notches. Center frequencies can range from 2 Hz to 30 kHz. Separate integral potentiometers are provided to adjust band gain or notch depth.

The filters' set frequencies are stable to within 50 ppm. They operate from ±15-V supplies, drawing 35 mA from each; for low-power applications, 3-mA versions are also available. Input impedance is 20 kΩ and maximum input is 8 V rms.

The output impedance of the filters is less than 1 Ω and dc offset is 5 mV, externally adjustable. With the input shorted, output noise is 70 μV rms.

The six-pole units can be supplied in Bessel, Butterworth, Chebyshev, and elliptical versions. A printed-circuit board with trimmers and capacitors for mounting the filters, designated model S-AP6, is also offered. Standard filters are priced at $150 each in quantities of 3 to 10. Delivery time is one to three weeks.

A. P. Circuit Corp., 865 West End Ave., New York, N. Y. 10025. Phone Felix Ellern at (212) 222-0876 [343]

Brushless dc motors offer 14-oz-in. torque

Brushless dc motors of the 1AD42/43 series exhibit maximum rated operating torques of up to 14 oz-in. and maximum starting torques of up to 28 oz-in. These ratings make the units suitable for use in printers and tape drives.

Motors in the series can be supplied with integral tachometer/position-encoder circuitry. In quantities of 1,000, they are priced from $34 each.

Siemens Corp., 186 Wood Ave. S., Iselin, N. J. 08830 [345]

Low-profile transformers plug into pc boards

The PF6 and PF12 series of power transformers were designed for mounting on printed-circuit boards. The 6-VA PF6 units are 0.850 in.

Fight the protection racket.

Why pay for back-to-back zeners to get positive/negative protection, when a single Panasonic ZNR can provide complete, highly reliable circuit protection in either direction... and for less cost.

These zinc oxide nonlinear resistors also provide an excellent alternative to RC circuits and spark gaps. Their ohmic values change in less than 50 nsec when subjected to impulse surges, so their response time is fast...without the discharge lag conventional gap-type arrestors can't avoid.

Result: you can use them for ground fault interrupter circuits or input line transient protection. Use them in applications ranging from low-voltage switchboards and communications equipment to video displays and TVs. Use them anywhere you want an economical, efficient way to protect vulnerable AC and DC circuits against repeated high voltage transients (positive or negative), or such steep-rise surges as those caused by lightning, switching or noise spikes.

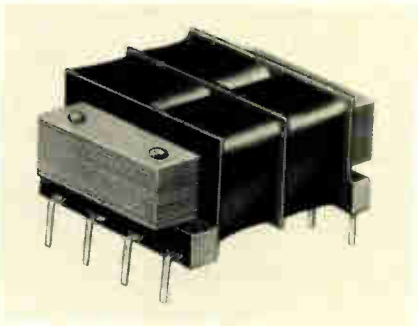
Providing excellent temperature and humidity characteristics, ZNR's are available in a wide varistor voltage range—from 22 V to 1800 V in the PC-mountable D Series and the top-connected, flange-mounted E Series, and in stacked types for voltages up to 26 KV. Surge withstand capabilities are from 50 to 2,000 amps in the D Series, or 2,500 to 20,000 in the E. Our D series includes several UL recognized numbers for line voltage applications. For complete details, samples and prices, write or call: Panasonic Company, Electronic Components Division, One Panasonic Way, Secaucus, N.J. 07094; (201) 348-7282/7289.

With one Panasonic ZNR transient/surge absorber instead of back-to-back zener diodes

Panasonic®
just slightly ahead of our time

Circle 167 on reader service card

New products



high and weigh 7 oz; the 12-VA PF12 types are 1.065 in. high and weigh 11 oz. All transformers in the series are dual-primary units capable of working from either 230-V, 50-Hz or 115-V, 60-Hz lines.

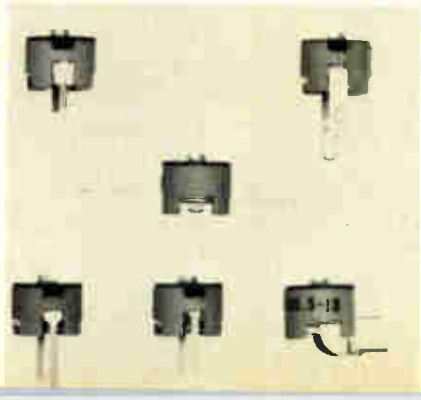
Primary and secondary windings are terminated in pins to permit easy board mounting and pin jumpering of the primary inputs for compatibility with domestic or overseas line voltages. The transformers also have dual secondary outputs that can be connected in parallel or series. Models are available with output ratings ranging from 5 to 56 V rms and 1.2 to 0.1 A.

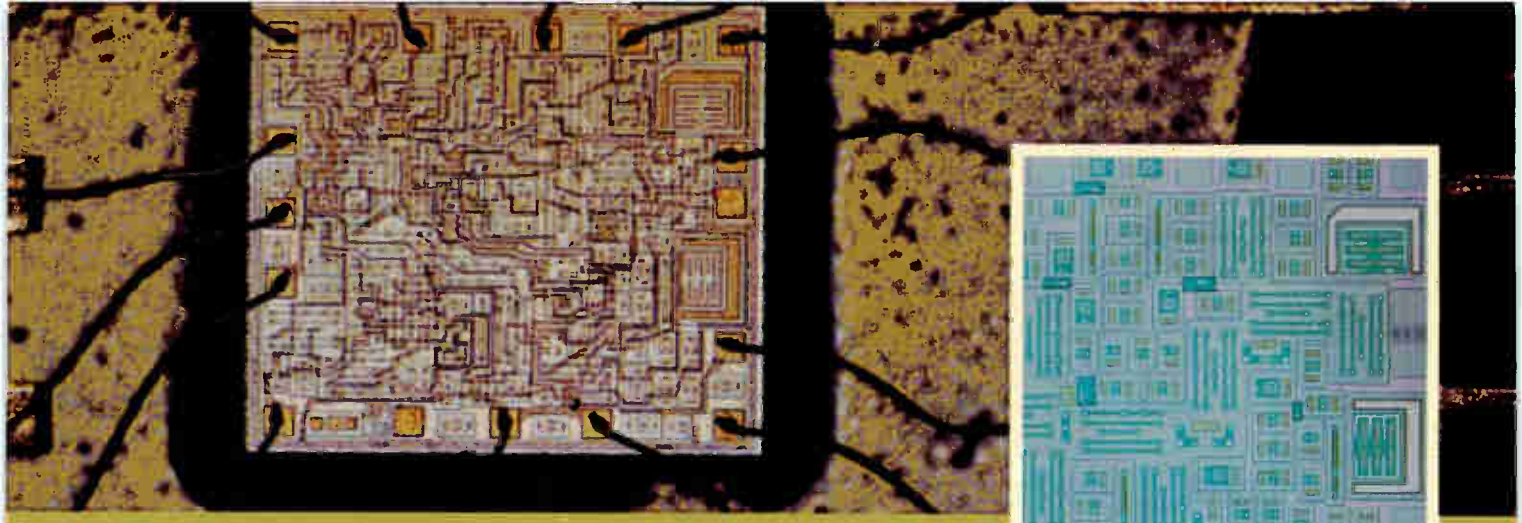
The transformers are built using a split bobbin to decrease leakage and with balanced windings to reduce magnetic-field radiation. In quantities of 100, they range in price from $8.80 to $11.30 apiece; delivery is from stock.

Microtran Inc., P. O. Box 236, Valley Stream, N. Y. 11582. Phone (516) 561-6050 [346]

Small trimming capacitors mount in many ways

Available in a variety of mounting configurations, a line of 0.375-in.-diameter trimming capacitors uses a stator-rotor design that increases electrical stability, according to the manufacturer. The stator-termi-





Section of an Exar Master Chip before customizing. Note the individual circuit components already on-chip, but still unconnected. After the customer has designed circuit connections according to his system needs, Exar prepares a final mask and fabricates the custom chip, as shown in large photograph above.

This integrated circuit was manufactured to a custom design and delivered in a matter of weeks.

YOU CAN CUT DEVELOPMENT TIME UP TO NINE MONTHS ON BIPOLAR AND I^2L CUSTOM CHIPS...WHILE YOU SLICE COSTS TO THE BONE...THROUGH THE UNIQUE "SEMI-CUSTOM DESIGN PROGRAM" FROM EXAR INTEGRATED SYSTEMS. Compared to traditional development times for custom ICs, which frequently exceed one year, and tooling costs which can be five to ten times greater, this new concept allows custom chips to be justified economically at far smaller quantities than previously thought practical.

How the semi-custom idea works.
Exar's standardized circuits contain undedicated active and passive components such as transistors, resistors, logic gates, etc., fabricated onto the chip, but left unconnected. You choose how to interconnect these components to create your own custom circuit. The actual interconnection process is simple, requiring only one to three layers of tooling. As a result, development time compresses drastically, becomes far less expensive and virtually risk free.

Choose from eight different chips.
Five of the standard semicustom chips are bipolar, and are best suited for linear designs. Some (XR-A100, XR-C100, XR-F100) feature high current NPN output transistors, making them suitable for drive circuits. The others (XR-B100, XR-D100), more appropriate for signal amplification or control circuits, contain only small signal, low current transistors. All, however, present the designer a wide variety of NPN and PNP transistors, Schottky diodes, various resistors and ample bonding pads.

Exar's three I^2L digital chips (XR-300, XR-400, XR-500) contain high density I^2L logic arrays and bipolar interface circuitry. Outwardly they look and perform like a bipolar LSI chip, readily interfacing with TTL or MOS level signals. This feature, incidentally, makes it very convenient to retrofit I^2L LSI designs into existing MOS or TTL logic systems.

And Exar has in development additional semi-custom chips offering even greater applications flexibility.

If you decide to modify your design.
Even after evaluation of initial design prototypes, if you see a need to modify the custom chip, a new design iteration usually takes less time than the original development cycle. And typical costs of additional design cycles are proportionately less than the original prototype development cost.

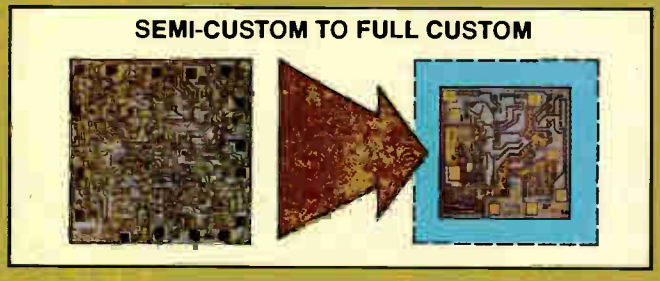
What about second sources?
This is one of our most asked questions. In response, Exar has made alternate-source agreements with other IC manufacturers, so you can specify and order custom circuits with confidence.

Testing, testing.
After prototype acceptance of semi-custom devices, Exar will develop software and fixtures for fully testing all production ICs. Production devices receive 100% electrical testing, and are screened to agreed-upon Acceptable Quality Level (AQL) standards. Charges for this test engineering are nominal, and vary depending on the complexity of the tests.

Semi-custom to full custom. For when the numbers get big.
Because Exar manufactures its own wafers, it can grow with your needs. As your product matures we can convert your semi-custom chip into a customized IC. Consider the advantages: You get the quick, inexpensive turnaround of semi-custom chips, providing prototypes and intial production units; then when your design has proven itself and your market has developed, the subsequent full custom product provides further cost savings at high volume production...often with a significant improvement in product performance!

Design kits make it simple.
Exar provides linear and digital design kits, including circuit components for breadboarding, comprehensive design manuals and layout worksheets corresponding to Exar's master chips. These, as well as technical assistance when you need it, will speed and simplify your preliminary steps toward custom IC design.

Learn the economics and advantages of semi-custom.
Exar's entire semi-custom story is detailed in a 40-page data book, "Semi-Custom IC Design Programs." For your copy, write on company letterhead to your nearest Exar representative or to Exar, 750 Palomar Ave., Sunnyvale, CA 94086.



Exar can convert your semi-custom chip to a custom IC, reducing chip size, saving money, and often providing added performance benefits.

EXAR CUSTOM

FOR THE EXAR REPRESENTATIVE NEAREST YOU, CALL EXAR AT (408) 732-7970.

New products

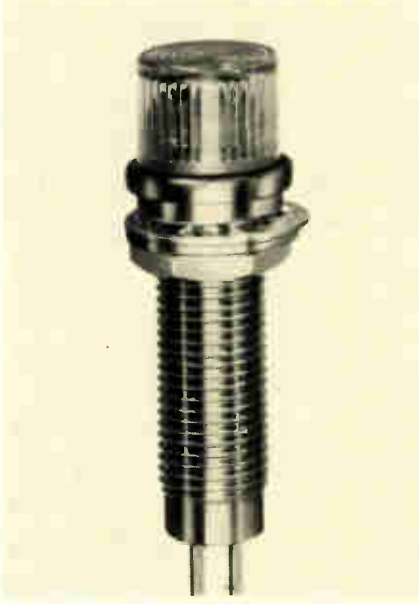
nated units are available with ranges starting at 2 to 8 pF, increasing to a maximum range of 15 to 60 pF.

Depending on temperature requirements and the dielectric selected, the trimmers can be purchased with working voltages of 100 to 350 V dc. They can withstand temperatures of −55° to +125°C.

Spectrum Control Inc., 8061 Avonia Rd., Fairview, Pa. 16415. Phone John Lane at (814) 474-1571 [347]

Front-panel LED indicator emits up to 50 mcd

The 2L7 panel indicator uses a T 1-¾ light-emitting diode and Fresnel lens to provide an output of 50 mcd with 180° visibility. It also has a threaded body for secure mounting

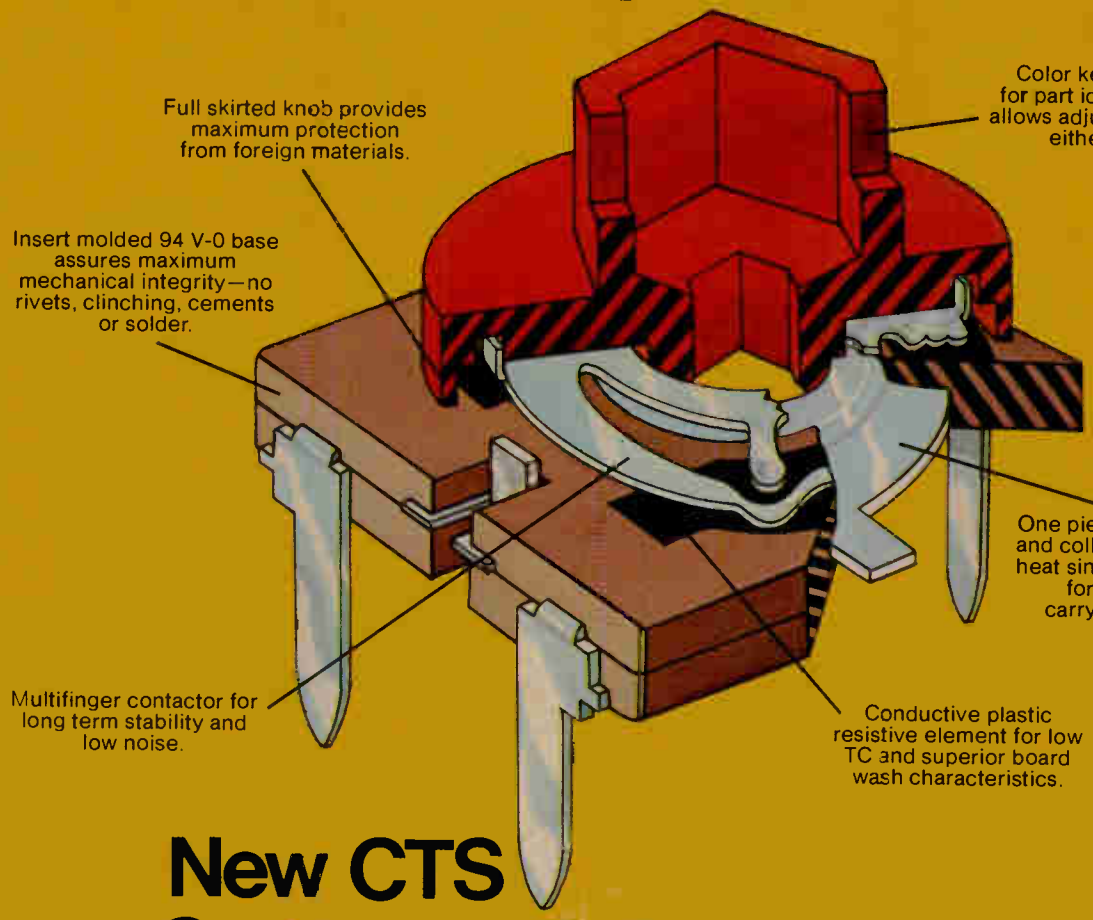


and wrapped-wire posts for gas-tight connections.

The lamp is available with a red, green, or amber LED and a transparent or translucent lens of high-impact plastic. The unit has a built-in resistor to permit operation from voltages of up to 48 V. Free samples of the 2L7 indicator are available upon request.

Sloan Co., 7704 San Fernando Rd., Sun Valley, Calif. 91352. Phone (213) 875-1123 [348]

Performs like cermet. Costs like carbon. Stands up like steel.



New CTS Consertrim™ 10mm resistors.

These high performance CTS trimmers feature a conductive plastic element on a UL-94 V-0 rated fire retardant, molded substrate; stability and load carrying characteristics approaching cermet; at a price close to carbon. Add to this a mechanical integrity that can withstand forces best described as brutal. Insert-molded terminations provide solid mechanical anchoring and double as an effective heat sink.

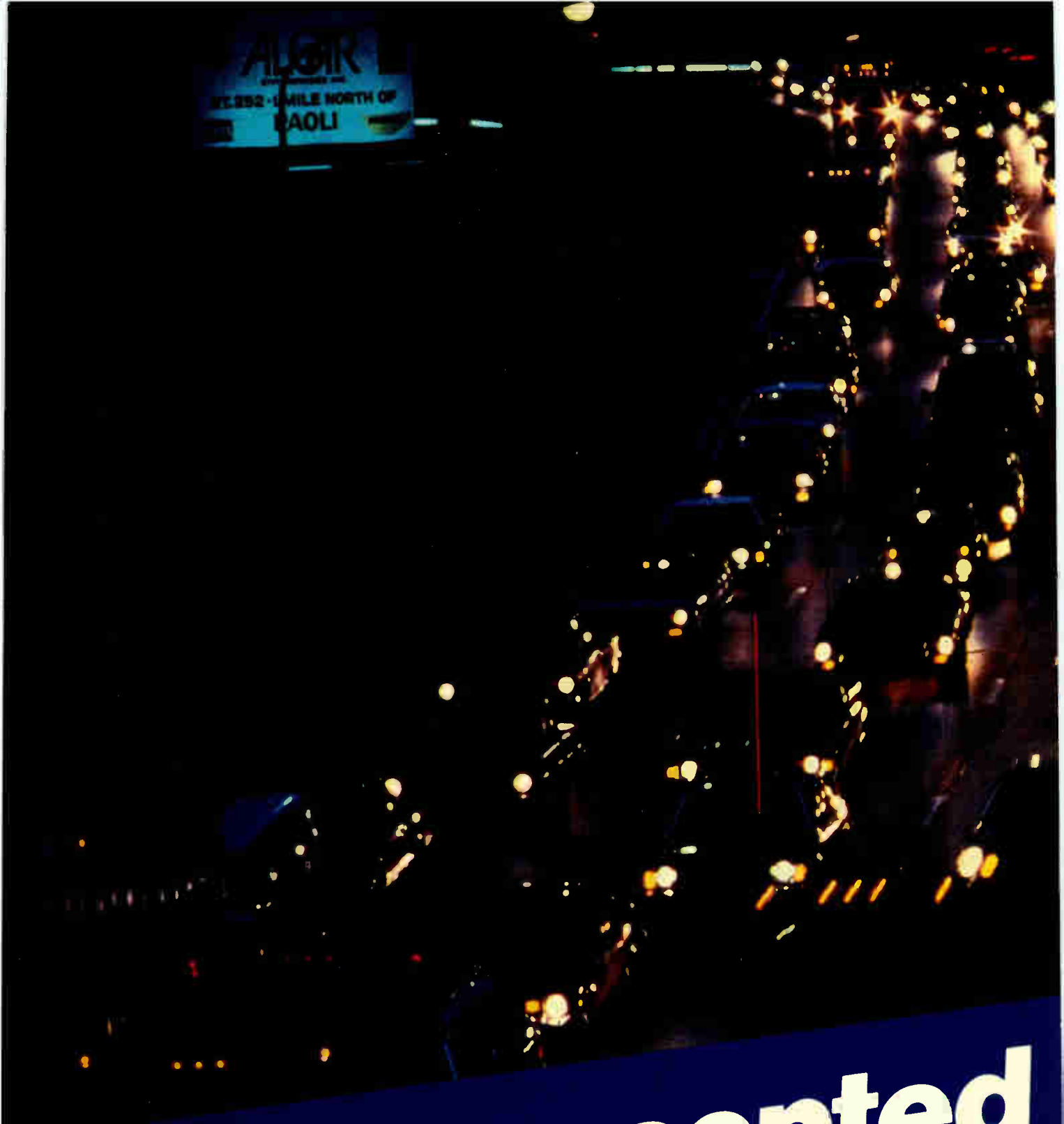
CTS series 268 Consertrim resistors are adjustable from both the top/front and bottom/rear; adjustment axis may be either parallel with, or perpendicular to, the PC board. A wide resistance range is available in a new standard of reliability and performance... with superior board wash characteristics.

Resistance Range: 500 ohms—5 megohms.
Power Rating, Watts: ⅓ watt @ 70°C.
TC: <400 ppm/°C typical.
Settability: 0.05%
Noise: <1% CRV initial.
Operating Temperature Range: −55°C to +125°C.

Consertrim resistors have performance characteristics exceeding most carbonaceous trimmers, yet are competitively priced. For complete series 268 catalog literature, write or call CTS of Elkhart, Inc., 1142 West Beardsley Avenue, Elkhart, Indiana 46514. Phone: (219) 295-3575.

CTS CORPORATION
ELKHART INDIANA

Circle 171 on reader service card



We've accepted of cost

Low cost...high reliability...and quick interconnection! Tough for any connector. A tougher challenge yet for demanding automotive specs. TRW Cinch engineering met the cost effective challenge with the New Cinch Plastic Polarized Subminiature Connector.

Originally designed for cost-conscious automotive systems, the quick PCB snap-mounting device makes the new high contact density connector a logical choice for a wide range of applications including computer peripheral equipment, test equipment and telecommunications.

Check these other outstanding Cinch features...25-pin polarized arrangement...compact all-plastic shock and vibration resistant design...interchangeable, intermatable, intermountable with all standard "D" subminiature connectors.

Meeting all of your interconnection needs is the challenge of the NEW Cinch. Just as we worked with this automotive manufacturer, we'll work with you to solve your connector problems with a highly reliable product and prompt delivery schedule. Need a connector?

Challenge Us!

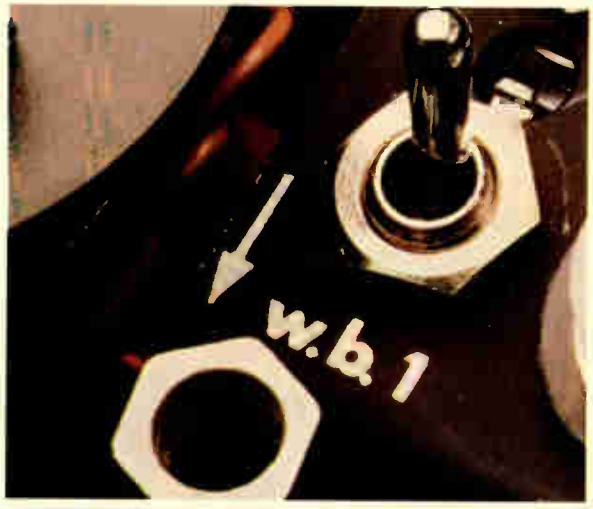
For all the facts on the Plastic Polarized Subminiature and the full line of Cinch connectors, contact your local TRW Electronic Components Sales Office...listed in EEM.
TRW Cinch Connectors,
A Division of TRW, Inc.,
1501 Morse Avenue,
Elk Grove Village, IL 60007
(312) 439-8800.

the challenge effectiveness.

TRW CINCH CONNECTORS

Circle 173 on reader service card

Store Recorders have made



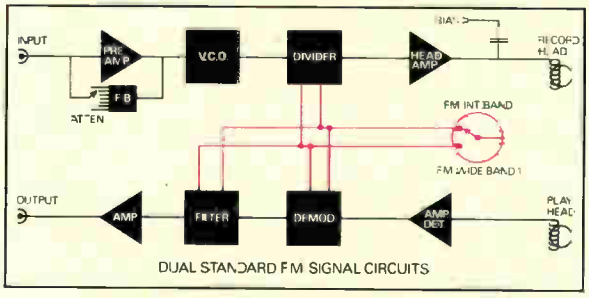
Flick a single switch on a dual standard recorder in the new Racal Store DS range, and you've changed instantly from Intermediate Band to Wideband operation on FM. A single switch that selects either recording standard – without the need to interchange plug-in modules. A single switch changes all the signal channels (four to fourteen) on all seven speeds.

FM Capability

The Store range of instrumentation recorders, well-renowned for research in the scientific, automobile, aerospace and medical fields, now offers an FM capability over the entire band DC to 40 kHz, and up to 300 kHz on Direct Recording.

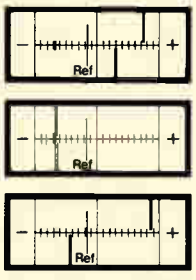
Greater Flexibility

And even greater flexibility. Switch any channel to unipolar, and the full dynamic range becomes available to either positive or negative going signals. Switch any channel to offset, and you can record a 100 mV peak-to-peak signal on a 20 V step–without losing any dynamic range.



DUAL STANDARD FM SIGNAL CIRCUITS

a quick switch to wideband.



Proven Success

All these outstanding new advantages have been added to the host of features which have made the existing range such a success–like single switch seven-speed selection, full servo operation, dual peak-indicating meters, full remote control of all functions, portability, and operation from AC or battery power sources.

That's why, by switching to the Racal Recorders' new Store DS range, you can make a quick switch to a whole new wideband world.

Racal Recorders Limited Hardley Industrial Estate,
Hythe Southampton Hampshire SO4 6ZH England
Telephone: 0703-843265 Telex: 47600.

Racal Recorders Inc 5 Research Place,
Rockville Maryland 20850,
Telephone: (301) 948 3085.

Racal Recorders Inc, 1109 West San Bernardino Road,
Suite 110 Covina California 91722
Telephone: (213) 967 2869.

Racal Recorders Always on the right track

RACAL

Circle 175 on reader service card

that can read such codes even if the distance between bars is as little as 8 mils. Furthermore, the entire sensor—light-emitting diode, photodetector, and precision optics—fits into a small TO-5 package of metal and glass.

The sensor, which the manufacturer states can read any color-bar code now on the market, emits a near-infrared light with a wavelength of 700 nm. The light is created by the 7-mil-diameter LED and is focused on the image plane by half of a bifurcated plastic lens; the plane can be anywhere from 150 to 190 mils from the lens to maintain the 8-mil resolution.

The other half of the lens gathers the reflected light and projects it onto the photodetector. The response rate of the photodetector depends on the rate at which charge is created by light impinging on it; hence the actual operating rate depends on the reflectivity of the image plane. For a specular surface, the unit can operate at speeds up to 1 MHz.

In addition to reading bar codes,

the HEDS-1000's resolution and operating speed suit it for other pattern-recognition applications. Industrially, they could be employed for counting, sorting, edge sensing, tachometry, and sizing, as well as for detecting surface flaws. Where space is critical, they should be particularly attractive to designers of, say, printers, plotters, and copiers. The

CANNON. THE SOURCE.

Cannon KJL/KJ Connectors.

Your ITT Cannon Electric distributor has an in-store supply of Cannon KJL Series I and KJ Series II connectors for your MIL-C-38999 requirements.

High reliability connectors with superior contact stability secured by the Super Caesar™ rear release contact retention assembly.

A design variety for temperature environments from -85°F to +392°F with nine shell sizes each series. Fifty-nine contact arrangements from 3 to 128 contacts. All contacts adaptable to AWG wire sizes 16-28 and easily installed by simple and fast customer tooling to lower your total installed cost.

So when you need KJL and KJ connectors, remember the source. ITT Cannon.

For more information contact your local distributor. Or write to: Product Manager, Circular Division, ITT Cannon Electric, 666 East Dyer Road, Santa Ana, CA 92702. For 24-hour service, call toll-free (800) 854-3573; in California (800) 432-7063.

For all your Cannon connector needs see the EEM directory.

Six decades on the leading edge of interconnect technology.

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Lukwila
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WISCONSIN
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Wisconsin
West Allis
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Circle 179 on reader service card

New products

HEDS-1000 operates from a single 3.5- to 20-V supply and is priced at $18.50 per unit for 100 or more. Delivery is from the distributor's stock.

Hewlett-Packard Co., Inquiries Manager, 1507 Page Mill Rd., Palo Alto, Calif. 94304 [373]

Pressure transducer conditions signals

The 140PC is a solid-state pressure transducer that provides a fully conditioned output signal for absolute, differential, or gauge-pressure readings in the range from 0 to 30 psi. It offers exceptionally high repeatability and low hysteresis, according to the manufacturer, and provides readings that are stable to within 1% of the full-scale output over an 80°C range.

The 1-oz unit contains a 0.1-in. silicon chip with ion-implanted resistors that sense the flexing of an etched diaphragm at the chip's center. The resistors' outputs are amplified by thick-film circuitry that compensates for temperature-induced errors.

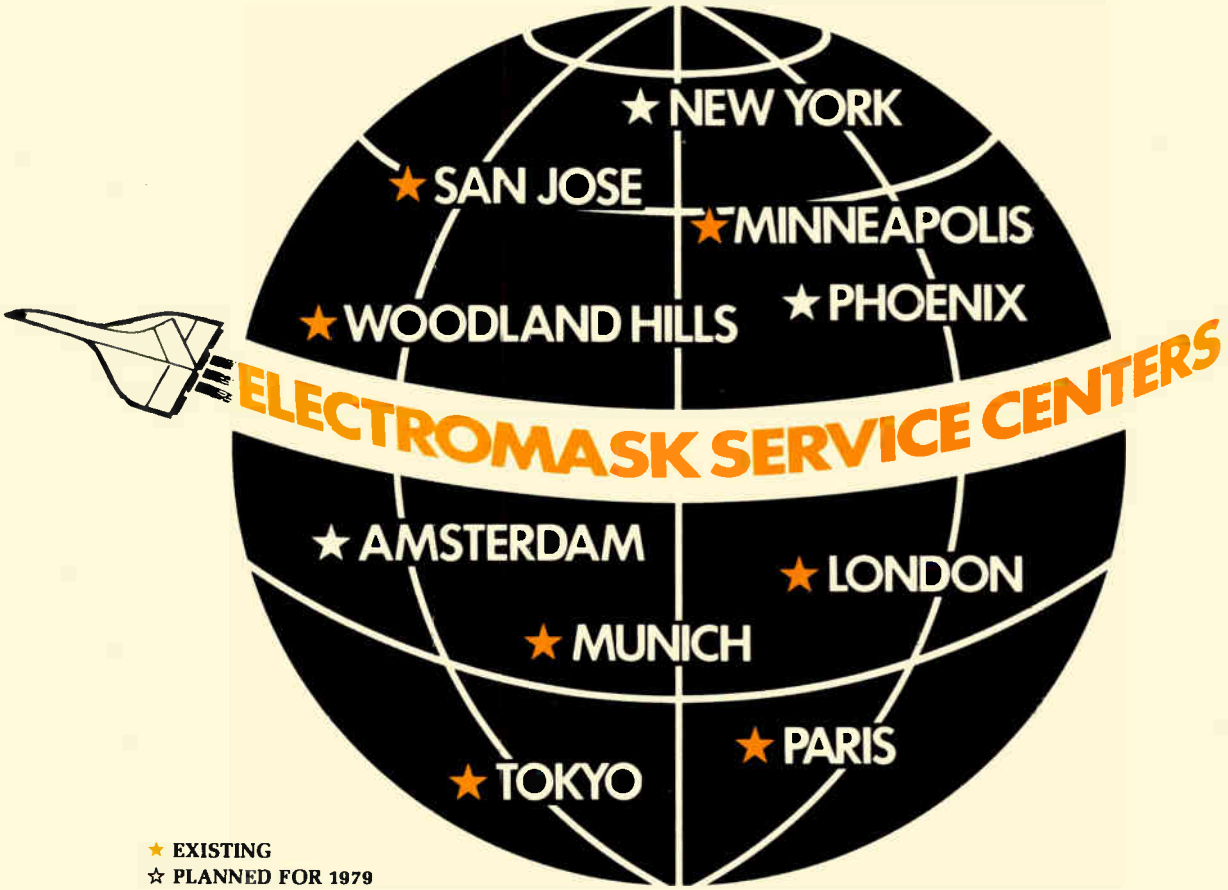
The 140PC is available in versions that will respond to maximum pressures of 1, 5, 15, or 30 psi. Its dc voltage output is ripple-free and

responds to input changes in 1 ms or less. A supply voltage ranging from 8 to 20 V dc, from which it will draw a maximum of 20 mA, will power the transducer.

Operable over the range from −55° to +125°C, the transducers sell for $37 apiece in quantities of 500 or more.

Micro Switch Division, Honeywell Inc., 11 W.

AROUND THE WORLD, YOU CAN COUNT ON ELECTROMASK SYSTEMS AND ELECTROMASK SERVICE.



★ EXISTING
☆ PLANNED FOR 1979

When you build sophisticated IC maskmaking and wafer stepping systems and ship them to the far corners of the world, you better back them up with service. That's why at Electromask we have positioned five service centers in the United States, four in Great Britain and Europe, and one in the Far East.

No systems are built to be more reliable than ours. We also employ a double acceptance-test procedure – testing both before shipment and after installation. But, although no systems have a better record in the field than ours, in time any sophisticated system is going to need some service. When that time comes for your Electromask system, you can be sure that no matter where it is located – an Electromask factory-trained service specialist can be on his way immediately.

But there's more. Our service specialists are based in the field at our service centers near our major system installation concentrations. So there is one near you. And we regularly bring our service specialists back to the factory for a refresher training course. So they maintain their expertise even on our newest systems. All our service centers stock the spare parts needed to keep your system on line. As a further convenience, we have arranged for the computer consoles of our systems to be serviced by the worldwide offices of the computer manufacturer, Hewlett-Packard. So from San Jose to Tokyo, if it's an Electromask system, you've got expert and reliable service at your door.

For the full story on the Electromask one-year warranty and the optional follow-on parts-and-labor service contract, use the reader service card or contact us directly.

Electromask, Inc., a subsidiary of the TRE Corporation, 6109 De Soto Avenue, Woodland Hills, California 91367. Phone: (213) 884-5050, Telex 67-7143.

TRE
ELECTROMASK

Circle 181 on reader service card 181

Spring St., Freeport, Ill. 61032. Phone (815) 235-6600 [374]

System measures movement with LEDs and cameras

A noncontact system for measuring the coordinates of multiple points, the Selspot optoelectronic movement-monitoring system uses a highly linear photodetector that is sensitive to the position of light-emitting diodes attached to the object under study.

Up to 30 infrared LEDs can be attached to the subject. Their light is focused by a 50-mm 1:0.95 lens system into the camera containing the photodetector. Two cameras may be used to monitor movement in three directions, and the system is capable of making up to 10,000 readings per second.

Signals from the camera are

processed by a main unit that provides both computer- and oscilloscope-compatible outputs. Options include an external power supply and a four-camera multiplexer unit.

Selective Electronics Inc., Dept. P-D, P. O. Box 100, Valdese, N. C. 28690. Phone Rolf Svensson at (704) 874-2289 [376]

Sensors note excessive rise or fall in liquid or gas flow

The FS-920 series is composed of flow switches designed to detect excessive or insufficient flow in liquid or gas systems. Units are available in two versions: one which can be set to activate at a point in the range from 0.1 to 1.5 gal/min and another settable in the range

Now OEM's can draw high quality graphics even when the bottom line is price.

Graphics gives you the best way to analyze and communicate data. But cost has been keeping it out of the picture for many OEM systems. That's why Hewlett-Packard is offering the new Model 7225A Graphics Plotter.

The price: $1750 (domestic USA price with 17602A general purpose "personality" module), in quantities of five. With further OEM discounts from there.

Plug-in "personality modules" customize the plotter for you.

HP's versatile 7225A converts the output of processor based systems into high quality charts and graphs in any size up to 8½ x 11" (A4). A wide selection of plug-in "personality modules" lets you adapt the plotter to suit your needs. Different modules determine interface hardware, language, and capabilities such as internal character sets, axis generation, labeling and scaling.

Simple linear stepping motors eliminate many moving parts to assure reliability. Visually smooth, high resolution ink lines of any length and angle are generated, requiring only end point data.

And you give your customers the confidence of Hewlett-Packard's worldwide service network.

So if you want high quality graphics but you draw the line at price, look into the Model 7225A Graphics Plotter. For a detailed 24-page OEM brochure, contact Hal Phillips at Hewlett-Packard, 16399 West Bernardo Drive, San Diego, CA 92127; (714) 487-4100. 11901

HEWLETT hp PACKARD

1501 Page Mill Road, Palo Alto, California 94304

For assistance call: Washington (301) 948-6370, Chicago (312) 255-9800, Atlanta (404) 955-1500, Los Angeles (213) 877-1282

Circle 183 on reader service card

Analog LSI testing

Giving an Eye to Laser Trimming.

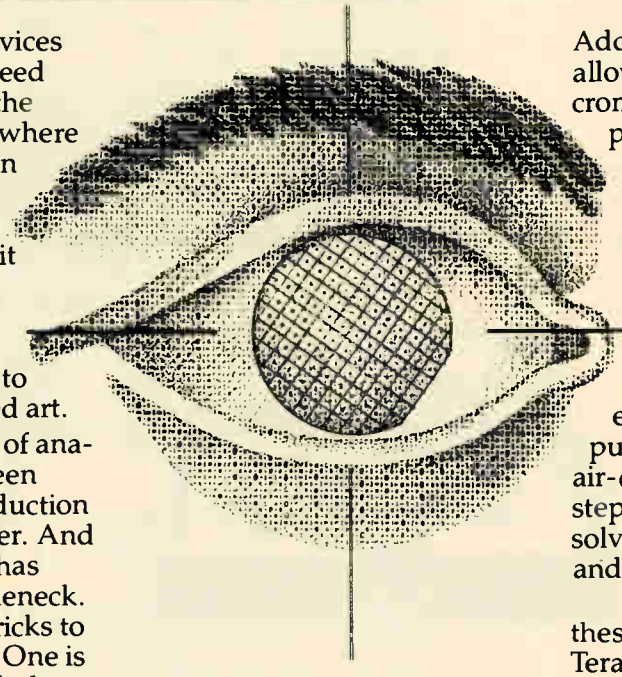
Today's monolithic devices demand a new order of speed and accuracy throughout the entire test routine, and nowhere is that more evident than in the laser trimming operation.

Here, increasing circuit densities and the growing number of capabilities assigned to individual dice have raised trimming to the status of a highly skilled art.

However, the growth of analog LSI applications has been accelerating, pushing production demands higher and higher. And this means that trimming has become an expensive bottleneck.

There are really two tricks to removing that bottleneck. One is to find a laser trimmer with the precise positioning accuracy, the small spot size, the speed and reliability to operate on complex analog LSI devices with minimum human involvement.

The other trick is to obtain that kind of trim capability integrated into a high-volume analog LSI test system. For only in such a trim/test combination can those superior trim specifications be put to their most effective use.



Teradyne, a pioneer in monolithic trimming and the acknowledged leader in linear test equipment, recognized early on the need for combining both trim and test functions in the same system. The result of that leadership and concern, the Monolithic Adjust systems in our new A300 Analog LSI Test/Trim family, are the semiconductor industry's first systems expressly designed for monolithic trimming and testing.

Among the A300's most critical innovations is the *LASER EYE*. An automatic edge sensing capability that seeks out the location of resistors and other elements, the *LASER EYE* positions the beam regardless of wafer orientation, with an accuracy better than 2.5 micrometers, relative to circuit features. Additionally, the *LASER EYE* allows resolution down to 1 micrometer, and system optics permit beam waists of 6 micrometers.

At the system's heart, computer-controlled and perfectly synchronized, are a fast, highly reliable galvanometer beam positioner, a YAG laser with excellent pulse-to-pulse stability, and an air-cushioned Sawyer-motor step-and-repeat handler that solves the problems of wafer warp and thickness variation.

Excellent predictability in these components, coupled with Teradyne's traditionally high vibration immunity, has produced a stable and reliable system, easily and quickly verified by glass grid auto-calibration, traceable to NBS. The end result of all that reliable accuracy is a uniformity of trimming, from wafer to wafer and from trimmer to trimmer, that is truly unprecedented.

If you would like more information on the A300 Analog LSI Test/Trim Systems, write Teradyne, 183 Essex Street, Boston, MA 02111.

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leads the way in hybrid data conversion.

As a pioneer in hybrid technology with over 16 years of data conversion experience, DDC has the circuit design and manufacturing capability to meet your most advanced hybrid data converter requirements.

In synchro and resolver converters, DDC has the only line of hybrids available *anywhere*. And in A/D, D/A converters, DDC has a broad line of the most advanced hybrids. For custom requirements, DDC has complete capability, from circuit design through fabrication and testing, to produce fully qualified hybrids to meet your specifications.

All DDC hybrids are processed to MIL-STD-883B and MIL-M-38510D, so they're suited for extreme environments in military and industrial applications.

To learn more about how DDC's engineering organization and hybrid capability can help you, contact us today. Our applications engineers are prepared to discuss your requirements in detail.

DDC

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A Wholly Owned Subsidiary of ILC Industries, Inc.

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ILC Dover—Sole designer and manufacturer of Apollo and Shuttle space suits

Circle 187 on reader service card

the tasa

Micro Proximity Keyboard

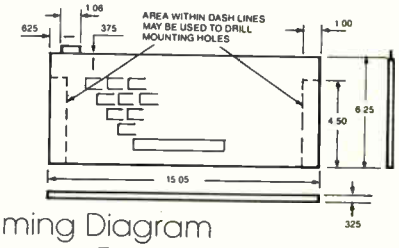
"THE DISHWASHER SAFE PLASTIC BRICK"

Full electronic keyboard, 128 ASCII output codes; 8 bit plus strobe, TTL compatible (or CMOS with pull-ups); connect directly to the data bus. Designed for large scale manufacturing and priced accordingly.

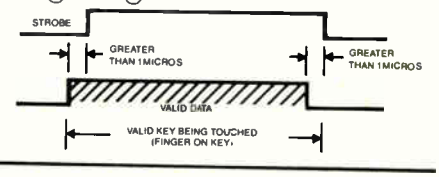
Available off-the-shelf in this standard evaluation configuration, this totally new solid state keyboard can be easily customized by TASA to your requirements.

If you haven't yet evaluated our micro proximity control technology for your application, you may be four months behind your competition.

Mechanical Outline



Timing Diagram



ORDER ONE NOW

Evaluation units, $80 each (prepaid UPS) plus appropriate sales tax for California residents; optional stand (as shown), $15. Master Charge or Visa accepted on phone or mail orders (include number and expiration date).

tasa

Touch Activated Switch Arrays, Inc.
2346 Walsh Avenue, Santa Clara, CA 95050, (408) 247-2301 TWX 910-338-7620

188 Circle 188 on reader service card

When you need rockers & toggles or more than rockers & toggles...

Come to the people who've always been specialists in having more good ways to solve problems: Dialight. What we've done in indicator lights, illuminated switches, readouts and LEDs, we're doing now in miniature rockers and toggles.

This new Dialight family of switches, which comes in a full range of sizes is, we're proud to point out, all-American made.

When you consider all the configurations of styles, sizes, life and safety ratings, colors and mountings, you'll find there are literally hundreds of thousands of design combinations. Such a number of possibilities can in itself be a problem, except that the new Dialight catalog is specifically designed to prevent confusion and help you quickly and easily find the most advantageous combination of features for your applications.

If you'd like to see what Dialight quality rockers and toggles can do for the looks, durability and economics of your products, contact us today for the Dialight "Meets Your Need" Book. Your free copy will include a list of stocking distributors in the U.S. and Canada.

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A North American Philips Company

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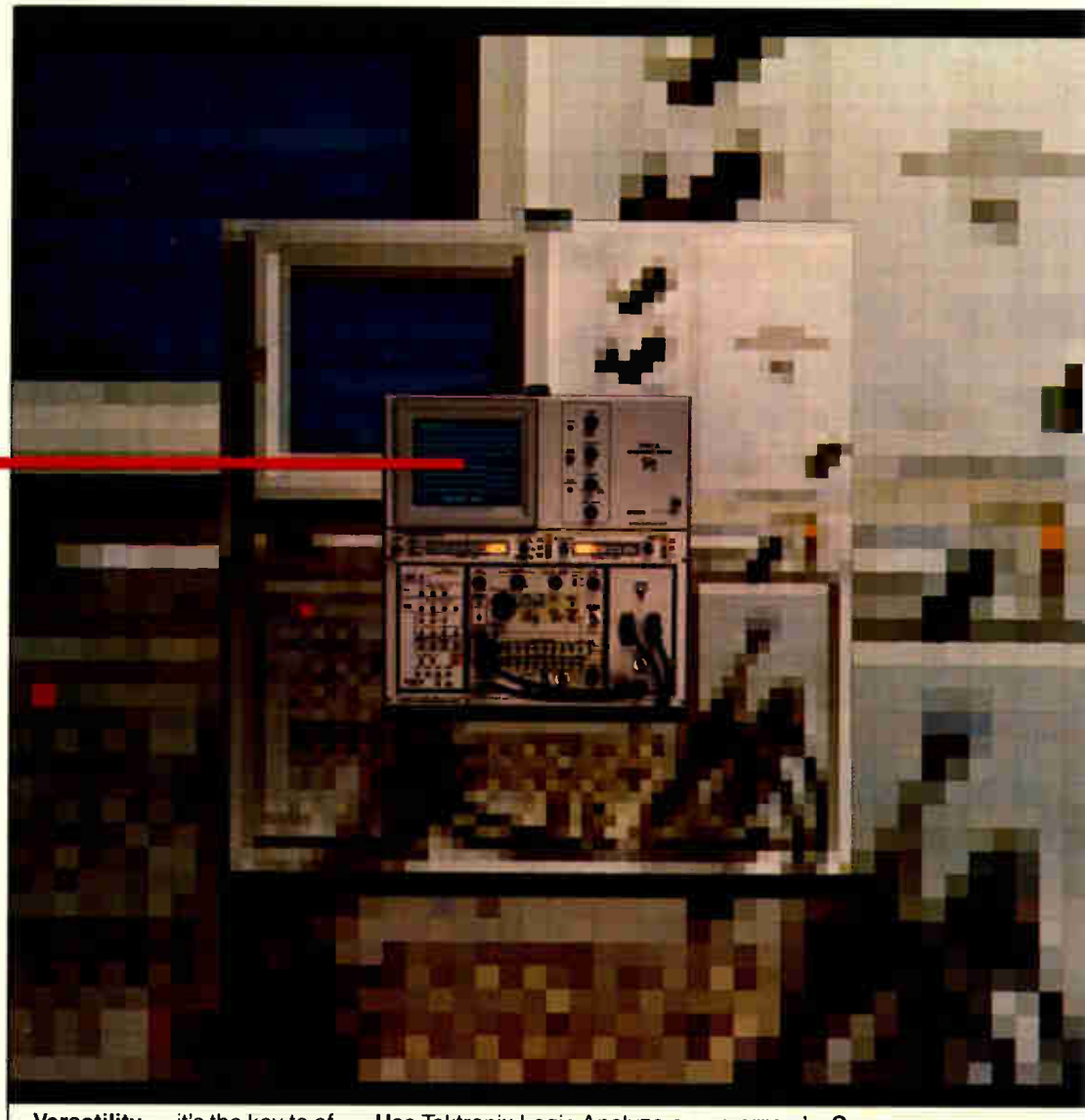
Dialight meets your needs.

Dialight, 203 Harrison Place, Brooklyn, N.Y. 11237 (212) 497-7600

Circle 189 on reader service card

TEKTRONIX thinks your logic analyzer should be as versatile as you are

So ours let you sample with *speed.* With *resolution.* With *confidence.*



Sample with confidence: up to 100 MHZ at 15 ns resolution

Versatility — it's the key to effective, efficient digital design. You've got to be versatile enough to make a variety of measurements every day. And so you need an equally versatile logic analyzer.

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TEKTRONIX LOGIC ANALYZERS THE VERSATILE ONES

Microcomputers & systems

Software meshes two ICE units

Package makes multiprocessing systems easier to build and repair

Multiprocessing, the use of more than one computer to solve a problem, is recognized as a key for unlocking powerful system capabilities. And microprocessors, with their small size and low cost, make this prospect all the more attractive.

There are reasons why multiprocessing is not practiced more often, however. Difficult as it is to design such a system, it is even more arduous to develop and test the hardware and software, mainly because of inadequate tools. The application of in-circuit emulation to a two-microprocessor system, for example, has forced designers to employ two independent development systems. This not only fragments the development process, it makes fault isolation, diagnosis, and repair a real hurdle—especially when programs must be intertwined for real-time execution.

In contrast, Intel Corp.'s Multi-ICE software package enables a single Intellec development system to control and coordinate the operations of two in-circuit emulators (ICEs). The two cooperating ICE subsystems suffice for most systems containing multiple microcomputers. Multi-ICE at present allows the concurrent use of two ICE-85 units or an ICE-85 and the new ICE-49 unit. ICE-85 is for designs based on the 8085 microprocessor, while ICE-49 will emulate the 8049, 8048, 8748, 8039, 8035, and 8021 single-chip microcomputers. Other combinations of chips will be supported at a later date.

Multi-ICE uses an interactive language, with commands in English, to provide a common syntax for the in-circuit emulators. Within this simplified framework, macro commands, and assembly-language displays, as well as symbolic and other advanced debugging techniques, are easily accommodated.

Three processes—one host and two ICE processes—are executed by the Multi-ICE package to create a software interface between user and system. The user communicates with the host process at the Intellec console to create execution lists for all three processes. Commands can also originate from diskette files. Overall coordination is managed by a dispatcher software subsystem, which determines the sequence in which tasks should be performed to carry out the commands. Software synchronization is also provided to start and stop the two in-circuit emulators.

Multi-ICE is available on single- and double-density diskettes for the Intellec MDS-800 and Series II model 220 and model 230 development systems. The package can also be used to upgrade earlier Intellec systems if they are equipped with peripheral diskettes. The software runs under the ISIS-II diskette operating system and costs $1,750. Deliveries of both the ICE-85/ICE-85 and ICE-85/ICE-49 versions will begin this month.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. Phone (408) 987-8080 [391]

Executive program orders system operation to events

Controlling an industrial process is like juggling with elephants—not only is it hard work, but if your timing is off you're in big trouble. So now that microprocessors are getting into the act, Systems & Software Inc. has designed an executive program for the 8080, 8085, and Z80 that is sensitive to the requirements of real-time interrupt processing, one that is driven by events.

Called the REDX-80, the program's fundamental units are user-defined tasks. Up to 16 tasks can share the operating system's resources at one time. Each task is

New products

assigned a two-character name and a priority level that covers the range from a low of 0 to the highest, 7.

The tasks are activated or suspended by stimuli called events, which are task-associated operations such as intertask communications using software channels, interrupt input/output processing through hardware channels, or time-relevant requests.

Each task can identify up to 16 events associated with it using flags, allowing such events to proceed concurrently and asynchronously with it. The tasks can be resynchronized with the events by making them wait for the event flag. Because of this scheme, the processing of the task and its use of system resources can be based on the actual processing requirements of the controlled system, as reflected in the priority structure developed by the user.

Separate versions are provided for use with Z80-based systems and those using 8080 or 8085 devices. Both are available in either ISIS-II relocatable object format or in RT-11/RSX-11M, and other formats can be provided upon request. The package contains the REDX-80 system module in object or source form and a macro library that contains the system directives for using the utility as well as assembly-time directives for building tasks. Also included in the package are a reference manual and application notes.

The single-use, nonexclusive license fee for the package is $1,500 and the source code may be purchased for a one-time charge of $7,500. A fee of $1,500 purchases a one-year update service, and training in the operation and application of the REDX-80 executive program is also available.

Systems & Software Inc., 2801 Finley Rd., Suite 101, Downers Grove, Ill. 60515. Phone (312) 932-9320 [393]

Single boards link LSI and PDP computers

Coupling computers to increase processing power, long the province of

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Data I/O's new gang module programs eight NMOS EPROMS at once! (Now that's an offer you can't refuse.)

Our new Gang Module fits neatly into the Data I/O System 19 and System 17 to give you production programming capability at surprisingly low cost.

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Worry free programming. Before any devices are programmed, the module conducts a blank check and an illegal bit check. After programming, the unit verifies the data in each device against the data in the RAM. If any test fails, the LED below the affected device lights up.

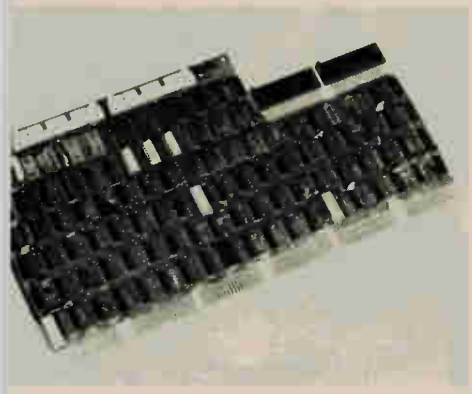
And with the Data I/O gang module, you can verify the data in all eight devices at once after burn in—an advantage not available on some programmers.

No matter what your production needs, talk to Data I/O. Besides our new Gang Module, we offer the unique Model 16—a sophisticated, high production unit for MOS devices.

You haven't shopped around until you've looked at Data I/O. Let us show you the difference. Circle the reader service number or contact Data I/O, P.O. Box 308, Issaquah, WA 98027. ***For answers fast, call toll free: 800-426-9016.***

Good idea! DATA I/O

Programming systems for tomorrow...today



mainframe users, is now possible for owners of LSI-11 or PDP-11 microcomputers. The Interlink/LSI provides a direct-memory-access interface and a Q-bus link to permit systems up to 50 ft apart to transfer data at the maximum Q-bus rate.

The quad-width board is transparent to software and takes up only one space in an LSI-11. It can also be used in conjunction with an Interlink/UNI to attach an LSI-11 to other models of the PDP-11 series. The Interlink/UNI is a hex-width board with similar capabilities that fits into a single PDP-11 slot. It can be used with other PDP-11 systems to provide data transfers at rates up to 500,000 words per second.

The Interlink/LSI and the Interlink/UNI are priced at $795 and $1,500 respectively. Both boards are available from stock.

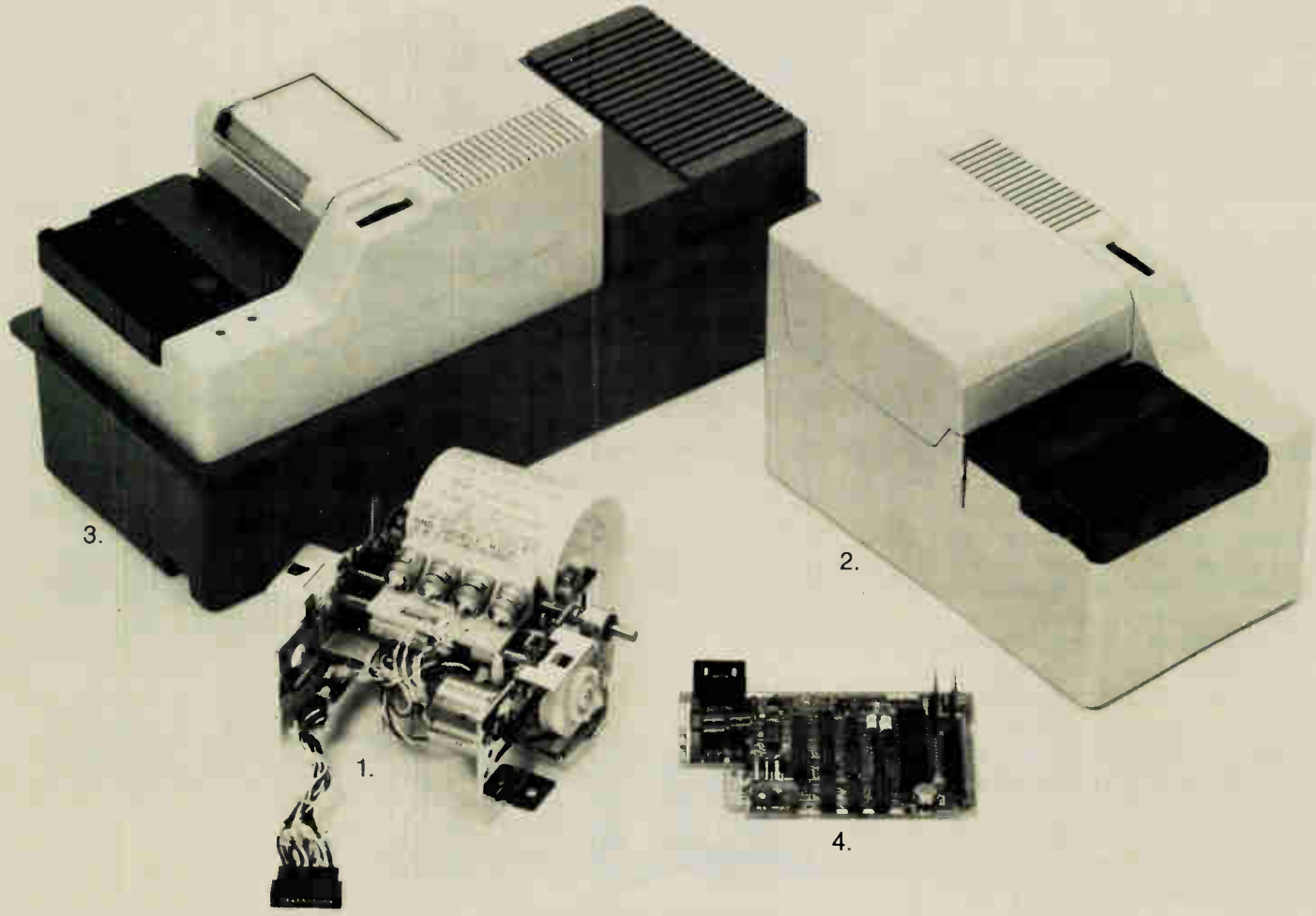
Able Computer, 1751 Langley Ave., Irvine, Calif. Phone (714) 979-7030 [394]

Board gets Z80 systems and IEEE-488 bus together

The GPIB board fits into any MCZ or PDS card cage, providing Z80-based microcomputers with an interface to the IEEE-488 instrument bus. The board, which contains its own Z80, can let the system act as a bus controller or provide it with talker or listener capabilities. Furthermore, the board can be used to provide any instrument with IEEE-488 compatibility.

In addition to the Z80 processor, the board contains 2 kilobytes of erasable programmable read-only

Have it your way



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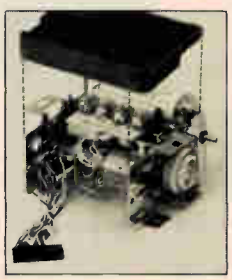

- Works as printer and/or plotter because of unique single wire design
- Multiple copy capability
- Prints up to 120 lines per minute
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(607) 273-6066.

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Circle 198 on reader service card

New products

when the system is turned on.

The high-level language it uses is a version of Basic expanded for solving business problems. Packaged with the system is The Controller, software consisting of three program modules: general ledger, accounts receivable, and accounts payable.

The general ledger module maintains a file of up to 250 types of accounts with up to $99 million in any one. Up to 1,000 entries can be made monthly. The accounts receivable module keeps files of up to 250 customers and will process up to 1,000 invoice statements of $99,000 maximum. The accounts payable subprogram keeps tabs on 100 vendors and can accept 300 monthly invoices for up to $99,000. The software will generate reports, mailing lists, invoices, and checks.

Apple Computer Inc., 10260 Bandley Dr., Cupertino, Calif. 95051. Phone Jean Richardson at (408) 996-1010 [398]

Triple-output power supplies tailored to microprocessors

Designed to support microprocessor applications, four additions to the RS/RT series of power supplies feature main and secondary 5-V outputs and a 12- or 15-V output. The 150-W models sell for $415 in quantities of one to nine and the 300-W versions are priced at $525 in the same quantity. Delivery is from stock.

Acdc Electronics Division, Emerson Electric Co., 401 Jones Rd., Oceanside, Calif. 92054. Phone Chris Edman at (714) 757-1880 [399]

Best by test after test.

You're doubly sure of quality with twice tested Buss® fuses.

This small dimension glass tube fuse may look good to you. And to us. But looks aren't enough at Bussmann.

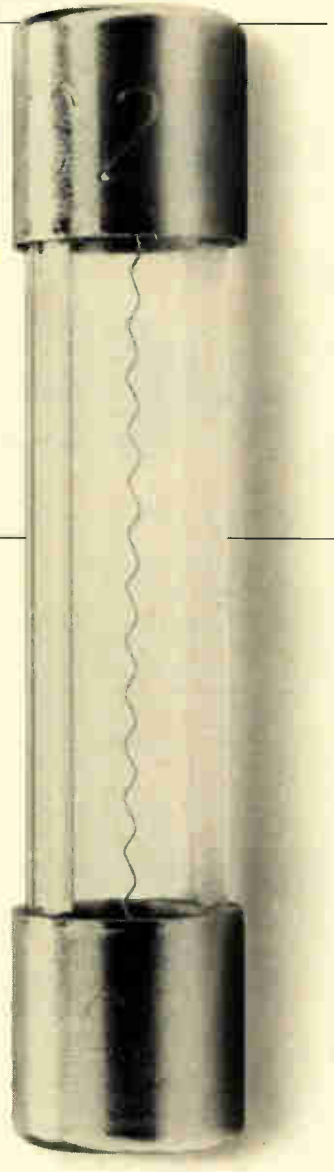
That's why Bussmann quality control involves more than a quick visual inspection. Or testing a random sample from our production line.

Instead, Bussmann tests every one of these fuses twice. Once for resistance, to measure electrical performance. Then again for dimensions, to make sure the length and diameter are right.

Few manufacturers test each and every small dimension glass tube fuse they make. Even fewer test each fuse both physically and electronically.

Our tougher testing assures that the Buss fuses you buy will perform exactly the way you want them to. When you want them to.

It also explains why Buss fuse quality is in a class by itself.



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Tone Receivers, two ways from two sources.

Two tone receivers with versatile performance capabilities are available from two sources, ITT and Mitel.

Both offer the 88205 single package Hybrid DTMF Receiver System.

Or ITT's 3044 and 3045 DTMF group filters, along with additional limiter circuitry, can be used with Mitel's MT 8820 — or any other similar decoder chip — to design your own tone receiver.

You will find all of these components to be of high quality, and packaged with reliability to meet your most stringent demands. Specify them for your next central office, PABX, key system, mobile paging system or signaling application.

For more information, contact: ITT North Microsystems Division, 700 Hillsboro Plaza, Deerfield Beach, Florida 33441. Phone: (305) 421-8450, TELEX & TWX: 510-953-7523.

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Circle 201 on reader service card

Micro power

R6500 any way you like it. That's Rockwell Micropower!

Rockwell's R6500 microcomputer system consists of a family of ten software-compatible CPUs featuring 13 powerful addressing modes.

You get general-purpose I/O, communications interface, standard memory, and combination memory-I/O-timer circuits. Our intelligent peripheral controllers provide cost effective software/hardware tradeoffs. And there's even a single-chip R6500/1 microcomputer.

R6500 CPU Options

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

To give you a headstart in microcomputing, AIM 65 (R6500 Advanced Interactive Microcomputer) puts a terminal style keyboard, 20-character alphanumeric printer and display, cassette interface, and more at your fingertips for only $375.

To put your design effort in high gear, Rockwell's SYSTEM 65 is a powerful, easy-to-use development system with two integral mini-floppy disk drives. High level PL/65 language designed to increase programming productivity is also available.

More to choose from in 1979 from the fastest selling microprocessor in 1978. That's Rockwell Micropower.

For more information, contact Department 727-F2, Microelectronic Devices, Rockwell International; P.O. Box 3669; Anaheim, CA 92803, or phone (714) 632-3729.

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For more information on: Intel circle 203, Motorola circle 261, Texas Instruments circle 262, Dec circle 263, Mostek circle 264, Pro-Log circle 265

Computers & peripherals

Disks driven to long life

Double-sided, double-density floppy-disk drive yields media life of 3×10^6 passes

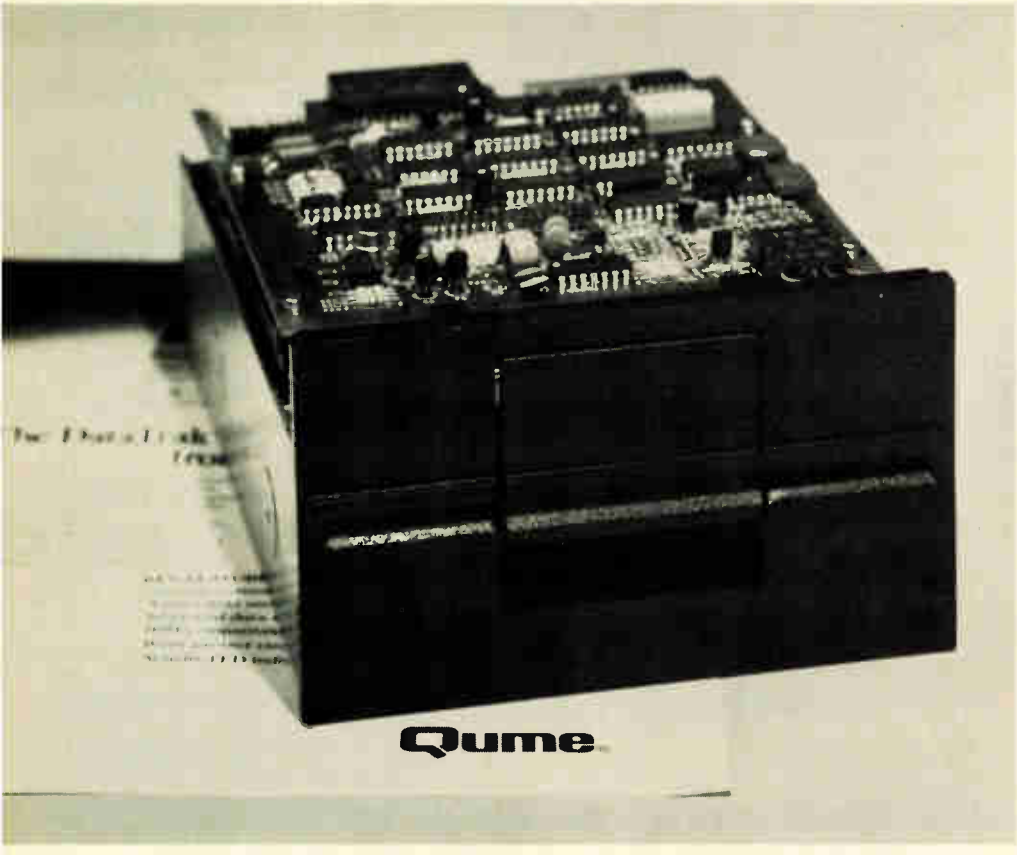
Dead disks don't deliver dependable data. And that goes for 5-inch floppies as well as for the 8-in. units. Qume Corp. has therefore taken the proprietary head-assembly design, which it first introduced on its DataTrak 8 drive, and applied it to a drive designed to work with 5.25-in. flexible disks. Called the DataTrak 5, the new drive is a double-sided, double-density unit that Qume says attains a recording-medium lifetime in excess of three million passes per track.

Unveiled at the National Computer Conference in New York earlier this month, the DataTrak 5 drive has an unformatted capacity of 437.5 kilobytes and a formatted capacity of 286.7 kilobytes. Its recording density is 5,456 bits per inch, and its data-transfer rate is 250 kilobits per second. Track-to-track access time for the 70-track drive is 20 ms, settling time is 15 ms, and average access time is 241 ms. Head loading, which is independent of media loading, takes only 50 ms.

In addition to its wear-reducing head design, the DataTrak 5 has a door-closure lockout that further protects the disk against damage. The lockout prevents the drive door from being closed if the disk is not properly inserted.

The drive requires only 12 W of power in continuous operation. It will work from either +5- or +12-V dc supplies. The unit sells for $465 in singles and will be available in production quantities in the third quarter of this year.

Qume Corp., P. O. Box 50039, San Jose, Calif. 95150. Phone Gail R. James at (408) 942-4000 [361]



NECIS introduces advanced Winchester disk family

NEC Information Systems, the Nippon Electric Co. subsidiary, has introduced a series of three high-performance disk storage subsystems based on an advanced Winchester-type design. Called the D-1200 series, the family comprises the 20-megabyte model 1210, the 40-megabyte model 1220, and the 1240, which has an 80-megabyte capacity. Four features cited by the manufacturer as particularly important for the American OEM market are high speed, field expandability, small size, and high reliability.

The speed specifications include a latency time of 8.3 ms, an average seek time of 40 ms, and a data-transfer rate of 1.2 megabytes per second. Field expandability is provided for the two smaller units in the family—each can be upgraded at a user's site in a few minutes by a field engineer. As their field-expandability implies, the three units are the same size: 17 in. wide by 10 in. high by 28 in. deep. They fit in standard 19-in. racks and weigh 99 lb. According to the company, the D-1200 units have a mean time between failure of 10,000 hours and a mean time to repair of 30 minutes.

OEM quantity pricing for the subsystems starts at $2,950 for the model 1210, $3,300 for the 1220, and $3,870 for the 1240. Delivery time is 60 days.

NEC Information Systems Inc., 5 Militia Dr., Lexington, Mass. 02173. Phone Douglas Campbell at (617) 862-3120 [364]

Fast cartridge system loads Winchester disk in 7 min.

Intended for archival storage in disk-based small business systems and the like, the Streaming Microtape cartridge ¼-in. tape drive accepts and puts out a stream of data at a 576-kilobit/s transfer rate. Thus it can store or restore the contents of a Winchester-technology fixed-disk drive in 7 minutes. Total capacity is

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D-8300 LANDSHUT-FEDERAL REPUBLIC OF GERMANY-TELEX 0 58 335 (erola)

Circle 205 on reader service card

New products

30.2 megabytes per cartridge.

To achieve an error rate of better than 1 in 10^{10} bits (less than one error in every 30 cartridges), the Streamer has internal error correction. It can read or write at 90 in./s without stopping between data blocks.

Also available is a stripped-down version, the Streaker, which can transfer data at 648 kb/s and has a total capacity of 34 megabytes per cartridge. It does not offer error correction.

Both of the new cartridge tape drives feature a data density of 6,400 bits per in. on standard ANSI/ECMA ¼-in. tape cartridges, as do earlier products in the Microtape line. They both use a seven-track bidirectional head. The Streamer fits into a 7-by-7-in. opening, requiring an 8-in. depth; the Streaker is not quite as high as the Streamer.

In effect, the Streamer and Streaker are first-in, first-out memories. They share the speed advantages of much more expensive tape drives, but they save money because they eliminate the fast start/stop operation necessary for random-access retrieval.

The Streamer will cost $1,219 in original-equipment-manufacturer quantities and will be available in mid-August. The Streaker costs $885 in OEM quantities and will be available in July.

Data Electronics Inc., 370 N. Halstead St., Pasadena, Calif. 91107. Phone (213) 351-8991 [362]

Tape system takes aim at DEC TM11-TU10

The PM-TS11 magnetic-tape subsystem from Plessey Peripheral Systems is compatible with Digital Equipment Corp. diagnostics and software and is intended as a direct replacement for DEC's TM11-TU10 tape system. A choice of non-return-to-zero or phase-encoded formats is provided by the PM-TS11 as are seven-track 4-4-4-4, IBM, and DEC byte packing for dumping memory.

To ensure accurate data transfers, the PM-TS11 employs a combination of vertical, longitudinal, and cyclic redundancy checking for NRZ formats, as well as single-track error correction in phase-encoded formats. The tape system can be set up to offer the user a choice of one of two of the following operating speeds: 12.5, 25, 37.5, 45, 75, and 125 inches per second.

Single-unit prices start at $5,874 for a 45-in./s, NRZ-only drive. Delivery time is 30 days.

Plessey Peripheral Systems, 17466 Daimler, Irvine, Calif. 92714. Phone Gerard Mottier at (714) 557-9811 [365]

CRT terminal is compatible with DEC's VT-100

First in the series 80 line, the DT80/1 is a cathode-ray-tube terminal that is fully compatible with Digital Equipment Corp.'s popular VT-100 video terminal. The unit can work independently as data is transmitted to an on-line printer, be used to control the printer's operation, or feed data to a printer from its CRT screen.

The self-diagnosing terminal has a detachable keyboard and can display 24 lines of 80 or 132 characters. Users can scroll through pages in either direction and can underline and blink characters or display them at two different levels of intensity.

NOW YOU CAN HAVE THE DISPLAY CIRCUITRY FOR A CRT TERMINAL YOUR WAY.

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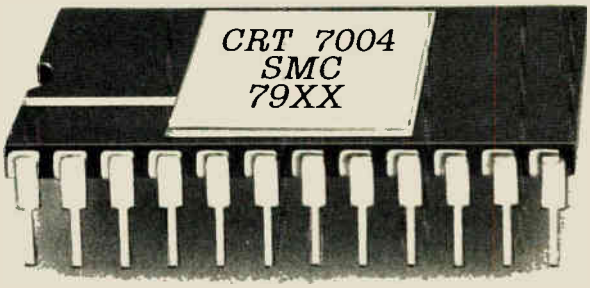
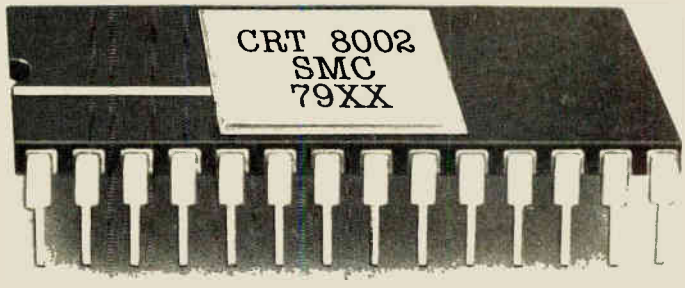


CRT 7004 $14.00*

FEATURES

On chip character generator (mask programmable).
128 Characters • 7 x 11 Dot matrix block.
On chip video shift register.
Maximum shift register frequency.
CRT 7004A 20MHz • CRT 7004B 15MHz
CRT 7004C 10MHz • Access time 400ns
No descender circuitry required.
On chip cursor.
On chip character address buffer.
On chip line address buffer.
On chip horizontal and vertical retrace video blanking.
Single +5 volt power supply.
TTL compatible.
MOS N-channel silicon-gate COPLAMOS® process.
CLASP® technology.
Compatible with CRT 5027 VTAC®
Enhanced version of CG5004L-1.

OR WITH THE WORKS.



CRT 8002 $24.00*

FEATURES

On chip character generator (mask programmable).
128 Characters • 7 x 11 Dot matrix block.
On chip video shift register.
Maximum shift register frequency.
CRT 8002A 20MHz • CRT 8002B 15MHz
CRT 8002C 10MHz • Access time 400ns
No descender circuitry required.
On chip cursor.
On chip address buffer.
On chip attribute buffer.
On chip horizontal and vertical retrace video blanking.
Single +5 volt power supply.
TTL compatible.
MOS N-channel silicon-gate COPLAMOS® process.
CLASP® technology–ROM and options.
Compatible with CRT 5027 VTAC®
Four modes of operation (intermixable).
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Wide graphics • Thin graphics •
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Reversible video • Character blank
Character blink • Underline • Strike-thru
Four on chip cursor modes.
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Reverse video • Blinking reverse video
Programmable character blink rate.
Programmable cursor blink rate.
Expandable character set.
External fonts • Alphanumeric and graphic RAM, ROM, and PROM.

*price for 100 unit quantity, "B" version in ceramic package.

STANDARD MICROSYSTEMS CORPORATION

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We keep ahead of our competition so you can keep ahead of yours.

Circle 207 on reader service card

New products

Reverse video is also keyboard-selectable.

Internally, the DT80/1 houses a CRT controller with two serial input/output ports. The ports operate asynchronously, interface to RS-232 lines and 20-mA current loops, and work at communication rates of up to 19,200 bits/s.

The DT80/1 is priced at $1,795 in single quantities and its delivery time is 90 days.

Datamedia Corp., 7300 N. Crescent Blvd., Pennsauken, N. J. 08110. Phone (609) 665-2382 [366]

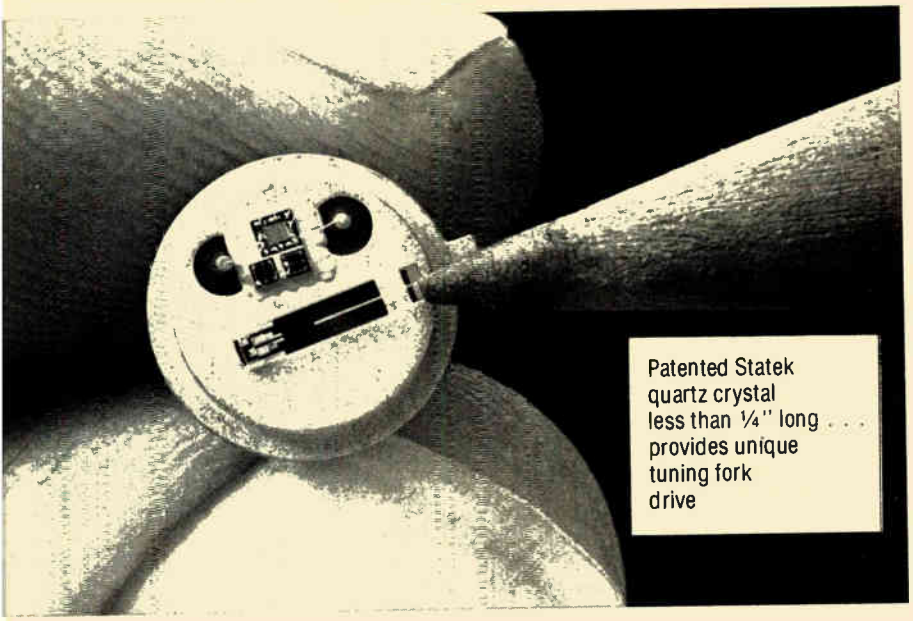
File system works with IBM Series/1 computers

Designed for use with IBM Series/1 computers with RPS (Realtime Programming System), RMS is an integrated technique for data storage, retrieval, and manipulation. The software product features uniform directory utilization to enhance and simplify RPS.

Operating in the shared task set partition, RMS is available to all users and user tasks. It is compatible with all versions of RPS and is used with Assembler, Cobol, Fortran, and PL/1. During compilation, preprocessors convert all RMS commands into source code with calls to the RMS run-time system.

RMS supports multiple-volume files, several file organizations, and multiple indexes per file. Record lengths may be variable and can expand or contract during updating. Although simultaneous access to a single file by several users is permitted, RMS protects files against

Circle 208 on reader service card



Is this the Ultimate Low-Frequency Oscillator?

Introducing the world's smallest, toughest, most accurate low-frequency quartz crystal oscillator.

Now available at modest prices IN ANY CUSTOM FREQUENCY from 350 kHz all the way down to 10kHz in a tiny TO-5 can.

If you need compact, low-frequency oscillators, our new SQ oscillators can save you money and headaches —no matter whether you need 5,000,000 pieces or just 50. They offer all the superb performance features associated with quartz crystal drive such as extreme accuracy, high temperature stability, low aging and very low power consumption. In addition, they offer Statek's patented quartz tuning fork which allows greater miniaturization, lower power drain and much higher shock resistance compared to any other low-frequency crystal on the market.

LONG LIFE

The typical no-load current drain of the SQ oscillator is only 500 uA, meaning extremely long life when powered by battery. Calibration accuracy is ±0.01% and remains within specification for enormous periods of time because of the microscopic aging properties of quartz.

REMARKABLE FOR $10

It is built to withstand a shock of 1000g (half sine wave) for one millisecond—the equivalent of a hammer blow. That's why the world's largest manufacturer of police radios uses our SQ oscillator for hand-held radios that take a tough beating every day. The temperature capability of the SQ oscillator is also exceptional. Thousands have been used at extremely high temperatures in torturous down-hole, oil-well logging operations. These are remarkable features for a $10 (1000-piece price) oscillator tuned to your custom frequency anywhere in the range 10 to 350kHz.

THE SECRET

How did we get such a lot of capability into such a tiny space—at such tiny prices? The secret is a unique quartz crystal design in the shape of a tuning fork plus patented production processes and nine years' experience in producing 20 million crystals. We manufacture crystals in the millions by semi-conductor manufacturing techniques and tune them to your special frequency with automatic high-speed laser systems that burn off deposited gold until each unit resonates at the correct natural frequency.

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Prices are for custom frequencies. Minimum order is five pieces.

5-24	$49.00
25-49	38.00
50-99	28.00
100-249	21.50
250-499	15.50
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1,000	10.00

Stock frequencies of 10.0, 12.8, 15.36, 16.0, 16.384, 19.2, 32.768 & 100.0 kHz available at even better prices.

NOTE: Extremely low custom frequencies—as low as 1 Hz per day—are also available in a divided output version of the SQ oscillator known as the DQ series.

Call Mal Kaufman now at (714) 639-7810 to discuss your application

STATEK *Innovators in Frequency Control*

Statek Corporation, 512 N. Main, Orange California 92668, phone (714) 639-7810 TELEX: 67-8394

Circle 209 on reader service card 209

New products

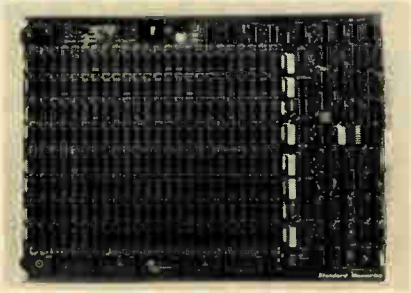
simultaneous double updates through a user-controlled record lock.

RMS is available on a license basis for $7,800 including training and documentation.

Data Structures Inc., 122 East 42 St., New York, N. Y. 10017 [367]

Memory board stores up to 131,072 words

The ECOM 137S is a memory card containing address registers, data registers, and interface control circuitry. Its capacity is expandable, in increments of 16,384 words, up to



131,072 words. Standard word lengths of 18 to 24 bits are offered for systems that require parity bits or error-correcting capability.

Starting addresses are switch-selectable and individual bytes can be read and written independently. Memory can be refreshed automatically or under external control. Backup power can be supplied continuously or in bursts to reduce power consumption. A light-emitting diode indicates when the memory is being accessed or that it was the last board accessed; the memory can be switched offline for troubleshooting while power is maintained.

The board's write access time is 150 ns, its read access time is 350 ns, and its cycle time is 450 ns. A 128-K-by-18-bit ECOM 137S is priced at $3,575 in single quantities and has a delivery time of 30 days.

Trendata/Standard Memories, 3400 W. Segerstrom Ave., Santa Ana, Calif. 92704. Phone Carl Peterson toll-free at (800) 854-3792 or at (800) 432-7271 in California [368]

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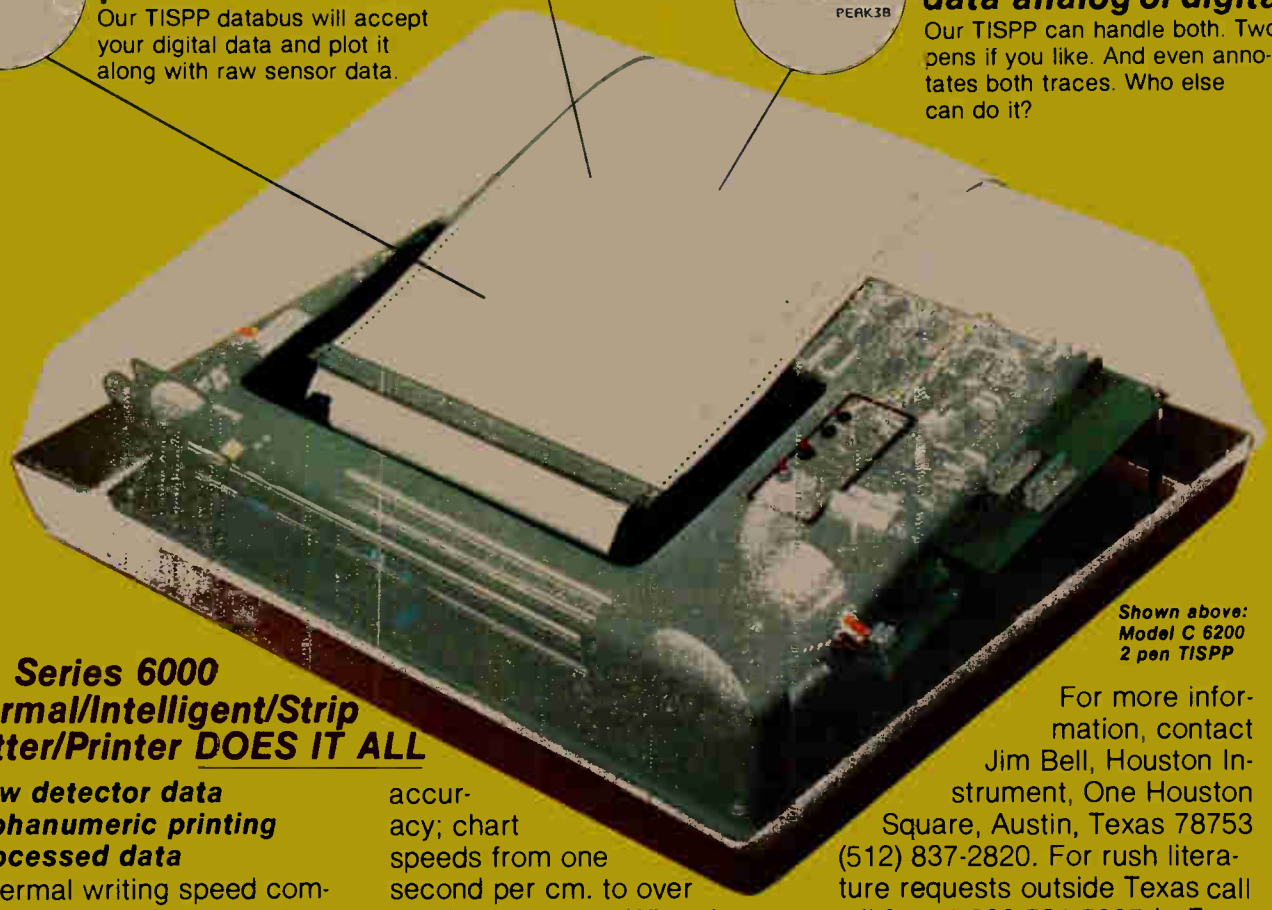
the ideal graphical device for builders of microprocessor controlled instrumentation systems

Do you need your data annotated with alphanumerics?
Our TISPP prints before, after, as well as during curve data input, on the same chart with simple ASCII inputs.

Do you want to graphically display processed data?
Our TISPP databus will accept your digital data and plot it along with raw sensor data.

Is your strip chart recorder data analog or digital?
Our TISPP can handle both. Two pens if you like. And even annotates both traces. Who else can do it?



Shown above: Model C 6200 2 pen TISPP

The Series 6000 Thermal/Intelligent/Strip Plotter/Printer DOES IT ALL

- ***Raw detector data***
- ***Alphanumeric printing***
- ***Processed data***

Thermal writing speed compensated; print speed 20 characters per second; sensitivity from 10mv to 5v full scale analog; 12 bit binary full scale digital; plot speeds up to 75cm. (30 in.) per second; 0.3% full scale accuracy; chart speeds from one second per cm. to over one hour per cm. Who else can give you this hardcopy capability, ready to be built into your system? Prices start at $1640* (quantity discounts available, of course).

For more information, contact Jim Bell, Houston Instrument, One Houston Square, Austin, Texas 78753 (512) 837-2820. For rush literature requests outside Texas call toll free 1-800-531-5205. In Europe contact Houston Instrument, Rochesterlaan 6, 8240 Gistel Belgium. Phone 059/277445 Telex Bausch 81399.

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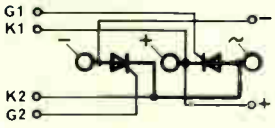
Original Module

What engineer would accept a copy?

The SEMIPACK is the most innovative and most copied multifunction semiconductor power module developed in the last decade. The major semiconductor manufacturers think so too — they are now copying the SEMIPACK. It's also true that many of the modules look-a-like. You can sure tell a copy from the real one if you know what to look for in performance.

Performance highlights: • extremely compact — complete with terminals and links • electrically isolated base eliminates all insulation problems • multiple units of single or three-phase assemblies can be mounted on a single heatsink • large power capacity — 25 to 90A per unit to 1400 PIV and • withstands current surges of up to 1750A at max junction temperature.



SEMIPACK — a modular concept based on series connected pairs of two diodes, two thyristors, or one diode and one thyristor — is the ideal building block for controlled and non-controlled systems that are compatible for simple assembly into single and three-phase bridges as in half-controlled, fully controlled, diode bridges and ac controllers. Typical applications include: phase and inverter motor controllers, electrical lighting controls, elevator controllers, welding . . .

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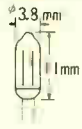
SUPER MINIATURE
Neon Glow Lamps

Dimension: mm



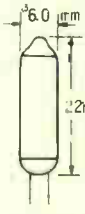
NL-8S

Circuits Volts ····· AC 105-125
Series Resistonce ····· 150KΩ
Nominol Current ····· 0.3mA
Totol Flux ····· 20mlm MIN.
Averoge Life Hours ··· 30,000

CLEAR-GREEN
Fluorescent Glow Lamps

NL-35 G

Circuit Volts ····· AC crDC 105-125
Series Resistonce ····· 33KΩ
Nominol Current ····· 1.6mA
Totol Flux(MIN.) ····· AC:120mlm,DC:130mlm
Avg. Life Hours ····· AC:30,000 DC:40,000



NL-21 G

Circuit Volts ····· AC 105-125
Series Resistoce ····· 27KΩ
Nominol Current ····· 1.5mA
Totol Flux ····· 90mlm MIN.
Avg. Life Hours ····· 20,000

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C.P. CLARE'S μP KEYBOARD WITH REEDS. THE BEST OF THEM ALL.

Best μP.
Here's why. Its second-generation microprocessor has EPROM capability — real smarts. It gets us from your keyboard concept to a prototype design in record time. It enables completely customized software control of all key functions. You can program in automatic repeats, multiple program a single keyboard, program changes in the field. You can have 8-bit serial and/or parallel I/O. Three-key rollover is built in with N-key rollover possible. There are no compromises and the options are unlimited.

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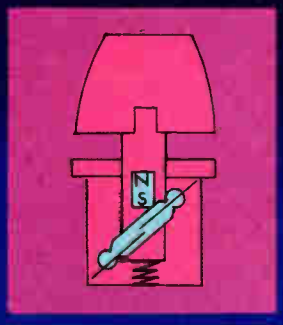
Couple this μP with the unique low-profile reed switches we manufacture and you've got the best of two technologies — an unbeatable keyboard system. You know reed contacts are sealed against hostile environments. You know reeds are extremely dependable and stable. They'll switch faultlessly over 10^8 times. They are low in power consumption. And zero in power drain. Another key point: they've got the feel operators like, so speed and accuracy increase.

Best keytops.
C. P. Clare's keytops are non-glare, 2-shot molded. The legends sharp and clear for life. The colors lab-quality, 3-dimensionally controlled. Yes, 3-dimensionally controlled.

Best advice.
C. P. Clare's μP keyboard is the best of them all. But is it best for you? Call the C. P. Clare sales office nearest you and arrange to talk to a keyboard expert. He'll tell you honestly if it is, or if you'd be better off with another C. P. Clare keyboard design. Talk to him today. Or, if you prefer, write C. P. Clare and Company, 3101 W. Pratt Avenue, Chicago, IL 60645. Or call 312-262-7700.

We help you compete



Height with keytop: 15/16"

C. P. CLARE & COMPANY
GENERAL INSTRUMENT CORPORATION

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Now! A revolutionary technology that overcomes the last obstacle to the universal application of power MOSFET transistors!

The application advantages of power MOSFET transistors are well established. But bipolar transistors had one significant advantage: a lower on-state voltage drop. International Rectifier technology has changed that. IR's radically advanced HEXFET™ chip design pictured below improves the $R_{DS(on)}$ for a given transistor die size by more than 3 to 1. Now MOSFET high input impedance, super-fast response, second breakdown freedom, and ease of paralleling is available in devices with forward voltage drops comparable to the $V_{CE(sat)}$ of bipolar transistors.

HEXFET technology is used in the new IRF150 rated at 100 volts, 28 amperes with an $R_{DS(on)}$ of 0.055 ohms max. The HEXFET IRF350 is rated 400 volts, 11 amperes, $R_{DS(on)}$ 0.30 ohms max. — a new world record in MOSFET power handling capability! Other smaller, more economical HEXFETs are also in production.

For details and prices on the year's most exciting power MOSFET development, dial (213) 322-3331 and ask for the HEXFET HOTLINE, or write to the address below.

The International Rectifier HEXFET!™

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233 KANSAS ST., EL SEGUNDO, CA 90245 (213) 322-3331
TWX: 9190-348-6291 TELEX. 66-4464

Circle 214 on reader service card

Products newsletter

Honeywell upgrades electrostatic printing system

The PPS II page-processing system from Honeywell Information Systems Inc., Waltham, Mass., is an electrostatic printer capable of producing 18,000 lines per minute. **An upgrade of the company's PPS I, the system is now capable of operating on line with a computer, and it also sports such extra features as software-encoded forms capability and software-loadable fonts.** The machine, which interfaces with IBM 360 and 370 host computers, is intended for users who print at least a million or so pages per month, according to products consultant Trish Roberts. Imbedded in it are a dedicated Honeywell Level 6 minicomputer and a storage disk for buffering incoming data.

When the printer's metal styli are used to form electrostatic images on the paper, resolution can be as fine as 200 dots per inch. If higher resolution is needed for intricate designs such as company logos, a metal format cylinder may be used. According to Roberts, a minimally configured PPS II capable of printing 8,000 lines per minute and including an operator's console, a Level 6 model 43 minicomputer with 64 kilobytes of memory, 96 megabytes of disk storage, and a single paper stacker, will sell for $140,000. Original PPS I pricing began at $160,000. Operation at 18,000 lines per minute adds $47,600 to the system price. Deliveries are scheduled to begin in the second quarter of next year. According to the company, all PPS Is are upgradeable to PPS IIs.

Alternative found for VT-52 terminal

Fans of the popular VT-52 display terminal can rejoice: an alternative is available. Hazeltine Corp., Greenlawn, N. Y., has introduced an addition to its 8080-based 1500 family—the 1552, which offers total software compatibility with the VT-52, now in minimal production at Digital Equipment Corp., Maynard, Mass. **Moreover, says Hazeltine, the 1552 has superior resolution and offers features not found on the VT-52.** Among them: field tab, insert line, delete line, and programmable key-switch audio feedback. Unveiled at the National Computer Conference in New York earlier this month, the 1552 sells for $1,500 in single quantities.

Prices dropped for semiconductor tester

Tektronix Inc., Beaverton, Ore., has reduced the price and instituted some changes in the basic configuration of its S-3250 automated semiconductor test system. **The new price is $159,500, down from $198,600.** The changes involve software primarily. Complete Tektest III operating software, rather than the somewhat modified Tektest 50, has been added to ensure software compatibility with other S-3200 family members. And terminal control mode software for interactive program debugging is now included in the base price. Graphics software to enhance data reduction routines is also included.

Wide-angle LED lamps get 50% brighter

The wide-angle LEDy Bug indicator lamp, which has a viewing angle of more than 180° [*Electronics*, Aug. 4, 1977, p. 123], may now be purchased in red and amber versions with a brightness of 8 millicandelas. The green version has a brightness of 5 mcd—the same as the original units. All three colors still sell for 56¢ each in quantities of 1,000 to 4,999.

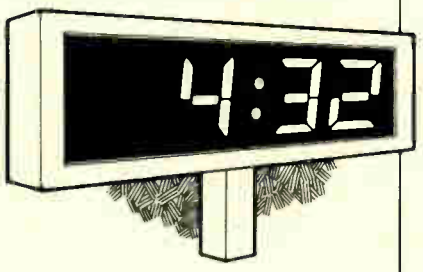
Keep Up With Change

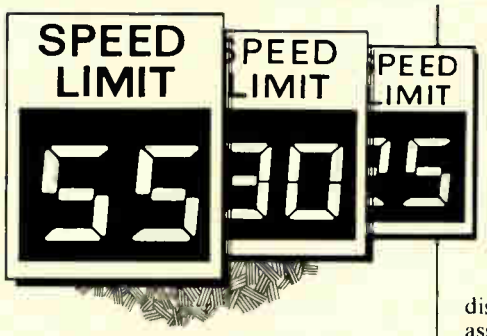
Ferranti-Packard Electromagnetic Modules Let You Create The System

There are three new additions to the Ferranti-Packard 7 Segment Readout Displays–9, 12 and 18-inch characters.

Now your customers who need large, remote controlled numeric readouts can use Ferranti-Packard Modules for time/temperature signs, price signs, speed limit signs, scoreboards and industrial displays. These new, large modules can be incorporated into almost any numeric display your customer could want–or you could design.

The light-reflecting display components come in white or fluorescent





fade-resistant colors. They're designed to ensure visual impact over an extreme ambient light range, even direct sunlight.

Each module is made of rugged molded plastic parts to stand up to the most extreme environment.

They contain only seven moving, self-lubricating segments rotating on stainless steel pivots and rated for 400 million operations.

There are no complex mechanical linkages to wear out or incandescent lamps and neon tubes to burn out. Save energy too! Remanent magnetism retains the data displayed with *zero power input.*

From one-inch characters to large 18-inch units, Ferranti-Packard Modules give you the combination of reliability, visibility and flexibility no other read-out component can match.

Before you design your next numeric display, call Ferranti-Packard for assistance you can count on.

Ferranti-Packard, the Pioneer in electromagnetic displays.

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Electronics Division
6030 Ambler Dr., Mississauga, Ontario
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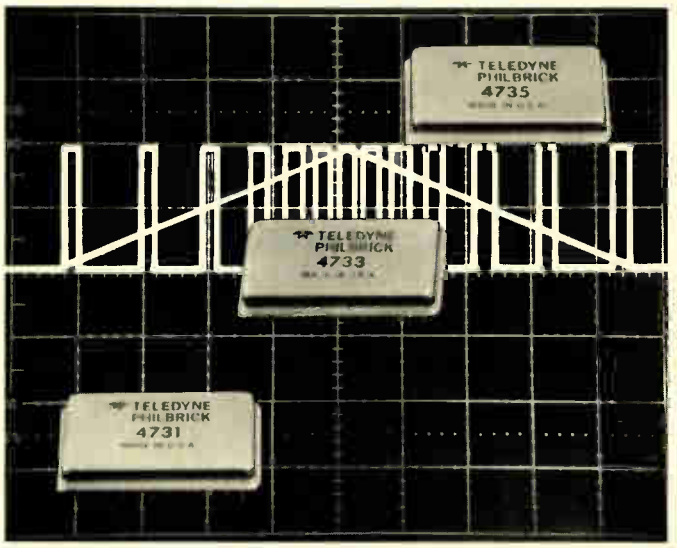
Telex: 06-961437

Circle 216 on reader service card

Hybrids: A New Dimension in Voltage to Frequency Converters



Ultra-Linear Voltage To Frequency Conversion

. . . is achieved with these new hybrid 10 kHz, 100 kHz and 1 MHz V to F converters where Nonlinearity is guaranteed to .005% Full Scale. Each model has exceptionally Low Drift specifications over the full –55°C to +125°C operating temperature range and offers up to 100% overrange. In addition, these highly reliable hybrids are screened to MIL-STD-883. Commercial versions are also available.

Just one more reason why . . .

No One Does It Better Than Philbrick

Circle 271 on reader service card

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Unretouched photograph

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Once again Calma is leading the industry in IC design solutions with our state-of-the-art advances to GDS II.

To aid on-line design, our command menus are continuously displayed on screen. So you don't lose time by looking away.

To provide user feedback, an alpha-numeric screen displays a variety of messages. Including what steps are being processed, status reports, error messages. Even information to explain commands. All in plain English.

And to help define layers, there is GDS II's color capability. You can assign any one of seven bright colors to each layer. Different colored layers overlap to produce numerous hues and tones. You can also code any shape with dotted lines, dashed lines, points or any combination of these. All shapes are maintained by refresh graphics and can be separately erased without affecting the remaining display.

Plus GDS II has the CAD features Calma pioneered. Like fast data entry, full function editing and simultaneous processing of multiple background operations. Including rules checks and matrix plotter support.

See the GDS II in full operation. Ask your Calma representative for a demonstration. Or send for our full color brochure. Write or phone Calma, 527 Lakeside Drive, Sunnyvale, California 94086, (408) 245-7522.

Dan Gillis photographer

CALMA
INTERACTIVE GRAPHIC SYSTEMS
A division of United Computing Systems Inc

UCS

Circle 217 on reader service card

New literature

Wafer testing. The 24-page report "A Wafer Chuck for Use Between −195° and 350°C" describes the design and features of a variable-temperature wafer apparatus for use in the detection of electrically active defects that produce deep levels in the band gap of silicon. Construction details and use of the apparatus are also discussed. To order printed copies, send $1.20, along with stock number 003-003-02017-6 to Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Outside the U. S., add 25% to cover mailing costs. To order microfiche copies, send $3.00 (U. S., Mexico, Canada) or $4.50 (elsewhere) along with NTIS number NBS-SP-400-55 to National Technical Information Service, Springfield, Va. 22161.

Data-communications standards. Specifications of important American communications organizations can now be found in the "Data Communications Standards Library." The 330-page book contains six Electronics Industries Association RS standards, three EIA industrial bulletins, a description of IBM's Binary Synchronous Communications protocol and AT&T's Advanced Communications Service Host and Terminal Functional interface. It is available for $85 from Remark International, 4 Sycamore Dr., Woodbury, N. Y. 11797.

Electronics hardware. Extensive lines of custom and standard printed-circuit-board racks, enclosures, and other hardware for electronic equipment are discussed in a 118-page engineering guide. The guide also contains detailed photos, drawings,

NORPLEX® POLYIMIDE-BASE LAMINATES

help you achieve high performance and greater yield.

Norplex G-30 laminates and prepregs are premium grade high-temperature base materials using polyimide resin with glass fabric reinforcements.

Developed for use in high-performance printed wiring boards and multilayer circuitry, G-30 polyimide laminates make possible design concepts that cannot be attained with epoxy-base materials. Because of their stability during fabrication and higher operating temperatures, these Norplex laminates are especially suited for microelectronics and guidance systems, computer logics and communications equipment.

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Technical information and assistance is available on these and other laminates from the Norplex Technical Service Department.

Norplex Division, UOP Inc., 1300 Norplex Drive, La Crosse, WI 54601. 608/784-6070. European Headquarters: Wipperfürth, West Germany. Pacific Headquarters: Kowloon, Hong Kong.

Norplex® laminates by UOP

One of The Signal Companies

Circle 219 on reader service card

New literature

and data on terminals, standoffs, feedthroughs, molded terminals, spacers, captive screws, terminal boards, enclosure handles, extractors, heat sinks, component clips, and component clamps. For a copy, write to Ed Karale, Industrial Products Division, Birtcher Corp., 4501 N. Arden Dr., El Monte, Calif. 91731. Circle reader service number 424.

Semiconductor guide. More than 2,200 solid-state replacement devices are listed in Sylvania's 1979 ECG Semiconductor Master Replacement Guide and Catalog. The 354-page guide also lists additions to the ECG line, which includes optoelectronic devices for control and display, radio-frequency power output transistors, high-voltage rectifiers, additions to the bipolar and field-effect transistor lines, and high-voltage multipliers. The technical section of the guide contains many specifications on transistors, diodes, rectifiers, thyristors, linear and digital modules, and integrated circuits. Copies of the guide may be obtained by mailing $2.95 to GTE Marketing Services Center, 70 Empire Dr., West Seneca, N. Y. 14224.

Generators. A four-page catalog contains detailed specifications, pictures, and applications information on Berkeley Nucleonics Corp.'s family of digital delay generators that are available with timing resolutions down to 1 nanosecond for generating delays, pulse widths, periods, and counted pulse bursts. Material describing trigger pulse amplifiers, power supplies, and a series of trigger coherent frequency sources is also provided. Berkeley Nucleonics Corporation, 1198 Tenth Street, Berkeley, Calif. 94710 [425]

Filters. The theoretical frequency, phase, and step responses of Butterworth, Chebyschev, and Cauer (elliptic) functions are presented in a 12-page bulletin, "Fixed-Frequency Highpass Filters." Available models are described. Frequency Devices Inc., 25 Locust St., Haverhill, Mass. 01830 [426]

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We're more than meets the eye.

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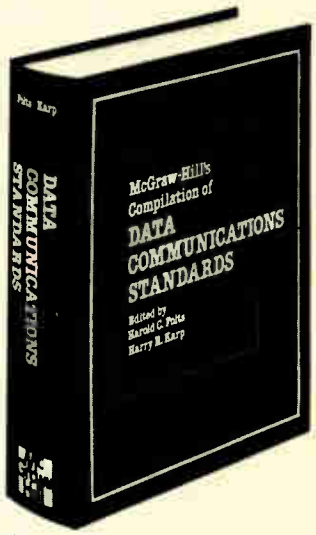
Instant access to all American and International

Data Communications Standards



Data communications standards are undeniably necessary and helpful. But... the proliferation of standards by the many committees and groups has left the data communications equipment user and designer searching through numerous publications to find the applicable standards for each job.

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Edited by
HAROLD C. FOLTS, data communications standards consultant; and
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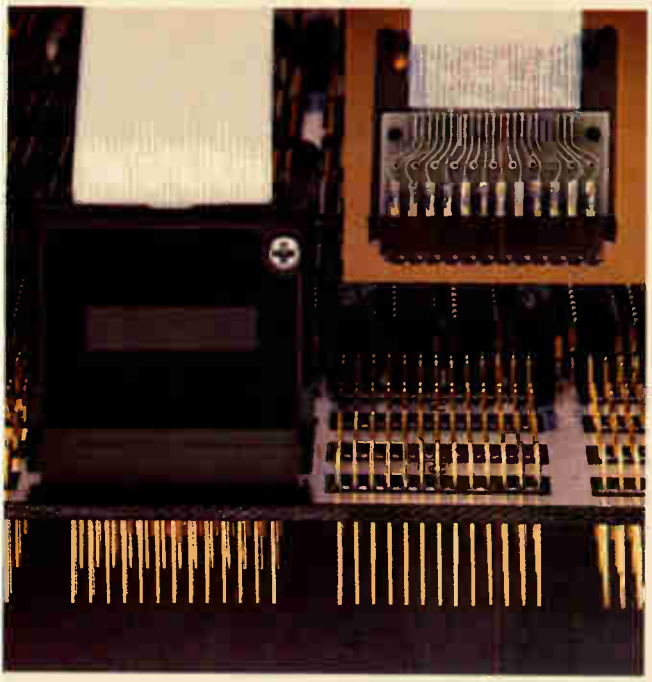
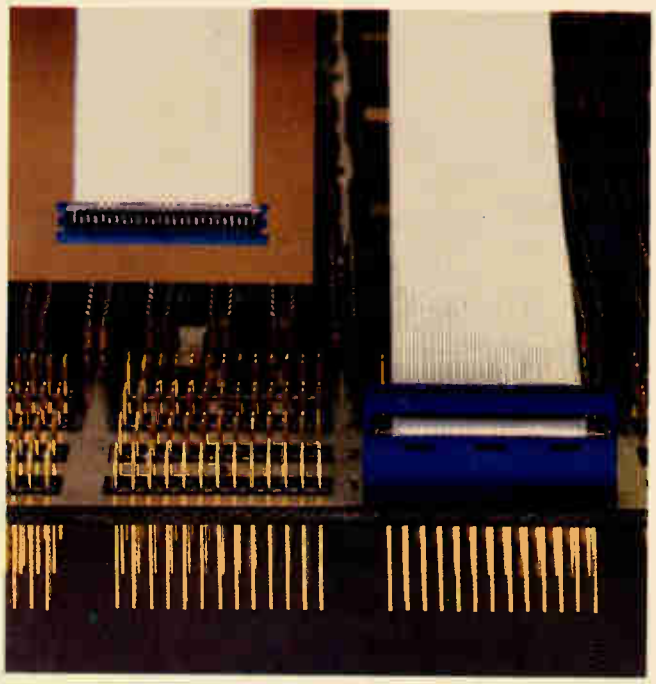


Paddleboard assembly–the slow way.



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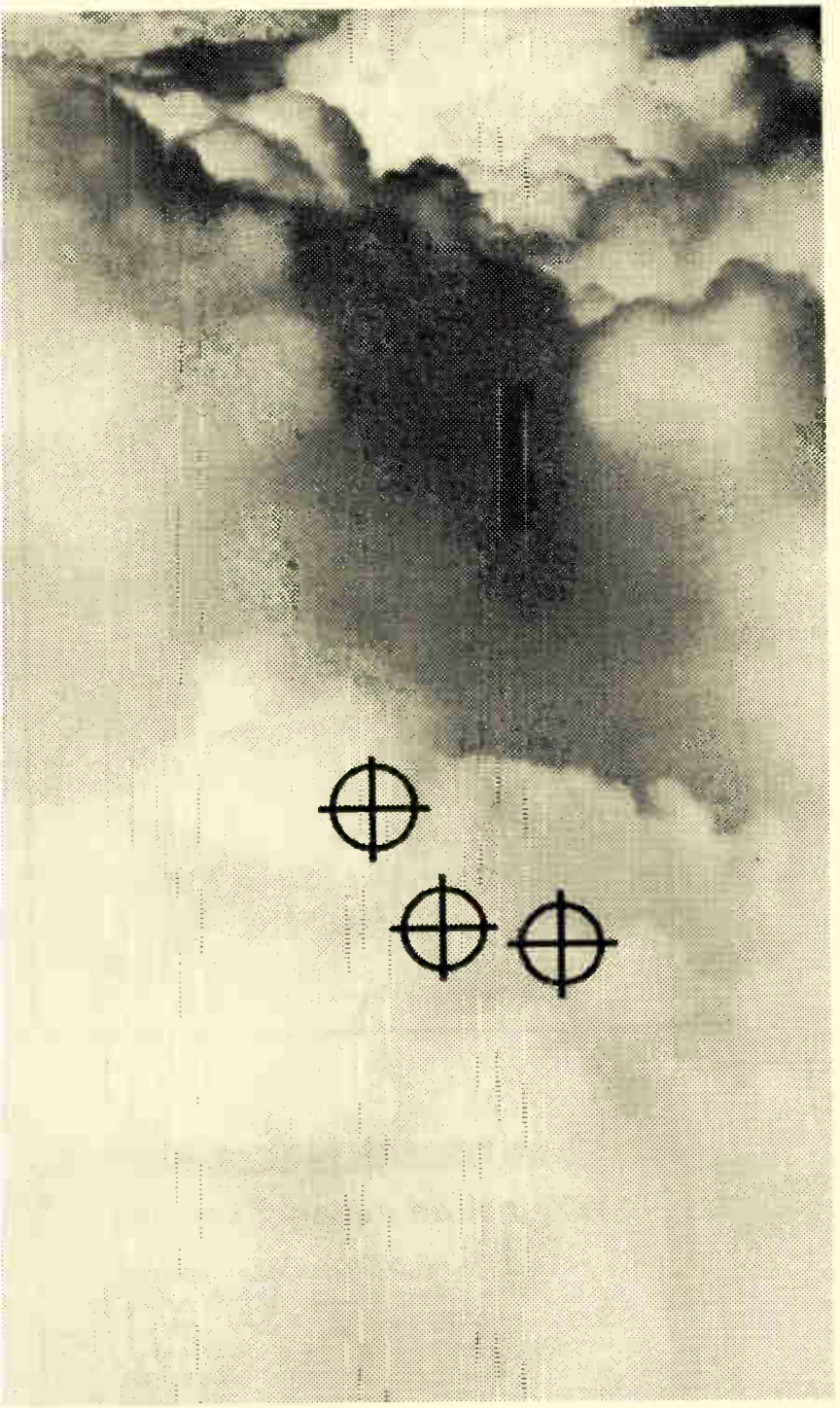

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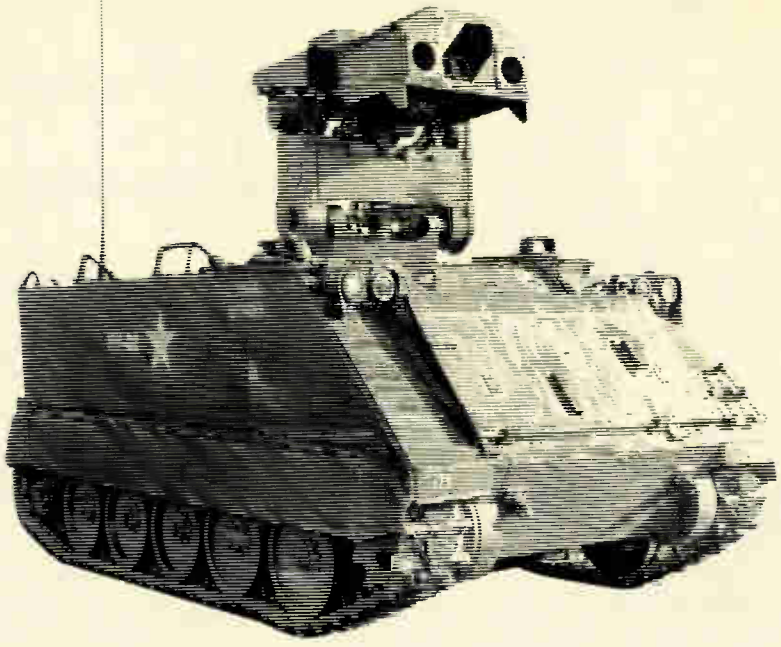

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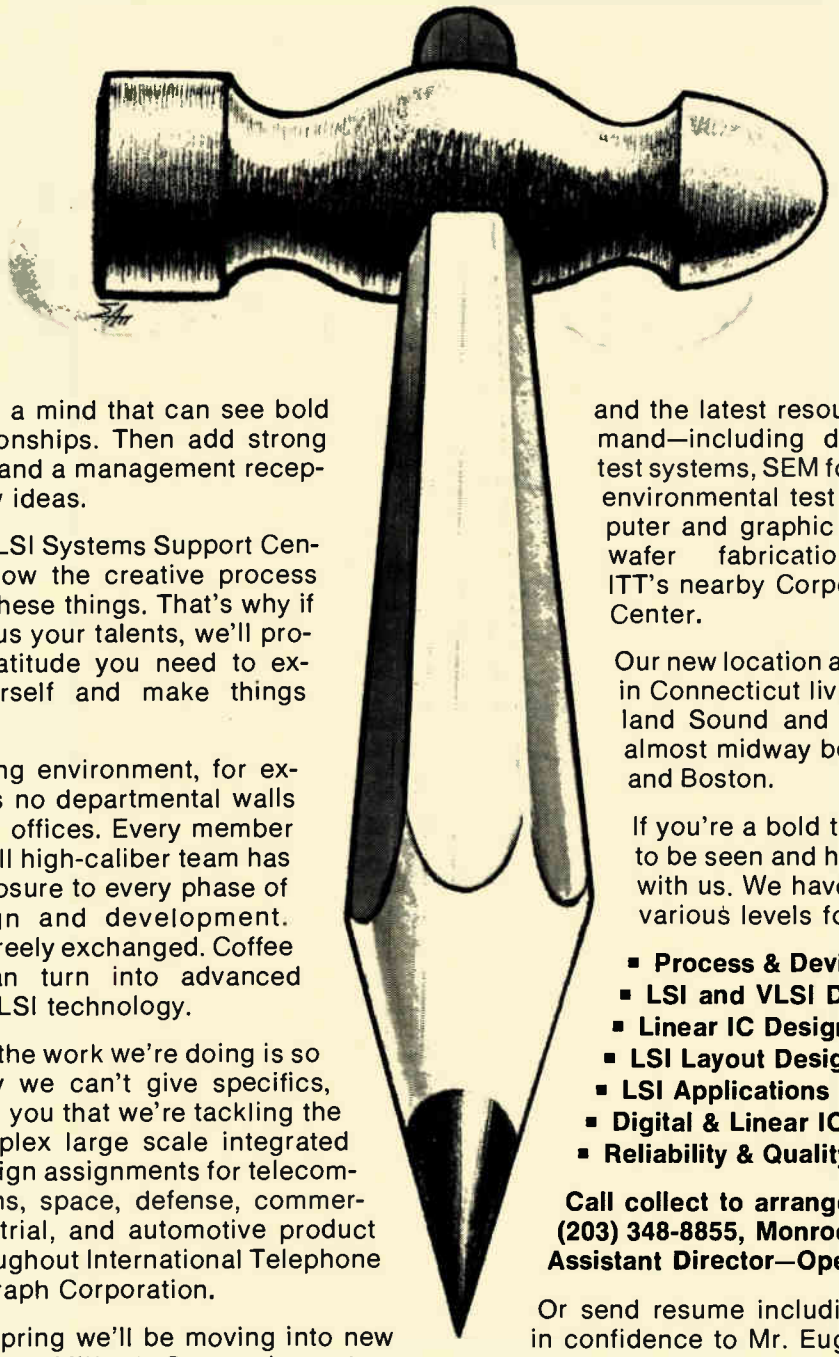

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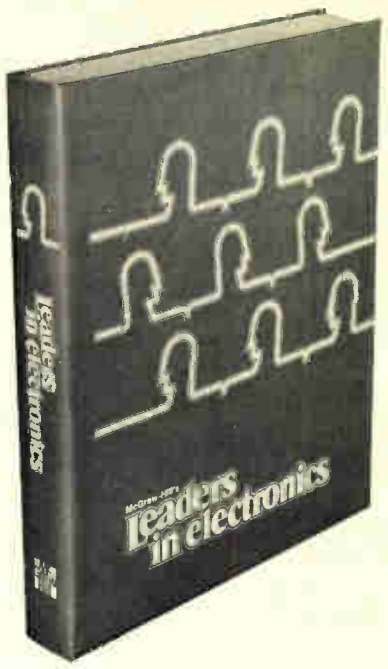

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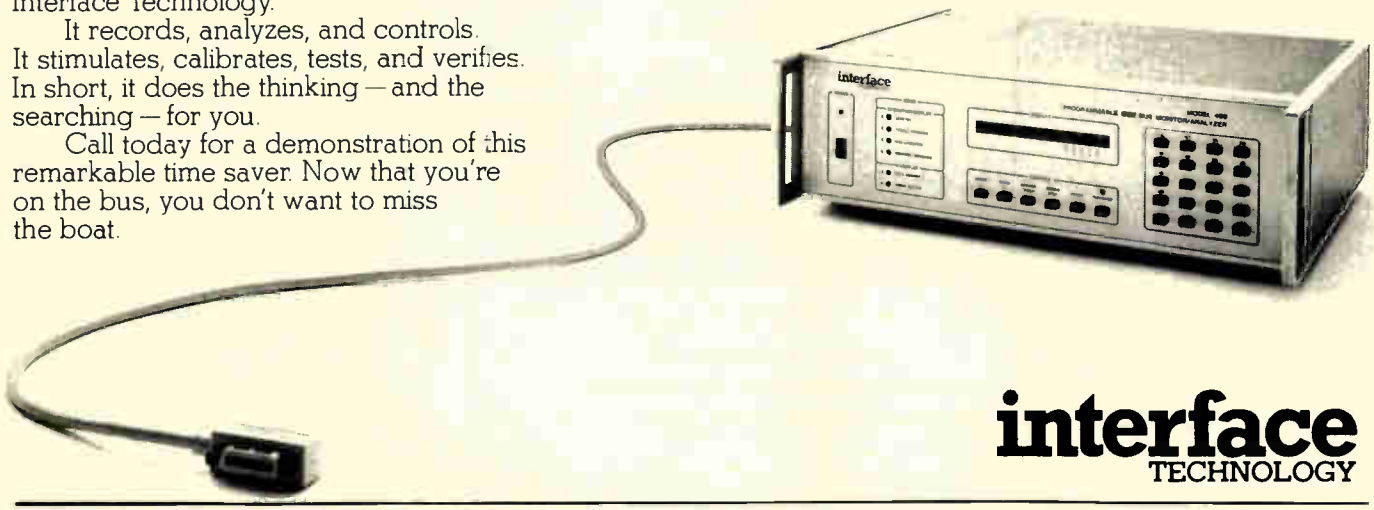

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13	28	43	58	73	88	103	118	133	148	163	178	193	208	223	238	253	268	345	360	375	390	405	420	435	450	465	480	495	510	715	958
14	29	44	59	74	89	104	119	134	149	164	179	194	209	224	239	254	269	346	361	376	391	406	421	436	451	466	481	496	701	716	959
15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	347	362	377	392	407	422	437	452	467	482	497	702	717	960

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