October 11, 1971

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Electronics®

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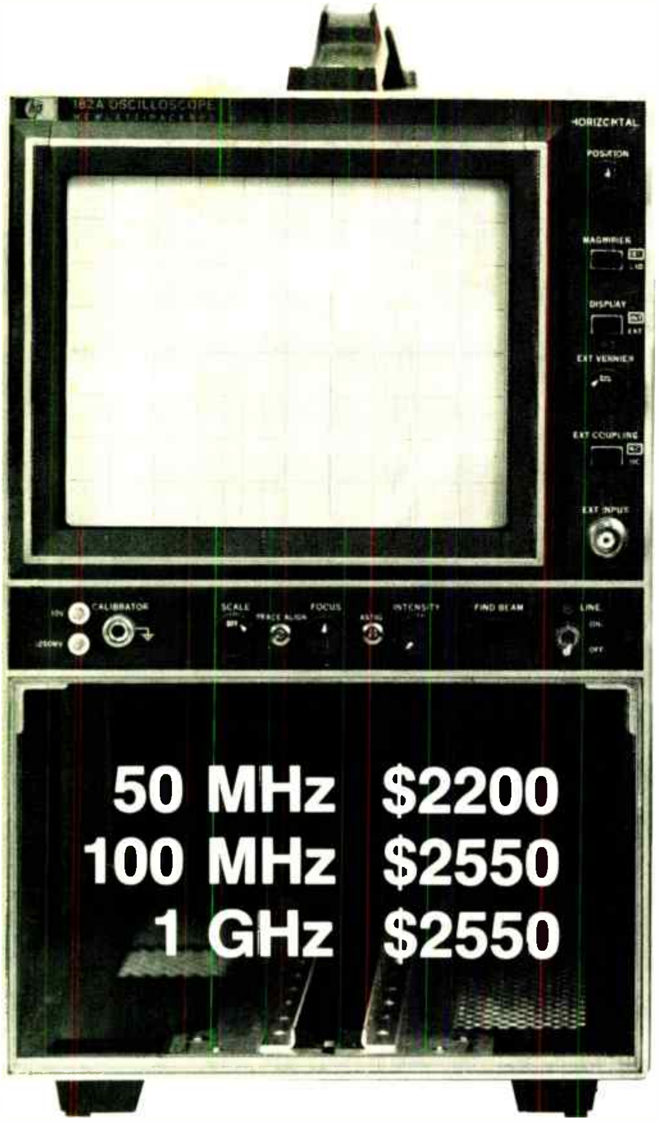
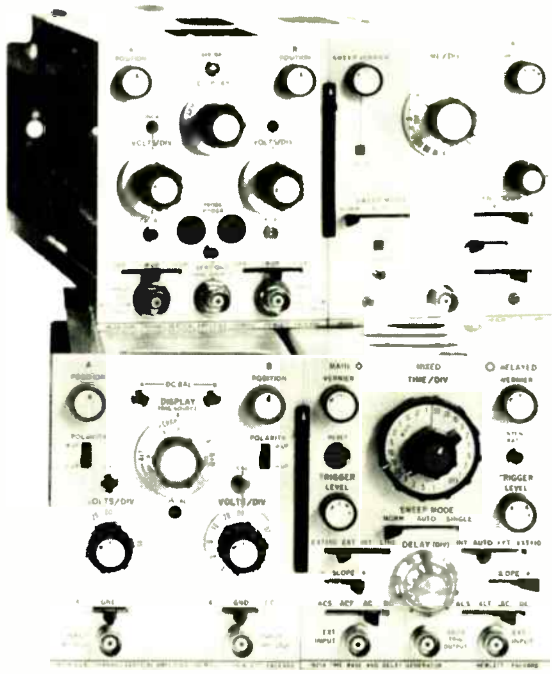
The big buy in big-screen lab scopes





You don't have to give up performance capabilities to save money on a big-screen scope; HP's 182A gives you both.

For $2200, you can get a mainframe, a 50-MHz dual-channel amplifier, and a delayed-sweep time base. This combination gives you the **biggest display area of any high-frequency scope** (8-div x 10-div, 1.3 cm/div), 5 mV/div sensitivity, and 10 ns/div sweep time.

And that's only the beginning. **The 182A system isn't limited to 50 MHz** in the plug-ins it can accept. Thanks to HP's pioneering advances in CRT technology, the 182A will take the entire family of 180 System plug-ins.

For $2550 you can get a 100 MHz system (mainframe, dual-channel vertical amplifier, and non-delayed sweep; delayed sweep $450 extra). Also available at $2550 is HP's new 1 GHz sampling system (mainframe and plug-in) that's as easy to use as a real-time scope! And the 182A is the only large-screen lab scope that has these capabilities.

So, if you're in the market for a high-frequency scope—get the 182A in the 50-MHz configuration, and protect yourself against having to buy a whole new system for 100-MHz capabilities in the future. **It's like getting free "bandwidth insurance" with your mainframe!**

For further information on the 182A, contact your local HP field engineer, or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

Scopes are changing.
Are you?

081/16

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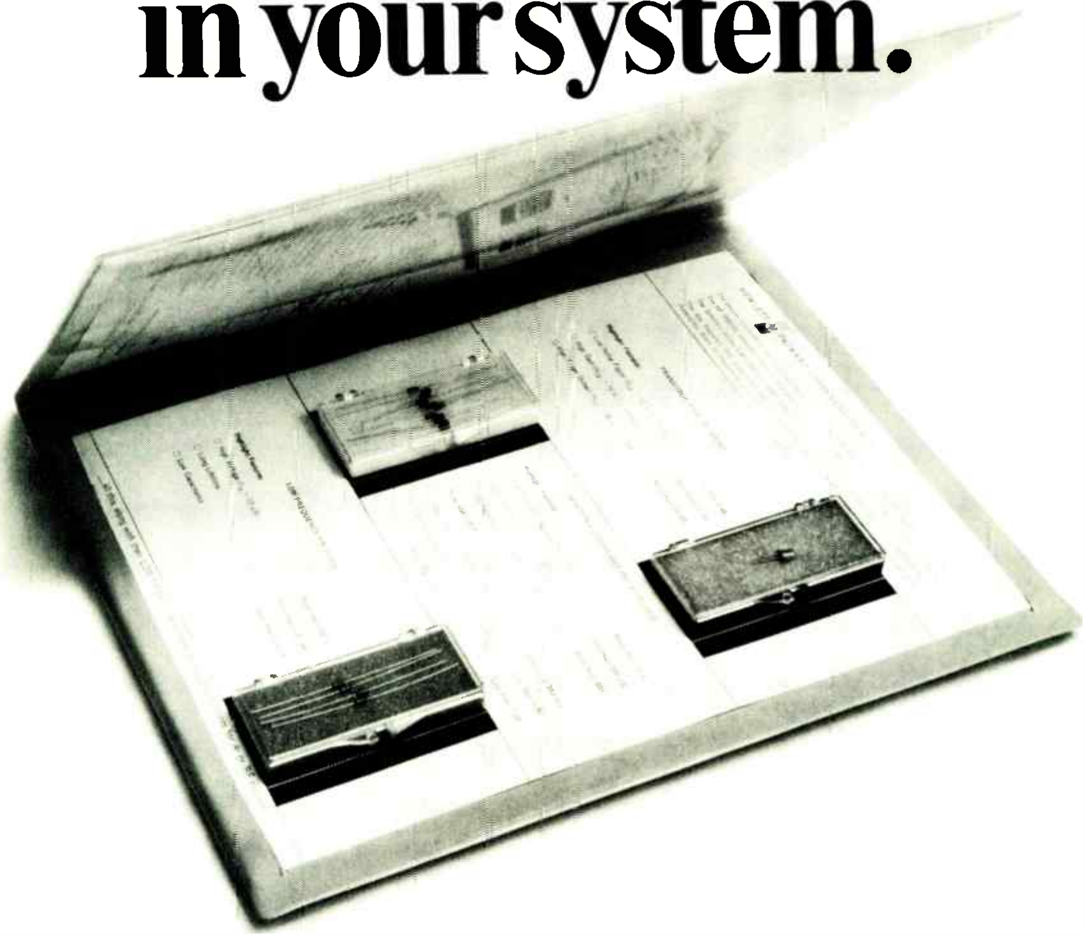
Save $15 on our new communications kit and get something special in your system.



The kit contains 12 Schottky diodes, 4 pin diodes, and one low-noise transistor. As well as application notes and data sheets.

If you bought these components separately, it would cost you more than $34. But right now you can buy the whole kit and kaboodle for $19.40. We're sure that once you've tried them, you'll come back for more.

This is the kind of performance that will bring you back. The HP 2800 Schottky diode is ideally suited for high level detector applications with a breakdown voltage of 70 volts. The HP 2835 Schottky diode with a breakdown voltage of 5 volts and a forward voltage drop of .33 volts at one mA makes an ideal VHF/UHF mixer.

The HP 3080 pin diode as an AGC element guarantees low cross-modulation and intermodulation down to frequencies of 5 MHz. The HP 35824A transistor makes an ideal low noise RF amplifier with a noise figure of 3 dB at 1 GHz.

So if you're looking for ways to improve the performance of your RF amplifiers, mixers, detectors or AGC's, tear out the coupon and a check and send them both in.

You may also want one of our very popular Schottky diode kits. For $8.40, you get eight each of three different Schottky barrier diodes. Try them and see what a difference they make in your circuits.

Clip this coupon and mail with check, money order or P.O. to: Hewlett-Packard Associates, 620 Page Mill Road, Palo Alto, California 94304. Your local HP sales office can also handle the order.

$34.00 value for $19.40!

(offer expires on January 31, 1972)

☐ Send me one of your communications kits. (HP 5082-0051)

☐ Here's $8.40 for a diode kit. (HP 5082-0050)
(California residents add 5% sales tax)

Name__________

Company__________

City/State/Zip__________

Frequencies ☐ less than 10 MHz
☐ 10 to 250 MHz ☐ 250 to 500 MHz
☐ 500 to 1000 MHz ☐ greater than 1000 MHz

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COMPONENTS 01109

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The International Magazine of Electronics Technology
October 11, 1971

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Electronics

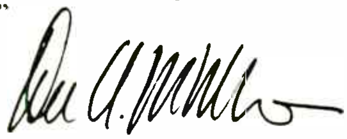
Publisher's letter

Our news staff, as we've pointed out here before, is strong on veteran reporters with newspaper, magazine, and wire service experience. But our eagerness to get the latest news into each issue of *Electronics* is not limited to the news side of the magazine. Our technical section is a more difficult place to break an important story. But sometimes an important development warrants extra efforts that enable us to be first and to describe in depth the technical details of a technological advance. In this issue, for example, the significant evolutionary step in the development of minicomputers embodied in the new Digital Equipment Corp. 11/45 computer, with its mixed semiconductor memory (see page 62), impelled us to cut some corners on deadlines and feature it on the cover.

Impressed as he was with DEC's work, Dick Gundlach, our associate editor who shepherded the article into the magazine, was struck by the improbable environment that spawned the development. "The same old brick factory that made blankets for the Union troops in the Civil War, is now turning out state-of-the-art computer gear," says Gundlach. It seems that, like other one-industry New England towns after the Second World War, Maynard, Mass., had a huge empty mill on its hands when the textile company moved out. When our computer editor, Wally Riley, first visited DEC a half dozen years ago, it was just one of many tenants rattling around in the old mill. Now, when Riley and Gundlach visited DEC to work on the article, the company occupied the whole place—and many newer glass-and-steel buildings around New England.

There may come a day when an American or a Russian astronaut will owe the very air he breathes to his "enemy." The work now going on to coordinate U.S. and Soviet spacecraft design to make space rescues possible (see Probing the news, page 103) has the solid ring of history in the making. And in a way, it represents an historic turnaround in the political relations between the two countries, points out Ray Connolly, our Washington bureau manager, who wrote the story. The politics of U.S.-Russian confrontation has taken on a whole new tone. It used to be that the leaders of the U.S. space effort justified their big budgets by warning that the Russians might beat us to the punch. But now, with the U.S. successful in its race to first set foot on the moon, the competition has quieted down. Indeed, the most powerful argument now used by Washington politicians is the "peace ploy."

But there are still elements of the fundamental competition between the U.S. and Russia. "Some suspicious people equate the Russian's strong cooperation in this project—and it is very strong—with a desire to know a lot more about our electronics expertise," says Connolly. "There appear to be some serious shortcomings in the Russian's communications systems. The fact that 10 of the 15-man Russian delegation are electronics experts is no accident."



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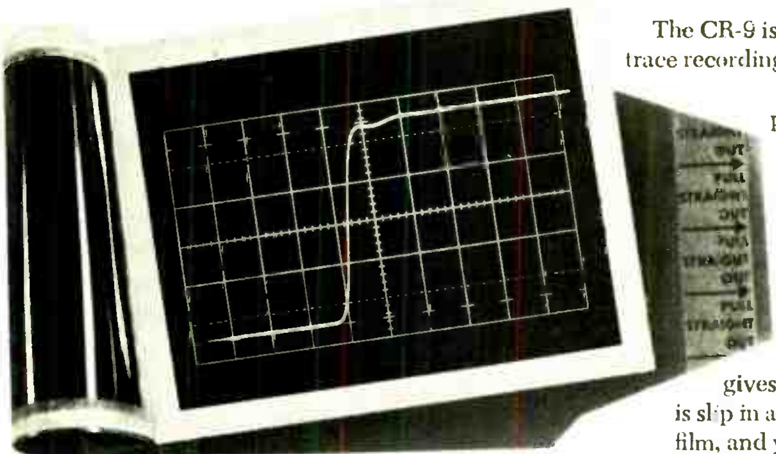
This $180 camera gives you a picture 15 seconds after you pull the trigger.



The CR-9 is a new camera specifically designed for oscilloscope trace recording. It costs only $179.95.*

And it weighs less than 24 ounces (700 grams). So, unlike permanently-mounted cameras, it can easily be used with more than one oscilloscope in your lab.

The Polaroid CR-9 Oscilloscope Camera is designed to take any one of 8 interchangeable, light-tight hoods. These fit almost all oscilloscopes with 6 x 8, 6 x 10, and 8 x 10 cm graticules. (You specify the hood you need when you buy the camera; additional ones cost a little extra.)

You don't need to focus, because the hood holds the camera at exactly the right distance from the CRT display. The camera gives you a picture that's virtually distortion-free. All you have to do is slip in an 8-exposure pack of Polaroid 3000-speed, self-developing film, and you're ready to shoot.

The CR-9 is a real problem solver for scientists and engineers. Because one picture is worth a thousand waves.

For additional information write: Polaroid Corporation, Dept. 35-218, 549 Technology Square, Cambridge, Mass. 02139. (In Canada: 350 Carlingview Drive, Rexdale, Ontario.)

The new Polaroid CR-9 Oscilloscope Camera

*Suggeseld list price. Polaroid®

Readers comment

Jeweled movements

To the Editor: The Washington Newsletter of Aug. 16 erroneously reported that Hamilton Watch Co. is "the last fully integrated watchmaker in the U.S. able to turn out precision timing devices vital to this country's industrial base." In fact, Bulova is the only movement producer left among the 60 American companies that had produced jeweled movements domestically during the past century. Elgin ceased domestic manufacture of jeweled movements in 1967 and Hamilton ended domestic movement manufacturing in 1969-70.

The Defense Department acquisition of Hamilton's facilities suggests there is a renewed appreciation of the unique defense capabilities of the quality watch industry. But Bulova—not Hamilton—is the sole domestic producer of precision jeweled movements.

William Gowen
Bulova Watch Co.
New York City

■ *Mr. Gowen is correct in noting that Bulova is the only domestic integrated watchmaker still producing precision jeweled movements for watches. However, both Bulova and Hamilton make such movements for applications other than watches.*

EEs in Britain

To the Editor: Those taking part in your ballot on a union for EEs [Aug. 2, p. 50; Sept. 21, p. 72] will be glad to know that we are in the process of solving the same problem in England. We have formed, with the full approval of the engineering institutions, our own union, the United Kingdom Association of Professional Engineers. Confined to degreed engineers, it will be equivalent to the British Medical Association. It has the powers of intervention between employer and employee and is technically a trade union; but through its special contacts and lobbying powers it achieves its ends without disruption.

We are pressing for a common code of professional conduct properly drawn up and enforced. We have also published a guide to sala-

Readers comment

ries and conditions of service. We intervene when an employer deals with an individual unfairly. (We are acting tough with an employer who has dismissed 38 of his professional engineers for refusing to join a blue-collar union with which he signed an agreement.) No union can enforce guaranteed job security, but when there have to be redundancies, we advise the employer on how to handle the problem and see that our members get the best possible terms and their full rights under the law. We then redeploy them with the aid of our appointments service; we offer career advice when required; we shall one day be able to offer career planning as a package service. We are lobbying for portable pensions, mid-career training, and a promotion ladder on the technical side.

Ukape emphasizes differentials, independence, loyalty to the firm, freedom of choice, and advancement by talent and not by age. Our member retains his professional integrity and outlook, remaining completely separate from the blue-collar union system, and yet strong enough to withstand its less desirable manifestations. He can get on with his engineering job, and leave the sordid details to Ukape, which sees that he gets a fair, not extortionate, reward. There is consequently no prejudice in management against Ukape. For Ukape, there are no "two sides to industry"; just one profession of engineering.

R. L. Clarke
United Kingdom Association
of Professional Engineers
London, England

Who's who

To the Editor: The article on Hall-effect ICs [Aug. 2, p. 46] attributes the discovery of the effect to E.F. Hall of Ohio State University. In fact, credit should go to E.H. Hall, fellow of Johns Hopkins University (E.H. Hall, "On a New Action of the Magnet on Electric Currents," American Journal of Mathematics, 2, 287, 1879).

Jerome H. Perlstein
Johns Hopkins University
Baltimore, Md.

40 years ago

From the pages of Electronics, October 1931

Out of each depression, economists tell us, some new invention or industry has always arisen to lead the world into new business activity.

If such is to be the way out of the present depression, then certainly on the horizon of 1931 there is no more promising prospect to perform such service, than the electronic tube with all its manifold applications.

But always over the brightest picture of electronic possibilities, hangs the spectre of patent infringement.

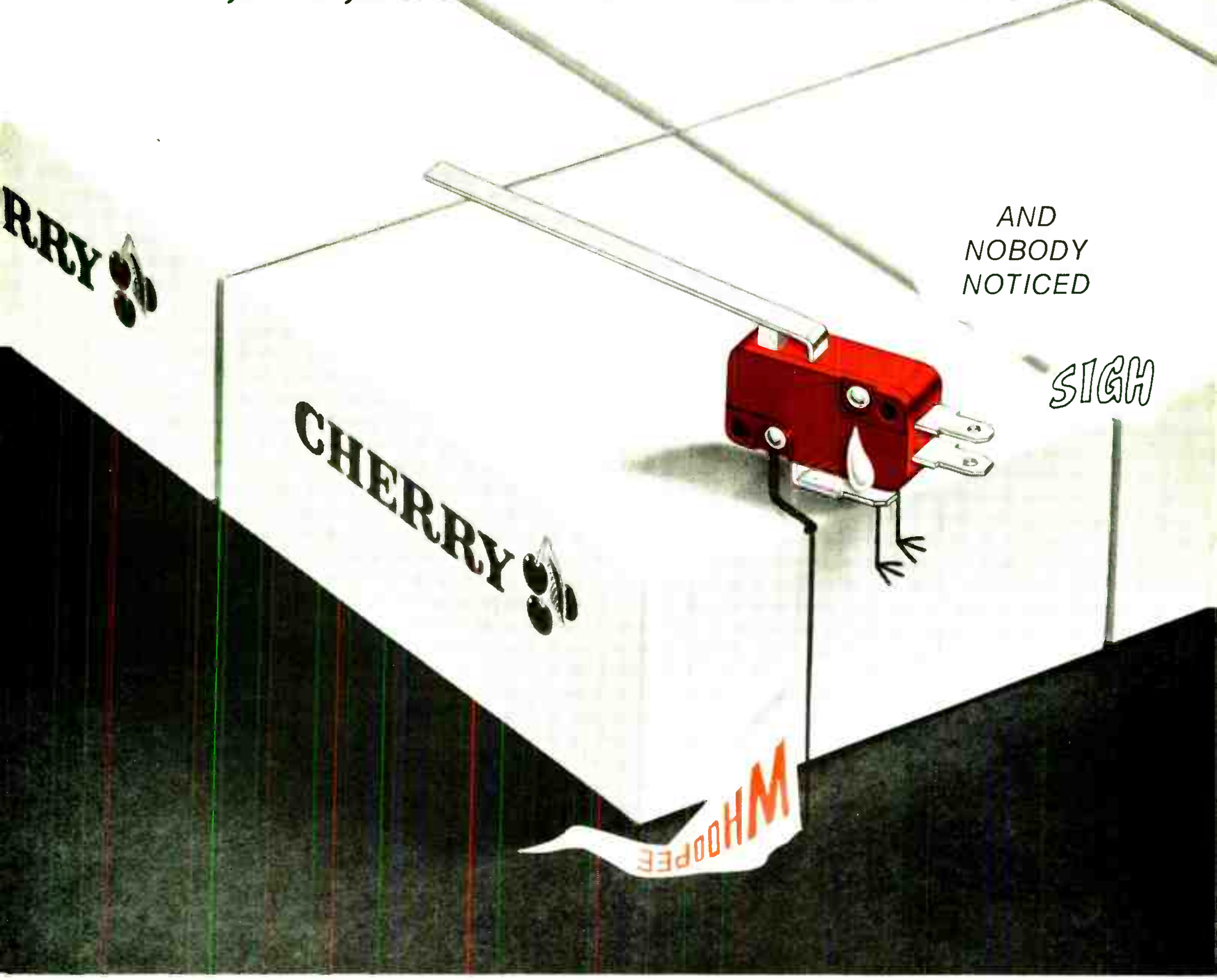
If the owners of electronic patents could see the advantage of cross-licensing and exchanging patent privileges under a voluntary pooling plan that would stimulate both manufacture and profits, how far would the development of this art be pushed ahead?

In schoolrooms during the winter months, natural illumination goes through wide changes, imposing burdens on little eyes. But with a photocell electric lights will be automatically switched on each time the natural light falls below a predetermined value. Since there are 400,000 schoolrooms having electric lights, the market for photocell control looks bright.

A device which amplifies an electric current ten quadrillion times was exhibited by E. S. Darlington of the vacuum-tube department of the General Electric Company at the radio and electric show of the Electric League of Washington, D.C., in September. The device is a low-grid-current tube, which in conjunction with a thyratron tube is capable of utilizing 0.00000000000000001 (10^{-17}) ampere to control 0.1 ampere—or 100 milliamperes—directly.

To demonstrate the remarkable sensitivity of the combination, Mr. Darlington utilized the relatively small current generated by rubbing an amber rod with a piece of paper, to turn on and off a 10-watt incandescent lamp, with the amber rod at distances varying from 5 to 15 feet. A current of 10^{-17} ampere thus directly controlled the 0.1 ampere used by the lamp.

WE JUST SHIPPED OUR 100,000,000th SNAP ACTION SWITCH



Sad but true. We were too busy working on our second hundred million snap action switches to bother much celebrating our first hundred million. And busy is the key word. Today, for instance, we'll ship about 70,000 snap action switches. And another 70,000 tomorrow. It goes on at this pace every working day. That's 17 million dependable Cherry switches a year to actuate 17 million dependable products. All because product designers like Cherry's long-life coil-spring mechanism. And because production people find high-overtravel Cherry switches easier —and faster—to install.

See for yourself why Cherry snap-action switches are so popular. Send for the complete Cherry switch catalog.

CHERRY

CHERRY ELECTRICAL PRODUCTS CORP.
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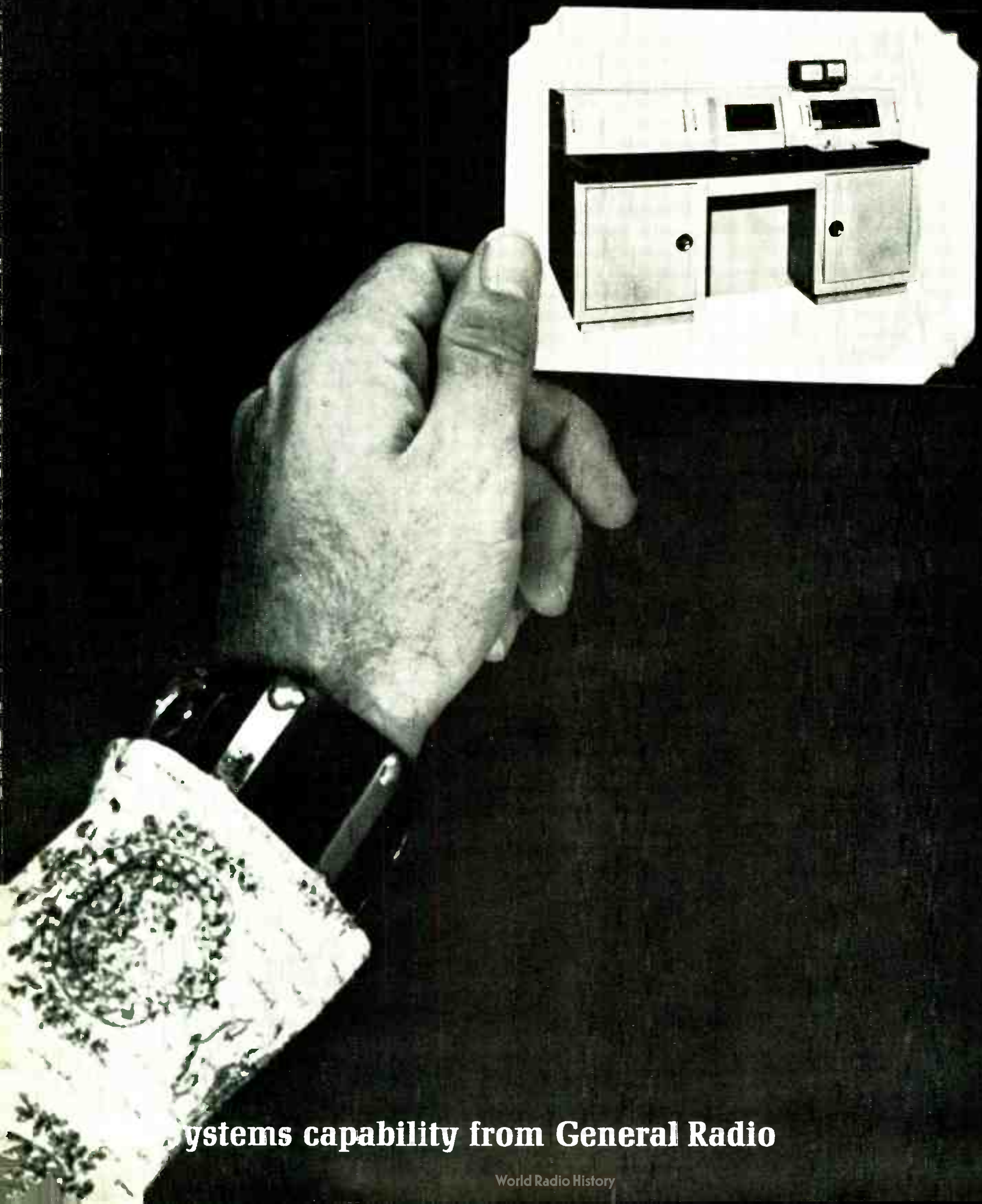
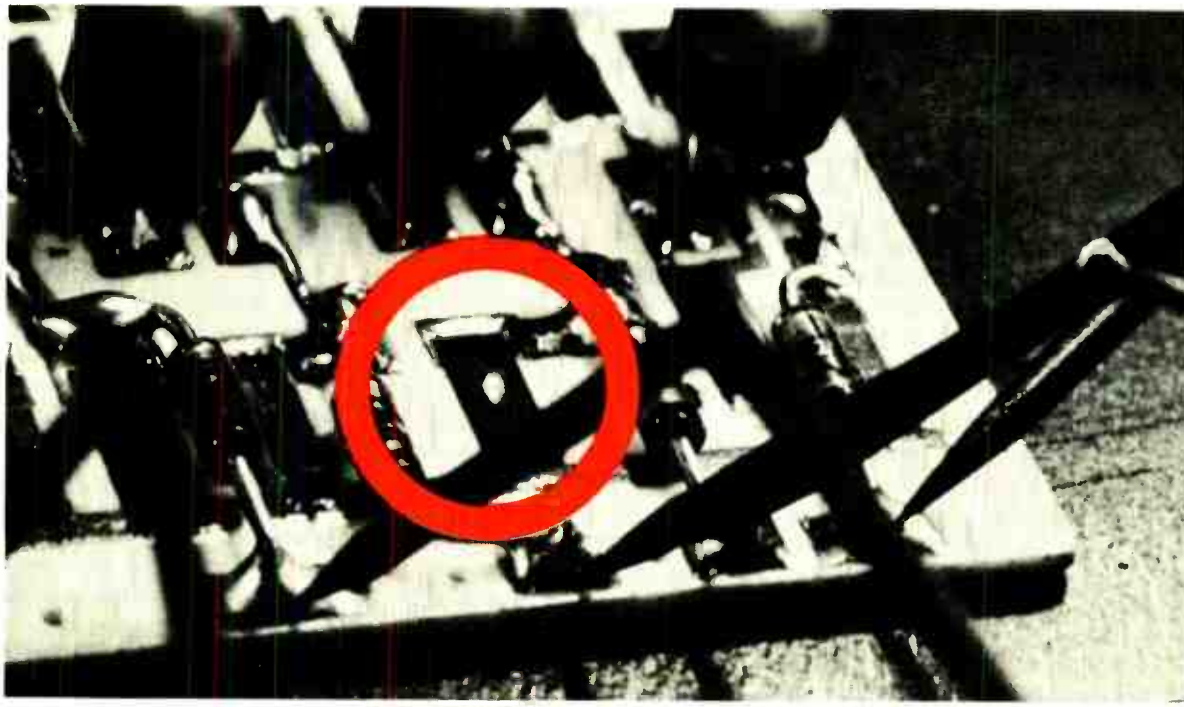
Makers of patented Leverwheel/Thumbwheel Switches, Matrix Selector Switches, Snap-Action Switches and Keyboards.

The GR Systems Family



…ystems capability from General Radio



Functional Laser Trim

Resistance Trimming is only the beginning...
complete functional trimming is now a reality

Resistance trimming at speeds to 10,000 trims per hour and accuracies to ±0.1% is only the beginning with Micronetic's new Model 80 Laser Trim System. Now you can select the specific functional trimming capabilities you need to trim your fully assembled hybrid circuits.

Functional trimming is fast and economical

Trimming assembled hybrid circuits to a functional specification can compensate for active device variations through the adjustment of only a few resistors. Throughput increases, yield improves, and the need for a separate final test operation is eliminated. In addition, because the Model 80 can functionally trim to compensate for wide fluctuations in active device parameters, specifications on these active devices can be relaxed for substantial added cost savings.

General Radio instrumentation makes it possible

Micronetic Systems has joined forces with General Radio Company to provide a complete functional

trimming system. The Model 80 measurement system is built by General Radio in modular plug-in form. The basic module is the Resistance Measurement Unit, standard on the Model 80. Separate plug-in modules to measure ac and dc voltage and current, frequency, and capacitance are available as options to provide complete functional trimming capabilities.

Functional software included

Micronetic's exclusive Resistor Trimming Language (RTL) software package allows complete flexibility by controlling all parameters of the laser trim system with simple English language statements. Instructions to control all the GR plug-in modules are included in the RTL software supplied with every Model 80.

Lowest capital investment

The standard system, complete with the basic resistance measurement module and RTL software, costs only $59,000, net FOB Watertown, Mass. Modular expansion capability means you pay only for the capability you need.

General Radio service

The complete Model 80 System carries a full one-year warranty. Service, if required, is performed by General Radio's worldwide service organization.

Write or call Micronetic Systems or your local GR sales engineer for information on how you can save money with the Model 80. Resistance trimming is only the beginning . . .

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People

"**I knew** the silicon-on-sapphire technology was ready, but the company wasn't making any effort to shift into the manufacturing," says Joseph R. Burns, describing the situation during the last of the 11 years he spent at RCA's David Sarnoff Research Laboratories in Princeton, N.J. Burns' reaction was typical—he quit to set up his own company. But his timing, he's the first to admit, was terrible. It was September 1970, the stock market was down, and "electronics" was a dirty word among Wall Street investors. But Burns, holder of a Ph.D. in electrical engineering and a leading contributor to RCA's SOS expertise, when he was in charge of semiconductor device applications there, [*Electronics*, July 20, 1970, p. 82], figured he needed $1 million to get his company started. He got it and now as president of Inselek, the 34-year-old, 6'5" Burns, a forward on Princeton's basketball team for three years, is ready to make some big noises in his old college town. Inselek, billing itself as "the silicon-on-sapphire components company", is the electronics industries' first commercial supplier of SOS wafers—offered to semiconductor houses like Fairchild Semiconductor and Texas Instruments—and it will soon introduce both memory and linear SOS devices for circuit designers.

Burns predicts great things for the fledgling technology. The inherently great isolation afforded by the sapphire insulator will lead to very high-speed MOS products having very high packing densities and dissipating low powers, he points out. And they will be extremely competitive with bipolar devices.

By way of example he cites two devices he helped develop while at RCA: a 50-bit dynamic shift register operating at a spectacularly high 90 megahertz (for the Avionics Laboratory at Wright-Patterson AFB, Ohio) and a 256-bit, fully-decoded random access memory with 35-nanosecond access time (for NASA).

Inselek will introduce in the next few weeks a 64-bit static RAM, compatible with transistor-transitor logic and with less than 40-nanosecond access time. And early next

Burns: Beginning to scratch the surface.

year, the company will have a 256-bit unit with less than 75-nanosecond access time. Both units will dissipate about 0.1 milliwatt per bit compared with the 2 to 5 mW/bit dissipated in the same speed range by bipolar units, Burns asserts. He is also planning large-capacity RAMs—1,024- and 2,048-bit devices for mid-1972.

In the linear area, Inselek's first offering will be a quad-transistor configuration on a chip—four MOS devices to serve as building blocks for linear ICs.

Overall, Burns' feeling is that Inselek is "just barely scratching the surface of the technology, without really pushing the devices' true capabilities." He predicts at least a factor of four improvement in both speed and packing density in the next 18 to 24 months.

The communications and electronics industries don't seem to be having any problems with President Nixon's new economic policies [*Electronics*, Aug. 30, p. 21]—or at least that's the view the Federal Communications Commission (FCC) gets, concedes Executive Director John M. Torbet. "Of course we don't try to make economic policy here," explains Torbet, recently charged by FCC Chairman Dean Burch to field questions on the President's new economic stabilization plan, "but we have to interpret it for the industry in the industry's terms." To date, all the questions

People

Torbet: We don't make economic policy.

he's forwarded to the Cost of Living Council have been concerned with the complex formula used to calculate television advertising rates—dependent upon changes in audience, season, and time of day or day of week.

Torbet took the administrative helm of the FCC earlier this year after wearing the uniforms of the four services—most recently as deputy chief of staff of the U.S. Air Force Academy, Colorado Springs. The lean, gray Torbet, with degrees from Michigan State University and the Air Force Institute of Technology, is responsible for the day-to-day operation of the FCC. Activities on a recent day ranged from requesting a budget increase from the White House to ordering removal of Gay Lib's lavender graffiti from the stone front of the Federal Communications Commission's Washington headquarters.

Torbet also has had to solve the FCC's own problems resulting from Nixon's new economic policies. "For example, a personnel realignment we didn't foresee," he admits. "Although we haven't heard the details on the 5% Federal job cutback from the White House, when we do, we're ready to accomplish it through existing vacancies and attrition.

"In addition, we have kept the President's views on economic stabilization in mind in writing the fiscal '73 budget request," he continues. Torbet last week asked the Office of Management and Budget for only a modest increase over last year's $31 million. "We're anxious to move into new programs," he says., "but with the new economic policies, we will not achieve all of those we want."

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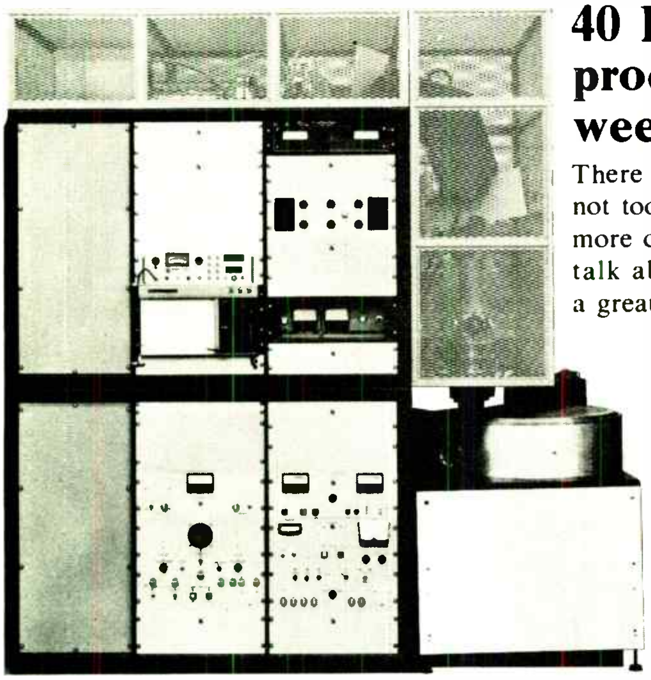

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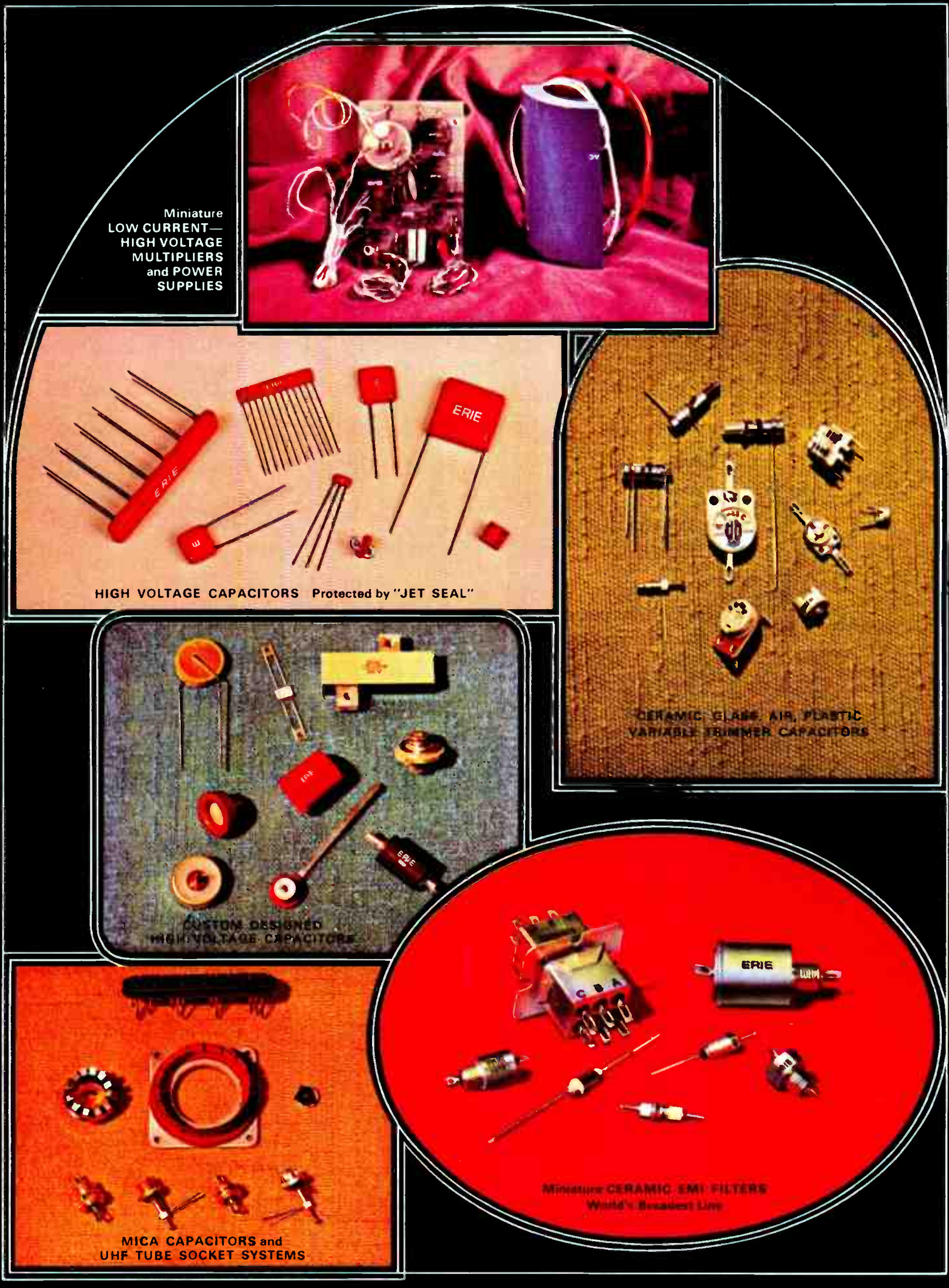
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Meetings

Switching & Automata Theory: IEEE, Michigan State University, East Lansing, Mich., Oct. 13-15.

Holm Seminar on Electric Contact Phenomena: IEEE, Illinois Institute of Technology, Drake Hotel, Chicago, Oct. 13-15.

1971 Region 8 Convention-Eurocon: IEEE, Le Palais de Beaulieu, Lausanne, Switzerland, Oct. 13-15.

Fall Electronics Conference: IEEE, Pick Congress Hotel, Chicago, Oct. 18-20.

Annual Electronic Connector Symposium: IEEE, Cherry Hill Inn, Cherry Hill, N.J., Oct. 20-21.

Electronic & Aerospace Systems Convention: IEEE, Sheraton Park Hotel, Washington, Oct. 25-27.

1971 Joint Conference on Major Systems: IEEE, Disneyland Hotel, Anaheim, Calif., Oct. 25-29.

Int'l Electron Devices Meeting: IEEE, Hilton Hotel, Washington D.C., Oct. 11-13.

Northeast Electronics Research & Engineering Meeting (NEREM): IEEE, Sheraton Boston Hotel, War Mem. Aud., Boston, Nov. 3-5.

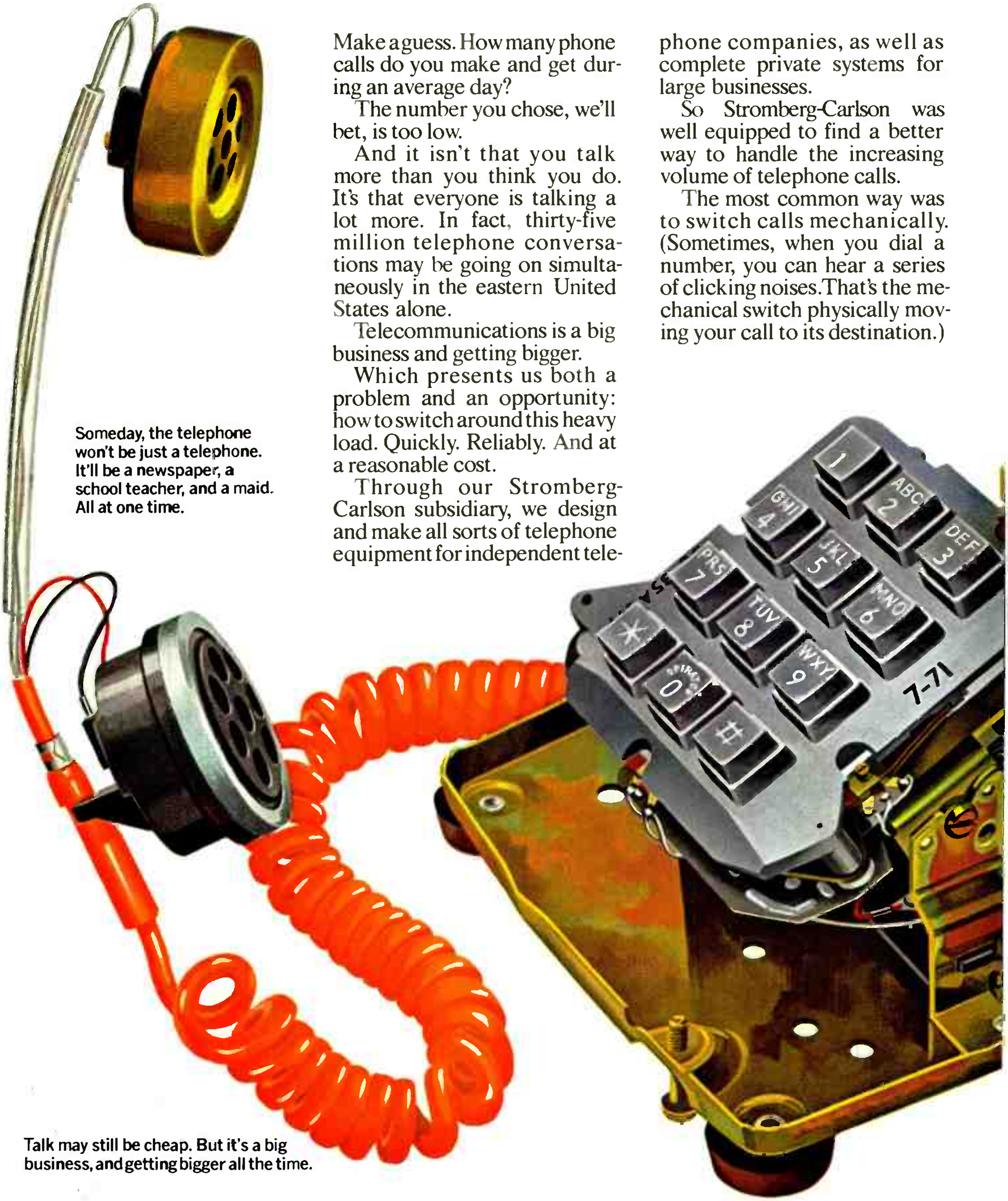
Nuclear Science Symposium: IEEE, Sheraton Palace Hotel, San Francisco, Calif., Nov. 3-5.

CALL FOR PAPERS

International Conference on Computer Communication (ICCC 72): IEEE, Washington D.C., Oct. 24-26, 1972. Deadline for submission of papers is March 6, 1972 to Dr. Stanley Winkler, gen. prog. chairman, IBM Corp., 18100 Frederick Pike, Gaithersburg, Md. 20760

International Conference on Magnetics: IEE, Kyoto, Japan, April 10-13, 1972. Deadline for digests is November 20, 1971 to Professor Eiichi Goto, c/o INTERMAG 72 Secretariat, KDD Research & Development Laboratory, 1-23 Nakameguro 2-chome, Meguro-ku, Tokyo, Japan.

One of our products doesn't fly, float, submerge, or blast off. It still carries a heavy load.



Someday, the telephone won't be just a telephone. It'll be a newspaper, a school teacher, and a maid. All at one time.

Make a guess. How many phone calls do you make and get during an average day?

The number you chose, we'll bet, is too low.

And it isn't that you talk more than you think you do. It's that everyone is talking a lot more. In fact, thirty-five million telephone conversations may be going on simultaneously in the eastern United States alone.

Telecommunications is a big business and getting bigger.

Which presents us both a problem and an opportunity: how to switch around this heavy load. Quickly. Reliably. And at a reasonable cost.

Through our Stromberg-Carlson subsidiary, we design and make all sorts of telephone equipment for independent telephone companies, as well as complete private systems for large businesses.

So Stromberg-Carlson was well equipped to find a better way to handle the increasing volume of telephone calls.

The most common way was to switch calls mechanically. (Sometimes, when you dial a number, you can hear a series of clicking noises. That's the mechanical switch physically moving your call to its destination.)

Talk may still be cheap. But it's a big business, and getting bigger all the time.

While mechanical switching works, it's still mechanical, subject to maintenance, to a set amount of time to perform its task, to a small number of other functions that it can handle. (It can't handle push-button dialing, for instance.)

Our answer was to create an entirely new type of switching system: an electronically controlled switch. We call it the Crossreed® Electronic Switching System.

It is a major improvement over electromechanical switching. It can set up many more calls per minute. Switching each of them within a fraction of a second.

Innovations like Crossreed switching aren't anything new to our Stromberg-Carlson subsidiary.

But even when we aren't first with something, we look for a unique application.

Our Vistaphone® telephone is a good example. The possible uses for it are endless. But our first Vistaphone system is being used experimentally by the National Technical Institute for the Deaf, in Rochester, New York.

This is the wonderful part about it: for the first time, our Vistaphone system makes it possible for direct communications between deaf persons via the telephone.

That's for today.

In the near future, telephone communications will be changing dramatically.

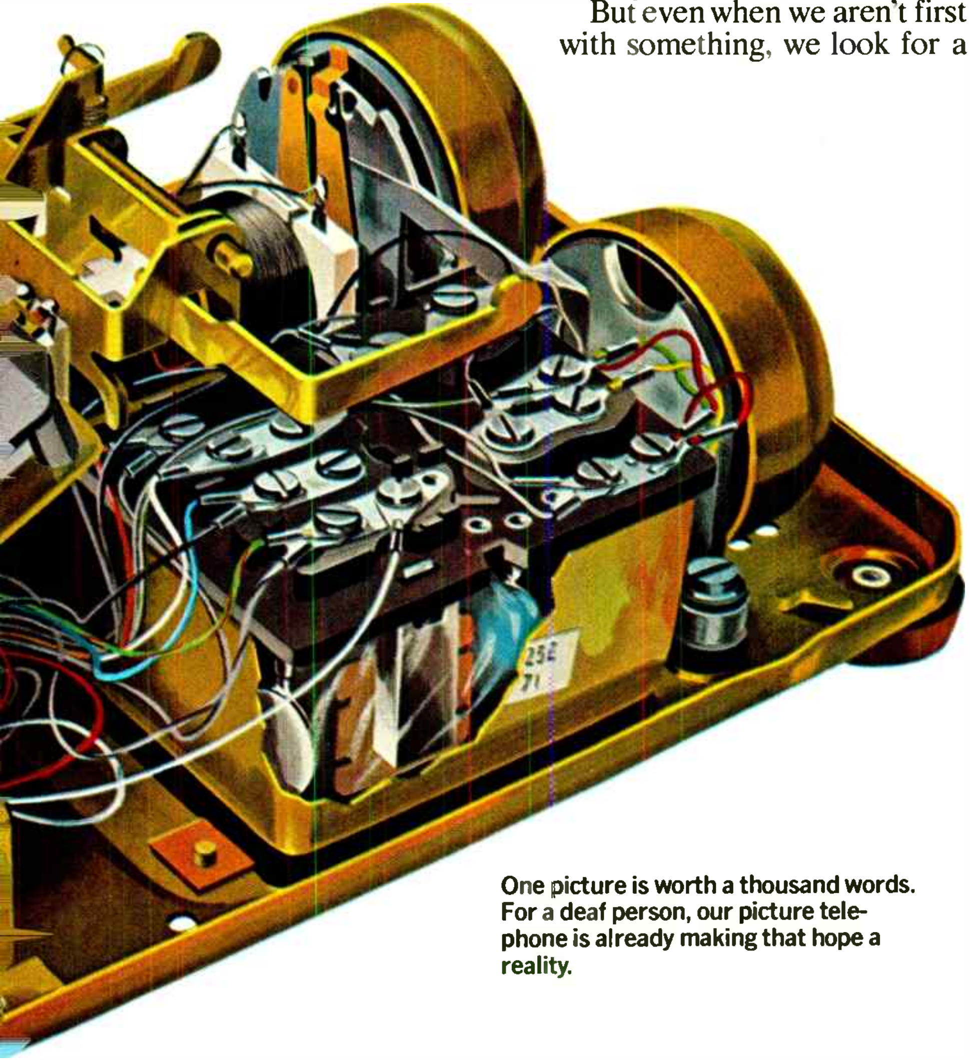
For one thing, by the end of this decade, computers will talk to other computers more than people will talk to people.

For another thing, in the years ahead, newspaper facsimiles will be carried over phone wires. Children will learn at home by phone. A simple call to your home will open and close windows or turn your oven on or off. Endless possibilities.

Many of the possibilities will become realities. Because we are able to use our technology to create one thing—like the Crossreed switching system or adapting Vistaphone systems for the deaf—and then find further uses for the same technology.

This is an ability we apply to all of our markets.

The ability to do things no one's been able to do before.



One picture is worth a thousand words. For a deaf person, our picture telephone is already making that hope a reality.

By the end of this decade, something other than people will be using the phone. In fact, computers will be using the phone more than people.

GENERAL DYNAMICS

Electronics Newsletter

October 11, 1971

Mexico staring hard at U.S.-owned 'garage operations'

Growth of U.S.-owned electronics operations in Mexico has accelerated faster than most people—and the Federal Government—realized. The total is now an astonishing 180, sources at the Department of Commerce estimate. This hasn't gone unnoticed by the Mexican government. There are now indications, based on industrial intelligence from Washington, that Mexico is planning to cash in on this growth by requiring owners to capitalize their operations to increase tax revenues.

The extent of such operations was realized only recently by Commerce when operations owned by "U.S. individuals" not previously tabulated were added to those held by U.S. corporations. The planned move by the Mexican government is not expected to make Mexico less attractive as an offshore assembly area to the U.S. semiconductor industry and some systems houses. It would take something drastic to slow this trend, sources say, something that isn't expected to happen. The Mexican government, they say, has taken no action against a large number of "garage operations" packed with "wall-to-wall workers and, in some cases, no toilets," but is waiting for the industry to flourish—obtaining large orders and making delivery commitments—before it cracks down.

First balloon goes up on Nixon R&D plan for 1972

The Nixon administration's 1972 plan to dramatically raise America's declining investment in industrial R&D [*Electronics*, Sept. 27, p. 33] will emphasize a more liberal tax structure for rapid depreciation and writeoffs of new R&D equipment and facilities, rather than direct Federal investment. This is the conclusion drawn by some electronics industries leaders after hearing former Treasury official Murray L. Weidenbaum address the Electronics Industries Association's Fall Conference. Though economist Weidenbaum has returned to the faculty of Washington University, St. Louis, his recent role as Treasury's assistant secretary for economic policy made him privy to the Nixon "game plans," and some listeners sensed a trial balloon in Weidenbaum's comments.

Weidenbaum, who first gained prominence in the mid-60s as a critic of the defense industry's profit structure, reflects Nixon Administration concern that "since 1964, this nation has been investing an ever smaller share of its national resources in R&D," and believes it can best be turned around by private sector financing encouraged by a high and rising level of economic activity; tax advantages such as those employed by Australia, Britain, Canada, Norway, Spain, and other West European countries; a broad approach to civilian markets with steady funding not limited to single economic sectors or mechanism such as existing institutes or universities; and more research on the R&D process itself.

Pad relocation goes into multiplier

Possibly the most sophisticated bipolar logic device available anywhere is being offered by the Microelectronic Products division of Hughes Aircraft. It's an eight-bit multiplier fabricated on a full 1.5-in.-diameter wafer using three layers of metal interconnects and a technique called pad relocation—a technique that Hughes officials believe is an improvement over Texas Instruments' discretionary wiring [*Electronics*, Oct. 13, 1969, p. 44].

The TTL multiplier is the first of a family to come from Hughes, and consists of 52 full adders plus 96 additional gates for the equivalent of

616 gates. Developers say it can form 8 million products a second, multiplying two eight-bit numbers plus sign to get a 16-bit result plus sign each time it forms a product.

It's aimed initially at military computer applications, such as airborne computers, for fast-Fourier transforms or digital filtering, but Hughes hopes to expand on the concept to provide other devices for the commercial computer market.

Under-$100 calculator set for January

The first under-$100 electronic calculator is on the way—and it's all-U.S. made. Ragen Precision Industries of North Arlington, N.J., will ship in early January the shirt-pocket-sized device. Designed with two C/MOS logic chips and an eight-digit liquid crystal display, it's a four-function device with floating decimal point. Ragen builds both electronics and display.

Ragen has an order from Alexander's, a New York Department store chain, for 20,000 calculators with an option for 20,000 more.

Measuring 2⅜ inches by seven-eighths of an inch by 3½ inches, it will operate for more than a year on a 9-volt dry cell battery. The chips drive the liquid crystal displays directly.

Coast Guard search for Loran resumes

The Coast Guard is trying once again to acquire a solid state Loran C transmitter. Originally christened Transloc, for transportable Loran C, and contracted to Sylvania, the program ran into technical and funding problems and was dropped. The new contract is with Megapulse Inc. of Waltham, Mass., and is for about $940,000 all told. The old Sylvania contract was about $6 million. The cost differential is largely due to a proprietary approach taken by Megapulse to generation of ultrahigh-power pulses, and to a relaxation of the Coast Guard's pressure for a transportable system.

Due to be delivered before October 1972, the megapulse transmitter would be a preproduction prototype capable of delivering more than 200 kilowatts effective radiated power—and, when paralleled with others like it, come up with the megawatt or more the Coast Guard requires.

TI to sell TV tuning diodes

Texas Instruments shortly will enter the market for tuning diodes for VHF and UHF television, a market it says can approach 1.5 billion units by 1980. TI products are electrically similar to parts Siemens has been making in Germany for a few years, but TI uses a standard small-signal glass diode package rather than the plastic used by Siemens and Motorola, the only other domestic producer.

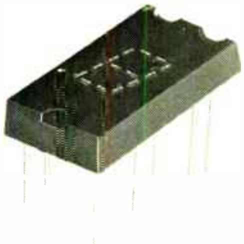
This means TI can use its automated diode production line, which is becoming available as ICs take over computer diode applications.

Electronic Arrays sells calculator firm

International Calculating Machines, the calculator manufacturing subsidiary established late last year by Electronic Arrays, has been sold to Lago-Calc Inc. An outright sale was one of three options Electronic Arrays president Mois Gerson suggested recently [*Electronics*, Sept. 13, p. 38]. Lago-Calc is headed by Max Lagomarsino, son of the founder of Totalia Calculator Co. of Italy, who has sold calculators as a distributor in this country for years. Lago-Calc will sublease the ICM facility, use ICM designs, and retain the top management.

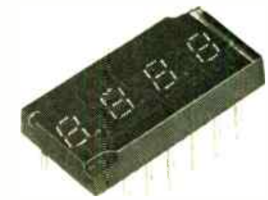
BIG TIME BRIGHT LIGHTS

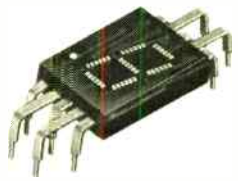
LED displays and Litronix have hit the big time. Our displays are in volume production. They are low cost and they are totally reliable. But don't just take our word for it—try them. Compare the long run advantages in design, reliability, availability and cost. Take a look at a few of the LED stars now playing in full production at Litronix.



◂ Outshines MAN-1 at lower cost. Introducing the Data Lit 10A, MAN-1 economy model. Has an amazing brightness of 500 foot Lamberts at 10 mA with 0.27 inch character. High quality, high volume new star with low price tag. $6.75.*

New 4 digit array. Small, bright display with .125 inch character heights and packaged for assembly economy. The Data Lit 34 is designed for low power and high brightness needs. It has four times the light emitting area as the MAN-3A. You can end stack it for 8, 16, etc, etc, digit displays. $3.80 per digit. ▸





◂ Power Saver, Money Saver too. The Data Lit 8 display, with .24 inch character height, consumes half the power of the MAN-1 type display, and half the voltage drop. It's just as bright. Mounts on 0.3 inch centers. Priced at $6.25.

World Famous "Skinny DIP." Perfect display for small calculator and portable instruments. Has .120 inch characters and comes in a very thin, DIP package, Data Lit 30, priced at $3.80. ▸

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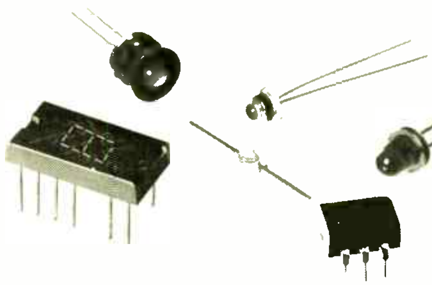

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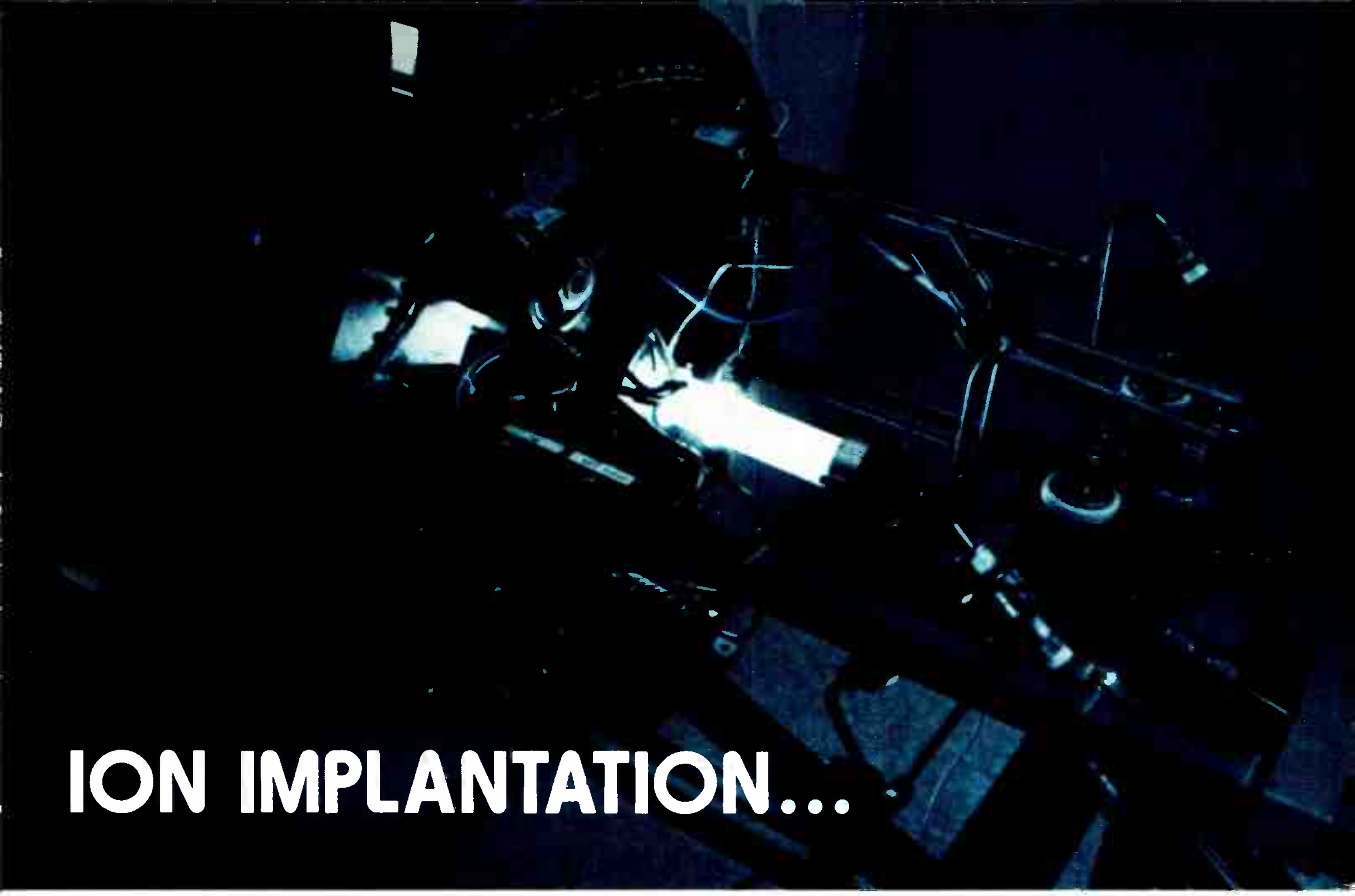

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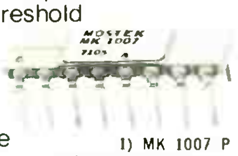
Your key to MOS performance – today!

Our revolutionary production process, ion implantation, has quietly come of age. Today it's the most uncomplicated method for achieving such sophisticated benefits as low threshold voltages for TTL compatibility and depletion mode devices for state-of-the-art performance. Want proof? Then take a look at some examples of the advantages offered by MOSTEK's ion-implanted product line:

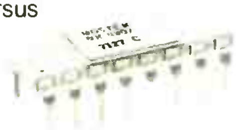
(1) Threshold Adjustment. Take our MK 1007 P 4x80-bit dynamic shift register, for instance. Ion implantation makes possible a low threshold device for full TTL compatibility without the need for interface components or high voltage, high power clocks. Our clock is single phase, low capacitance and TTL compatible.



1) MK 1007 P
4x80-bit Shift Register

(2) Depletion Mode Devices. With ion implantation we have replaced enhancement type load resistors found in all MOS/LSI to date with constant current, depletion devices. Results? See for yourself:

Low power over a wide supply range for memories such as our MK 4007 P RAM is illustrated by the constant current drain versus supply voltage shown in Figure 1. Power remains low with the depletion loads compared with the enhancement loads of the competitive 256-bit circuit.



2) MK 4007 P
256x1-bit RAM

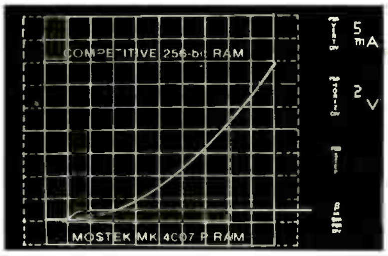
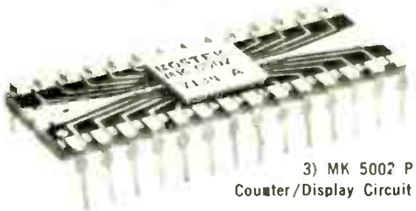


FIGURE 1

Single 5V supply operation. MOSTEK's MK 5002 P 4-digit counter/display circuit for instrumentation purposes can operate from a single −5V logic supply, drawing less than 25 mW, or from any supply from 4.5 to 20V! Ion implantation is the only processing tool capable of delivering this performance from otherwise conventional, cost-effective P-channel LSI.



3) MK 5002 P
Counter/Display Circuit

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Circle 28 on reader service card

Current switch scheme promises fast LSI logic

By cutting propagation delay and power hunger, HP configuration can yield larger, faster logic chips

Logic designers working with LSI circuits have a problem: their rulebook hampers both circuit size and performance because the logic configurations they are working with weren't intended for LSI circuits. DTL, TTL, and ECL configurations originally were designed as gate functions and not for highly integrated functions. The power/delay product of these circuit configurations is about 80 picojoules; a TTL gate typically has an 8-nanosecond propagation delay and requires about 10 milliwatts, and an ECL gate has a 0.9-nanosecond propagation delay and draws approximately 90 milliwatts. In terms of LSI, this means circuit size is limited by allowable propagation delay and package power limitations.

Other roads. There are other logic configurations, however, and an engineer at the Solid State Laboratory of Hewlett Packard Labs, Palo Alto, Calif. is working with one that cuts this power/delay product by a factor of four. According to John E. Price, a member of the technical staff at Hewlett Packard labs, a power-delay product of only 5 pJ can be obtained with a form of current switching logic. Price is working with two versions of such a gate: one employs positive feedback and the other a reference signal—the base of the transistor that's tied to the V_{01} output is connected to a 200-millivolt reference source instead of being connected simply to V_{01}.

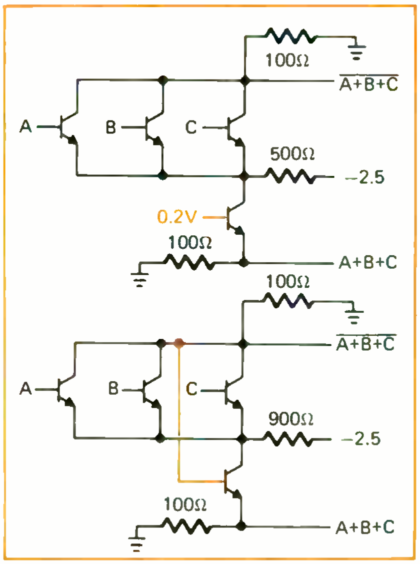
Price says that with the current switch configuration, "I've built gates that have a propagation delay of about 0.4 nanosecond and dissipate 10 mW, and gates that have delays of 2 nanoseconds and dissipate 2.5 mW. The basic figure of merit remains around 5 pJ." HP's interest in the high-speed circuit could be for new calculator circuits, high-speed counters, or high-frequency oscilloscopes, but Price won't comment on this. Price's work will be described at the International Electron Devices meeting in Washington.

Both circuits' configurations have been built with both conventional phosphorous-doped and arsenic-doped emitter structures [*Electronics*, Sept. 13, p. 36]. The arsenic emitter devices offer a propagation delay of from 0.4 to 0.6 nanosecond with power dissipation from 6 to 10 mW while the conventional phosphorous emitter structures have delays of from 0.4 to 2 nanoseconds with dissipation amounting to from 2.5 to 18 mW.

Price says that besides being fast, the current-switching configurations are easy to work with. A fanout of 5, for example, is easy to obtain, and noise margin is over 100 millivolts with an output swing of from 0 to 200 mV, which Price says "is quite good." Supply voltage is 2.5 to 3 V and there are no speed-limiting resistors in the signal path.

As an example of how an LSI or MSI circuit could be improved with the current-switch configuration, Price points to the TTL type 7483 MSI four-bit full adder. This circuit requires 500 mW and has a propagation delay of from 32 to 48 nanoseconds. A similar function implemented with current switching logic requires only 150 mW and a propagation delay that adds up to only 6 nanoseconds.

Logical. The difference between reference-voltage circuit (top) and positive-feedback circuit is shown in color. Reference-voltage is faster, hotter, costlier.



Memories

Sangamo division buys Soniscan from Sylvania

Soniscan, the magnetoacoustic bulk memory that promised multimegabit storage at 0.1 to 0.2 cents a bit [*Electronics*, July 6, 1970, p. 49], has been sold by GTE Sylvania to a division of the Sangamo Electric Co. The purchaser was Microsonics Inc. of Weymouth, Mass; the deal was consumated Sept. 27.

The dealings were quite complex;

negotiations went on for almost six months. A possible factor in the length of the negotiations were Sylvania's simultaneous investigations of "several joint venture and technology exchange offers," according to a company spokesman.

Financial details have not been disclosed, although both firms appear to have established solid patent positions for themselves. And Sylvania, through its royalties, can hope to share in what many observers feel will be a lucrative piece of the mass memory market. But the question remains: why did Sylvania share when it could have had it all?

Stability woes. Although Sylvania claimed greater success with ferroacoustic techniques than other firms that had tried similar memory technologies, Sylvania was believed to have had problems with the long-term stability of Soniscan-stored data and with addressing—its engineering teams simply did not have the training and experience to solve them. This may have been a key reason for Sylvania's sale to Microsonics.

Microsonics, according to its general manager, T.J. Geoghegan, has the required skills. "Our business for years has been delay lines for storage, display refreshment, and other applications. And we have the experience with bulk and surface-wave propagation, transducers, and production techniques which we feel can solve Soniscan's problems."

Navy waits. Geoghegan says that the firm plans to seek out commercial markets. But the military may be on the preferred customer list. The Naval Air Systems Command still is interested in Soniscan for its Advanced Airborne Digital Computer System—and though neither the Navy nor Microsonics will comment, the Navy's own comparative tests during 1970 pegged Soniscan—with its low power needs, high packing density (5,000 bits per cubic inch), 75-nanosecond read-write time, and its low price—as the best among available and future bulk memory technologies. The Navy has been waiting like a cat for the mouse ever since, and so even though Goeghegan won't say anything about the Navy's potential as a customer, it's safe to say that the Navy brass in the Pentagon has his phone number.

Lasers

High-gain, flash-pumped laser gives coded pulse

If lasers are to become realistic communications tools, it will be necessary to obtain efficiently a coded-pulse output from a high-power, flash-pumped laser. Two experimenters at Texas Instruments' Central Research Lab think they've found the key with an acousto-optic modulation technique that permits not only switching of high-power flash lasers, which isn't new, but variable output pulses.

The approach taken by Warner C. Scott and M. DeWit was to use an acousto-optic beam deflector—a quartz resonator whose transmissive or reflective properties can be controlled by exciting it with radio frequencies—arranged so that the undeflected portion of the laser beam provides an output pulse, while the deflected portion re-enters the laser's feedback loop. The deflection of the acousto-optic device depends on the power applied to it, hence the threshold population inversion can be electronically controlled by varying the rf power; an additional feature is that very low rf power is required, typically only a watt, compared to the higher levels necessary with conventional Q-switching.

Using the quartz resonator as a switch is not a new approach, but it's done in a different way: a Bell Labs technique uses the switch to vary the loss of a continuously pumped laser resonator from high (no lasing) to low, with consequent lasing and output. But it is impossible to obtain variable pulses in this manner from a flash-pumped laser, since the energy output is a function of the population inversion within the laser at the time of the flash; this means that threshold inversion is generally predetermined by mirror transmissions. Thus, variable pulses could be obtained only with a deflecting mirror, unsuitable for high frequencies and not amenable to wide control.

In experiments, Scott and DeWit switched a krypton-pumped neodymium-YAG laser, providing both single and multiple pulses, using a 100-megahertz acousto-optic deflector. Single 70-millijoule output pulses, 30 nanoseconds wide (3½ to 4 megawatts peak) have been obtained, with even higher power obtained with double pulses. According to Scott, energy and times were completely stable and the pulses could be varied in energy from zero to the maximum available.

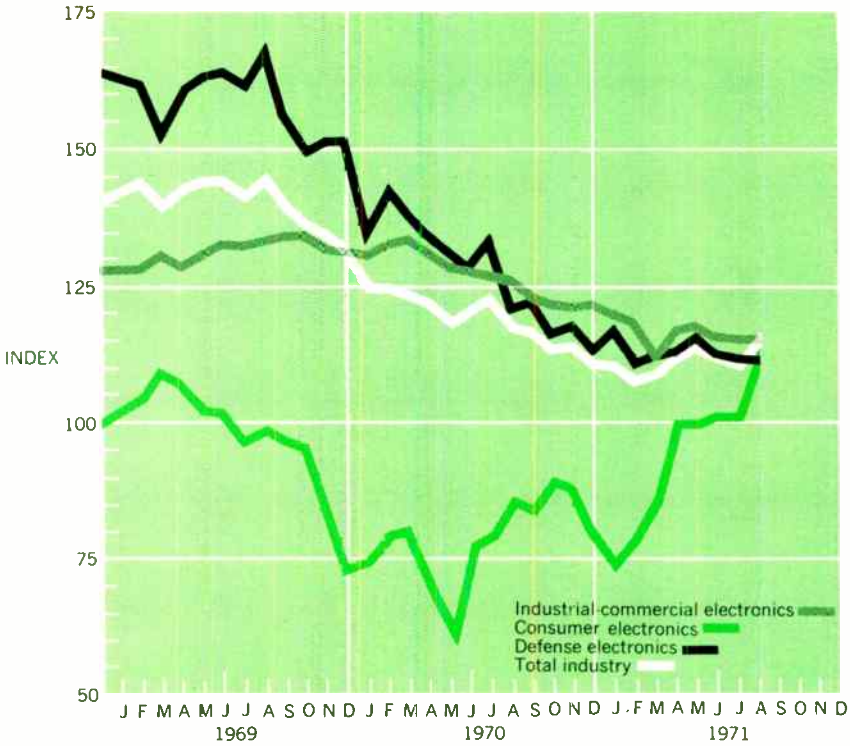
Scott will not comment on possible applications at TI, but TI's equipment group is very active in military laser-controlled bombs and surveillance systems using infrared detectors. Possible applications could lie in this area, or in communications.

Commercial electronics

Rotating-ring watch display may leapfrog LEDs, crystals

Low-cost complementary MOS digital countdown circuits have made electronic wristwatches a reality, but since most of these timepieces use gear-driven hands to display the time, they still have numerous moving parts. Light-emitting diodes also have been used to display the time, and liquid crystals hold promise, too. But to display digits constantly, both require more power than the 1.5-volt batteries in these watches can provide. And liquid crystals have limited lifetimes, and are temperature-sensitive.

A Southern California inventor has come up with a new kind of display system for electronic watches that might offer an attractive alternative to gear-driven hands, LEDs, and liquid crystals. What's more, the rotating-ring display system, as it's called, is compatible with the 1.2-to-1.5-V batteries now used in electronic watches, and can have all the drive circuitry on one C/MOS



Electronics Index of Activity

Oct. 11, 1971

While the index of total industry output for August climbed 4.5 points from July's figure, it was still 1.8% below the August 1970 total. Consumer was the largest contributor to the late summer rise as it chalked up an 11.4% increase. Experts are crediting President Nixon's new economic program for the generally improved air of consumer confidence.

Industrial-commercial also made a slight contribution with a 0.2-point increase. The only August loser was defense, down 0.3% from the previous month and 10% from its year-ago level.

Segment of Industry	Aug. '71	July '71*	Aug. '70
Consumer electronics	113.4	101.8	86.2
Defense electronics	112.4	112.7	126.0
Industrial-commercial electronics	116.3	116.1	127.8
Total industry	116.1	111.6	118.2

Indexes chart pace of production volume for total industry and each segment. The base period, equal to 100, is the average of 1965 monthly output for each of the three parts of the industry. Index numbers are expressed as a percentage of the base period. Data is seasonally adjusted.
*Revised.

chip, says the inventor of the display system, Hans Dill.

Dill is manager of the solid state device research department at Hughes Aircraft Co., Newport Beach, Calif., but his application for the patent on the rotating-ring display system has been assigned to him by the company, and all his work on the concept and a feasibility model has been done at home outside company time. Dill also is an authority on ion-implanted MOS devices, and several Hughes patents, including one covering the silicon gate process, bear his name.

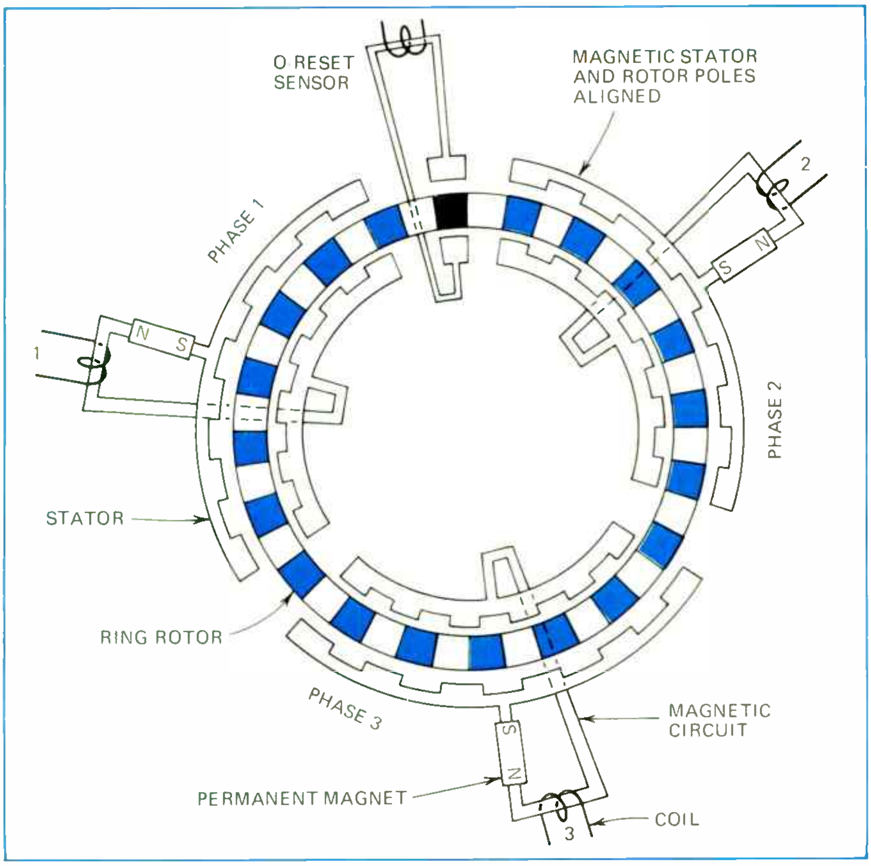
In his system, the rotating rings, which ultimately may be made of metal-impregnated plastic (all-metal rings are used in the working model), form the rotor of a pulse-driven step motor that's moved either forward or reverse by a three-phase stator drive. The rings rotate in grooves once a pulse is applied, but are held at rest by permanent magnets. No power is consumed while they're not moving.

Three or more such rings could be arranged concentrically on the face of a watch with appropriate indicators for the second, minute, hour, and date. The indicator might be a simple dark printer on one part of the ring, the rest of which is painted the same color as the watch face to provide contrast. The concept also is applicable to instrumentation in which a large variety of information must be observed or monitored quickly via a multichannel analog display.

The ring or rotor contains equally spaced magnetic and nonmagnetic areas. The stator poles of the magnetic drivers are grouped into three phases, each covering about a third of the ring's circumference. In one phase, the ring poles (magnetic areas) and stator poles are aligned with each other; the other two phases have a one-third overlap of the magnetic poles—clockwise for one phase and counter-clockwise for the other. Thus, the stator poles of the three phases are displaced by two-thirds of a division along the circumference.

Ring movement, which corresponds to hand movement in conventional watches, is triggered by a pulse from the C/MOS drive circuit. This compensates the magnetic field of the fully aligned phase and one of the phases that are one-third aligned. Then the magnetic field from the permanent magnet in the remaining nonaligned phase reduces magnetic reluctance by aligning the magnetic areas of the ring with the stator poles. This moves the ring by two-thirds of a division. Direction of ring movement is governed by which of the partly overlapping phases is compensated.

The single-ring prototype steps in less than 50 milliseconds with pulses that deliver about 100 ampere-turns. Magnetic flux should accelerate the ring with about 20 g's, resulting in stepping speeds of 5 milliseconds. Dill calculates the power consumption of the entire system at 5 to 6 microwatts; this could extend the life of a 1.2-V battery to two or three years instead of the usual year. The rings may be driven separately



Time turns. Rotating-ring display system for electronic watch can use single C/MOS chip.

or be electronically coupled, but they're always completely sealed and are the only moving parts in the watch.

Dill's next step is to build a better-looking model than his original. Then he hopes to license the rotating ring display system to a major watch manufacturer.

Computers

Illiac 4 to go operational by spring of '72

Spring of '72 is the magic date now for the giant Illiac 4 computer. That's when the unique system is scheduled to be turned on operationally. An object of intense interest by the data processing community because of its 64 processors, each with its own memory, the huge parallel system is also becoming associated less and less with the University of Illinois—its designer.

First major break in the university's involvement was the decision to locate the system at NASA's Ames Research Center in California. The building to house Illiac 4 is under construction now, and officials say it will be ready in time for the spring date. The move to the Government facility was made primarily to safeguard the machine from possible student rioters. Hardware is being built and put together at the Paoli, Pa., plant of Burroughs, the builder, where debugging is currently under way. Not all the processors are working in the system yet—there are some input/output problems—but Illiac 4 will be ready for its spring timetable, officials maintain.

The university still has contract responsibility for hardware, but transfer of diagnostics and maintenance from the school is the latest step in the gradual phaseout of the school's involvement. NASA has awarded a contract to Automation Technology Inc., Champaign, Ill., to continue development of off-line diagnostics, create a maintenance team to monitor the system on-line, and formulate and build a tester for the printed circuit cards.

Under the new contract, some of the people who were working on the project at the school have transferred to ATI; and four Burroughs engineers will form the nucleus of the maintenance team. All eventually will be transferred to Ames. Even the existence of ATI is, in a sense, part of this phasing out; its president, Arthur B. Carroll, was second in command of the Illiac project for several years.

Univac aims 1616 at military, FAA markets

With an order for its new 1616 computer in hand, Univac has formally unveiled the breadbox-sized processor. The announcement comes as no surprise [*Electronics*, July 5, p. 18]. The sale of the first machine to ITT Gilfillan for evaluation in its Navy AN/SPS-48 long-range air-search radar confirmed reports of Univac's market plans for the system. The three-dimensional SPS-48 shipboard system for attack carriers, cruisers, and frigates will feed into the Naval Tactical Data System and provide information for carrier aircraft interceptor control, and ship missile launching. Though Univac says the 1616 model to be delivered in December for the SPS-48 will have 32,768 words of memory, it declined to disclose price or application in the ITT system.

However, the company said typical applications cover "air traffic control; converting radar data and flight facts into visual displays; preprocessors for the front end of centralized shipboard systems; sonar and beacon signal processing, transferring data in real time; and shipboard control systems such as radar, electronic countermeasures and navigation." Beyond military sales, Univac clearly is shooting for Federal Aviation Administration business, specifically the expansion anticipated for the Automated Radar Terminal System on which it's already prime contractor.

And the Sperry Rand computer

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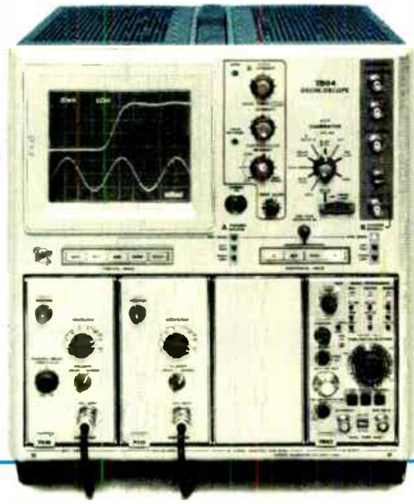

7904 Oscilloscope

From 500 MHz at 10 mV

or: 1 GHz @ <4 V/cm direct access plug-in

For those who have requirements in between 500 MHz and 50 MHz there's the 150-MHz 7704 (R7704 rackmount), 90-MHz 7504 (7514 storage), all with 4 plug-in compartments; 90-MHz 7503 with 3 plug-in compartments.

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Deflection factors and sweep speeds, the DMM and counter outputs, invert and uncalibrated symbols, etc., are automatically displayed on the CRT—where you look for information. CRT Readout can be ordered initially or as a conversion kit that is easily installed. In each case the cost is only $400. And it is available in all scopes except the 7403N.

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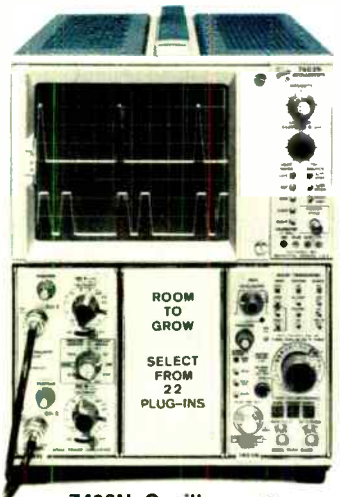
to 50 MHz at 5 mV

dual-trace, 6½-inch CRT and delaying sweep for only $2200



7403N Oscilloscope
(R7403N 5 1/4-inch rackmount)

7000-Series Scopes, complete with plug-ins, start as low as $1670. Call your nearby TEKTRONIX Field Engineer today for a demonstration of the scopes that make *more* measurements *easier* and *quicker* or write: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.

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Circle 33 on reader service card

division declares "it is not a minicomputer" in terms of performance, though its size and price suggest it. The 1616 base price is $16,000 for a 16-bit machine with 4,096 words of core memory that can be expanded to 65,536 words. Cycle time is 650 nanoseconds for the 2-foot-square box that stands 14.25 inches tall.

The company says that "against computers in the same price range, the 1616 requires less memory for handling data, less instructions to solve a given problem, and has faster execution time."

Univac says also that the industrial version of its 1616 with commercial-grade memory has about 6,000 hours mean time between failure for the total system.

Heat will limit specs, says IBM researcher

Between them, semiconductor and computer makers create the impression that computers continually will become faster, more powerful, and smaller, whether in single large mainframes or in nets of minicomputers. But IBM research scientist Robert W. Keyes figures that the time may be near when IC computer performance specifications and cost reductions are going to be limited simply by heat.

"If you look at the indicators like throughput, speed, declining cost, and so on, they all project toward infinity. Circuits per computer appear to rise asymptotically, speed is rising about linearly as the years pass. But from the rise of the alloy diffused transistor to the IC, speed-power products have remained within a fairly well-defined ballpark," he says.

And after a mathematical investigation of the facts of life within a computer, Keyes predicts that the clamps will come not because of gate propagation delay or device size limits, as some have predicted, or because packing density will level off ("Indeed, using variations of electron-beam lithography, it should be able to make ICs with active elements measured in molecules), but just because chips will overheat.

And so long as computers are tied to semiconductor technology as we know it, there doesn't seem to be any way out of the bind.

Speed—a factor of packing density, device size, and power—is expected by Keyes to level off at 10 times today's available speeds. Since the industry now is using circuits with gate propagation delays in the nanosecond region, things should top out at about a few tenths of a nanosecond.

"But high packing densities combined with small device areas (junctions) are going to make the heat transfer problem ever tougher," he says. "Even using liquid cooling, it is hard to dissipate much more than 10 watts per square centimeter today. A hundred watts per square centimeter, not an unreasonable figure for some large-scale integrated devices in the minds of designers, if not on their drawing boards, is going to be just about impossible."

This will limit propagation time and thus limit speed because LSI devices will have to be designed less densely than electron-beam lithography or other techniques might allow.

And while they have not made a vigorous study like Keyes, the economics of the situation is becoming apparent to computer makers. A spokesman for one quality minicomputer producer notes that "for the next 10 years at least, it's software where the breakthroughs will come."

Some of Keyes' colleagues disagree. One of them, Gerald A. Maley of IBM, would add new functions to existing chip designs and put more thought into architecture to improve machine performance.

Companies

Solitron to head down C/MOS path

A new marketing strategy is beginning to emerge at the San Diego plant of Solitron Devices Inc. now that Walter Greenwood, the ex-Hughes Aircraft Co. executive, has had time to assess and influence it in his new job as executive vice president [*Electronics*, June 7, p. 14]. Perhaps surprisingly for a company that showed a loss in its 1970 net, the strategy includes ambitious plans to go up against the formidable competition already in the rapidly growing market of complementary MOS.

From Japan. Solitron also has a foot in the calculator camp, with a contract from Matsushita Communications in Japan for 15,000 sets of five chips each. A sizable follow-on order is being negotiated with Matsushita, says Peter Gopal, manager of MOS custom systems. The calculator chips are p-channel MOS devices.

Both the C/MOS and calculator capabilities were acquired from outside Solitron. The C/MOS expertise came with the hiring of three former employees of Hughes Aircraft's Microelectronics division. Carroll Perkins was most recently MOS marketing manager at the Hughes division; he's now Solitron's MOS product manager, with responsibility for both C/MOS and p-channel devices, excluding calculator devices.

The C/MOS effort will emulate the RCA CD4000A series. Solitron's CM4000 series, like RCA's, will consist of 41 basic devices, but whether or not all 41 are produced will depend on demand. The company currently has four products available in sample quantities of a few hundred and is generating artwork on new types at a rate of two a week.

"We have generated artwork on about 15 types and will start shipping about five types during October," says Perkins. He has his sights aimed high. "By year end we should have 25, and by the end of the first quarter of 1972 we should have caught up with RCA," he says.

Solitron is following the RCA lead because the RCA series has been well promoted and well established as standard devices. However, Solitron regards the 4000 series mainly as a springboard for developing custom-made devices.

Perkins calculates the 1971 mar-

Bell & Howell & Heads You Win

"Wow! We've done it! A super headed recorder/reproducer like nothing nobody's ever seen!"

This from one of our brighter back room boys as he charged into our office.

"Take a look guys. 2MHz performance at 60 ips. Realize what that means? Perfect recording with half the tape. And at about $200 a reel, that's a cash register full of saved bucks."

"Not bad."

"And it's so good we've given the record head a whompin' 5,000 hour warranty."

"Well, I think we got something to work with. Anything else?"

"Yeah, those are both industry firsts from Bell & Howell."

"And?"

"Well, it has the usual 14 channels. 15/16 to 240 ips and stuff like that, in the conventional format."

"Ummm, who uses the thing?"

"R & D types mostly. It's about as sophisticated as you can get. They use it for aircraft tests. Cars. To pull down whole libraries of data from field recorders. That sort of thing."

"Sounds like a heckuva machine."

"System."

"Okay, system. So what do you call the super headed system?"

"The VR3700B."

"Wow. That really tells it like it is. Okay, we'll do an ad. But first I'll flip you for coffee. Call it."

"Heads."

"You win."

"Hey, not a bad headline for the…"

"Are you kidding? Beat it. Sheez, can you imagine."

Read about it. Bell & Howell, CEC/Instruments Division, 360 Sierra Madre Villa, Pasadena, California 91109.

CEC/INSTRUMENTS DIVISION

BELL & HOWELL

Circle 35 on reader service card

ket for C/MOS at slightly more than $5 million, increasing to $15 million in 1972, $80 million in 1974, and $170 million by 1975. While counter-type circuits now account for more than 80% of sales, he expects that random access memories will be the biggest single factor within about three years.

Employment

Self-help groups see some daylight

Are engineers becoming employable again? Maybe so. Certainly some of their self-help group efforts appear to be bearing fruit after nearly a year [*Electronics*, Jan. 18, p. 34].

The depressed Boston area spawned many such groups, and now one of them has decided to close—despite the recent RCA computer division shutdown—because 80% of its participants have been hired. Called the Sudbury Experiment, the group was small, too small for projecting national trends. But now other groups are reporting a gradual improvement in hiring. And in every case, the jobs are in engineering.

Interestingly, the key men in some of these efforts are quickest to land jobs themselves. Once the most vocal, the Economic Action Group Inc., Needham, Mass., continues to function, though more quietly—its founder, Gerald Wallick, has moved after finding a new job in New Hampshire. Paul Jackman, head of the Topsfield Group, now wears two hats as head of the group and consultant to the Massachusetts Science and Technology Foundation.

The largest effort in Massachusetts has been the state-sponsored Route 128 Center for Professionals, a clearing house for jobless technologists and potential employers. In August the center held a special seminar for about 20 jobless engineers. At the same time, the center kept records on 50 other engineers.

Like the IEEE-AIAA sponsored "Tiger Breeding" sessions [*Electronics*, Jan. 18, p. 35], the seminar was aimed at improving the job-landing skills of the participants, and it seems to be successful.

During a 30-day period beginning halfway through the seminar, the participants had about four interviews each, versus about 2.5 per man in the control group. "Apparently engineers need nudging," says a spokesman. Compared to the control group, the trained 20 are scheduling more interviews, going to more job placement agencies, carrying in more resumes personally, and generally being more aggressive than their counterparts.

And the payoff is in jobs; of the 20 seminar-trained engineers three soon found work compared to one of the 50-man nonseminar group.

Government

Electronics figures heavily in negative trade balance

Disclosure of August's trade figures—the numbers that triggered President Nixon's 10% import surcharge—show that electronics imports, though still on the plus side, made a significant contribution to that month's negative balance of $259.7 million. When added to earlier figures, the August total showed that U.S. imports overall exceeded exports in the first eight months of 1971 by $936.1 million—a sharp contrast from the $2.23 billion surplus in the same 1970 period.

A precise breakout of figures on electronic products and components exports and imports in August will not be available for several weeks, but increases occurred in all electronics categories—manufactured goods and electrical machinery, apparatus and appliances.

Commerce also came up with another set of supporting figures: for the first time the U.S. imported more than half of Japan's electronics exports in 1970. American purchases of $1.2 billion in Japanese electronics last year were up 14% from 1969. Consumer products accounted for 84.7% of the total, and showed an 11% increase. Since consumer products have long been Japan's bread-and-butter business in the U.S. market, the Commerce figures are less startling than the agency's disclosure that the U.S. more than doubled its imports of Japanese computers in 1970. Their value: $78 million vs $36.5 million the year before.

Component shipments to the U.S., at $67.9 million, represented 5.6% of total electronics imports, although this figure slipped $6.6 million from the 1969 peak. All other equipment areas showed gains, however, rising to $116 million, or 0.7% of the total. Included in this last category are telephone and telegraph equipment—particularly switchboards and exchanges—where sales to the U.S. totaled $15.7 million, more than triple the 1969 level for such sales.

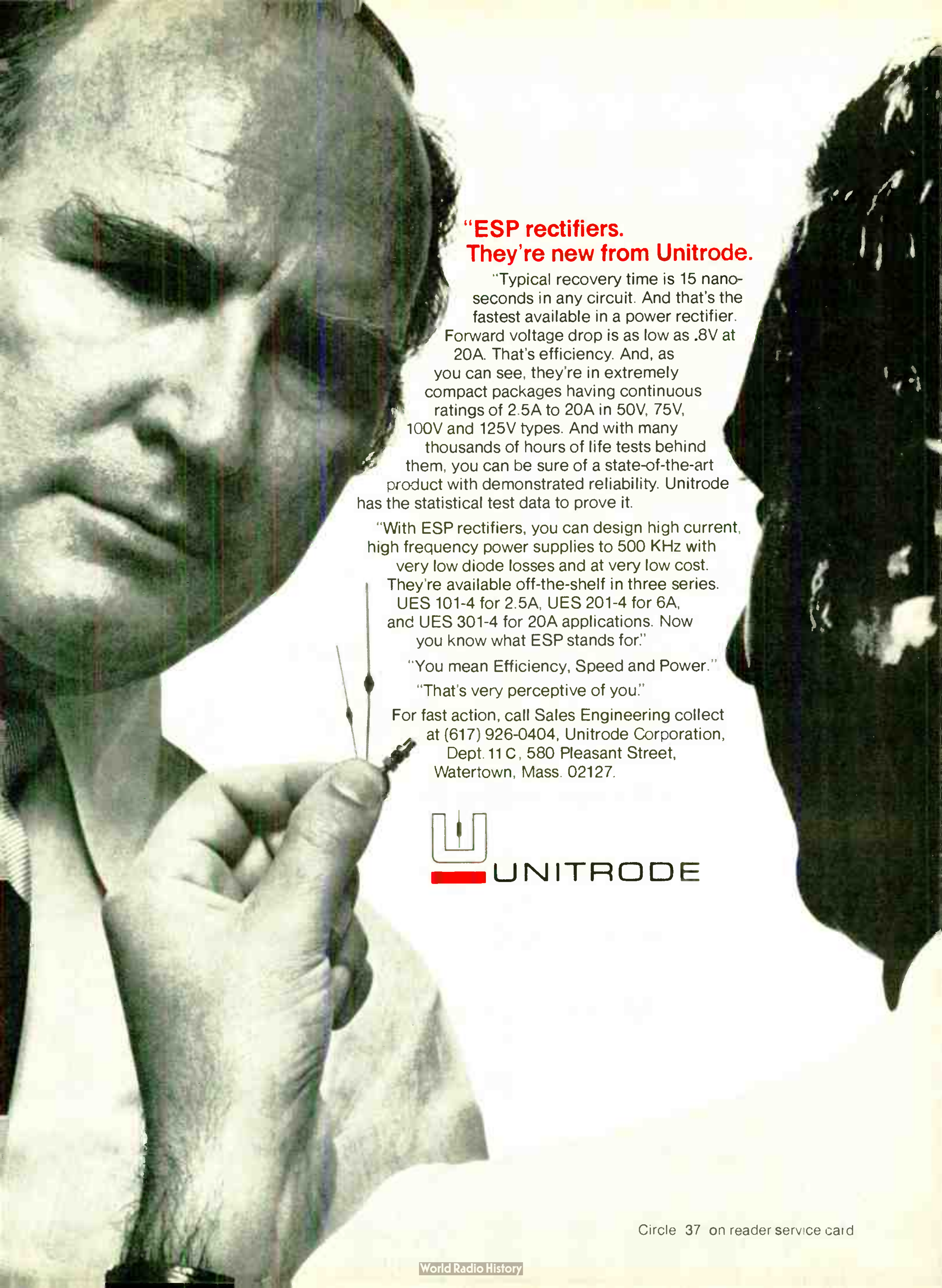
One intriguing aspect of the U.S. data is the notation that Japan—which has mounted a sharp export drive in all world markets for every kind of telecommunications equipment—also is expected to import more of this hardware in 1971 as its own domestic requirements increase. For example, its imports of communications and electronics this year are expected to rise 20% to 30% from the 1970 total of $590 million. Leading this increase will be computers, integrated circuits, and test and measuring instruments.

Nevertheless, Japan's Communications Industry Association expects its members' exports throughout the world this year will jump another 19%. The biggest boost, 30%, is expected in wire telephone and telegraph equipment, with respective increases of 17%, 16%, and 15% for microwave hardware, carrier equipment, and broadcast systems.

Packaging

Brushes, tags bid for place in connector sun

"Brush" and "laundry tag" may conjure visions of a dry-cleaning establishment, but if the Bendix Electrical components division in Sid-


"ESP rectifiers.
They're new from Unitrode.
"Typical recovery time is 15 nanoseconds in any circuit. And that's the fastest available in a power rectifier. Forward voltage drop is as low as .8V at 20A. That's efficiency. And, as you can see, they're in extremely compact packages having continuous ratings of 2.5A to 20A in 50V, 75V, 100V and 125V types. And with many thousands of hours of life tests behind them, you can be sure of a state-of-the-art product with demonstrated reliability. Unitrode has the statistical test data to prove it.
"With ESP rectifiers, you can design high current, high frequency power supplies to 500 KHz with very low diode losses and at very low cost. They're available off-the-shelf in three series. UES 101-4 for 2.5A, UES 201-4 for 6A, and UES 301-4 for 20A applications. Now you know what ESP stands for."
"You mean Efficiency, Speed and Power."
"That's very perceptive of you."
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UNITRODE
Circle 37 on reader service card

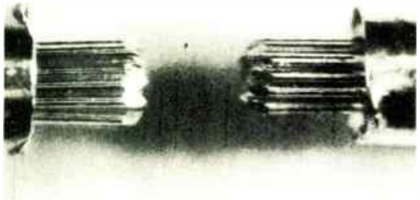
ney, N.Y., is successful, they may become familiar terms in the connector business. Bendix has been researching two new types of contacts—the brush contact, a bundle of small wires that makes contact with another bundle by simply interleaving the wire ends, and the laundry tag, a contact intended for edge connections to printed circuit boards by gripping plated-through holes with a pair of jaws that closes through the hole when the board is inserted.

The brush contacts, now being sold in prototype quantities, are envisioned in several applications, including almost any situation now using a pin-and-socket arrangement, according to Donald E. Michel, Bendix chief engineer for microelectronics. Michel says that the contact insertion force for a brush is about 1¼ ounces, much less than the typical 6-ounce insertion force for pin-and-socket contacts. When putting together matching halves of a 100-contact connector, Michel says, "you might need a sledge-hammer if you used pin and sockets" but it could be managed easily by hand with the brushes.

Michel also points out that since brush contacts are hermaphroditic, it might be possible to build connectors that interconnect flat-pack hybrid circuits by stacking them up and do away with printed circuit board interconnections entirely.

The laundry tag contacts are a little further away from regular use—Michel estimates samples will be available by early 1972—but he does feel that they can compete as a low-cost connection medium with any of the present pc board connector contacts, such as the tuning fork and the pin and socket.

The laundry-tag grippers are shaped as chamfered jaws on the ends of a tuning fork. When the pc board is inserted, the insertion force can be transmitted to the jaws to cause them to close and lock through the plated-through hole, putting pressure on the inside hole surface to make electrical contact. Several mechanisms have been used to provide the closure force—rollers in the connector that ride up a ramp to a detent position to close the jaws, a set of polypropylene hinges where insertion force is used to move one hinge member relative to the other and close the jaws, and a simple cam mechanism that might serve several connectors that could be actuated with a screwdriver.



Fit. Bendix connector's brush contacts

The push contact is made by cutting chamfered ends on phosphor bronze wires each about 6 mils in diameter and then crimping the 14 wires in a holder. The contacts, when engaged with another bundle of brushes, are designed for a total engagement of 0.125 inch, resulting in 5 milliohms contact resistance. A lower engagement gives inconsistent contact resistance; a greater figure tends to accentuate wire bending as the two bundles are engaged. Test results show that up to 500 matings produced little change in contact resistance.

Military electronics

Displays, computers to teach dogfighting

Close-range aerial combat is one of the most difficult skills a fighter pilot must master. But the most effective way to learn it is to get involved in the real thing—roughly analogous to learning to swim by being thrown in a river.

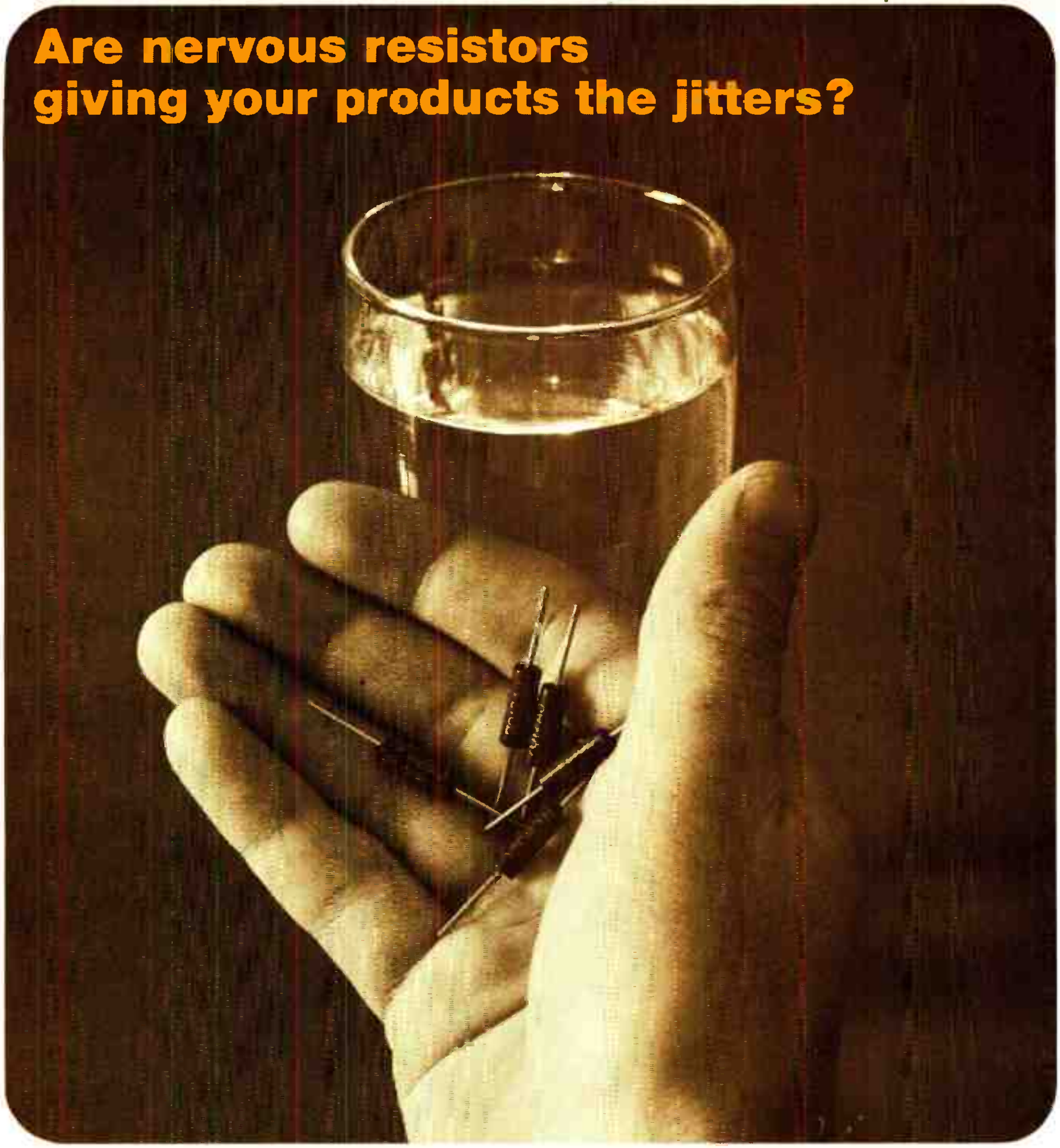
The U.S. Navy hopes to do the next best thing to boost the dogfighting skills of student pilots with an electronic system being developed by Cubic Corp., San Diego, Calif. Called the Air Combat Maneuvering Range, it will enable pilots to practice dogfights in the air while a ground instructor monitors the action in real time on a computer-driven video display and gives instructions by radio.

Two important benefits of the system are that it will get the instructor out of the air and on the ground where he can better observe the action, and help teach pilots to identify the "missile envelope," the effective area in which he should fire to hit the target. This will be accomplished by transmitting an audio tone automatically when a pilot is in the right position.

The system will consist of four major elements: a computation and control subsystem by System Development Corp.; a tracking instrument subsystem—a high-speed, phase-locked-loop ranging system operating at L band; display and debriefing subsystem by Adage Corp.; and an airborne instrumentation subsystem by Lear Siegler. The latter is an instrument pod 9 feet long and 5 inches in diameter that will be carried in place of the usual Sidewinder missile. The pod will house a distance-measuring-equipment transponder, attitude-heading reference unit, angle-of-attack sensor, weapons-bus monitor (for weapons status information), and a data encoder.

The computation and control subsystem will consist of three Xerox Data Systems Sigma 5 computers. One of these will compute aircraft positions and one will simulate the firing of missiles when a pilot pushes a button, displaying the imaginary trajectories on the display. The third computer will be the system's overall controller.

At the Yuma, Ariz., training range, the tracking instrumentation subsystem will consist of a manned master station and six unmanned remote transponder sites. On command from the computer, the master may instruct a particular remote unit to interrogate a given aircraft by its identification code. The aircraft pod's response will be picked up by all six stations and relayed to the master station, which will compute the slant ranges of all six, using a Kalman filter program, and transmit the data to the central computer.



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Circle 39 on reader service card

Under contract to the Naval Air Systems Command, Cubic is scheduled to have the first unit operating at the range at Yuma by November 1972. Two more ranges are planned, including one at Cherry Point, N.C. Total value of the contract, including four tracking stations for aircraft and missile testing, is expected to be about $47 million.

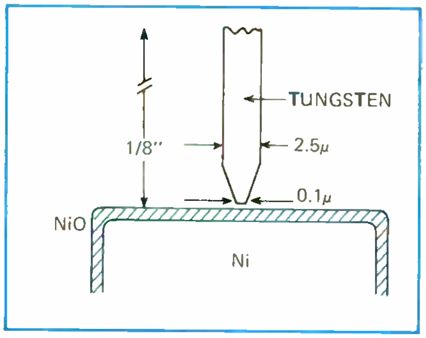
Advanced technology

Diode key to first precise measure of speed of light

MIT experimenters led by Ali Javan, father of the gas laser, may have come up with the most precise method yet of measuring the speed of light. They have developed a diode that's small enough to measure infrared wavelengths. The development is a result of work going on in the Physics department's laser group since 1968 on direct measurement of the frequency of light waves.

Their method involves focusing laser beams on a diode and measuring a resultant harmonic beat on an oscilloscope. But this necessitated the diode development because ordinary silicon diodes have tungsten leads that are 1 mil or more in diameter, too large to resonate beyond the submillimeter range. But a diode that works with light waves must have an "antenna" smaller than one wavelength of light—or smaller than any antenna built before.

The structure of the MIT diode is conventional, and the only differences lie in size and composition. The tungsten wire is about 2.5 microns in diameter and ⅛ inch long, and is electrochemically etched to a point about 1,000 angstroms in diameter. This wire is mounted at the end of a coaxial cable and makes a mechanical contact with a nickel post. David R. Sokoloff, a member of the group, says "We suspect that an oxide layer forms on the metal post so it's really a metal-oxide-metal diode. Electron tunneling causes rectification, and some theoretical studies have been done on the response, but no one really knows what is going on."



Small beat. Diode developed at MIT to measure speed of light precisely.

Focusing the light beams from two-near-infrared gas lasers on a diode's whiskers sets up electrical oscillations at their infrared frequencies. Simultaneously, a microwave beam from a klystron is directed at the diode, which also responds electrically at that frequency. The frequencies of the laser and microwave beams set up a harmonic beat note at a low frequency. The tungsten transmits the optical frequency alternating currents to a thin film of oxide on the diode post, where electron tunneling mixes the currents and converts them to a current that carries the beat to a scope for measurement. The frequencies of the two laser beams are then compared through harmonic analysis and measurement of the beat note.

In an experiment using four lasers, the laser frequencies were mixed in the diode and tuned to a time signal sent from the National Bureau of Standards, making it possible to compare the various laser frequencies in several steps. With this method, a carbon monoxide laser frequency was found to be precisely 58,024,341 million cycles per second. With silicon diodes the highest frequency measured was about a twentieth as high.

Sokoloff says the group is now experimenting with a method of vacuum-coating thin filaments on plastic to make still smaller whiskers capable of measuring frequencies into the visual range. "Up until two years ago people thought this couldn't be done," observes Sokoloff, adding that now "we can make measurements that have never been made before."

For instance, the speed of light is the product of its frequency times wavelength. Wavelength is normally measured by interferometer or grating, and frequency is calculated using the experimentally known value of the speed of light. But with the ability to directly measure frequency in the infrared and optical ranges, it will be possible to determine the true speed of light more accurately. It is also possible that the standards of length and time will be made interdependent through a defined value of the speed of light. One possible use for time and distance measurement by lasers is laser ranging of the moon.

For the record

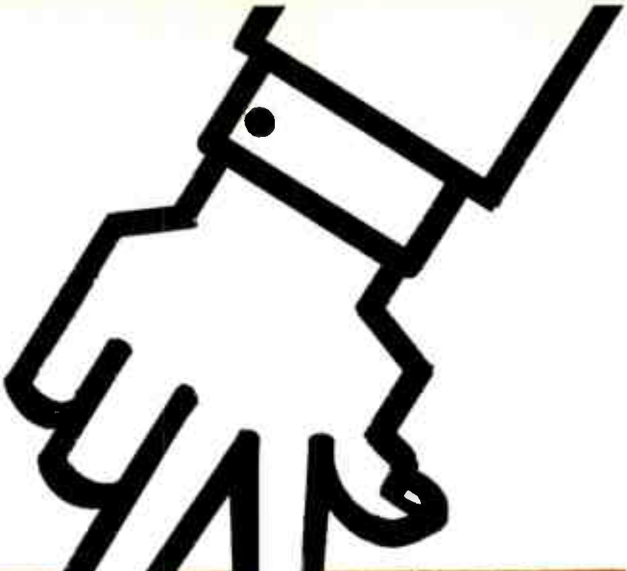
Sale. United Aircraft Corp.'s Hamilton Standard Medical Electronics division, Windsor Locks, Conn., reportedly has been sold to General Medical Corp., Richmond, Va., at an undisclosed price. A spokesman for General Medical says the sale is not final, and the company will not discuss details until it is. Hamilton Standard has been in the medical electronics business for five years, spinning-off UA-developed space technology for use in artificial kidney machines, and blood circulation and respiratory apparatus.

Goldmark's goal. Having turned down $750,000 a year at CBS to sit back and think, Peter C. Goldmark, retiring head of CBS Laboratories, Stamford, Conn., has instead set up a new company to solve communications industry problems. The firm, to be located in Stamford, will be a systems engineering venture to bring state-of-the-art CATV and video cassette technology to bare communication needs of urban centers. His long-range objective is to piece together the many forms of communications, including satellite, for the cities of the future.

Fast miniprinter. A serial printer up to 10 times faster than available competitors has been unveiled by

This new IEC 10 MHz Function Generator has a couple of things going for it!

(like sweep & phase lock)



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And that's not all. Sweep and phase-lock are just two of the numerous features that distinguish this new IEC 0.0005 Hz to 10 MHz all-purpose test instrument. For example, trigger/gate, and calibrated output attenuation. The F55. The Great One. Top of the Series 50 line that includes four other brand new function generators. What do they have in common besides superb performance? 10 MHz capability, fixed and variable offset, variable width pulses as well as fixed width pulses and ramps, simpler man/machine interface and much, much easier maintainability. That's what. Plus the special features of each model, such as the sweep and phase-lock blend of the F55.

Depending on requirements, there's a particular Series 50 model that's exactly right for your needs. And priced accordingly, from $595 up. Like a look? Call, TWX, write or wire our John Norburg at Interstate today. Ask for a demonstration. Get a new IEC Function Generator going. For you.

Printer Technology Inc., Woburn, Mass. Priced at $1,700 in OEM lots, the Printec-100 is aimed squarely at the minicomputer market, now using output devices like IBM's Selectric (at 10 to 15 characters a second and about $3,000), Teletypes, and more costly line printers. The new device's claims to fame are full characters, not dot matrices, a 1,200-baud phone line communications capability (said to cut communications costs), and its pricing.

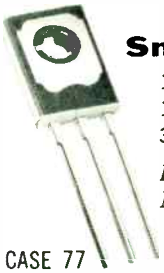
Manpower. Electronics and aerospace engineers show the highest unemployment rates—5.3% each—in a new National Science Foundation survey of engineering society members. EEs with computer and mathematics specializations also suffered unemployment rates higher than the 3% average for all engineers, while electrical and communications engineers were better off, with rates of 2.2% and 2.9%, respectively.

The survey, conducted by the Engineers Joint Council this summer and published in late September by the NSF, showed the highest unemployment figures for young EEs [*Electronics*, Sept. 27, p. 27]—5.5% for those under 24—followed by the 60- to 64-year age group with 4.2% and the 55- to 59-year-old group at 4.1%. Those engineers without an academic degree were the hardest hit with 4.4% unemployed, followed by those with master's 3.2%; bachelor's, 2.8%; and doctorates, 1.9%.

Defense-aerospace unemployment was the highest, with engineers previously working in positions directly related to aerospace reporting a rate of 6.3%; defense, 4.8%; and transportation, 3.3%. The lowest rate, 1.3%, was reported by engineers previously employed in public works.

Boost. By adding an optical cavity or waveguide region beside the p-n light-generating junction within a GaAs semiconductor laser, RCA Laboratories in Princeton, N.J., says it has doubled the output efficiency at peak powers. Varying cavity size affects output power, with units producing anywhere from 1 watt peak to 20 watts.

Will The Designer Who Ordered Plastic Silicon Power In More Than One Package Size, Power Rating and Lead Form,

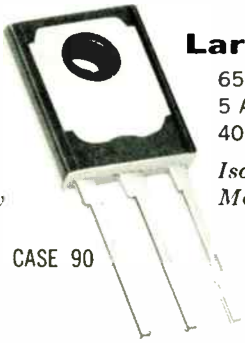


CASE 77

Small
10 to 40 W
100 mA to 5 A
30 to 350 V
Isolated Mounting Screw

CASE 199

Medium
30 to 90 W
100 mA to 10 A
30 to 350 V
Non-Isolated Mounting Screw



CASE 90

Large
65 to 100 W
5 A to 15 A
40 to 80 V
Isolated Mounting Screw

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And you've got over 120 types to do it with: 33 registered and 90 house-numbered units that ensure your getting exactly what you need . . . eliminating over or under-design . . . without costing more than you want to pay!

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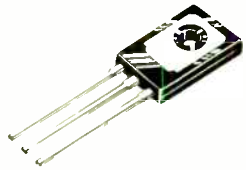
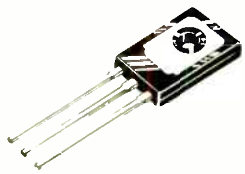
CASE 77



Standard Straight Pin
E-C-B Pin Style

CASE 77

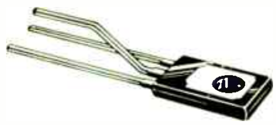


Standard Straight Pin
B-C-E Pin Style

CASE 77

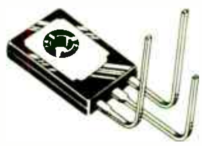
TO-5 PCB Pin Circles
(Heatsink Optional)
Collector Bent
Away From Heatsink Surface

CASE 77



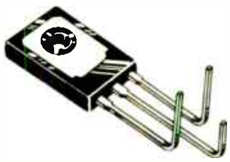
TO-5 PCB Pin Circles
(Heatsink Optional)
Collector Bent Toward
Heatsink Surface

CASE 77



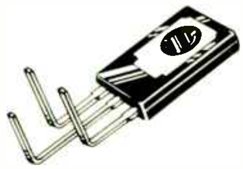
TO-66 Sockets
Standard Lead Length

CASE 77



TO-66 Sockets
Long Lead Length

CASE 77



PCB Mounting
Trimmed Leads

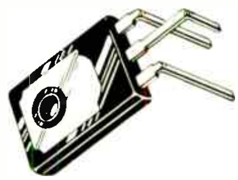
CASE 77

PCB Mounting
Heatsink Surface Down

CASE 90

Standard Straight Pin
E-C-B Pin Style

CASE 90

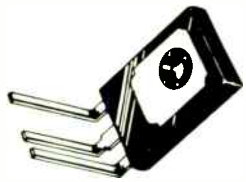


Flat Mounting On Heatsink

CASE 90

PCB Or Heatsink Mounting
Long Collector Lead

CASE 90



PCB Or Heatsink Mounting
Short Collector Lead

His Sockets.

CASE 199

Standard Straight Pin
B-C-E Pin Style

CASE 199

TO-66 Sockets
Electrically Integral Collector

CASE 199

TO-66 Sockets
Trimmed Collector

CASE 199

Popular Plastic
Flag Mounting

CASE 199

PCB Sockets
Flag-Mounting,
Trimmed Collector

CASE 199

TO-66 Sockets
Optional Center Lead Connection

CASE 199

PCB Sockets
Flat Mounting
Without Heatsink

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19 Different Lead Forms To Choose From!

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Circle 45 on reader service card

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Availability	In quantity	In quantity
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Reliability	Excellent	Excellent

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But you save other ways, too. For instance, you can cut your inventory and service costs because you only have to stock one kind of memory, instead of a different masked ROM for every variation of your truth table.

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U.S. sales reps in all major cities.

Circle 47 on reader service card

When the Apollo 15 astronauts went for a drive in their Lunar Roving Vehicle, they could depend on a reliable navigation system to get them "home" to the Lunar Module again.

Distance and heading back to the Lunar Module were displayed continuously on the LRV console, derived from the output of a unique Signal Processing Unit designed and built by Boeing.

This compact digital/analog computer had to meet some of the toughest specs ever for electronic hardware. Such as gravity forces of 12½ Gs during launch. Temperatures from minus 250 to plus 250 degrees. And hard vacuum.

What's more, the SPU, along with the rest of the navigation system and the complete LRV, was designed, built, tested and delivered to NASA by Boeing in the shortest time ever for Apollo-qualified hardware. It's a typical example of Boeing's total capability for on-time delivery of highly reliable special-purpose computers.

Other Boeing computers now in development include a controller for the USAF Airborne Warning and Control System, a central computer for Mariner/Venus/Mercury '73, and a low-cost attitude computer for spacecraft. Early development work is under way on advanced configurations for an ultra-reliable Grand Tour computer.

When you need a special-purpose computer, come to Boeing. We can do the exact job you need. At very competitive prices.

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Introducing the little counter that can.

It can become four different systems.
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It can make buying and maintaining a counter less expensive than ever before.

Meet the Hewlett-Packard 5300, the snap-together counter that's not much bigger than the palm of your hand. It has six digit accuracy, solid state display and autoranging. It'll make period, frequency, time interval and ratio measurements, operate on its optional snap-on battery pack and drive a printer. Rugged dust-proof aluminum case resists almost any bumps it might get in the field. Prices start at only $520 for one of the most amazing counters you've ever owned.

Start with the basic mainframe ($395). Then snap on any of the following modules (more on the way) to make just the counter you need, and avoid obsolescence, too:

10 MHz frequency module. Model 5301A, $125.

50 MHz all-purpose module includes period, time interval. Model 5302A, $250.

500 MHz module with both 50Ω and 1 MΩ inputs. Model 5303A, $750.

100 ns time interval module with: unique "time holdoff" feature, dc coupling, slope and trigger level controls, and period and frequency measurements to 10 MHz. All the functions you'd pay $1200 for in a universal counter. Model 5304A, $300.

Rechargeable battery pack module works with any of the other modules for cord-free operation. Model 5310A, $175.

The 5300 is one system you have to use to appreciate. If you've ever needed to accurately measure frequency or time interval, you owe it to yourself to call your nearby HP field engineer for further information. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

Counters that promise a lot and deliver it all.

02109

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ELECTRONIC COUNTERS

Circle 49 on reader service card

Washington Newsletter

October 11, 1971

EDP buys for Army top DOD list . . .

Beyond the World Wide Military Command and Control System's (WWMCCS) 13 computers, scheduled for contract on Oct. 15, military sources predict awards for the purchase, lease, or expansion of 140 more systems during the next six months. Biggest single piece of hardware in the Army's 74 computer actions is the Persincom 70X, a large personnel management system using 126 remote terminals in the Washington area to replace three CDC 3800s, one Burroughs B3500 and six IBM machines. The Army also plans two computer moves for automated telecommunications centers at Bayonne, N.J., and Oakland, with options for more.

With most of the acquisitions by all the services falling in the category of standard business computers, IBM stands tallest in the competition. Nevertheless, Univac and Burroughs are competing strongly for many of the big machine orders, with Honeywell, although not a military favorite, also pushing.

. . . With DSA taking 11, the Navy 37 and USAF 31

Though the Navy plans 37 computer acquisitions and the Air Force another 18 in addition to WWMCCS, the second biggest dollar buy contemplated probably will be the Defense Supply Agency's award for 11 processors to be used in its Samms program for supply and material management. Big Navy programs include: 11 small shipboard computers to be acquired by NavShips, six large-scale machines for Naval Ocean Surveillance Centers, and one large-scale system to replace two CDC 3800s at the Naval Research Laboratory. Potentially big is the sale of a single machine for the first phase of the Automatic Data Distribution System that will interface with the Naval Tactical Data System. Other Navy EDP efforts in the next six months cover one general-purpose machine for the Underwater Systems Center, six small ones for hospitals, and seven numerical control systems for rework centers.

The Air Force is still after six large systems for regional use in its delayed Advanced Logistics System effort, another to replace an IBM 7040 at the Human Resources Laboratory and 10 small systems for as many of its hospitals.

NAE urges NIH to build engineering effort . . .

The National Academy of Engineering has asked the National Institutes of Health to expand and clarify its role in biomedical engineering. To help do this, NAE wants NIH to create an overview body of industrial, medical, engineering, and social experts. In a report to be published late this month, the academy also recommends that NIH expand its in-house engineering competence, support goal-oriented research, help establish university programs for design and product-oriented biomedical engineers, and support engineering internships at the institutes.

Dr. Herbert H. Rosenberg, director of NIH's resources analysis office, says he expects the hierarchy at the Department of Health, Education, and Welfare to respond favorably, but cautiously, to the report, which reflects an Arthur D. Little survey of 50 biomedical engineering firms.

. . . as group defines biomedical specialty

Biomedical engineers should be applying their skills to health service rather than to basic research, researchers at George Washington University medical school have decided in a study funded by the Engineering Foundation. That school's James C. Aller estimates that there may be about 3,000 biomedical engineers currently employed in what is now called a "clinical" engineering capacity, but the health care industry **could use up to 50,000 profitably**—decreasing the cost of health care by reducing equipment costs.

"The research and manufacturing segments of the biomedical instrumentation industry are reaching maturity, so the thrust of biomedical engineering curricula should be redirected towards keeping equipment in service," Aller says. **"Engineers should be more concerned with the selection and upkeep than with the design of new instrumentation."**

LEAA leans to computers for voice recognition

Future LEAA research in speaker recognition may be limited to computer techniques, implies a Law Enforcement Assistance Administration study to be published later this year. "This method of speaker recognition may prove to be the most promising," concludes the report, written for LEAA by the Michigan state police. The potential for legal acceptance of speaker verification by panels of listeners, and by observers examining voice prints, the report explains, is diminished by the fact that those methods are not completely objective.

LEAA, which has put $500,000 into speaker verification so far, has subcontracted Stanford Research Institute for specification of criteria, and perhaps hardware, for computer recognition techniques. About $25,000 of the SRI award is going to Texas Instrument to maintain a liaison with a manufacturer.

Jobs in aerospace engineering seen stabilizing by June

Though Federal officials contend "the worst is behind us" when they speak of the economic slump and its related job losses, there is fresh **evidence that aerospace and its related electronics will be among the last industries to stabilize. Overall jobs are expected to continue to decline through June 1972, says the Aerospace Industries Association, to a level of approximately 894,000.** Of these jobs, 147,000 will be engineers and scientists—a drop of 37.5% from the 1967 peak of 235,000.

A breakout of engineering jobs by product groups shows there were 83,000 engineering and scientific jobs in the aircraft industry in March, for example, but this slipped to 77,000 by June and will drop to 75,000 in December, before levelling off at 69,000 next June. Comparable openings in missile and space work were 51,000 in March and 49,000 in June, will decline another 1,000 by December and stabilize at 47,000 by June. Other aerospace engineering jobs—ground electronics, for example—stood at 32,000 last March, dropped to 31,000 by June and are expected to slip another 1,000 by year end before bottoming out at about 30,000 by the middle of next year.

Addenda

The Navy committed itself at the Sept. 30 deadline to buy 48 more F-14 fighters from Grumman Aerospace for $806 million when Senate floor opposition to eliminate the buy crumbled, as anticipated [*Electronics,* Aug. 16, p. 48]. . . . **But the Navy apparently lost on its extremely-low-frequency Sanguine system** for shore-to-submarine communications [*Electronics,* July 5, p. 35] with 44-42 Senate passage of an amendment to cut its $5.57 million appropriation by $2 million. The Navy may recoup, however, on a vote to reconsider if the 13 senators absent can be rounded up.

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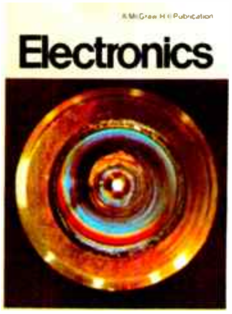

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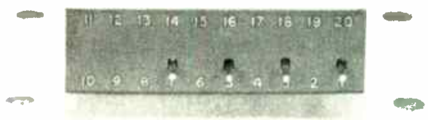

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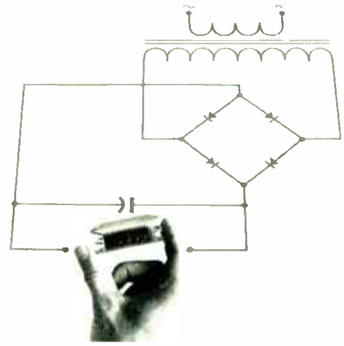

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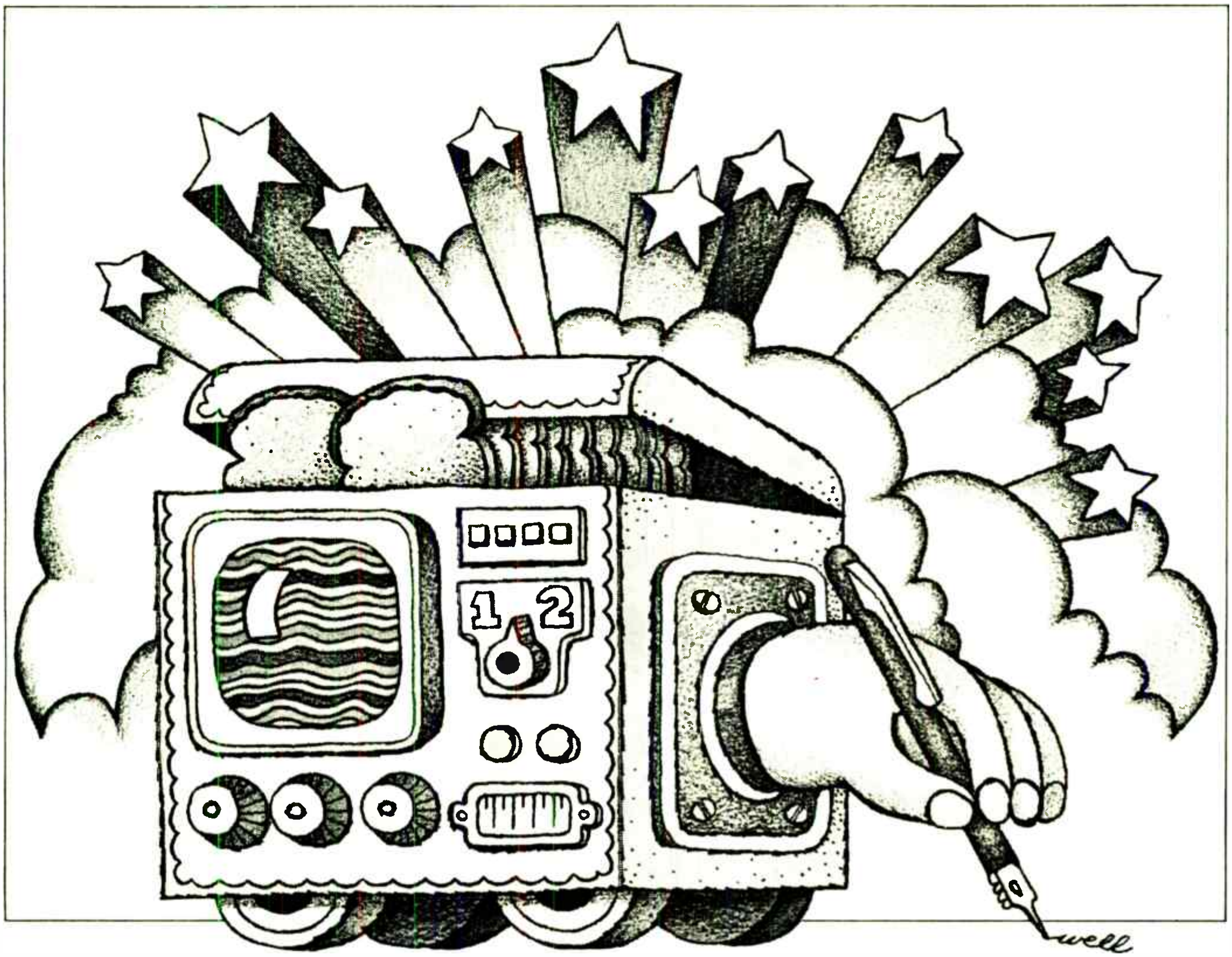

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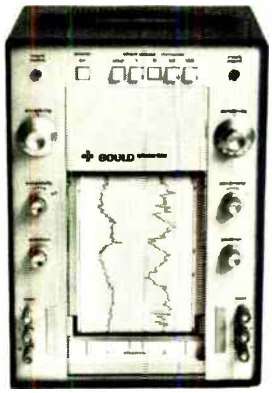

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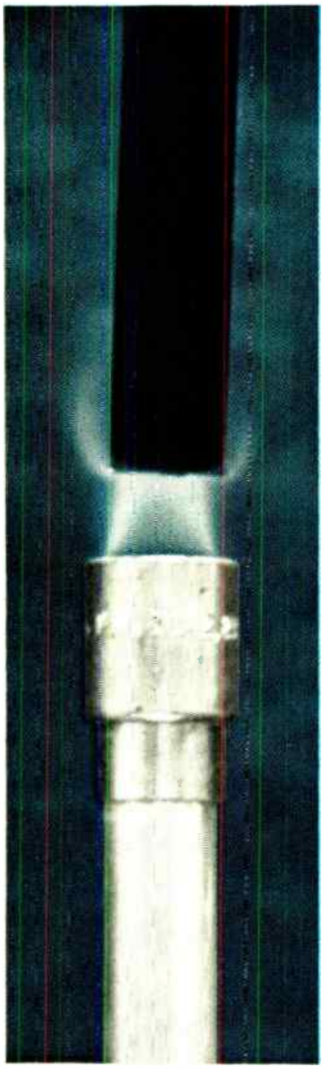

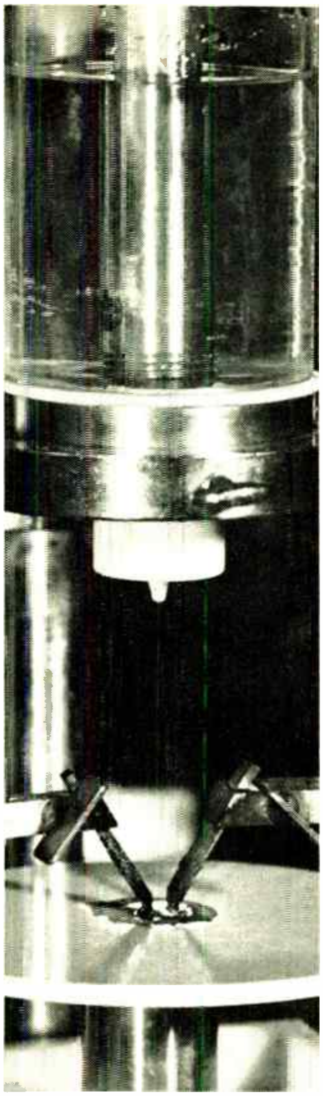

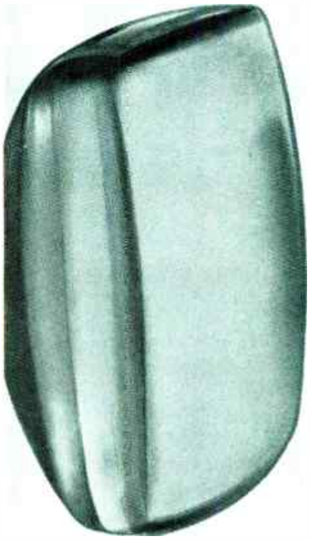

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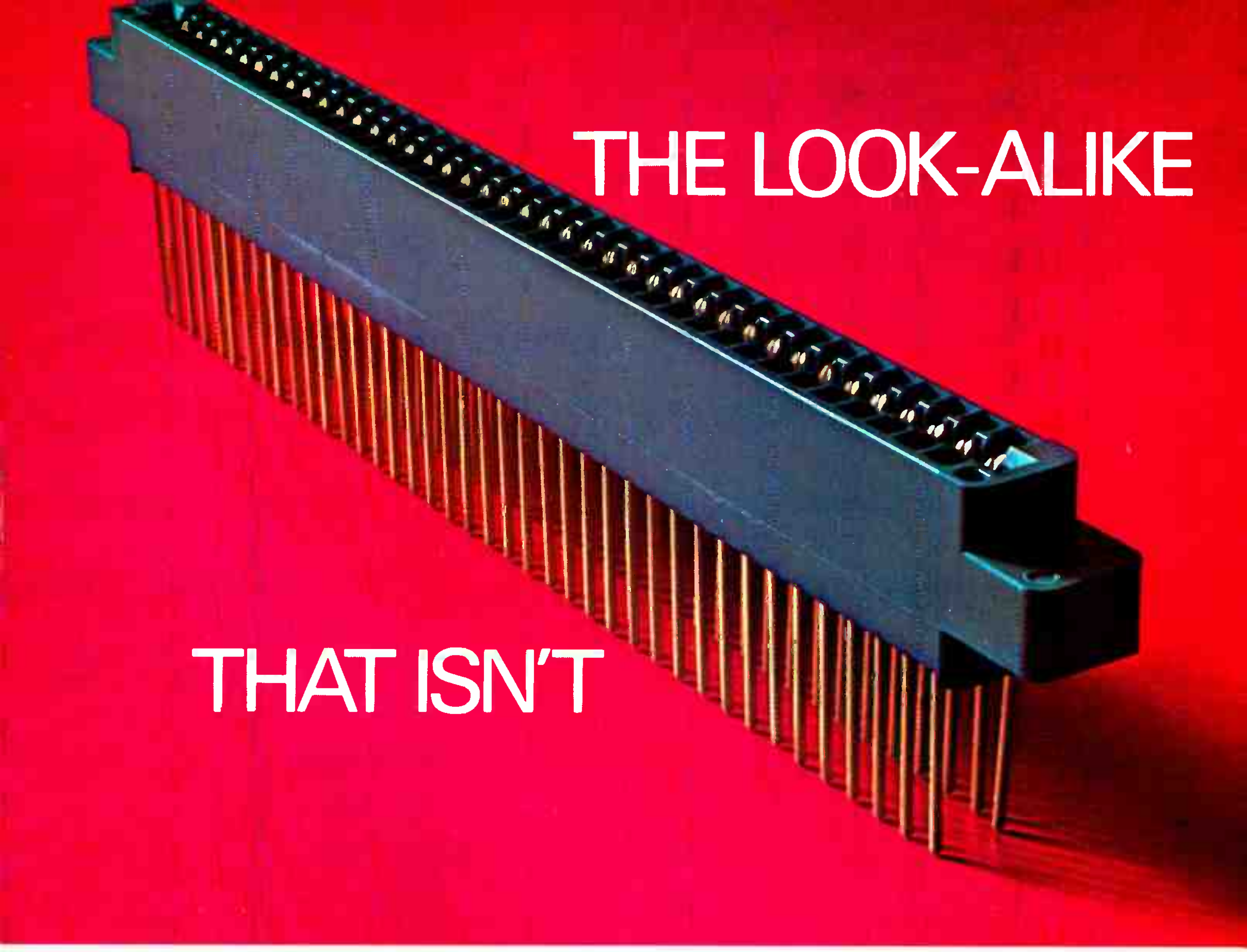

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Technical articles

Minicomputer evolves with maxi capabilities: p. 61 (cover)

What is a minicomputer? If your answer is a small computer that performs simple functions economically where speed and capability aren't important, you're not with it, says a trio of authors from Digital Equipment Corp. The latest addition to the PDP-11 family, with its Schottky TTL/MSI logic, semiconductor mixed memories, and floating-point units, has evolved into the general-purpose sector formerly the exclusive domain of much larger machines; yet it maintains the cost-effectiveness that originally made minicomputers feasible.

The cover: The front panel of the new PDP-11/45 gives a hint of its impressive capabilities. The address control board, with its Schottky TTL/MSI circuits and its bipolar read-only memories for microprograming functions, tells even more.

Computer modeling works for zener diodes: p. 67

Despite the widespread use of the zener diode in a host of circuit designs, only a few computer models are available for it, and these don't adequately deal with its thermal effects. The latest of the models, however, not only can handle the thermal considerations, says author Emanuel Schnall, but uses easy-to-evaluate circuit elements and can adapt to linear and nonlinear analysis programs.

Millimeter-wave applications and Impatt diodes—the perfect match: p. 78

The proliferation of millimeter-wave communications, alarm, landing, and radar braking systems is greatly increasing the attractiveness of silicon Impatt diodes as a solid state source, notes author N.B. Kramer. The diodes give high power with high efficiency, are compact, and offer impressive flexibility in a number of important applications.

Bit error rate detector—handy tool for digital data links: p. 82

Digital data transmission system designers have a problem. As their systems proliferate, there's an increasing need for bit error correction, but the usual approach is through software—frequently expensive and complicated. The solution, says author Kingsley P. Roby, is to implement bit error rate detection in hardware: the technique is simple and inexpensive, and uses the same principles as in analog networks.

Taking on interconnection problems in big multilayer pc boards: p. 88

In very large, very dense systems, designers can't afford to ignore the considerations involved in making thousands of reliable interconnections, says author P.O. Benham. One such challenge was a 3-foot-diameter, nine-layer pc board for a phased-array antenna system that needed 23,000 plated-through holes. It was conquered with a numerically controlled drilling operating and a plastic-encased preform solder system.

And in the next issue. . .

How electronics companies are automating to survive hard times . . . shortcuts for Chebyshev and Butterworth filter analysis . . . how gallium phosphide and gallium-arsenide-phosphide stack up . . . timing for semiconductor memories.

←Circle 60 on reader service card

Evolution breeds a minicomputer that can take on its big brothers

Fast Schottky TTL/MSI, semiconductor memories, multiple unified buses, microprograming, and floating-point units bring minicomputer up to large-machine capabilities without sacrificing cost-effectiveness

by Richard J. Clayton, Bruce A. Delagi, and Rony Elia-Shaoul, *Digital Equipment Corp., Maynard, Mass.*

□ By incorporating the newest technological developments and building on changing user requirements, the minicomputer is evolving along lines that are putting less emphasis on the "mini" and more on the "computer." Now, instead of remaining the limited-performance, stripped-down version of the bigger machines that met a need for economical computing power where speed and capacity weren't essential, the minicomputer is fast reaching the capabilities of the larger computers. At the same time, the cost-effective design philosophy that established the minicomputer concept is being retained.

The latest step in this evolution is the PDP-11/45, the newest addition to the PDP-11 family. The 11/45 is a 16-bit, general-purpose computer that refines minicomputer organization and technology to solve problems normally associated with larger computers. Multiple unified buses, mixed memory systems (bipolar, MOS, and core), an exceptionally powerful instruction set, microprograming, hardware floating-point units, memory segmentation, Schottky logic gates, and multilayer boards are some of the techniques that are helping the PDP-11 family to redefine the boundaries of minicomputers.

To understand minicomputer evolution consider the basic structure of the first minicomputer, as shown in Fig. 1 (a). In such early machines, separate buses to and from the central processor were provided for input/output and for memory. In most cases, the input/output bus operated synchronously (clocked), could handle only those peripherals within a narrow range of response times, and was relatively slow. The memory bus was fast and generally asynchronous.

With this configuration the limit on memory usually was no more than eight modules of 4 kilowords each. Also, bus length was held to about 10 feet and terminations had to be tuned rather carefully. Speed ranges were quite restricted, and mixed memory add-on capability was not available.

Minicomputer design made a significant advance when the concept of unified busing was introduced in the PDP-11 architecture [*Electronics*, Dec. 21, 1970, p. 47]. The Unibus is essentially a fast asynchronous system for data transfer between computer system elements. Its features are overlap of bus transfer, selection of the next system element to be granted use of the bus (bus arbitration), fast asynchronous operation, and improved drive capability over previous minicomputer memory buses—twice as many loads can be driven over five times the distance.

Overlap of bus transfers and bus arbitration increases bus channel capacity. Multichannel direct memory access and all interelement communications are obtained in this way with the involvement of no additional cost or time penalty.

Because the Unibus operates asynchronously, a user can mix memories of different speeds, and bus buffers (bidirectional repeaters) can be added to expand load capability and line lengths as required. System communication on the Unibus, as used in the 11/20, the first general-purpose member of the PDP-11 line, is illustrated in Fig. 1.

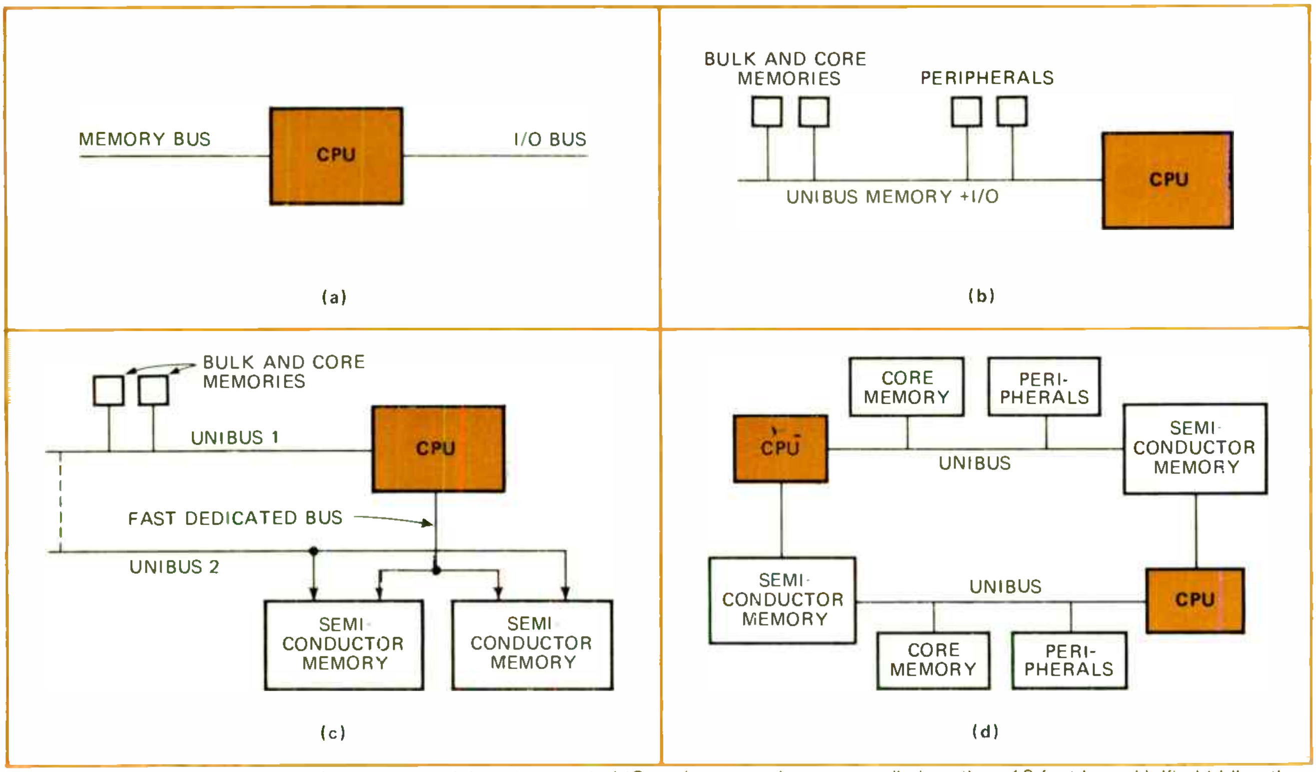
Even though the Unibus was successful in increasing system generality, the advent of high-speed semiconductor memories, with access times surpassing the maximum speed of the bus, required a new approach to memory organization.

Basically, the new approach, shown in Fig. 1 (c), is to separate the memory system into two parts: one for the slower core, bulk memory devices, and conventional peripherals; and the other for the higher-speed semiconductor memory units. To accomplish this, a very fast, short, dedicated bus is added to the system. This bus connects a dual-port semiconductor memory system to the central processor. The second semiconductor memory control port is a standard Unibus interface (Unibus 2 in the figure).

The dual-port architecture brings to a minicomputer a degree of flexibility and system performance improvement previously only seen in much larger systems. Because communications between the central processor and solid state memory need involve only one of the two semiconductor memory controls, the second control is free to handle external Unibus data requests up to the full Unibus rate of 40 million bits per second.

In more advanced configurations, Unibus 2 need not be directly connected to Unibus 1, but may be used as a second bus operating simultaneously and independently of Unibus 1. Thus, Unibus 2 can be a very high-speed swapping channel while keeping Unibus 1 to handle interrupts and other external requests.

One of the more interesting applications, shown in Fig. 1 (d), of this second Unibus is in cross-connecting two processors so that both operate in an environment



1. Comes the evolution. Early minicomputers (a) had separate I/O and memory buses, usually less than 10 feet long. Unified bidirectional bus concept (b) could handle more loads on lengths up to 50 ft. New approach in the 11/45 (c), required for fast IC memories, uses several buses: a Unibus for slower-speed memories; another for faster ones; and a dedicated unit to handle transactions between CPU and fast semiconductor storage. Dual-processor 11/45 system (d) allows both to share data with virtually no conflict or data time penalty.

that offers virtually no conflict or data time penalty in accessing a common data base.

The high-speed semiconductor memory system as shown in Fig. 2 comprises matrix and control modules. The matrix module contains the actual memory elements. The two semiconductor memories currently available for the PDP-11/45 are MOS units with 4,096 words of 16 bits and bipolar stores with 1,024 words of 16 bits. A control module provides timing, central processor interface, and Unibus interface circuitry for up to four matrix modules. MOS and bipolar matrix modules require different control modules.

The 11/45 contains physical provisions for up to two controllers, each associated with four matrix modules. Thus, a maximum of 32k words of MOS, or 8k of bipolar, or 16k of MOS combined with 4k of bipolar, is possible. This organization is suited to accommodate any future higher-density semiconductor memory elements.

The MOS memory used right now is the 1103-1, a 1,024-bit chip first delivered by Intel. This choice was based on cost and performance of production-proven devices. The MOS memory system level access time is 350 nanoseconds, and unlike core memory systems offering comparable access times, is much less dependent on addressing patterns.

While the MOS memories offer a substantial speed improvement, the PDP-11/45 was designed for still faster operation and also offers a lower-density, higher-power, and higher-cost bipolar memory system for high-speed applications. On a system basis, access time here is 295 ns, again largely independent of addressing pattern. The primary memory component is a 256 bit, TTL-compatible bipolar chip available from Intersil and Texas Instruments.

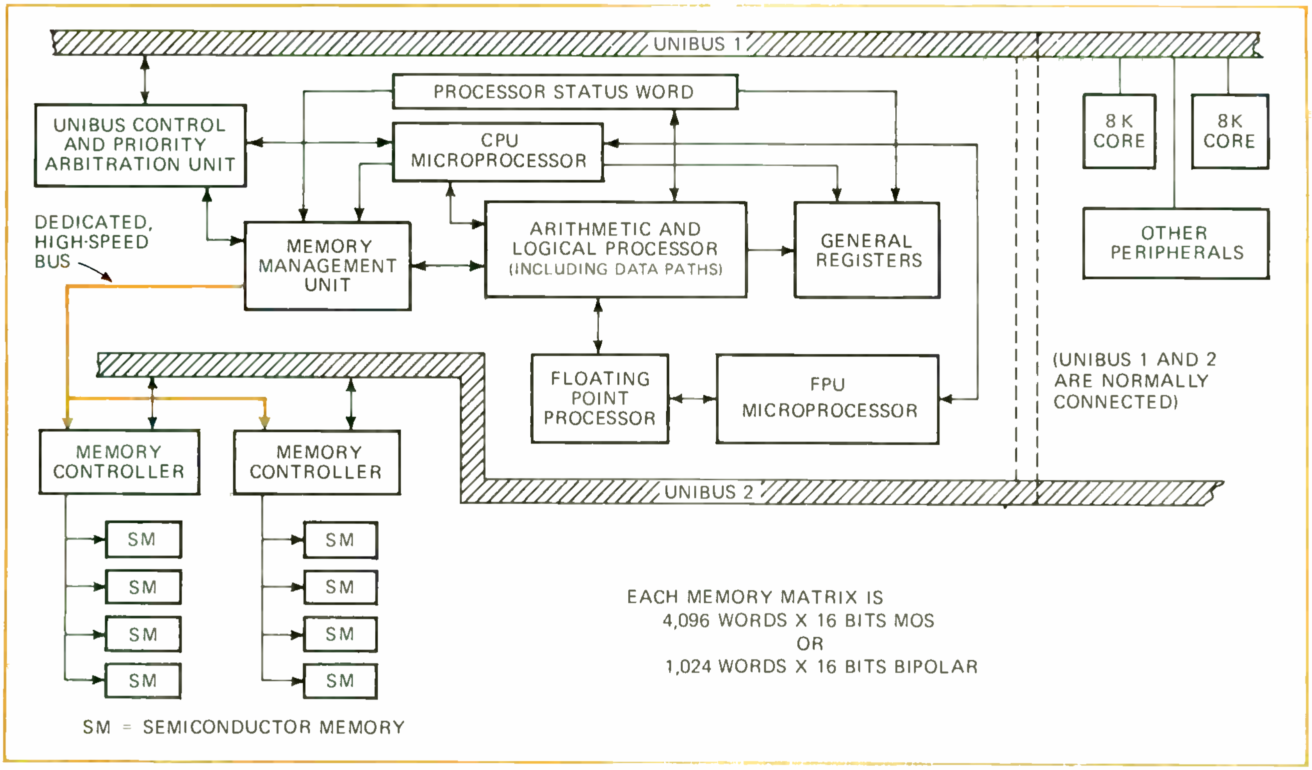
Because semiconductor memories are inherently volatile, several methods are available to the user to handle temporary power outages. Of these, the most common is to keep basic process-state information in core memory, which usually is available on all large systems, while dedicating semiconductor memory to program storage. Since programs are generally not self-modifying, they can be kept on disk or tape storage and then replaced automatically when power is restored. Also, a range of power-retention options is available to keep the system up until backup primary power can be restored.

Without semiconductor storage the 11/45 is about twice as fast and costs, depending on memory and instruction execution mixes, about 1.5 times as much as the 11/20; with semiconductor storage, the system can be as much as seven times faster, but only twice as expensive.

All of the PDP-11/45 memory systems offer optional byte parity. This increases the word length of the matrix to 18 bits and provides additional reliability.

The PDP-11 family instruction set also represents an evolutionary step in minicomputer architecture. The worth of an instruction set is evaluated on the basis of three criteria: how easily coding to solve problems may be accomplished by the user; once coded, how fast the program runs; and how much storage is required to contain this code and the data on which it operates.

In the PDP-11 family, focus is on the data types, the data structures, the operations, and the interrupt sys-



2. New approaches. The CPU's memory management unit accesses the fast semiconductor stores through the dedicated bus, and provides address mapping and memory protection. Optional floating-point processor operates asynchronously to implement floating-point arithmetic.

tems that form the basis of the solutions of problems. The entire range of data types (bit, byte, word, multiple word, signed and unsigned integer, and floating-point variables) can be effectively handled by the PDP-11 family instruction set. Byte data, for example, is commonly used in both operating systems and customer environments. Because a programer working with the 11 family has many byte instructions available, he can handle words or bytes as the program demands without loss of coding, storage efficiency, or speed of operation. In addition, he can conveniently deal with signed and unsigned data. For example, it's frequently necessary to add, subtract, or compare signed operands, (data) or unsigned operands, (address), and detect overflows. Most machines can handle only one, not both. In earlier machines, for instance, unsigned arithmetic comparisons were done with hardware; the signed arithmetic comparisons were handled by software, which took several instructions to accomplish. This not only prolonged computer time, but greatly increased the probability of programer error. In the 11/45, a complete set of conditional branches and condition codes provide the hardware to handle both signed and unsigned operands.

In virtually all applications, data elements are organized into structures. A key feature of the 11 family is its ability to directly support a wide variety of data structures by any of 12 distinct addressing modes. This support lets the programer choose one that's optimal to his specific problem.

Even as recently as 1968, minicomputers had very primitive interrupt structures, and no way of controlling priorities. Thus, when a request for access to the bus was received from a teleprinter, disks, or tapes, the system had little flexibility to determine which request was more important and what time slot to allot to it. Further, all the devices on the line had to be polled to determine which had made the request. Moreover, there was no software interrupt system to book requests that could be serviced at a later time when processor priority level dropped.

When the PDP-11/20 was introduced, four priority levels for interrupts were provided. And in the 11/45, the number of priority levels has been increased to eight, four for hardware or software interrupts and four for software interrupts only. Also, polling was eliminated—the interrupting unit provides a unique interrupt vector that identifies the requesting device.

Another feature of the 11/45 is a second set of general registers. With it, the processor status word can be used to specify which set of registers is assigned to a particular device interrupt-service routine. Thus some of the general registers can be dedicated to servicing very fast devices only, reducing interrupt service times by as much as 50%.

The classic approach to CPU design is to implement major state registers, instruction decoders, and other functions using networks of combinational logic in discrete elements. Although usable in a system with the extensive range of features of the 11/45, these networks are expensive, physically big, and difficult to debug.

However, in the microprocessor design approach for the 11/45, bipolar read-only memories are used to interpret instructions and operate the control points both within the computer's data path and the external environment. Because microprocessor implementations directly realize instruction flows, the design goes much faster. Debugging of the initial breadboard proceeds rapidly because it's easy to change the control memory's

Why Schottky TTL won

High-speed logic was essential in achieving the 295-nanosecond operating speed of the PDP-11/45. The choice fell between the well-established emitter-coupler logic and a newer family recently introduced by Texas Instruments—Schottky TTL.

Small component size is a key design element in fast systems because of the need for short signal paths. Availability of a wide range of MSI/TTL circuits (both Schottky and standard) was a key point in the choice of Schottky TTL over ECL. In many cases non-Schottky MSI gates operate faster than a logically equivalent collection of individual Schottky gates, so both types of TTL can be used wherever either type is most cost-effective.

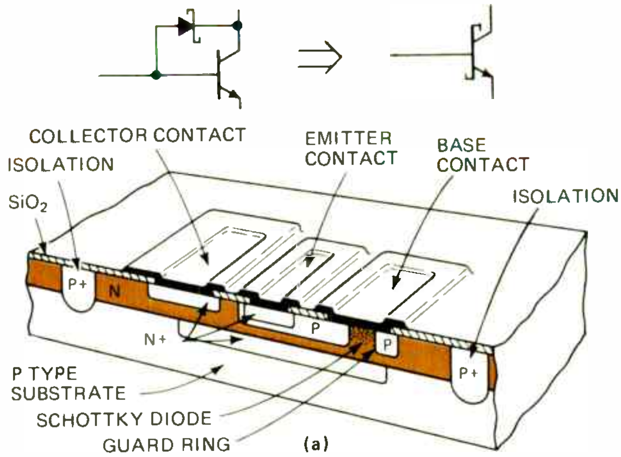
Schottky TTL utilizes the same thresholds, logic levels, and power supplies as conventional TTL, so that a single power supply, regulated to a tolerance of ± 10%, can be used. No level shifters or logic circuits are required to interface with TTL, DTL, and low-threshold MOS circuitry, thereby reducing system costs and eliminating associated system propagation delays. A system can be graded according to speed requirements by carefully mixing standard TTL, MOS, high-speed TTL, and Schottky TTL circuits to provide optimum cost/performance benefits to the equipment users.

TI's series 54S/74S Schottky TTL has impressive specs: power dissipation of 20 milliwatts per gate and a typical propagation delay of 3 ns, similar to the speeds of ECL. This performance is achieved by using Schottky-barrier diode clamps across the collector and base on all normally saturating transistors.

In Schottky TTL, the Schottky-barrier diode is employed as a Baker clamp across the base-collector junction of an npn transistor (Fig. a). Since the diode has a lower forward-voltage drop than the base-collector junction, base drive current is diverted through the diode when the transistor is turned on, preventing the transistor from reaching saturation due to elimination of excess charge storage in the base region. As a result, turn-off times are dramatically reduced. For example, the basic 54S/74S gate circuit, (Fig b), achieves 3-ns propagation delay while maintaining rise and fall times in the 2–3-ns range to minimize system noise considerations.

All input transistors in the basic Schottky TTL gate schematic are clamped by Schottky diodes instead of pn diodes as in conventional TTL. The lower forward voltage drop of the Schottky units gives greater protection against both negative voltage transients and positive line reflections possible in high-speed digital systems. And since the reverse input characteristic of a Schottky TTL gate more closely approximates an ideal termination, resistive terminals usually are not required for lines of impedances between 50 and 150 ohms.

In addition to the Schottky diode clamps, 54S/74S employs other basic design changes to reduce internal circuit propagation delays. Transistor geometries are approximately one-half the area of conventional TTL transistors, resulting in reduced delays due to minimize parasitic capacitive effects. Although Schottky diodes and advanced design geometries are used in Schottky TTL, basic processing steps are very similar to those employed in conventional TTL. Over 2 million device hours have been logged under high-temperature accelerated stress tests to Mil-Std-883 conditions. Failure rates that have been verified at TI have proven to be as good as those logged in for standard TTL devices.

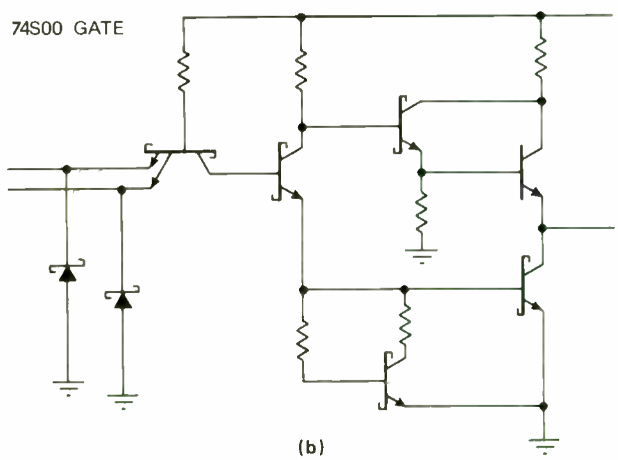


(a)

Use of Schottky barrier clamps and elimination of gold-doped slice processing in 54S/74S circuits results in stability of ac delays and dc thresholds over operating temperature ranges. Stability of dc thresholds (and thus, noise margins) is important where devices of varying complexities drive each other—when driving an MSI function with a simple gate, for example.

Other circuit design techniques minimize switching overlap of the totem-pole output transistor, thus reducing current spikes—about 20% of those in 54H/74H high-speed TTL. Thus, fewer decoupling capacitors need be used with Schottky TTL. And the lower dynamic power dissipation permits increased complexity and use of smaller power supplies— Schottky TTL circuits of up to 80-gate complexity are now possible. The SN74S181 arithmetic logic unit used in the PDP 11/45 computer is a 75-gate chip that can perform 16 arithmetic or logic functions. Even when used with a standard TTL carry/look-ahead package, the SN74S181 provides a 16-bit addition time of 25 ns against 40 ns when using an equivalent conventional TTL circuit.

In general, MSI-level Schottky TTL greatly decreases system interconnections (and thus, wiring delays) and reduces on-chip delays. The SN74S153 dual four-input multiplexer achieves a propagation delay of 5.8 ns through two logic levels, or 2.9 ns per level. THE SN74S153 was also used in the PDP 11/45 and was instrumental in achieving the processor speed goals. However, with basic Schottky TTL gates, delays of 4 to 5 ns per logic levels are typical; on-chip MSI delays usually remain between 2.5 and 3.0 ns per logic level.



(b)

contents. But most importantly, the size and cost of control logic are significantly reduced.

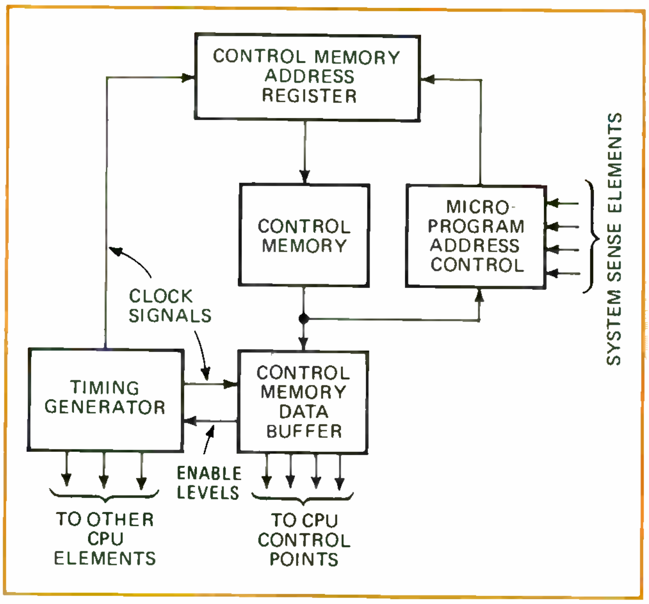
Both the central processor and the floating-point processor contain microprocessors with bipolar ROMs. These microprocessors, shown in Fig. 3, handle state sequencing and data-path and bus-control supervision. These microprocessors comprise the microprogram address register, control memory, control memory output buffer, and microprogram address control unit.

The microprogram address register is made of D-type flip-flops holding the next address of the control memory to be read (similar to major-state shift registers of conventional machines).

The control memory is a 256 × 64 masked ROM array. Its output is fed to the control memory output buffer, a 48-bit D-type flip-flop register, and also to the microprogram address control. The control memory output buffer drives multiplexer selectors and provides enabling levels for timing pulses throughout the machine. The control memory output also supplies its own next address and selects the external signals and internal sense points which modify that address.

The optional floating-point instructions represent another area where microprograming techniques and fast, high-density ROMs now permit the user to achieve substantial system improvements at low cost.

Floating-point capability in a computer system relieves the user of keeping track of the decimal point which is cumbersome in applications where the dynamic range of the variables is large. It also allows the programer to use higher-level languages, such as Fortran and Basic, providing faster problem-solving. Using these types of languages, at least sevenfold increase in programer efficiency can be achieved over assembly language techniques. The floating multiply time is 8 microseconds for 32-bit numbers and 15μs for 64-bit numbers. As a result, more than 20 times as many calculations can be performed with the 11/45 floating-point processor than with programed operations.



3. Microprocessor control. Microprocessor controller supervises state sequencing and data-path bus control. It's analogous to instruction decode and major-state control of conventional machines.

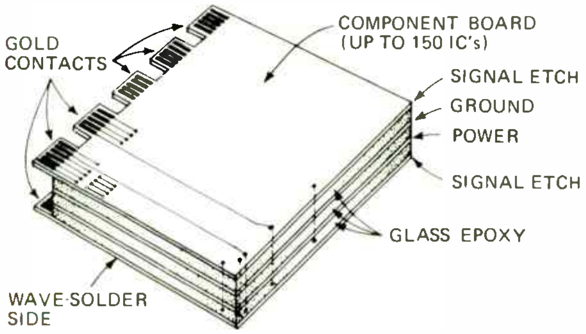
Multilayer boards, too.

Because of the high speed achieved in the PDP 11/45's central processor, both crosstalk and the propagation characteristics of the signals become an important consideration. With Schottky TTL, typical rise times of from 1.5 to 3 nanoseconds made the use of multilayer boards for all high-speed elements the logical choice. Although multilayer technology isn't new, the PDP 11/45 represents one of its first high-volume, low-cost computer applications.

However, an extra bonus resulted. Not only did this technique improve the electrical environment, but it resulted in a 20% increase in packaging density. This increased density, in turn, shortened interconnection distances, thus reducing system noise and lowering drive requirements of the individual circuits.

These boards are 8.5 inches by 15 inches, and have four layers and 216 edge contacts along one side. One of the two inner layers is used for a ground plane; the other serves to carry power lines. All the logic signals are kept on the two outer layers. The components are placed on one of the outer layers; the other layer is wave-soldered.

A standard grid pattern, which can house a maximum of 144 ICs or equivalent components, is used on most boards. This allows the two inner layers to be identical for all of the multilayer boards used in the computer. That way manufacturing costs and production lead time are reduced considerably.



The computing power of the 11/45 system is well suited to time-sharing applications. The key to a time-sharing system is management of system resources—perhaps the most important of which is memory. The 11/45 segmentation unit provides a mechanism by which a system supervisory program can control allocation of active storage to each user. This is realized by segmenting each user's program and assigning such segments to specific elements of the storage system. In this way, for example, frequently executed portions of a program can be assigned to the high-speed bipolar memory, while large data arrays are located in a much slower memory (such as core). These procedures implement a software cache system.

What's ahead for the 11/45 architecture? One development will be extension of the semiconductor memory system as soon as more cost-effective, higher density, faster components are available. While continued higher performance systems will be implemented, the major direction of future evolution will be toward multiple-processor configurations. □

A convenient way to model the handy zener diode

Unlike earlier computer models, this set copes adequately with the zener diode's thermal effects, uses easy-to-evaluate circuit elements, and is well suited to available linear and nonlinear analysis programs

by Emanuel Schnall, *Design Automation Inc., Lexington, Mass.*

☐ The zener diode is an important and frequently used circuit component, but only a few computer models of it are available for computer-aided design. None of them fully account for thermal effects, and they are often difficult to adapt for circuit analysis programs. Moreover, a special computer program is frequently needed to determine model parameter values.

A new set of linear and nonlinear zener models solves these problems. Besides providing for all thermal effects, they can be adapted to all popular linear and nonlinear analysis programs. Their parameters also may be found directly from a data sheet, by graphical analysis, or by measurement.

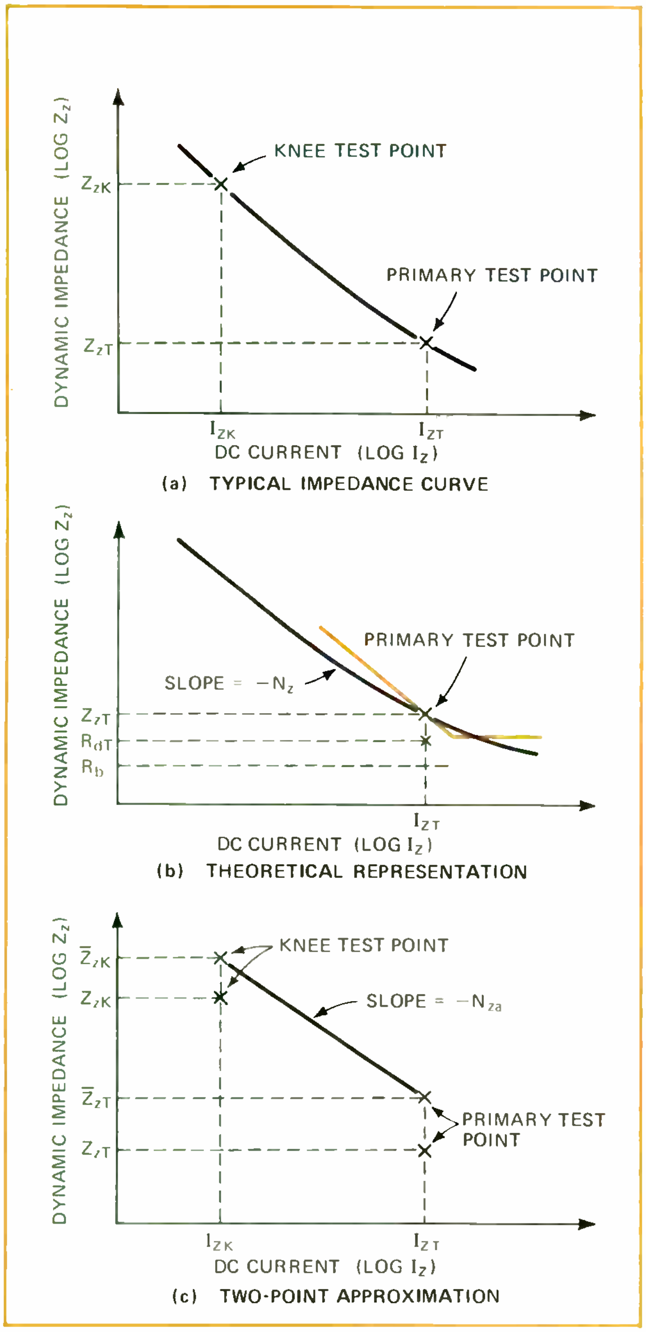
A linear zener model can be regarded as a simplified portion of a nonlinear model. Any single linear representation cannot be used for all zener operating regions and then, of course, it is necessary to modify it to account for the nonlinear aspects of diode performance.

In any case, it's easier to start by developing linear models, since this will establish certain circuit elements that can also be used later in a nonlinear model. Zener impedance, for instance, is common to both types of models, as are thermal compensation components, a constant back-voltage, and transition and package capacitances. Once these elements are described by parameters that can be evaluated directly, then the problems of fitting the model to existing computer programs can be tackled.

RATED POWER P (WATTS)	NOMINAL BREAKDOWN V_{ZT} (VOLTS)	DIODE TYPE	TEST POWER P_T (WATTS)	BULK RESISTANCE R_b (OHMS)	DYNAMIC RESISTANCE R_{dT} (OHMS)	EXPONENT N_z	EXPONENT N_{za}	REGULATION COEFFICIENT $R_{dT}I_{ZT}$ (VOLTS)
0.4	3.3	1N746	0.07	0.5	18	1.08	*	0.36
	4.7	1N750	0.09	0.2	9	1.36	*	0.18
	5.6	1N752	0.11	0.3	2	0.62	*	0.04
	8.2	1N959	0.12	1	3	0.93	1.37	0.05
	39	1N975	0.12	10	25	1.00	0.99	0.08
	75	1N982	0.13	25	160	0.93	1.04	0.27
0.5	3.3	1N5226	0.07	0.5	20	0.91	0.93	0.40
	5.1	1N5231	0.10	0.2	7	1.21	1.04	0.14
	27	1N5254	0.12	0.2	30	0.74	0.92	0.14
	75	1N5267	0.13	0.5	160	0.71	0.96	0.27
1	4.7	1N3825	0.25	0.2	5.5	1.20	1.10	0.29
	5.6	1N3827	0.25	0.4	1.6	1.31	1.26	0.07
	6.8	1N3829	0.25	0.4	0.8	1.37	1.61	0.03
	10	1N3020	0.25	0.2	2.1	1.05	1.00	0.05
	47	1N3036	0.26	1	54	0.94	0.95	0.30
	110	1N3045	0.25	20	200	1.33	0.99	0.46
5	10	1N4958	1.25	0.02	1.2	0.86	*	0.15
	20	1N4965	1.30	0.1	4	0.79	*	0.26
	51	1N4975	1.28	0.2	16	0.77	*	0.40
	75	1N4979	1.50	0.7	30	0.71	*	0.60
10	10	1N2974	2.5	0.1	0.35	0.81	0.80	0.08
	47	1N2995	2.6	1.5	6.5	0.86	0.84	0.36
	110	1N3007	2.5	3	25	0.88	0.96	0.58
50	5.1	1N4552	12.5	0.03	0.005	1.19	1.39	0.01
	30	1N3324	12.6	0.6	0.7	0.72	0.78	0.29
	50	1N3331	12.5	0.6	2.0	0.77	0.77	0.50
	110	1N3342	12.1	1.5	5.5	0.88	0.65	0.61

* Z_{ZK} not specified; N_{za} cannot be evaluated.

1. Zener data. Tabulation of typical parameter values for small-signal zener model lists 27 representative diodes. The data can be used to approximate circuit parameters for both linear and nonlinear zener models. Diodes are arranged by power rating and then by voltage rating.



2. Impedance curves. Log-log plots of dynamic impedance, Z_z, versus test current, I_Z, are useful for determining resistance parameters. Impedance curve of (b) mathematically approximates actual Z_z variation (a). Asymptote to (b) allows values of dynamic resistance (R_{dT}) and bulk resistance (R_b) to be determined. Two maximum impedance values ($\bar{Z}_z$) can also be used to approximate Z_z (c).

To describe the zener (or avalanche breakdown) diode completely, three linear models are needed, one for each region of operation. In the zener's usual area of operation, the reverse breakdown region, the device's dynamic resistance, self-heating effects, and voltage regulation are the major considerations. In the reverse-biased region, below breakdown, capacitance and leakage current become important. In its forward-biased region, however, where the zener performs like an ordinary diode, many satisfactory linear computer models already exist for the regular conduction diode, and no further modeling is necessary for the zener.

In developing a linear model for the reverse breakdown region, the first thing to consider is zener small-signal or dynamic impedance, Z_z. In the breakdown region, Z_z is generally measured with an alternating test current that is a tenth of the dc zener current, I_Z.

Actual curves of Z_z versus I_Z for a number of zener diodes indicate that Z_z can be expressed as:

$$Z_z = R_b + R_d(I_Z) = R_b + R_{dT}(I_{ZT}/I_Z)^{N_z} \qquad (1)$$

where R_b represents contact, lead, and semiconductor bulk resistances; R_d the small-signal, I_Z-dependent, dynamic resistance; and N_z is an exponent that permits a best fit to available data. Subscript T refers to a specific test condition, which usually corresponds to a quarter of the power rating.

Linear model. Equation 1 provides an accurate fit for Z_z within about 25% for the published impedance curves of 26 of the 27 representative zener diodes listed in Fig. 1. The exception is the type 1N4552 diode, which is modeled with only 65% accuracy. At the other extreme, the type 1N5226 diode has an impedance curve that is accurate within about 1% over three decades of current.

As can be seen from the table, N_z ranges from only 0.62 to 1.37, while diode ratings vary from 0.5 watt to 50 W and 3.3 to 110 volts. Typical R_b and R_{dT} values also vary considerably as do zener voltage and power ratings. One reason is the drop in dynamic resistance R_{dT} at about a 6-V breakdown rating, corresponding to the end of the transition from a field-emission (low-voltage) mode to an avalanche-breakdown (high-voltage) mode.

By way of illustration, Fig. 2(a) shows a typical dynamic impedance curve between the zener's knee test condition (the point at which avalanche breakdown begins) and the primary test point, while Fig. 2(b) plots the impedance curve using Eq. 1.

There are many zener diodes, however, for which impedance curves are not published, but maximum Z_z values at two currents are provided. In many instances, R_b can be neglected or set equal to some typical value. Then, N_z is approximated by:

$$N_{za} = \ln(\bar{Z}_{zK}/\bar{Z}_{zT})/\ln(I_{ZT}/I_{ZK}) \qquad (2)$$

where the overscored quantities are maximum values, and subscript K indicates the zener knee test point at a current ranging from 0.0033 to 0.33 of I_{ZT}. Figure 2(c) plots Eq. 2; Fig. 1 lists the values of N_{za} that approximate N_z within +47% and -26%.

Thermal effects. Zener current can vary enough to cause significant junction heating or cooling and so affect voltage. This voltage change can be modeled by adding a thermal-effect resistance, R_θ. R_θ represents the linear effect of zener current on junction temperature (T_J) and breakdown voltage (V_Z):

$$R_\theta = \frac{\partial V_Z}{\partial T_J}\,\frac{\partial T_J}{\partial P}\,\frac{\partial P}{\partial I_Z} = a_v\,\theta_{JA}\,V_Z^2 \qquad (3)$$

where a_v is the fractional temperature coefficient (in percent per °C) of breakdown voltage θ_{JA} the thermal resistance (in °C per watt) from junction to ambient temperature, and P the power dissipation ($P = V_Z I_Z$). Maximum θ_{JA} (or $\bar{\theta}_{JA}$) is equal to the reciprocal of the diode power derating factor.

The zener thermal voltage effect has a dynamic lag due to the thermal time constant of the junction. Since only one mode of cooling is usually significant, a simplified single-node thermal model can be used. And the dynamic lag is realized by shunting R_θ with a thermal-effect capacitance, C_θ;

$$C_\theta = \tau_{JA}/R_\theta = C_{JA}/a_v V_Z^2 \qquad (4)$$

where C_{JA} is the thermal capacitance (in watt-seconds per °C), and τ_{JA} the thermal time constant ($\tau_{JA} = \theta_{JA} C_{JA}$).

When the zener is cooled primarily by convection, the single-node approximation lumps the thermal capacitance of the case and the diode chip together. This produces thermal time constants of about 0.5 second to 50 seconds for axial-lead-mounted diodes, varying with lead length and case design. Alternatively, if cooling is mainly by conduction, the junction-to-case thermal resistance predominates, and the thermal capacitance of only the diode chip applies. Thermal time constants are only about 0.05 to 0.5 second for diodes that are bolted and heat-sunk.

Finishing the model. Now that the essential circuit elements for the reverse-breakdown zener are defined, a linear model can be synthesized for this most frequently used mode of zener operation. Combining all elements (bulk resistance, dynamic resistance, and thermal-effect resistance and capacitance) with a battery that represents breakdown back-voltage results in the linear model of Fig. 3(a) for zener reverse-breakdown operation. The fact that it's valid only when current flows in the direction indicated implies that the nominal breakdown voltage, V_Z, is greater than the breakdown back voltage, V_b:

$$V_b = V_{ZT} - I_{ZT}(R_b + R_\theta + R_{dT}) \qquad (5)$$

Voltage V_b is determined by a specific test voltage and current.

In contrast to its performance in the reverse-breakdown mode, the zener behaves similar to an ordinary diode when reverse-biased. For this reason, the elements used for its reverse-biased linear model are the same as those for an ordinary diode. However, the parameters defining these elements can be so selected as to simplify the job of relating the description to the real device.

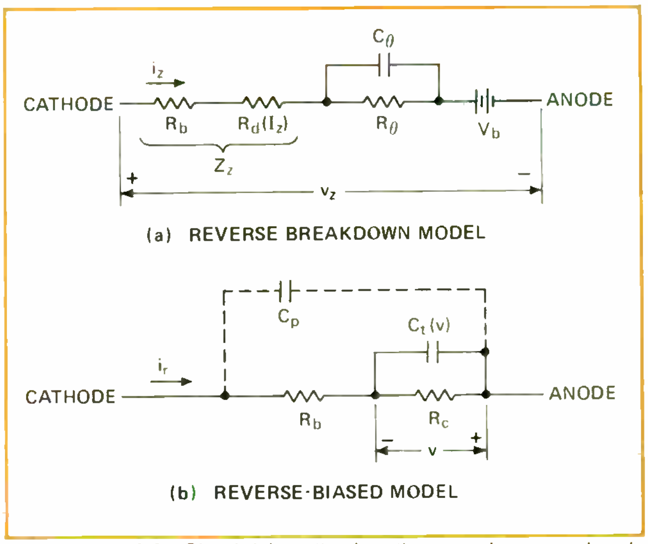
The linear model of Fig. 3(b) synthesizes zener leakage and capacitive currents in the reverse-bias region, below breakdown. Resistor R_c represents the junction ohmic leakage resistance at a given temperature, C_p the capacitance of the diode package, and C_t the voltage-dependent transition capacitance.

Transition or depletion-layer capacitance C_t varies with junction voltage, v:

$$C_t(v) = C_0/(1 - v/V_C)^{N_c} = D/(V_C - v)^{N_c} \qquad (6)$$

where V_C is the diffusion potential (typically 0.7 v for silicon, 0.3 v for germanium), and N_c represents a grading constant, which ranges from 0.33 for a graded junction to 0.5 for an abrupt junction. Constant C_0 represents the capacitance at v = 0, while constant D is the capacitance at $v = V_C - 1$. Eq. 6 applies for reverse junction voltages smaller than V_{ZK}, at which C_t rapidly drops towards zero.

There are several methods for evaluating parameter values. Even low-accuracy techniques are helpful since they aid in determining expected-value ranges when deciding if and how laboratory testing should be used.



(a) REVERSE BREAKDOWN MODEL

(b) REVERSE-BIASED MODEL

3. Linear models. Circuit (a) synthesizes the zener in reverse breakdown. It consists of I_z-dependent dynamic resistance R_d, bulk resistance R_b, breakdown back-voltage V_b, and thermal-effect components R_θ and C_θ. Reverse-biased model (b) includes leakage resistance R_c, package capacitance C_p, and voltage-dependent transition capacitance C_t. Ordinary unit models forward-biased zener.

The typical or approximate values, indicated for most model parameters, may be accurate only within 20%, but yield an overall model whose accuracy can be within 5%.

In estimating resistance R_b, either the values in Fig. 1 or a multi-point data curve can be used. A log-log plot of zener impedance versus I_Z, like the one shown in Fig. 2(b), yields an asymptote that will fix a value for R_b.

This same curve also yields exponent N_z, though it can also be approximated from the two-point data of Fig. 2(c) or by using Eq. 2. A simple and often acceptable method is to set N_z equal to unity. Then, once Z_z, I_Z, R_b, and N_z are known, R_d can be found from Eq. 1.

Thermal-effect resistance R_θ is computed with Eq. 3, after a_v and τ_{JA} have been determined from test or design data. Alternatively, thermal resistance τ_{JA} can be assigned some typical value like 0.7 divided by the power derating factor. Or again, a_v and θ_{JA} can be estimated from data for diodes with a similar package type, zener voltage, and zener current.

Next, leakage resistance R_c can be obtained in two ways— from the average slope of a curve for v versus reverse current (I_r), or by dividing a reverse-bias test voltage by the appropriate leakage current. Back-voltage V_b can then be computed directly from Eq. 5.

Transition capacitance C_t is measured at various test voltages. Next, exponent N_c can be found from a log-log plot of C_t versus v, or assumed to be 0.33 for diffused-junction diodes (0.5 for alloy-junction diodes). Diffusion potential V_C can be solved graphically as the intersection of horizontal and diagonal asymptotes on a log-log plot of C_t versus −v, or it may be assumed to be 0.7 v (for silicon at 25°C).

Once C_t is known at some voltage, the value of D can be computed with Eq. 6. Otherwise, approximations derived from handbook data can be used: $5{,}200/V_{ZT}^{0.9}$ picofarads for ¼-W diodes, $24{,}000/V_{ZT}^{0.9}$ pF for ¾- to 10-W diodes, and $58{,}000/V_{ZT}^{0.9}$ pF for 50-W diodes.

What's been done for the zener?

Since its introduction in the late 1950s, just five computer models have been developed for the zener diode through 1970. The first and still most widely used linear model is a battery and a series resistance.

Accuracy was improved somewhat by Chandler[1] in 1960. He added a second series resistance to represent the zener self-heating effect. Chandler's addition was extended by Mollinga[2] in 1963.

A third independent investigation by Rigg[3] in 1962 led to another refinement of the linear zener model. Rigg introduced a junction transition capacitance shunted by a junction resistance to represent zener impedance below the diode's knee region.

There are only two nonlinear zener models, and both are difficult to program. Daniel's[4] model (in 1967) includes nonlinear current sources that realize dynamic, bulk, and leakage resistances, and transition and diffusion capacitances, but does not satisfactorily represent zener self-heating effects. Todd's[5] model (in 1970) employs a temperature-dependent, constant-current source for leakage.

REFERENCES:
1. J A. Chandler, "The Characteristics and Applications of Zener (Voltage Reference) Diodes," Electronic Engineering, Vol 32, February, 1960.
2. T Mollinga, "Effect of Temperature and Current on Zener Breakdown," Electro-Technology, Vol. 72, October, 1963.
3. B Rigg, "The Characteristics and Applications of Zener Diodes," Electronic Engineering, Vol 34, November, 1962
4. M E Daniel, "Development of Mathematical Models of Semiconductor Devices for Computer-Aided Circuit Analysis," IEEE Proc., Vol 55, Nov, 1967
5. C.D. Todd, "Zener and Avalanche Diodes," Wiley, N.Y. 1970.

The value of package capacitance C_p can be obtained from a bottom asymptote to the log-log plot of C_t versus $-v$. It can also be measured by using an internally open-circuited packaged zener. Thermal-effect capacitance C_θ is computed from Eq. 4, after the thermal time constant τ_{JA} has been obtained from test data. (It is also possible to use a typical value estimated from a similar package for τ_{JA}.)

Analysis problems. Now that linear models for synthesizing the zener in either its reverse-breakdown or reverse-bias region have been described and the ways to evaluate their parameters discussed, it's possible to consider how to use the models in current computer programs. Unfortunately, there are potential problems in any adaptation of a model to a computer program, but fortunately, they are not insoluble.

In general, most linear circuit analysis programs, such as ECAP (electronic circuit analysis program) and equivalent time-shared software packages, allow the models of Fig. 3 to be represented by fixed-value resistive and capacitive elements. Naturally, the loss in accuracy that results from using fixed values for $R_d(I_Z)$ and $C_t(v)$ depends on the magnitude and importance of the variations omitted. That loss can be minimized by ECAP's transient analysis capability if R_d and C_t are expressed as piecewise-linear variables.

A few numerical considerations should be observed for computer analysis. Thermal-effect resistance R_θ can have negative values at zener voltages below about 6 V, where temperature coefficient a_v can become negative. This leads to convergence problems in dc analysis if circuit resistance external to the zener is unusually low—for instance, if it is comparable to dynamic resistance R_d. The problem can be avoided by reducing the magnitude of R_θ to obtain a positive net series resistance for $R_d + R_\theta + R_b$ in the model of Fig. 3(a).

The extremely short time constant of the path through R_b and the two capacitors in Fig. 3(b) could make the time taken by transient analysis excessive. Very short integration time steps and, therefore, long computation times are needed to prevent a numerical error buildup. The difficulty is usually circumvented by placing package capacitance C_p in parallel with transition capacitance C_t, since C_t is normally higher in value. The two can then act as a single capacitor.

Using linear models for a zener diode, however, will not yield the most accurate results possible because such models are an approximation of the diode's nonlinear performance. But linear models do provide a basis for developing a computer-adaptable nonlinear model— and a major problem with existing zener models is the difficulty in adapting them for computer use.

A linear small-signal model is unable to deal with fractional current variations that are large enough to cause significant changes in zener diode voltage, $R_d(I_Z)$, or $C_t(v)$. It also cannot handle transitions from one zener operating region to another. These functions require some kind of nonlinearity. An appropriate form for the nonlinearity can be derived from a consideration of the voltage regulation of the linear zener diode model of Fig. 3(a).

From linear to nonlinear. Zener voltage regulation is found by integrating dynamic impedance Z_z in Eq. 1 with respect to current. When $N_z \neq 1$, the calculation yields:

$$V_Z - V_{ZT} = (R_b + R_\theta)(I_Z - I_{ZT}) + \frac{R_{dT} I_{ZT}}{1 - N_z}\left[\left(\frac{I_Z}{I_{ZT}}\right)^{1-N_z} - 1\right] \qquad (7)$$

If $N_z = 1$, then:

$$V_Z - V_{ZT} = (R_b + R_\theta)(I_Z - I_{ZT}) + R_{dT} I_{ZT} \ln(I_Z/I_{ZT}) \qquad (8)$$

Equation 7 could cause computational difficulties if N_z is close to unity, because it approaches an indeterminate numerical form. Moreover, the equation is difficult to rewrite into the explicit voltage-dependent current form needed for compatibility with presently available nonlinear circuit analysis programs. It is convenient, therefore, to let N_z be unity and use Eq. 8, which is determinate for all positive values of I_Z, and which results in an explicit voltage-dependent current source.

Both Eq. 7 and Eq. 8 have a voltage regulation coefficient, $R_{dT}I_{ZT}$, associated with the nonlinear logarithmic current term. In Eq. 8, this coefficient gives the effective nonlinear regulation for a current change of 2.718:1. Figure 1 includes typical regulation coefficient values, which range from 0.01 V (for a 5.1-V breakdown rating) to 0.61 V (for a 110-V breakdown rating).

Nonlinear model. A basic nonlinear zener diode model that covers all three regions of operation is shown in Fig. 4. The circuit employs an Ebers-Moll model for the forward diode, which consists of R_b, R_c, $C_d(i_1)$, $C_t(v_1)$, and $i_1(v_1)$. The model also has an exponential current source, $i_2(v_2)$, which represents zener voltage regulation.

The dependent Ebers-Moll diode current source, $i_1(v_1)$, can be expressed as:

$$i_1(v_1) = I_{s1}\,[\exp(qv_1/MkT) - 1] \tag{9}$$

where I_{s1} is saturation current, M a junction emission constant, k Boltzmann's constant, T junction temperature (in °K), and q the charge on an electron. M usually ranges between 1 (ideal) and 2, while kT/q is always 25.7 millivolts at 25°C. Diffusion capacitance C_d is:

$$C_d(i_1) = q[i_1(v_1) + I_{s1}]/2\pi FMkT \tag{10}$$

where F is the intrinsic diode cutoff frequency.

Back-voltage V_B is defined to obtain zero terminal current at zero terminal voltage, allowing the model to be used for both high and low operating currents. If $v_2 = 0$ at the zener test condition (V_Z, I_{ZT}) and $i_1(v_1)$ approaches $-I_{s1}$, then V_B can be given by:

$$V_B = V_{ZT} - R_b I_{ZT} - R_\theta I_B \tag{11}$$

where:

$$I_B = I_{ZT} - I_{s1} - (V_{ZT} - I_{ZT}R_b)/R_c \tag{12}$$

The value for V_B lies between breakdown back-voltage V_b and zener test voltage V_{ZT}.

The logarithmic component of zener voltage in Eq. 8 is represented by current source $i_2(v_2)$:

$$i_2(v_2) = I_{s2}[\exp(v_2/R_{dT}I_{ZT}) - e_o] \tag{13}$$

where I_{s2} is:

$$I_{s2} = I_B/(1 - e_o) \tag{14}$$

and where e_o is defined as:

$$e_o = \exp(-V_B/R_{dT}I_{ZT}) \tag{15}$$

to obtain zero diode terminal current at zero terminal voltage when $v_2 = -V_B$ (for accurately modeling zener leakage current or a low operating current).

Since regulation coefficient $R_{dT}I_{ZT}$ ranges from 0.01 to 0.61 v for the diodes listed in Fig. 1, the exponent in Eq. 15 varies from −8.3 to −510. This indicates that typical e_o values are below 0.0003, making e_o significant only at currents lower than those in the zener test current region.

Except for $R_d(I_Z)$, all the elements in both linear models of Fig. 3 are explicitly called for in the nonlinear model of Fig. 4. Dynamic resistance R_d, however, is implicitly modeled through current source $i_2(v_2)$. Differentiating Eq. 13 with respect to v_2 and inverting the result yields:

$$dv_2/di_2 = R_{dT}I_{ZT}(i_2 + I_{s2}e_o)$$

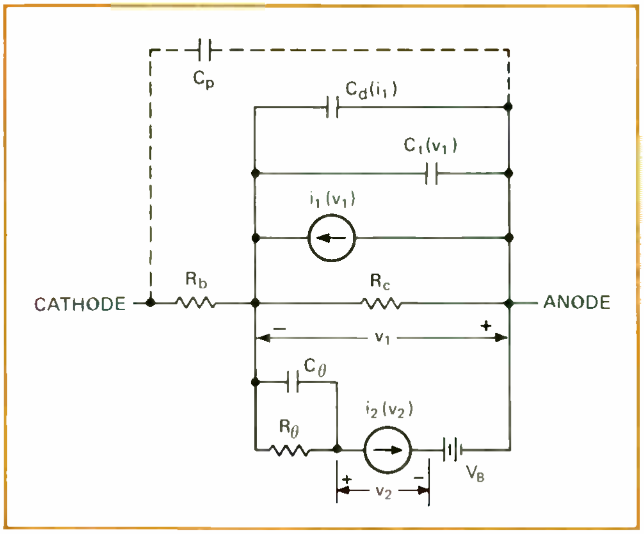
This expression represents R_d for $N_Z = 1$, in accordance with Eq. 1.

Nonlinear analysis. Parameter values for the nonlinear model are obtained in the same fashion as for the linear models. The methods already discussed for finding R_b, R_c, and C_p, and for solving the equations for R_θ, C_θ and C_t are identical. Values of saturation current I_{s1}, cutoff frequency F and junction emission constant M are determined by measuring diode leakage current, storage time and forward voltage, respectively.

Regulation coefficient $R_{dT}I_{ZT}$ can be estimated from data like that of Fig. 1. The remaining parameters of diffusion capacitance $C_d(i_1)$, back-voltage V_B, and current source $i_2(v_2)$ are computed using Eqs. 10 through 15, once all necessary variables are known.

Again, certain computer numerical analysis precautions must be observed. Those previously mentioned for R_θ and C_p also apply to the nonlinear model.

Forward voltages approaching diffusion potential V_ϕ can lead to numerically excessive values for transition



4. Nonlinear model. Adding C_p, R_θ, C_θ, back-voltage V_B, and voltage-dependent current source i_2 to Ebers-Moll diode model accounts for zener self-heating effects and nonlinear voltage regulation. The circuit is accurate for all operating currents.

capacitance C_t in Eq. 6. This may require a restriction that limits the magnitude of C_t or a convenient larger value of V_ϕ: the first modification is preferable. If NET-1 (network analysis program) is used, the magnitude of C_t is automatically limited. But floating voltage source V_B requires a series element, which should be a small resistor approximately equal to 0.001 R_θ.

The nonlinear model of Fig. 4 makes it possible to save programing time since the dependent exponential currents, $i_1(v_1)$ of Eq. 9 and $i_2(v_2)$ of Eq. 13, have the same general mathematical form:

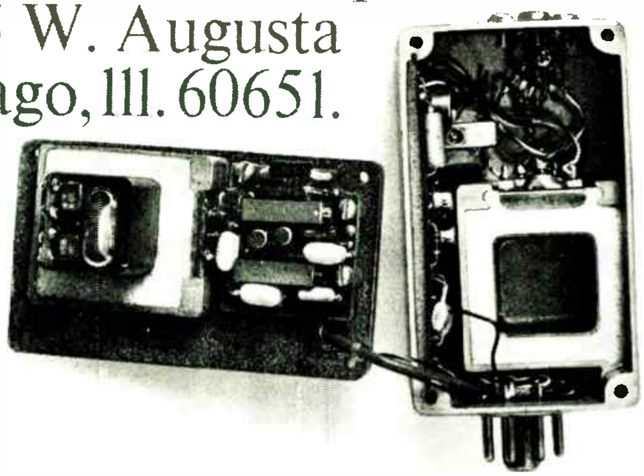
$$i = I[\exp(a) - b]$$

where $I = I_{s1}$, $a = qv_1/Mkt$, and $b = 1$ when $i = i_1(v_1)$, and where $I = I_{s2}$, $a = v_2/R_{dT}I_{ZT}$, and $b = e_o$ when $i = i_2(v_2)$.

On the other hand, the model may be difficult to represent with some circuit analysis programs. NET-1 and Circus (circuit simulator), for example, must include both exponentially dependent current sources as part of the diode model. Since the sources are connected to elements that cannot be eliminated from the network, an internal computation loop is formed with very short time constants. This, in turn, results in excessive computation time for transient analysis because extremely small integration time steps are required.

Sceptre (system for circuit evaluation and prediction of transient radiation effects), however, provides ideal diode current sources that implement Eq. 9 and that can be used without an R_b element. Then C_t and C_θ shunt $i_2(v_2)$, thus avoiding computational delay errors in Sceptre's state-variable transient analysis, without introducing a short time constant.

Dc analysis usually presents no problems; modeling compromises are generally necessary only for efficient transient analysis. In many applications, the forward-biased portion of the nonlinear zener model can be eliminated to ease the short-time constant problem for transient analysis with NET-1 and Circus. The variables $C_d(v_1)$ and $i_1(v_1)$ are simply omitted from the model. □



One-of-eight decoders test and correct parity

by Michael J. Gordon, Jr.
Psynexus Systems, Wilmetter, Ill.

Only four one-of-eight decoder packages are all it takes to build an eight-bit parity checker that also can be used for parity correction. Either odd or even parity testing can be done.

The basic circuit can be adapted to suit almost any logic family; complete data is given for TTL and MOS packages. When wired as indicated, the decoders produce a logic 0 output for correct parity, a logic 1 output for incorrect parity.

Suppose the input word is 10111001, and it is to be checked for even parity. Since there is an odd number of 1s, a parity error should be indicated. The three least-significant bits become the I_0, I_1 and I_2 inputs. The next three bits, going from right to left, are inputs I_3, I_4 and I_5. The last two bits become I_6 and I_7.

Because decoder D_1 receives only a single 1, its output is 1. The input to D_2 contains three 1s, causing another parity error. Decoder D_3 also produces a 1, since its input contains just one 1. Three 1s, therefore, are applied to D_4, resulting in a 1 output, indicating a parity error.

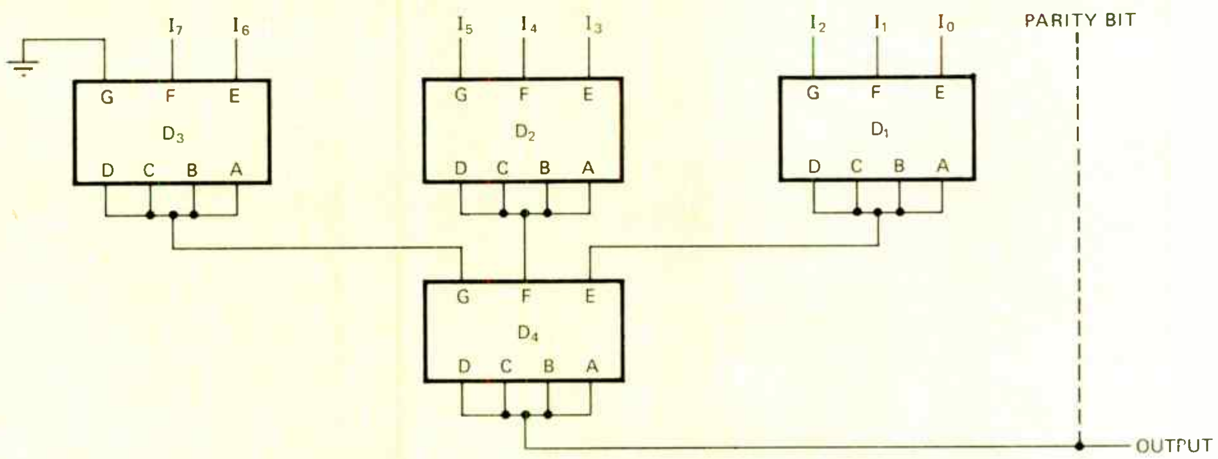
If the input word has correct, even parity, the output will be a 0. Let the word be 10010110. Now D_1 produces a 0, D_2 a 1, and D_3 a 1. Since the input to D_4 contains an even number of 1s, the output is 0, indicating correct parity.

Using the output as the parity bit corrects any parity error. If the circuit is wired for even parity, there will always be an even number of 1s. When wired for odd parity, the circuit will always supply an odd number of 1s.

For example, if the seven-bit word 1101101 is checked for even parity, the circuit's 1 output can become the eighth bit to correct the parity error. Of course, whenever word parity is correct, the circuit produces a 0, which does not change parity.

The outputs of the decoders shown in the diagram are wire-ORed together. If the decoder package used does not have this feature, an OR gate must be added to its output.

Testing, testing. Eight-bit parity checker generates a logic 0 for correct parity, a logic 1 for incorrect parity. Decoders D_1, D_2 and D_3 accept input data word and supply three-bit input for output decoder D_4. Circuit can test for either odd or even parity, depending on how it is wired. An OR gate must be added to output of each decoder if the type of logic employed cannot be wired-ORed.



DECODER	LOGIC	PARITY	PACKAGE PIN NUMBERS						
			A	B	C	D	E	F	G
MOTOROLA MC4038P	TTL	ODD	13	2	4	11	15	6	1
		EVEN	3	5	12	14	15	6	1
MOTOROLA MC1150L	MOS	ODD	2	5	12	13	15	9	7
		EVEN	4	3	11	14	15	9	7

With feedback, isolation amp gives better-than-unity gain

by Roland J. Turner
RCA Corp., Missile and Surface Radar division Moorestown, N.J.

An isolation amplifier with degenerative feedback provides gain over a large bandwidth, yet keeps output impedance low. An amplifier set up this way can be an excellent driver for long, low-impedance transmission lines or other highly capacitive loads. The circuit can even be used as a gate when its dual MOSFET is driven to cutoff. (Conventional isolation amplifiers, like emitter-followers, are usually unity-gain circuits.)

Moreover, gain and output impedance in the improved amplifier are insensitive to variations in the MOSFET's transconductance (g_m) and the bipolar transistor's beta (β). Normally, g_m drops by a factor of three as temperature rises from room conditions to 60°C, while β increases with rising temperature. In this amplifier, the changes in g_m and β can offset each other.

Gain is 17 decibels from several kilohertz to 20 megahertz; output impedance is less than 10 ohms. Furthermore, isolation greater than 50 dB can be achieved at frequencies as high as 6 MHz. The circuit's input can be operated either matched or unmatched.

As can be seen from the diagram, MOSFET Q_1 has two control gates. When the bias (V_{G2S}) of the second control gate (G_2) is decreased from 4 to −3 V dc, the forward gain through gate G_1 can drop by 50 dB, without adversely affecting its input characteristics. As V_{G2S} becomes negative, Q_1 is driven into pinchoff, reducing its drain current. Transconductance through the signal gate then drops from 15 millimhos to 50 micromhos.

The voltage transfer function for the amplifier is:

$$\frac{e_o}{e_i} = \frac{g_m[\beta R_1 + (\beta + 1)R_2]}{1 + g_m(\beta + 1)R_2}$$

which indicates that amplifier gain is directly proportional to g_m. If $g_m(\beta + 1)R_2$ is greater than 1, e_o/e_i reduces to:

$$\frac{e_o}{e_i} \cong \frac{1}{1 + 1/g_m(\beta + 1)R_2} + \frac{R_1}{R_2}$$

and circuit output impedance becomes:

$$Z_o = \frac{1}{g_m(\beta + 1) + 1/R_2} + \frac{R_1}{\beta + 1}$$

which equals R_1/β for frequencies to 10 MHz.

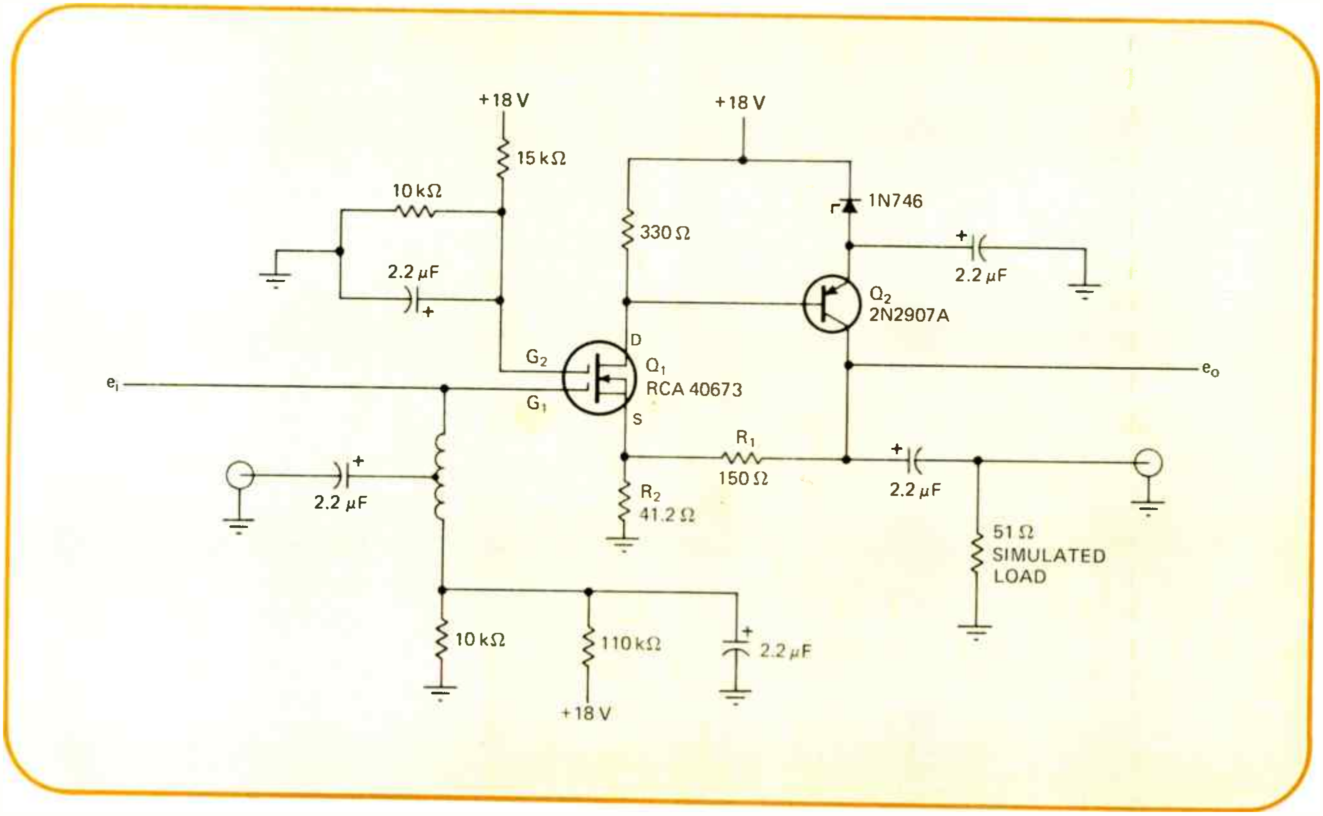
As Q_1 approaches pinchoff, its drain current drops, thereby driving Q_2 towards cutoff. Since Z_o increases as β decreases, amplifier gain is effectively reduced by mismatch. In the limit, as both g_m and β approach 0:

e_o/e_i approaches $1 + R_1/R_2$, and

Z_o approaches $R_1 + R_2$.

The input transmission-line transformer is similar to a Z-match type 50-200E. If the secondary of the transformer is terminated with 200 ohms, a low input VSWR can also be realized. Total parts cost is less than $5.

Line driver. Isolation amplifier makes ideal line driver. It supplies more than unity gain while holding output impedance under 10 ohms through frequencies as high as 20 megahertz. Degenerative feedback through Q_2 makes circuit performance insensitive to device parameter changes. Bias of Q_1's control gate G_2 effects gating action without harming input characteristics of signal control gate G_1.



Diode and SCR protect multiple-voltage equipment

by Peter T. Uhler
Midwest City, Okla.

Placing a diode between two different power supply lines permits one low-power SCR to control both supplies, thus protecting components from an overvoltage condition. Often, several supply voltages must be used to power a single piece of equipment, creating a hazard for those circuits that operate from a low voltage. If critical components fail, or if two or more supplies are accidentally shorted, these low-voltage circuits are usually destroyed.

Multiple-voltage protection is quite important for equipment containing integrated circuits, since ICs generally operate from low-voltage supply lines. The circuit shown is intended primarily for overvoltage protection—overcurrent protection is secondary in this case.

The voltage at point A or B determines when the SCR fires. Transistors Q_1 and Q_2 act as current-sensing elements. Resistor R_1 and diode D_1 trigger Q_1 at around 250 milliamperes, as do R_2 and D_2 for transistor Q_2. The SCR requires only about 5 microamperes to trigger it.

In the event of a fault (when the output currents of Q_1 and Q_2 exceed 250 mA), the SCR fires, turning transistor Q_3 off. Diode D_3 then turns off transistor Q_4, thereby permitting two supplies to be controlled by one SCR. More than two supplies can be controlled by a simple extension of this basic technique.

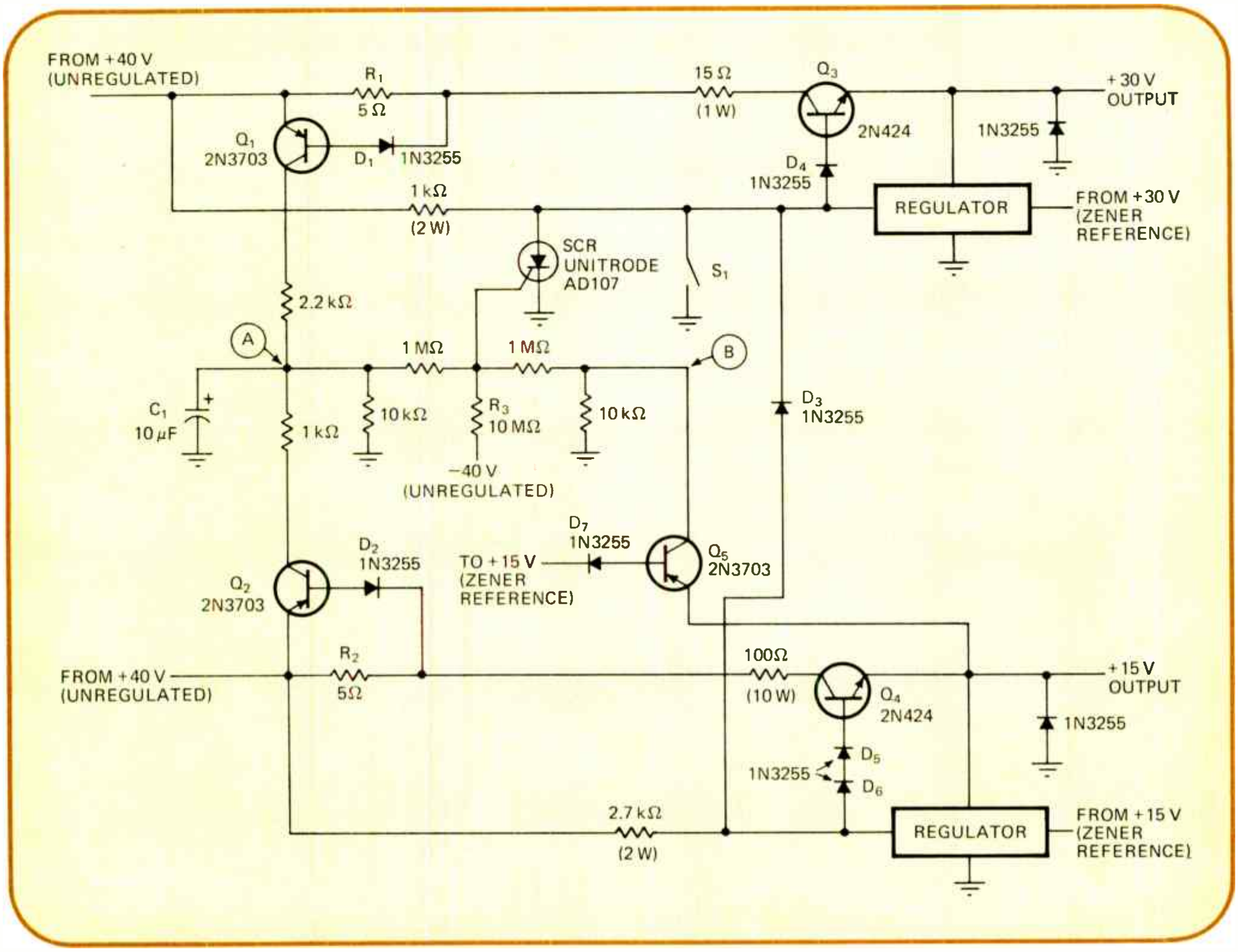
Diodes D_4, D_5, and D_6 assure that transistors Q_3 and Q_4 are turned off completely. Capacitor C_1 at point A provides a time delay of about 0.1 second so that initial load-current surges will not trigger the SCR.

Should the 15-volt supply rise about 16.4 V, transistor Q_5 fires the SCR immediately since there is no capacitor at point B. Diode D_7 protects Q_5 if the 15-V supply becomes shorted.

Premature triggering of the SCR due to its differential voltage (dv/dt) effect is prevented by resistor R_3. Switch S_1, which should be part of the power control switch, resets the SCR after the supplies are turned off.

Approximate parts cost for the protection portion of the circuit shown is $10.

Double protection. Overvoltage protection circuit monitors 15- and 30-volt supply lines at the same time. Because supplies are interconnected with diode D_3, only one SCR is needed. If output currents of Q_1 and Q_2 exceed 250 milliamperes, SCR fires, turning Q_3 off, while D_3 turns Q_4 off. Q_5 can also trigger SCR if 15-V supply reaches 16.4 V. Capacitor C_1 prevents transient current overloads from firing SCR.



Dual op amp comparator controls ramp reference

by Ronnie Jack McKinley
Duncan, Oklahoma

A control comparator can be used to establish the end points of a sawtooth generator's ramp output. That way, the sawtooth's end points don't drift with temperature, providing a stable output. The ramp, which travels from absolute zero potential to 5 volts, can be varied over a frequency range of 0.33 hertz to 1 kilohertz.

Constant-current source Q_1 linearly charges capacitor C_1, whose voltage is buffered by unity-gain follower A_1. Comparator A_2 is formed by two operational amplifiers operating at open-loop gain; a flip-flop is realized from NOR gates G_1 and G_2. Diodes D_1 and D_2 prevent gate inputs from becoming more negative than −0.5 v, while the 4.7- and 3.3-kilohm voltage dividers stop the gate inputs from exceeding 5 v.

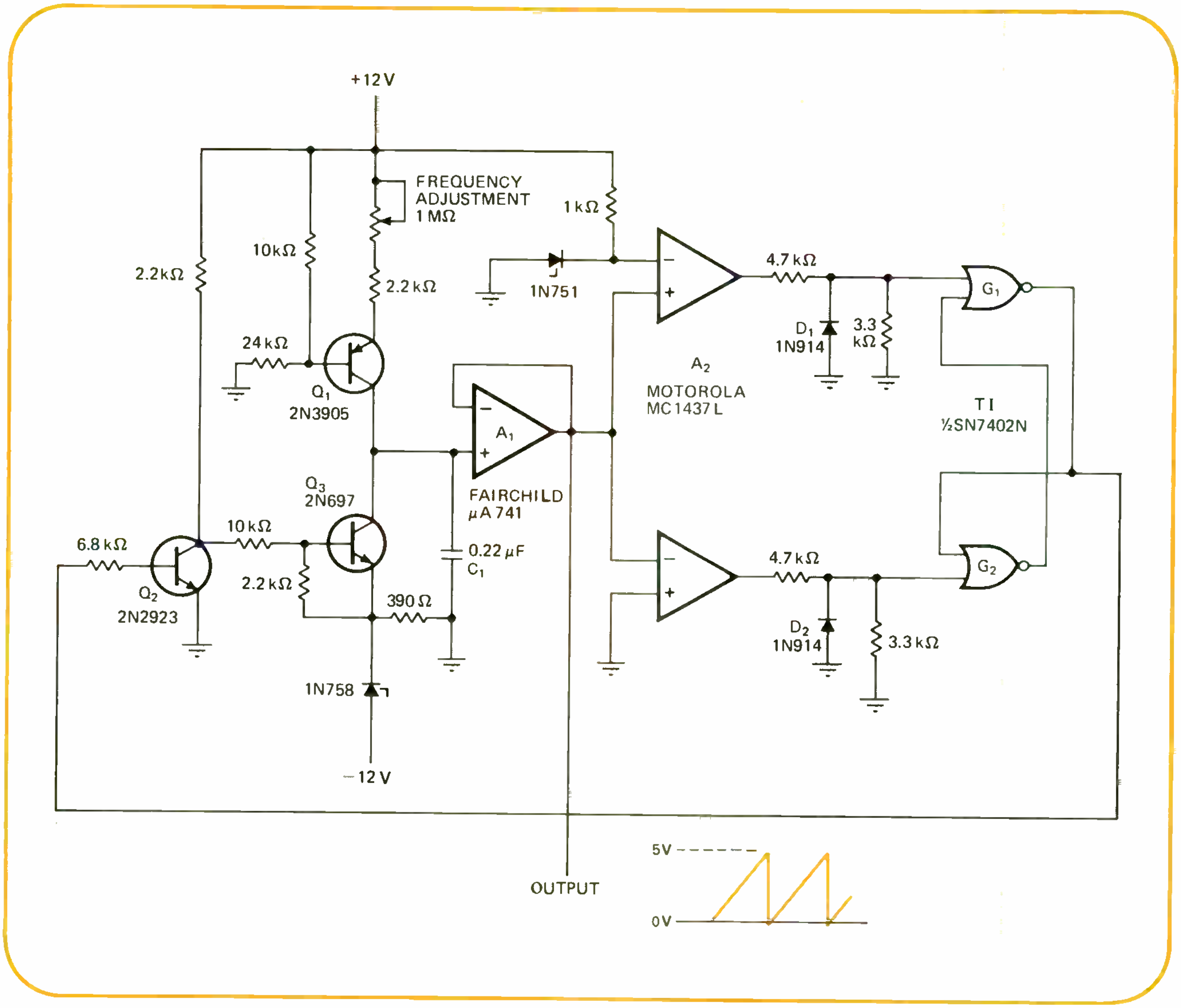
The comparator sets up two threshold reference points—one at absolute zero potential, the other at 5 v. When the voltage across C_1 reaches 5 v, A_2 switches, causing the flip-flop to produce a negative pulse. This turns Q_2 off and Q_3 on so that C_1 discharges.

Since Q_3's emitter is biased at -2 v, the discharging capacitor tries to reach V_{SAT} -2 v. However, when the voltage across C_1 becomes zero, the comparator switches, returning the flip-flop to its original state.

Transistor Q_2 now conducts, Q_3 goes off, C_1 begins charging again from a stable zero point, and the cycle repeats. Because of the comparator reference, the baseline of the ramp cannot be shifted by any temperature variance in the V_{SAT} of Q_3.

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.

Supplying temperature-stable output. Dual comparator in this sawtooth generator sets lower and upper end points of ramp. Constant current from Q_1 charges C_1 until the capacitor's voltage becomes 5 V. Comparator A_2 then switches, toggling flip-flop formed by G_1 and G_2. Q_2 turns off, Q_3 turns on, and C_1 discharges until its voltage is zero. Then A_2 switches again, triggering the flip-flop, which turns Q_2 on and Q_3 off.



Impatt diodes and millimeter-wave applications grow up together

As millimeter-wave communications, alarm, and landing systems proliferate, silicon Impatt diodes, with their impressive flexibility, power output, and efficiency, become more attractive as solid state sources

by N.B. Kramer, *Hughes Research Laboratories, Torrance, Calif.*

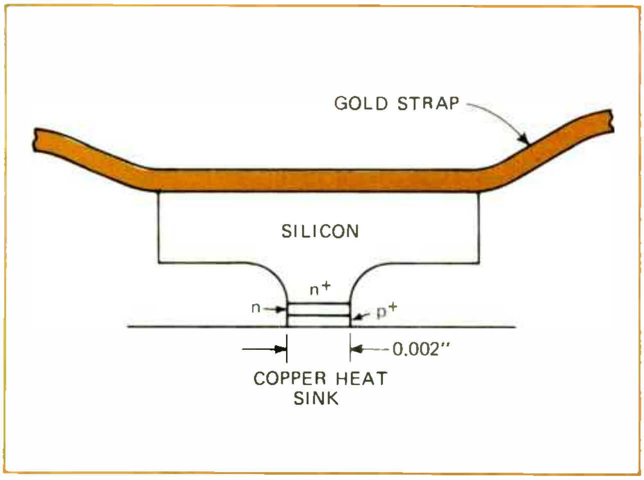
☐ The applications for systems using millimeter-wave frequencies are growing, and so is the attractiveness of silicon Impatt diodes as solid state sources. Recent development work has done much to enhance the advantages of the diodes. Among those advantages: Impatts give the highest millimeter-wave cw power of any solid state device—as high as 150 milliwatts at 100 gigahertz. Moreover, Impatts are many times more efficient than LSA diodes and are at least as efficient as the best Gunn devices. And Impatts are vastly smaller, lighter, and simpler than the old varactor harmonic generators.

Flexibility is another important plus for Impatts. They can be operated efficiently as stable amplifiers and already are providing serious competition to traveling wave tubes at the higher millimeter-wave frequencies. Small, simple, wideband Impatt sweep generators are becoming standard throughout the millimeter transmission band. Parametric amplifier pumps using stabilized Impatt oscillators are being designed into a number of new systems and appear to provide paramp noise figures as good as conventional pump sources. Millimeter-wave communications systems, such as Bell Laboratories' trial transmission unit, will use silicon Impatts for transmitters and local oscillators. And other potential uses include small doppler radar for intrusion alarms, aircraft landing systems, and collision avoidance networks. Many new applications will be explored as experience with Impatt devices increases.

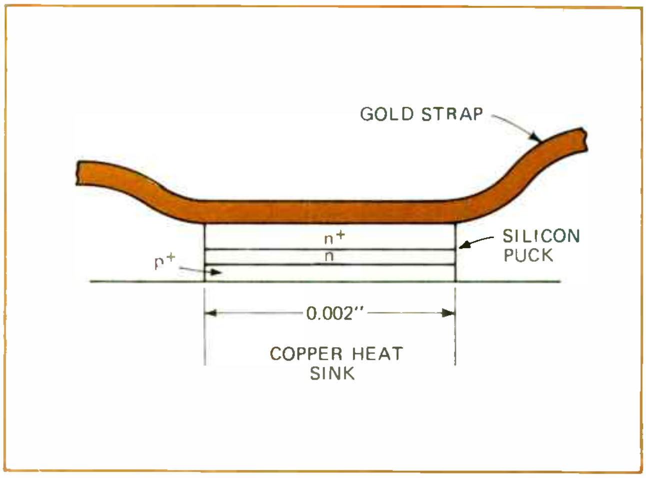
A silicon Impatt's electrical performance is impressive. At millimeter wave frequencies, Impatt diodes operate at less than 30 volts bias with bias currents in the 100–300-milliampere range. Conventional single-drift structures regularly give power output levels in the 100-milliwatt range at efficiencies of a few percent. And recently developed configurations, such as the double-drift diode, promise significant increases: power output approaching the 1-watt level with 10% efficiency will be possible under operating conditions.

One problem with Impatts has been the high noise encountered in avalanche devices. But in many applications, such as power amplifiers, noise is not important; in others, such as paramp pumps, problems due to noise can be eliminated by using a stabilizing cavity. In fact, extensive investigations have shown that Impatt sources make attractive pumps for low-noise, wideband paramps for application in radar and communications systems.

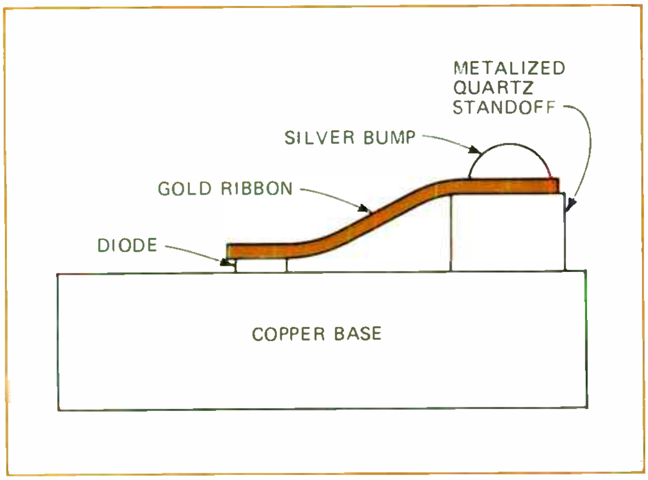
State-of-the-art Impatts. The first practical Impatts were silicon pn junction diodes for computer switching and these form the basis of the present cw Impatt structures. Operating in X band, the early devices were planar or mesa diodes with junction areas of about 10^{-4}



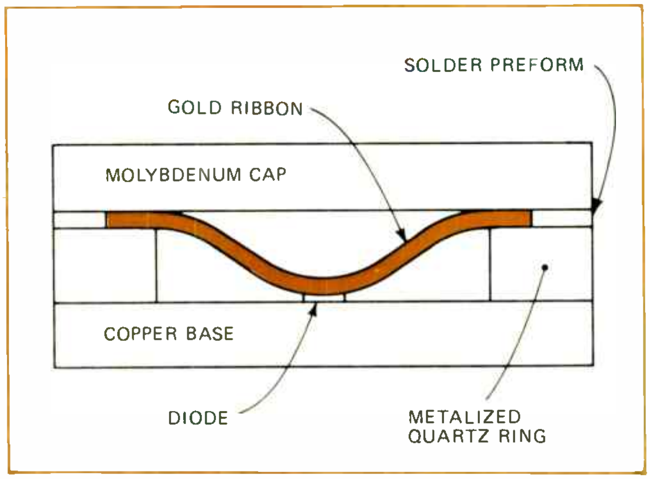
1. Old ways. Showing the way to today's Impatts were these old mesa diode structures. Used primarily for computer switching, these devices relied on close bond between surface adjacent to junction and copper heat sink to provide a good heat transfer.



2. New ways. Modern Impatt design eliminates excess high resistivity material by forming epi-layer; Punch-through occurs only at avalanche. Less material also reduces rf series resistance and lowers the overall thermal resistance to tne back contact.



3. Lab pack. This typical stand-off package exhibits low loss because stand-off volume can be made small. It can also be tailored for low parasitics but the drawback is that it cannot be sealed completely immediately around the actual diode area.



4. Tough contender. More suitable for industrial applications, this hermetically sealed package is good at the lower millimeter-wave frequencies; however, it has higher rf loss and less flexible parasitic adjustment than does the stand-off package.

cm^2, compared to the 10^{-5} cm^2 areas attainable now for mm wave devices.

In addition to a geometry change, the new devices have been greatly refined to minimize thermal resistance, resulting in higher power capability. Careful attention also has been given to precise control of the doping profile to minimize rf series resistance. Then scaling of the basic diode design to operate at higher-frequency ranges is easily accomplished and performance agrees with simple lower-frequency models.

The great improvement in Impatt performance levels over the last five years has been closely related to reduction in diode volume. Early cw diodes were upside-down-diffused mesa structures that relied on the intimate bond between the surface adjacent to the pn junction and a copper heat sink for good heat transfer (Fig. 1).

A modern diode is represented in Fig. 2. Excess high-resistivity material is eliminated by tailoring the epitaxial layer so that the depletion layer just punches through to the substrate at avalanche breakdown. Most of the excess substrate material also has been removed to reduce rf series resistance and lower the thermal resistance to the back contact.

New silicon processing techniques, as well as careful application of some old techniques, work together to yield the high performance of Impatt devices: epitaxial layers grown at low temperatures (below 1,000°C) have given the best results. Non-abrupt doping gradient at the nn^+ interface, caused by outdiffusion during conventional high-temperature epitaxial growth, resulted in lower efficiency.

More recently, ion implantation has been utilized successfully for junction formation. The high temperatures associated with conventional diffusion processes are not required in the ion implantation process; therefore, abrupt doping transitions at the p^+n and nn^+ junctions can be maintained. Also, the extremely shallow junctions that can be made with ion implantation result in minimum thermal impedance.

Complementing ion-implantation methods, a low-temperature diffusion process has been developed that provides equally good junctions. Wafer thinning and special bonding techniques also have contributed significantly to improved performance at millimeter wavelengths.

Ion implantation and low-temperature diffusion will play an increasingly important role in silicon Impatt diode fabrication. In addition to the usefulness of implantation in forming highly controllable shallow p^+ regions, it is an indispensable tool in forming the new p^+pnn^+ (double-drift) Impatt structure for millimeter-wave operation. The double-drift diode is more efficient because it utilizes both carrier species (electrons and holes) created in the avalanche process. Moreover, the diode's active region is thicker and junction area can be increased while maintaining sufficiently high diode impedance levels.

The combination of increased efficiency and larger active volumes result in significantly improved power output capability (it's theoretically quadrupled). Ion implantation is used to build this new type of diode structure by employing the range-energy relationship to tailor the diode's p region.

Packaging of diodes for millimeter-wave applications has always been a problem. Reduction of package parasitics is a must because of the high frequencies and low diode impedance levels. Furthermore, millimeter waveguide dimensions are very small, putting size and tolerance constraints on diode packages. Rf loss increases with increasing frequency, so only low-loss materials can be used in package design. The additional requirement of minimum thermal impedance for power devices like Impatts makes package design critically important for efficient rf performance.

A package that is convenient for laboratory experiments is shown in Fig. 3. A small metalized quartz standoff is mounted near the diode and a ribbon bond is made from the standoff to the back of the diode. The standoff's small volume gives this type of package its low loss. And parasitics can be easily tailored—ribbon inductance and shunt capacitance can be varied by changing standoff dimensions and position.

However, this lab package is completely open, pre-

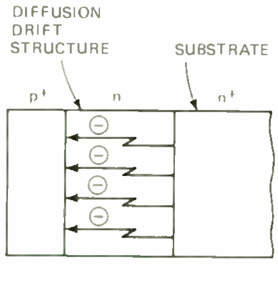
Impatt power

Avalanche diodes operating in the Impatt (impact avalanche transit time) mode develop their considerable power output when carriers at a pn junction build up due to avalanche and then move across the structure's drift region. A simple three-layer (single drift) p^+nn^+ device is shown in Fig. a. To function as an amplifier or oscillator, the device must deliver power to its output circuit—it must have a negative-resistance characteristic. In the Impatt mode, negative resistance develops as the result of a phase delay of drifting carriers. This is due to both avalanche generation and transit time delay.

In avalanche, internal secondary emission occurs at a pn junction that has been reverse-biased into breakdown. At high fields (several hundred kilovolts per centimeter), carriers will acquire enough energy to knock valence electrons into the conduction band, producing hole-electron pairs. These new carriers cause further generation, until a critical field is reached and avalanche occurs.

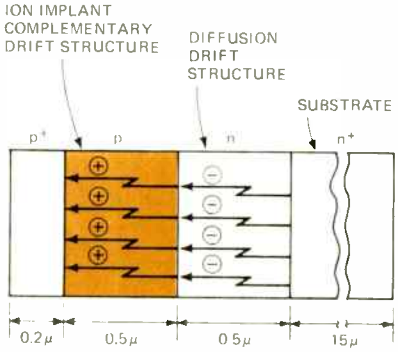
Under steady state conditions the maximum field across the junction will be limited to the avalanche or critical field. But under transient conditions, if the field is moved rapidly from below critical level to above it, and then below it again, the current will still be increasing when the field has passed its maximum; in effect, a phase delay will be introduced. This is the delay caused by avalanche buildup. The current-voltage phase shift can be as great as 90° under small-signal conditions. This, combined with transit time delay (between 90° and 270°) allows the diode to exhibit the required negative resistance over a microwave frequency band.

However, a double-drift-space (2d) Impatt diode gets its greater power from the additional drift region implanted onto the simpler structure. It has four layers (Fig. b) instead of the usual three, and this double-drift region, together with the resulting bigger diodes, is responsible for the power increase over the single-drift structures. thus. in a double-drift diode, (a p^+pnn^+ structure for example), in addition to the drifting electrons on a p^+nn^+ diode, holes drift across the added p region in phase with the electrons, resulting in greater power outputs. **—Laurence Altman**



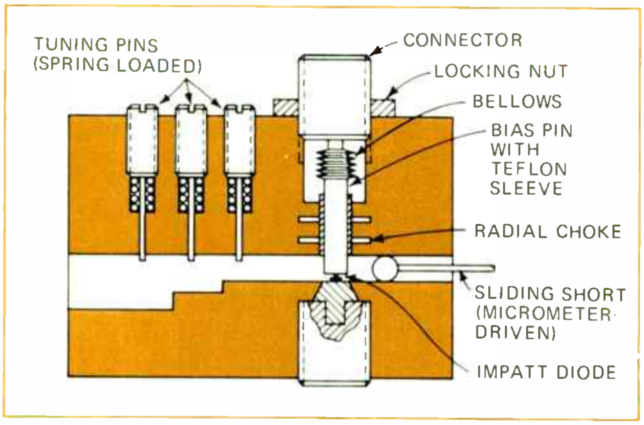
SINGLE DRIFT STRUCTURE

(a)

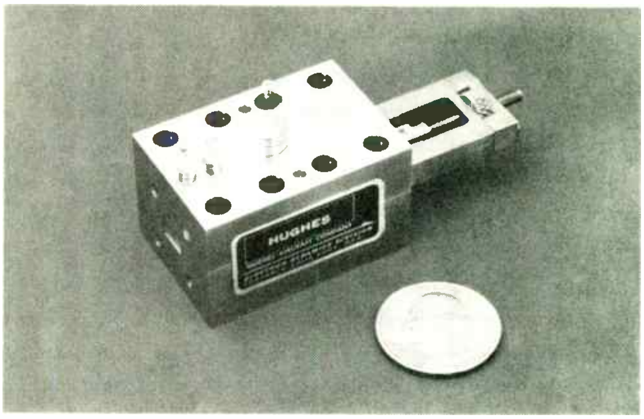


DOUBLE DRIFT STRUCTURE

(b)



5. In tune. Typical millimeter-waveguide cavity structure has considerable mass for heat sinking but mass can be reduced if external sinking is available. Mechanical tuning in the structure is accomplished through a sliding-short technique.

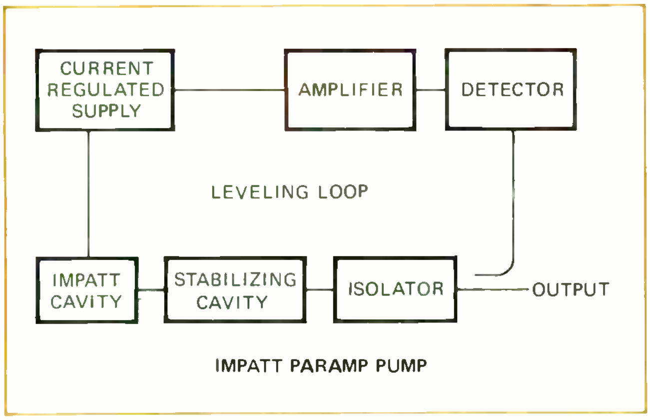


6. Run for the money. Impatt packages such as this one are becoming strong competitors to klystron oscillators. This unit, cheaper than comparable klystrons, gives continuous tuning over a 30 to 40 gigahertz range with a minimum output of 50 milliwatts.

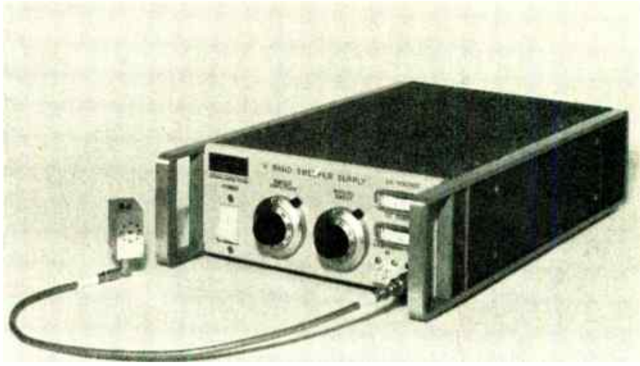
cluding hermetic sealing immediately around the diode. In addition, the small standoff makes the package delicate; its use is justified only in systems where rf power output and efficiency are of paramount importance.

A rugged, hermetically sealable package is shown in Fig. 4. This type can be very useful at the lower millimeter-wave frequencies even though rf loss is higher than in the lab version and tailoring of the parasitics less flexible. The package also can be made with a ceramic body for added strength.

Due to the high power densities (2×10^5 W/cm^2) required for efficient Impatt operation at millimeter wavelengths (corresponding to junction temperatures of approximately 200°C), some attention must be given to



7. Widely used. Paramp pumps made with Impatts are being adapted for radar systems. These pumps are smaller, lighter, and less complex than varactor chains they replace.



8. And back at the lab. Millimeter-wave sweep generator has Impatt oscillators for laboratory testing. Bias-current tuned, the head is fixed by flexible cable to the power supply.

diode life. Certainly, silicon Impatts will not be attractive as millimeter-wave power sources if the junction temperature must be limited to values equivalent to conventional transistor and diode ratings. Though extensive life data is not available, experience in limited life testing and in operational systems has revealed no fundamental failure mechanisms that would inherently limit longevity at these power densities and junction temperatures. Care must be taken in diode design and fabrication to avoid metalization or mechanical weaknesses that might be aggravated by high-temperature operation.

For optimum efficiency, cavity design must be closely related to diode design. Waveguide circuitry is used almost exclusively at millimeter wavelengths and waveguide cavities for Impatt diodes generally have proven highly versatile and flexible. This has resulted in similarity of physical size and configuration among millimeter-wave Impatt diode mounts.

A schematic of a typical cavity with bias connector and tuning elements is shown in Fig. 5. At high frequencies and power outputs the cavity mass must be large to assure adequate heat sinking. Where external heat sinking, such as a cold plate, is available, cavity volumes can be reduced significantly.

Applications. With the appropriate cavity design, mechanically tunable cw oscillators using Impatt diodes will be replacing klystrons at millimeter-wave frequencies. An oscillator capable of continuous tuning over a 10-GHz band (30 to 40 GHz) with 50 mW minimum output is shown in Fig. 6. This unit is cheaper than a klystron of comparable performance, requires a simpler power supply, and is easier to tune. The oscillator also has an electronic tuning sensitivity of 2 MHz/mA, making it useful for phase-lock jobs.

A millimeter-wave Impatt oscillator used with a stabilizing cavity and an appropriate leveling circuit makes an efficient solid state pump source for low-noise parametric amplifiers. A block diagram of such a paramp pump, being designed into several wideband radar and communications systems, is shown in Fig. 7. A complete Impatt pump is much smaller, lighter, and less complex than a varactor multiplier chain providing equivalent paramp performance.

Stable circulator-coupled reflection amplifiers employing Impatts have been successfully demonstrated at millimeter-wave frequencies. At V band, small-signal gain-bandwidth products of 15 GHz have been measured with power outputs exceeding 100 mW obtainable at 8-dB power gain. Comparable performance has also been observed in the 30–40-GHz range. This type of amplifier will be useful for low-level transmitters and for TWT preamplifiers.

Injection-locked oscillators for power amplification of wideband fm and phase-modulated millimeter-wave signals also have been demonstrated. Impatt oscillators have a good locking figure of merit (product of fractional locking bandwidth and voltage gain) and can be used to efficiently amplify angle-modulated signals. The advantage here is that unwanted amplitude modulation is stripped from the signal due to the limiting characteristic of the locked oscillator.

A new millimeter-wave sweep generator for laboratory instrumentation has been developed using a bias-current tuned Impatt oscillator; a photograph of the complete unit is shown in Fig. 8. The rf head is connected by flexible cable to the power supply, permitting the sweeper to be conveniently connected at any location in a test system. The Impatt sweeper is more compact and less complex than a comparable backward-wave oscillator sweeper. Sweep bandwidths up to 15 GHz can be obtained with power output of greater than 1 mW over the band. The power output variations with frequency are smooth when suitable isolation or padding is used. The wideband bias-current tuning capability of this oscillator should make it attractive for other electronic tuning applications.

Doppler radar is another type of millimeter-wave system that should find wide use with the availability of simple solid state sources. Demonstration units have been built in the 50-GHz range that employ a single-drift Impatt diode for the transmitter/local oscillator in a homodyne configuration. This type of radar can be small, inexpensive, and portable. Range over 100 yards can be easily obtained in an inexpensive unit. With a good-quality mixer and a high-power Impatt, range could be extended to 1,000 yards or more. Foreseeable applications include such products as intrusion alarms, and such automotive tasks as braking radars and speedometers. □

Digital data links deserve a bit error rate detector

Hardware is replacing software for the job of picking up errors in digital data transmission; the equipment is based on the same mathematical principles as are used in monitoring analog networks

by Kingsley P. Roby, *Data-Control Systems Inc., Danbury, Conn.*

☐ Since the early days of digital data transmission and processing, there have been software programs for bit error correction. But as the use of data links spreads, the need arises for simple, inexpensive hardware to monitor digital equipment. Recently the surge in digital transmission has made the need more urgent.

The tool that has been developed for this job is the bit error rate detector. The technique is basically the same as that used for the evaluation of analog data networks, where the input characteristics of frequency versus phase/amplitude are compared with those of the output, except that for digital networks an equivalent digital mathematical model is used.

With digital systems, however, distortion of the signal is not necessarily cumulative. If signal distortion exceeds the system design threshold, the information is totally lost; if it is less than the threshold, the information can be totally recovered. A bit error rate detector simply compares a pattern that has passed through a digital device with an identical pattern generated by a reference code generator, as the block diagram in Fig. 1(a) shows. The comparison is made on a bit-for-bit basis. If the two states disagree, an error is counted, and displayed as a function of time or as bit errors per n bits transmitted.

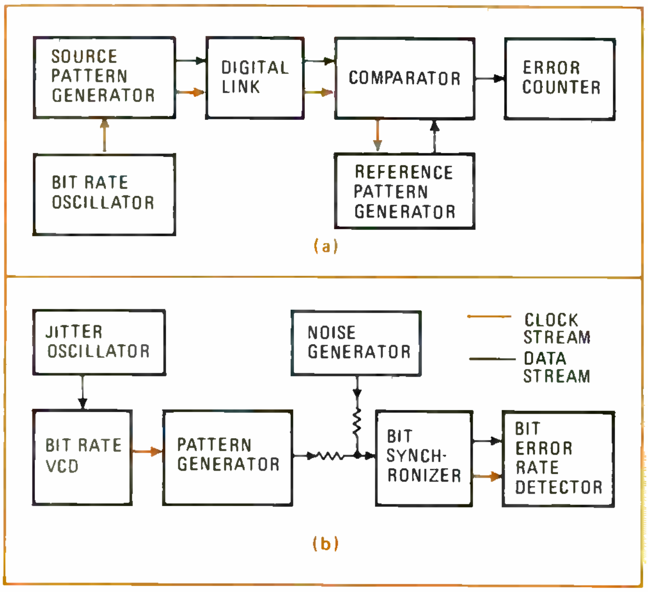
The detector is as versatile as it is easy to use. It can check performance in any digital line—telephone lines, magnetic tape recorders, data modems, or pulse code modulated telemetry links. About a dozen different versions of the device are being manufactured, and some can be used to test at rates up to 400 megahertz.

In almost all cases, the equipment to be tested must be taken out of operation. The detector generates a known digital pattern, and inputs it to the digital device. Because an independent code is generated at the receiver, the delay through the system does not have to be compensated for. But it is necessary to synchronize the reference code generator to the incoming data.

When a link does not transmit its own clock, or where the received data includes much jitter or noise, a bit synchronizer is needed. This accepts the data, and recreates a clean data stream and an accompanying clock by using the data transitions (ones and zeros) to synchronize a phase-locked, voltage-controlled oscillator with the incoming data. The oscillator then functions as the clock. In the absence of transitions, the VCO will "coast," or mark time, and still be synchronous at the end of the coasting period.

To check the bit synchronizer itself, jitter is simulated by modulating a VCC that acts as a bit rate oscillator and controls jitter amplitude and frequency. Noise is summed with the code generator output, and the composite signal (jitter plus noise) is applied to the bit synchronizer input, as in Fig. 1(b). The synchronizer's performance is verified by comparing its bit error rate with curves of bit error rate versus signal/noise ratio.

There are three basic types of digital communication links that can be tested: simplex links, where data flows in one direction only; duplex links, where there is simultaneous two-way flow; and half-duplex links, where data flows in one direction some of the time and in the opposite direction the rest of the time. The basic configurations are shown in Fig. 2. Simplex testing requires two bit error rate detectors, one at the data source to act as the transmitter and one at the data sink to act as the receiver. Duplex testing also usually requires two error rate detectors, the pattern generator output of one unit being sent to the error rate detector of the other unit.



1. What BERDS are and do. Bit error rate detectors are used to test digital links by comparing a known pattern transmitted from a data source with an identical pattern simultaneously generated at the data output (a). By adding a noise generator and a jitter oscillator, a BERD also may test the ability of the bit synchronizer to recreate clean data stream and the accompanying clock (b).

The arrangement for testing a half-duplex loop is similar to duplex, except that the link can only be used in one direction at a time. In this case, each error rate detector is used as a pattern generator when testing in one direction, and as an error rate counter when testing in the other direction. In doing this, the pattern generator is independent of the error rate detector, since data may be sent at different rates in either direction.

It is possible to measure error rate on a duplex or bidirectional simplex communication link with one detector, but only when the data link can be looped back to the source. In this case, if errors are incurred randomly throughout the link, the actual bit error rate is half that recorded. When no clock is available, it may be necessary to include a bit synchronizer at the receiving end to simulate the clock function. If there is no jitter or frequency variation, the clock used in the pattern generator to the bit error rate counter can be bypassed. This method is useful particularly with hardline links which can be looped back to the source.

The type and length of digital pattern determines the extent that the bit error rate measurement includes a sufficient variety of pattern combinations. A simple pattern—a series of marks, a series of spaces, or alternating marks and spaces—suffices for a primitive test setup. This type of pattern is easy to generate and to synchronize, but provides only limited information about system performance, and is effective only for low-speed data systems. Another type of pattern generator, intended for systems with a fixed word length, is a fixed-length, switchable, repeating word generated by a presettable shift register, as shown in Fig. 3(a). This is useful where a data sink, such as a teletypewriter, can interpret patterns.

The switched shift registers may be replaced by a programed sequence which would step through each combination of n bits. When an 8-bit pattern is used and placed within proper framing, the pattern generator provides signaling to the teletypewriter, which then types out a particular sequence of symbols, such as "The quick brown fox, etc." Bit error rate is then determined by the number of incorrect symbols.

The most frequently used pattern generator is the pseudo-random noise, or shift register, generator, shown in Fig. 3(b). It combines the output of some of the shift register stages to produce a repeating pattern of a particular length. One of the primary advantages of this arrangement is that the output is a long, random sequence which contains all the combinations of 1s and 0s characteristic of normal data transmission.

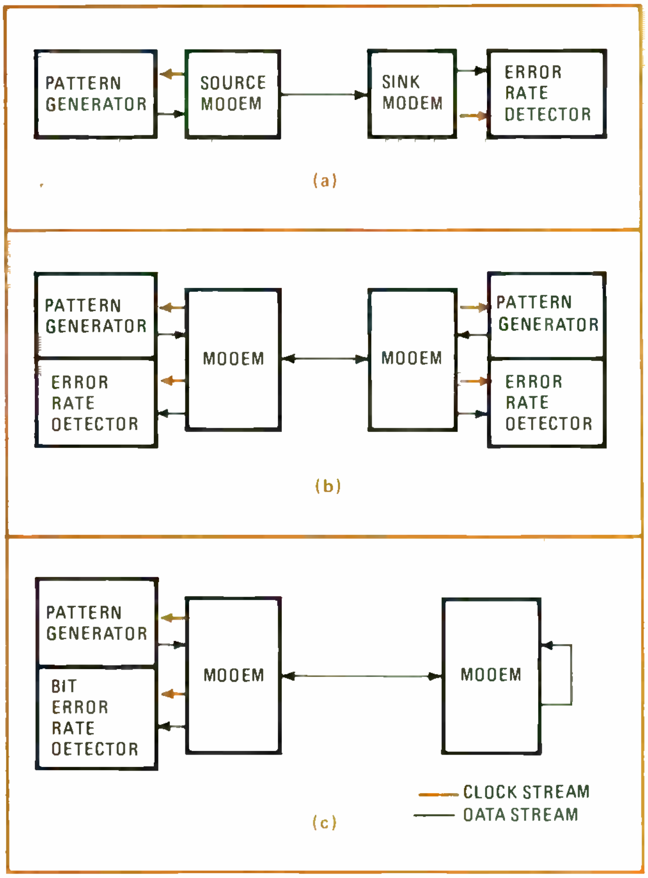
A fairly continuous spectrum from dc to the bit rate is obtained by using a maximum pattern length, which is usually 2^n-1 bits long. The maximum number of 1s in a row is n and the maximum number of 0s is n–1. (Observing the code n bits at a time, that is, bit 1 through n, then 2 through n+1, will reveal all possible combinations of logical 1s and 0s in n bits.) The longer and more complex the pattern, the greater the spectral density, or number of pattern combinations, that can be analyzed.

There are several standard interfaces used to adapt bit error rate detectors to various digital systems. Usually, the test equipment interface is determined by some common logic family, such as TTL, where 0 to 0.8 volt indicates one state, and 2 to 5.5 V indicates the other. But bipolar and neutral transmission are still used in some teleprinter systems. The neutral mode uses a pulse current for a 1 and the absence of current for a 0. The bipolar mode is similar, except that the polarity of the current is used to distinguish 1s from 0s.

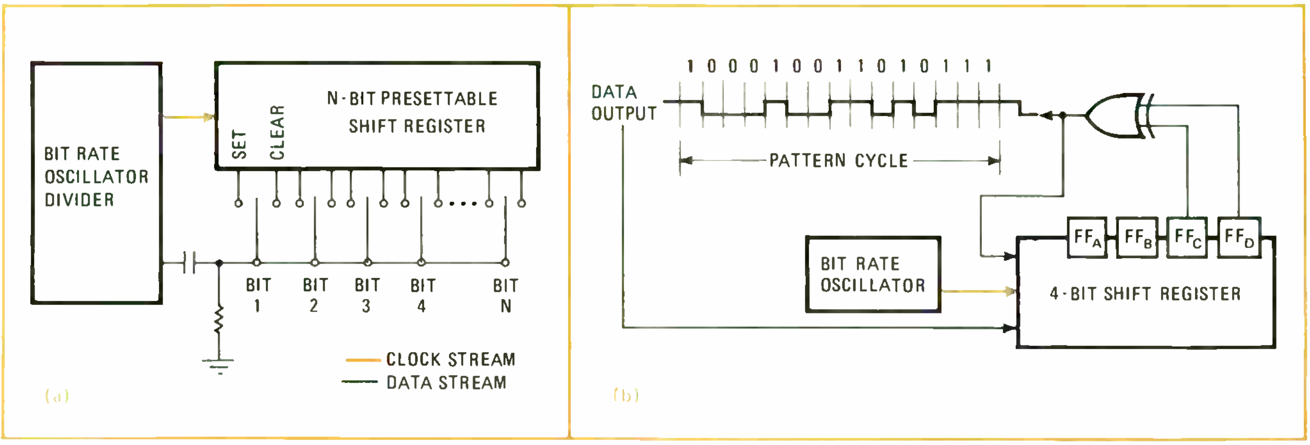
The EIA standard interface is designated RS-232. The transmission is basically a polar signal ±5 to 15 V in amplitude where a 1 is negative and 0 positive. An interface similar to RS-232 used by the military is Mil Std 188. The logic levels are polar ±6 V with the positive voltage indicating a 1.

In addition to interfacing voltage level, code formats must also be considered. The seven Inter-Range Instrumentation Group (IRIG) codes are the standard of the aerospace industry (Fig. 4). The RZ (return-to-zero) code is used when a dc response is not required. Where the absolute polarity of the logic does not have to be maintained, the mark and space codes have the advantage. This is because a logical 1 (in the case of a mark code) is indicated by the change of state and not the absolute level as in the case of NRZ-L (non-return-to-zero level) code.

A biphase code requires a higher frequency response for a given data rate, but due to its high transition density provides improved performance in the absence of excessive jitter. For this reason, it is often used with tape recorders. Delay modulation, or DM, was developed to



2. Digital link trio. In simplex transmission, data flows in one direction (a); in duplex and half-duplex, two BERDS are needed because data flows in both directions (b); however, one BERD may be used (c) if the transmission line can be looped back to the source.



3. Generating patterns. Test patterns for a BERD can be pre-set into a shift register (a) so that it repeats each n bits. The output of the bit rate oscillator provides the clock for the shift register. To generate a variety of more complicated patterns, the feedback points can be changed and more flip-flops may be added to the shift register (b).

provide maximum transition density with minimum frequency requirement. DM has a transition in the middle of the bit period for a 1 and a transition at the beginning of a bit period for a 0, except that when a 0 follows a 1 there is no transition. DM can provide packing densities of up to 20 kilobits per inch on magnetic tape.

Several highly specialized codes have also been developed. One is the two-tone coding used over telephone lines for long-distance calls: the flurry of beeping heard after dialing is a series of tone pairs representing numbers which transfer billing information into the telephone company office.

A different technique is used by the telephone company to transmit 1.5-MHz synchronous data over pairs of wires. It's done in the T-1 PCM transmission system with a bipolar format in which there's a pulse for each 1, and no pulse for a 0. Each successive pulse is of opposite polarity. Every 6,000 feet, a repeater detects, resynchronizes, and reamplifies the data to its nominal value. This system is transformer-coupled and balanced, and has a high common-mode rejection ratio that allows it to perform well in a multiconductor cable with other noise-producing signals. The average signal current approaches zero because each pulse equals the previous pulse in amplitude and is opposite to it in polarity. This means that the system requires no dc response. With a repeatered line, signals can be transmitted over at least 25 miles without degradation.

After the interface requirements have been met, the digital information may be considered in terms of the logic family in the bit error rate detectors. To measure the bit errors in the incoming data stream, a synchronous clock is needed to feed the data into the sink portion of the bit error rate detector. It is also necessary to synchronize the reference pattern with the incoming pattern.

The synchronous clock can be provided in a number of ways. Usually, the input data is transferred into a flip-flop register bit by bit. If the data is entered in NRZ-L form, then an optimum clock transition occurs in the middle of the bit period. However, because the data exists at a 1 or a 0 level for the entire bit period, the input clock and data may be at any phase relationship so long as they are synchronous, that is, with one clock pulse occurring within the period of each data bit.

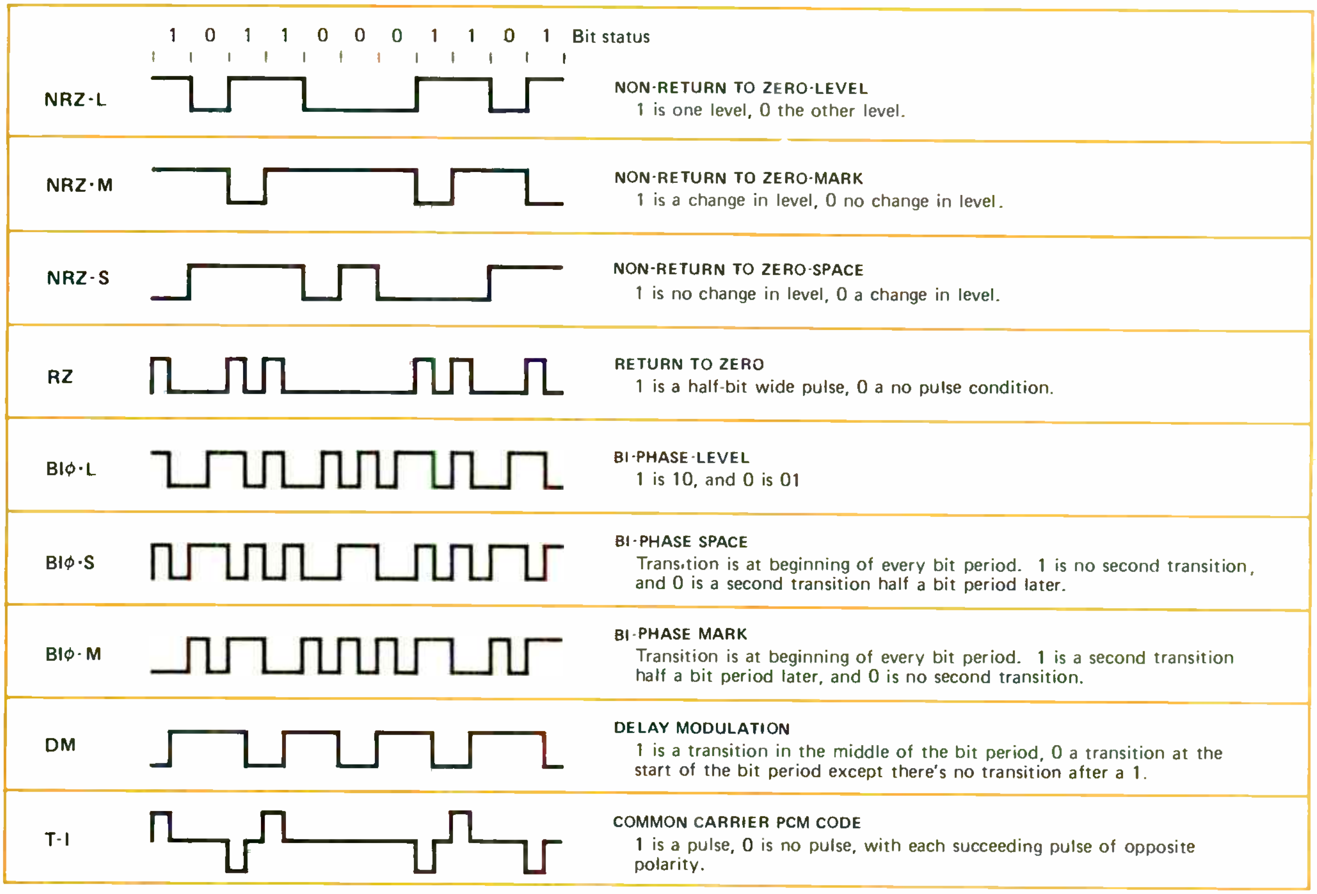
To make bit-for-bit comparisons, the input data must be synchronized with the reference pattern generator. There are several ways of doing this, depending on the type of pattern generator used, length of code, and number of bits. The most obvious method is to observe the incoming data, recognize a particular part of the pattern, and simultaneously preset the reference generator to that state. A faster method is to preset the reference pattern generator to the state of the incoming data.

To synchronize input data with the reference pattern at high bit rates, the clock to the reference generator can be deleted once each pattern cycle as long as the pattern comparator exhibits a high error rate. Eventually, the two patterns will fall into synchronization, and no more clock pulses will be deleted. The problem here is time. It takes an n-bit code approximately $m2^n/2$ bits to acquire sync, where m is the number of bits used to determine an out-of-sync condition. When using a shift register generator, the method of synchronization is simple and efficient, as Fig. 5(b) shows. The state of a pattern generated by a maximum-length n-bit shift register counter is determined by n bits of the code. To acquire sync, at least n bits of incoming data will be gated into the reference shift register. After the register is filled, the feedback loop is reconnected, and incoming data is applied to the comparator. All bits used for synchronization must be error-free. If not, the shift register will be faked into a different part of the pattern. For this reason, if the error rate is very high, several attempts at synchronization may be required.

Because of errors and jitter, the reference code generator may jump out of synchronization with the input data. If this happens, it is convenient to have a circuit to detect the out-of-sync patterns and automatically resynchronize them. Loss of sync is evidenced by a 50% error rate. Consequently, the obvious way to uncover out-of-sync conditions is to detect error rates of 50% over a given interval.

However, the random errors can approximate loss of sync, and, as the error rate increases, there is a greater probability of mistakenly attributing an error burst to loss of sync.

By observing the error rate over fairly long periods,

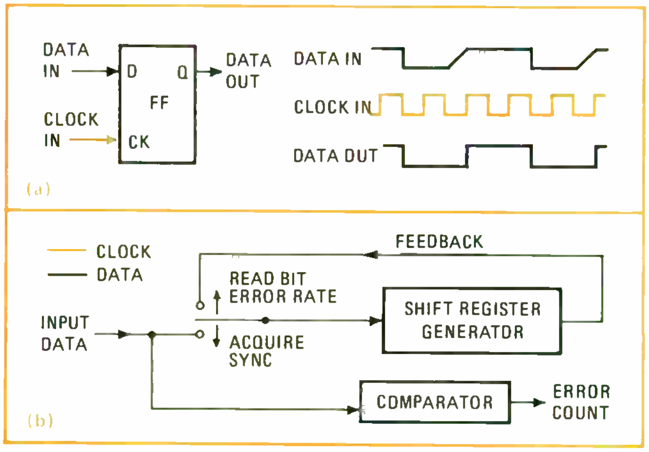


4. Codes. The top seven codes are aerospace standard. DM is for high-density tape recording; T-1 for telephone PCM systems.

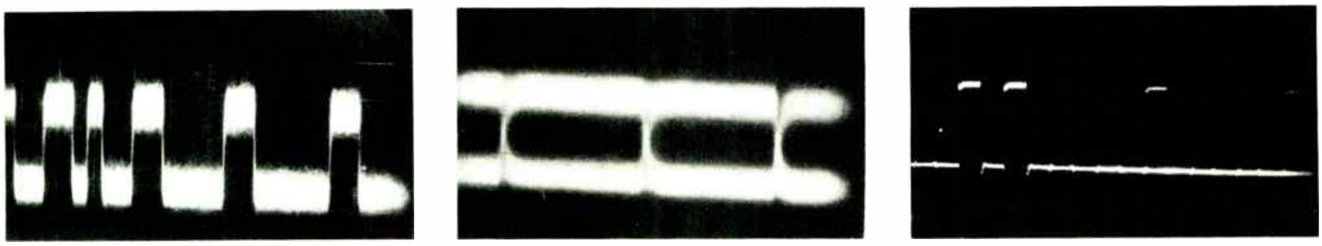
the chances of such misinterpretation are reduced, except that if the patterns are in fact out of sync, a large number of errors are incurred while the decision is being made, and this results in a distorted bit error reading. The problem boils down to a tradeoff between accuracy in determining out-of-sync conditions and the number of bits required to do this job. A practical solution is to have a monitor of resynchronization pulses, so that the operator can interpret bit error rate measurements according to the incidence of resync pulses.

When bursts of errors cause a false resynchronization pulse and the error rate is high, the attempt to resynchronize usually fails. The net result is that the automatic resync circuits, instead of keeping the reference pattern in sync, are knocking it out of sync, and causing an abnormally high error-rate reading. One solution to this problem is a switch that disables the automatic resync whenever error rate reaches a certain threshold. But if this is done, a manual resync switch must be included in the design, to allow the operator to resynchronize whenever the 50% error rate indicates an out-of-synchronization condition.

To see how all these elements combine to form a practical bit error tester, take the example of the DCS Model 4660 Bit Error Rate Counter. This unit was developed for aerospace and wideband synchronous data communications. It uses a 2,047-bit pseudo-random noise code at data rates up to 10 Mb/s. A sync pulse is provided for both the source pattern and the reference pattern, and is used to synchronize an oscilloscope with the source pattern. To modify the source and reference pattern, a control is included that provides a period of no transitions in the code called "blanking." This blanking control forces the pattern output to the zero state for the first 32, 64, 128, or 256 bits after the sync pulse in each pattern cycle. Basically, this provides an extremely low-frequency component in the pattern to test the "coasting" ability of bit synchronizers. Because the control is separate for source pattern and reference pattern, it can also be used to introduce errors at a known rate; that is, by selecting "0" blanking in the source pattern and "32" blanking in the reference pattern, the source



5. Synchronizing methods. If the clock code format is in NRZ-L form, the optimum transition occurs in the middle of the bit period (a). To synchronize input data with the reference pattern, the shift register generator must be filled with return data (b).



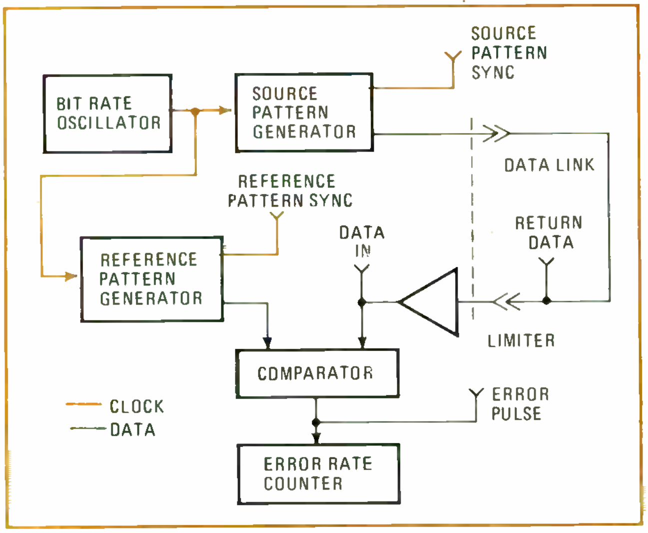
6. Typical BERD scope displays. Returned data is summed with noise (a). The same data is synced to the data transitions showing the "eye" pattern (b). With source synced to reference pattern, defined traces are characteristic errors, faint ones are random errors (c).

pattern will have, for instance, 23 logical 1s that the reference pattern isn't expecting. This provides a calibrated error rate of 23/2047, or $115/10^4$ on the three digit display.

To test a two-way data loop, the bit error rate counter is connected to the data source and sink. A source code clock synchronizes the returning data. (If the counter were used to test a radio transponder link or one with severe data degradation or frequency shift, a bit synchronizer at the data sink would have been necessary.)

After the switches have been adjusted for the proper code format and data inversion, the bit error rate counter acquires sync either automatically or manually, and bit error rate is shown as a digital display. If it indicates an excessively high error rate or an out-of-sync condition, the return data is examined to determine that it really exists and isn't a random result, and that it meets the minimum operating criteria for the 4660 input limiter or for the bit synchronize input, if used.

The first step in characterizing system performance is to observe the input data on an oscilloscope synchronized to the data transistions and study the "eye" pattern. Some of these are shown in Fig. 6. By superimposing many data transitions, the full range of effects of jitter and noise can be seen at a glance. The measure of data ambiguity is related to the amount the "eye" of Fig. 6(b) is closed. This indicates the difficulty encountered by the input limiter in making the logical 1/0 decision. If the scope external sync is connected to the source pattern sync on the link counter, the pattern can be seen bit for bit. With a delay sweep scope it is possible to examine the entire 2,047-bit pattern.



7. Testing the tester. Test points in the Model 4660 bit error rate calculator permit testing not only the quality of the transmission link but the accuracy of the test device itself.

The next step is to examine the errors. These appear as pulses each time a disagreement occurs between the two patterns. By observing error pulses and data simultaneously on a dual beam oscilloscope, with source pattern sync connected to the scope external sync, it is possible to determine the errors characteristic of the transmission system. Random errors are caused by noise and appear on the scope display as scattered pulses. Characteristic errors are those that occur consistently at a particular part of the pattern. Both random and characteristic errors are shown in the scope trace in Fig. 6(c). Errors that occur after a period of no transitions indicate poor low-frequency response, while those that occur only during a peak transition—101010—indicate poor high-frequency response.

Another method of ferreting out the cause of errors is to synchronize the scope to the error output; this means the first bit on the scope is always the erroneous one. If the errors are predominantly 1s they may indicate induced spikes, if predominantly 0s they indicate signal dropouts. The scope trace may be used to synchronize the errors with other equipment, as well. For example, if errors were being introduced by a nearby printer, the print command pulse could be synchronized on the scope trace by the error pulse from the link counter.

Another characteristic which can be measured using this configuration is transmission delay. This is done by making source pattern sync serve as the oscilloscope external sync and observing the reference pattern sync on the oscilloscope display. A calibrated sweep shows the delay as the interval between the start of the sweep (source sync) and the occurrence of the pulse (reference sync). For accurate measurement, it's necessary to subtract from this the delay occurring in the bit error rate counter by connecting the pattern output directly to the bit synchronizer input. If the total delay is greater than 2,047 bits, it is also necessary to estimate overall delay and add an integral number of 2,047-bit delays to the final figure.

In bit error rate testing, it is important to remember that this is basically a digital distortion measurement. Just as the phase error in a distortion meter is nulled out to take a reading, errors introduced by the test equipment must be removed. To make these measurements, test points on the bit error rate detector itself are usually provided. Test points for the model 4660 are shown in Fig. 7. Ideally, the test fixture should simulate exactly the equipment receiving the data. Since the information is digital, this is usually not a question of impedance and levels but rather of timing and inversion. □

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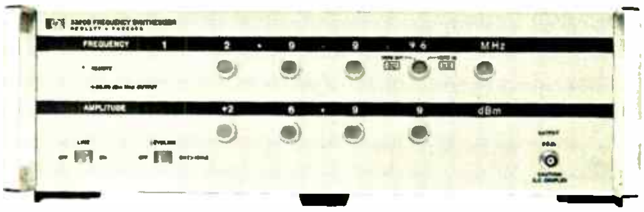

091/18

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Solving interconnection problems in big multilayer pc boards

The task was formidable: interconnecting 23,000 plated-through holes in a 3-ft, nine-layer phased-array antenna board; the solution: numerically controlled drilling and a plastic-encased preform solder system

by Philip O. Benham, *Raytheon Co., Bedford, Mass.*

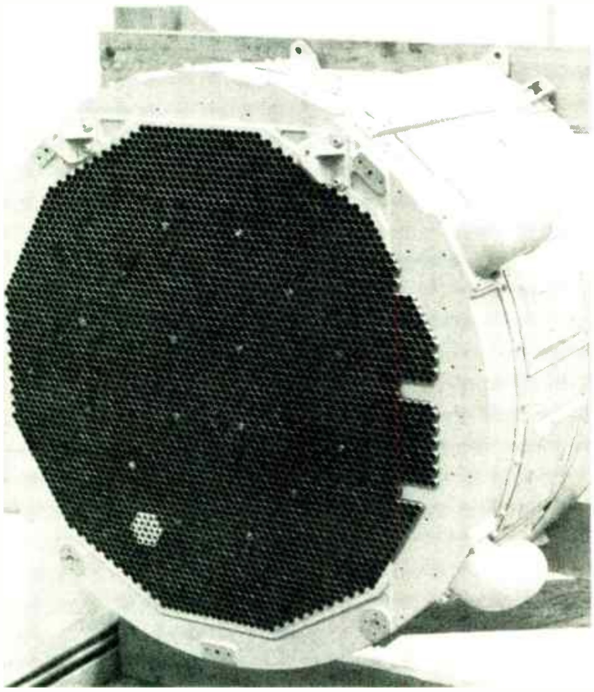
☐ As systems grow larger and more complex, formerly routine considerations such as interconnections for printed circuit boards are becoming increasingly important and potentially troublesome for designers. A very large multilayer board presents soldering, drilling, and interconnection problems that become a critical part of the overall design. These problems came to a head in a multilayer board designed for use in a phased-array antenna system, and their solution provides a model for other high-density pc board applications.

The antenna, developed under an Air Force contract, required a nine-layer pc board about 3 feet in diameter with about 23,000 plated-through holes, each of which required a soldered contact for a receptacle that holds a phase shifter.

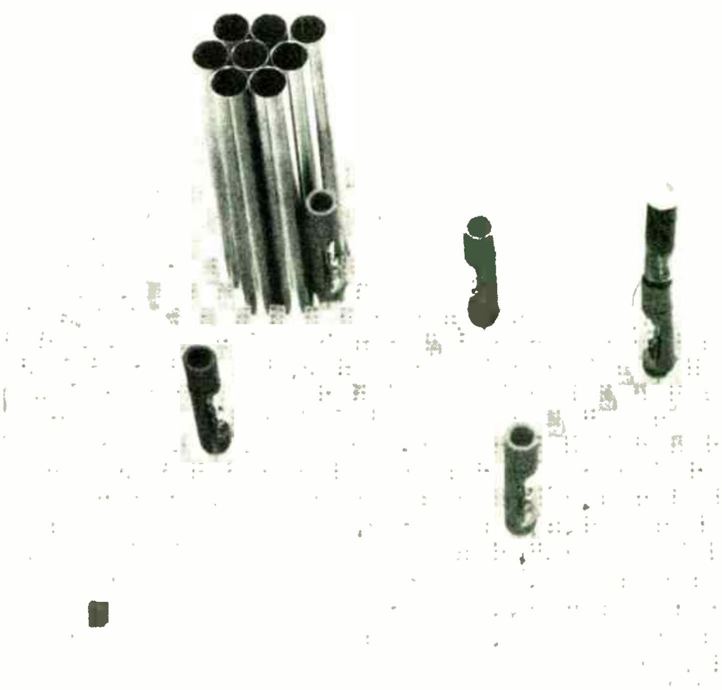
The antenna, a space-fed reflective array of ferrite phase shifters, is illuminated with rf energy by a single four-square horn (a cluster of four horns that defines the four quadrants). The reflector is an array of 3,850 high-permeability Hipernom metal tubes welded together (Fig. 1); each tube is fitted around a ferrite phase shifter (Fig. 2). Each phase shifter plugs into a six-pin connector mounted on the 34-inch-diameter multilayer circuit board, which carries the logic and control currents (Fig. 3).

Before deciding on a single, large multilayer board, a set of smaller boards was considered. But the problems of interconnecting the smaller boards with wires having controlled capacitance and inductance were too formidable; hence the single-board approach. However, the single-board method presented four challenges: generating accurate artwork; finding a laminating press large enough to handle the 34-in. board; assuring good laminating over the entire board; and accurately drilling the 23,000 holes.

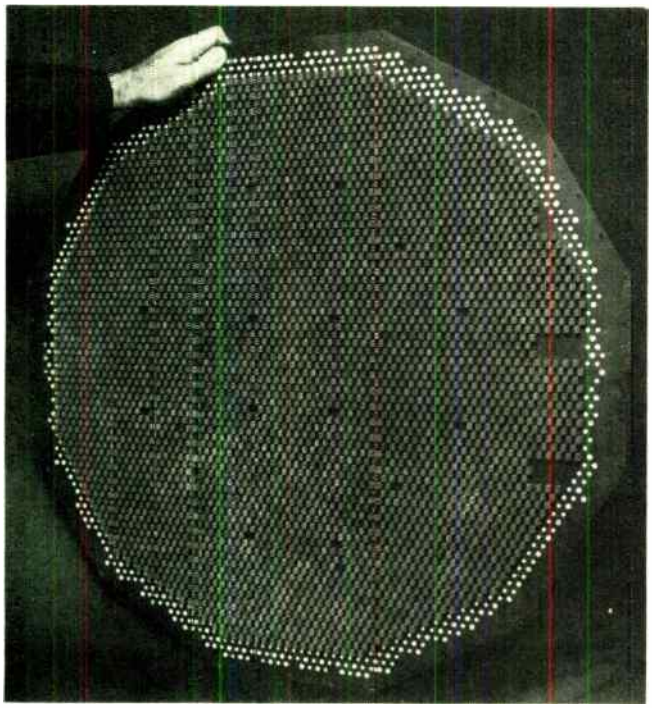
A board fabricator was found whose presses were large enough and whose laminating techniques were adequate to assure quality work, but the artwork and



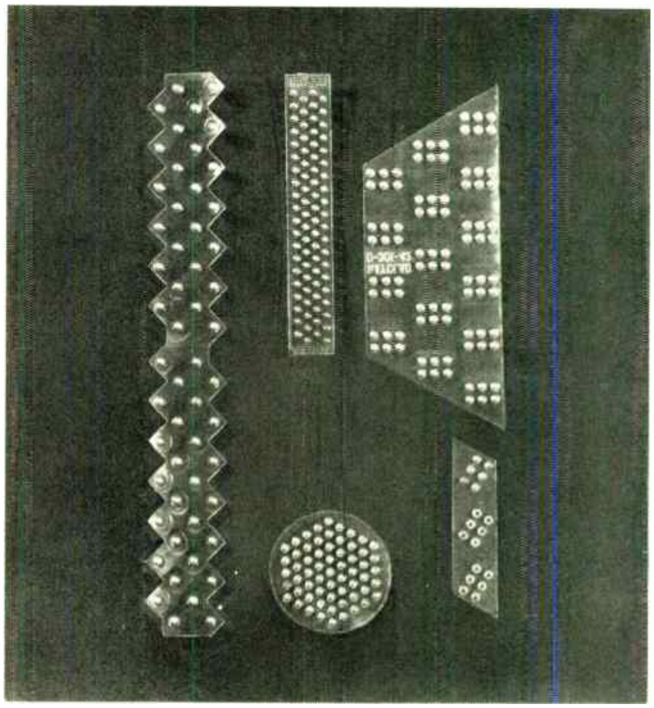
1. Down the tubes. Array of high-permeability Hipernom tubes fits over phase-shifter array in space-fed system.



2. Inside look. Mockup shows how Hipernom tubes enclose ferrite phase shifters with their coils and drive networks.



3. Big board. This nine-layer printed circuit board holds 3,850 receptacles for the plug-in phase shifters.



4. Dimple-strip. Sections of Dimple-strip show solder performs—solid for flush pins and with holes for through-pins.

drilling were more difficult. To attain the needed accuracy in the artwork, it was necessary to apply a technique commonly used in integrated circuit mask-making. And accurate drilling of the holes in the boards required the use of a numerically controlled drilling machine.

With such a large board, it's not practical to generate oversize artwork and then reduce it with a camera, as is common practice with smaller boards: accurate 1-to-1 artwork must be produced. But since the pattern is composed mainly of six-dot groupings corresponding to the receptacle terminals, a master six-dot pattern was produced at 10-to-1 scale (a larger scale, say 100 to 1, would not have been justified for the accuracy needed). Then it was reduced and reproduced with a step-and-repeat process to form the artwork master for the complete board.

When the antenna is finally assembled, each of the Hipernom tubes must line up accurately with its own ferrite phase shifter. To assure alignment, the tubular array was made first and measurements were taken directly off the array and transformed into coordinate information for a numerically controlled drilling machine. Each multilayer board is thus drilled to match one particular array of Hipernom tubes, and a separate drill tape is made for each board.

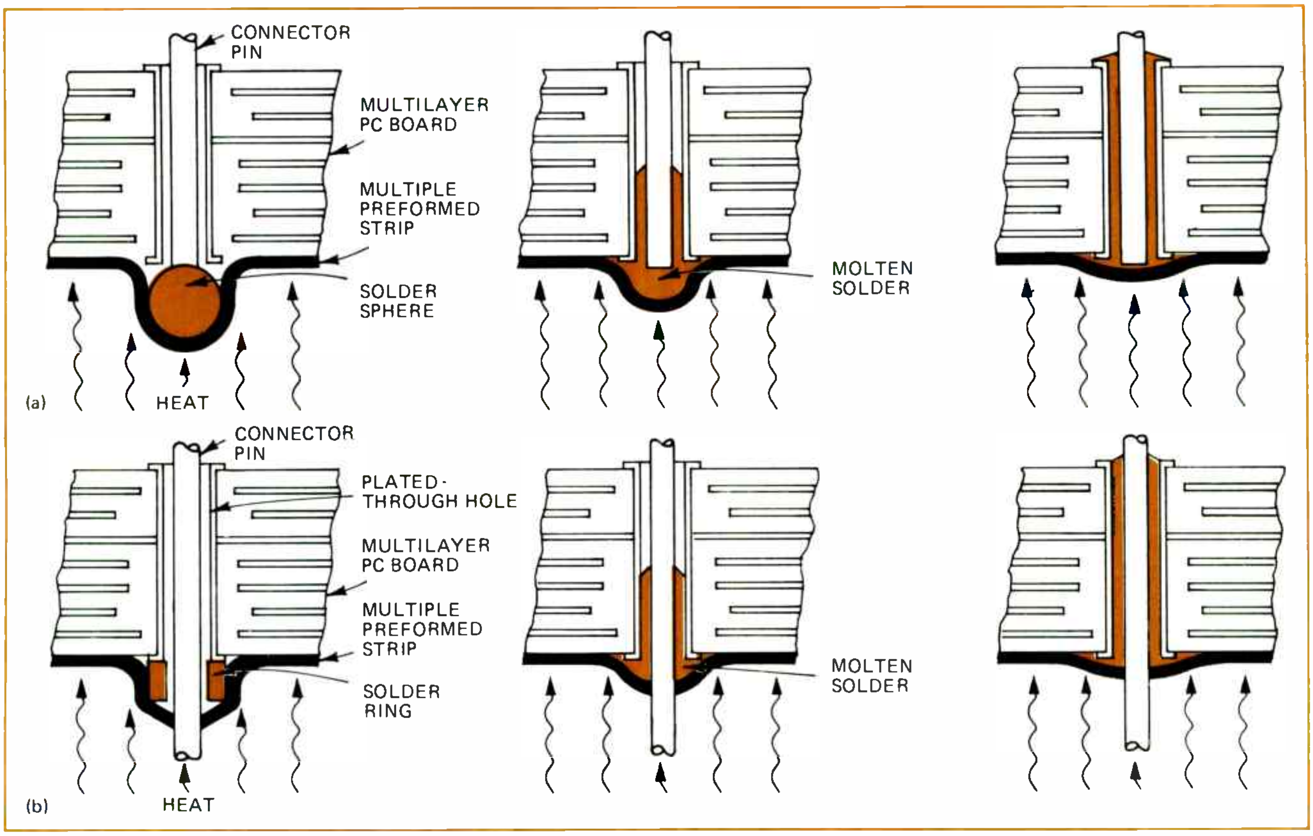
Once the board is made and drilled, the receptacle contacts must be attached. Hand soldering is insufficiently reliable as well as time-consuming and costly. Flow-soldering methods also are not practical because of the great size of the board—large copper areas would cause uneven heat distribution, leading to warpage.

The choice fell to a system based on prepackaged, measured amounts of solder in irradiated heat-shrinkable plastic. The plastic recovers from its initial shape to a flat sheet when heated above a predetermined temperature. It's a specially compounded polymer composed of long, chain-like molecules. To achieve its heat-shrinkable properties, the polymer is bombarded with ionizing radiation from a high-energy electron beam to form cross links between the molecules. This molecular change creates a new material that no longer melts and flows at the low temperature it would have prior to cross linking. The new melting point is higher than the temperatures needed to melt the preform's solder.

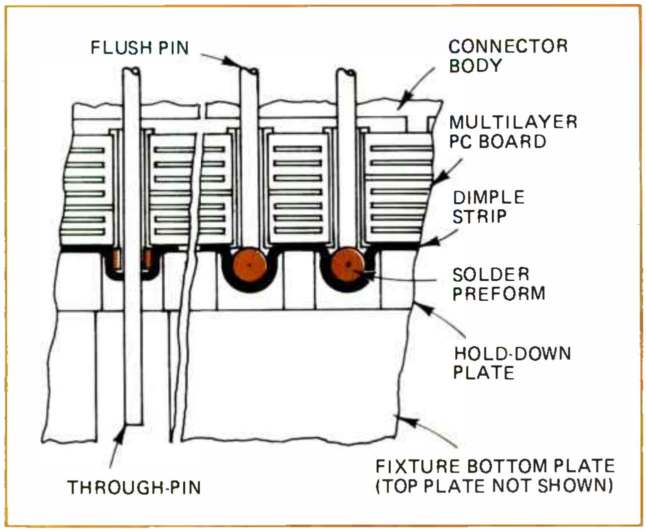
The cross-linked polymer can be expanded, molded, or shaped when heated above its melting point before irradiation. If the irradiated material with its cross-linked molecules is cooled while being held in a particular shape, it will retain that shape until it's heated above the original pre-irradiation melting point again. The material then returns to the shape it held prior to cross-linking. Thus, it has an "elastic memory," and it is this action that forces the molten solder into the plated-through holes.

A commercial version of the soldering preform, called Dimple-strip (made by Raychem Corp., Menlo Park, Calif.), was redesigned to make the size and spacing of the solder preforms fit this job. Most connector pins are essentially flush with one side of the board, as shown in Fig. 5(a), and thus require only a solid solder preform. However, some pins also pass through the board and extend outward to connect to flat cable. To handle these pins, a solder ring and a plastic dimple with a perforation was developed so that the pin could pass through but still make an effective seal to the plastic, thus preventing solder from escaping.

To form the Dimple-strip, cavities or dimples are shaped while the material is heated above its original melting point, then solder forms are inserted in the dimples. The solder used is 50-50 indium/tin with a melting



5. Shrink and press. Three stages (a) of heating for flush-pin connections show original solder sphere in its dimple, molten solder moving up plated-through hole as dimple shrinks, and final state, with solder fillet on both top and bottom. Similar action occurs for the through-pin connection, except that a solder ring and a punctured dimple are used. Normal elasticity of the material creates a seal around pin.



6. Seal it. The Dimple-strip is sealed to the multilayer printed circuit board to prevent solder leakage, with pc board hold-down plate, base plate bolted together.

point of 117°C or 242°F, chosen so that the board will not be exposed to high temperatures during formation of the solder contacts.

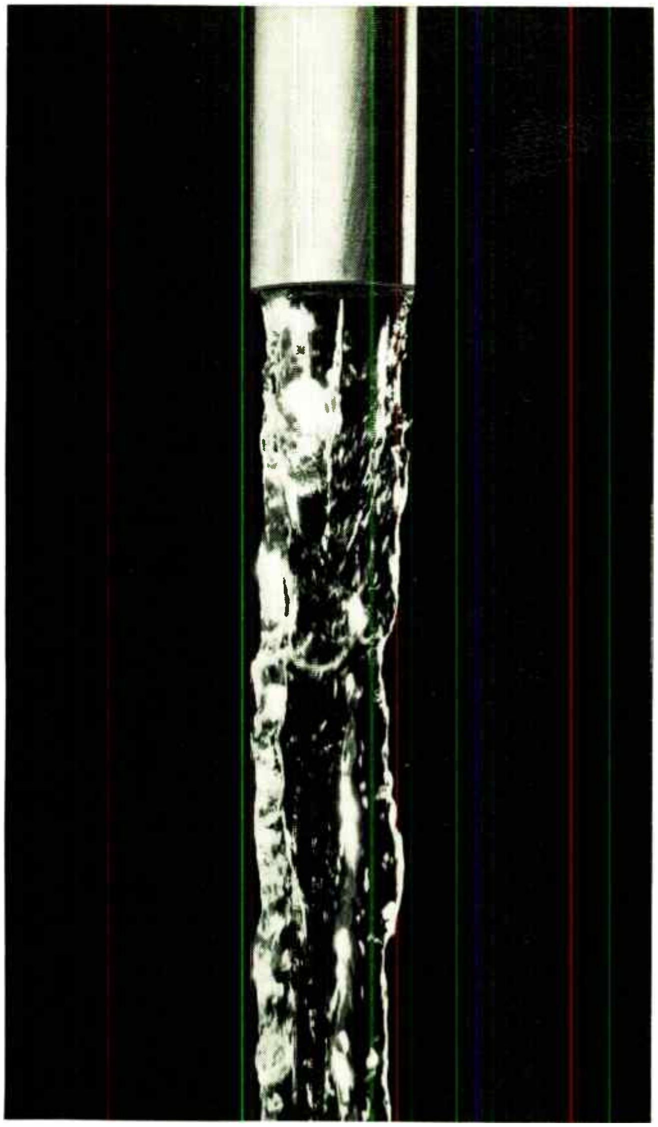
The key to successful soldering with the Dimple-strips is to get a good seal between the plastic and the board around the base of each dimple; otherwise, solder will escape during heating. A good seal can be assured by using a hold-down plate that clamps the board and plastic together (Fig. 6).

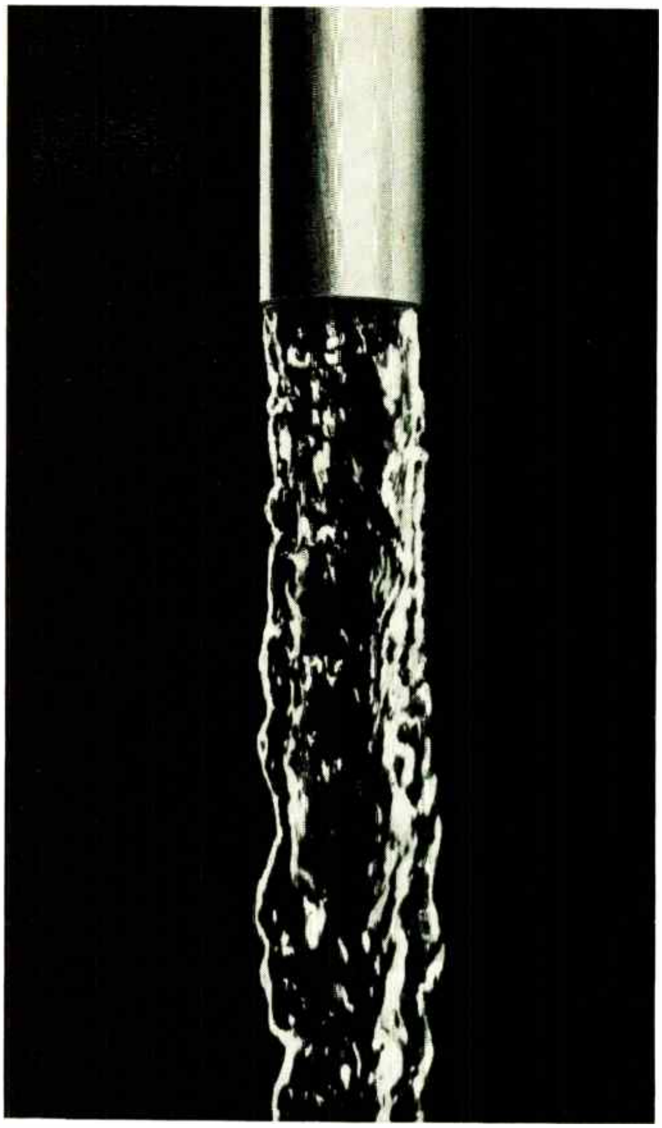
Before soldering, all pins, which have been plated with tin, are cleaned and coated, and the board is coated with liquid flux, such as the type 611 made by Alpha Metals or Kester type 1544. This assures good solder coverage of the holes. The hold-down plate then is loaded with the flush-pin Dimple-strips, omitting areas where through-pins occur. The through-pin Dimple-strips then are placed in position on the hold-down plate. The board, with flush pins inserted, is placed over the Dimple-strips on the hold-down plate. After it's registered to the circuit board with special pins, the through-pins are inserted.

The connector backup plate then is placed over the connectors and the whole assembly is bolted together. The assembly next goes to a preheated base plate, with a preheated top plate clamped in place. Preheating is needed to bring the mass of metal in the clamping plates to near the soldering temperature before the assembly goes in the oven; without preheating, the solder might melt in the oven before the copper of the plated through holes is at the proper temperature, resulting in poor solder joints.

The assembly stays in the 300° oven for 5 minutes under a vacuum of 25 inches of mercury. Thus, more than 23,000 connections are made in just a few minutes without temperature variations that might cause warpage in wave-soldering.

After removal from the oven, the board is inspected, and a small soldering iron is used to reflow solder around unsound joints. Yields generally have ranged near 97%, with the remaining 3% easily touched up. □





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TI sees computers in its future

Though avoiding confrontation with IBM, Dallas firm seeks 'significant' share of market for big scientific machines, minis, and process control

by Paul Franson, Dallas bureau manager

While RCA Corp. is folding its computer operations, Texas Instruments Inc. is slowly unfolding its plans for expanded activity in that very area. However, the Dallas-based organization, unlike RCA, will avoid competing with IBM and will concentrate on minicomputers, process control systems, and giant scientific machines, typified by its Advanced Scientific Computer (ASC). TI won't release any details on its ASC or say what its specific plans are; when asked what part of the market they expect to corner, company officials smile and reply, "a significant share."

The answers to questions like "how much", "how big", and "how soon?" are still locked up in TI's executive row. But there's no question that TI wants to significantly expand its computer sales. Right now, the company is selling minicomputer systems, manufacturing almost in secret two ASCs, and diversifying its line of peripherals.

TI firmly denies it is getting into computers because mainframe makers are manufacturing more and more of their own semiconductors. Although IBM contributed greatly to TI's early semiconductor growth, and has always been TI's major customer, the machines from Poughkeepsie, N.Y., are using more and more in-house ICs. And TI accordingly has reduced its dependence on sales to IBM. But other computer makers are not expected to follow IBM's example in developing in-house components, according to Grant A. Dove, TI's vice president, corporate development. "In fact," he says, "some computer makers seem to be getting out of semiconductor production."

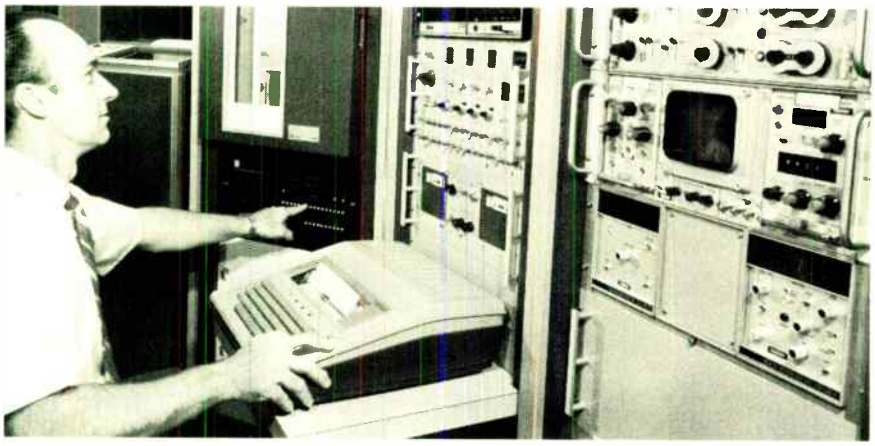
Overall growth is providing the impetus for TI's push into computers. Last year's sales were $826 million, and by 1980, the company says it will nearly quadruple that figure to $3 billion. That kind of growth probably cannot come from semiconductors, airborne radar, oil exploration, and the numerous smaller business areas that TI is active in. The company is highly integrated vertically, producing and selling materials and equipment, and coordinating these activities from a sophisticated technological and management base.

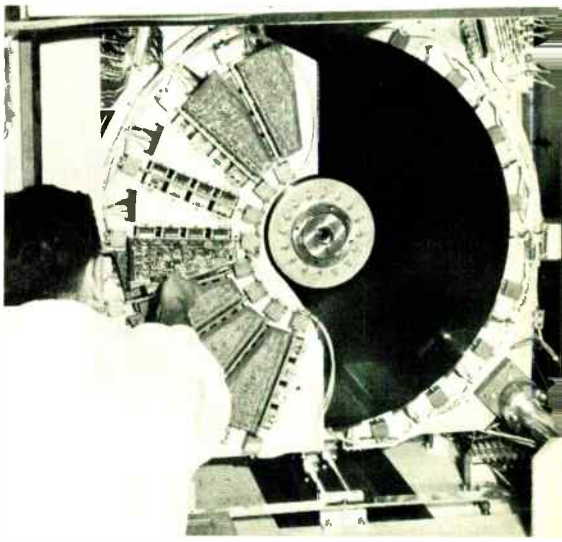
A. Ray McCord, group vice president, equipment, says, "Our major goal is solving the customer's problem. If that requires a computer, we'd like to sell a TI computer. But we want to keep the problem-solving vector far in front of the black-box vector. We have only so many resources and feel we can get the best return this way."

TI has plenty of experience in automating its own crystal-growing, transistor, and IC production and testing. And recently, the firm has been increasing its emphasis on outside marketing of computers and customer service, according to McCord. Sales offices will be increased from 19 to 57 by the end of next year, he says.

It was the oil exploration end of

More coming. TI's Silent terminal (below) checks solid state radar. Multiple-head disk (right) is one of four units used in TI's ASC.





the business that led to TI's entry into computer development and manufacture. As early as 1958, Geophysical Services Inc., TI's subsidiary, developed the TIAC 827 for handling the immense quantities of seismic data involved in locating oil deposits. Several machines were purchased by major oil companies. And in 1967, GSI introduced the 870A, which is still being built and sold for seismic work. But the big machine for seismology will be TI's ASC.

TI once considered bidding on another giant computer—the University of Illinois' Illiac 4—but didn't because it looked like a money-loser, according to insiders. Burroughs Corp. got the contract. Now, with TI trying to get into the big computer market, James Marley, marketing manager at Burroughs, says TI won't be a serious competitor for some time because even with its technical capability, the Texas firm doesn't have Burroughs' experience in software and maintenance.

Meanwhile, TI's competition in maxi and minicomputers is maintaining a wait-and-see attitude. "We don't know enough about TI's Advanced Scientific Computer to know whether or not we should be worried," says James Thornton, vice president of Control Data Corp., Minneapolis, Minn. Thornton doesn't expect to learn much about the ASC until either TI gets a contract and has to reveal its designs or the company changes its traditional tight-lipped policy.

At the Foxboro Co., Foxboro, Mass., Bruce H. Baldridge, manager of corporate marketing and product planning, recalls discussions with TI about a year and a half ago regarding a possible OEM agreement for a TI process-control computer: "At that time," says Baldridge, "they had no software, no marketing group to sell to end users, no systems engineering, no systems analysis. We looked upon them as a possible computer supplier." But TI has now established application engineering and software groups, and has beefed up its marketing.

If TI starts selling process control systems to customers who will do the systems application, analysis, and other work, says Baldridge, "we wouldn't likely shrug them off." But if TI decides to stay in the semiconductor process control area, Baldridge says, "we may not bump into them at all. Process control is a big field."

While TI's ASC grew out of the requirements of its geophysical operations, the TI minicomputers were motivated by factory automation and, to some degree, military activity. One of TI's early minis was the 856/7, developed to replace an SDS 910 that, in turn, replaced paper tape in programing the TI continuous automatic test (CAT) system for transistors. These 5-microsecond, 24-bit computers were patterned after the 910, and a smaller, more practical version, the 853, was used for the CAT and other test systems.

A recent venture was a joint development by TI and Applied Kinetics Inc., a subsidiary of Alloy Metal Products, Inc., of Davenport, Iowa, of an advanced process-control computer system for melting applications in the metals industry. The AKI series 70 system includes a TI 980 minicomputer; the system is installed by AKI and serviced by TI.

Peripherals. In peripheral equipment, TI's Silent terminal uses a thermal printhead and is made in portable versions, and as replacements for the IBM 1050 and 2741 terminals and teleprinters. The company's line of tape transports includes plug-in replacements for the IBM 360 series 2400 (TI has a $1.8 million contract from the General Services Administration) for relatively low-cost OEM transports and transports and controllers for the IBM System 370. TI's focus is ruggedness, mechanical simplicity, and electronic sophistication.

McCord says TI needs a broad line in peripherals, and is working to develop more equipment. Moreover, though TI hasn't announced any definite intentions, it's hinting strongly that some of the work on the big scientific computer could lead to sales of the high-speed disk recorder for the ASC. □

TI's super computer

The Advanced Scientific Computer may sound impressive, but it's still a mystery to most experts in the computer community. TI began work on what was to be a more powerful computer than anything else available in 1966. Today, the company says that one ASC is in final stages of hardware and software checkout in Austin, Texas, and another is being built for TI's computer center near Amsterdam, the Netherlands. Possible ASC applications, in addition to processing of seismic data and design automation at TI, include weather forecasting, atomic energy research, air traffic control, and antiballistic missile analysis.

The ASC's main memory is built with hybrid MOS circuits made by TI in its Houston facility. It will be the first really large computer to be built with an MOS memory, or for that matter with any semiconductor memory—the largest to date has been IBM's System 370 model 145, which uses bipolar circuits. No official information is available on size or speed of the ASC's main memory; but it probably uses TI's 2,048-bit MOS arrays, which cycle in 150 nanoseconds, and contains an estimated 2.5 million bits. The ASC also contains an associative memory made of TI's high-speed emitter-coupled logic. This array probably is used with the main memory as a speed-enhancing buffer.

Backing up the associative array and the main memory are four-multiple-head disk units with a total capacity of 3.2 billion bits—each equal in capacity to the largest commercially available disks—IBM's 3330 and similar competitive gear. These, however, use removable disk packs, whereas TI's disks are fixed, and have faster access time through their multiple heads.

The ASC is a pipeline machine (the output of one of a large number of processors is the input of another). As a one-pipe machine, the ASC isn't as powerful as the Star-100, according to an outside expert; but in four-pipe form it is said to be equal or better than CDC's big machine.

An important difference between the two computers is memory organization. In the Star-100 one memory access brings out eight 64-bit words in 1.25 microseconds and once the first word is out, the following words come faster. Random access to any word in the ASC high-speed semiconductor arrays is something like 150 nanoseconds. The pricetag for an ASC: about $10 million.

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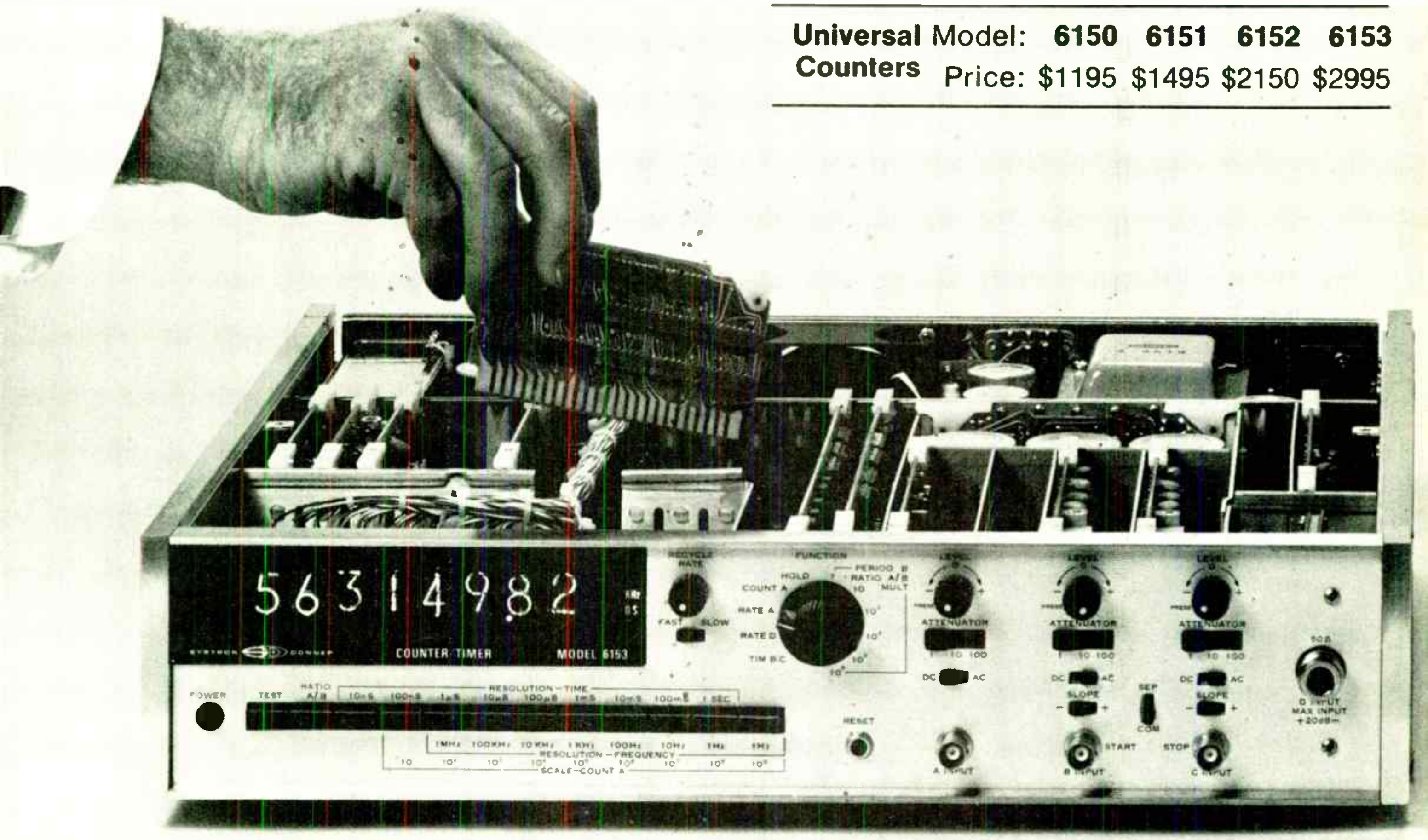

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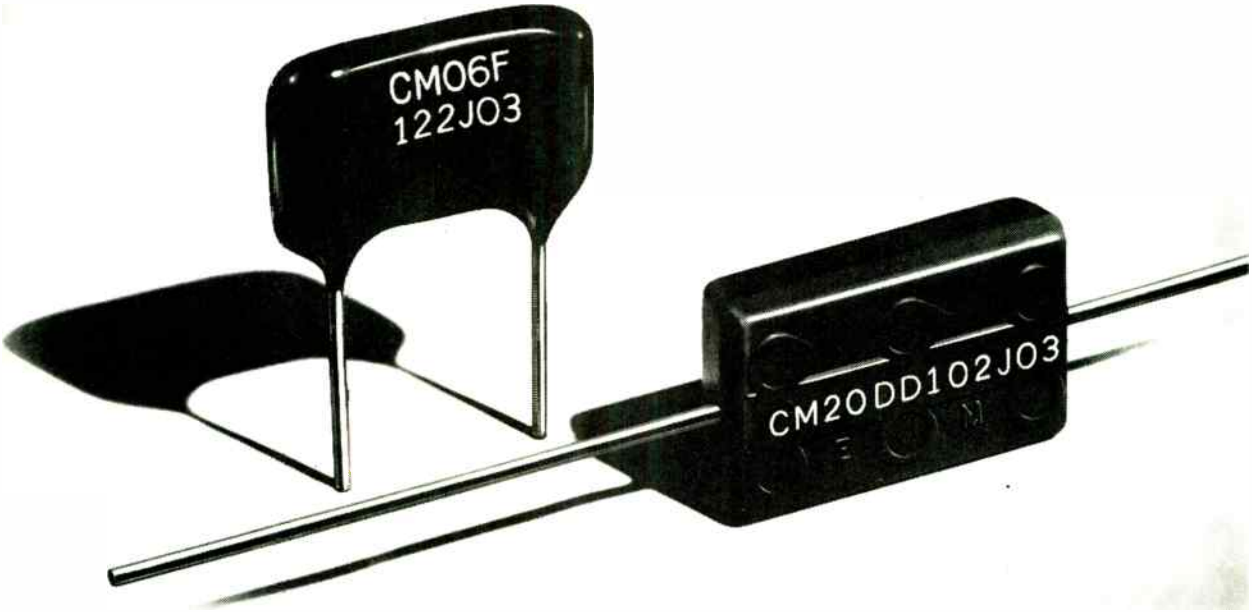

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Linear IC market in ferment

Reshuffle caused by recession and saturation of op amp sector pushes designers into consumer, computer interface, other special-purpose ICs

by Lawrence Curran, Los Angeles bureau manager

There's a shakeup going on in linear integrated circuits. The day of the dominance of the general-purpose operational amplifier is fading and semiconductor companies in the linear business are concentrating on the more-specialized devices.

The shakeup has been triggered by a number of factors that have combined to slow the brisk new product introduction pace of the years from 1967 through mid-1970. They include an apparent near-saturation of the op amp market, a recession that redistributed linear designers and process engineers, and a recognition that the growth markets are now in consumer and computer-interface circuits.

The action has already started. There's a big surge in demand for consumer circuits—mainly devices that go into sockets in television and stereo sets—and the market for computer-interface ICs is blossoming.

Not that linear suppliers are abandoning op amps. The LM 118 introduced in August by National Semiconductor Corp. has most people, including at least one competitor, convinced it's the newest industry standard. More than one firm will become alternate sources for the unit, including Motorola's Semiconductor Products division. National calls the LM 118 an easy-to-use device with a very high slew rate—the minimum rate is 50 volts per microsecond with zero offset—and the unit is internally compensated. High-slew-rate op amps have typically required external components for compensation.

Few, if any, other truly new op amps are being introduced in the industry, as suppliers think the op amp market is saturated. So linear IC houses are going through a transition period as the emphasis shifts to consumer circuits and a variety of interface devices for the industrial market, such as line drivers and receivers, sense amplifiers, digital-to-analog and analog-to-digital converters, and comparator circuits for level sensing. There's also some effort to develop new voltage regulators and custom circuits for the automotive market.

But the transition hasn't been smooth so far, and it doesn't look like it will settle down for awhile. Most linear suppliers were caught with big inventories in mid-1970 when the recession began to hit hard. This led to price cutting, which is still going on, even though business is picking up at most firms. Just how hard this price cutting has hit makers is reflected by first-half linear sales. Units were up to 26.5 million compared with 24 million in the first half of 1970, but dollar sales dropped from \$44.6 million in 1970 to \$40.3 million this year. This dropped the average selling price for a linear IC from \$1.86 to \$1.52.

The price cutting is evidence of the linear market's "immaturity," says Steve Thompson, linear IC marketing manager at Motorola, who says the pricing trends have become "almost irrational" at some companies. If it continues he says, it will lead to the cutthroat pricing that hit bipolar TTL circuits. But he doesn't think the downward trend can continue for too long: "enough people are aware of the situation so that economic conditions may not force the same degree of price cutting that happened when inventories were high." Thompson looks for 1971 linear IC sales to be in the area of \$86 million, up \$6 million over last year. For 1972, he sees sales hitting \$98 million.

Slowing new products. Playing a big role in the linear business shakeup are key personnel shifts among the companies. As the recession set in, many companies were forced to let some of their linear designers go. Other key linear people left voluntarily to accept better job offers. As a result, new linear products have been slow in coming on the market. For example, late last year Fairchild Semiconductor officials were hoping to introduce some 40 new linears in 1971. It now looks like only about a third of these circuits will reach the market by year end. The reason is personnel cutbacks and "some premature announcements," says Anthony Livingston, Fairchild's product marketing manager for linear ICs.

No more super op amps? Nearly all linear IC makers feel the evolution of the general-purpose op amp has reached the end of the string. "No more super op amps are coming," says Fairchild's Livingston, "although you'll see specials like the 776 programable op amp." The industry has been through four generations of op amps now, "and it's difficult to design the fifth-generation device, though the LM 118 looks like it could be it," says Thompson.

Agreeing with Thompson on the op amp's future is Robert Dobkin, National's director of advanced circuit development. Linears grew initially because of the popularity of the Fairchild μA709, but he says that they may have reached a practical limit with the LM 118 in terms of ease of use and wide application. "I don't see much in the way of innovation in op amps," he observes, "but I do see new device types—circuits that people don't normally think of as being linears. National is working on a new type of voltage regulator and a high-speed comparator circuit and expects to introduce 40 linears in 1972.

While Sprague Electric Co. isn't talking about op amps as a growth business either, it is moving strongly into linear ICs. The company is beefing up its consumer-oriented linear IC design and development efforts with the emphasis on TV and automotive circuits. It expects to double the number of designers for these circuits to about 20 by the end of the year. "We're so enthused about projections in these fields that we are more or less downplaying digital circuit development to concentrate more fully on the linears," a Sprague official notes.

Texas Instruments, which hasn't been recognized as a strong factor in the linear market, is coming on strong now, particularly in consumer parts and computer-interface circuits. And even though Lawrence J. Housey, product manager for linear circuits in Dallas, says the industry can still expect evolutionary improvements in op amps he concedes that "the tradeoffs are getting harder to make."

Signetics Corp. is about the only major semiconductor manufacturer hinting at big new things in the op amp arena. Alan Gregory, director of linear products, says that while the company initially "chased the market" with its versions of Fairchild and National op amps, "We will not have any new op amps that employ present technology for the time being. To make a significant improvement in op amps will require a technological breakthrough—and we're working on it."

Signetics appears to have a leg up on its linear competitors with its phase-locked loop devices. These give the company an edge in linear circuits for the communications and computer peripheral market because they're being designed into modems, printers, and receivers. National Semiconductor has already become a second source for the phase-locked loop units, with Fairchild and Advanced Micro Devices to follow soon.

Consumer: the action. The potentially lucrative high-volume consumer circuit business is the market that has the linear houses really turning on. Motorola's Thompson says the consumer portion of the market grew by 120% in dollar sales from 1970 to 1971 and the same kind of growth is predicted for 1972 over 1971. Reducing it to dollars, National's Dobkin pegs the consumer linear market, excluding automotive parts, at $10 million this year, doubling to $20 million in 1972.

National has established a new group to concentrate on consumer circuits, from which products should be flowing within the next few months, Dobkin says. Fairchild's Livingston says his company has developed or is developing a color processing IC for television sets, a circuit that contains the complete audio section of a television set including the 5-watt output amplifier, and a general-purpose monolithic circuit that can control all the timing functions in an appliance such as a washer or dryer. And Motorola is moving into volume production with a phase-locked loop stereo demultiplexer that's scheduled for formal introduction in November.

Most of the major linear suppliers are casting a wary eye toward Dallas as TI readies its consumer product push. Motorola's Thompson characterizes TI as being "very aggressive on price, and they're second-sourcing everyone in the indus-

Problem-solving at Motorola

Rumors have been flying in the semiconductor industry that the linear IC operation at Motorola's Semiconductor Products Division is crumbling—that few new product ideas are being generated outside of the consumer product area, that Motorola lost control of its process, and that circuit designers have been given production line responsibilities to solve some of the problems. And this is the company that many objective observers have ranked as number one in linear IC sales for the past two years or more.

Steve Thompson, Motorola's linear IC marketing manager, doesn't deny there have been problems, but insists they're all under control and the division is moving again at full capacity in linears. The process difficulties were mainly attributable to Motorola's use of silicon with a 1-0-0 orientation rather than the more prevalent 1-1-1 type. This reportedly leads to linear devices with limited density, and which require channel stops on metal runs to prevent the creation of transistors where they shouldn't be. Thompson says Motorola has been "completely off" 1-0-0 silicon for about two years. "We got everything changed over by the end of 1969 and we saw no ill effects after the first part of 1970."

Op amp specialists at Burr-Brown Research Corp., Tucson, Ariz., designed the MC-1539 op amp marketed by Motorola, which was being supplied in large volumes to Burr-Brown about two years ago. When the processing problems occurred at Motorola, Burr-Brown turned to Sprague to supply the device. Motorola's Thompson says that his firm cleaned up the design and processing problems affecting the MC-1539 a year ago and has been changing over to a modified design for the last six months. "These changes put us in a delivery bind," he says. "There's no technical problem now, it's simply a capacity problem," but he concedes Motorola still isn't supplying the MC-1539 to Burr-Brown.

Thompson suggests that the recession was the principal culprit in slowing the pace of new product introduction. "Business conditions did affect us. We had cutbacks and some people were redistributed to production jobs. We didn't reduce our R&D, but we combined production engineering and R&D to shorten product introduction cycle times. Our R&D people now know the day-to-day production problems and they don't specify themselves into a corner."

He cites recent Motorola activity in sense amps, line drivers and receivers, comparator circuits for level sensing, and digital-to-analog and analog-to-digital converters as evidence that there's no dearth of product development. One major Motorola competitor isn't taking any comfort from past Motorola problems, saying that while the company may have been momentarily stopped, "they'll come back strong, especially in consumer circuits."

try in the consumer area." TI's Housey is reluctant to talk about TI's specific plans because so much of its work is custom and is being done for a limited number of customers. He will say, though, that the firm has 40 to 50 consumer linears in development.

Computer market: good. Linear IC houses are also watching growth curves in computer-interface circuitry, which are not expected to be as steep as those in the consumer product arena, but offer great potential, nevertheless. National's Dobkin says the 1971 industry figure for sense amps, line drivers, and receivers will be about $20 million, growing to about $30 million next year.

TI's Housey feels his firm is especially strong in line drivers and receivers, memory drivers, and sense amplifiers. TI is heavily involved in custom work, also, including what Housey calls "linear LSI" for multiple memory interfaces.

Fairchild recently introduced a precision comparator circuit and a high-speed comparator as the vanguard of a new series of interface circuits. Motorola has developed an ac-coupled sense amp for plated wire memories, which is described as a comparator type of amplifier that will probably bow later in October. Motorola also has a six-bit monolithic digital-to-analog converter circuit ready for the market; it will sell for about $5 in large quantities. This compares with $10–30 for the nearest monolithic six-bit unit and $70–80 for an eight-bit monolithic d-a converter on the market. Motorola also has coming an MOS clock driver aimed at doing a job done only by hybrid circuits today— driving the heavy capacitive loads of MOS devices and handling swings in voltage from −30 to +5 volts.

What it all boils down to is that high-volume, general-purpose linear IC makers are bumping into the limits of optimization and innovation. The tradeoffs are forcing them to the specialized and custom devices. How it changes the job of the circuit maker is best summed up by Signetics' Gregory: "Rather than telling a customer what we have and what he should use, we will go to bed with him and build what he wants, based on the technology we have." □

International

Electronics to impact European automobiles

Fuel injection, electronic ignition, antiskid braking will proliferate as pollution, safety issues catch on

To many car buffs, U.S. automobiles are not even in the same league as European models. Yet visitors to the Paris Auto Show this month will not find much difference between new European offerings and 1972 U.S. cars in the way of electronic accessories. Like U.S. car makers [*Electronics*, May 10, p. 105], European manufacturers are slowly adding nonentertainment electronics to their products, with the big expansion expected in three or four years.

And despite their current lead in developing car electronics, Europe may eventually lag the U.S., since the legislative outlook in Europe is not nearly as clear as in the U.S. Voluntary adoption of electronics will rest heavily on substantial price cuts, asserts a spokesman for British Leyland Motors, makers of Austin and Morris cars. He feels electronically controlled alternators and fans are good bets, but believes antiskid brakes and electronic fuel injection and ignition won't be able to compete with conventional approaches without tough laws to back them up.

In Paris, Daimler-Benz will unveil its new 35-SLC sedan with the electronically controlled fuel injector developed several years ago by Robert Bosch, GmbH. Mercedes models will include electronic windshield and headlight wiper-washer combinations. The only electronic gear on a French car will be the Citroen DS-21's Bosch fuel injector and electronic tachometer, neither new this year. The Aston Martin and Jaguar V-12, however, will have the new Joseph Lucas electronic ignition. Also not being shown are the antiskid systems developed by Daimler-Teldix, Bosch, Bendix, and Peugeot.

The legislative situation is most advanced in West Germany, making that country the leader in automotive electronic systems. By 1975, 80% to 90% of all cars in West Germany are expected to have electronic fuel injection and in the next four years the car electronics market will quadruple from its present $10 million in total sales to $40 million, according to Eckhard Zeiffer, marketing manager at Texas Instruments' Freising, Bavaria, facility.

At TI's Freising plant, circuits are being developed for electronic direction indicators, speedometers, tachometers, fuel injection, antiskid units, and voltage regulators. TI is cooperating with nearly all major car equipment suppliers in Europe, including Bosch, Smiths Ltd., and Lucas in Britain, and with Italian firms. Siemens AG, Munich, and several other German firms are working on custom-tailored ICs. Intermetall GmbH, a subsidiary of the ITT Group, has already hit the market with an integrated circuit, the SAK 110, designed for tachometers; the circuit has a maximum frequency of 10 kilohertz and comes in an eight-pin mini-DIP package.

Innovative. However, Bosch is far and away the most active automotive electronics supplier in Europe. Bosch, which recently opened a $10 million R&D facility near Stuttgart, makes an electronically controlled fuel injection system that's used on a dozen European cars, including the Volkswagen 411 and the Mercedes-Benz 280 SE. And now the

Probing the news

system is being redesigned to make all the circuitry integrated. Bosch has developed a four-wheel antiskid device, an electronically controlled transmission that shifts gears in 0.3 second, and an electronic control unit to evaluate inputs from the brakes, accelerator, steering wheel, and engine.

Bosch's four-wheel antiskid systems are being tested by several automobile companies. The big obstacle to mass application of such systems, Bosch maintains, is price: the system that will go into the Mercedes 350 SL as optional equipment next year will run about $400, easily within range of buyers of expensive Mercedes models but too high for the low-priced market. Bosch feels that the price must be halved before large demand can be expected.

Bosch is working on the electronically controlled transmission in conjunction with Zahnradfabrik Friedrichshafen (ZF). The heart of the system is a solid state control that functions without any interruption of tractive power during the gearshift operation. One version now being tested and developed specifically for trucks shifts gears up to 10 times faster than an experienced truck driver can. Electronic transmission units should hit the market in about two years initially as optional equipment on trucks and then for passenger cars.

Future. Collision avoidance is another Bosch activity, but an economically viable system is still far off. Last year, the company made an extensive evaluation of systems proposed so far and ruled out radar-based or laser-based approaches as impractical. The company feels that an inductive loop-based system is technically better, although very expensive. The company also is making electronic windshield wiper control units; a windshield washer-wiper combination; wiper control systems for front and rear lights, and a headlight illumination regulator that helps prevent drivers in oncoming cars from being blinded.

Reports from France say that all four of the country's car makers—Peugeot, Citroen, Renault, and Simca—have felt no competitive pressure from the U.S. car sales overseas to go electronic, although Peugeot is working on its own fuel injection system and Citroen's high-priced DS-21 model will include the Bosch fuel injector.

In England, while Lucas has electronics systems for fuel injection, ignition, antiskid brakes, systems monitoring, and engine speed control, buyers are few. Steve Rayner, chief engineer of the company's electronic design group, says he wouldn't be surprised if the biggest orders for car electronics come from Continental Europe rather than Britain. Jaguar and Aston-Martin use the Lucas electronically switched breakerless ignition, but neither will talk about future plans.

The two auto manufacturers in Sweden, Volvo and Saab, both use the Bosch electronic fuel injection on certain models; 30% of Saab cars are equipped with it. The only other electronic system in Saab's auto is the transistorized timing units in the car's gasoline-fired heater. The heater is made by Ebers Pacher of West Germany, which also builds the timer. Electronically controlled windshield wipers and turning signals look attractive, says Bertil Ylhage, head of Saab auto electrical systems, but the costs for such devices are still too high.

The outlook for automotive electronics is less than certain in Italy, too. A planner from the Fiat electronics division in Milan says, it is safety that the Italian will pay for and it is probably in that area that electronics will gain entry into the car market."

Tests. Toward that end, Fiat is testing an antiskid device for its model 130 luxury sedan. The company says the device meets U.S. standards that will go into effect in 1973. Fiat is also experimenting with a fuel injection system developed by its subsidiary, Magnetti Marelli in Milan.

Marelli's biggest seller is electronic ignition used on prestige sports and racing cars. Marelli is also working on an electronic windshield washer, which will provide 12 to 40 strokes per minute and is slated to hit the market next year. □

Contributing to this article were *Electronics* staffers John Gosch in Frankfurt and Michael Payne in London, and McGraw-Hill World Newsmen Michael Johnson in Paris, Andrew Heath in Milan, and Robert Skole in Stockholm

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Aerospace

Joint space talk outlook: clear skies

Spotlight at second round in Moscow will be on guidance and communications group; though hardware is a long way off, both sides praise progress

by Ray Connolly, Washington bureau manager

Achieving compatibility among electronic systems, even on the smallest scale, is one of the most trying tasks engineers face. And they could be forgiven for thinking that anything on such a grand scale as compatible systems for U.S. and Russian manned space flight would be all but impossible.

Yet the prospects for attaining this goal are good as engineering teams of the National Aeronautics and Space Administration and the Soviet Academy of Sciences make ready for a November meeting in Moscow. This will be their second in a series designed to make the civilian space hardware of the two superpowers compatible.

How long the 15-man American team, headed by Glynn Lunney of NASA's Manned Spacecraft Center, will meet with the Soviets is not yet certain, but U.S. sources believe the stay will far outlast the initial two-day session in Houston last June since NASA wants its negotiators to complete agreement on a number of technical specifications.

Details. While the June meeting produced agreements on more than 60 points in principle, technical details remain to be worked out on spacecraft docking and related communications, stabilization, and close-in navigation systems. As the minutes of that meeting note, "A great amount of work will be necessary, jointly and in each country."

Before the two nations reach the point of undertaking a joint effort from scratch, they will begin by docking spacecraft in orbit, most likely an Apollo vehicle with a Salyut-class craft, both proven systems. The second phase will be docking of a Russian Salyut spaceship with America's Skylab scheduled for 1973 launch [*Electronics*, Sept. 13, p. 40].

Most significant for the long-term plans of the U.S. electronics community are the efforts of the second of three working groups, the one responsible for compatibility of radio guidance, optics, and other guidance and communications systems. During the June sessions, NASA's Donald C. Cheatham, chairman of the five-man U.S. team on Working Group 2, found Viktor Legostayev and his 10-man Russian team to be "most cooperative." Continuation of that relationship is seen as essential in achieving mutually acceptable operational standards in the 37 areas covered by that group. There are 15 standards for communications alone to be decided on.

Rendezvous and docking methods are being explored by Working Group 1. This group also must establish requirements for automatic linking of electrical power and communications systems after docking. Working Group 2 has agreed that the docking procedure itself will be best achieved manually using on-board systems only. "For the present," said the group, "rendezvous guidance systems would not depend upon the accuracies of ground tracking systems." Both sides agreed to look further at laser and radio systems with passive reflectors for rendezvous. Papers proposing values for these and other still-undefined parameters are being exchanged by both countries as a basis for discussions in November, according to NASA.

Agreement has been reached on some of the more obvious communications requirements. For example, Soviet and American spacecraft in Earth orbit will have simplex communications links at distances to at least 150 kilometers, voice communications, and omnidirectional antennas. A Russian proposal to use telegraphy to extend communications range and simplify possible language barriers still is

Space meeting? U.S.S.R's Soyuz (above) or Sa'yut may linkup with NASA vehicle.

being considered by the U.S. But both sides agree on the frequencies for spacecraft communication.

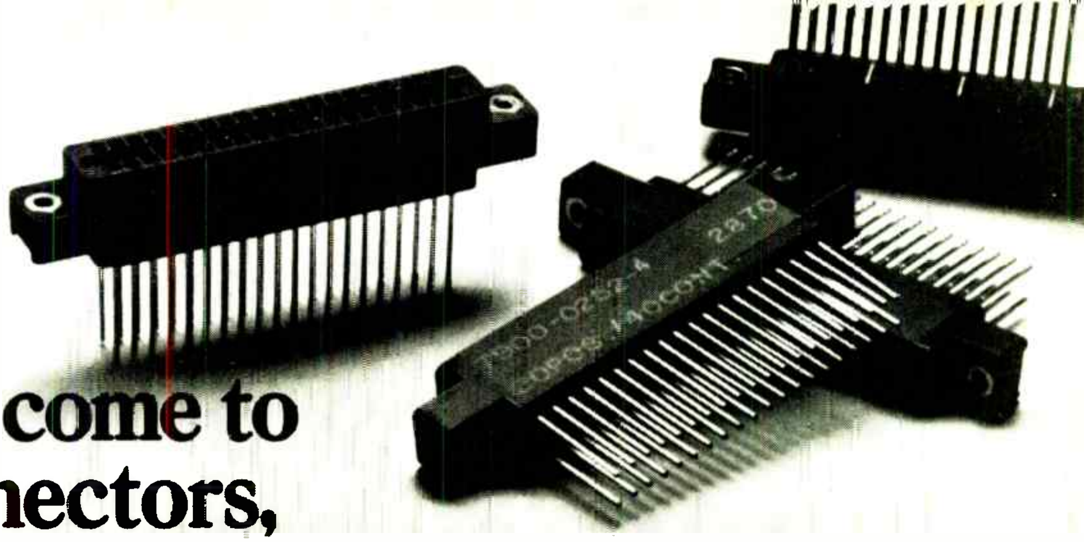
Russian cosmonauts will use the uhf band between 120 and 140 megahertz, while the U.S. has tentatively agreed to 250-300 MHz. The type of modulation to be used by U.S. spacemen also is pending. Both countries will carry transceivers using hardware provided by each for its specific frequency. Both nations also decided that communication "would be useful" between spacecraft, astronauts outside the vehicles, and ground stations, although ground stations on each side will use only their own frequency.

The U.S. said NASA is considering technical parameters for the transceivers proposed by the Soviets. Once technical requirements are drawn up at the November session, both countries will participate in design, development, manufacture, and testing of the new transceivers.

More specs. Though both countries agree that a coherent transponder using an omnidirectional antenna (4-pi steradian) will be required on board passive spacecraft, at least five transponder specifications still must be worked out in Moscow. The list, which may be expanded later, includes receiver and transmitter frequencies, receiver sensitivity, transmitter power output, transponder phase delay, and bandwidths. In addition, planning of maneuvers leading to rendezvous will demand accurate data exchanges between Russian and U.S. ground stations on spacecraft state vectors.

The Americans and Russians have agreed that their first considerations should not depend on ground tracking for rendezvous guidance. They also concurred that more long-range discussions will be needed to define space mission models, their probable ranges, and approximate accuracies applicable in each case.

Though an equivalent set of nonelectronic hardware problems also faces the negotiators (space docking, vehicle atmosphere, and astronaut transfer systems are a few) engineers at NASA see none that cannot successfully be resolved. □



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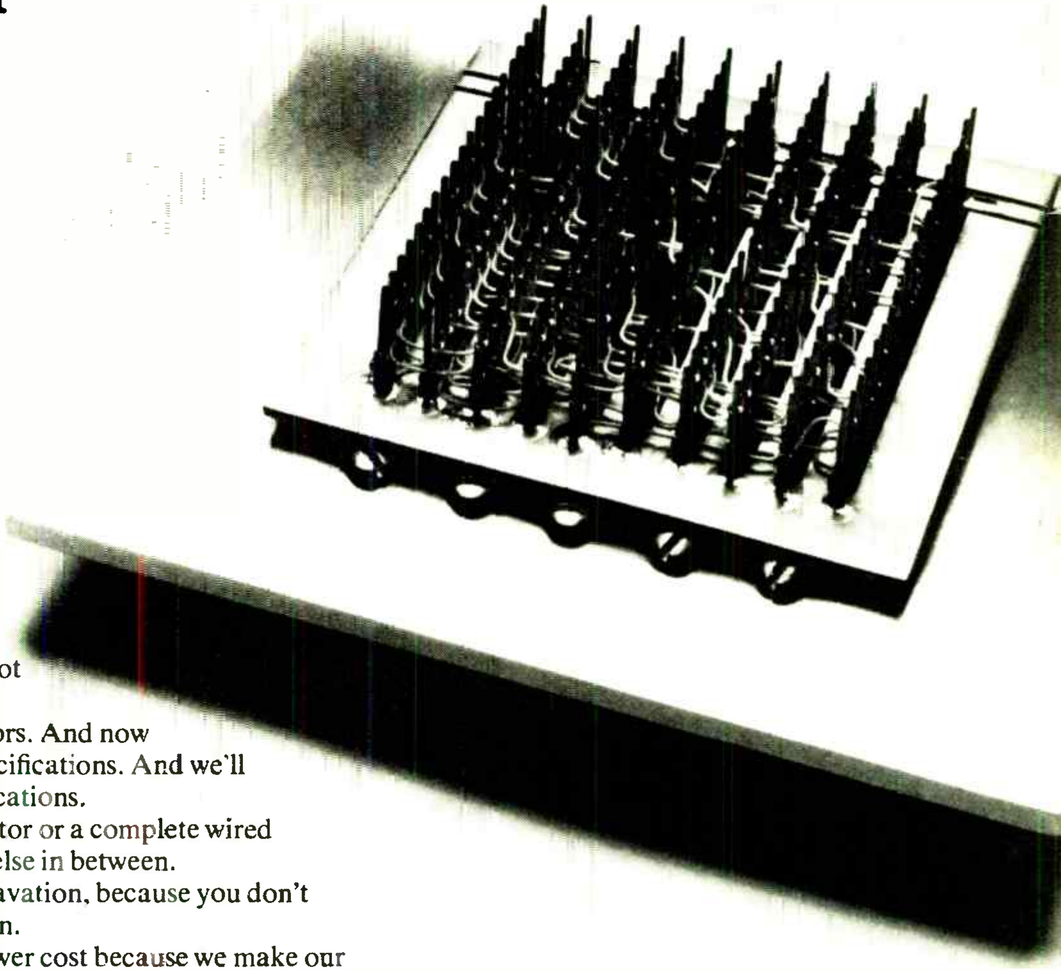

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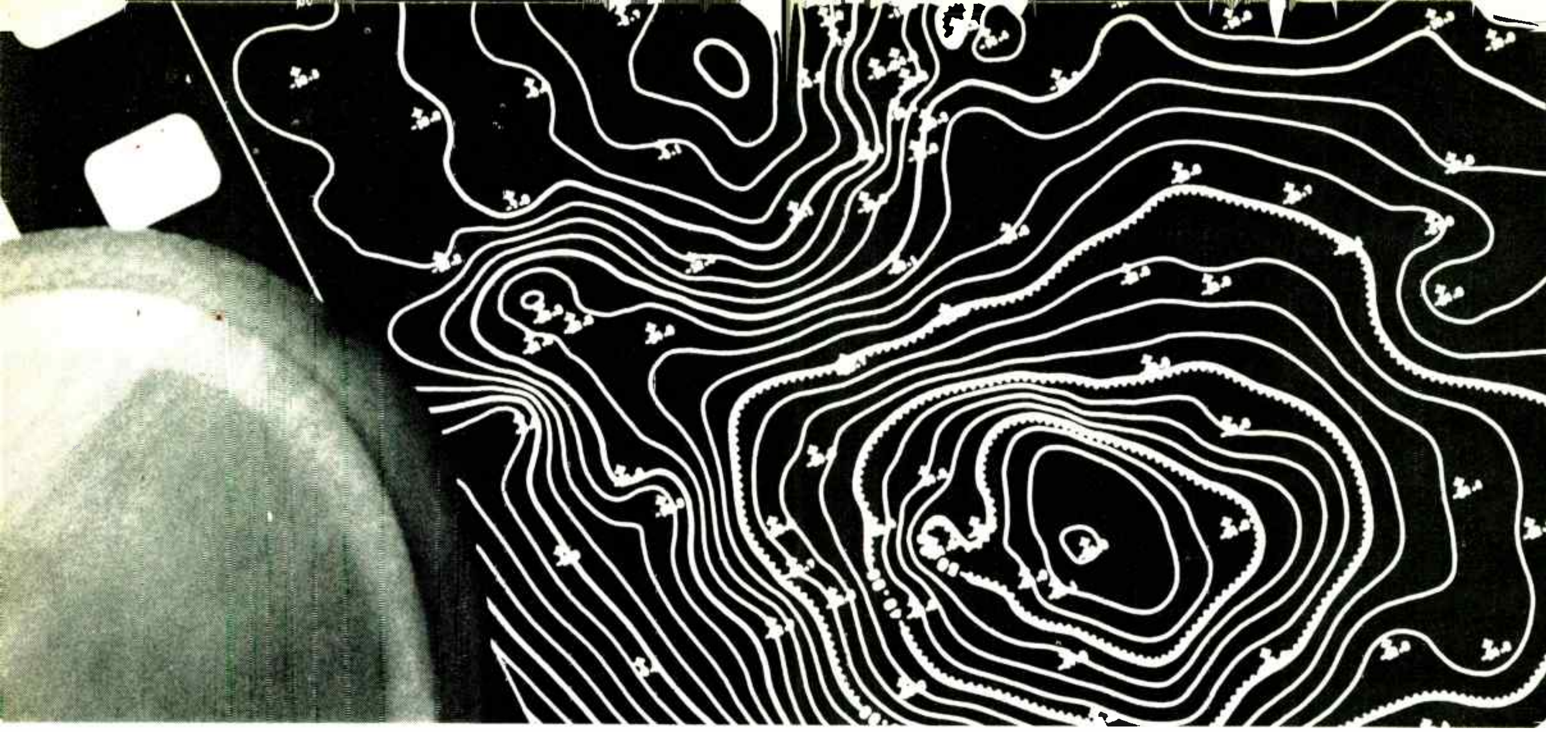

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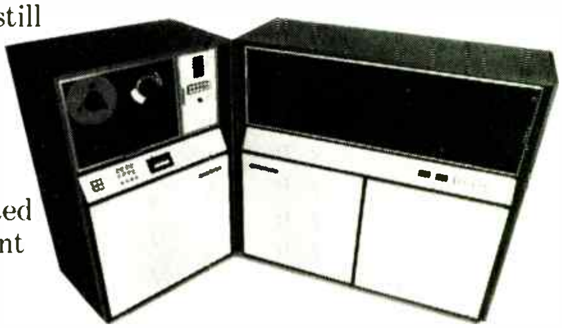


CALCOMP

Linear 'LSI' shrinks scope for field work

By Stephen Wm. Fields, San Francisco bureau manager

Three ICs hold most of circuitry in battery-powered instrument; new gain cell controls sensitivity variation

A new low—in size, that is—has been reached with the introduction of the model 211 portable oscilloscope from Tektronix. The 211 is a single-channel, laboratory-quality, 500-kilohertz, battery-operated scope that measures 3-by-5-by-9 inches and weighs about 2.5 pounds.

The 211 is aimed at field maintenance applications where small size and low power drain are important. Vertical calibration is variable from 1 millivolt per division to 50 volts per division. Horizontal sweep rates are variable from 5 microseconds per division to 200 milliseconds per division, and a continuously variable sweep magnifier provides uncalibrated sweep rates to about 1 μs per division. CRT viewing area is 3 by 5 centimeters.

One of the keys to the 211's small size is large scale integration. Most of the 211's circuitry is contained in three monolithic integrated circuits, all proprietary to Tektronix. According to David Allen, the designer of the 211, "two of the ICs contain 70% of the active circuitry—sort of like linear LSI." One IC contains the sweep circuit, the trigger circuit, and the horizontal amplifier, and is made up of both npn and pnp transistors. This device, says Allen, is manufactured with a compatible FET/bipolar process that is proprietary to Tektronix.

Another IC contains both the vertical and horizontal output amplifiers. It provides the 4-milliamp vertical drive current and the 1-mA horizontal drive current required by the CRT. The third IC is a quad op amp in which two act as current sources and the other two are the vertical amplifier.

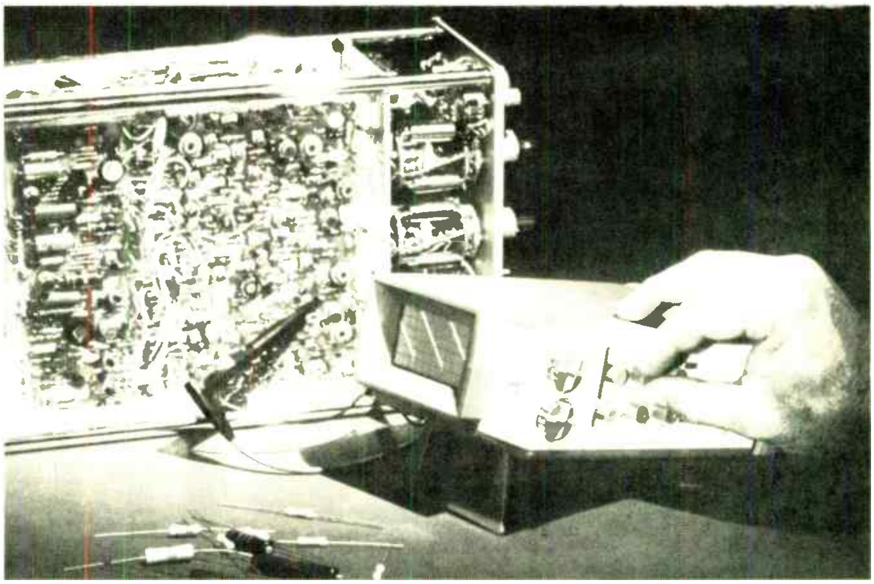
According to Allen, the biggest problem in designing the ICs was in "squeezing in all of the components. When you are putting 104 transistors on a 65-by-65-mil chip, you run into signal path problems and parts placement problems. For example, during one of the early designs, we had the trigger interfering with the sweep circuit." As a result of this, about 90% of the silicon surface is used—there are even devices placed between the bonding pads.

Power supply design was also an obstacle in reducing the scope's size. Allen says that the sensitivity of an oscilloscope is a function of the CRT intensity. In standard-size scopes, the power supplies are regulated twice—once at the input and once at the high-voltage output. But to save space in the 211, only input regulation (2 to 5%) is employed. To control the intensity/sensitivity variations, the 211 uses a gain cell in a feedback loop. This gain cell is a Tektronix development that's based on a circuit whose gain is dependent on the input current. In the 211, as the intensity control is turned up, the voltage goes down and the sensitivity goes up. "To correct this," says Allen, "we feed back high voltage through the gain cell." This approach is employed in both the horizontal and vertical circuits.

The 211 will be available by the end of this year at a price of about $500.

Tektronix Inc., Box 500, Beaverton, Ore. 97005 [338]

On the spot. Portable scope weighing 2.5 pounds is designed for field maintenance jobs.



Instruments

Light meter is highly stable

Compact, low-cost unit uses photometric filter and Schottky-barrier diode

As the field of optoelectronics expands, the need for instruments to accurately measure light increases—especially for instruments that are highly stable, compact and portable.

A Santa Monica, Calif., company, United Detector Technology, says it has such an instrument in its model 40A Opto-Meter. The unit solves the chief problems of those who have had to use bulky, difficult-to-calibrate instruments in this fledgling field, says Paul Wendland, president.

His company has specialized in silicon photodiode detectors since starting in business five years ago, and such a detector is a key part of the model 40A. The unit can be hand-held and operates on power supplied by two internal 12-V mercury batteries.

Bulkier instrumentation using photomultiplier tubes can't be built for less than $3,000, Wendland says, and would have to be calibrated daily against a National Bureau of Standards lamp.

The model 40A is guaranteed not to drift more than 1% in six months in responsivity after its initial calibration against such a lamp standard by the manufacturer.

The Opto-Meter sensor head incorporates a computer-selected photometric filter and a Schottky-barrier p-i-n photodiode combined with an operational amplifier. The photometric filter consists of four pieces of colored glass cemented together after being computer-selected to give the desired spectral response in the filter. The Schottky-barrier diode's response is nearly flat. Wendland says that at 4,500 angstroms, this means a response that's 80% of the peak response vs. about 1% for a photomultiplier tube.

The model 40A measures both radiometric and photometric power and energy. The light power range is from 0.001 microwatt to 10 milliwatts in six ranges in the radiometric mode, and 0.001 foot candle to 10,000 ft. in the photometric mode. On the most sensitive scales, the Opto-Meter can resolve 10^{-9} watt and 10-3 ft. The instruments light energy range is from 0.001 microjoule to 1 millijoule in five ranges in the radiometric mode, and 0.001 ft-candle-second to 1,000 ft-c-s in the photometric mode.

The $495 price includes the sensor head and both the radiometric and photometric filters. Delivery is from stock.

United Detector Technology, 1732 21st St., Santa Monica, Calif., 90404 [351]

Digital wattmeter reads to 20 kW at 20 kHz

Simplicity is the strong suit of the Model 235 wattmeter, made by Clarke-Hess Communications Research Corp. For one thing, it's simple to read—it has a digital display using cold-cathode tubes. But more important, it's easy to use.

The unit has a wide frequency and power range. The 235 measures power from 2 watts to 20 kilowatts over a span of 20 hertz to 20 kilohertz. Such ranges usually require external circuitry before taking a reading. But with the 235, voltage and current leads from the load are attached to the instrument, a range is selected with a front-panel switch, and that's it. "There aren't 62 shunts or 62 dropping resistors to put in," points out company president Kenneth Clarke.

The selectable ranges are delineated according to maximum voltage and current. The A setting permits a maximum rms input of 632 volts and 31.6 amperes. For B, it's 200 V and 10 A; for C, it's 63.2 V and 3.16 A; and for D, it's 20 V and 1 A. For all settings, the accuracy is ±1% of the full-scale reading for currents between 1 and 30 A.

The 235 computes power with a solid state multiplier. At the instrument's input is a 30-A shunt in series with a variable-gain amplifier. It's this amplifier that's adjusted to select ranges.

"We're still digging up applications," says Clarke of his instrument. Among those already found are measuring the output of choppers and silicon controlled rectifiers.

Size of the 235 is 8½ by 10 by 11 inches, and weight is 13 pounds. It sells for $2,500.

Clarke-Hess Communications Research Corp., 43 W. 16th St., New York, N.Y. 10011 [352]

System quickly pinpoints communication-line faults

Diagnostic system called Detect performs end-to-end testing of data networks. The system consists of a central station and individual units at remote locations in the network. Applications are in commercial end-user organizations and common carriers. It can be incorporated into any existing single-or multi-line network on a plug-in basis. The unit may be either desk- or wall-mounted.

Data Products Corp., Telecommunications Div., 17 Amelia Pl., Stamford, Conn. 06904 [353]

Capacitance meter/converter provides 4½-digit readout

A capacitance meter/converter, series 2450, measures high-Q capacitors with 0.2% of full scale accuracy. Single-capacitor or three-terminal differential measurements can be made in ranges of from 0 to

1.9999 pF, to 0 to 1,999.9 pF. Drive signal is a 10 kilocycle square wave, and analog output is 1.9999 volts full scale. Price is $1,875.

Spearhead Inc., 1401A Cedar Post Lane, Houston, Texas 77055 [354]

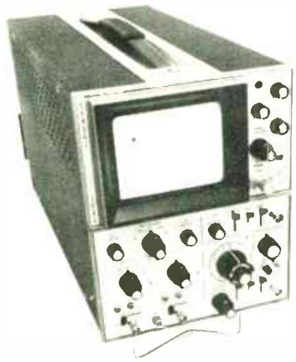
Digital voltmeter offers resolution of 100 μV

DigiTec model 266 digital voltmeter features 4½ digits, and an accuracy of 0.02% of reading. Indicators are LED displays, and front panel controls include self-check zero and calibration to assure maximum accuracy. Other features are guarded input, isolated BCD and system functions, 100 μV resolution, and voltage measurement to 1,000 v dc. Price is $525. Delivery time is up to eight weeks after receipt of order.

United Systems Corp., 918 Woodley Rd., Dayton, Ohio 45403 [355]

Oscilloscope has 5 mV/cm sensitivity at 60 MHz

Model 1062 scope offers 60 MHz bandwidth at 50 mV/cm. A triggering system provides flat full-band-



width sensitivity. Variable hold-off allows synchronous triggering on digital word lengths. Price for rack-mounted version R1062 is $2,045, and for 1063/R1063 without delayed sweep it is $1,845.

Dumont Oscilloscope Laboratories Inc., 40 Fairfield Pl., West Caldwell, N.J. 07006 [356]

Time interval meter gives resolution of 1 ms or 1μs

Time interval meter, model 355, has five-digit display, separate input channels and input signal conditioning. Resolution is 1 ms and 1 μs, switch selectable, and readout ranges from 1 μs through 99.999 s. An internal crystal-controlled oscillator determines accuracy. Price is $450 and an optional computer printer interface is available for $100.

Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, Calif. 94520 [357]

Portable photometer aimed at process control

Model 3100 photometer calibrates illumination and brightness for inspection of photocells and phototransistors, can also function as a process control instrument and as an edge sensor. Unit is available with four probes having a sensitivity to 0.0002 foot-candle. Price of the photometer is $295.

Vactec Inc., 2423 Northline Ind. Blvd., Maryland Heights, Mo. 63043 [358]

7-channel monitor scope fits in 3½-inch-high rack

Designed around linear and digital integrated circuits, monitor oscilloscope system includes seven independent oscilloscopes using a 1-in. by 3-in. CRT, packaged in a 3½-in.-high rack mount configuration. Features include no vertical drift from 0 to 55°C, bandwidth from dc to 10 MHz, and sensitivity from 50 mv/in. to 10 v/in. Automatic triggering is on a 5-mv signal. Primary applications include calibration, real time data monitoring, and data playback for wideband analog tape recorders in pcm, fm, direct, and pdm record modes. Price is $2,795.

California Instruments Co., 5150 Convoy St., San Diego, Calif. 92111 [359]

Non-reset counters designed for low-cost metering jobs

Series 8Z9 counters go up to 99,999 and then repeat. Applications are in metering or timing of business machines, photo equipment, and packaging and production machinery. Unit runs at 500 counts per minute and has an operating life of five million counts at 10 unit counts per revolution. Price of the model 8Z9 is $4.50.

Stock Drive Products, Div. of Designatronics Inc., 55 S. Denton Ave., New Hyde Park, N.Y. 11040 [360]

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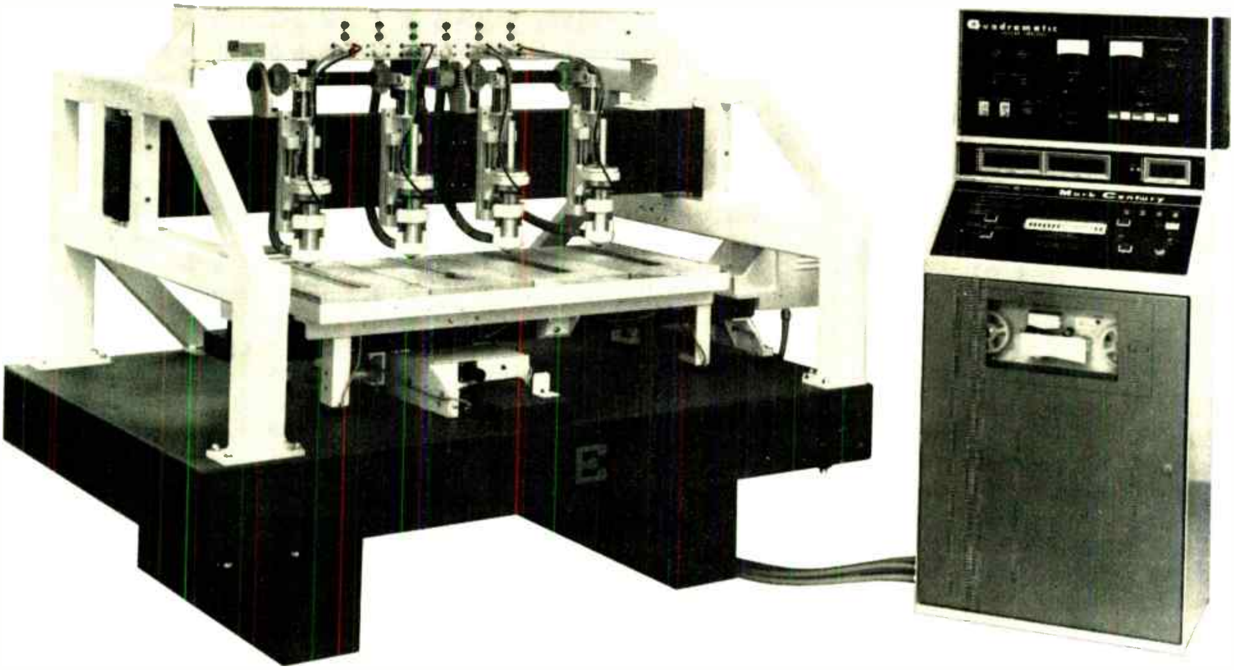
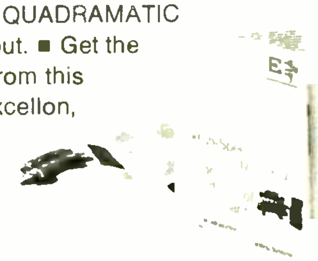
Up to 12 different drill sizes/setup.

...The QUADRAMATIC MARK II is up to it!



TOOLING UP for p.c. board drilling need not rely on your skill with a crystal ball. It's true that there is no predicting just what your circuit designers will need next year... even next week... but you *can* anticipate a need for fast drilling of clean holes by the thousands or millions. ■ That's where the QUADRAMATIC MARK II comes in. It's a numerically controlled, granite framed, very accurate, very fast p.c. drilling machine that can simultaneously drill 0.0135″ to 0.250″ holes in four *stacks* of 20″ X 12.45″ circuit boards...or three stacks 20″ X 16.60″ ...or two stacks 20″ X 24″. *And with the optional Excellon automatic drill changer, the MARK II can drill up to twelve different hole sizes per spindle with the same setup;* or it can exchange dull drills for sharp ones *automatically;* or both! ■ With four boards/stack, and four stacks, a $5/hour operator can deliver *up to 330 holes for one penny of labor cost!* That includes *multiple* hole sizes. And that means versatility plus economy... which is what the QUADRAMATIC MARK II is all about. ■ Get the rest of the facts from this brochure from Excellon, the recognized leader in p.c. drilling.



Where variety is the problem, versatility is the answer

Excellon

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How can Philips **guarantee** the performance of its RF power transistors for mobile transmitters?

Yes...the word is **guarantee.**

No more wondering "50 watt is 50 what?"

With Philips RF power transistors for mobile transmitters, you know precisely what you're ordering. You get precisely what you order. If used as specified, it will not fail... or your money back!

How is this possible? Not as difficult as it seems.

It starts, of course, with a product of superior reliability. But the real secret is in the specifying.

We provide you with a set of SOAR (Safe Operating ARea) curves setting forth, in detail, at exactly what combination of VSWR, temperature and supply voltage variations the transistor will operate correctly. When we say "25 watt", we mean, for example, "25 watt performance, with a 70°C heat sink, withstanding a VSWR of 50, 20% overvoltage and an increase of 20% drive power". Rather than forcing you to build in your own safety margin... with the probability you will over-specify and over-spend to be on the safe side... we determine all the derating parameters for you. The specification is part of the product... and we stand behind it.

The full range of Philips RF power transistors for mobile transmitting equipment... civil, military, aerospace or maritime... is shown in the accompanying table. Write for full specifications.

PHILIPS electronic components and materials

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Division Eindhoven, The Netherlands.
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a division of Philips Electronics
Industries Ltd. 116, Vanderhoof Avenue
TORONTO 17 - Ontario

Pout (Watt)	SSB 30 MHz 28 V	VHF 175 MHz FM 13.5 V	VHF 175 MHz FM 28 V	UHF 470 MHz FM 13.5 V	UHF 470 MHz FM 28 V
0.5				2N4427	
1.0		2N4427			
1.5			2N3866		
2.0				BLX65	
2.5			2N3553	BLX66	
3.0		2N3924		BLX67	BLX92
4.0		BFS22A	BFS23A		
6.0			2N3375		
7.0		2N3926		BLX68	BLX93
8.0	BLX13	BLY87A	BLY91A		
12.0		2N3927			
13.0			2N3632		
15.0		BLY88A	BLY92A		
20.0				BLX69	BLX94
25.0		BLY89A	BLY93A		
40.0					BLX95
50.0	BLX14	BLY90	BLY94		
100.0	BLX15				

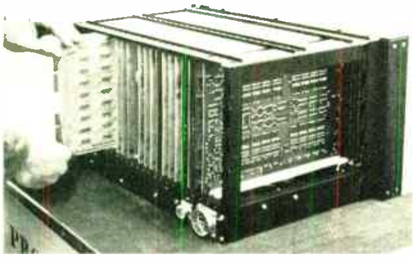
PHILIPS

Data handling

Controller is multi-purpose

Asynchronous serial model handles CRTs, printers, cassettes for Varian 620

One of the problems a minicomputer manufacturer faces is that of designing custom interfaces for the myriad peripheral devices offered with the machines. It can cost \$5,000 to \$10,000 to develop such a



custom controller, and it's usually expensive to produce because it has to be a wire-wrapped rather than a printed, flow-soldered board.

Engineers at Varian Data Machines have attacked this problem with a universal asynchronous serial controller that interfaces any Varian 620 minicomputer to any peripheral device using an asynchronous serial interface. Thus the range covered is from cathode ray tubes through serially connected printers to tape cassettes and teletypewriter terminals.

James Orris, director of product management, says that 40% of his firm's business is in peripheral devices—and it's growing, so Varian wants to cut out that custom interface development cost and be able to mass-produce the controllers. The trend among peripheral equipment makers to furnish serial interfaces with their equipment has enabled Varian to come up with the model E-2184, a versatile serial controller that will be available on one flow-soldered circuit board to plug into any Varian 620 computer.

There are three versions of the unit, ranging in data rate from 40 to 10,000 bits per second, and with five, six, seven, or eight bits with parity. Cable lengths from 20 feet to one mile are offered. A buffered CRT would require the 10,000 b/s rate, as would interfacing with another computer, Orris says; a peripheral device such as a card punch would require the 40 b/ rate.

But Orris adds that printers are probably the biggest market for the serial controller. Varian usually includes two printers or two CRT units in its standard price list for the 620 computer line. The model E-2184 will allow the firm to offer a wider range with far less interface development cost. The controller board has rear edge connectors and requires only one input/output slot in the central processor mainframe or I/O expansion chassis.

All versions are serial, direct-connect, character-buffered units capable of half or full duplex operation. Existing teletypewriter command set is utilized. Operation can be either under program control or in an interrupt mode using a priority interrupt module option. Another option permits automatic block transfers in conjunction with a buffer interface controller.

A typical model E-2184 will sell for approximately \$600. Delivery time for the controller is 30 days after receipt of order.

Varian Data Machines, 2722 Michelson Dr., Irvine, Calif. 92664 [361]

Portable cassette recorder designed for remote input

In many business and record-keeping operations, data is entered during the day via inexpensive, slow-speed teleprinter, and at night the remote terminals are polled automatically at high speed by a central computer.

This is the type of application that International Computer Products Inc. has in mind for its TermiCette 3300, a portable unit that is truly incremental in record and playback. It permits corrections and editing, even deletion of characters, at any location on the tape.

The recorder uses a bit-mark sequencing technique that permits the recorder to sense the beginning and end of each character, and position the tape accurately for recording or corrections. It operates at 10, 15 or 30 characters per second for compatibility with data terminals, and can record at the 10 c/s of a conventional teleprinter, then transmit at higher speed over the telephone lines, or to a higher-speed printer or a terminal with cathode ray tube display. It can be used with wired or acoustically coupled terminals, and simply plugs into the terminal through the standard EIA RS-232-C interface. A current loop is available as an option.

The standard TermiCette is controlled from the front panel switches, but a remote-control option permits control either from the keyboard of the terminal, or over a line from the central computer.

Each 300-foot cassette can hold approximately 50,000 characters, and the error rate is less than one per million. Fast-forward operates at 400 characters per second, and fast-reverse at 100 c/s.

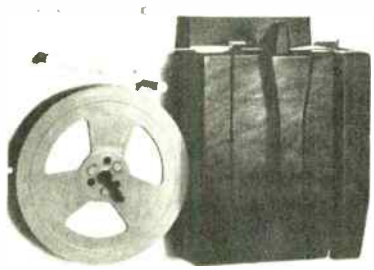
A feature of the TermiCette is easy manual search for data. Pressing the standby button (or hitting the proper key in remote operation) puts a six-second space in the tape, and this can be located in fast-forward or reverse by watching an indicator that lights when data is being recorded or transmitted over the system.

The 3300 is packaged in a carrying case with protective cover. It is 16¾ inches deep, 10½ inches wide and 6⅞ inches high, and weighs 18 pounds. It requires 75 watts at 115 volts. Price is \$1,650 in unit quantity, with discounts available for volume users. Delivery time is 30 days after receipt of order.

International Computer Products, Inc., P.O. Box 34484, Dallas, Texas 75234 [362]

Tape perforator handles 120 characters per second

Model P-1200 tape perforator operates at 120 characters per second, using punch pins that extend mechanism life by reducing the force necessary to perforate heavy-duty tape materials. Other features include

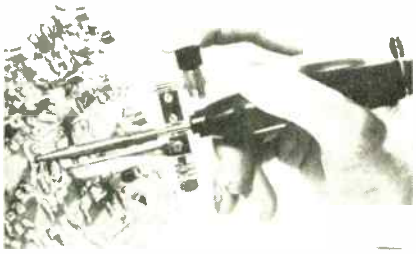


synchronous operation, five-through eight-level operation, and a capstan drive that requires no adjustment. Price is $1,500, with quantity discounts available.

Tally Corp., 8301 S. 180th St., Kent, Wash. 98031 [363]

Desktop display terminals offer 1200- or 2400-baud rate

Interactive display terminals, series 45, have detachable keyboards with 64 characters, 32 control codes, 17 functioning keys, and 12 editing keys. Models 80 and 84 are fully buffered, with 12-in. screens and switch-selectable data rates of 1,200 baud asynchronous or 2,400 baud

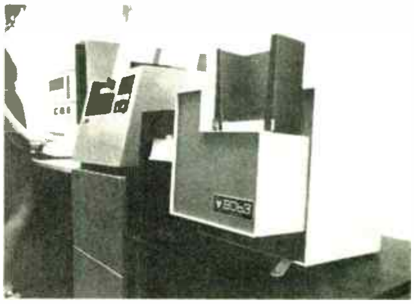


synchronous. The model 80 displays 1,000 characters in 25 lines of 40 characters and the 84 displays 960 characters in a 12-by-80 format. Price of the desktop-size units is $3,430 to $4,650 depending on quantity. Leases are available.

Photophysics Inc., 1601 Stierlin Rd., Mountain View, Calif. 94040 [364]

80-column-card reader processes 500 per minute

The capability of plugging into the IBM System/3 computer is offered by the model 8063 card reader designed for 80-column-card reading at 500 per minute. Life expectancy is more than 10 years or 20,000 hours, read error rate is less than one in 300 x 10^6 data bits, and each column of data is individually synchronized with a strobe signal. Price



is less than $5,000, and leasing for a 36-month period costs about $200 per month.

Bridge Data Products Inc., 738 S. 42nd St., Philadelphia, Pa. 19104 [365]

Graphics display terminal aimed at business uses

A business-oriented graphics display terminal, the model 4010, is compatible with more than 20 timesharing systems, more than 20 minicomputers, and with IBM 360/370 systems. A software package, Plot-10, is provided. The CRT terminal offers alphanumeric input to the computer by a teletypewriter, and graphic input by a dual thumbwheel arrangement on the keyboard. Price is $3,950 or $3,400 for 20 or more. Leasing costs $200 a month, includ-

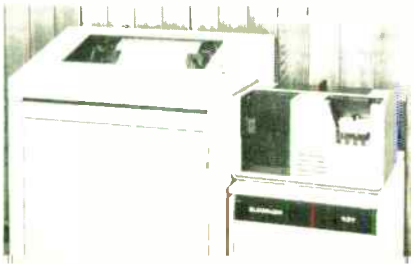
ing complete maintenance.
Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97005 [366]

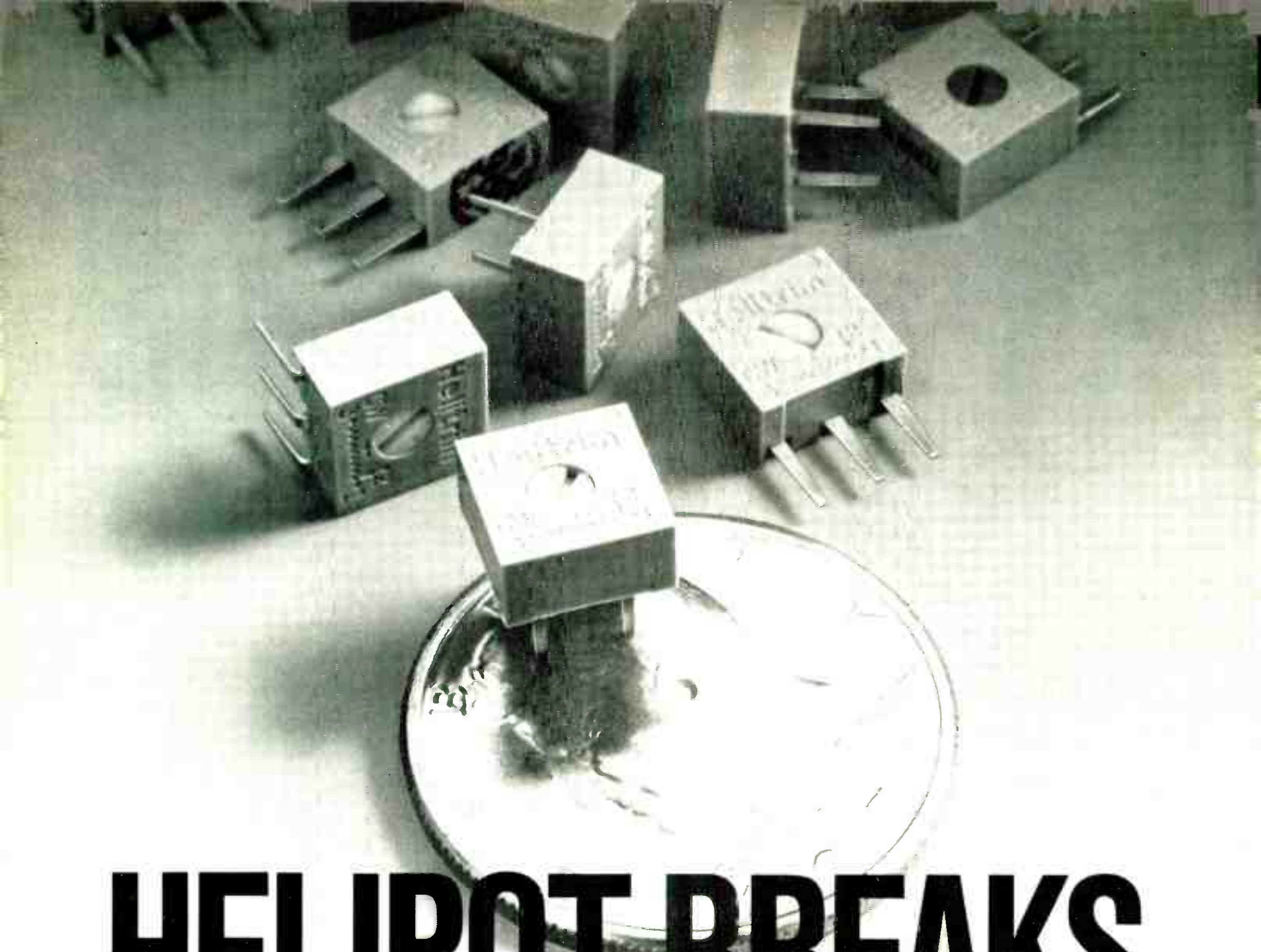
Data coupler provides link to switched networks

Data coupler, model EDC1001A, connects customer-provided automatic data equipment to the switched telecommunications network for data and voice communications. The unit has a voltage interface for use with terminal equipment that cannot tolerate contact bounce and electromagnetic radiation. The EDC1001A provides automatic linear control of signal levels above a specified threshold.
Elgin Electronics Inc., Walnut St., Waterford, Pa. 16441 [367]

Remote batch terminals feed into any computer

Designed to communicate with any computer, the series 120 remote batch terminals are multiprogramable. Models 123 and 124 use a 4,096-word core memory, a 300-card-per minute reader, and a 135- or 600-line-per-minute printer. The model 125 offers a standard 4k memory, two magnetic tape cassettes, an IBM 735 Selectric typewriter, and either a synchronous or asynchronous controller. The 125 can also act as a stand-alone computer when it is not being used on-line.
Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, Calif. 94520 [368]





Packaging and production

Board tester isolates faults

Computerized unit runs variety of checks on digital, analog and hybrid modules

At first glance, test systems for LSI circuits and those for circuit boards and assemblies are similar. But there's an important difference: you throw away a bad IC, but generally fix a defective module. And the

problem of isolating a specific bad part on a board can be even more difficult than finding out whether the complex logic board is bad.

The equipment group of Texas Instruments, which markets transistors and IC testers developed for TI's components group, has now begun selling an assembly tester developed for its own use.

The ATS-960 (it uses a TI 960 computer) performs functional, ac and dc parametric and special tests on analog, digital or hybrid modules. Results can be in go/no-go form or actual measurements, and the system can also be used for adjustments to bring the module into specification. For the latter, a CRT display can tell the operator "turn potentiometer R15 clockwise 15 turns, then counterclockwise until the pass light appears."

The ATS-960 can be used with up to four independent test stations; each station can be running tests on different modules. The maximum number of pins per station is 256.

Any commercially available or special programable test instrument can be used. The system can even be bought without any test instruments, for users who already have their own or wish to make voltmeters, counters, function generators and pulse measurement systems. TI supplies special forcing/measuring power supplies rated at up to 100 volts or 1 ampere, a digital functional test unit, and analog and digital fault isolation units. Up to 16 low-frequency, eight high-frequency, and 32 sampling probes can be used.

For fault isolation on analog boards, clip-on probes are employed with special diagnostic routines. For digital assemblies, two techniques are available: the conventional approach using computer-generated diagnostic routines is most appropriate for high-volume boards where the considerable cost of program generation can be amortized. An alternate technique developed by TI utilizes a universal program with a multi-pin IC probe.

The ATS-960 test system is priced at $50,000 to $150,000.

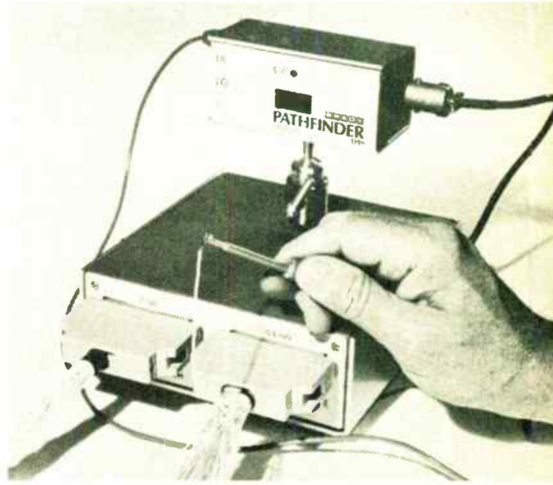
Texas Instruments Equipment Group, Box 1444, Houston, Texas 77001 [391]

Computer logic helps solve wire identification problems

Identifying a wire in a jungle of cables has always been a hair-pulling experience. Now the W.H. Brady Co., Milwaukee, Wis., promises to make the job easier with a system called the Pathfinder. The machine locates and identifies wires by using computer logic; coded pulses sent through the cables are picked up by a display and instantly translated into a digital number.

Capabilities include locating random wires, specific wires among any number, and shorts or selected terminals on all types of connector assemblies. The Pathfinder eliminates the use of multicolored wire, as well as assembly errors, and it reduces inspection time. In addition, the unit will detect crossed wires, incorrect wires, high and low resistance shorts, and open circuits.

The Pathfinder is capable of cod-



ing up to 999 wires and will identify pulses up to two miles away from the encoder unit, using a common-ground principle. The unit will also trace and identify telephone circuits, and complex missile and aircraft cabling.

Users can design their own systems by selecting the necessary components to accomplish specific requirements in wire identification.

Two basic versions of the Pathfinder are available. The model 99 is for assemblies, harnesses, or wiring systems requiring as many as 99 leads; and the model 999, a high-capacity unit, offers a minimum of 199 pulse signals, with capabilities up to 999.

W.H. Brady Co., 727 W. Glendale Ave., Milwaukee, Wis. 53201 [392]

Ultrasonic bonder can shift to thermocompression type

Model NU-822 wire bonder is for hybrid circuit, semiconductor and IC production. It can be converted from cold ultrasonic ball bonding to thermocompression bonding by the operator. Work height range is ½

in., and a manual control permits multilevel bonding without search height adjustment.

Mech-El Industries Inc., 73 Pine St., Woburn, Mass. 01801 [395]

DIP cartridge has its own heat sink and rfi shielding

IC packaging system, designated Dipstik, eliminates soldering, pc boards, card files, extractors, extenders, and related hardware. Instead, a cartridge and receptacle will hold up to five dual in-line ICs, providing its own heat sink and emi/rfi shielding. Receptacle provides standard 0.025-in. wirewrap pins for interconnecting logic wiring, while the cartridge with feed-through terminals provides test or tie points. Price is about $1 per position.

SAE Advanced Packaging, 2165 S. Grand Ave., Santa Ana, Calif. 92705 [393]

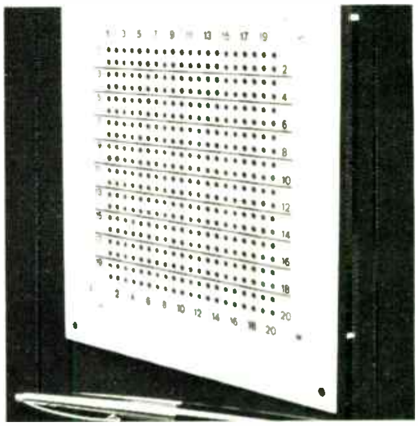
Pc terminal strengthens DIP-to-board connections

Printed circuit terminals, model 1938-8, are available in chain form or precut strips to fit specific IC requirements. The DIP connector has a grid contact arrangement, and holds typical on-center spacing of 0.100 inch between terminals of DIPs.

Molex Inc., 5224 Katrine Ave., Downers Grove, Ill. 60515 [398]

Matrix board simplifies data, control programing

Matrix programing board is designed for computer, machine tool control, data handling, and processing applications. Program preselection is executed by connecting the X-Y coordinates by means of a shorting pin or diode plug. The board measures 20 by 30 by 4.5 mm, and has 4.5-mm spacing between centerlines of holes. A special tool is not required for this 4.5-mm configuration. Price is $66 in quantities of 50. Delivery is from stock.



Interswitch, 770 Airport Blvd., Burlingame, Calif. 94010 [399]

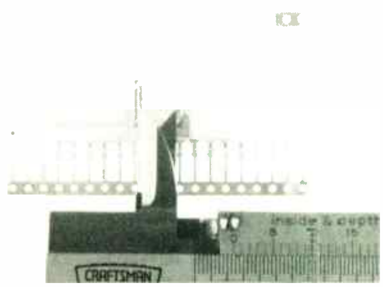
Desoldering tool uses jet of high-velocity air

Desoldering tools, models GSS and ESS, are self-cleaning and are designed for one-hand operation. The work is done by a jet of high-velocity air, controlled by a finger valve, moving past a hollow heated tip. Air jet creates a suction which entrains solder particles and catches them in a receptacle. Price is $21.95.

Hunter Associates, 792 Partridge Dr., Somerville, N.J. [394]

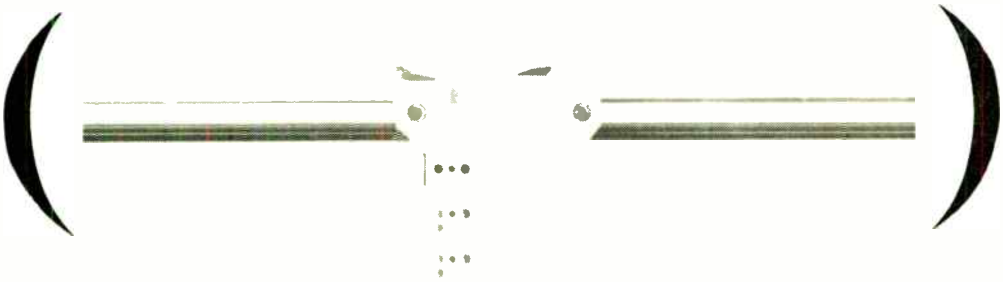
Wide-cavity MOS packages accommodate larger chips

MOS packages with 28- and 40-lead composite housings are available with 0.240-sq.-in. cavities, 0.040 in. deep with a 0.050-in.-wide gold-plated seal ring. The housings are



designed with the leads brazed to the bottom of the package, allowing the cavity to be expanded without extensive modification. Price is from

A very uncomplicated new OEM recorder with just one thing going for it...



You'll like what you see in our new approach to dedicated OEM strip chart recorders. First, we eliminated all those complicated moving parts from the writing mechanisms. No more pulleys, cables and slip clutches. Instead, there's just one simple moving part—the slider/pen assembly. That's because a linear servo motor keeps the pen going magnetically ...and very reliably.

When you see the HP Model 7123, you'll notice how the low power servo system makes the recorder smooth, precise and trouble-free. You could drive it off scale around the clock without noise or danger.

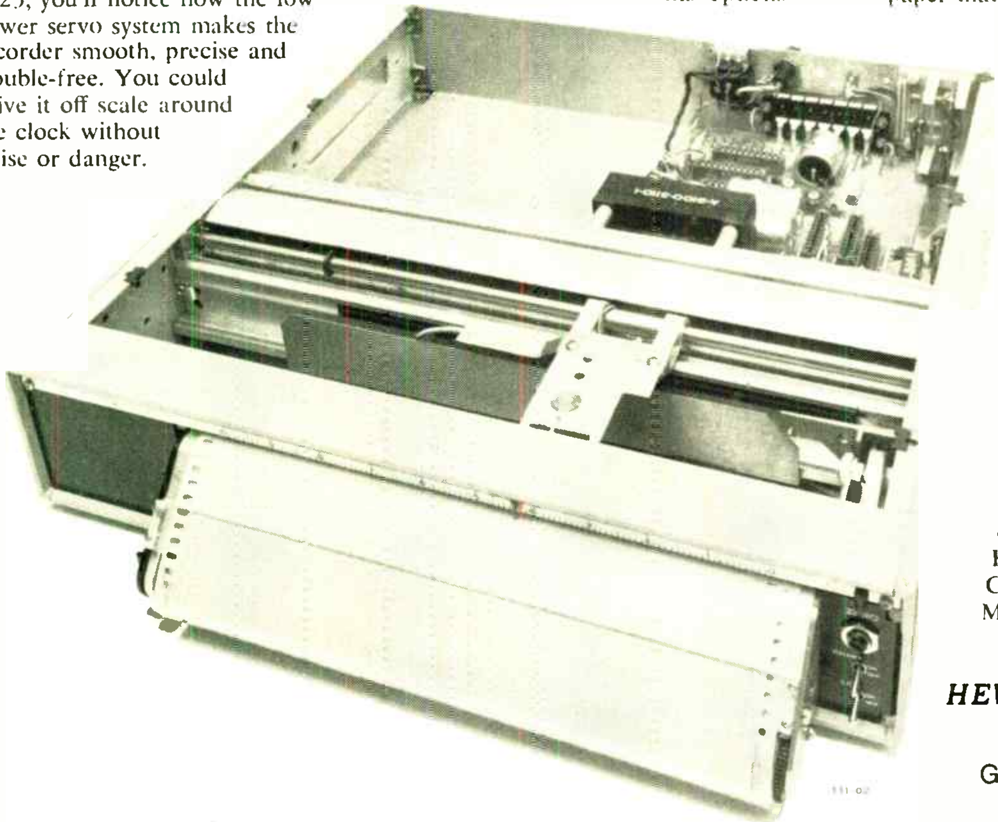
Even with all that, you've got a lot more going for you with the 7123. Like a swing-out chart paper drive for quick reloading and reinking. The viewing/writing area is slanted so you can make notes right at the disposable pen tip. And you can work without worrying about a lot of circuit adjustments. They're simply not needed anymore.

Since it's an OEM machine from the ground up, the 7123 has options for everybody. Select any chart speed and voltage span in English or Metric scaling. In all, nearly 50 options will customize the recorder exactly to a specific application.

You'll probably be most intrigued by an option we call electric writing. Normally, the ink system works like a cartridge fountain pen. But electric writing is designed for people who don't even want to mess around with that. A highly stable electrosensitive paper that gives you a crisp, clear trace without ink.

Available in full rack or half rack versions, the 3½ inch high 7123 makes totally unattended operation a reality. Simplicity, reliability, precision and even electric writing. With all that going for you, you can turn it on Friday and forget about your work all weekend.

To see the uncomplicated new 7123 and its matching price and OEM discount schedule, call your nearest HP sales office. Or write, Hewlett-Packard, Palo Alto, CA 94304; Europe: 1217 Meyrin-Geneva, Switzerland.



HEWLETT hp PACKARD

GRAPHIC RECORDERS

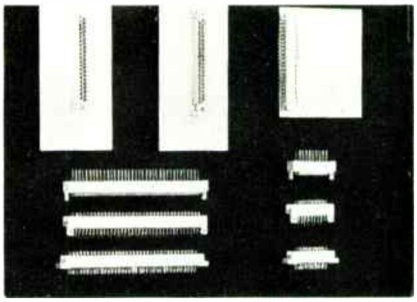
New products

$1.07 to 97 cents for 28-lead packages, depending on quantity, and from $1.30 to $1.18 for 40-lead packages. They are available within six weeks of receipt of order.

3M Co., St. Paul, Minn. 55101 [396]

Circuit card connector uses low-withdrawal-force contact

Two-piece metal-to-metal pc card connector features a contact with a withdrawal force of one to six ounces. Contact is designed to provide low insertion and extraction forces, permitting mating of large



numbers of contacts without mechanical jacks, screws, or cams. Called series 8219, connector is a high-density unit with contacts spaced on 0.050-in. centers. Connector sizes are 18, 30, 36, 42, 54 and 72 contacts.

Elco Corp., Willow Grove, Pa. 19090 [400]

DIP handler feeds and sorts up to 4,000 units per hour

Integrated circuit handler, model IC 2500A, accepts dual in-line packages having from eight to 24 leads. It can handle up to 4,000 devices per hour in general-purpose applications of feeding and sorting DIPs, such as digital and linear integrated circuits, pulse transformers, and resistor networks. The unit accepts most commercially available shipping magazines and interfaces with all test systems using TTL or DTL levels. Test leads are brought out in short wire lengths to connector, resulting in low capacitance. Price is $6,500.

Computest Corp., 3 Computer Dr., Cherry Hill, N.J. [397]

INVITATION TO DEMONSTRATE AN AUTOMATIC VEHICLE IDENTIFICATION SYSTEM FOR BUSES

All present or prospective suppliers of Automatic Vehicle Identification (AVI) systems are invited to demonstrate the performance of their equipment in a preliminary screening test any time during 1971. Successful systems will provide transponders to be mounted on buses, and capable of transmitting at least 9,999 individual codes as the vehicle is moving at least forty miles per hour, to an interrogator located on or near the particular lane in which the bus is traveling. Systems which demonstrate this capability in the approximately two-hour screening test involving temporary mounting of transponders on three buses and temporary installation of an interrogator and appear promising with respect to final installed costs and benefits, will be invited to participate in a full scale test.

Lasting at least six months, the full test will involve approximately forty buses each equipped with at least one transponder from each participating supplier. At least one interrogator from each supplier will be installed. Signals from each bus will be transmitted to a computer at the Lincoln Tunnel, which will be checking performance of the AVI systems and interpreting the AVI information to determine the actual travel time of individual buses through the corridor. Transponders and interrogators are to be supplied and maintained without cost to the test. Costs for installing transponders and interrogators, transmitting signals, computer processing, evaluating and reporting the performance of the candidate AVI systems will be borne by the project.

The United States Department of Transportation has authorized the test to evaluate the benefits and costs of an Automatic Vehicle Identification (AVI) system for buses using the I-495 corridor between the New Jersey Turnpike and the Port Authority Bus Terminal. Participating agencies include the Tri-State Regional Planning Commission, The Port of New York Authority, the New Jersey Department of Transportation, the New Jersey Turnpike Authority, and Transport of New Jersey (the major operator of interstate buses in the New Jersey-New York area).

If the full test is successful, recommendations will be made to USDOT for equipping most, if not all, buses using the Port Authority Bus Terminal with an AVI system. Installation of a system of this magnitude is likely to set the pattern for more widespread introduction of AVI for such purposes as fleet control by truck and other operators, automatic toll collection, motor vehicle administration, etc.

Interested suppliers may obtain a copy of "Feasibility Study-Automatic Vehicle Identification Systems" from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151. The Reference No. is PB 185387, and the cost is $3. This study was performed for the United States Department of Transportation to determine the feasibility of adopting a national standard for an AVI system.

Prospective suppliers desiring further information are invited to contact Mr. Robert S. Foote; Manager, Tunnels and Bridges Research Division; The Port of New York Authority; 111 Eighth Avenue, New York, New York 10011; telephone (212) 620-8144.

Remember . . .

MAIL MOVES

THE COUNTRY

but . . .

ZIP CODE MOVES

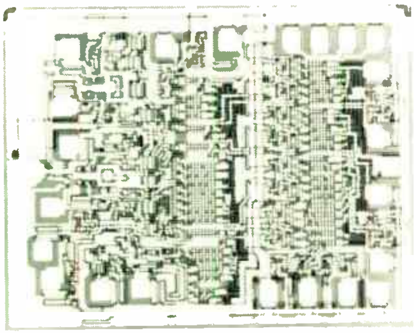
THE MAIL

Semiconductors

TI adds three Schottky TTLs

High-speed MSI units include arithmetic logic circuit with 15-nanosecond add time

An easy way for designers to upgrade the speed of their conventional transistor-transistor-logic equipment is to use Schottky-clamped TTL, but not all popular functions are available in STTL.



Texas Instruments, which produces the only generally available STTL line, has now expanded its family with high-speed versions of three popular TTL MSI circuits. The three provide speeds previously obtainable only with emitter-coupled logic, which can not be conveniently added to a TTL system.

First in the trio is the SN54S/74S181 arithmetic logic unit, the Schottky version of the SN54/74181. This MSI function has proved a great attraction to users, for it can save many packages; Motorola has even taken the number (181) for an ECL part performing the same function even though it isn't a plug-in replacement. The S181 performs 16 binary arithmetic manipulations on two 4-bit words, including add, subtract, decrement, and direct transfer. Typical add/subtract time is only 15 nanoseconds (the conventional part requires 24). The 181 also performs 16 logic functions of two Boolean variables, including NAND, AND, NOR, OR, and exclusive-OR.

Power dissipation of the 54S/74S181 is about 700 milliwatts, or 10 mW per gate, and it operates from the standard 5-V TTL supply. The plastic DIP, commercial range 74S181 is priced at $26 in 100-piece quantities, and delivery is 2 to 4 weeks. Military range units and ceramic DIP and flat packs are also available.

The SN54S/74S153 is a dual 4-to-1 multiplexer, the Schottky version and plug-in replacement for the SN54/75153. It can be used to convert serial to parallel data or to randomly select data from a number of sources. Typical delay time from the data input is 6 ns, compared to 14 for the standard 153. Power dissipation is typically 225 mW. Price is $6.85 for the plastic version in quantities of 100.

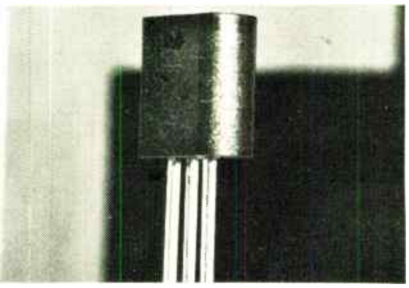
The third new Schottky part is a 110-MHz dual type D flip-flop, the SN54S/74S74, a plug-in replacement for the standard 7474 and high-speed 74H74 flip-flops. Up to now, TTL was limited to about 40 MHz input. Each half of the unit features a typical propagation delay of 7 ns. This part, unlike ECL versions, is a true dc-coupled flip-flop rather than a tracky ac type. Power dissipation is typically 75 mW per flip-flop.

The least expensive version, the SN74S74 in plastic, costs $3.01 in quantities of 100.

Texas Instruments Inc., Inquiry Answering Service, Box 5012, M/S 308, Dallas, Texas 75222 [411]

Unijunction transistors in plastic are programable

Programable unijunction transistors, series P13T1-2 are packaged in TO-92 cases constructed from an

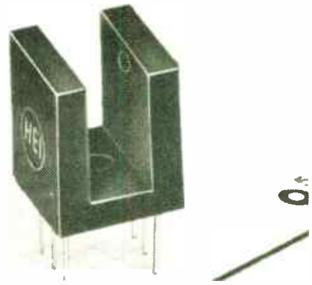


epoxy compound featuring moisture resistance and stable performance under high humidity. The units are planar passivated. Price is as low as 55 cents in 1,000 quantities.

Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172 [415]

Optical switch provides 50 ns square-wave rise time

Optical switch, model OS-391S-060 or -200, offers Schmitt trigger circuitry in a device using LEDs and phototransistors. This circuitry allows the switch to directly drive DTL and TTL levels. Typical square-wave rise time is 50 ns. and the trigger



permits clean logic switching and wave shaping with no oscillations in response to slow mechanical action through the optical switch. Price is $12.90 in 100 lots.

HEI Inc., Jonathon Industrial Center, Chaska, Minn. 55318 [417]

Read-only memories are field-alterable

Off-the-shelf read-only memory units can be supplied after customer specifies desired data contents in

punched tape, card, or tabulated listing formats. Bit capacities range from 8 k to over 200 k per system, and a variety of basic word/bit configurations are available, many of

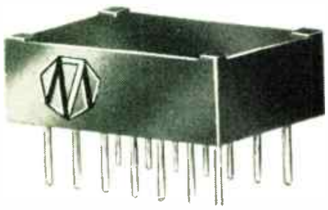
them alterable to give additional formats by changing the input code and drive matrix circuitry. Price is 0.8 to 2 cents per bit depending on speed, capacity, and quantity.
Datapac Inc., 3180 Redhill Ave., Costa Mesa, Calif. 92627 [419]

LED display and decoder included in plug-in package

Light-emitting diode displays called GaAsLites include a digital display-module, solid state indicator lamps, and a display bezel assembly. The display-module combines a seven-segment display, current limiting resistors, and a decoder/driver into one plug-in package. Price is $21 to $12 depending on quantity.
Monsanto Co., 277 Park Ave., New York, N.Y. 10017 [413]

Optical coupler offers high input-output isolation

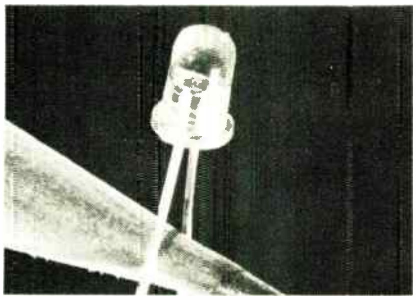
Optical coupler permits ±3,000 (or more) volts isolation between input and output sides and higher output-input current ratios. The unit can also serve as a high-speed solid state switch or relay, as an interface de-



vice between systems, or as a line driver-receiver element. It is housed in a DIP compatible with standard 14-pin IC sockets.
M7 Inc., 210 Campus Dr., Arlington, Heights, Ill. 60004 [416]

Low-cost phototransistor aimed at card-reading jobs

Model TIL78 phototransistor for card-reading and other applications features a light current of 7 milliamperes typically at 20 milliwatts per square centimeter. Dark current is 25 nanoamperes at 30 volts reverse voltage, and continuous power dissi-



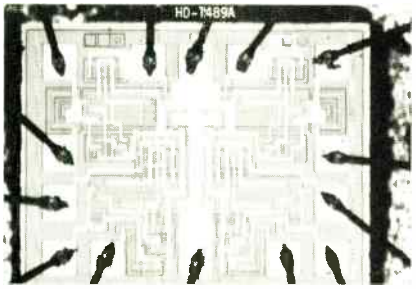
pation at 25°C is 50 milliwatts. The unit has an emitter-collector voltage and a collector-emitter voltage of 7 and 50 V respectively. Price is 50 cents in 1,000 piece orders.
Texas Instruments Inc., P.O. Box 5-12, MS/308, Dallas, Texas 75222 [418]

Buffer ICs drive clocks, lamps, lines, memories

TTL Quad 2 NAND buffers drive transistor-transistor logic and DTL clock lines, lamps, medium length data lines, TTL gates, and high capacitive loads such as MOS memory arrays. Unit output is low only when all inputs are high, and propagation delay time is less than 15 ns. Version N7437A is 78 cents in 100 to 999 quantities, and the S5438F is $5.04 in the same quantities.
Signetics Inc., 811 E. Argues Ave., Sunnyvale, Calif. 94086 [414]

Quad-line receiver design gives high noise immunity

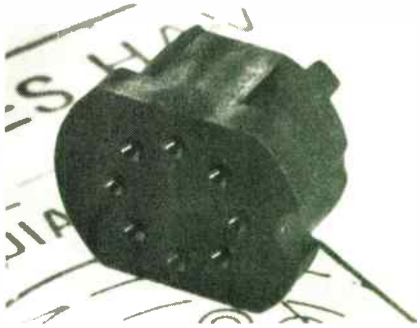
Quad-line receiver, type HD-1489A, is designed to interface between single-ended transmission lines and



data terminals. Typical hysteresis is 1.15 V, resulting in high noise immunity, and a response control pin in each of the four circuits permits the filtering of high-frequency noise or the paralleling of several receivers on a single line. Price is $4 in quantities of 100 to 999.
Harris Semiconductor, Melbourne, Fla. [420]

IC sockets accept TO cans with up to 12 leads

A series of 12 integrated-circuit sockets, type 131-55, fit into TO packages with up to four leads on a 0.100-in. pin circle, and up to 12 leads on a 0.200-in. pin circle. The



body material is made of glass-filled nylon to provide continuous operation from −55 to +125°C. Usage is in a wide variety of production applications, and three different styles are available.
Barnes Div., Bunker Ramo Corp., 24 N. Lansdowne Ave., Lansdowne, Pa. 19050 [487]

C/MOS digital ICs offered in chip form

Unencapsulated chips, previously available in standard packages, are offered in a line of logic circuits selected for a wide variety of applications in hybrid design such as automotive circuits, industrial controls, appliances, clocks, medical electronics, computers, and communications equipment. Prices of the CD4000A series, for 100 to 900 lots, range from $1.98 to $8.95 depending on type of circuit.
RCA Commercial Engineering, Harrison, N.J. 07029 [486]

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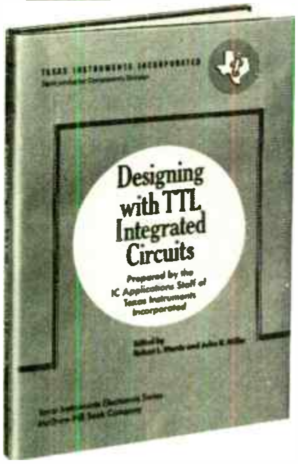

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Acrylic optical components including prisms, beam splitters and light pipes can be custom-generated in a variety of sizes. Impact strength is said to be six to 17 times greater than glass, and other features include low cost, high visible light transmittance, and haze held to 2% or less. Applied Products Corp., 451 Caredean Rd., Horsham, Pa. [481]

Solder process called Solderex is for through-hole rack plating of printed circuit boards. The tin/lead method does not emit hazardous or offensive fumes, and has high throwing power. It produces bright, readily-flowed 60/40 deposits. Sel-Rex Corp., 75 River Rd., Nutley, N.J. 07110 [482]

Epoxy molding powder, Eccomold 1099, is formulated for transfer-molding applications where low density and/or dielectric constant are required. Typical applications include encapsulation of aerospace components, integrated circuits, coils, capacitors, and semiconductors. Price is from $6 to $8 per pound. Emerson & Cuming Inc., Canton, Mass. 02021 [483]

Epoxy coating powder called Novaloy 6521 is for fast packaging of heat-sensitive electronic components. Processing temperatures may be as low as 120 C, and coating times as fast as one second are possible at higher temperatures. Edge coverage values range from 40% minimum to 65% or higher. Coating thicknesses from 0.010 to 0.035 in. can be obtained with one application. Rogers Corp., Rogers, Conn. 06263 [484]

New books

Thick-Film Microelectronics Fabrication, Design, and Applications
Morton L. Topfer, Van Nostrand Reinhold Co., 210 pp., $10.95

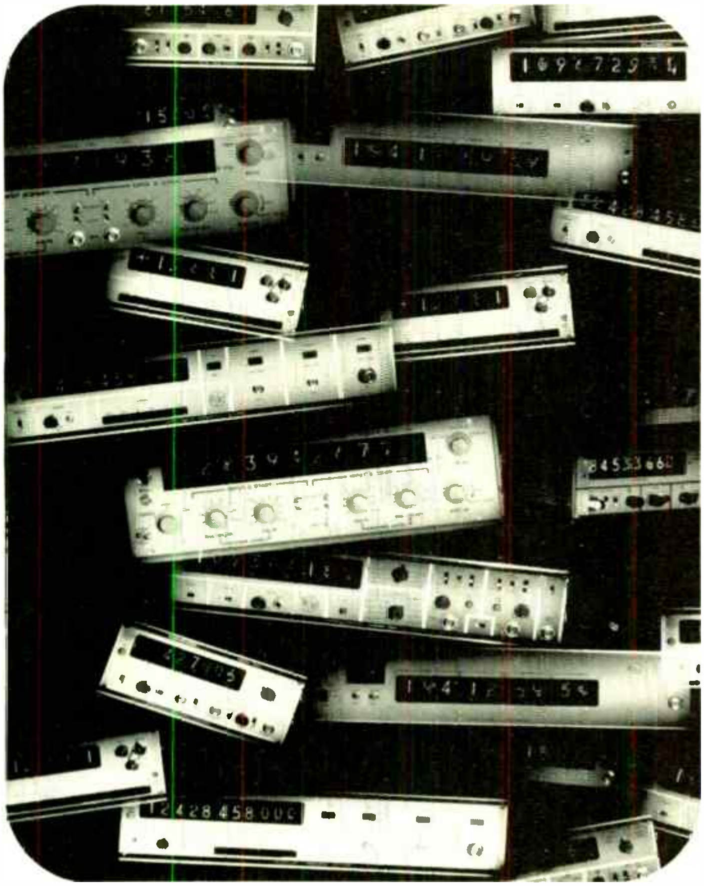
No one becomes an expert by reading alone; but a book should provide a start in the right direction, some insight into potential trouble areas, and a good list of references to back up statements in the text. Morton Topfer's book fulfills all these criteria.

The strongest sections are those covering technology, equipment, processing, assembly, and packaging techniques, which as an aggregate make up about half the text. Though each specific topic is necessarily brief (it's impossible to completely cover resistor pastes in only two pages) the central points are covered.

In the equipment and processing sections, there's a good discussion of screen printing, including a useful table showing production rates. Assembly techniques are discussed, with special attention to flip-chip and beam-lead connections, while the packaging sector details all the various approaches, including plastic encapsulation.

About the only point that's open to criticism is that the sections on applications seem to stray from the main point of the book—they get involved in details of circuit operation simply from a circuit standpoint without any real relation to the book's main topic, thick-film technology.

Other sections, on system partitioning, reliability, and thick films in hermetic and nonhermetic applications, also contribute to the book's value. Several examples are included to show how the problems of hybrid design differ from those of discrete circuits. For example, it's pointed out that level shifting usually may be implemented with a capacitor, diode, and resistor clamp, but in the hybrid approach, the large capacitor presents a serious problem. The circuit therefore is redesigned to a resistor-transistor unit, which can be easily handled in hybrid form. Data on reliability also is included.



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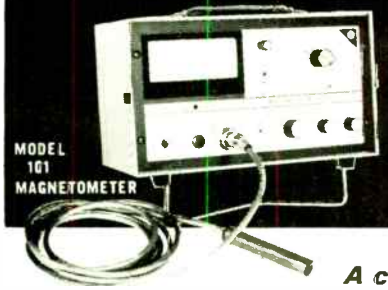

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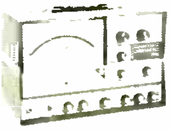

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New Literature

Relays. International Rectifier Corp., Crydom Div., 1521 Grand Ave., El Segundo Calif. 90245 has published a brochure describing a line of computer-compatible, solid state SPST ac relays. Specifications and a chart are included. Circle 421 on reader service card.

Linear encoders. Sequential Information Systems Inc., 249 N. Saw Mill River Rd., Elmsford, N.Y. 10523. A two-page product sheet provides features, applications, and outline drawings of modular optical linear encoders. [422]

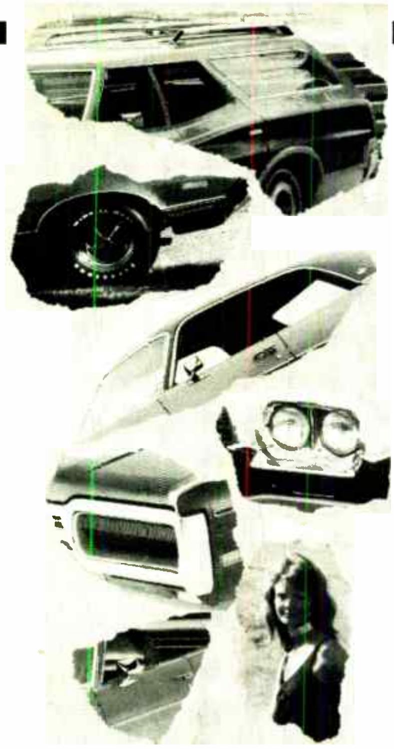
Thin film etchants. Transene Co., Route 1, Rowley, Mass. 01969. Techniques for generating thin film microcircuits and data sheets on thin film etchants are included in a 15-page bulletin. [423]

Audio signal delay. Gotham Audio Corp., 2 W. 46th St., New York, N.Y. 10036 has available a six-page brochure describing the Delta-Tau model 101 for digital processing of audio signals. [424]

Flat load cells. Strainsert Co., Bryn Mawr, Pa. 19010. Brochures 365-2 and 365-2MP give dimensional data, specifications, and model designations for general-purpose, precision universal, and compression flat load cells. The four-page bulletins describe mechanical properties and include tabulations of deflection and spring rates. [425]

Computer graphics system. Concord Control Inc., 1282 Soldiers Field Rd., Boston, Mass. 02135. Two brochures describe a graphic data processor which is a digitizer, plotter, and edit station; and two high-precision plotter systems, the MK 8 and the MK 10. [426]

Panel meters. Digilin Inc., 1007 Airway, Glendale, Calif. 91201. A set of technical notes describes the uses of digital panel meters, with specific applications for the company's line of 2½-, 3½-, and 4-digit meters. Included is a discussion of noise rejection, active filtering techniques, and display of sensor outputs. [427]



Dick Wolters

OCTOBER 1971

CARS
A fast look at the new 72s

INVESTMENTS
Mutual funds race for profits
Taking a flyer with high-yield corporate bonds

FAMILY
Parents' plight; the school and college drop-out

THE GOOD LIFE
Tailgate parties: pass the Klops and the mulled wine

TRAVEL
Washington's new Kennedy Center

HEALTHY, WEALTHY AND WISE

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The custom touch: Suddenly a man's car is his castle

One prosperous New York motorist hardly flinches anymore when buzzers sound and lights flash on the dashboard as he turns the ignition key. The audio-visual display is merely a built-in warning system reminding him to fasten his seat-belt. Federal safety regulations say a new car (all built after Jan. 1) has to have one. But how about the refrigerator, telephone and television set in the back seat? That was his own idea.

Between government edicts on safety "extras" and his own desire for personalized motoring, the affluent American car buyer can—and increasingly does—keep a platoon of white-smocked technicians busy installing, adjusting and repairing a bevy of intricate hardware that has very little to do with moving the car down the road. For anywhere from $300 (for a 9-in. TV set) to $30,000 and up (for the accoutrements of a salon-on-wheels), a veritable arsenal of luxury equipment is being marketed for the motorist with a penchant for comfort, convenience, and individual expression on the road.

Any car nowadays can be personalized, but usually the investment is warranted only on the costlier ones, such as the Continentals, Cadillacs, Thunderbirds, and the like. Only the owner's imagination limits what can be done to them in the way of customization. Whole new interiors are being fashioned for some out of crushed velvet. Others have deep-pile carpeting, or one-way glass. Station wagons are being made out of Cadillacs and Lincolns, which do not ordinarily come from the factory in that form. The list of possible custom "extras" is just about endless:

- A 2½ cu. ft. bar and refrigerator that starts at about $1,000. A complete service of goblets, decanters, ice bucket and walnut cabinet can run to $1,700.
- A toaster and coffeemaker set with a 110-volt A.C. adapter, at least $700.
- A rolling executive conference room installed in a limousine. It starts at $10,000, but a walnut cabinet-desk ensemble can be had for only $1,600.
- High-intensity lights for reading. A small battery-powered unit may cost $100. An installation of several Tensor or quartz lamps can run to $1,000.
- Personal television. A 9-in. black-and-white set may cost only $300, but a large color set can hit $1,700—and also present some tricky antenna problems.
- Private communications. Telephones have to be purchased from the local telephone company, but a shortwave radio makes a good substitute, at between $300 to $1,500.

A custom paint job can run $1,335 and up; consider, for instance, one in Morono Pearl, which gives something in the way of added value by seeming to change colors as the car travels down the highway. On the less frivolous side, executives and professional men claim that customizing to provide on-the-road conference space or such things as

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stereo sound on which technical and business reports can be played while driving return at least some of their cost in time saved.

Detroit's car builders will install some luxury items, such as plush carpeting and stereo tape sets (which start at $35), right at the factory. With the new 1972 cars, indeed, they are offering a host of comfort-and-convenience items. Air-conditioning (starting at $400) and "climate control" devices ($500 up) are increasingly common options. Rear window defoggers ($30) take some of the sting out of winter driving, and electric seat adjusters can be had for between $90 and $140.

For driving comfort and safety, the manufacturers gladly come through with disc brakes, which last longer, stop more smoothly, and come as standard equipment on all Imperials, Cadillacs and Lincoln Continentals; they are at least a $75 option on most other cars. Anti-skid brakes are also now available on Thunderbirds, Mark IVs, Cadillacs and Imperials, for $220 and up. Automatic devices are also proliferating. For $50, a motorist can have his headlights rigged to dim automatically as other cars approach. With another $40 attachment, his headlights won't flick off as he leaves the car until he has time to get into the house.

Anti-theft devices on the steering column and warning buzzers to alert drivers that they left the key in the ignition are standard equipment (by law last year), but the sporty Chevrolet Corvette is the only '72 car with an anti-theft audio alarm system as a standard item. One, of course, can be put on any car.

Both domestic and foreign auto companies—and a host of custom shops—stand ready to add just about anything a motorist's heart desires. First step in getting a customized car is to get the car itself from a local dealer. Some money may be saved by dealing directly with a custom shop for the alterations, but letting the dealer make arrangements may save some headaches. It saves some fretting, too, when an owner realizes that his car is not going to be transformed into the chariot of his dreams overnight. Customizers say he should expect to allow as much as six weeks for a major job.

Most automobile dealers can recommend a custom shop, but two prominent Midwest customizers who do work across the country are Custom-Craft, Inc., a division of American Sunroof Corp. (which builds all sun roofs for U. S. cars) and Moloney Standard Coach Builders of Chicago.

The 1972 models: little change in a mark-time year

The big-splurge so traditional to Detroit's announcements of its new cars is oddly subdued this year. The reason is that Detroit has fewer really "new" cars to talk about than it has had in recent memory. Rising costs, a tight market, and unanswered questions about future federal safety standards (which could dictate major design changes next year) have made it so.

There are, to be sure, enough cosmetic changes in grilles and exterior metal work to distinguish a '72 model from a '71. But the car buyer who feels he must look over everything new that Detroit has to offer will find he has an easy assignment this season. The Ford Motor Co. is the only domestic manufacturer offering a totally different '72 body. The all-new Thunderbird and luxurious Lincoln Continental Mark IV have it. So do the Ford Torino intermediate lines and the Mercury Montego.

For the economy-minded, the modest appearance changes in most other lines offer a special break. Detroit insiders suggest that a thrifty buyer look over his dealer's '71 left-over cars before signing up for a '72—they are not only lower in list price than the new models, but the dealer also gets a 5% price rebate from the factory on the out-dated models and may be willing to shave the price even further.

The new Mark IV is competing this year with Cadillac's unchanged Eldorado for buyers in the sporty $8,000 and up (far up) range. For luxury at a lower price (in the $5,500 to $8,000 category), shoppers should check the new Thunderbird, which Ford is pitting against the Oldsmobile Toronado and Buick Riviera, both hardly altered from last year. The all-new Torino and Montego are aimed at the buyer in the mid-$3,000-and-up category, whose alternate choices might be the Chevrolet Chevelle, Pontiac LeMans, Dodge Coronet and American Motors' Ambassador—all of which have only received a face-lift for '72.

In a season of minimal change, there are still enough variations to invite some looking. Dodge's top-of-the-line Polaro and Monaco ($4,000 and up) are more different from each other than in several years. The Plymouth Fury ($3,000 and up) and Chrysler ($4,000 and up) also have some new styling worth noting. For the high-style-minded, Detroit observers of the new-model year suggest a close inspection of the Chevrolet Caprice. When it is loaded with extras, it takes on a remarkable Cadillac-like look—and it costs about 40% less, or near $5,000.

New Ford Thunderbird

Chevrolet Caprice

Lincoln-Continental Mark IV

The mutual fund derby is off and running again

Small, fast-moving mutual funds are back in action, and once again there is a profit-performance contest to watch. But they aren't the go-go funds of a few seasons back. They are saner, more sober, and managed with more caution. Maybe, just maybe—for an investor—they are a place to lay new bets. "But before stepping in," says a top Wall Street pro, "a man will want to bone up. Among other things, this means studying the prospectus for a change."

In 1967 and 1968, a youthful generation of mutual fund managers refined the art of stock-price appreciation and renamed it to suit the speculating public. They called it "performance" and this quickly became a watchword for smart innovation and unique ways of evaluating securities for a fund portfolio. The method—as Fred Carr, former head of Enterprise Fund once said—was to "conversationally develop the concept of the company" whose stock was being considered. "Fundamentals" such as price-earnings history and company rank and position in the industry often took a back seat to a company's real or imagined "concept"—or its uniqueness. The result: a host of fund investments in thinly-capitalized stocks, many of them over-the-counter.

For a time, it worked like clockwork, and men such as Carr, Manhattan Fund's Jerry Tsai, Winfield Growth Fund's Dave Meid, and Security Equity Fund's Fred Alger became as familiar to Wall Street board rooms as a big-city commuter is to broken down trains and delayed buses. By discovering unexplored "situations" and searching the woodwork for obscure upbeat companies, these men of the go-go funds were called "gunslingers"—and they lived and breathed high appreciation. They made the conservative "Dow" and the Standard & Poor's average pale by comparison. In 1967, for instance, Winfield Growth *doubled* its assets, and Carr's speedy portfolio managers at Enterprise managed a 117.5% jump.

Then the clock stopped. The gunslingers hadn't reckoned on a crashing bear market. So when the Dow went from its December 1968 high of 995 to a woeful May 1970 bottom of 631, the go-go funds fell in line—and fell apart. It was so bad that even the "little guy"—the naive small investor—figured that too many stocks were overpriced. Suddenly, "fundamentals" became vital again, and even the gunslingers were lining up and pledging allegiance to them.

For nearly 18 months or so, it seemed that the "performance" craze was dead.

But like the Phoenix rising from ashes, a new bull market began to bob and weave last November. With it, the go-go fund managers reappeared. True, the cast of characters has changed (Carr, for one, no longer runs Enterprise), and attitudes have been tempered by past disaster. But if the results in 1971 are an indication, a number of fund managers are once again taking up the basic pattern: fast in-and-out trading, and picking long-shots.

In the first half of this year, the Dow went up a modest 6.23%, and the S&P 500, jumped 8.19%. At the same time, some 55 mutual funds turned in impressive gains in asset value of 25% or more, according to Arthur Lipper Corp. in a survey of the fund business. Topping the Lipper list: Channing Venture Fund, a tiny $1-million grown fund with gains of nearly 80%. Channing's style has been not unlike that of the small high-performance funds of years back: 40% of its assets riding on two companies—National Patent Development (soft contact lenses, a volatile stock), and Banister Continental (Canadian pipeline). Before Channing sold Banister convertible stock, its investment had doubled.

Of course, it is probably much easier to manage $1-million than it is to oversee $100-million or more. Thus, most of the new-breed high-performance funds are small—most have assets somewhere under $20-million. At this size, they can locate enough small fast-moving "situations" to largely fill their portfolios, whereas $100-million funds are forced into more conservative investments at the expense of high performance. In any case, the manager of the small go-go hopeful must strive to discover the so-called hot stocks—and time their acquisition precisely. The investor must learn to live with the idea of taking maximum "reasonable" risk to get maximum gain—or else switch to bluer chips.

Though they believe in their approach, the managers of the small, higher-risk funds are—today—aware that the golden gate can always swing shut. For one thing, the ordeal by fire that saw the Dow decline 50% has not been deftly skipped over by the fund men. They know the real score. High-risk situations and volatile stocks still have their old appeal: but for the most part, the go-go mentality that characterized the 1967-1968 bull market period has been diluted to the point where "fundamentals"—meaning sound analysis—are given at least reasonable attention. Moral: Review the fast appreciation funds—but do so cautiously, with a keen eye on both management and prospectus.

Corporate bonds: booming yields for easy sleepers

Yields in the corporate bond market have been so high lately that investors have been nailing down 8% returns by simply buying bonds of the Bell System. Some have gone even higher in profits by picking such companies as ITT and Chrysler. "But it's crucial to buy quality," says a top bond man on Wall Street. "If you're bond-minded, you want one that will let you sleep at night."

But what about yields that are truly high, in the 11% to 15% range, for instance? If sleep is no object, an investor can find literally dozens of unusual situations—what might be called Bonds for Iron Stomachs.

Hunting for high yields is like taking a tour of the disaster areas of American business. Aerospace, airlines, conglomerates, computer leasing—these industries are fraught with problems that range from the nightmarish to the merely hair-raising. Buying their bonds can be so perilous that ordinary brokers hardly know such securities exist. "Nobody in his right mind would touch those things," says one bond trader who sells strictly "investment grade" paper for large institutions.

Yet some investors—or better, some gamblers—buy them; otherwise, their prices would sink to zero. But, cautions Russell Fraser, the vice-president who heads Standard & Poor's corporate bond rating operation: "You've got to be the kind of guy who takes a crack at new issues in stocks—a really speculative kind of animal."

In general terms, the risks are twofold, and they are very real risks indeed. One is that the corporation's business may get so bad that it can no longer meet the interest payments. In that case, the bonds go into default, and the bondholder loses his yield. The other risk is that the company may simply go bankrupt, or go into reorganization to avoid bankruptcy, in which case the investor might very well lose all his principal, too.

The other side of the coin, though, is that yields are fat, and if the company's fortunes improve, the bondholder can make substantial capital gains as well—gains that are taxed at only half the rate of interest payments. Capital appreciation might occur, too, if the operation is taken over by another company. Further, bondholders, as creditors, rank far higher than stockholders when it comes to gathering in the remains of a defunct business. If the company fails, there is often enough left over from auctions to pay bondholders 10¢ or 15¢, say, on the dollar.

With this in mind, an adventurous soul might, for instance, runmage among the shards of James Ling's old empire. LTV Ling Altec has a sinking-fund debenture—a senior security—with a 6¾% coupon due to mature in 1988. Originally issued with warrants, since detached and exercised, these debentures trade for around $480, far below their $1,000 par value. At that price the coupon equals a *current* yield of 14.06%.

Savvy bond buyers also deal in *yields to maturity*, which are calculated according to a complex formula that takes into account both compound interest and the capital gain to be scored when (or if) the bonds are payed off at par when they mature. In practice, bonds' market prices usually rise in anticipation as the maturity date nears. In the case of Ling Altec's 6¾s of '88, the yield to maturity works out to nearly 15.5%.

J&L Industries, which controls Jones & Laughlin Steel, has a 6¾ senior debenture due in 1994. Priced around $490, it has a current yield of 13.78% and a yield to maturity of 14.44%. Okonite, a cousin in the Ling empire, has a 6½ senior debenture of 1988, trading around $460, to yield 14.13% currently, 15.62% to maturity. Okonite was recently taken over by Ling's new vehicle, Omega-Alpha. The old holding company, Ling-Temco-Vought itself, has a bond outstanding, the 5s of '88, that trades around $445. Its current yield is 11.24%. Yield to maturity is 13.39%.

S&P's ratings, which are familiarly triple-A or double-A on high quality bonds, descend from B down through triple-C and double-C to no rating at all on high-yield securities. Such a rating means pretty much "outright speculation," with increasing emphasis on "outright." LTV and Okonite have B ratings; J&L and Ling Altec, are rated triple-C.

The nearer the maturity date, the higher the yield to maturity. The computer leasing company Levin Townsend, for instance, has a 7½ debenture due in 1979. Recently priced around $600, it boasts a current yield of 12.5%. The yield to maturity, though, is 17.2%.

Leveraging, of course, can make the potential gain even greater. If he can arrange to buy on 25% margin, an investor need put only $150 to buy a $600 debenture, making the potential capital gain equal to 267%. He would have to pay 7% or 8% interest, naturally, on the $450 he borrowed from his broker, but that would be more than covered by the 12.5% current yield. If he is optimistic enough, he might even reason that, should worse come to worst, enough might be salvaged in bankruptcy proceedings to pay bondholders 15¢ on the dollar—and he would recover his $150.

Anyone daring enough to plunge into deep-discount bonds would be wise to check how large the issue is outstanding. If the issue is less than $10-million, the market may be so thin that only a small amount of trading will produce sharp price swings—when the bondholder decides to sell his own bonds, for instance. That is a risk, for example, in First National Realty & Construction 6½s of '76, of which only $2.6-million are outstanding. Priced around $580, these yield 11.21% currently and 19.54% to maturity. Another Levin Townsend issue, the 9s of '74, have $5-million outstanding. They trade for around $770. The current yield: 11.69%. The yield to maturity: 19%. But the thinness of the market needs inspection.

Beehive: NYSE's busy Bond Room

National dilemma: How to cope with college drop-outs

EMOTIONAL OUTBURSTS WIN LOW MARKS WITH CAMPUS COUNSELORS

Steve's parents started saving for his education when he was a toddler. All of a sudden, it seemed, Steve was in high school, earning good grades and participating in sports. To everyone's pleasure, he was accepted by his first-choice college, an Eastern "name" school. Then Steve came home for Thanksgiving. He had a knapsack and a girl in tow, and announced that he was dropping out of school. For his parents, the news bore all the sting of the proverbial serpent's tooth.

The scene that followed is being replayed with increasing frequency in homes across the country. The college "drop-out" is not only a major heartache for an increasing number of American families, but he—or she—is also a troubling concern for college administrators as well. Of all the freshmen they see entering their ivied gates this fall, college officials are acutely aware that only 55% will stay around long enough to earn diplomas. The real puzzler is that reasons for campus failure these days are far more often of an emotional nature than academic, and thus harder to remedy.

A study in 1965 by Edward A. Levenson, M.D., of the William Alanson White Institute in New York, draws a portrait of the typical drop-out which highlights the problem. The study indicates that he is generally above average in intelligence and creativity. His mind is bright, but mixed up. Socially he is likely to be a "loner." When these psychological traits collide with the alien environment of the campus, the potential drop-out becomes an actual drop-out.

Lately there has been a growing feeling among administrators that perhaps dropping out in many cases is not entirely the wrong move. Many of these students, they say, may actually be in the wrong school, with choice of colleges probably directed more toward prestige than toward curriculum. Once enrolled, they may find that their "education" is preparation for graduate school and practically nothing else. They may back down on the idea of "adjusting" to college life. Beyond this, there is the student who is suddenly confronted with more independence than he has ever known.

Administrators realize that behind such pressures lies one that is even more difficult to handle—the American success syndrome. Success to many American parents is synonymous with a house in the suburbs and a college education for the children. They push for these goals, and consider anything short of them as failure. College deans hear constant reports of parents who resort even to bribery (a new car or trip to Europe) to bend their children to working for that all-important diploma.

But Dr. Robert W. Pitcher, co-author of *Why College Students Fail,* finds that today's teenagers simply are not motivated as strongly as their parents. "They are frequently over-protected by people who want them to have everything they didn't have—such children have never really heard 'no.' " Consequently, says Dr. Pitcher, the adolescent's motivation and perseverence are slow to develop.

Wise parents, say such experts, will start emotional preparation for college in the high school years, if not sooner. They will try to discover their child's true ambitions, and provide realistic help in attaining *his* goals—not their own.

Donn Albright

Fathers have a special role to play, these authorities say. Typical "businessmen" fathers find it hard to encourage their children to make their own decisions. If the father is quite successful in his business or profession, he poses another stumbling block; a college-age son may feel he could never compete on his Dad's level, and quits.

"Too many boys come to my office still holding onto their father's coattails," says Eugene S. Wilson, former dean of admissions at Amherst College. "The boy, not Dad, should map out a college admissions program, for example. But a lot of fathers can't let go." Compound paternal pressure with maternal possessiveness, says Dr. George Hall, head of psychiatric services at New York University, and you have a child with a highly developed "separation anxiety." In this state of helpless dependency, he is a prime candidate to flee school.

Counselors advise parents to allow their youngsters to make some real blunders before they have to face college. One suggested trial is to let the youth manage his own checking account, and to learn to live with the consequences of his own bloopers. "Let him cover his own bounced checks," Dr. Pitcher strongly advises.

Finally, campus counselors implore parents to soft-pedal their emotions if and when a son or daughter does drop out. Irate fathers, full of blame for the college, are familiar to deans across the country, and mothers who suffer "nervous breakdowns" are more common than realized. All of which, the officials point out, does no good for anybody.

Psychiatrists now suggest that for some young people dropping-out may even be beneficial—if the youth is put on his own to seek a job or serve in the military, and find his own way back to campus. "He'll get back, if he has the basic stuff," says Amherst's Wilson. "Many do, and then college has some real meaning for them."

Besides Dr. Pitcher's *Why College Students Fail,* other recent works that explore the drop-out problem include *Anyone Can Go to College,* by Herbert Livesey, Ph.D., director of admissions at NYU (Viking, $6.50), and *Einstein's 1971 College Entrance Guide* (Grosset & Dunlap, $3.95).

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A pre-game treat: Drop that tailgate and pass the Klops

GERMAN MEATBALLS AND MULLED WINE? IS THERE A TASTIER DEFROSTER?

To paraphrase the poet, October's bright blue weather all too often is the time when the frost is on the bleachers and the spectators are turning blue. Even the excitement of football can be thin cover from the keening wind, unless, of course, proper provision has been made to insulate the inner man from all that hostile cold. One of the more hospitable ways to do it is with a tailgate lunch outside the stadium just before the game.

This is no time for a dry ham sandwich and a hard-boiled egg. The station wagon tailgate should beckon with something sturdy and rib-sticking, and festive as well—perhaps a lusty hot soup plus *charcuterie*, or the makings of a Klops party. Klops, for the uninitiated, are German meatballs.

To begin with the soup, the occasion calls for a good thick potage, one that can be made one day, heated up the next, and poured into thermos jugs for the trip to the stadium. One candidate is a split pea soup which the French call *St. Germain*.

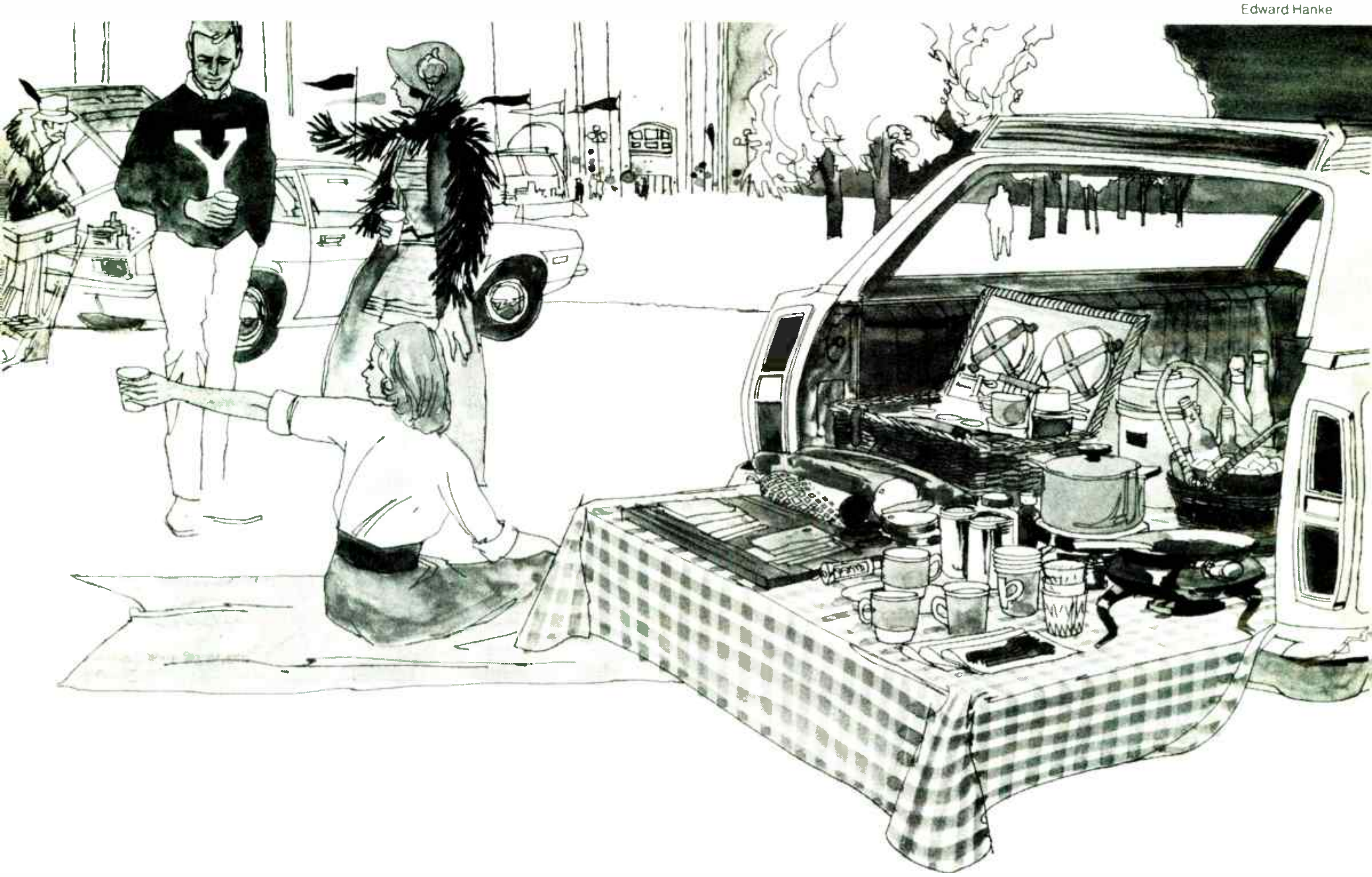
It takes the following ingredients for two quarts (six servings): 1 pkg. (2 cups) split peas, 1 ham bone (or ½ lb. ham in 2-in. cubes), ½ cup chopped onion, 1 cup chopped celery (with leaves), ½ cup chopped carrots, 1 bay leaf, 1 clove garlic (slivered), 1 tsp. sugar, ¼ tsp. thyme, 2 tbsps. butter, 2 tbsps. flour, salt and pepper to taste.

Soak the peas overnight in enough water to cover. Save the liquid, and add enough water to it to make 12 cups. Put the bone (or ham) into the peas and water, and simmer three hours. Add the rest of the ingredients, and simmer another hour. Put through a sieve or strainer. Mix the butter and flour into a paste. Mix with a little of the soup, then add it to the pot. Bring to a boil once, then season and pour into a thermos. The consistency should be that of thick cream; if it's too thick, add a little milk, and if too thin, more flour and butter.

At the game, serve in big mugs with a few croutons on top, and offer a platter of *charcuterie*—sliced ham, Swiss, tongue, cervelat or salami, and some French bread, buttered and cut horizontally, for make-it-yourself sandwiches. Bring along the mustard (try Dijon)—or some Major Gray's English chutney.

For drinks, a hot rum toddy (in thermos) is in order for starters. To serve six, dissolve six lumps of sugar in a tumbler of hot water. Add a good shake of cinnamon, another of allspice, three or four small pieces of lemon rind, and one

Edward Hanke



clove per drink. Add 12 oz. of golden rum and enough hot water to make eight generous drinks. Pour piping hot into the thermos. For something to go with the cold cuts, a good ale is hard to beat—Ballantine's India, or the English Bass or Whitbread, are favorites.

With all the hot-food carriers now on the market, carrying a hot dish for tailgate consumption is no problem. A real cold weather favorite are German meatballs, or *Konigsberger Klops*. For six servings, ingredients are two slices bread (soaked in water), 1 lb. ground beef, ½ lb. ground veal, ½ lb. ground pork, three eggs, 2 tbsps. butter, ½ cup minced onion, 3 tbsps. chopped parsley, 1 tbsp. grated lemon rind, 2 tsps. lemon juice, 1-½ tsps. Worcestershire, salt and pepper, and 5 cups of stock or canned beef broth (boiling). For the sauce, 2 tbsps. of capers and enough butter and flour roux to thicken will be needed.

Saute the onion in butter. Squeeze the water out of the bread. Mix these and all ingredients and form 1-½-in. balls. Drop them into boiling stock or beef bouillon and the butter-flour and capers. Bring to a boil. Keep separate in the thermos. At the game, serve the sauce over the meat balls on paper plates.

A hot mulled wine goes well with Klops. To serve six, heat (but do not boil) one bottle of red wine in a suitable saucepan. A regional Bordeaux such as St. Emilion, or a chianti, Spanish Rioja or California burgundy will do. Add 1 qt water, ¼ cup sugar, two or three twists of lemon peel, a couple of dashes of Angostura, a pinch of allspice, ½ tsp. cinnamon, and six cloves. When it is piping hot, strain it into thermos bottles.

Tailgate party fans generally have their own preference for cocktails before digging into the food, but an excellent choice before serving the Klops and wine would be a *whiskey sour de luxe*. The recipe calls for the following per drink: a drop or two of Pernod, two jiggers of bourbon (2 oz.), the juice of half a lemon (or more, if the fruit is not particularly juicy), and a half teaspoon of sugar. Shake it all together with ice, and shake real hard. Then pour it into a thermos for the trip to the game.

Most hosts figure about one or one and a half drinks per guest when they load up the thermos. But the total volume depends on the nature of the guests—and how frosty a reception October has whipped up at the stadium.

Veteran tailgaters add these pointers: Bring plenty of paper napkins, forks and spoons (knives are not really necessary). Plastic cups serve better than paper. The soup goes best in heavy mugs of china or enamelled tin, even if they must be washed later. Above all, be prepared to serve without delay; the game, after all, is the thing—fiddle too long, and you may lose your audience.

It's the season for apples—and cider, too

Apples have been bred in just about as many varieties as their distant cousin, the multinonymous rose. But does an apple by any other name taste as sweet? Americans, according to a recent survey, couldn't care less. Just three names—Delicious, McIntosh, and Winesap—top all others as the favorites.

Delicious is semi-tart and particularly favored as a desert just as it comes from the tree. It has excellent keeping qualities, although it does turn mealy when over-ripe. The more globular McIntosh has dense meat that is crisp and tangy; its main drawback is that it bruises easily. Winesaps are particularly fine for pies and for making sweet cider.

Cider is most easily made with a cider press. Anyone without one, however, is free to substitute time and muscle. One process is to run cut-up apples through a meat grinder, then mash them to a finer pulp with a mortar. The pulp is then placed in the center of a length of strong but loosely woven cloth. By twisting from both ends, a willing worker can hope to express about a gallon of juice from every 30 pounds of apples. A few ripe crabapples added to the mix lends zest.

The cider one buys in markets and at roadside stands usually contains preservatives. Occasionally it can be found without these additives, and the temptation is to use it to make hard cider; indeed, some of it is sold that way, with or without the proper credentials for peddling alcoholic beverages, which it is, running to about 12 to 14 proof. But trying to ferment your own sweet cider can prove to be a disaster unless the proper equipment and strain of yeast are used. One source of information and supplies can be found at Semplex of U.S.A., Box 122276, Minneapolis, Minn.

Just how "hard" pure sweet cider gets depends, in the end, on the degree of aging. For the impatient, there are some quick substitutes. One is concocted by shaking together 8 oz. of freshly expressed apple juice, 1½ oz. of vodka, a dash of bitters, the juice of half a lime, and a pinch of cinnamon.

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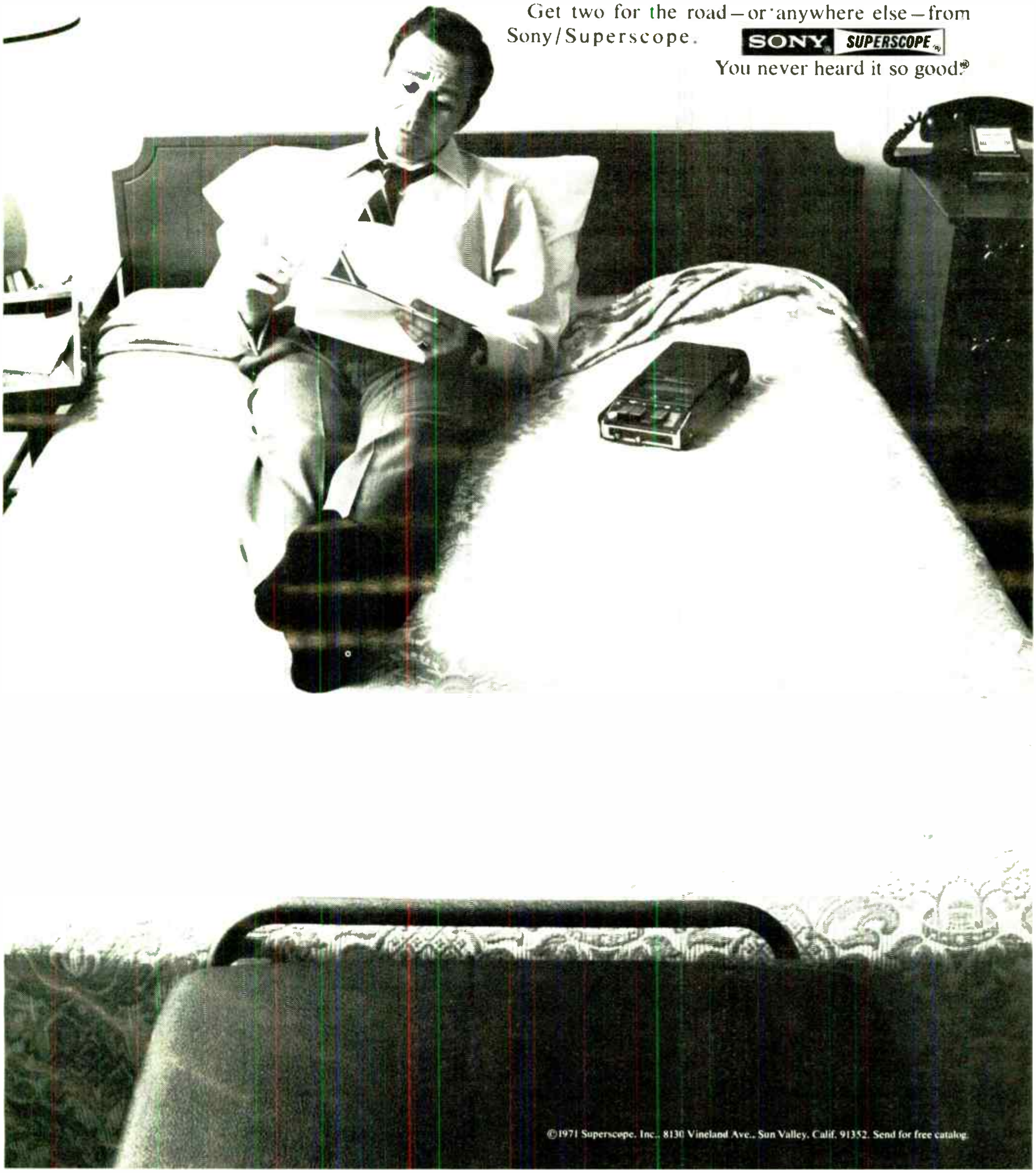


Kennedy Center: VIPs and tourists jamming the aisles

IN WASHINGTON, THE ARTY FARE SPANS AFRO AND BOSTON POPS

When the John F. Kennedy Center for the Performing Arts opened in Washington last month, it had an immediate and paradoxical effect on night life in the capital. It made it harder to get tickets for plays and concerts—but more fun for the man who lands a pair on the aisle. Music-loving tourists as well as locals and all stripe of VIPs—who formally picked up tickets to most Washington shows at the last minute—are learning to plan in advance. Those from out of town are lining up their seats through their out-of-town ticket brokers, or are putting the bee on contacts in the capital.

And advance planning pays. The Center, a huge white marble palace at the Potomac waterline, is spacious, gracious, delightful. Its cream-white-red interiors glisten with imported mirrors and crystal, and provide acres of room to promenade, possibly to view the political luminaries who have been drawn like everybody else to the Center. Or (thanks to a special mandate from the Congress) a lover of the arts can sip cocktails between the acts, and—if installed in one of the poshier boxes—can chat with friends in a private anteroom almost as big as the den back home. Democratic is hardly the term.

The Center's entrance is from a landscaped flagstone terrace off an extension of New Hampshire Ave., and it is no place to arrive at the last minute. Showgoers have a 300-ft. walk through flag-draped halls to the Center's river side where the foyers of the various auditoriums flow into the main thorofare. The 19-million cu. ft. structure has four theaters (including a film house to open next season), a cocktail lounge, and three quite pleasant restaurants.

The acoustics?—There's not a "dead" seat in the house: this holds true for the largest auditorium, the concert hall, seating 2,760.

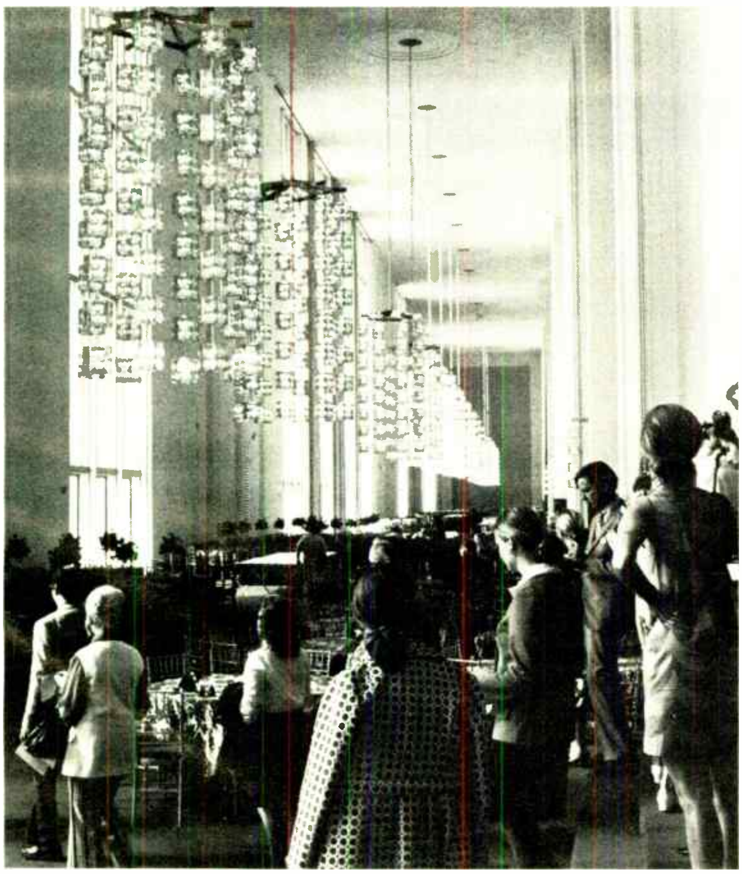
A few of the big-name performers have been sold out for weeks, and scalpers in and about the town's big hotels are charging hold-up prices. But there remains an opportunity to obtain tickets conventionally for such items as:

- The world premier this month of *Wilderness Journal*, a symphony by John Lemontaine, especially commissioned for the Kennedy Center.
- A founding-artists series to raise money for show tickets for the poor; among the pop stars appearing are Diahann Carroll (Oct. 8), Pearl Bailey (Oct. 9), Victor Borge (Oct. 29), Tony Bennett (Nov. 13), Duke Ellington (Dec. 26).
- Two top American ballet companies—the National, using the opera house the weeks of Oct. 10 and Dec. 5, and Ballet Theater, the Center's own company, opening for two weeks on Dec. 19.
- A refurbished version of Leonard Bernstein's 1956 musical *Candide*, with a new book and changes in the score—a pre-Broadway run (Oct. 21-Nov. 19).
- Concerts by many of the world's great symphony orchestras, including not only such standards as the Philadelphia (Oct. 4), Boston (Oct. 25), Detroit (Nov. 5), and Chicago (Nov. 19).
- An Afro-Asian festival built around dance troupes from Senegal, Iran, Cambodia, and Morocco, and featuring such theatricalism as the sword dance.

Other star billings include Antal Dorati leading the National symphony and chorus, and various soloists, in a complete version of Haydn's *Creation* (Nov. 2-4); England's new Philharmonic, with Lorin Maazel conducting (Nov. 15); a new production of Verdi's comic opera *Falstaff* (Dec. 2-6); *Story Theater*, Paul Sill's unique combination of mime and fable-telling that clicked last season as a Broadway attraction for children (Dec. 6-Jan. 1); and the Moravian Folk Company of singers, dancers, and musicians from Czechoslovakia (Dec. 12).

With as many as three major attractions in the Center the same night, the managers have tried to unmuddle the traffic crush by staggering curtain times. Still it can be a nerve-racking affair to have to inch a car into or out of the 1,600-space underground garage. Waiting for a cab for the after-show trip to your hotel can be a drag, too. So Washingtonians and repeat visitors have found that the best gambit is to arrive early and stay late, dining and drinking at La Grande Scene or at one of the two other restaurants in the Center.

The Kennedy Center sits alongside Rock Creek parkway, with little else but trees and the river close by. One dining spot within wandering distance is the first-rate Watergate Terrace, in the apartment-hotel complex that has become so popular with the upper echelon of the Nixon administration. It is a well-lit two-block walk from the Terrace to the Center, and a number of showgoers have been dining there. There is also a Howard Johnson at hand.



The teen-ager, the parent —and alcohol

"It isn't always pot, by any means," says Dr. Şelden Bacon, director of the Alcohol Studies Center, Rutgers University. "Parents, some of them, anyway, ought to take a close look at the teen-ager versus alcohol." Why teen-agers drink, how much, when, where—and with what effects—are carefully explored in an excellent study, *Teen-age Drinking*, by Bacon and Jones (Crowell). It's a book that pulls few punches—and a lot of them are aimed at parents with dated misconceptions. The obvious point is made: By and large, a teen-ager's drinking habits are patterned after what he sees his parents do. Then the advice becomes less obvious. Some examples:

Drugs: Don't relate the drinking experimentation of a teen-ager to the use of drugs. The two habits are quite different, and drinking rarely leads to drugs. Driving: Drinking is *not* a prime cause of teen-age auto accidents; teen-agers are generally well aware of the drinking-driving problem, often more so than their parents. Sex: Drop the notion, too, that teen-age drinking is a sure sign of an inner maladjustment; and as for sex, the evidence shows that most teen-agers are, again, well aware of the alcohol-sex relationship. Some evidence indicates that modest drinking actually may reduce experimentation in sex. Finally, the authors pose the question: Why are so many parents so ready to believe the worst about teen-agers?

Tax scene: the smartest way to handle "T & E"

Anybody who fails to keep clear, complete records of travel and entertainment ("T & E") expenses may face double jeopardy: They may miss out on the business expense reduction and pay a penalty besides. Lately the IRS has been undercutting deductions by 100% where records have been poor (and on appeal, the Tax Court has sided with IRS). Now, a hot stick has been poked. In a recent case, the Tax Court backed the IRS and disallowed an MD's professional entertainment costs due to faulty records—then slapped on a heavy penalty. Question of the deductions' legitimacy made no difference. *Moral:* Keep a detailed T & E tax diary, plus receipts for all outlays of $25 or over. . . . Brighter side: A new Tax Court case shows that travel expenses can be deducted where a taxpayer goes on a trip to inspect a piece of investment real estate—even in a resort-area.

Estate tax trend: There is no question about taking the proceeds of your private life insurance out of your taxable estate—by giving all interest in the policy to your wife, with no strings attached. Now you can do the same thing with *group* life insurance (company, association, or the like)—*if* state law specifically allows it. States have been changing their laws on the point, and at latest count, Iowa and Missouri have brought the total to 39. . . . The hitch? You can't back out later on, and change beneficiaries.

Jet-setters may not zoom down on Florida's brand new Disney World, but you'll find families with kids (and without) jamming the place. This $300-million, 27,000-acre spread of fun, fable, and Americana a la Disney, 15 mi. south of Orlando, inland—*is* fabulous. If you plan a visit, take this tip: Book a hotel weeks ahead, but don't count on those at the site or in Orlando. Drive to and from the show in a car, from Tampa (try the Causeway Inn, Causeway Inn South, or Manger Motor Inn), from Sarasota (Three Crowns, Frontenac), or St. Petersburg Beach (Treadway Inn). . . . Now is the time to book hotel space for the summer Olympics, Munich, West Germany (Aug. 26-Sept. 10, 1972). Recommended hotels are Bayerischer Hof (rooftop pool), Continental (excellent grill room at this writing), Regina Palast, Vier Jahres-zeiten, and the Germania. Send letter with check for two nights of a week's stay ($60); or, because Munich will be jammed, stay at a small town inn within commuting distance. Write 20 Olympiade, No. 8 Munchen, 13, Saarstrasse 7, Abteilung W, Munich.

International Newsletter

October 11, 1971

U.S. computer firms turn out for Soviet EDP show . . .

Foreseeing a breakthrough in electronics trade with the Soviet bloc, more than 100 Western manufacturers of computers and related hardware have turned up at "Systemotechnika 71," a data processing and office equipment show now being held in Leningrad. Glahe International, a German trade-fair organizer instrumental in lining up the firms, regards **the big turnout of U.S. companies—14 altogether—as the first major step toward an East-West rapprochement in the electronics sector.** Among the 14 American firms are IBM, Western Electric, NCR, ITT, Bell & Howell, Rank-Xerox, and Memorex.

Glahe International says that the lineup of Western hardware was selected to meet Soviet needs in computer and peripheral device applications, in air and road traffic control, in hospitals, schools, universities, statistical offices, and at various administrative centers. **One requirement that the Soviets insisted upon was that Western peripherals be able to work in conjunction with Russian-made computers.**

. . . as IBM moves closer to deal with U.S.S.R.

The Leningrad show is another step in IBM's march on the Soviet Union's market for computers and related equipment. **IBM is using an impressively large stand at the show and is displaying a 360/50—hitherto not sold in the U.S.S.R.** Moreover, IBM recently disclosed that it had engaged the services of Satra Consulting Corp., a New York-based firm specializing in East-West trade, to handle some of its needs in developing eventual Soviet business.

These two moves represent a further significant coming-together for IBM and Soviet computer planners. A year ago, a top-ranking delegation of IBM officials visited Moscow, but chairman Thomas Watson refused to comment on the prospects of dealing with the Soviet Union, pending the outcome of consultations with Administration officials. At that time, he only hinted at what he termed a "potential relationship."

European firms seek to fill void left by RCA

RCA Corp.'s abrupt scuttling of its computer manufacturing operations is intensifying negotiations toward cooperation among European electronics companies interested in building their own computers. Siemens AG, which was a partner with RCA in computer manufacturing [*Electronics,* International Newsletter, Sept. 27] **is said to be moving toward alliance with the Netherlands' Philips to form a combine that could take second place in the European computer market behind IBM.**

The RCA move also is said to have given new impetus to talks among those two firms and France's CII and Britain's ICL, leading to a possible tie-in for computers. The companies are reported to be seeking some form of collaboration without government intervention to take up the slack left by RCA. **ICL may be a big gainer in any such move;** the company was said to have been working on a deal with Siemens about three months ago, but the German firm, at that time still linked with RCA, was reluctant to flash the green light.

British firm builds 350-MHz counter

A new high in frequency rating for a direct-gated frequency counter is claimed by Britain's Racal Instruments Ltd. The instrument gives 1-hertz resolution on a one-second sample to 300 megahertz under adverse conditions and 350 MHz in normal use. Available higher-frequency counters divide down the input frequency before gating a sample, so that last-figure resolution is lost, says the company. Racal uses MECL-3 ECL gates on multilayered thick film substrates to keep interconnections short and precise, plus a thick film preamplifier with 10-millivolt sensitivity and a programable attenuator to adjust the input level. U.K. price will be $1,860. Higher-frequency counters are in development.

Sony develops consumer Earom...

A nonvolatile semiconductor memory that can be erased with impulses of reverse polarity from the writing pulses has been developed by engineers at the Sony Corp. The memory uses a single metal-alumina-oxide FET of the n-channel enhancement type to obtain read-access times in the tens of nanoseconds. However, write and erase times are too slow to allow use in read-write applications, so the new unit will be used as an electrically alterable read-only memory. Single-chip devices built thus far have had up to 256-bit capacities; larger configurations with decoding capabilities are planned.

The Earom was developed in Sony's semiconductor production plant rather than in the laboratory, and so company engineers feel they can move it into products as early as next year. Applications may include programing radios or TVs to turn on a specified station at a predetermined time or programing jukeboxes.

...as GEC works on silicon gate associative memory

In a joint effort, GEC Semiconductors Ltd. and GEC-Marconi Electronics Ltd. are developing a 128-bit silicon gate associative store for production next year. Experimental MOS content-addressable chips show that search time will not be longer than 10 nanoseconds and write time within 15 ns. The chips measure about 120 mil^2 in a dual in-line package. Normal arrangement will be 16 words of eight bits and the price objective for 1,000-and-up quantities is less than $30. GEC men envision a substantial market in parallel data processing and in high-speed correlation functions, particularly in radar where the existing trace can be held in the store and the incoming trace compared with it very quickly.

Nixdorf takes award for Spanish terminal network

Winning out over heavy competition, West Germany's Nixdorf Computer AG has landed a $1.5 million contract to set up a nationwide computer terminal network in Spain. The system will consist of 120 terminals and eventually tie together all revenue-collecting offices around the country. The terminals initially will be used in off-line operation but later will be put on-line to work in conjunction with a central computer—an IBM 370/135, located in Madrid. The terminals are Nixdorf 820/05 models.

Addenda

Interdata Inc. is buying an assembly plant in Britain for its new model 70 and 80 minicomputers, and plans to be fully operational by next summer. The New Jersey firm plans for eventual full manufacturing in Britain . . . The Swedish Ministry of Industry has named a commission to study the steps necessary to improve the native computer industry's competitive position, and to promote better use of EDP by industry . . . Australian sources report that nation's computer companies are being flooded with job applications from the U.S. following the demise of RCA's computer division.

Read-only memory cut out for the job

Diagonal slots in plane dividing word and sense lines couple lines when signal polarization is correct

A read-only memory, claimed to be 10 times larger per module and four times faster than existing units, has been developed at Philips' Gloeilampenfabrieken's sprawling laboratories in Eindhoven, Holland. The unit uses a new matrix in which information is stored in linear inductive coupling elements between the word and the sense lines.

The construction sandwiches a ground plane between a set of horizontal word lines and a set of vertical sense lines. To obtain the coupling, slits are etched in the ground plane at each crossing of word and sense lines. The slits are oriented in either of two 45° diagonal positions. The structure is completed with two shielding ground planes on either side of the sandwich.

High-frequency components of the magnetic field of the word lines penetrate the ground plane through the slits. The direction of the field that penetrates the ground plane depends on the orientation of the slits. The result is not a yes/no system, as are most capacitance or inductive stores, but a coupling that is either positive or negative.

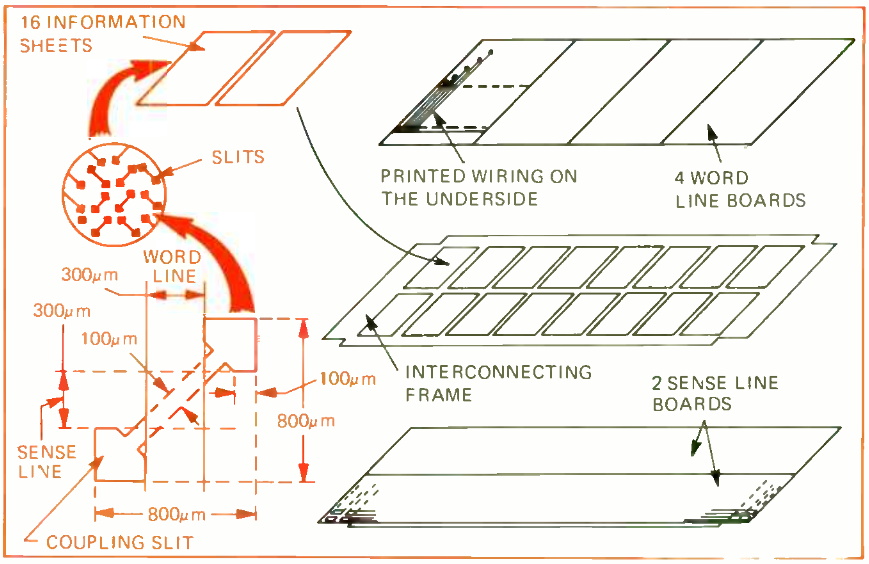
In working out the concept over the past five years, Philips researchers were influenced by what they felt were two disadvantages of existing capacitance systems: "If you take a capacitive coupling element," says R.M.G. Wijnhoven, research scientist at the Philips lab, "you can have the situation where only one capacitance is loading the other word line." This loading variation results in variations in driving wave form, and, to give adequate tolerances on timing, elongates cycle time. The same situation occurs on the sense line where one or many, or even no, capacitances are coupled to it. This influences propagation characteristics, again resulting in variations in timing.

Considerable research went into determining the best slit shape. To avoid parasitic capacitance couplings, the slit must be as narrow as possible near the crossing of the sense and word lines, yet there must be space for the magnetic field to penetrate the ground plane. Capacitance coupling is minimized in the Philips system by giving the word and sense lines a pitch of 1 millimeter. Also, inductive couplings are optimized by use of dumbbell shaped slits (see diagram).

The biggest trouble, however, stemmed from noise due to the eddy current in the ground plane. Connections of the word lines to the ground plane at edges of the matrix were tricky because the ground plane current spread out to regions of neighboring slits. The solution was to allow for a 1.5 centimeter unused edge.

The complete memory stack, consisting of 2,048 words, is made up of four submodules of 512 words each. These submodules are built up of two sense line sets, each 100 lines wide, on a flexible Mylar sheet, which is then glued to a 0.6-mm glass-epoxy board, with the ends of the sheet used to interconnect the sense lines via a pressure contact.

Instead of an integral information-carrying ground plane, Philips opts for a plane made up of small pieces covering 64 words and 100 bits. These are mounted in a ground plane frame made of gold-plated copper on Mylar and containing windows in which fit the smaller in-



formation planes. The gold-plated edges of the small planes overlap the window edges and pressure contact makes an integral ground plane system. On top of the ground plane, perpendicular to the sense lines, are placed 512 word lines, etched on four 0.6-mm boards. The sense lines, information plane, and word line boards are positioned simply by using registration holes and pins.

The pitch of 1mm for word and sense lines is a practical minimum, fixed both by the limits of etching very long lines and the fact that the output signal becomes extremely small when the stack is reduced. "With this pitch," says Wijnhoven, "if you feed in 200 milliamperes with a rise time of 10 nanoseconds you get an output signal equal to, or larger than, 1.2 millivolts." Maximum propagation delay on the sense line is 16 nanoseconds and the attenuation is 4 decibels. Word line delay is 2 nanoseconds.

In the electronics around the memory, Philips licked the small signal detection without major difficulties by using a preamplifier which boosts the signal up to about 20 millivolts. A post selection circuit using MOS/FET transistors condenses the internal 200-bit word to an external 100-bit word. Then comes a polarity detector with an input sensitivity of 10 millivolts. Detection chain delay is 11 ns.

West Germany

Crossed light beams bridge operator/display interface

Take an array of light beams, crossing at right angles, mount it about half an inch in front of a display—CRT tube, microfilm screen, even a TV set—and you've got a novel method of selecting and marking the information displayed for computer processing.

That's the approach taken by Siemens AG in a system that allows an operator to merely jab a finger or a pencil, which interrupts two of the crossed beams, at a spot on the screen to select a displayed item. Siemens called the system a light-gate, field-selection matrix.

The new technique, devised by Peter Salminger of the company's Munich-based data technology laboratories, offers several advantages to terminal designers. Since information selection can be done directly with the finger and without any space-consuming aids in front of the terminal, the equipment layout is considerably simplified. It's further simplified because the selection process is not incorporated into the display but is performed external to the screen. What's more, since the beams can be in the infrared range, the displayed information is not obscured, as it might be in selection schemes using an overlay of touch-sensitive wires.

Matrix. In the prototype setup, the light beams that form the selection matrix are produced by a series of light transmitters arranged along two adjacent edges of a frame. On the opposite two edges are semiconductor light-detector elements, one for each transmitter. The light comes from a single gallium-arsenide source, the emission of which is distributed to individual transmitters through glass fiber light pipes. Lenses produce the required beam collimation.

The beam pattern is made up of five vertical and six horizontal beams, giving a matrix with 30 possible selection fields. Of these, five are used as control fields and 25 as information fields. Thus, with a typical screen display capacity of 14 80-character rows, each information field can accommodate an information item, or discriptor, with up to 45 characters. The five control fields are used to initiate specific hardware functions such as transmission, reset, or display-erase, and thus correspond to special-function keys of keyboard-type control devices.

VW harnesses a computer to diagnose bugs

Despite the inroads electronic measuring instruments have made into automobile service shops, the mechanic's job of pin-pointing faults can still be an exasperating one. Now, Volkswagenwerk AG, Germany's biggest automobile maker, has introduced an electronic fault-location setup. Built around a small computer, the system links up with the test circuitry being installed on all new VW models and carries out up to 88 different checks—many of them fully automatically—in about half an hour. At the same time, the system prints out the test results to tell the repairman which parts are defective or are expected to go bad shortly. For the car owner that printout also serves as a record of his car's performance.

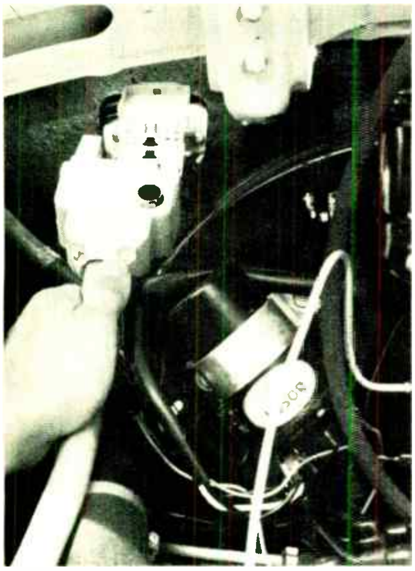
To get maximum effectiveness from the system, VW is incorporating the test circuitry in all models in serial production. The internal circuitry, which comes at no extra costs to VW car buyers, will also be installed in the Audi models made at the company's Audi-Union division.

On line. The first such computer-run diagnostic stands, will show up shortly at the company's service shops in Germany. By May all 2,500 VW shops there will be equipped. Later, the setup will be installed at VW shops elsewhere in Europe and overseas.

The diagnostic stand costs around $3,000, complete with computer, the printer, a reader, and a small keyboard unit. To speed up hardware delivery for the systems, two firms have been chosen as the prime electronics suppliers—Siemens AG and Hartmann and Braun, a Frankfurt company. Hartmann and Braun is building the systems—about 1,500 of them—that will go abroad.

The systems will be installed at VW shops on a lease basis; shop concessionaries must pay a rental fee of about $86 a month. The 88-point test will cost car owners between $3.60 and $4.20 depending on VW model. The first five diagnoses after a new car purchase will be free, however.

To perform the tests the mechanic fits the plug at the end of the diagnosis cable into a multi-pole socket on the car. Next he replaces the oil dipstick with a temperature sensor, because oil temperature is one pa-



Check out. Volkswagen's new models have computer connection tap.

rameter to which some of the subsequent measurements are related. He then inserts into the system's reader a plastic punch card containing the test program. A number pasted next to the test socket tells the mechanic which card to use for the particular VW model being checked. The punch card contains all the data for the diagnosis program plus the nominal values of test parameters with which the actual ones obtained during the tests are compared.

The test program begins with a few visual inspections, which include checking the play of the steering wheel, the clutch, the handbrake, and other mechanisms. During these checks the mechanic uses the portable keyboard unit pushing "plus" or "minus" buttons depending on whether results are good or bad.

Next come the test items that the computer checks out automatically: brake lights, turn signals, rear window heaters, battery, and other electrical systems. In the battery check, for example, the state of charge is determined as well as the voltage drop it produces across various electrical devices. Compression is determined indirectly by measuring the amplitude of the starter current which is required to turn over the engine. In these and similar tests, the computer compares the nominal values with those fed in by the test circuitry.

Some of the checks do demand a bit of work on the part of the mechanic, however. For instance, in toe-in, toe-out, and camber measurements of wheel suspension and alignment, the mechanic removes the front wheel hub caps and mounts a small mirror in their place. About two feet off to the side is a projector and an array of photocells. When the steering wheel is moved back and forth, a small cross of light formed by the projector is focused on the photocell array. The currents produced by the cells are added and the corresponding voltages are changed into degree and minute readings, which indicate whether or not limit values are exceeded.

France

Home-grown CAS system enters world competition

French engineers have developed an aircraft collision avoidance system (CAS) that threatens to collide head-on in the international electronics market with American systems now being developed. The French have taken pains to make their version compatible with the systems in the United States so that they will be in position to capture a good share of the business—once airlines decide to equip all commercial craft with anticollision gear.

Jean Besson, chief of the design team working on the system, says it can achieve distance accuracy of 3 meters and speed accuracy of 20 knots/second, a performance he claims surpasses that of U.S.-developed versions. The French have followed the standards set down by the U.S. Air Transportation Association, which has been encouraging development of CAS prototypes. McDonnell Douglas, Bendix and Sierra Research all have come up with proposed systems.

The French prototype, now in its final development stages, is being handled by ONERA, the National Office of Aerospace Study and Research, located just south of Paris in the suburb of Chatillon.

Final tests are planned for this autumn, Besson says, when the system will be tried out over the sea and mountainous terrain to check for echo problems and to increase the range of the system to 50 miles. Tests over flat terrain this spring were successful. "We have no reason to expect any obstacles," says Besson, who hopes to turn the test findings over to French industry for commercialization.

ONERA believes that with the growing number of aircraft in the skies—and the imminent arrival of supersonic transport—CAS will soon be standard equipment for commercial and business aircraft. It already has assurances from the Concorde builders that the ONERA system will be a recommended Concorde accessory.

Compatibility. ONERA's system would work only between planes equipped with the same or compatible gear. It would operate with a 50-watt transmitter on a frequency of 1.6 GHz. Besson says that when two aircraft enter the 50-mile range, they would pick up each other's signals. The distortion from the assigned frequency would permit equipment aboard to calculate the rate of approach by measuring the amount of Doppler effect, or change in frequency due to the movement of the transmitters toward the receivers. The distortion would be only 0.0001%, if the two craft were approaching at a rate of 300 meters per second, about 600 miles an hour, Besson adds; hence the need for precision equipment to analyze the signal.

Due to the high frequency of the signal, however, Besson's team had to add a frequency divider to reduce it to 50 MHz, a measurable range. The distortion is then reamplified and measured to provide the exact tau factor—or rate of approach. Meanwhile, the precise distance between the crafts is being measured by timing the exact moment of reception.

Transmissions from all equipped aircraft would be synchronized by precision oscillator clocks. ONERA tentatively plans to use a rubidium atomic clock developed by Thomson-CSF.

The clock controls the emission of the radio signal every three seconds. Each three-second burst is divided into slots of 1,500 microseconds, allowing for each aircraft to read messages from many aircraft at once. Every emission contains the transmitting craft's altitude.

These data are compared in a minicomputer with the altitude of the receiving craft. The computer sounds the alarm if it calculates a collision course and the pilot is advised by a flashing light to climb or dive immediately.

Japan

Coding opens way for semiconductor laser link

Based on a small solid state laser, a communications system developed by Nippon Electric provides performance rivaling that of systems with large gas lasers—at a lower price. The system can transmit six telephone voice channels, or 300-kilobit-per-second data, up to 3 kilometers and in Tokyo's climate achieve error-free operation more than 99% of the time. If the distance is reduced to 1 kilometer, 99.9% operation is achieved.

Price of the equipment, about $10,000 per unit, includes coder and decoder, laser transmitter and avalanche photodiode receiver, and receiving and transmitting antennas. The receiving antenna is an inexpensive-to-make fresnel lens, and the transmitting antenna is a camera telephoto lens specially coated for use at near infrared.

The semiconductor laser can deliver reasonably large pulses, but its duty factor is low. Thus a highly efficient modulation scheme is needed.

The laser is operated at a peak power output of 0.5 watts and a duty factor of 0.1% with a pulse length of 20 nanoseconds and repetition rate of 20 microseconds. With on-off modulation the data transmission rate is only 50 kilobits per second. This data rate can be increased by the use of pulse-position modulation. Each 20-microsecond interval is divided into a number of equal length time slots, and the slot in which the pulse appears can be made to vary with the input information. A 20-nanosecond pulse length gives up to 1,000 slots.

Nippon Electric goes one better, though. It uses differential pulse-position modulation, which eliminates the need for synchronizing or other noninformation pulses.

In this approach, each 20-microsecond interval is divided into, say, eight equal-length time slots repeating endlessly. As opposed to standard pulse-position modulation, where the signal for succeeding time frames may appear in, say, positions five, three, and four, in differential pulse position modulation the first pulse appears in slot five, but the following number, three, will appear three empty positions later, or slot one of the second frame.

If no special precautions are taken, the following four would appear in time slot six of the same frame. This cannot be allowed because two pulses in the same frame exceeds the laser's allowable repetition rate. What's more, the average signal pulse rate would exceed the sampling rate, an impossible situation. Nippon Electric engineers solved that by shifting the pulse by the length of one frame, or eight time slots, an innovation that makes the approach practical.

The actual system built by Nippon Electric can transmit six telephone channels or 300 kilobits per second and so requires 2^6 power or 64 time slots. It expects to use an even shorter pulse and build a system with 4,096 time slots.

Great Britain

Car's image displaces radar in speed checking gear

Speed trap radars used by the police in Britain date back about a decade and need a heavy-duty battery to power a klystron. One candidate for the next equipment generation is the Gunn-diode powered radar, which is very much lighter. But the Home Office, which supplies speed trap equipment to the police, may abandon radar altogether and use the optical image of the vehicle.

The principle is to look at the passing car through a fixed vertical grating and use a photodiode to register the frequency with which a bright spot in the image moves in and out from behind the grating bars. The fluctuations in diode output will be directly proportional to vehicle speed, and so provide an easy basis of measurement.

Home Office men say the main advantage of the proposed equipment is that it can be very light; the solid state electronics are low voltage and use little power because the system uses no transmitted beam. It will also be used across the road at right angles, which will get rid of the doppler radar squint angle that sometimes produces ambiguous results and legal arguments.

Peaks. Though an unambiguous waveform from the photodiode might seem to depend on nonuniform distribution of bright spots on the vehicle, engineers at Marconi Radar Systems Ltd., which is developing the system for the Home Office, say that in practice this is not a problem. If it did become a problem—that is if reflectivity is just too uniform—it could be dealt with by tracing the peaks of individual bright spots, they say. For night operation, it would probably be used along with a weak light pointed across the road.

Marconi's prototype equipment obtains a grating effect by using 16 narrow, vertical mirrors side by side and slightly separated. The mirrors focus the vehicle's image on a single photodiode. IC logic is used for establishing the validity of the signal, frequency counting, and driving a three-figure readout, which may be solid state or liquid crystal. The aim is a system that will give an accurate reading from 20 to 150 miles per hour and fit in a box that can easily be carried around, resited and put into service by one man.

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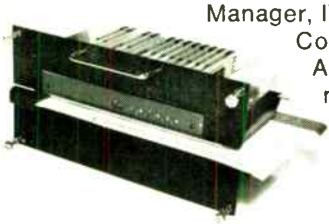

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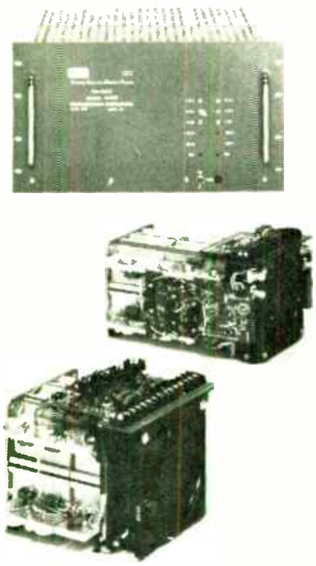

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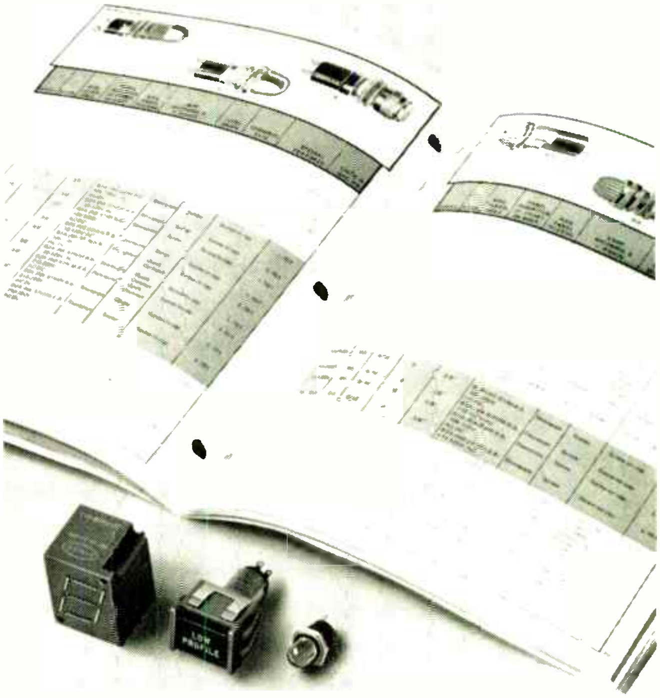

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October 11, 1971

Electronics

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*For *employment* inquiries fill in *home* address. October 11, 1971 card expires December 11, 1971

Name ____________________ Title ____________

Company* ____________________

Address ____________________

City ____________ State ____________ Zip Code ____________

1	22	43	64	85	106	127	148	169	190	211	232	253	274	295	316	337	358	379	400	421	442	463	484	960
2	23	44	65	86	107	128	149	170	191	212	233	254	275	296	317	338	359	380	401	422	443	464	485	961
3	24	45	66	87	108	129	150	171	192	213	234	255	276	297	318	339	360	381	402	423	444	465	486	962
4	25	46	67	88	109	130	151	172	193	214	235	256	277	298	319	340	361	382	403	424	445	466	487	963
5	26	47	68	89	110	131	152	173	194	215	236	257	278	299	320	341	362	383	404	425	446	467	488	964
6	27	48	69	90	111	132	153	174	195	216	237	258	279	300	321	342	363	384	405	426	447	468	489	965
7	28	49	70	91	112	133	154	175	196	217	238	259	280	301	322	343	364	385	406	427	448	469	490	966
8	29	50	71	92	113	134	155	176	197	218	239	260	281	302	323	344	365	386	407	428	449	470	491	967
9	30	51	72	93	114	135	156	177	198	219	240	261	282	303	324	345	366	387	408	429	450	471	492	968
10	31	52	73	94	115	136	157	178	199	220	241	262	283	304	325	346	367	388	409	430	451	472	900	969
11	32	53	74	95	116	137	158	179	200	221	242	263	284	305	326	347	368	389	410	431	452	473	901	970
12	33	54	75	96	117	138	159	180	201	222	243	264	285	306	327	348	369	390	411	432	453	474	902	971
13	34	55	76	97	118	139	160	181	202	223	244	265	286	307	328	349	370	391	412	433	454	475	951	972
14	35	56	77	98	119	140	161	182	203	224	245	266	287	308	329	350	371	392	413	434	455	476	952	973
15	36	57	78	99	120	141	162	183	204	225	246	267	288	309	330	351	372	393	414	435	456	477	953	974
16	37	58	79	100	121	142	163	184	205	226	247	268	289	310	331	352	373	394	415	436	457	478	954	975
17	38	59	80	101	122	143	164	185	206	227	248	269	290	311	332	353	374	395	416	437	458	479	955	976
18	39	60	81	102	123	144	165	186	207	228	249	270	291	312	333	354	375	396	417	438	459	480	956	977
19	40	61	82	103	124	145	166	187	208	229	250	271	292	313	334	355	376	397	418	439	460	481	957	978
20	41	62	83	104	125	146	167	188	209	230	251	272	293	314	335	356	377	398	419	440	461	482	958	979
21	42	63	84	105	126	147	168	189	210	231	252	273	294	315	336	357	378	399	420	441	462	483	959	980

21 14

*For *employment* inquiries fill in *home* address. October 11, 1971 card expires December 11, 1971

Name ____________________ Title ____________

Company* ____________________

Address ____________________

City ____________ State ____________ Zip Code ____________

1	22	43	64	85	106	127	148	169	190	211	232	253	274	295	316	337	358	379	400	421	442	463	484	960
2	23	44	65	86	107	128	149	170	191	212	233	254	275	296	317	338	359	380	401	422	443	464	485	961
3	24	45	66	87	108	129	150	171	192	213	234	255	276	297	318	339	360	381	402	423	444	465	486	962
4	25	46	67	88	109	130	151	172	193	214	235	256	277	298	319	340	361	382	403	424	445	466	487	963
5	26	47	68	89	110	131	152	173	194	215	236	257	278	299	320	341	362	383	404	425	446	467	488	964
6	27	48	69	90	111	132	153	174	195	216	237	258	279	300	321	342	363	384	405	426	447	468	489	965
7	28	49	70	91	112	133	154	175	196	217	238	259	280	301	322	343	364	385	406	427	448	469	490	966
8	29	50	71	92	113	134	155	176	197	218	239	260	281	302	323	344	365	386	407	428	449	470	491	967
9	30	51	72	93	114	135	156	177	198	219	240	261	282	303	324	345	366	387	408	429	450	471	492	968
10	31	52	73	94	115	136	157	178	199	220	241	262	283	304	325	346	367	388	409	430	451	472	900	969
11	32	53	74	95	116	137	158	179	200	221	242	263	284	305	326	347	368	389	410	431	452	473	901	970
12	33	54	75	96	117	138	159	180	201	222	243	264	285	306	327	348	369	390	411	432	453	474	902	971
13	34	55	76	97	118	139	160	181	202	223	244	265	286	307	328	349	370	391	412	433	454	475	951	972
14	35	56	77	98	119	140	161	182	203	224	245	266	287	308	329	350	371	392	413	434	455	476	952	973
15	36	57	78	99	120	141	162	183	204	225	246	267	288	309	330	351	372	393	414	435	456	477	953	974
16	37	58	79	100	121	142	163	184	205	226	247	268	289	310	331	352	373	394	415	436	457	478	954	975
17	38	59	80	101	122	143	164	185	206	227	248	269	290	311	332	353	374	395	416	437	458	479	955	976
18	39	60	81	102	123	144	165	186	207	228	249	270	291	312	333	354	375	396	417	438	459	480	956	977
19	40	61	82	103	124	145	166	187	208	229	250	271	292	313	334	355	376	397	418	439	460	481	957	978
20	41	62	83	104	125	146	167	188	209	230	251	272	293	314	335	356	377	398	419	440	461	482	958	979
21	42	63	84	105	126	147	168	189	210	231	252	273	294	315	336	357	378	399	420	441	462	483	959	980

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Sperry explodes the LED myth

There has been a lot said in recent months about LED's representing the most significant advance in display technology and how they are destined to dominate the digital display market. We feel it's time to explode the myth and set the record straight. So, here's a direct, point-by-point comparison of Sperry seven segment gas discharge planar displays† vs LED displays.

COST
For the price of a single ¼" LED digit you can buy three ½" or three ⅓" Sperry display digits*. And, in the future, the Sperry displays should continue to be less expensive than LED displays. Gives you something to think about, doesn't it?

SIZE Let the size speak for itself.

Sperry ½" Sperry ⅓" LED ¼" LED ⅛"

READABILITY
Have you tried to read a ⅛" or even a ¼" LED display at 20'? On the other hand, the Sperry ⅓" display is easy to read at that distance and the ½" model can be read at up to 40'. See the difference?

COLOR
With LED's, you have the choice of red, red or red. Not so with Sperry. They come in an eye appealing orange — with amber and red available with filters. If you like red, why pay more for a LED?

APPEARANCE
Which do you prefer — looking at individual red dots on LED devices or at continuous unbroken Sperry figures. The choice is yours.

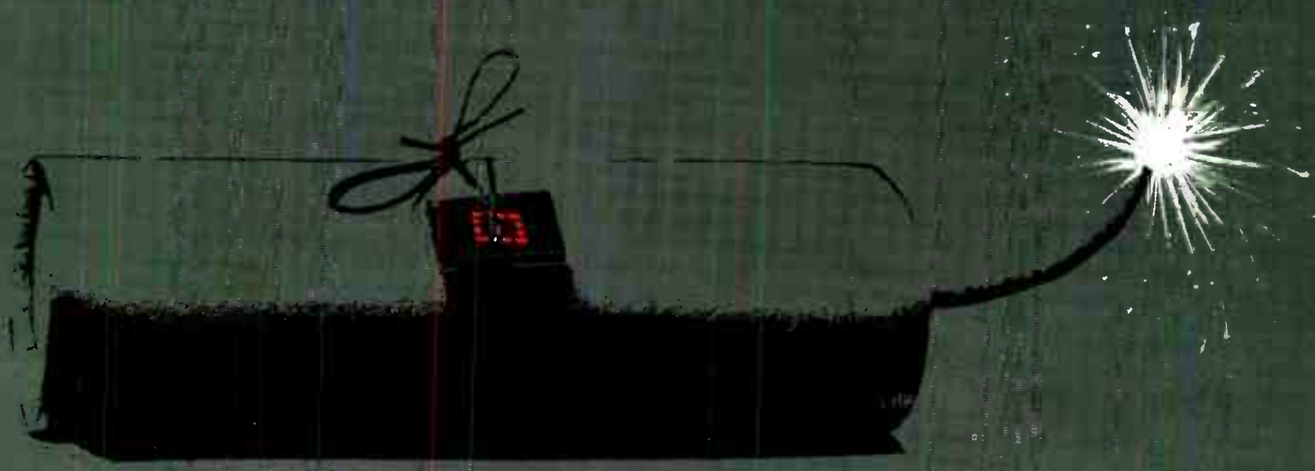
BRIGHTNESS
Sure you can read LED's indoors, but how about in bright light or direct sunlight? LED's fade fast while Sperry displays stay clearly legible with no appreciable loss in brightness. And, Sperry devices won't poop out when it gets hot!

Sperry advantages don't stop here either. The small Sperry package is only a shade larger than a LED and nearly as thin. Sperry power dissipation is also significantly lower. And, Sperry reliability is so good that they have proven fail-safe in stringent, high performance aircraft applications including the Boeing 747. There are no wire bonds to go bad, either. Don't just take our word for it. Arrange for a comparison demonstration and see for yourself what the difference will mean to your particular application.

For complete technical information on Sperry displays, use this publication's reader service card or phone or write:
Sperry Information Displays Division
P.O. Box 3579, Scottsdale, Arizona 85257
Telephone (602) 947-8371

SPERRY
INFORMATION DISPLAYS

It's a whole new ball game in display devices!

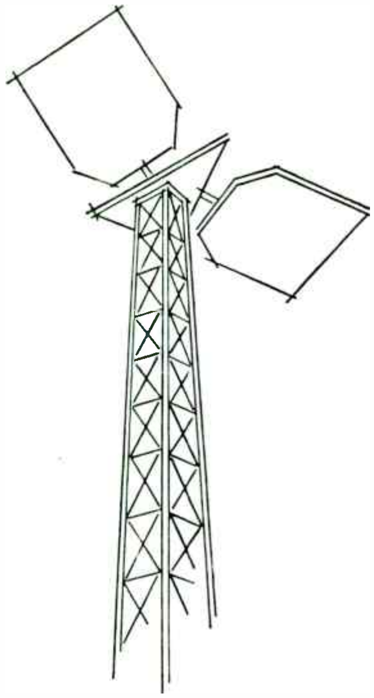


† Patents pending

*based on 1,000 digit quantity, and above. Sperry displays are available in 3 digit, 2 digit, and 1½ (7 segment character and a 1 with + and —) digit models in both ⅓" and ½" sizes.

SPERRY RAND

Circle 901 on reader service card



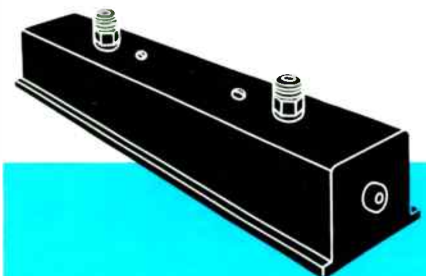
The easy way to communicate

Just look at the charts. The basic facts they present dramatize RCA's single-source capability in total product for your communications needs.

These devices are performance-proved. You get maximum dependability in communications applications.

For more information, see your RCA Representative or call Microwave Marketing: (201) 485-3900; TWX 710 995-4474. International: RCA, 2-4 rue du Lièvre, 1227 Geneva, Switzerland, or Sunbury-on-Thames, U.K., or P.O. Box 112, Hong Kong.

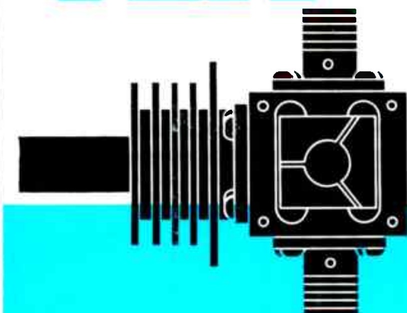
TWT's



Choose RCA traveling-wave tubes. Select from one of the industry's widest lines, supported by a 20-year background in developing and field-testing state-of-the-art systems.

RCA Type	Power Output (W)	Frequency (GHz)	Application
A1378	20	7.9 – 8.4	Government
A1446	20	9.8 – 10.7	Government
A1447	5	7.9 – 8.4	Government
A1390	20	10.7 – 11.7	Common Carrier
A1443	15	10.7 – 11.7	Common Carrier
A1455	20	12.7 – 12.95	Community Antenna Relay System
A1456	20	10.7 – 13.2	Common Carrier, Community Antenna Relay System
A1460	15	13.0 – 14.0	Government

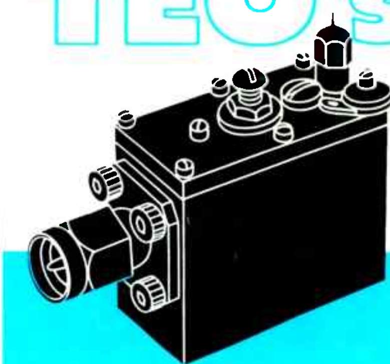
TEA's



Now you have the transferred-electron amplifier, introduced by RCA to the industry earlier this year. This is the first available octave bandwidth solid-state amplifier for C-band and above.

RCA Type	Power Output (mW)	Frequency (GHz)	Application
S384	250	6.0 – 8.0	Common Carrier
S385	250	8.0 – 10.0	Government Common Carrier
S386	120	14.0 – 16.0	Community Antenna Relay System

TEO's



You have accepted the transferred-electron oscillator as another of RCA's major contributions to microwave design. Now you have a choice in standard products and subsystems for pulsed and CW applications from L- through Ku-band.

RCA Type	Power Output (mW)	Frequency (GHz)	Application
S409	100	6.0 – 8.0	Common Carrier
S410	30	8.0 – 10.0	Government, Common Carrier
S411	30	10.0 – 12.0	Common Carrier
S412	10	12.0 – 14.0	Business Radio, Community Antenna Relay System

RCA