April 26, 1971

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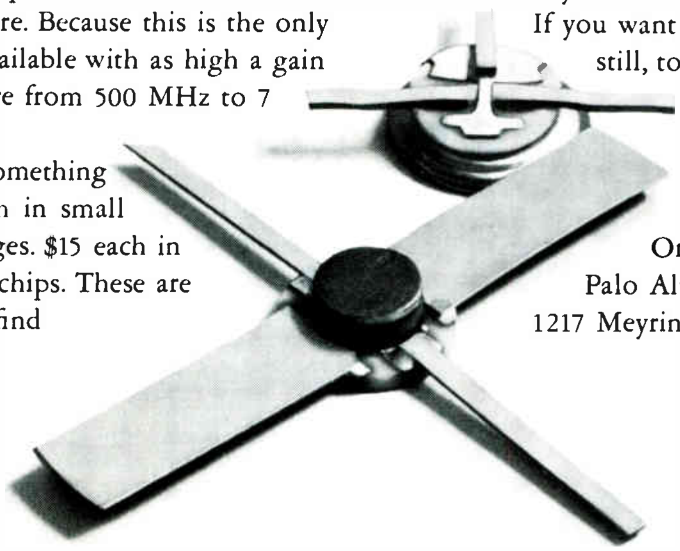

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Electronics

The International Magazine of Electronics Technology

April 26, 1971

Volume No. 44, Number 9

Electronics

Publisher's letter

Washington loves to label people in politics, and because there are so many in any given Administration, it likes to do it quickly. But no one yet has come up with any pat category for President Nixon's newest science adviser, Edward David (page 73). As our Washington bureau manager, Ray Connolly, found out when working with McGraw-Hill World News' reporter Wil Lepkowski, David is known on Capitol Hill only as a practical, likeable man "who used to work for Bell." As David's views on national science and engineering policy emerge in Congressional testimony, he's likely to face some stern questioning from a hostile Congress in what is shaping up as an acrimonious political year. One member of the powerful House Appropriations Committee, for example, believes David is "prescribing aspirin for a cancer" by not advocating massive engineer retraining and employment programs.

That is but one sample of what the former executive director of Bell Labs' Communications Principles division faces in the months to come. "Ed David is going to learn what President Nixon already knows very well," says Connolly. "Winston Churchill described it best when he said, 'politics are almost as exciting as war and can be quite as dangerous. In war you can be killed only once, but in politics many times.'"

We've put together a questionnaire (see page 53) hitting key questions in engineering that we feel every reader will want to have something to say about. The topics, such as your goals and plans for continuing education, are meaningful in themselves—and will be even more meaningful if a large enough sample of readers fills in and returns the questionnaire. We urge you to take the time to respond and make the engineering silent majority a trifle smaller. The results will appear as part of a special report we're now putting together on the problems facing engineers.

MOS/LSI, among other things, brings people together. There's a lot of design togetherness behind the article on new technologies in instruments which begins on page 38. Hewlett-Packard Co.'s Loveland division wanted to build its newest rms digital voltmeter around this young technology. Some 1,000 miles away, H-P's Santa Clara division had the same thing in mind for its proposed counter. When engineers from the divisions compared notes, they found that in many cases one circuit design would work equally well in both instruments.

When it came time to make a display, still another division—H-P Associates—signed onto the design team. The result of the combined efforts is a new readout—a single ceramic substrate containing several LED dot-matrix arrays.

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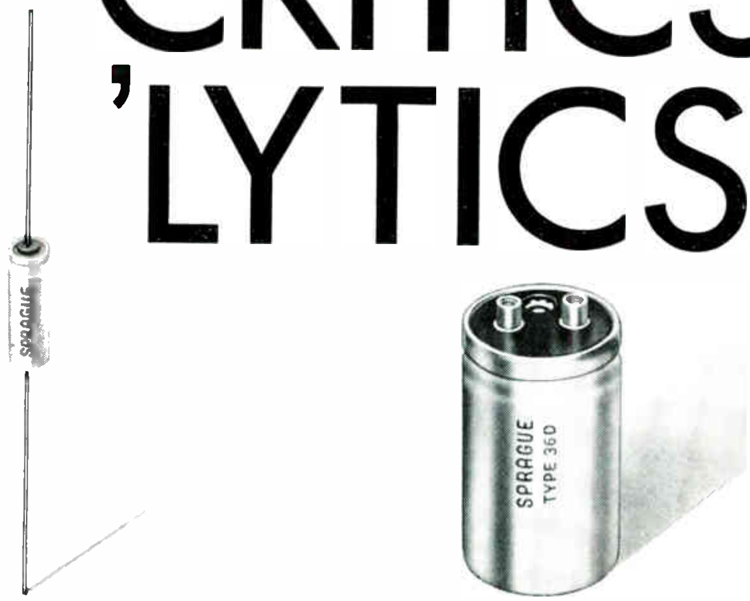

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Circle 5 on reader service card

Readers comment

Plodding plotters

To the Editor: The article on computer-generated artwork [Jan. 4, p. 22], contained some errors. First, drawing a paper pattern on an automatic drafting machine doesn't take as long as exposing the film on the artwork generator. In fact, most automatic drafting machines are 10 to 20 times faster than their artwork generator counterparts. In our plotters, the artwork generating systems are driven by the same controllers and digital stepping motors as the automatic drafting machines. High resolution is achieved by using 1/10-mil gears instead of the 1-mil gears used in the drafters; since the control and motor are identical, speed is 10 times that of an art generator.

Second, by using a flatbed or drum plotter, a verification plot the same size as the original sketch can be produced. Such a plot can permit direct verification by overlaying the drafting machine plot over the input sketch.

The claim of "several hours" plotting time is fiction. Most artwork verification plots of average density requires less than a half-hour to plot.

Daniel J. Sullivan
Product Manager,
Drafting systems
Gerber Scientific Instrument Co.
Hartford, Conn.

▪ *Automated Technology Inc. claims that verification plots made on drafting machines lack line width and flash-pad emulation. Furthermore, although the Gould printer is small,* ATI *says its software can create plots of up to 400 inches square full size by running them through the machine a strip at a time and then having the strips pasted together. And no hardware setup, such as changing gears, mounting pens, etc., is necessary with the Gould printer, says* ATI. ATI *also says it ran a plot of a high-density four-layer printed circuit board on its Gerber 2032 plotter in five hours and 14 minutes, and a verification plot of the same board on the Gould printer in 20 seconds.*

Medical electronics on wheels

To the Editor: I read the article on the Montgomery County, Md., Heartmobile [March 1, p. 26] and would like to note that the Dallons Instruments division of the International Rectifier Corp. has built the same type of vehicle for the Los Angeles County Heart Association in conjunction with the Daniel Freeman Hospital, named it the Heartmobile, and included in it the same gear and instrumentation mentioned in the article. We also manufactured a unit for the Scripps Clinic and Research Foundation in La Jolla, Calif. Both units have been in use for almost a year.

Jordan D. Frasier
Dallons Instruments
El Segundo, Calif.

To the Editor: The name Heartmobile is the property of the Ohio State University, and application for registration of the trademark is pending in the U.S. Patent Office. The Heartmobile, the first vehicle designed specifically for mobile coronary care, has been in service since April 8, 1969.

Jacquelyn L. Muter
Columbus, Ohio

Minicomputer project

To the Editor: Re the article on minicomputer networks [March 29, p. 56], we are working on a simulation system for the Naval Ordnance Laboratory using 14 Super Nova SC machines. In this configuration, a machine's address register will address 32K words; the system allows only 24K of private memory. If an address greater than 24K is detected, another register is enabled; it points to an 8K memory bank in another CPU. This 8K bank's position is determined by subtracting 24K from the memory address register. The foreign CPU memory is accessed through its data channel by a crossbar switch. This technique allows more flexibility than a memory transfer.

W. Louis Robinson Jr.
Systems Technology
Associates Inc.
Falls Church, Va.

40 years ago

From the pages of Electronics, April 1931

Serious injury may be done to the tone discrimination of children as well as adults in a home where an inadequate or "skimped" radio receiver permits only "mangled music," i.e. merely fragments of the rich musical treasures of modern broadcasting—to filter into the living-room or home circle.

Without parents realizing it, under such conditions children may be growing up in an atmosphere of musical distortion—may be listening to the bob-tailed harmonies of poor or antiquated radio sets—although all around them in the night air outside, are the utterly perfect tone values of the world's greatest broadcasting stations—tone perfections which have cost millions of dollars to attain.

No attempt can be made to conceal the disappointment which has been felt in the replacement market for tubes during the past year. It had been expected that tubes would accommodatingly burn out or "go blooey" right on schedule after 1,000 hours or one calendar year of use! But not so. Instead tubes faithfully hang on and hang on, until 2,000 hours and 3,000 hours are not exceptional, and some tubes exceed 4,000 and 5,000 hours. "Tubes are too long-lived" is the consensus of complaint everywhere in the trade.

A careful survey of the 155 firms in the set manufacturing field by the editors of *Electronics* reveals the appalling fact that with but two or three exceptions these firms did not make a profit on their radio business during the past year, if we exclude the concerns having other operations outside of radio. In a number of instances where other lines of manufacturing were carried on, profitable operations were reported for the year, but in these cases it would be impossible to analyze fairly the loadings of administration and overhead expense, hence the true picture of their radio situation, taken alone, would be difficult to ascertain.

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Are you thinking about your random access memories more than you want to?

Do you think you can't get speed and military processing in the same package? You can.

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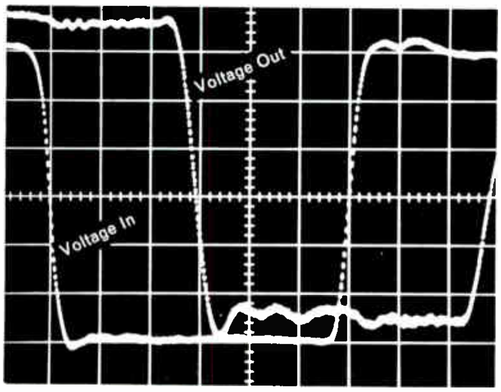

tpd minus: 29 nanoseconds
tpd plus: 28 nanoseconds

Advanced Micro Devices has a TTL 64-bit random access memory with a typical access time of 30 nanoseconds.

Our RAM

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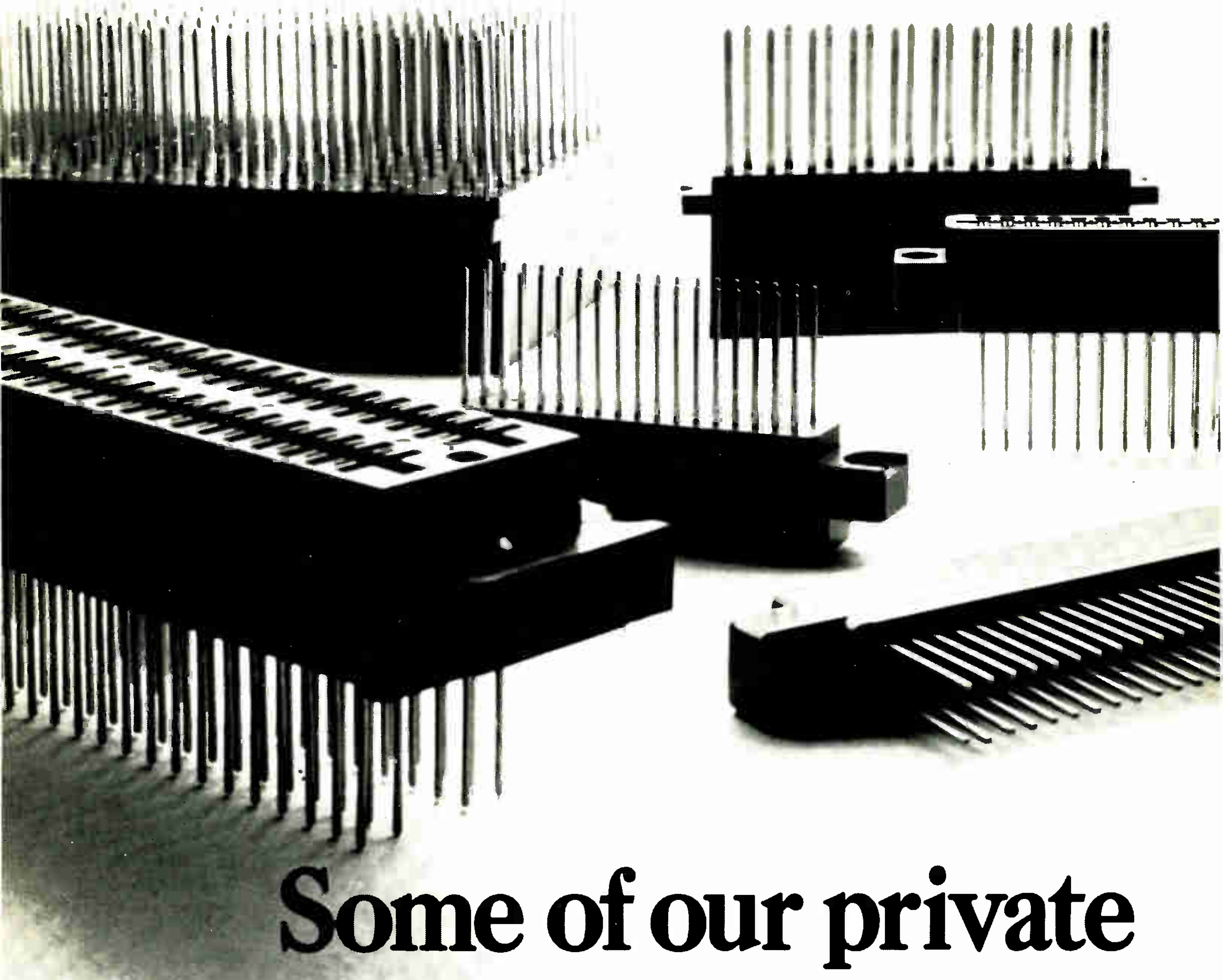


Some of our private

Most of our off-the-shelf connectors started out as custom designs for specific customers.

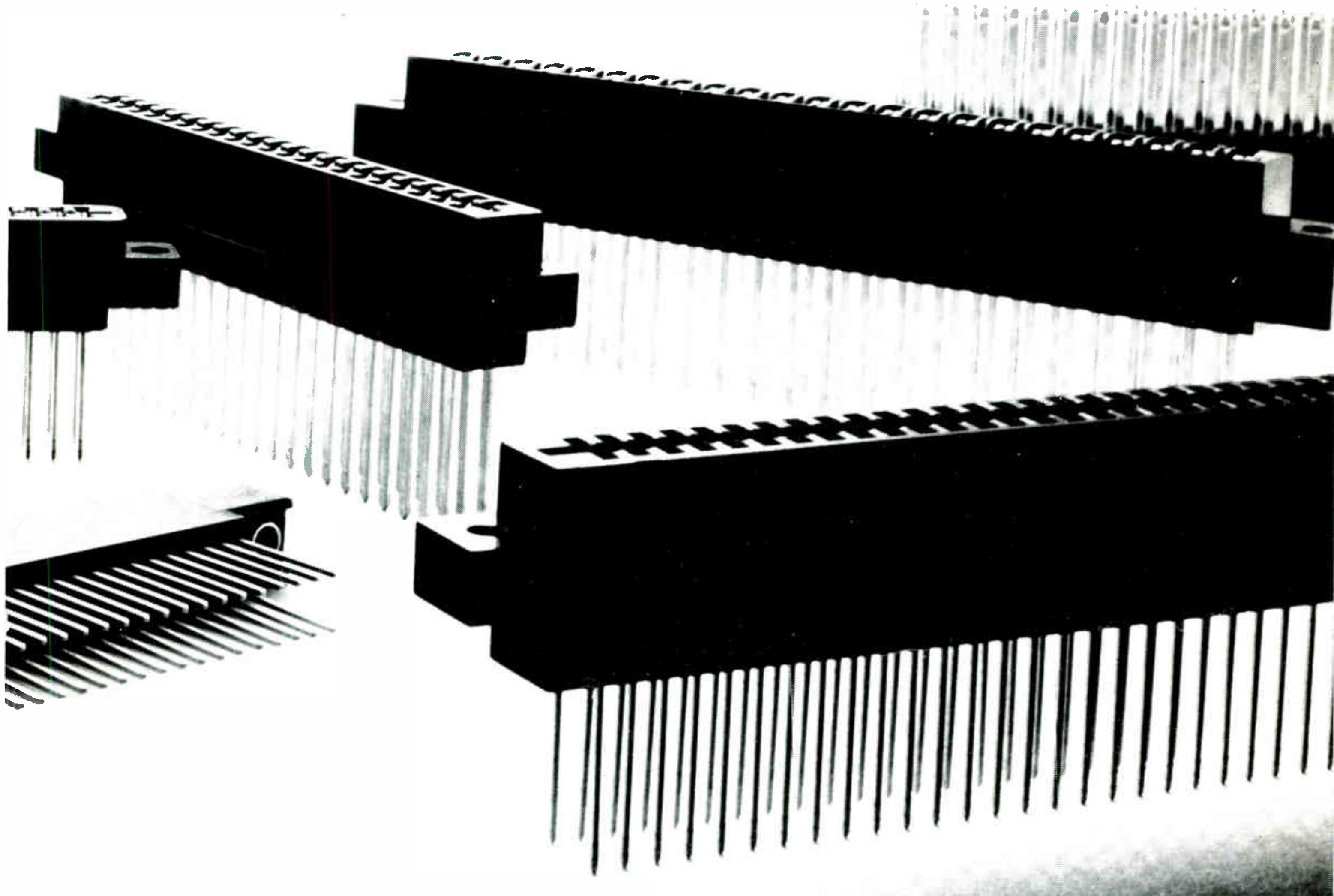
Now they're available to you.

You get a custom connector at off-the-shelf prices—and there's no tooling cost.

For example, our P101 and new P201 circuit-card connectors have custom features such as contact-tail tip locus within .020 inch diameter of true position; our exclusive gold-dot contact system (the dots don't fall off) and a life of at least 500 trouble-free insertions and withdrawals. The P101 is also available with gold-plated bellows contacts.

In addition to these, we've got other connectors coming off the drawing board.

For example, our soon-to-be-ready P108 is a rack-and-



lines have gone public.

panel connector designed for the same tight contact-tail tolerances. It features a solid pin, solid housing construction and a low price.

The P101 is available with 12 to 100 contacts, and the P201 comes in 36, 72 and 100 contact sizes. The P108 has 50 and 104 contacts. Additional sizes can be made available.

They can become public property at low cost.

And, of course, we still have our complete custom facility available.

For those things you just wouldn't want to do in public.

GTE Sylvania, Precision Materials Group, Parts Division, Warren, Pa. 16365.

GTE SYLVANIA

Circle 11 on reader service card

People

Many semiconductor marketing men, while they say they are finally seeing the long-awaited upturn, emphasize that the slump has caused changes in buying patterns. For example, Gene Carter, newly named microcircuits product marketing manager at National Semiconductor, Santa Clara, Calif., says that "Now, systems houses are not so willing to spend thousands of development dollars in designing custom MOS/LSI circuits. They would rather go with a standard product and take advantage of the price break."

Before the recession, Carter says, systems houses didn't really care what it cost them to design an MOS chip so long as the design was theirs alone. "But now," says Carter, "they are trying to squeeze out every last bit of value for their device dollar and so they are turning to standard products." And Carter believes that the switch in attitude is better for the device makers. "Custom products are generally not high-volume products, and what squeezed Philco and Sylvania out of the semiconductor business was the fact that they weren't high-volume producers. Even IBM has turned to buying 54/74 TTL off the shelf because they can buy it cheaper than they can make it," Carter says.

Making the changeover easy is the fact that some semiconductor companies—National included—are offering standard MOS digital systems for calculator and miniprocessor applications that can be set up with the user's instruction set and instruction sequence. This, says Carter, enables each systems house to keep its programing proprietary.

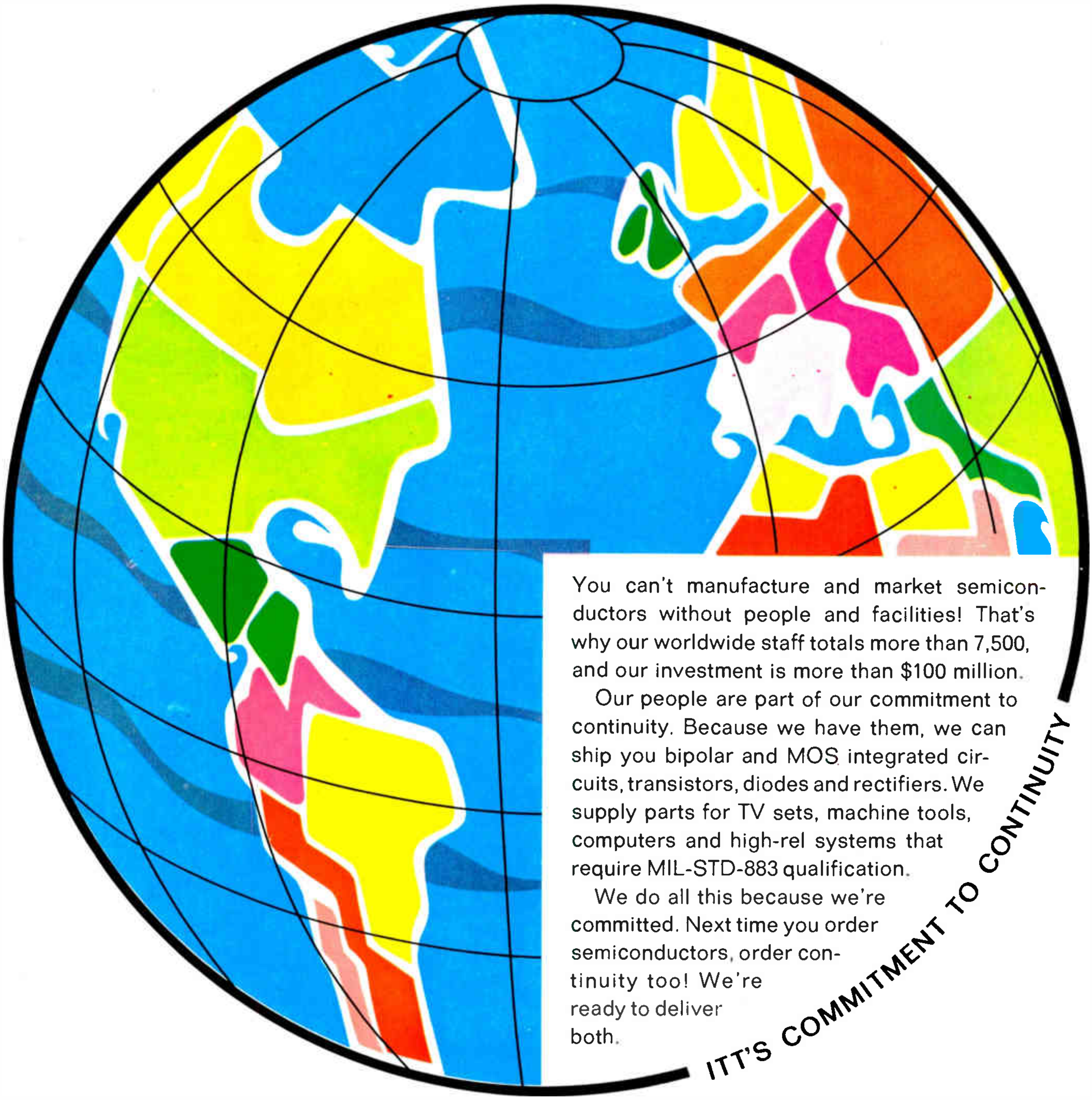
Carter also points out that miniprocessors can now be bought for about $2,000, but for systems houses to get into some of the newer markets—such as industrial control—the machines will have to cost only $200 or so. "And in the low volumes that they are talking about—thousands of units and not hundreds of thousands of units —the only way for them to go is with a standard set."

"Maybe all I am is a marriage counselor, in a sense," says Edwin I. Golding, "but I think I can focus for industry what I think the problems are." And the wedding of law enforcement and the electronics industries, however great its potential, is still shaky. Golding, as chief of the Center for Criminal Justice Operations and Management, is in charge of the development of electronics and communications for the National Institute of Law Enforcement and Criminal Justice, the research and development arm of the Law Enforcement Assistance Administration.

"Industry must start thinking about small markets all around the country," Golding contends, and points out that the law enforcement market is not one but 36,000 customers spread across the country.

Besides the use of video techniques in local police departments, such as video cassettes of lineups and training films, Golding's 15-man staff is interested in noninking fingerprint mechanisms, digital and optical scan fingerprint classification and location systems, crime deterrent systems, technical communications such as auto vehicle locaters and riot communications, and the evaluation and development of standards for weapons and equipment. Golding directs the Law Enforcement User Standards Laboratory, a dedicated facility at the National Bureau of Standards which defines the standards that Golding promulgates.

Golding moved to LEAA from the Office of the Secretary, Department of Transportation, last August, having previously worked for the Defense Department's Advanced Research Projects Agency. An EE from the U.S. Naval Academy, Golding holds a doctorate in operations research and systems analysis from the University of Michigan, and teaches an introductory course in systems analysis to seniors and graduate students at the University of Maryland.



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Meetings

Calendar

Symposium on Theory of Computing, Association for Computing Machinery; Shaker Heights, Ohio, **May 3-5.**

Society for Information Display International Symposium, Sheraton Hotel, Philadelphia, **May 4-6.**

National Meeting, Operations Research Society of America; Sheraton-Dallas Hotel, Southland Center, Dallas, **May 5-7.**

Electronic Components Conference, IEEE; Statler-Hilton Hotel, Washington, **May 10-12.**

Electron, Ion, and Laser Beam Technology Conference, IEEE; University of Colorado, Boulder, **May 12-14.**

International Microwave Symposium, IEEE; Marriott Twin Bridges Motor Hotel, Washington, **May 16-20.**

Aerospace Electronics Conference (NAECON), IEEE; Sheraton Dayton Hotel, Dayton, Ohio, **May 17-19.**

International Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, **May 17-21.**

Spring Joint Computer Conference, IEEE; Convention Center, Atlantic City, N.J., **May 18-20.**

Power Industry Computer Applications Conference, IEEE; Statler Hilton Hotel, Boston, **May 24-26.**

Electric & Electronic Measurement & Test Instrument Conference, IEEE; Skyline Hotel, Ottawa, Ontario, Canada, **June 1-3.**

Conference on Laser Engineering & Applications Conference, IEEE; Washington Hilton Hotel, Washington, **June 1-4.**

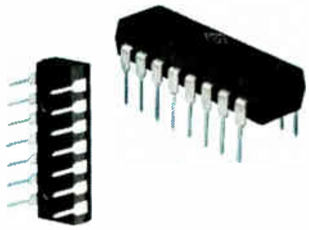
Symposium on Applications of Ferroelectrics, IEEE; IBM Research Center, Yorktown Heights, N. Y., and Holiday Inn, White Plains, N. Y., **June 7-8.**

Design Automation Workshop, IEEE; Shelburne Hotel, Atlantic City, N.J., **June 27-July 1.**

Call for papers

Vehicular Technology Conference, IEEE; Detroit, Dec. 7-8. **June 15** is deadline for submission of summaries to Mr. A.E. Marshall, Ford Motor Co., 23400 Michigan Ave., Dearborn, Mich. 48124.

Centralab DIPs have a secret...



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Power density	up to 3 watts
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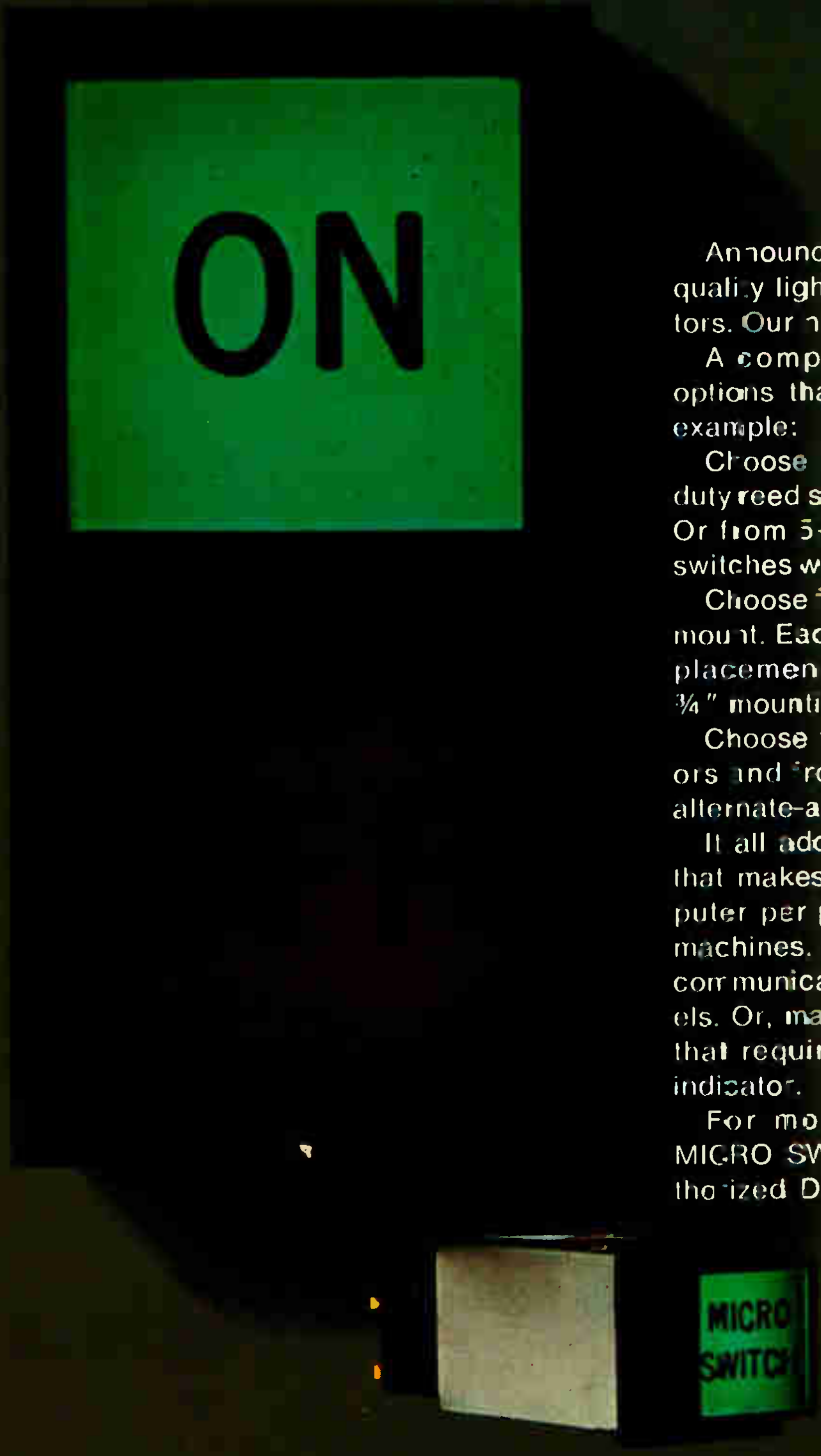

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Electronics Newsletter

April 26, 1971

Navy, AF fund Hamilton gyro

Several single-axis laboratory models of a "differential" laser gyro should be ready for the Naval Air Systems Command by the end of the year. Hamilton Standard Systems Center, Farmington, Conn., is building the helium-neon devices under a $205,000 contract just received from the Air Force and Navy.

The company has a proprietary concept for avoiding mode locking, an inherent problem in laser gyros that prevents the detection of low angular rates of motion. Laser gyro designers usually get around this by imposing a bias on the gyro that, in effect, makes the device think it's rotating faster than it really is, but the bias must be carefully controlled and it is subject to electro-magnetic interference. Hamilton Standard says its approach doesn't need accurate bias control.

The military eventually hopes to use laser gyros in strapdown guidance systems aboard tactical missiles. Such systems offer the possibility of greater reliability and lower cost than conventional gimballed systems. Laser gyro sensors are needed here because conventional electromechanical gyros cannot withstand the high stresses exerted on them in a strapdown environment.

H-P, Varian to unveil 16-bit minicomputers

Hewlett-Packard and Varian Data Machines are readying low-cost 16-bit minicomputers for introduction at the Fall Joint Computer Conference. Both machines will employ 1,024-bit MOS random access memories. **Hewlett-Packard is believed to be close to production because it is buying the semiconductor memories in production quantities.** The Varian machine will be available with 2,048 words of semiconductor memory and is said to be aimed at the low-cost digital-controller market.

IBM puts attributes of disk and drum into optical memory

Both machines will employ 1,024-bit MOS random access memories.
IBM has built an experimental beam-addressable optical memory file with an access time of 5 milliseconds—similar to that of a very fast drum—and a density of about 4 million bits per square inch—comparable to a disk's. **IBM says it could increase density to 20 million bits.** The goal of computer makers is memories with the low cost and high density of disks plus the fast access time of drums; **IBM says its optical memory, when perfected, should cost as low as .0001 cent per bit.**

The memory uses an iron-doped europium oxide storage medium. Because it must operate at cryogenic temperatures, the model also demonstrates the feasibility of a sealed liquid nitrogen disk file. Honeywell has built an optical memory using manganese bismuth at room temperature (see p. 21).

The IBM memory uses a GaAs array laser to read and write, and pin diodes for detection.

AIL-Collins team joins ILS competition

Cutler-Hammer's AIL division and Collins Radio are teaming to bid on the microwave frequency successor to the present vhf instrument landing system that's been proposed by the Radio Technical Commission for Aeronautics [*Electronics*, Feb. 1, p. 24]. One other such team has been announced—Texas Instruments and the French company, Thomson CSF (see p. 25)—and more may emerge.

Electronics Newsletter

Ampex developing cockpit display using color video cassettes

Ampex is developing a color video map-display system for cockpit use by the Navy. **The system employs a cassette video tape recorder to store maps covering possible flight areas.** In operation, the on-board navigation computer calls up the map for the area of flight; at the same time, the three adjoining maps are displayed. These are stored on a video disk similar to the instant replay units that Ampex makes for commercial television. The display is a 5-inch CRT with 600-line resolution under development at Hughes Aircraft.

Scantlin building its own computer for omnibus stock setup

Scantlin Electronics of Los Angeles is marketing a data retrieval and communications system that can handle just about every data job performed by stock brokerage firms. **Driving the system is a new "major line of general-purpose computers" which Scantlin has designed and will manufacture.** The 16-bit communications-oriented processors—the series 800—have 750-nanosecond cycle times and memory capacity expendable upward from 8,000 words of core.

The system utilizes the new Quotron 800 desk-top CRT terminal **to control operations usually handled manually or by individual special-purpose computer systems.** In addition to displaying such usual items as stock-price quotations, the terminal can also be used to enter orders and have them switched automatically to the floor of the stock exchange, and to display financial and customer account information.

Monsanto offering magnetic materials

In a move to cover all technology bets, Monsanto, long a leading supplier of silicon and gallium arsenide, has jumped into magnetic-bubble materials, apparently banking on a boom in that technology. **What Monsanto would like is to be the first to offer a production line capability in bubble materials**—in this case, generally the rare-earth garnets.

Monsanto feels the easier-to-handle liquid phase epitaxial technique that Bell Labs favors may offer certain short-term advantage, mainly in short turnaround time useful in optimizing compositions, but that the greater control of chemical vapor deposition gives it the edge.

Addenda

Macrodata Co. of Chatsworth, Calif., has won a contract from NASA's Marshall Space Flight Center to deliver in six months an LSI test system that will probably be used in a central quality control facility. **The $400,000 system will include the company's MD-200 general-purpose, computer-controlled tester** plus temperature chambers Macrodata will integrate into the system. . . . Signetics Corp., which initiated its push into the linear IC business last summer [*Electronics,* July 20, 1970, p. 33] **is now getting into the consumer linear business as have Motorola and General Electric.** The company will soon announce a class AB monolithic power amplifier that's capable of putting out 1.2 watts by itself or 35 watts rms driving a complementary transistor pair. Fifty watts can be achieved when driving a Darlington-connected output stage. . . . In a move that's bound to be imitated by other makers of light-emitting diode displays, **Monsanto has cut prices almost in half.** The MAN 1, a quarter-inch seven-segment readout, will sell for $7.75 in 1,000-unit lots, down from $11. The one-eighth-inch MAN 3A, another seven-segment numeric, is now $3.95 in 1,000-unit lots; it was $7.

FABLES FROM SEMICONDUCTOR MEMORYLAND: PART ONE

The little people who kept quiet.

THE LITTLE people lived under the mushrooms. Nobody quite knows why. It is simply a fact that in fableland all the little people always lived under the mushrooms. And there was something about the mushrooms that made them gregarious. They yelled a lot.

Except for one group of little people who lived under a toadstool. They were a very quiet and industrious lot. And the mushroom little people — MLP's as they liked to call themselves — thought of them as dull and slow witted.

One day all the little people discovered a new way of making a living. They found out that they could take the fluffy dandelion seeds from the nearby meadow, process them into wondrous tiny weaves, and then sell them to the big giant and the six dwarves who lived on the big hill.

The giant and his dwarves made wondrous magical machines that stored all the fable knowledge from the beginning of fableland. For the very hearts of these machines they had been using spiderwebs. And the little people figured out a way to do the same job with their fluffy dandelion seeds. Less costly. Much smaller. And more reliable.

In theory. But in practice, there were a lot of problems to be solved. Like keeping the dandelion seeds from getting soggy in all that moisture under the mushrooms. And packaging them the right way so they wouldn't just blow away when the giant sneezed. Yield problems. Quality assurance problems. And so forth.

The MLP's solved some of these problems. But, as usual, they spent an awful lot of their time standing on their mushrooms and yelling up at the hill. "Penny-a-seed," they shouted. And, "The end of the spiderweb!" They were great little sloganeers.

And all this time, the little people under the toadstool just kept working away. They concentrated their initial energy on a technology called bipolar, because it was predictable and reliable. And because it offered much higher speed. They came up with a process that is crystal defect free — CDF. They improved their yields until they were in the 30% to 44% range. And they kept improving until their cost-per-bit at the wafer level was better than other processes. And at much higher speed.

And they didn't just offer a bunch of dandelion seeds. They offered a complete system. With inputs and outputs specified at the same current and voltage levels as TTL/DTL logic. And with power consumption less than twenty percent of the old spiderwebs.

And when they finally had everything ready, they quietly marched up the hill and presented their offering to the giant and his dwarves. And they were told:

"Yeah, we've been hearing all that noise from the little people. And we've been listening, even though it hurts our eardrums. What we want to know is — will yours really work and can we really buy it right now?"

"We've got a lot more where this one came from," was the answer. "And if you want to know how it works, just plug it in and try it."

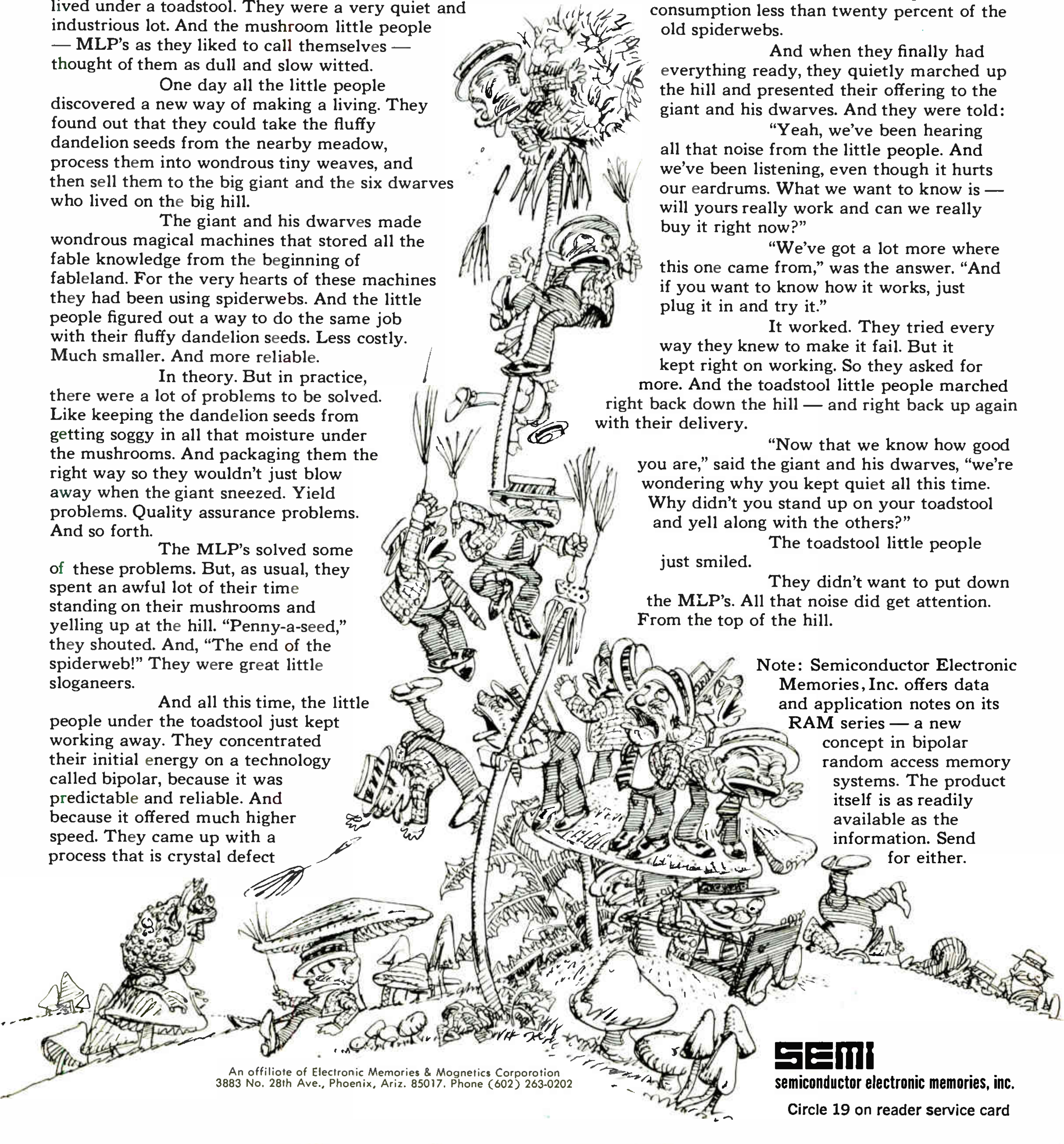
It worked. They tried every way they knew to make it fail. But it kept right on working. So they asked for more. And the toadstool little people marched right back down the hill — and right back up again with their delivery.

"Now that we know how good you are," said the giant and his dwarves, "we're wondering why you kept quiet all this time. Why didn't you stand up on your toadstool and yell along with the others?"

The toadstool little people just smiled.

They didn't want to put down the MLP's. All that noise did get attention. From the top of the hill.

Note: Semiconductor Electronic Memories, Inc. offers data and application notes on its RAM series — a new concept in bipolar random access memory systems. The product itself is as readily available as the information. Send for either.



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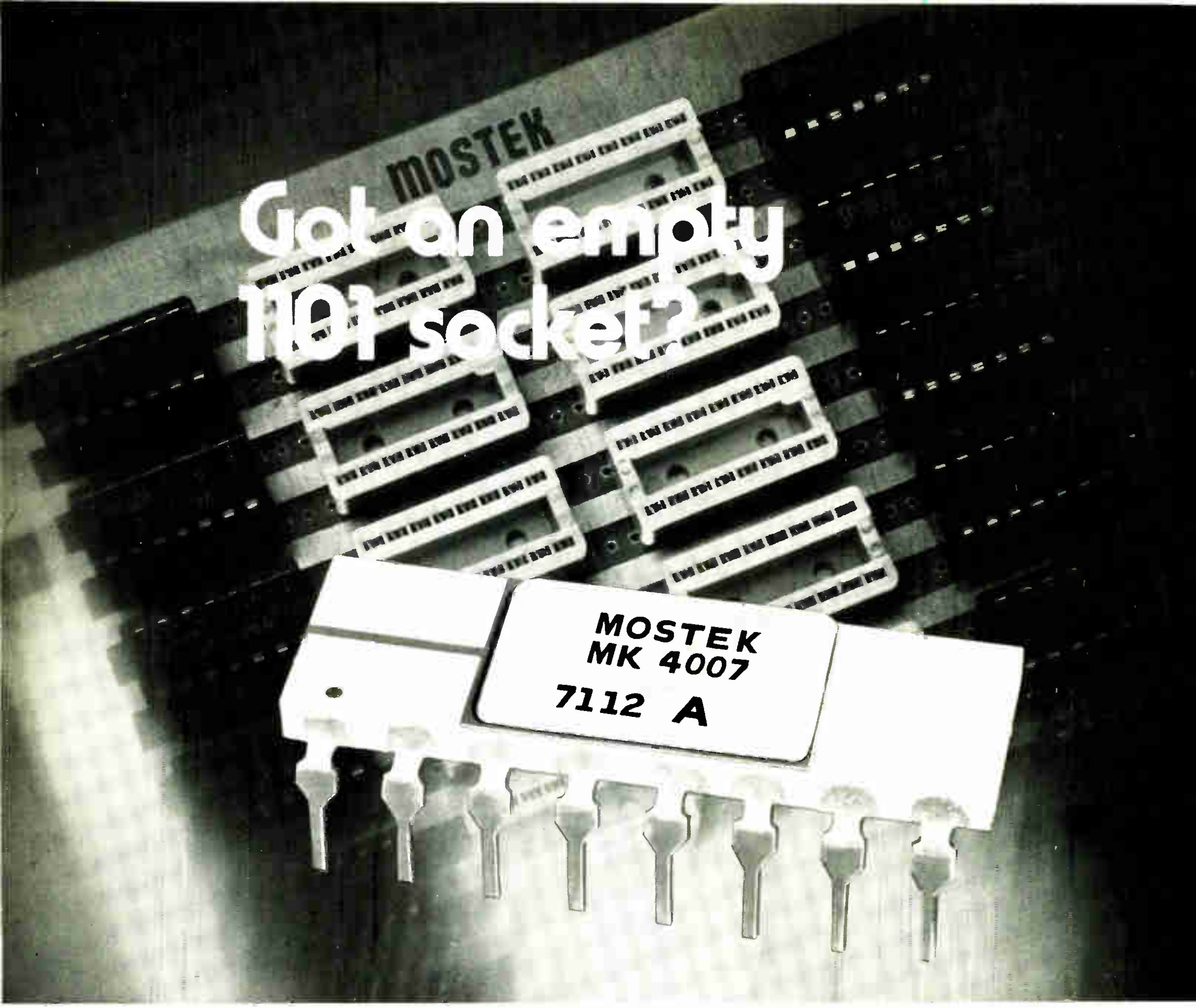

Fill it with the coolest 256-bit RAM around... from MOSTEK

Whether you've already got an empty 1101 socket—or just considering a replacement—you'll find MOSTEK's new MK 4007 P your ideal choice in 256 x 1-bit RAMs. Here's why:

Low power: 250 mW!

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16-pin ceramic package: You get ceramic hermeticity at plastic prices!

Now, add-up these key benefits and compare them with what you get in any other 1101 replacement. Wouldn't it be smart to switch **now** rather than try to fix? Find out for yourself how MOSTEK makes it easy to use MOS by calling Gordon Hoffman or Dave West at (214) 242-1494. Or contact your nearest Sprague Electric Company representative or distributor.

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Circle 20 on reader service card

Number reaches 18K in monolithic RAM derby

TI lab puts 32 cells on chip and keeps wiring down to one from each cell plus 40 for the package leads

Researchers at Texas Instruments have made in the laboratory what they call 18K monolithic random access memories. Each of the MOS chips, which measures 1.05 by 1.15 inches, contains 32 cells of 1,024 bits each; 18 are actually used. While the dynamic devices were made only to demonstrate capability, the project could lead to simpler, more reliable mainframe semiconductor memories.

A single bonding wire from each cell to a bus is used to connect the 18 required for a complete memory. The approach immediately brings to mind TI's now-dormant discretionary wiring program, but Donald L. Benefiel, MOS manager, says he feels that that isn't a very apt comparison: the MOS parts require testing of only up to 32 identical cells instead of hundreds of individual gates. Moreover, only 18 bonding wires are required in addition to the 40 used to connect the chip to the package leads. This contrasts with the usual method of removing a test layer of metal, then replacing it with a complex, computer-derived pattern.

Power dissipation can be a problem in large memories, but TI has kept it down to 80 microwatts per bit in the circuit, which uses conventional high-threshold, p-channel MOS technology. Benefiel even feels that 40 μW is practical. The part was made on a one-chip-per-wafer basis, leaving a significant marginal area.

Benefiel indicates that much higher complexities are achievable and could offer economic advantages to the user. He says that the computer industry may not be paying sufficient attention to the number of bits per pin in semiconductor memories. In large systems, total cost and reliability could be adversely affected by the many wire bonds and solder joints this requires: "For big systems, small memory chips (up to 4,096 bits) may not be adequate."

The part wasn't developed for introduction to the market, but Benefiel says, "We could probably sell similar devices if the opportunity arose."

Advanced technology

Bell builds first complex bubble memory

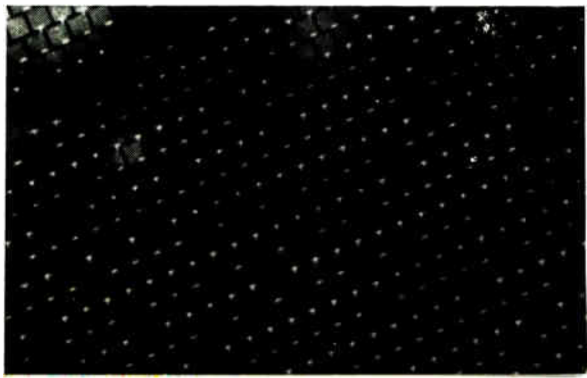
Development at Bell Laboratories of the first working complex magnetic bubble memory may mean that bubble technology, alternately hailed for its potential and dismissed as a laboratory plaything, is finally ready to live up to predictions. After Bell announced the technology almost two years ago, there were hints of fundamental problems with magnetic materials. But the advent recently of epitaxially grown garnets, replacing orthoferrites that couldn't provide sufficient density [*Electronics*, June 8, 1970, p. 39], put Bell's bubble technology right on the money.

The new memory, a 3,648-bit epi-grown garnet chip, will give important data on the implementation of a working bubble dialer system. It should also go a long way in showing the potential of bubbles.

The bubble's potential in just a single area—as a replacement for disk memories—could explain the early excitement. For a moderately sized disk file—10 million to 100 million bits—the bubble memory would occupy only 2 to 3 inches of space, compared to the disk's 2 feet on a side. For power, the bubble requires 10 watts, the disk 500 W. Access time for the bubble is an order of magnitude less, while its storage density is three orders of magnitude better. And although Bell System managers aren't making any claims, it's no secret that bubble files could cost a tenth of disk files, a saving which could be meaningful in the mini-disk-file business as well.

The bubble repertory memory is

Bit o' the bubbly. Bell repertory dialer using magnetic bubbles (white spots) on a bulk garnet chip.



based on an interesting series-parallel organization—38 storage loops connected to a common assembly loop. Bits of information are distributed equally throughout the storage loops, then are fed out simultaneously as required into the assembly loop, from which they're read. Thus, although the memory operates serially, as do all bubble memories, it's not necessary to run through the entire store to obtain a desired piece of information. This greatly reduces access time; with a data rate of about 1 megahertz, overall access time is less than a millisecond.

T-bar elements are used in both types of loops. Forty-eight words of 76 bits are stored in two bits to each storage loop. Each loop's capacity is 96 bits, for a total for the system of 3,648 bits. Also included are a wire-controlled generator to give data input, an annihilator to dispose of undesired bubbles, and a single detector to provide the readout.

In an actual dialer system, a number of chips, called platelets, would make the memory. A given number of platelets would be put on a card, called a plane; the card stack would be built up to total the desired storage capacity. Thus, a system might have 20 to 80 kilobits per platelet, about 4 million bits per plane, and a total capacity of about 16 million bits, about the range of Bell's Electronic Switching System disks.

Lasers

MIT tunes in on pollution . . .

Three laser developments, two at MIT Lincoln Laboratory, Lexington, Mass., and one at MIT itself in Cambridge, may be laying the groundwork for optical pollution-detection systems of the 1970s and 1980s.

Each system would use the optical absorption spectra of pollutants, as individual as fingerprints, to spot their presence in air, auto exhausts, stack gases, and elsewhere. Insisting that new technology is needed here, Lincoln Lab's E. David Hinkley, a research physicist, points out that "there are no devices now available which are capable of accurately measuring all auto exhaust pollutants to upcoming 1975 standards." So there's speculation that these laser experiments could form the basic technology for what still must be considered an embryonic pollution instrumentation industry.

Hinkley may be working with the most exact, at present, of the three systems. He and fellow Lincoln Lab staff member P. L. Kelley would build semiconductor diode lasers, tailoring them to specific, relatively narrow bandwidths, and then tune the output across the bandwidths by varying applied current. "It is possible that two or three different types of three-element diode lasers could be made to cover an output spectrum of about 0.5 to 32 microns," says Hinkley. Individual diodes so far tune at 40 to 50 megahertz per milliamp, over bands up to 60 gigahertz.

To date, Hinkley has been working with lead-tin-telluride diodes, a family capable of emitting over a 3×10^{13} hertz bandwidth at optical wavelengths. With one, he and his colleague have been able to measure the amount of ethylene in automobile exhaust to within a few parts per million, and they feel that parts-per-billion resolution is within reach.

They've also been able to spot nitrous oxide, whose absorption pattern usually is masked by water vapor, hydrocarbons, and carbon monoxide. The reason for their success is, first, the output line width of the diodes—only about 40 to 50 kilohertz at optical frequencies, which is narrower than the gas's absorption spectra—and second, use of a low-pressure (5-torr) cell, through which the light beam is passed on its way to a germanium detector. The narrow line width dissects the absorption spectra with high resolution, bringing out formerly masked, but distinctive, detail. The 30-centimeter-long low-pressure cell helps eliminate so-called collision broadening, a molecular interaction which blurs absorption lines.

Current tuning of the diode over as little as 200 hertz during measurement makes a chopper at the detector unnecessary and could help cut the cost of future systems. Unfortunately, the diodes now in use work only at cryogenic temperatures, and this ups cost.

While Hinkley and his men are working in the infrared, C. Forbes Dewey, a professor in MIT's mechanical engineering department, is working with a dual ruby-dye laser combination to get tunable output in visible and near infrared wavelengths. Dewey uses part of the ruby laser's output to trigger lasing in the dye. The dye is an iodide known as DTTCI, dissolved in dimethyl sulfoxide, or DMSO.

To tune output, Dewey places a diffraction grating at one end of the dye laser's cavity. By tilting the grating slightly, he's able to get outputs ranging from 0.84 to 0.89 micron. Combining this with the ruby's 0.69-micron output in a lithium niobate crystal yields output at wavelengths that range from less than 3 microns to about 4.5 microns.

Dewey and his co-worker, research associate Lon O. Hocker, now hope to extend this range—possibly to beyond 25 microns—with different dyes, and with upcoming nonlinear crystals with broader bandwidths than lithium niobate.

. . . as Lincoln Lab looks at Raman-effect device

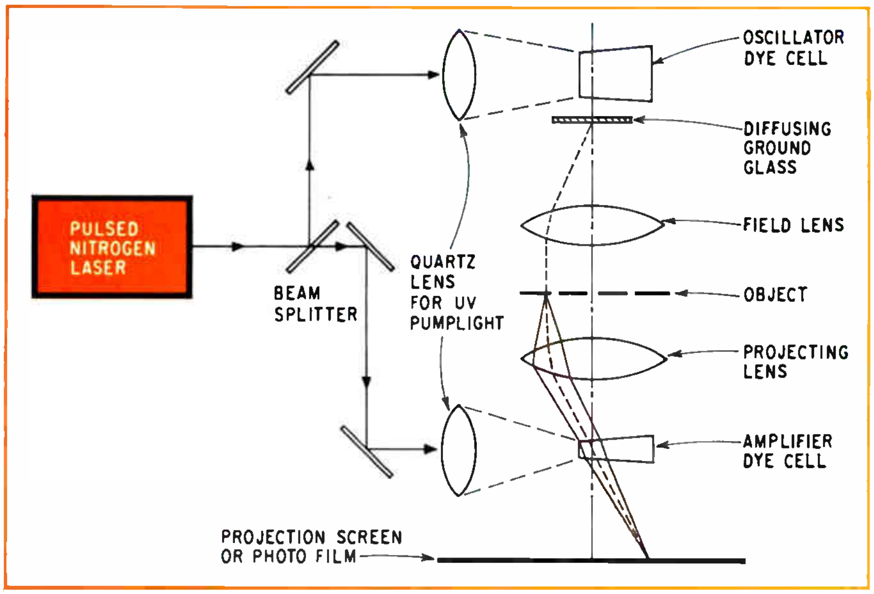
Still another group at Lincoln Lab, this one headed by Aram Mooradian, is using a Raman-effect laser in its pollution-detection efforts. Mooradian, who is associate leader of the lab's optical and electronic physics group, figures that the Raman device complements the semiconductor approach used by Hinkley. "We could scan across broad bands," he says, "locating pollutant concentrations in a gross fashion, and hand over the job of fine definition of pollutant concentration to the diode laser gear."

There's even the possibility that the Raman laser could take over both tasks, he feels. Line widths of a few hertz, according to Mooradian, should be obtainable simply through refining existing techniques, and since the threshold of the indium antimonide in use is only about 10 to 30 milliwatts, it might also be possible to use a semiconductor laser instead of the larger, 2-watt CO device. This would open whole new wavelengths to the Raman system. "A laser diode emitting at, say, 15 microns, should be able to feed a Raman-effect device, which in turn could yield outputs from 15 to 150 microns. We haven't done this yet," he admits, "but we're game to try."

At least 12 laboratories here and abroad are working with Raman-effect lasers. Mooradian believes the system has an excellent chance of tuning without interruption across a band extending from near-millimeter wavelengths to visual frequencies. Raman versions have the potential of doing the work of both diode and dye lasers.

Mooradian is now working with a carbon monoxide laser, and tuning its output by using an indium antimonide block in a strong magnetic field. As the laser's initial 5.3-micron output passes through the block, it is converted with an estimated 75% efficiency to 5.5 microns, at which the indium antimonide begins lasing; the final emitted wavelength is controlled by varying applied current and magnetic field. So far output ranges from about 5 microns to 8 microns.

Formerly, a disadvantage of the technique was the superconducting magnet needed to make the indium antimonide operate. But Mooradian now has substituted a 500 to 600 kilogauss permanent magnet and added a small solenoid capable of applying an extra 500 to 1,000 gauss. With this coil it's possible to tune laser output over about 60 gigahertz at optical frequencies.



Light path. Stanford University's light amplifier can solve the problem of film burnt from too much light. The system has a dye cell strategically placed at the focal point of the lens between the lens and the image plane.

The indium antimonide emitter does "mode hop"—emits over a discrete band and then jumps to another without emission between bands, as is characteristic of semiconductor lasers. But Mooradian has established that it's possible to pull the output into these "blacked-out" regions either by using a piezoelectric mirror to change the length of the cavity (including the CO laser) or by changing the applied magnetic field.

But the Raman system is going to prove the most costly of the three approaches, at about $100,000 for now. Mooradian says he's working on a method to lower cost drastically, but isn't ready to make it public yet.

Dye laser helps keep film cool

One of the limits on projecting film is the amount of light energy that passes through it—too much light means too much heat, and the film burns. But researchers at Stanford University, Palo Alto, Calif., have developed a light amplifier that, according to Theodore W. Hänsch, one of the inventors, can be placed between the film and the screen to eliminate that distructive heat.

The amplifier is actually a dye laser—the lasing material is an organic dye—excited by a pulsed nitrogen laser. Unlike conventional crystal or gas lasers that produce a narrow beam of high-intensity, single-frequency light, the dye laser increases the intensity of light passing through it. And because the dye solutions are not limited to a single frequency, says Hänsch, "they can amplify many colors over a wide color range." Though present solutions encompass only one portion of the visual spectrum—the yellow-green-blue, for example—Hänsch feels that a medium can be developed that will amplify over the complete range. Kodak is believed to be working on this.

Another important difference between conventional single-frequency lasers and Hänsch's dye laser is the amount of light amplification. "With a helium-neon laser," says Hänsch, "we get a one-pass gain of about 5% in a tube that's a meter long. With a ruby laser, we get about two times the light out in a rod that's 10 centimeters long in one pass. But in one millimeter of length, we get 1,000 times the light out with a dye solution. Of course," he adds, "in single-frequency lasers, the beam is reflected back and forth in a cavity to increase the light output. But in amplifying images, it has to be a one-pass situation to preserve the image format and reduce distortion."

In a typical setup, a pulsed nitrogen laser is used both for illuminating the object (film) and for amplifying the image. The beam from a pulsed nitrogen laser is a broad rectangle of ultraviolet light that is easily split into two beams. One excites a dye cell that illuminates the object and the other excites the amplifier. Light from the illuminated object passes through a focusing lens and then onto the image plane. The dye cell is placed at the focal point of the lens between the lens and the image plane. Light passes through it and the other portion of the laser beam excites it from the side.

At this point, explains Hänsch, "all of the light is concentrated in one small area. For each point on the object, there is a corresponding light beam at a specific angle at this point—the focal point is a Fourier transform of the object." Because all of the beams share the same small volume where amplification takes place, brightness and contrast of the amplified image are uniform. "And," he adds, "there is no scanning involved, so all of the signal is amplified in a very short time."

The dye cell itself is a clear container that's about 0.25-inch in diameter and 0.25-inch long. The end plates—one facing the lens and the other facing the image plane—are at a slight angle to eliminate internal reflections. Cell efficiency is about 50%—dye laser output vs pump energy input. This compares to about 1% cell efficiency for a ruby laser.

Besides amplification of film images, Hänsch says, the dye laser can be used in electron-beam-controlled display systems such as television projection—it might solve some of the contrast problems that Frazier-Ali fight fans complained about—and in large-scale optical information processing with optical memories. He is now passing it on to the engineers for development.

Manufacturing

Electron beam machine does it all to devices

There are plenty of ways to test the mechanical integrity of beam-lead transistors and IC bonds, as well as the dice themselves, but they all take time, and no one of them can tell users that the devices will withstand the stresses of the real world. That's why engineers at Sandia Laboratories, Albuquerque, N.M., decided to use a Febetron 705 flash electron beam machine to reveal bonding and device failures in beam-lead parts.

James R. Adams, a member of the technical staff at Sandia, explains that for certain applications of beam-lead devices in hybrid circuits, his group wants to test the circuits at accelerations of 1 million Gs, even though they won't encounter that much acceleration in use. Adams says a few centrifuges can deliver up to 200,000 Gs, which isn't satisfactory. Standard shock and vibration tests, with their usual 1-millisecond pulse widths, are equally unsatisfactory. And air-blast tests pose repeatability problems—devices from the same batch will withstand varied numbers of cycles before they fail.

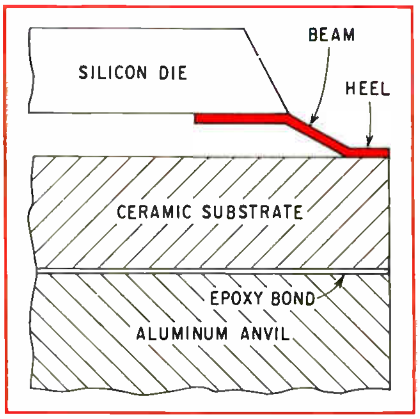
Not happy with these conventional destructive-test results, the Sandia group devised two kinds of fixtures on which to mount beam-lead transistors and ICs; the latter holds two ICs that have been electrically tested and visually inspected. The beam leads are conventionally bonded to a ceramic substrate, which in turn, is epoxy bonded to an aluminum anvil 1.5 inches in diameter and 0.25-inch thick.

In the test, the aluminum anvil is shot with a flash electron beam from the Febetron 705, which can deliver up to 2 million electron volts in a 30-nanosecond pulse with a beam diameter of approximately 1 inch. The electrons are deposited in the first 1 to 2 microns of the aluminum anvil, causing heating. But the pulse is so short that the anvil doesn't have time to expand. Instead, the heat is converted into mechanical energy—a compressive stress on that front surface of the anvil.

The substrate bangs against the bottom of the beam leads supporting the silicon die, and against the die itself. This generates stresses in the silicon that converge toward the center of the die and cause tensile stresses that can fracture it. After impact, the die is decelerated by Newton forces in the beam leads; this is where beam failure can show up.

Adams says the thicker (5-mil), anisotropically etched beam-lead ICs either pulverize or are pulled off the substrate at the heel of the beam-lead bond when the substrate moves back into place after striking the beams and die. The thinner (2-mil), larger-area, non-anisotropically etched die tends to crack or cave in at the center. In those that cave in, the beams still hold pieces of silicon to the substrate. Other failures induced include silicon nitride/oxide peeling

Banging away. Electron beam machine shoots anvil to trigger test of beam leads and bonds in system developed at Sandia Laboratories.



off the chip, beams peeling off the silicon nitride, bond delamination, and platinum delamination from the back of the beams.

The Febetron 705 flash electron beam machine costs about $30,000 and Sandia Labs didn't buy it just for these tests. Adams says it can be used to show up "just about every type of mechanical failure encountered in beam-lead chips." Testing itself is inexpensive if the Febetron machine is available, and the energy levels can be controlled so that the tests aren't always destructive. Adams and his colleagues will probably propose the test procedure as a lot-sampling incoming inspection screen for 20 to 30 beam-lead dice on each wafer.

Computers

Intel set to chip at process-control field

As MOS manufacturers choose sides in the custom-calculator-set-vs-standard-kit question, the Intel Corp. of Mountain View, Calif., could find itself on both sides. Intel has developed a set of four chips for Japan's Busicom Corp. (formerly Nippon Calculating Machine Corp.) to be used in medium and large calculators. Busicom previously had purchased a one-chip calculator array from the Mostek Corp. [*Electronics*, Feb. 1, p. 19]. While the Intel set—a controller, an interface, a read-only memory, and a random access memory—was custom designed, Busicom says that Intel can sell it to other companies if Busicom approves.

That proviso just about rules out other calculator makers. But Robert F. Graham, vice president of marketing at Intel, says he envisions a market for the chips anyway—the industrial process-control field. Graham says that the same versatility that Busicom wanted in the calculator set—the same basic chips can be used in a complete line of calculators—also will provide designers of digital control equipment with both flexibility and the cost break in buying a standard set.

The set combines to produce a machine that is just like a computer. "We have a CPU, an I/O buffer, and a mainframe memory that's split up into two sections—the ROM for addresses and the RAM for data," says Graham. The basic set is a calculator, so it is good at arithmetic and arithmetic operations similar to those employed in controllers for, say, canneries or fuel oil processing plants. One CPU chip can be combined with up to 16 RAMs and up to 32 ROMs. All are interconnected on a four-line data bus.

The ROM is organized as 256 words by eight bits. Address and data are transferred in and out by time-multiplexing on the data lines. And Graham says that the ROM also can be used as an I/O control device. "In this mode, the ROM chip routes information to and from data lines in and out of four I/O ports, decides whether it is an input or an output operation, and then executes the instruction."

The RAM provides data storage; it's organized as four 20-character registers with each character four bits long. The interface chip actually is a 10-bit shift register that acts as a buffer between the ROM and RAM on the inside and a keyboard, display, or printer on the outside. Data is loaded serially and is available in parallel on 10 output lines.

A typical machine cycle starts with the CPU sending a synch signal to the ROMs and RAMs. Next, 12 bits of ROM address are sent to the data bus using three clock cycles (at 1 megahertz). The address then is incremented by one and is stored in the address register. The selected ROM sends back eight bits of instruction or data during the following two clock cycles, and this information is stored in two other registers. The instruction is executed during the next three cycles.

The basic set has 44 instructions. Graham points out that more than one CPU chip can be used for eight-bit or 12-bit machines. All the chips are in standard 16-pin dual in-line packages.

Avionics

TI and French company to sell Category 3 ILS

Not a single U.S. airport has an operating Category 3 instrument landing system, and Texas Instruments' Equipment group in Austin, Texas, hopes to change that statistic. TI is teaming up with Thomson CSF of France, a major worldwide ILS supplier, to sell a new ground system, the LS373, in America. The move comes at a time when the FAA is calling for bids on the first such U.S. system. And while TI is aiming at Category 3 installations (700-ft visibility, no decision height)—the highest class set by the International Civil Aviation Organization—the system can handle Categories 1 and 2.

Thomson developed the concept and equipment in Europe, while TI has redesigned and modified it for domestic requirements. Thomson counts six Category 3 layouts—four in France and two in the USSR—among its 100 ILS installations around the world. Moreover, the equipment can handle all three subcategories—3a, 3b, and 3c. TI will supply a complete system including antennas; it also will provide turnkey installations. The LS373 is compatible with all aircraft ILS receivers.

According to Verlin W. Fisher, a systems engineer in the TI group, the company's entry into the ILS field is based on its experience with other airport equipment: TI has supplied about 200 surveillance radars and 600 alphanumeric displays for the new ARTS 3 air traffic control installations.

An ILS includes a localizer (in the 108 to 112 megahertz range) that centers the aircraft on a runway horizontally, and a glide-path transmitter (328.6 to 335.4 MHz) for vertical location along the proper path. TI's Category 3 equipment transmits two closely spaced frequencies (approximately 10 kilohertz apart) for each function, one for the course, and one for clearance, and depends on receiver capture effect for selection of the proper signals as the aircraft approaches the runway. The localizer signal has a range of about 25 nautical miles, the glide path 10.

The differences between the system categories are largely redundancy of equipment and monitoring. Since performance is easy to achieve, says Fisher, safety and reliability are more important than performance. TI's system includes extensive monitoring—at the antennas, about 300 ft. away, and at 4,500 ft. Automatic switching to a standby transmitter takes less than half a second after a main transmitting system failure. The equipment can operate from batteries with trickle charging, providing three hours of emergency power.

The LS373 is completely solid state. Systems now in use in the U.S. have mechanical cams and motors for switching in coaxial lines for modulation; the TI system uses diodes.

Consumer electronics

Thermal duplicator handles all video-tape formats

The video cassette market would face nothing but clear skies were it not for one cloud: the high cost of tape duplication. There are many formats for video ¾ in., 1 inch, and 2 in.; and both helical and transverse scan—and no one piece of equipment that can duplicate all types. A new company in Santa Clara, Calif., hopes to change this.

Charles T. Webb, vice president and director of marketing for newly formed Consolidated Video Systems Corp., says that with a thermal duplication process, a machine can be built that can handle many different formats. The process can be applied only to chromium dioxide-coated tape—a new type of magnetic tape developed by duPont. Thermal duplication in itself is not new, but there has been no commercially available equipment to implement it. High-speed thermal duplication of magnetic tape is made possible by the unique Curie point properties of chromium dioxide.

Unlike standard iron oxide tapes, which have a very high Curie temperature (high enough to damage the polyester base film), chromium dioxide has a Curie temperature of 125°C, well within the physical properties of the polyester base. At and above the Curie temperature, chromium dioxide becomes paramagnetic and can't accept magnetization from an external source. Below the Curie point, in the range from 125° to 105°C, chromium dioxide is extremely efficient in receiving external magnetic fields.

In the thermal transfer process, a prerecorded magnetic tape master (the master, as well as the slave or copy tape, must be chromium dioxide) is placed in high-speed contact with slave tape—coating to coating. The temperature of the slave tape is brought down through the Curie point very rapidly during contact; the magnetic signal from the master then is imparted to the slave under ideal magnetic conditions, and as the master returns to room temperature, it regains its full magnetic properties.

The present contact video duplication method employed by Ampex and others for commercial use requires an ac field to transfer the signal, and it only works for the video tracks—the audio and control signals have to be rerecorded. Thermal duplication works for all tracks. And, says Webb, "it has the unique ability to duplicate all helical scan video tape formats, including those in which the video information tracks are written across audio and control tracks."

A spokesman at the Ampex Corp. in Redwood City, Calif., says that while high-speed thermal duplication of chromium dioxide tape "has definite benefits such as better video output, a higher-signal-to-noise ratio, and the ability to transfer audio as well as video, there are two drawbacks: the availability of chromium dioxide tape and the deformation of the polyester base—Mylar doesn't like high temperatures." Ampex recently announced a new broadcast ac contract duplicator and is "working on thermal duplication in the lab."

Webb points out that Memorex, BASF, and Sony will be coming out with chromium dioxide tape soon. In fact, BASF and Memorex now have audio tape on the market and a Memorex spokesman says that "the video tape is ½-, 1-, and 2-inch sizes will be out soon." As for the deformation problem, Webb says that "this is where we feel we have developed a patentable art—we can handle the tape and there is no deformation."

Optoelectronics

Reading and writing with manganese bismuth

Capacity means money in the computer business, so the big machine makers always have eyed optical memory systems to give them the big lead in the megabit race. But making a practical optical storage medium has been something else—either it had to be cryogenically cooled or it required a laser too powerful for production systems. Honeywell Corp. now has shown the feasibility of a manganese bismuth optical memory with a first model of 10^9 bits and a projected density of 10^{10} to 10^{11} bits. Most important, this kind of density translates into low prices—less than 10^{-4} cent per bit.

The key development is an improvement in the quality of the MnBi film materials. Honeywell's film has a pinhole imperfection rate of only 0.1%. Because of this uniformity Honeywell can demonstrate a packing density of 150 megabits per square inch.

As with all MnBi storage memories, data is entered by Curie point writing, during which the local temperature of the film is raised above its Curie point. When cooled this spot has a distinctive magnetization state that can be optically detected to retrieve the information. Writing is done with a high-power helium-neon laser (a few milliwatts for 1 microsecond),

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INSTRUMENTS DIVISION

BELL & HOWELL

Circle 27 on reader service card

and reading is accomplished with the same laser operating at reduced levels (less than 0.1 mW) [*Electronics*, Nov. 13, 1967, p. 50].

In operation, a 1-inch strip of film is put on a 6-inch disk and the disk is rotated across the laser beam to access the spot on the film to be written or read. Using a disk-rotation rate of 10 rotations per second, the read and write data rate is 1 megahertz with an average access time of approximately 30 milliseconds. A cycle life time of 1 million already has been shown with no reduction in output power. Honeywell developer Di Chen expects that in 1 to 2 years this optical storage can be made to interface with an operating computer to establish the overall requirements of an optical memory system.

For the record

Cable scramble. Athena Communications Corp., Los Angeles, has developed a new sound and video scrambling system that will be tested this fall on six Athena CATV netw networks. An encoder, which will be leased to cablecasters, generates a gray-blank picture by replacing the synchronizing and blanking components of the composite video signal with a steady voltage at the transmission end. It also bumps the sound out of frequency. The cable customer who agrees to pay for the programing on the scrambled channels gets a decoder built into a standard multichannel converter that resurrects the sound and picture. According to Athena, a CATV broadcaster will be able to use the decoders for about $20 to $25 each, depending on the number installed. Another pay-as-you-view encode and decode system developed by Zenith is primarily intended for over-the-air telecasts.

Fooled again. IBM has once more confounded the IBM-watchers by announcing the System 360 model 22, described as "a general-purpose computer that combines intermediate-scale data processing capability with small-system economy." Supposedly the 360 series was condemned to oblivion last June when the System 370 was announced [*Electronics*, July 20, 1970, p. 109]; the low end of the line was expected to be filled with either a bigger and better model in the System 3 line or a smaller and cheaper model in the 370 line.

The model 22 has one multiplexer channel and one selector channel for low- and high-speed input-output equipment respectively, and has a main memory of up to 32,768 bytes cycling in 1.5 microseconds. A typical system will rent for $5,600 per month.

New entry. Intersil Inc., the Cupertino, Calif., LSI house, is on the verge of moving into the electronic watch parts field with a liquid crystal display. The company's interest was triggered by watchmakers' search for a small, low-power digital display, says Robert Dugan, marketing manager for time systems.

Dugan says that Intersil has come up with a liquid crystal material that scientists feel can be multiplexed. If, in fact, it can, Intersil likely will develop a commercial display and start putting money into production facilities.

Confident that it has found the right material, Intersil already is planning to show a feasibility model of a three-digit readout in mid-summer. Dugan estimates that a liquid crystal watch could eventually come to market for as little as $25.

Japanese EVR. CBS has licensed four Japanese consumer electronics manufacturers to market Electronic Video Recording units in the U.S. in competition with Motorola, previously the sole CBS licensee for this country. This brings to 10 the number of worldwide EVR producers. Officially, Motorola greeted the Hitachi, Matsushita, Mitsubishi, and Toshiba entry, due in 1972, as welcomed help in convincing the American consumer to buy EVR rather than competing home video cassette systems. The Japanese firms also will sell the more expensive industrial-educational version in this country. Lloyd W. Singer, vice president for Motorola Systems Inc., says his company will sell its Teleplayers to the Japanese in order to get them into the market quicker.

Share the work. A lengthy battle over who buys what from whom is shaping up as delegates from 79 member nations of the International Telecommunications Satellite Consortium meet in Washington to write a permanent charter.

At the heart of the controversy will be an attempt by the Europeans and the Japanese to make sure the charter requires the board of governors of the consortium to spread around contracts from nations offering comparable proposals for satellites.

Something new. Development of hardware for the next-generation air traffic control system is expected to begin well before the FAA completes upgrading its existing system, a top Department of Transportation official says. Within two years, says Donald E. Findley, Deputy Assistant Secretary for Systems Engineering, the Department of Transportation plans to turn over its conceptual designs to the FAA, which will develop the hardware. Assuming that new-generation system components will be needed in the early 1980s, hardware development could begin within three to four years.

Cash needed. Cogar Corp. has laid off 300 employees, about half its total labor force, most of them from its Information Systems division at Schuyler, N.Y. The Technology division, Wappingers Falls, N.Y., escaped relatively unscathed. Two reasons were cited for the layoffs: first, the semiconductor memory business (Technology division) is not growing as fast as predicted; second, the Cogar 4 data entry system (Information Systems division) is being leased by far more customers than are buying it, requiring a large cash flow.

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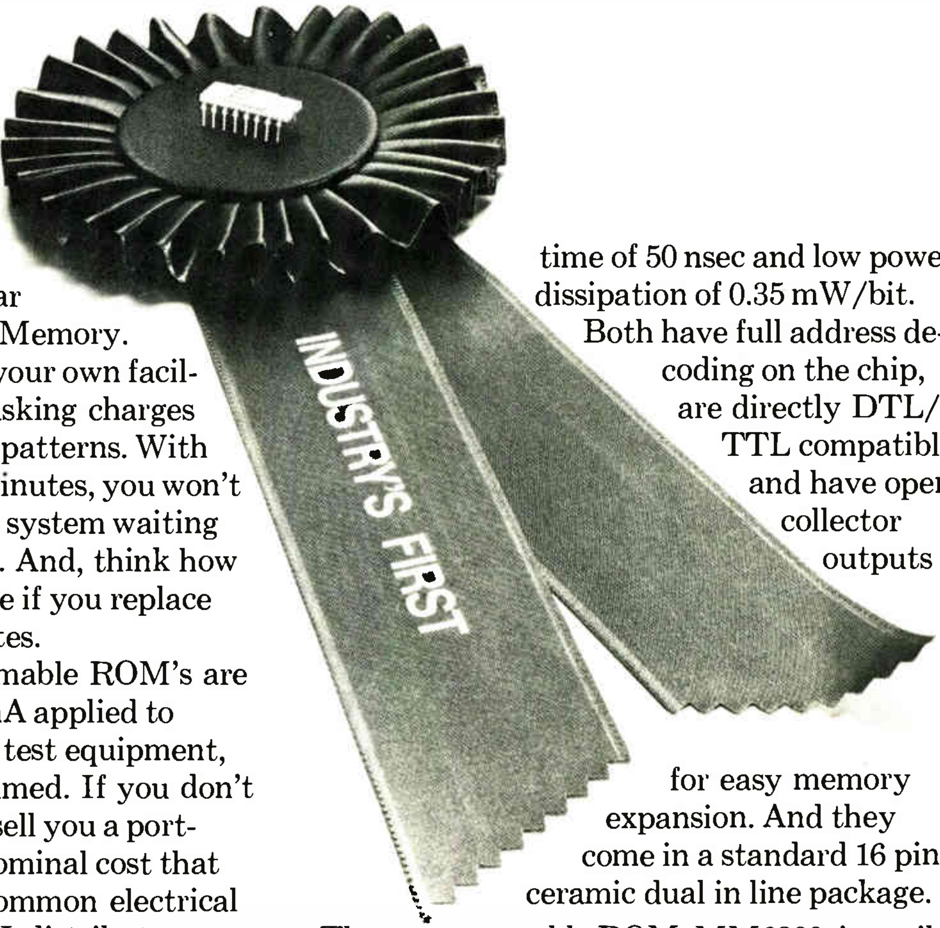

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Washington Newsletter

April 26, 1971

DOD has designs on new Navsats . . .

A $9-million chunk of new money in the Defense Department's fiscal 1972 space program budget will kick off system definition and design of the next-generation Defense Navigation Satellite System with a broad range of capabilities. Experimental components are already being designed in-house and through small, scattered R&D awards to contractors who have not been told of the application in mind. As now conceived, **the DNSS could be used for military air traffic control as well as ocean navigation, position fixing, charting and ground mapping.** The system, say Pentagon officials, could eventually replace the broad mix of equipment now used for these purposes, including the Loran and Omega radio system, navigational onboard radar and the Navy's navigational satellite, Transit.

. . . and FAA's Aerosat may serve maritime uses, too

The controversial U.S. aeronautical services satellite (see p. 75) may become a maritime services satellite as well if several prospective bidders have their way. Having noted that the Federal Aviation Administration plans not to buy the spacecraft outright but just to lease three voice channels aboard it from the successful bidder, several **industry teams are seriously considering the launch of a high-capacity satellite that could serve both aeronautical and maritime interests. Such a system would increase its proposer's chance of winning the FAA contract by decreasing channel costs.**

One bidder on the contract, which is due to be awarded this fall, says that his firm has all along been considering a multiple-use satellite over the Pacific. The firm's reasoning is also supported by a recent Department of Transportation study indicating that **the maritime industry will need a minimum of five voice channels and one 2,400-bit-per-second data channel by 1980.** These channels would be shared by 3,739 probable users of the system in the Pacific, the DOT study says.

Postal Service, Philco keeping mum on mail study

Both the U.S. Postal Service and Philco-Ford are maintaining a low profile as they begin the conceptual design of an all-electronic network to carry high-priority first class mail. Sources close to the program note that neither Philco's Communications and Technical Services division nor the Postal Service has announced the April 12 award of a one-year $249,000 design contract to the firm since both fear the wrath of Congress and the common carriers [*Electronics*, March 15, p. 54]. They add that **Western Union and AT&T can be expected to fight the program since it would create Government competition in communications and that Congress will probe the privacy of electronic mail.**

In winning the contract, Philco outpaced some of the industry's toughest competition. Although postal officials decline to confirm who the bidders were, industry sources mention IBM, RCA and Burroughs.

Army talks up new way to monitor R&D

Creation of "a small, high-caliber new institute" is being proposed by the Army to evaluate its seven "new initiatives" in research and development planned for fiscal 1972 [*Electronics*, Jan. 4, p. 33]. At the same time, Army sources privately hope the institute will take some of the Congressional heat off the service for soaring R&D costs.

Specific "new initiatives" program developments include the Hellfire missile, a nametag derived from heli-borne, laser-guided, "fire-and-forget" weapon, one which homes on target independently of the launch vehicle. Complementing this is a program to assist in target illumination by equipping infantry and artillery forward observers as well as helicopters with lasers. In addition, the Army wants to upgrade its Light Observation Helicopter into an all-weather system to assist helicopter gunships. Other "initiatives" are the upgrading of forward area air defense systems such as the Chaparral/Vulcan; aircraft electronic warfare protection equipment; and the integrated battlefield control system known as Stano—Surveillance, Target Acquisition, and Night Operations—which includes $11.5 million in fresh money for an aerial Stano system.

NASA supporting holographic memory efforts by RCA

With the help of space agency money, RCA Laboratories, Princeton, N.J., is launching a major effort to develop a read-write holographic memory [*Electronics,* Jan. 18, p. 61] that would replace both mainframe and peripheral memory units. NASA sources say that RCA is pumping at least $600,000 into the project and that the agency's $200,000 contract was given to the firm so that "we would hold some of the stock in the program." The award is part of NASA's program to build a trillion-bit memory by 1977 for space station and earth resources satellite applications.

RCA hopes to complete a feasibility model of the memory, consisting of 1,000 "pages" of data blocks, by March of next year. Each page will hold 1,024 bits in a hologram 1 millimeter on a side. However, only 10 bits will be alterable in each page, simplifying the electronics that will be required to prove the concept.

DOT to study national system for flight plans

Work on a massive computer-based system that may someday revolutionize the way air traffic is managed will be started after July by the Department of Transportation. Called flow control, the DOT system would store all flight plans filed by pilots seeking to fly between air traffic control sectors. If a flight plan called for the use of the same airspace at the same interval of time as a previously filed plan, the computer would immediately flag the conflict and either give the pilot an amended plan or ask him for a new plan.

Such a system would mark one of the first steps in the creation of a strategic or flow planning air traffic control system as opposed to the present day flight-oriented system, Federal Aviation Administration planners say. About $500,000 is budgeted for fiscal '72 studies of the system, with hardware and software development scheduled for the late 1970s.

Addenda

The Air Force is asking for $23.7 million to begin procurement in fiscal 1972 of its Command Data Buffer System, a scaled-down substitute for the Minuteman Integrated Command and Control System which was dropped last year when costs began to get out of hand. . . . The Bureau of Radiological Health wants to receive comments on proposed amendments to electronic product radiation regulations, including the stricter record-keeping requirements and new exemptions to manufacturers of products intended for classified Government use.

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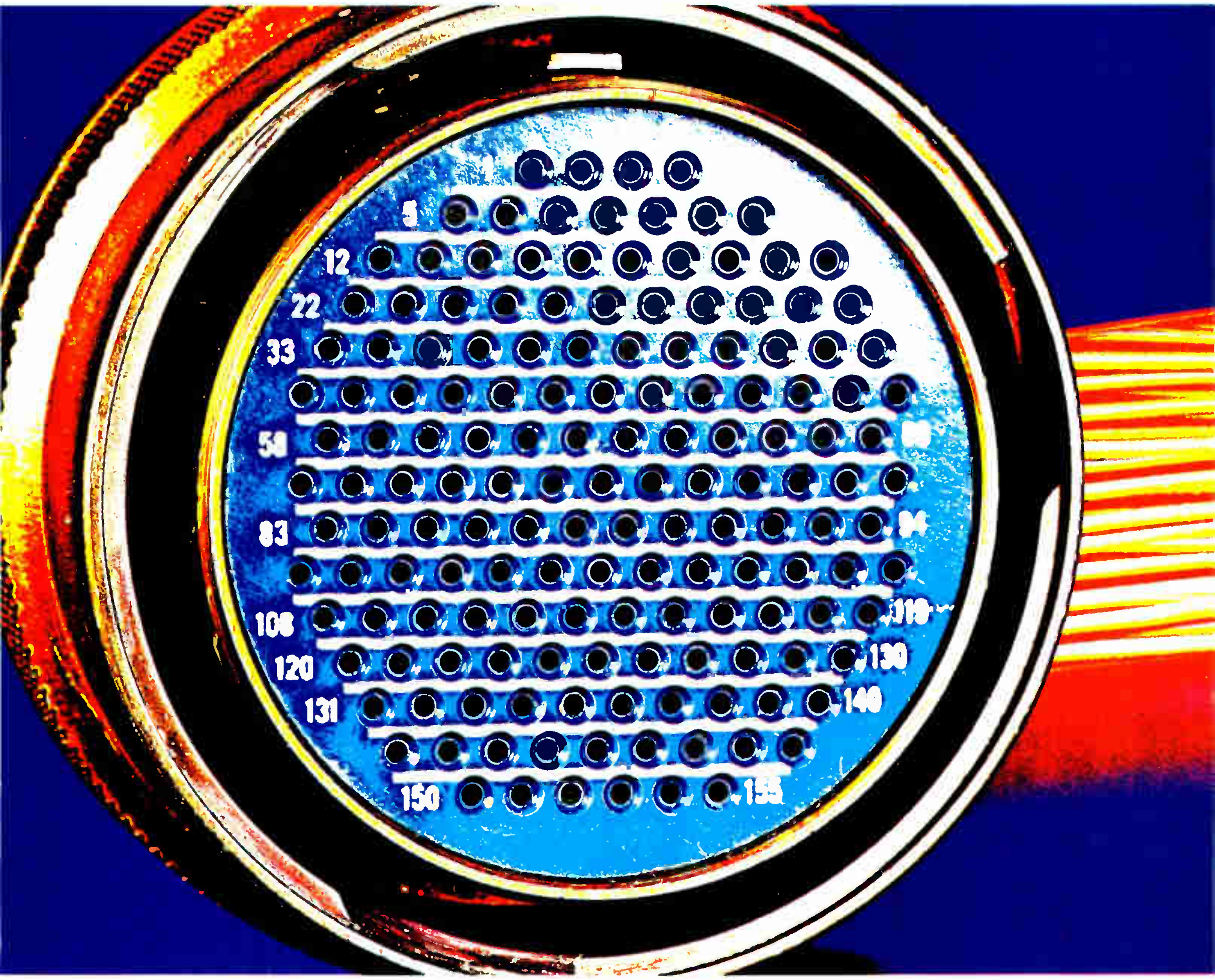

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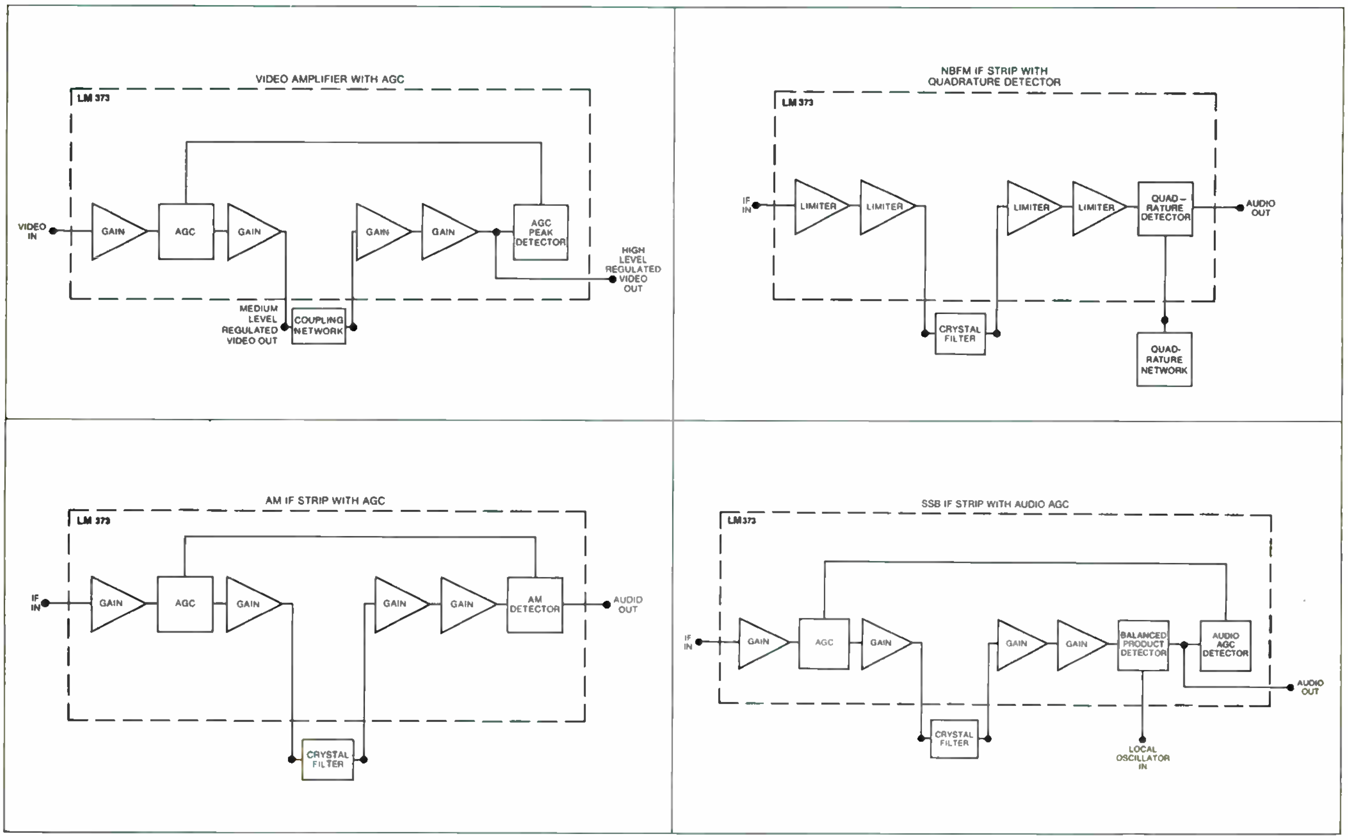

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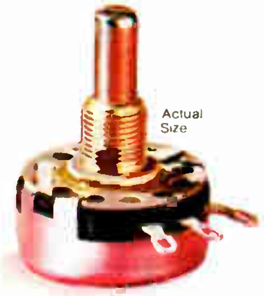


NEW DIMENSION ELECTRONICS

ALLEN-BRADLEY

Circle 36 on reader service card

Technical articles

New technologies give instruments high performance: page 38 (cover)

The mission was to design a new line of instruments with high performance built in from the ground up. The approach was to use the best advantages of MOS/LSI, solid state displays, and thin film circuitry. And the results, say the authors from Hewlett-Packard Co., are a counter and a digital voltmeter that provide impressive capabilities usually available only at higher prices.

Fast logic fans, let's hear it for ECL: page 48

When it comes to providing high speed with relatively low parts count, emitter-coupled logic wins hands down over its transistor-transistor logic and MOS counterparts. But to obtain maximum performance for computers, says author Anthony A. Vacca, the designer must consider the fabrication, packaging, and thermal tradeoffs in his application.

You and your career: what's ahead? A questionnaire: page 53

Buffeted by high unemployment and shifting national priorities, engineers are going through some agonizing reappraisals.
To gather the full story on how engineers feel about their careers and their changing role in society, the editors of Electronics invite readers to participate in a special report that will appear in an upcoming issue.

Problems are designed out of wide-angle color TV tubes: page 60

Increasing the deflection angle in a TV tube from 90° to 110° achieves a slimmer configuration—and brings with it tricky deflection, misconvergence, and distortion problems. For their new 18- and 19-inch color receivers, the first 110° units on the market in the U.S., RCA engineers controlled these problems by using a narrow tube neck, redesigning the yoke and gun, and putting tighter controls on manufacturing processes.

Designers, keep your eyes on multichip LSI packages: page 65

Those systems designers who feel it's unnecessarily wasteful to put a single 200-mil LSI chip in its own 2-inch package are not only right, but have an emerging alternative—multichip packages. In the second of a two-part special report, author Stephen E. Scrupski notes that prices of the multichip units are coming down, thanks in part to work in ceramic technology and multilayer structures.

And in the next issue . . .

Special report on LSI testing . . . communicating with computers by voice command . . . an MOS read-only memory that is electrically programable . . . using computer-aided design for pc board layout . . . TV color subcarrier as a frequency standard.

Three new technologies converge in high-performance instruments

Engineers drew on the latest advances in MOS/LSI, solid state displays, and thin film circuitry in designing a counter and a DVM; the units provide performance usually available only at higher prices

by Ian T. Band and Hans J. Jekat, *Hewlett-Packard Co., Santa Clara, Calif.* and
Jerry B. Folsom, *Hewlett-Packard Co., Loveland, Colo.*

☐ Providing a new generation of instruments that are smaller, less expensive, and more versatile, while meeting higher performance parameters, is a tall order that's best filled by designing in an ideal combination of new technologies—from the ground up. This approach—building in the best features of integrated circuit, solid state display, and thin film fabrication technologies—is being put to work in a line of counters and digital voltmeters.

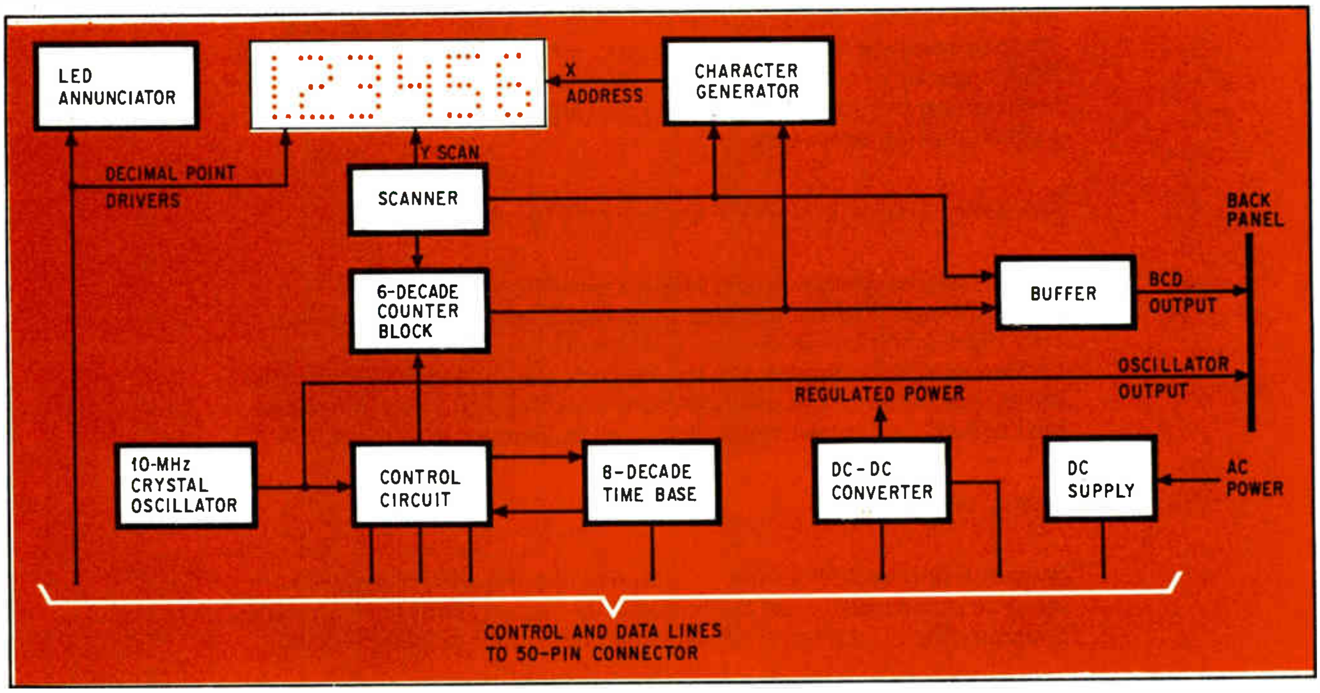
Two of the new instruments—the low-cost 5300A counting system and the 3403A 100-megahertz DVM—incorporate MOS/LSI chips that operate at 10 MHz; bipolar ICs that extend counter range to 500 MHz; a six-digit and a 3½-digit, time-shared, light-emitting diode display, and a hybrid thin film amplifier that meets exceptionally stringent specifications to permit dc to 100-MHz operation. This combination yields impressive performance in compact packages, as well as the capability to adapt to more functions and even higher performance as they are required.

An important benefit of designing with MOS/LSI technology is add-on capability. For example, it would be costly to add autoranging circuits to a counter, but it costs almost nothing to put them into the 5300A—they are fabricated on the same chip as the time base. The same applies to the DVM, where MOS MSI circuits give a decibel ranging capability.

Use of LSI and MSI techniques also severely cuts power requirements. And size, too, is significantly reduced, permitting the counter, which comprises a mainframe and a plug-in, to be built along the lines of a small computer. As shown in Fig. 1, data and control signals are routed through a central bus, which also serves as the connection between mainframe and plug-in.

During development of the instruments, it became obvious that design problems in both were alike in

1. Counter parts. The 5300A counter comprises a mainframe, shown in black diagram (below), and one of several plug-ins. Mainframe and plug-in are joined by 50-pin connector on underside of mainframe. Key components are two MOS/LSI circuits—counter block and time base. Shown at right are complete counter along with four plug-ins.



many respects and should be solved together. Accordingly, engineers in three separate divisions, building displays, voltmeters, and counters, combined resources and talents. Principal areas of mutual concern were counting logic and displays.

A frequency counter, a digital timer, and a dual-slope integrating digital voltmeter all incorporate a basic counting arrangement like the one shown in Fig. 2. Since most other fundamental parameters, such as temperature, power, and phase, can be converted to functions of voltage, frequency, or time, this basic counter can be applied to almost all digital measuring instruments. It consists of a chain of decade counters, a set of latches to store information, and decoding logic and gates to interface the stored data with a visual display or digital output circuit.

Basic counters usually are built with transistor-transistor logic, using off-the-shelf MSI circuits. However, these ICs consume large amounts of power and space, and can be expensive. That's why it was decided to design with p-channel MOS large-scale integrated circuits. In the counter, for example, two MOS/LSI circuits—the counting block and the time base—each replace approximately 20 bipolar MSI circuits. The space and power requirements are approximately one-tenth what they'd be with MSI devices, and production costs are cut by about 50%.

The frequency counter and the voltmeter called for slightly different counting block designs. The DVM display, for example, was to have only three digits plus an overrange digit, while the counter was to have a six-digit readout. The voltmeter required only a 60-kilohertz counting rate, while the absolute minimum acceptable specification for a frequency counter is about 10 MHz.

The first step in developing the MOS counting circuits was to build a three-decade counter block for the voltmeter. It was decided to aim for a 10-MHz circuit; that experience later would be used in building the counter's six-decade block.

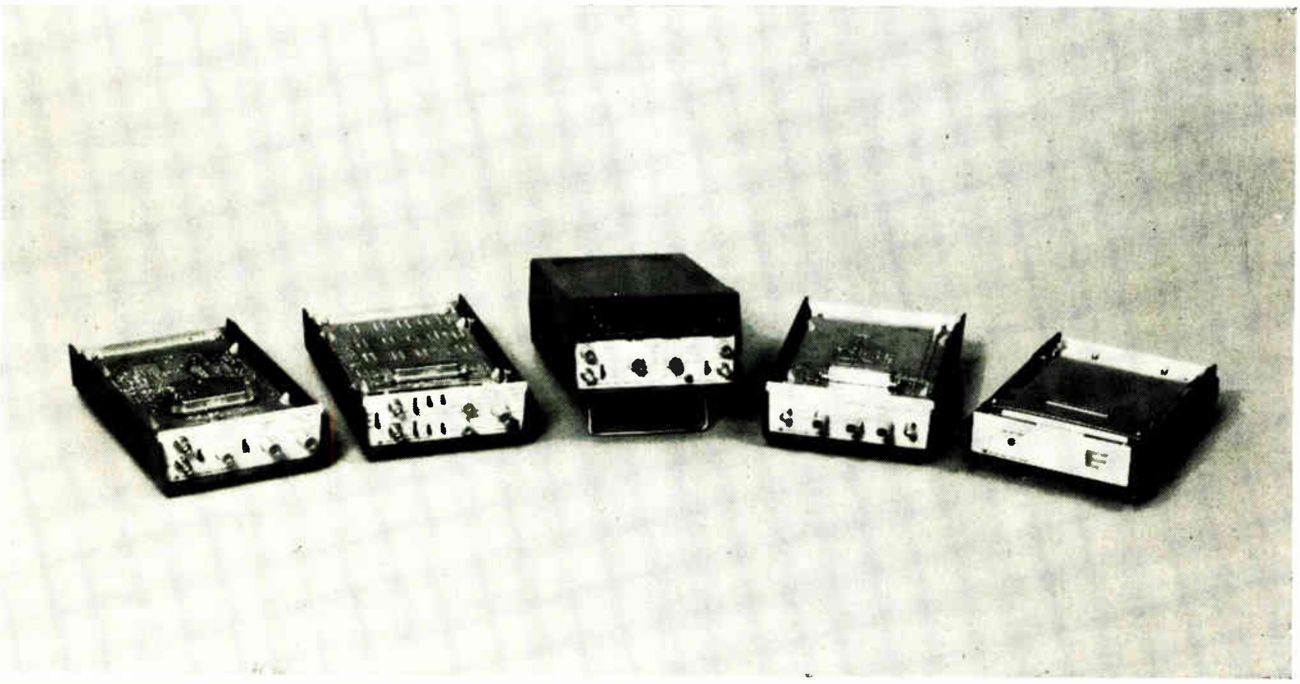
However, it would have been impractical to make all circuits in the counter operate at 10 MHz: the chip would have drawn too much power and would have been much too large to be economical. Fortunately, as shown in Fig. 2, most of the counting logic in a 10-MHz counter operates below 1 MHz; only the first decade operates at 10 MHz. Therefore, to keep overall size as small as possible, it was decided to divide the circuit into three sections—high speed (10 MHz), medium speed (1 MHz), and low speed (100 kHz and less) with the device geometries of each section optimized for those speeds. The high-speed decade easily could have been made bipolar, but at some sacrifice in size, power, and cost. Instead, the entire counter block was made as a single MOS/LSI circuit.

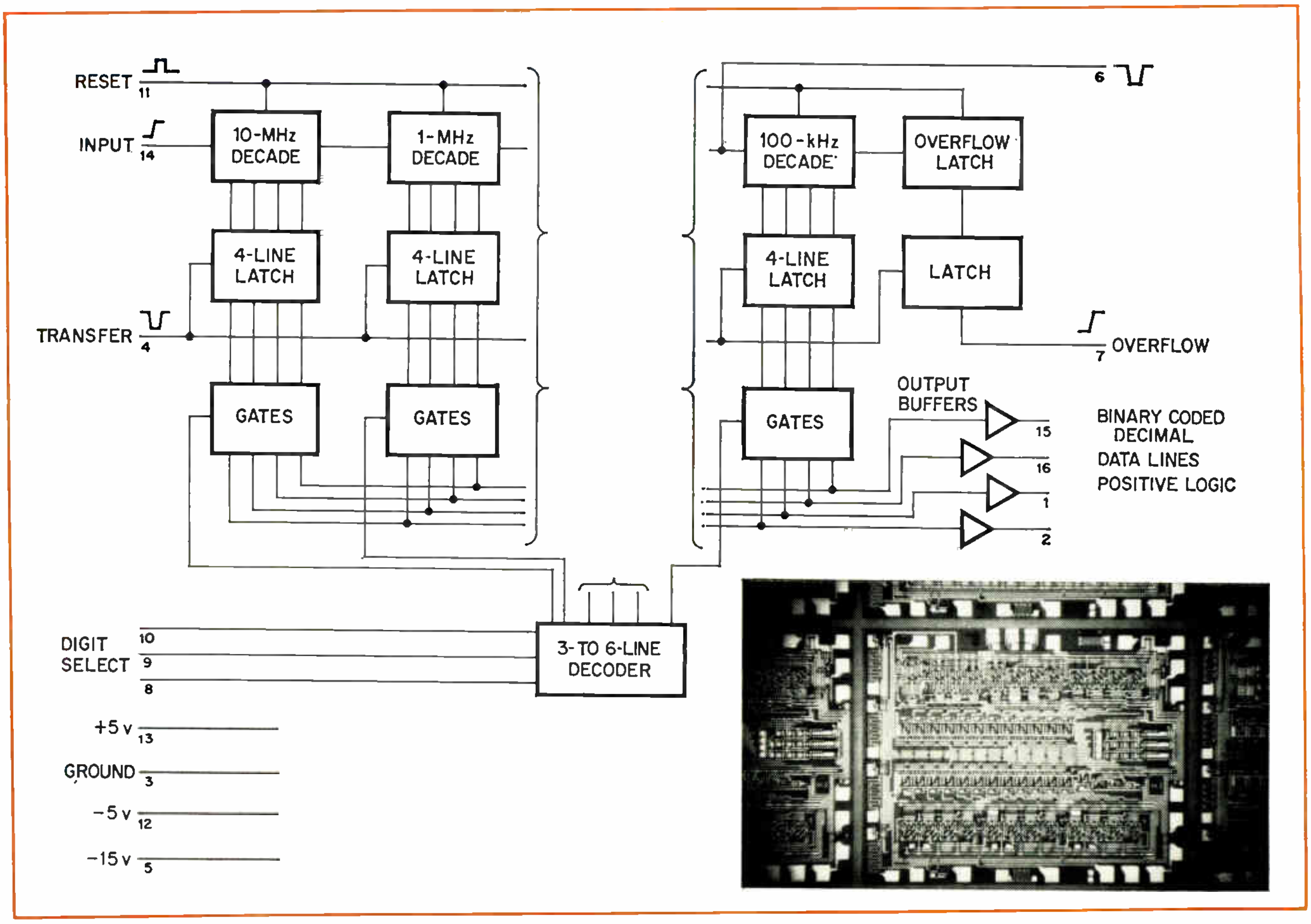
Figure 3 shows the block diagram of the high-speed decade. The design is conventional. It uses master-slave flip-flops and an asynchronous, ripple-through counting technique with a delay circuit in the feed-ahead loop. The first flip-flop divides by two while the last three combine to divide by five.

Still, it seemed impossible at first to build even the 10-MHz segment with a conventional low-threshold p-channel MOS process. The large size needed to satisfy the high-frequency requirement would have resulted in a level of interconnection capacitance that ruled out 10-MHz operation. (Newer MOS processes promise much faster operation, but they don't yet pro-

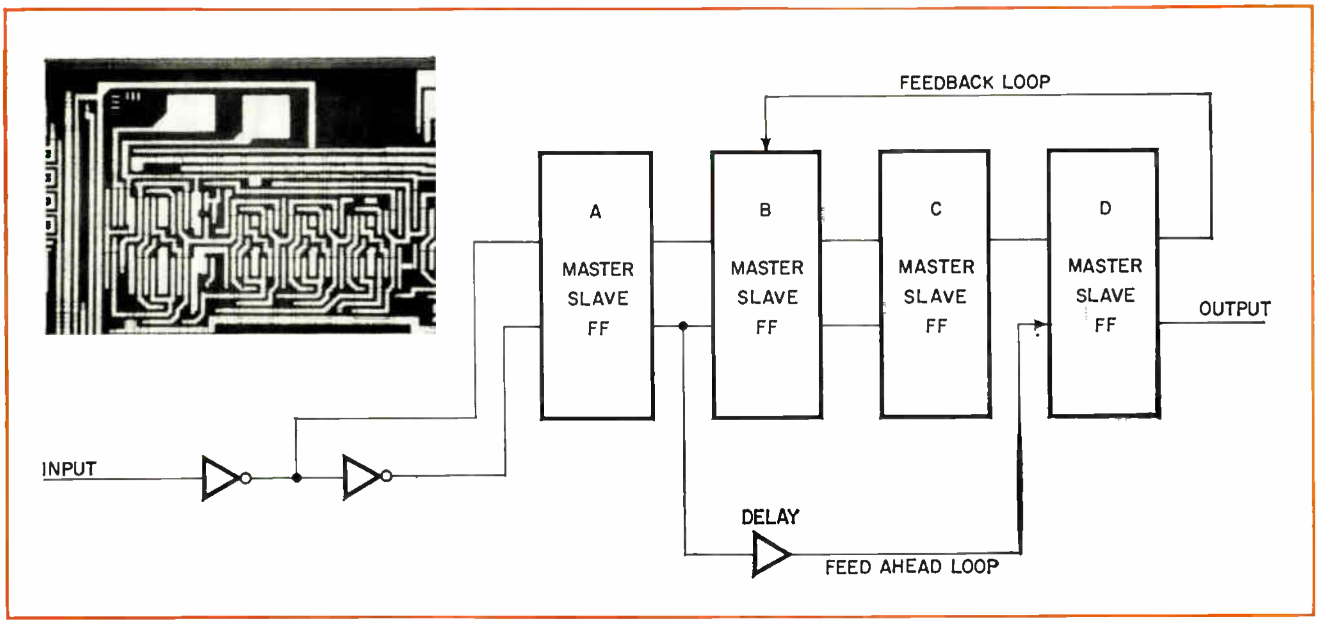
On the cover

Against a backdrop formed by the rms converter section of H-P's new 3403 voltmeter are some of the high-technology components that went into it, including solid state displays, MOS/LSI modules, and thin film hybrid circuits.





2. Counter block. Counting circuitry in 5300A is of standard design. Clock signal comes into row of decade dividers, each connected to latch and gate. Decoder provides serial output in BCD form. What's unusual is that this entire circuit—including the 10-MHz decade—is on one 16-pin MOS chip, shown on right.



3. High speed. The 10-MHz decade in counting block is an asynchronous ripple-through counter. Flip-flop A divides clock-signal frequency by two; B through D combine to divide A's output frequency by five. Since maximum frequency applied to quinary divider is 5 MHz, B, C, and D can be half A's size. Size difference shows up in microphotograph of high-speed portion of counter block. A, at left, takes up approximately a quarter of picture width. To right are B, C, and D.

vide the reliability and high yields of conventional p-channel MOS.)

The solution, as it was with the counter board as a whole, was to segment. Only the first binary divider (flip-flop A) has to accept the full clock rate of 10 MHz. The remaining quinary divider (flip-flops B, C, and D) operates at half the incoming frequency.

Thus, the high-speed decade was sectioned into 10-MHz and 5-MHz portions. Building the 5-MHz portion wasn't particularly difficult, but the 10-MHz flip-flop demanded further innovation.

The 10-MHz transistors were made larger than the 5-MHz ones: the ratio of gate width to gate length (Z/L) was doubled. This halved gate resistance and almost doubled operating speed. (Differences in transistor sizes can be seen in Fig. 3.) Doubling Z/L wasn't enough to assure 10-MHz operation—again because larger devices usually mean larger capacitance. To minimize the drain and Miller capacitances, channel lengths were reduced to 2.5 microns after side diffusion, and the gate metal overlap before diffusion was cut to 1.25 microns. The lower-speed transistors (5 MHz and less) also have a 2.5-micron channel length; their gate metal overlap is 2.5 microns.

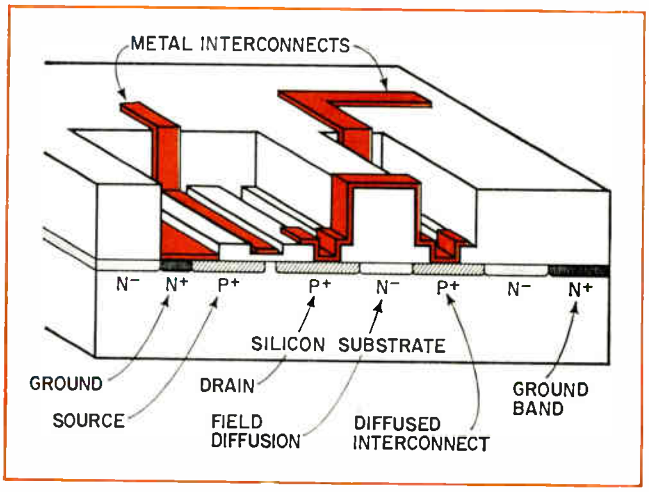
To reduce interconnection metalization, a "ground riveting" technique was developed that eliminates almost all ground lines to the sources of the MOS transistors (typically, half the transistors in an MOS circuit are grounded). Though these lines cause very little capacitance, they make interconnection to various parts of the IC difficult. By eliminating them, interconnections can be made much shorter.

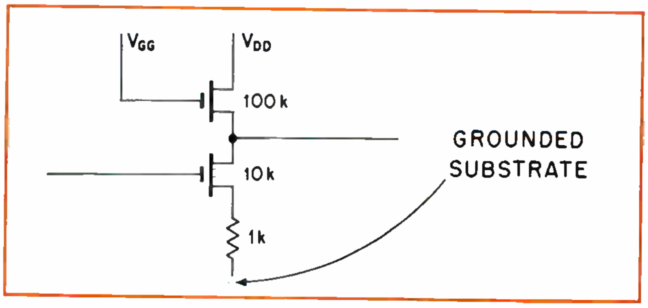
With ground lines largely eliminated, the size of the chip was reduced, and speed increased to the point where counting rates of 12.5 MHz to 20 MHz were consistently achieved. This is an acceptable safety margin for a 10-MHz specification.

The ground riveting technique is illustrated in Fig. 4. An n+ region is diffused next to the p+ source, and the two diffusions are connected by metal. This joins the source to the grounded substrate through a low-level resistance, made up mostly of the resistance of the metal joining the source to the n+ diffusion. To reduce this series resistance, a guard band of n+ material is diffused around the entire chip, dropping the series source resistance to approximately 800 ohms per square mil. Figure 4 shows a typical MOS inverter with one transistor riveted to ground. The 1-kilohm resistor represents the series source resistance. A load-to-source resistance ratio of 100:1 was selected to assure sufficient noise rejection.

The additional n+ "ground" diffusion, part of the ground riveting technique, yielded an unexpected benefit in the form of a unique gate protection scheme. An n+ diffusion and an adjacent p+ diffusion form a lateral diode whose breakdown voltage is between 9 V and 11 V. Such a diode can be used to protect transistors whose gates are connected directly to a pad. The diode is formed near the transistor, as shown in Fig. 5; the metalization from the pad makes direct contact with the diode's p region.

In effect, the pad has a pair of parallel diodes that connect it to the substrate: one is the lateral diode,





4. Ground riveting. Unique diffusion scheme reduces number of metal interconnects by making ground lines to sources unnecessary. An n+ region is diffused next to p+ source, and is joined to source by short metal strip. This connects source to ground via low-resistance path through metal, n+ region, and substrate. A second n+ region—the ground band—further reduces source-to-ground resistance by bringing ground point closer to all parts of the substrate. Schematic shows inverter with transistor riveted to ground. The 1-kilohm value represents metal strip and n+ diffusion.

the other is the junction of the p+ region and the bulk material. Together they form a protection circuit for the gate. The substrate is typically biased to a +5-V level. If voltage on the pad decreases to approximately −5 V, the zener diode breaks down, shunting current away from the gate. When pad voltage goes over approximately +5.6 V, the p+, n diode begins conducting. Advantages of this internal protection scheme over separate external protection circuitry are less capacitive loading, smaller geometry, faster response time, and lower protection breakdown voltage.

With the DVM's three-digit, 10-MHz counter out of the way, it wasn't difficult to apply the same techniques to a six-digit version for the counter. However, another problem did have to be solved: reducing the number of pin connections. A typical six-digit counter circuit has parallel readout with 24 outputs to the display driver—too many to fit in a compact package. So strobing was used to reduce the number of outputs. The digits are read out one at a time on the same four lines (pins 1, 2, 15, and 16 on Fig. 2). Three input lines (pins 8, 9, and 10) control the digit to be read out and the timing of the readout. In this way, 24 pins are reduced to seven, and the chip fits neatly into a 16-pin ceramic package.

A microphotograph of the counter-board chip is shown in Fig. 4. It measures 96 by 118 mils, contains 930 transistors, and consumes 300 milliwatts.

The time base circuit of an electronic counter also uses large amounts of complex logic. To achieve high measuring speed and resolution, the counter was designed with a 10-MHz time base, supplied by a 10-MHz crystal-controlled oscillator. Since gating intervals as long as 10 seconds were desired, it was necessary to divide the 10-MHz oscillator signal (with a period of 100 nanoseconds) down to a 100-hertz signal (with a period of 10 seconds). This meant that the time base would need eight, not six, decades. But it still proved feasible to build the complete time base as a single MOS/LSI circuit, using the same concepts that worked with the six-decade counter. The two extra decades operate at low speeds and therefore take up little extra real estate. Furthermore, the time base, unlike the counter block, doesn't need storage registers. Its chip is 109 mil^2 (Fig. 6) and contains 980 transistors.

To reduce pin count and utilize LSI technology, the architecture of the time base was changed from the traditional divider chain to that shown in Fig. 6.

The major distinction from previous counting instruments is a second time-base output that produces a train of logarithmically spaced pulses. This output provides the instrument's autoranging features.

At the beginning of each measurement, a start pulse is generated at the logarithmic output; thereafter, timing pulses are generated only when the number of input pulses is equal to a power of 10 (after 1, 10, 100, 1,000 pulses, etc.). Each pulse is precisely timed in relation to the start pulse. This logarithmic output allows the time base to be selected during a measurement. Traditional autoranging schemes are slower—the input is sampled and the time base is selected before the actual measuring begins.

In the autoranging mode, the measurement continues until the divider chain in the counter block is almost filled. Then the appropriate time base output pulse is selected to terminate the measurement before the display overflows. For example, if the frequency to be measured is 5 MHz, a gate time of 0.1 second would be needed to yield a full six-digit display of 5.00000 MHz. When the measurement starts, the first logarithmic pulse (at time = zero) opens the gate and allows the 5-MHz signal to be counted. The control circuits ignore the next logarithmic pulses, at 1 microsecond, 10 μs, 100 μs, 1 millisecond, and 10 ms. Just before the fifth counting decade overflows (after 20 ms) a signal from that decade causes the control circuit to terminate the measurement on the next logarithmic pulse—at 0.1 second. To determine decimal-point position and the units (i.e. Hz, kHz or MHz) to be displayed, the counter measures the number of logarithmic pulses that occurred.

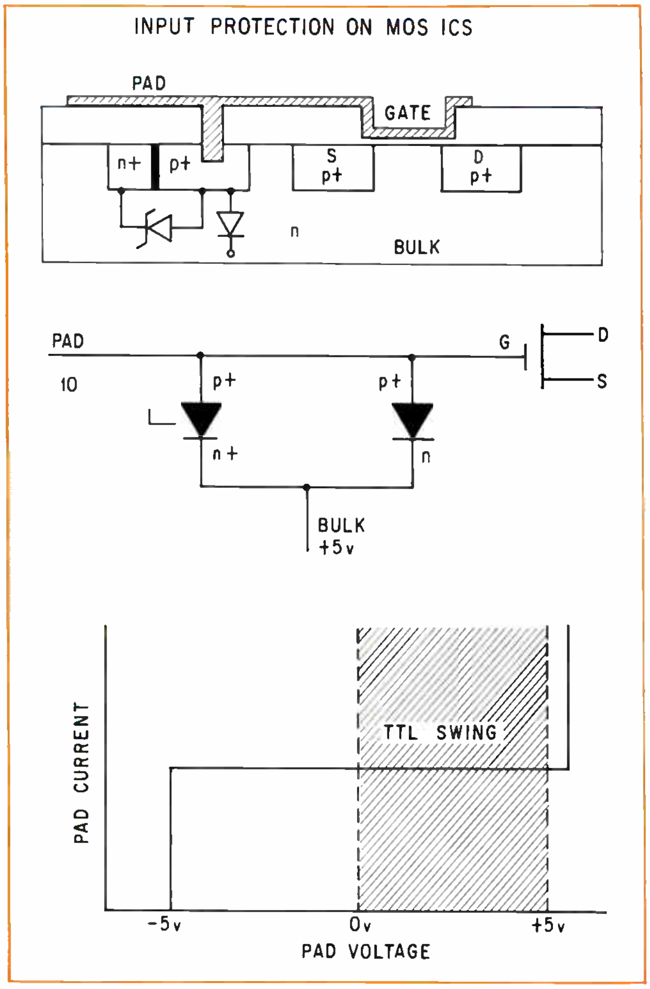
If the input frequency is too low to fill the display in a reasonable time, the regular time base output may be used to enable the control circuits at a selected maximum time, such as 1 second or 10 seconds.

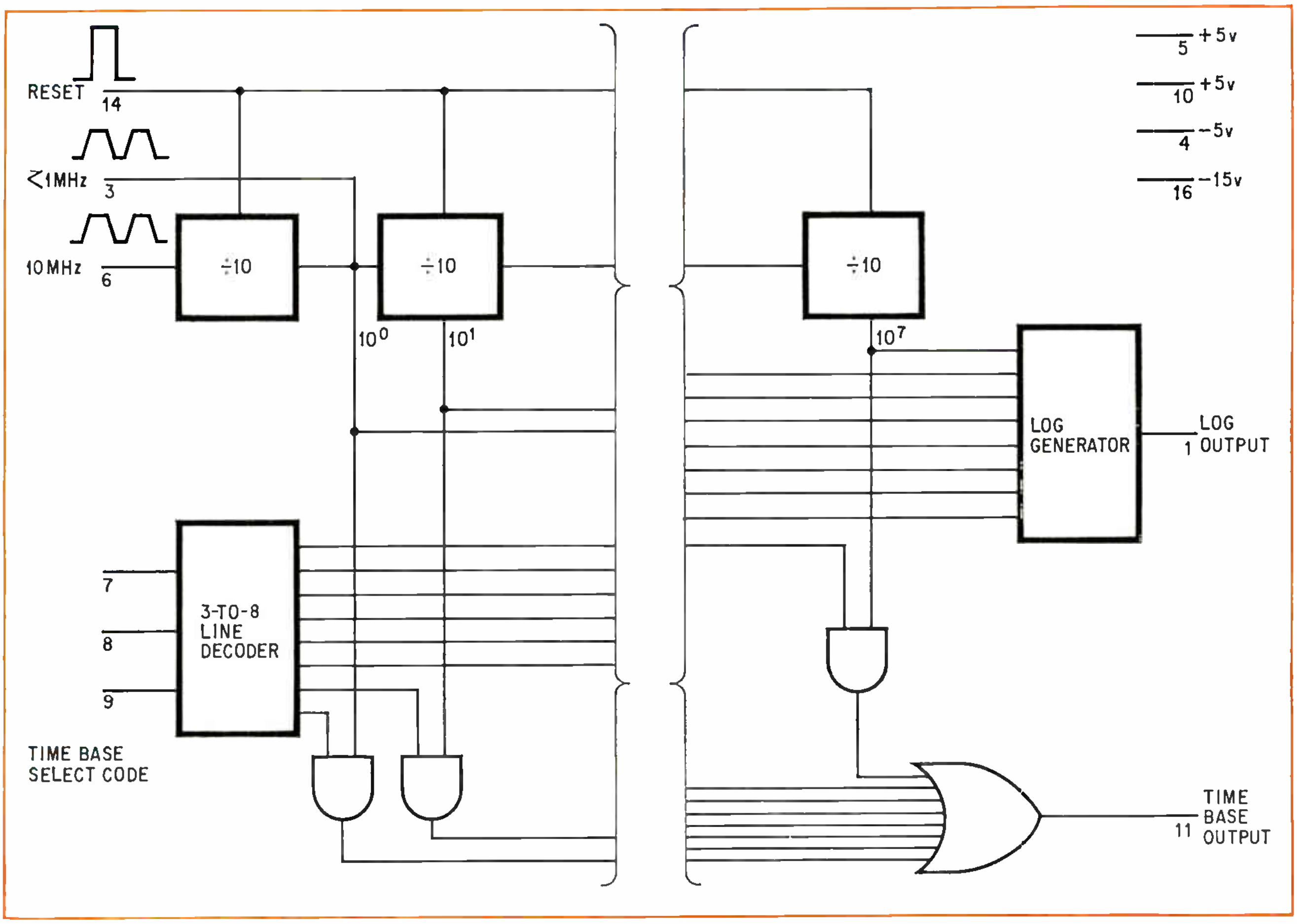
Timing and gating signals for the counter are generated by another IC—the control circuit, which processes the signals to the two MOS/LSI chips and provides all timing control for the measurement cycle. Not an MOS device, this IC is a high-speed (20 to 30 MHz) bipolar MSI circuit with about 200 transistors. High-speed gating and gate-control flip-flops minimize any measurement errors due to timing differences when the gate opens and closes. And high-speed Schmitt triggers reshape the input to reduce noise errors. The equivalent chip in the DVM is made with MOS technology. Since high speed wasn't essential, the low power of MOS was the deciding factor.

In selecting the display format and technology for the new instruments, readability and reliability were the key criteria. And low-power operation was a requirement—the display had to work with voltage and current levels obtainable from integrated electronics.

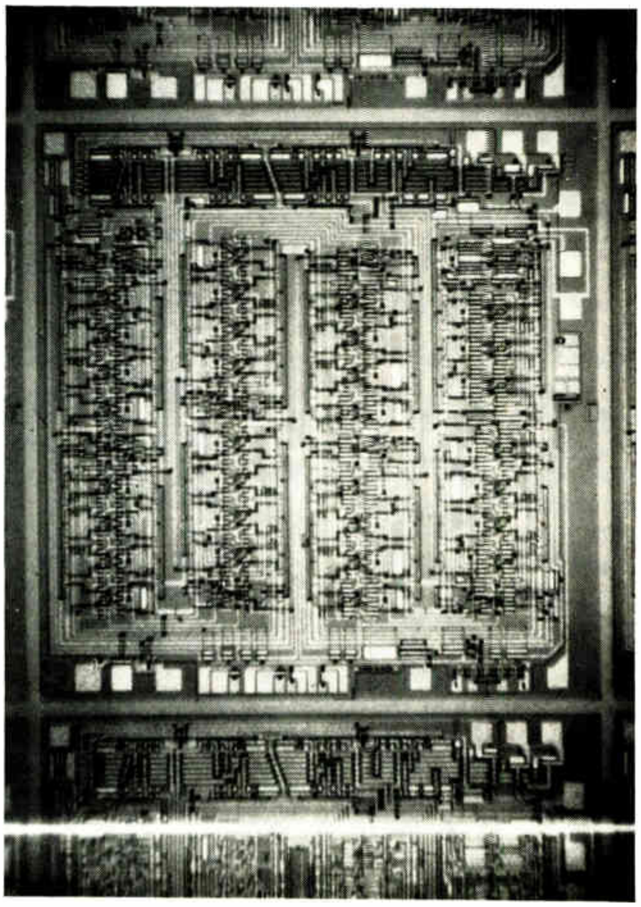
Another limiting factor was the small size of the

5. Gate protection. Lateral zener diode formed by side-by-side n+ and p+ diffusions helps protect gate that's connected directly to pad. When voltage across zener diode is approximately —10 V (for pad voltage equal to approximately —5 V), diode breaks down. When pad voltage tries to go over +5.6 V, diode formed by p+ region and bulk material conducts.





6. Time base. Eight-decade time base is on one MOS/LSI chip. With 10-MHz input from counter's crystal-controlled oscillator, circuit provides gating times up to 10 seconds. Unusual feature is logarithmic output that delivers a pulse every time total accumulation of pulses in time base's divider chain equals a multiple of 10. Log output plays role in autoranging.

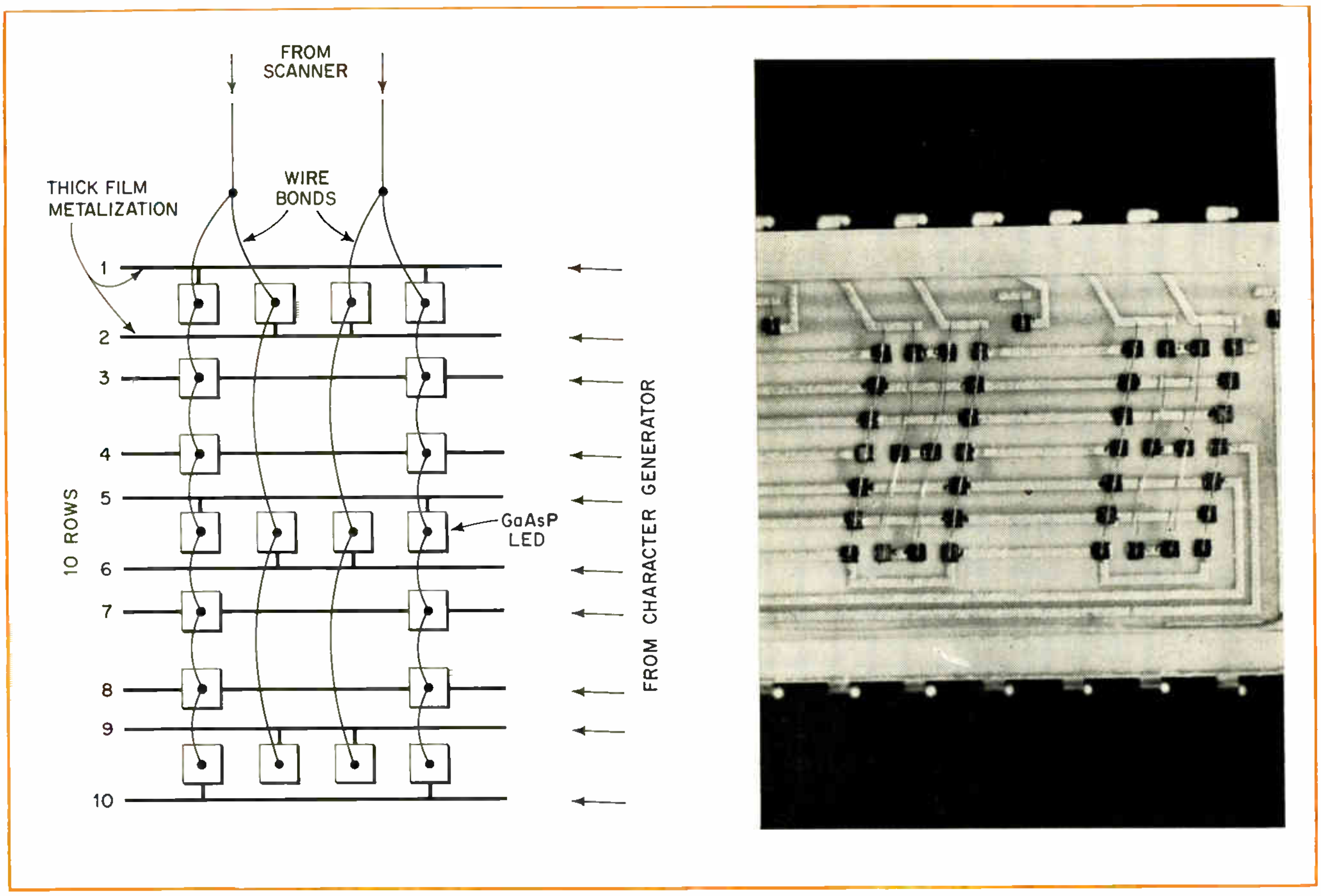


instruments, requiring a compact display. The most desirable configuration was a small, flat, single-plane display with a wide viewing angle.

Of all the available options, the most promising appeared to be light-emitting diode arrays of gallium arsenide phosphide. This type of display meets the requirements of compactness and single-plane construction; it's compatible with the low voltage levels of integrated circuits, and offers ruggedness and reliability advantages over other candidates.

GaAsP displays typically operate at 3.5 V and dissipate 250 mW per digit, against the 250 V and 500 mW per digit of cold-cathode displays. Incandescent filament displays use a lower voltage, but as tubes, they are not very rugged. Liquid crystals are certainly a long-range possibility for displays, but have yet to reach large-scale commercial production. And LED displays made with gallium-phosphide (GaP) diodes were rejected because they tend to saturate at high current levels, making adequate brightness difficult to achieve in a strobed display.

The major disadvantage of GaAsP displays was—



7. Few connections. Time-shared display for counter or voltmeter is on one ceramic substrate. Each digit is a 4-by-7 matrix of GaAsP diodes. Number of external connections is kept low by interconnecting diodes so that electrically, each digit is a 2-by-10 matrix. Thus, in the six-digit counter display, only 22 external leads (10 to the character generator and 12 to the scanner) are needed instead of the 31 demanded by a 4-by-7 array. Another advantage is that each 10-diode "column" is half a digit. Only 18 half-digit patterns are needed to form the 10 digits. They're stored in a read-only memory.

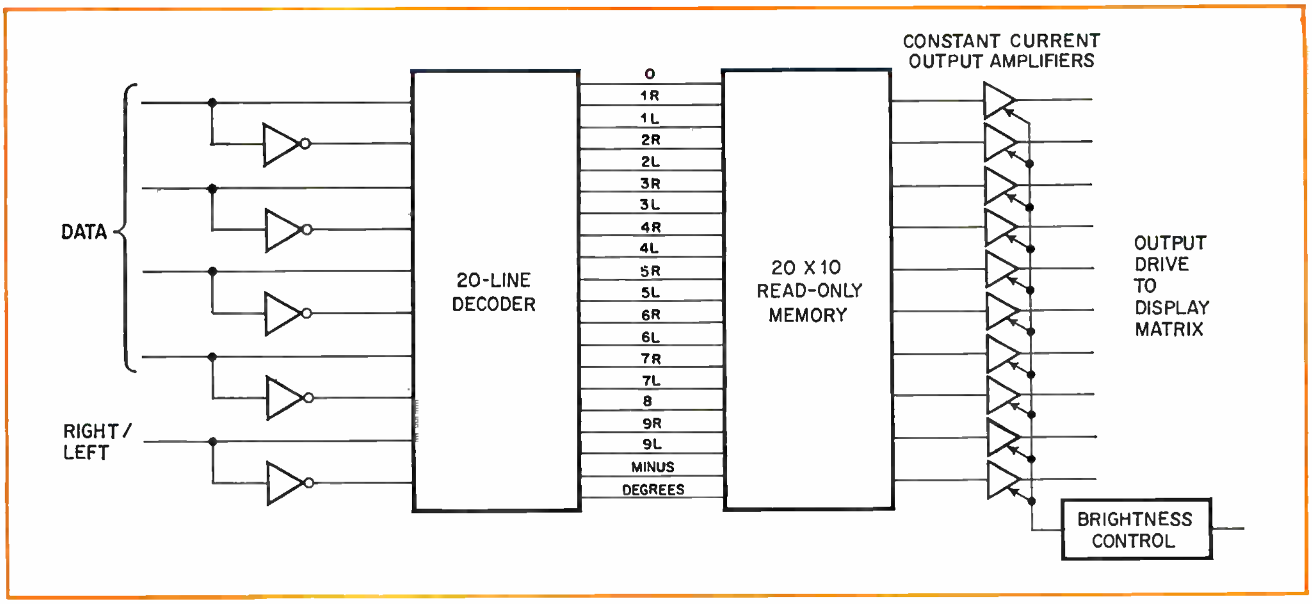
and still is—cost. The gas-discharge tube with drive circuitry typically sells for $4 per digit, against at least $10 for GaAsP numerics. However, it seemed likely that costs would decline with ongoing development, so it was the logical choice for an ongoing instrument line.

The displays in the counter and voltmeter are custom units, although many light-emitting diode displays were already on the market. The simplest seven-segment numeric was attractively low priced, but the display itself left much to be desired—the squared-off characters lack aesthetic quality, and the readout could be misinterpreted if one segment were to fail. Commercial dot-matrix characters avoided these problems, but were more expensive to produce because of the larger number of diodes required and the higher complexity of drive electronics.

The solution was a custom matrix display using a 4 x 7 array of diodes for each character. The matrix provides high legibility for a numeric-only display and is simple to construct. To minimize drive-electronics costs and to permit easy interfacing with the MOS counter block's digit-serial output, the display is time-shared. This scanning also simplifies construction of a multidigit display by minimizing the number of leads required.

The complete display is constructed on a single ceramic substrate, effecting substantial savings in cost. Although each digit is a 4 x 7 matrix of dots, the internal connections to the diodes were rearranged so that electrically, each digit looks like two columns of 10 diodes each, as shown in Fig. 7. The main advantage of rearranging the rows and columns is that 12 columns instead of 24 are required for a six-digit display. Since only one column at a time is driven, this reduction means on-time for each column is doubled, yielding an effective doubling in brightness. To avoid any flickering, the display is scanned continuously, approximately once every millisecond. At this rate, the display appears steady even if it's vibrated.

Decoding and driving circuits are also simplified with the 2 x 10 character—fewer combinations of patterns are required. In both the counter and the voltmeter, one custom MSI circuit—the character generator—does all the decoding and driving (Fig. 8). It must be bipolar because of the high current requirements (60 mA per diode). A read-only memory in the chip stores the pattern for each half-digit. Since sym-



8. Numerology. Single bipolar IC decodes display signal from counter board (output of pins 15, 16, 1, and 2 in Fig. 2), selects appropriate half-digit pattern from memory, and turns on appropriate diodes in display.

metrical characters 0 and 8 use the same pattern for each half, only 18 patterns are required for digits to 0 to 9. The memory also stores patterns for a minus sign and a degree symbol, which are symmetrical and therefore require only one pattern each.

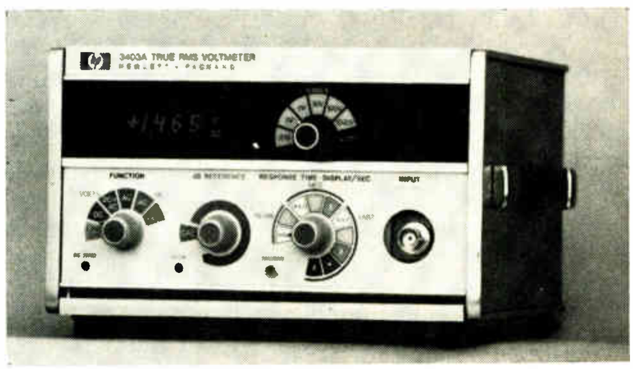
Display brightness is determined by the current through each LED. Instead of controlling the level with current-limiting resistors, which waste power, the character generator chip incorporates 10 regulating stages. The current is sensed at each output by monitoring the voltage across a 5-ohm resistor in a feedback amplifier that controls the driving current.

Current level is set by the voltage applied to a brightness-adjustment input. This input, which goes to the chip, can vary current from 0 to 50 mA at all 10 outputs to a half-digit. With this adjustment, brightness level can be set to match the number of digits in the display. The single-wire brightness control also blanks the display on out-of-range signals.

In both the counter and the voltmeter, all scanning logic is combined into one custom IC—the scanner. Again, the high current driving requirements (up to 20 mA) dictated a bipolar array. The chip contains a 12-bit counter, a 1-of-12 decoder and 12 regulated-voltage emitter-follower output circuits. The voltage regulation circuits track the display's temperature characteristics, minimizing the power dissipated in the constant-current outputs of the character generator.

The scanner also has its own internal multivibrator clock that sets the scanning rate. Thus, the display, consisting of the LED matrix, character generator, and scanner, is completely self contained. The scanner sends out a code to identify the digit being scanned; the character generator displays the data received in response to that code.

The free-running display's features were exploited in the modular approach to the construction of the counter. Since all data and control signals in the main-

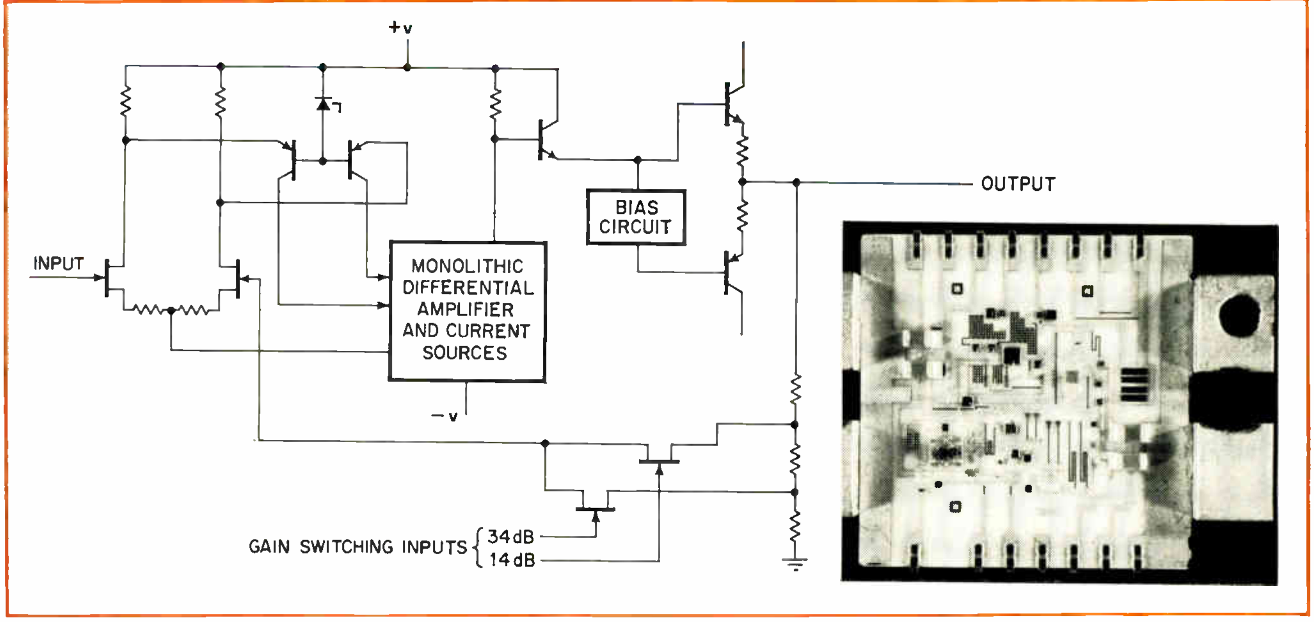


9. Large bandwidth. Rms converter and high-performance input amplifier—both thin film devices—combine to give 3403A DVM a range of dc to 100 MHz.

frame and plug-ins are routed through the central bus, any functional component in a mainframe, such as the display or the time base, can be used independently of the rest of the instrument. For example, any binary-coded decimal signal can be displayed on the counter's readout simply by tapping into the control circuit (see Fig. 1) in the 50-pin connector that joins mainframe to plug-in. The information from the six-decade counter can be reallocated to new positions in the display by a simple code conversion of the three-line digit address. This bus format also permits a higher-speed decade to be substituted for an MOS decade to extend the direct counting range beyond 10 MHz.

In the present unit a prescaler—the 5303A plug-in—permits operation to 500 MHz. This extended range was made possible by emitter-emitter-coupled logic [*Electronics*, Dec. 7, 1970, p. 62]. The plug-in's 500-MHz binquinary divider is an E^2CL circuit.

Still another technology—thin film fabrication—had



10. **Thin film help.** Input amplifier for voltmeter had to have very high input and very low output impedance as well as bandwidth in excess of 500 MHz. Thin film technology was needed to build a circuit that met these requirements and still fell within a reasonable size. Drawing and photo above shows amplifier's final configuration.

to be brought in for the prescaler. Amplifying small signals at frequencies up to 500 MHz is still beyond the capabilities of monolithic ICs. In their place, thin-film hybrid circuits were used to amplify, limit, and provide reliable triggering.

Thin film technology also played an important role in the design of the DVM. The unit's dual-slope analog-to-digital converter is a thin film hybrid circuit, as is its input amplifier. There, especially, the thin film approach made the critical difference between success and failure in obtaining the desired gain, bandwidth, and stability.

When considered separately, the many requirements placed on the input amplifier seemed reasonable enough, but together they represented a formidable design task. The input was to be driven from a high-impedance (10-megohm) attenuator. Therefore, amplifier input impedance had to be very high (on the order of 10^9 ohms) and the input bias current very low (a few nanoamperes). A field effect transistor input stage was dictated.

The output was to drive a load impedance (the thermopile of the rms converter) as low as 70 ohms to peak voltages of 5 V. Thus, a class B bipolar output stage was indicated. To drive this low impedance at frequencies down to 10 Hz, the amplifier output had to be direct-coupled, putting a premium on control of dc drift.

Since a continuous level of 5 V would burn out the thermopile, the amplifier had to be able to limit the rms value of its own output. To provide ac range from 1,000 V to 10 mV, the amplifier needed a gain switchable from 14 to 34 decibels.

Probably the toughest requirement was a combination of two rather basic needs. Since instrument accuracy would be a direct function of amplifier gain, accuracy, and stability, considerable overall negative feedback would be necessary. However, the instrument was to have a gain of 5 over its 100-MHz bandwidth. Thus, the amplifier's phase-shift and time-delay characteristics had to be well controlled above 1 gigahertz.

It became apparent that the ordinary fabrication methods would not suffice: stray capacitance and inductance levels simply could not be tolerated. So the choice went to thin film hybrid techniques (thin film was chosen over thick film partly because of an in-house capability for the former). As shown in Fig. 10, the substrate is a 1-inch square of ceramic material.

For rms measurements, the amplifier's output goes to a thermal converter that produces a dc voltage proportional to the rms value of the input. The converter has a thin film thermopile, similar to the one used in an earlier rms voltmeter (the 3480). The thermopile's geometries were slightly modified to achieve 100-MHz operation.

The basic circuit, shown in Fig. 11, uses matched thermopiles in a differential arrangement. Initially the output of amplifier A_1 is 0. When input e_i heats resistor R, the thermopile adjacent to R is exposed to the signal's rms (heating) value. Its output changes, producing a change in A_1's input (point 1). The resultant output E_o is a dc voltage that causes heating current to flow through resistor R_2, changing the output of the reference thermopile and therefore A_1's remaining input. Thus A_1 reacts to reduce its own differential output to zero by adjusting its output to a level that causes both thermopiles to be heated equally. As a result, A_1's dc output has the same rms value as the input signal to R.

At high input frequencies, the thermal time constant (approximately 40 ms) of the signal thermopile effectively filters its output, producing a dc voltage equal to the mean square value of e_i. Since a square-law device (the reference thermopile) is in A_1's feedback path, the closed-loop gain of A_1 and the square-law device have square-root characteristics.

For low-frequency converter inputs, additional filtering is provided by the feedback loop containing amplifier A_2 and two capacitors. The gain of A_2 is approximately square law so that the capacitance seen at the input terminal is independent of signal level.

Combined on one monolithic chip are A_1, an output driver stage that combines very low (less than 1 ohm) output impedance with positive-only drive capability, and A_2.

Some of the requirements for A_1 were low drift, no input offset voltage, high gain, and positive output swing only. (Because of the squaring action of the feedback thermopile, an effective phase reversal would result if the output should go negative; this would give positive feedback, and latch-up would occur).

One possibility for obtaining the low drift was to build A_1 on a temperature-controlled chip. However, at the time A_1 was designed these chips weren't available in suitable quantites or with suitable specifications to permit designing them into a high-volume instrument. It was decided instead to get the low drift by adjusting the collector load resistors of A_1's two input stage transistors. The input stage is operated with base-emitter voltages equal and the resistors are adjusted until dc output is zero. At this point, the temperature coefficient across the differential input is zero.

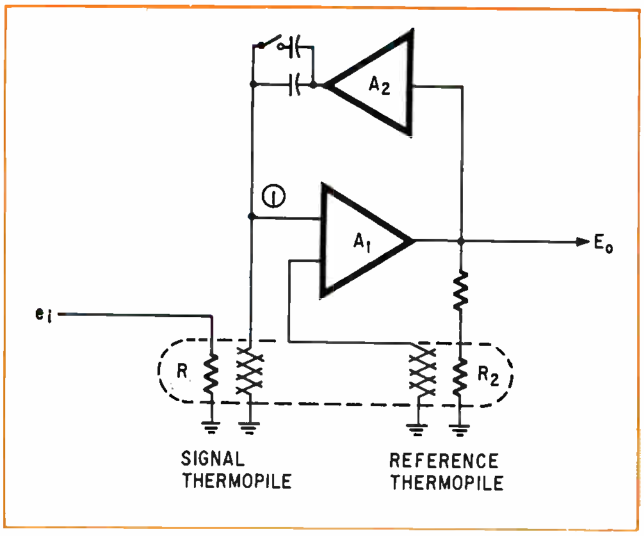
An advantage offered by this approach is that one adjustment simultaneously zeroes input offset and its temperature coefficient. The adjustment is made by shorting A_1's inputs, and setting the differential output to zero.

Log conversion and decibel ranging of the display were also requirements of the rms voltmeter. To measure in decibels, the voltmeter finds the ratio of two input voltages (or one input and an internal signal), calculates the logarithm of the ratio, scales this value, and displays it as a reading in decibels. The voltmeter's log converter—a bipolar IC—is of straightforward design. To maintain constant conversion gain under varying temperatures, it's constructed on a temperature-controlled chip.

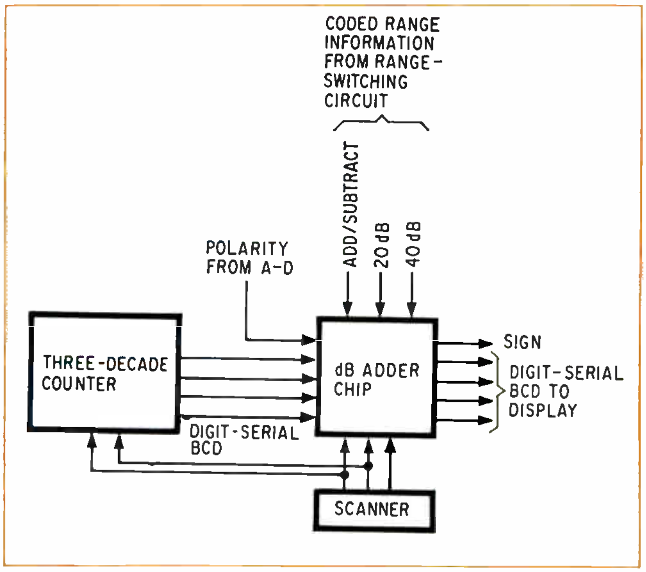
The new ranging circuitry called for a little more creativity. As in most digital voltmeters, the basic ranging involves changing the input attenuation or gain by factors of 10, and moving the decimal point. However, when the display is to be in decibels, a different scheme must be used, since a change of one range requires a display change of 20.0 dB, rather than a mere shift of the decimal point.

Two approaches were available: either add an offset of 200 mV to the analog voltage sent to the a-d converter, or add 20.0 digitally to the converter output. To do the addition in analog fashion requires two precise power supplies, a summing amplifier, and precision summing resistors. To do it digitally requires a digital adder/subtractor. When the tradeoff study was made, the digital method was chosen, primarily due to lower cost.

Then the choice of bipolar or MOS devices had to be made. Since the speed requirements were minimal (5 kHz), the advantages of MOS made the choice easy. And because the digital data inside the voltmeter already existed in serial form, a serial adder/subtractor was designed. It ties in with the three-decade counter chip as shown in Fig. 12. □



11. True rms. Voltmeter's thermal converter measures rms value of signal e_i from instrument's input amplifier. Key components are thin film thermopiles; each is a square-law device. Signal thermopile squares e_i, while reference thermopile in amplifier A_1's feedback loop makes closed-loop gain of A_1 a square-root function.



12. Ranging. Single MOS chip—a decibel adder—permits autoranging for decibel measurements. Signal from ranging circuit commands adder chip to add or subtract 20 or 40 dB to or from BCD signal going to character generator.

The case for emitter-coupled logic

Saturated circuit families still can't beat emitter-coupled logic for high performance at not too high a price. But this older style of logic demands rather different handling from the designer

by Anthony A. Vacca, *Control Data Corp., St. Paul, Minn.*

□ Transistor-transistor logic and metal oxide semiconductor circuits may be cheaper than emitter-coupled logic—but they're also slower. TTL that incorporates Schottky barrier diodes may be almost as fast as ECL—but its processing at a given performance level is also more complex. Only ECL circuits combine high throughput with a relatively low parts count, in a way that makes high-performance computers possible at reasonable cost. And this significant price-performance advantage over saturated circuit families is becoming increasingly obvious to systems designers, long accustomed to relegating ECL to large, high-throughput computers.

Furthermore, low-power, medium-performance ECL circuits are often suitable in peripheral devices, whose performance must keep pace with that of the central processor. Although TTL has been satisfactory in most applications of this kind, when that circuit family is pushed at high speed, its power dissipation rises to rather high levels.

The use of ECL, however, does involve some design tradeoffs. To get maximum performance, it often requires the most advanced semiconductor fabrication processes, and this means lower yields. Packaging concepts, thermal considerations, and other user requirements must also be designed to match, or at least not to undercut, the advantages of the circuit family.

In selecting which circuit technology to use in a new computer, the designer has to take into account such important considerations as system throughput requirements, computer architecture, memory performance, system size and cost goals—plus, in many cases, his own personal preferences. Within these broad considerations, other limiting conditions exist: for example, in logic implementation, there are constraints on the fanout from individual logic blocks, and on the difference between the minimum and maximum number of blocks in different logic paths. Constraints are also imposed by power distribution schemes, cooling techniques and capabilities, printed circuit board material, alternatives for module connectors and interconnections, and so on.

Only when these major factors and subsequent constraints have been decided upon can the designer get down to determining:

- The minimum number of different kinds of logic blocks his design will require.
- The area of panel space he will need to package the logic—or, conversely, the maximum packing density that the circuit choice will allow.
- The amount of power dissipation permitted by his choice of cooling technique (sometimes cooling requirements dictate a lower packing density than simple physical dimensions permit).
- The propagation delay per circuit that is allowable, given the particular combination of machine cycle time, memory technology, degree of parallelism, and other specifications that the designer has decided on previously.

In an increasing number of designs, after all these factors have been considered, ECL becomes the obvious choice—despite some design tradeoffs forced on the ECL user by the nature of semiconductor technology itself.

For example, ECL's basic speed advantage is achieved because its circuit configuration avoids saturation; therefore such tricks as gold diffusion and Schottky barrier junctions, which prevent saturation in TTL circuits, are not required. Instead, better performance must be achieved through more sophisticated methods such as reduced component sizes, shallow diffusions, and an optimum choice and placement of diffusion resistivities.

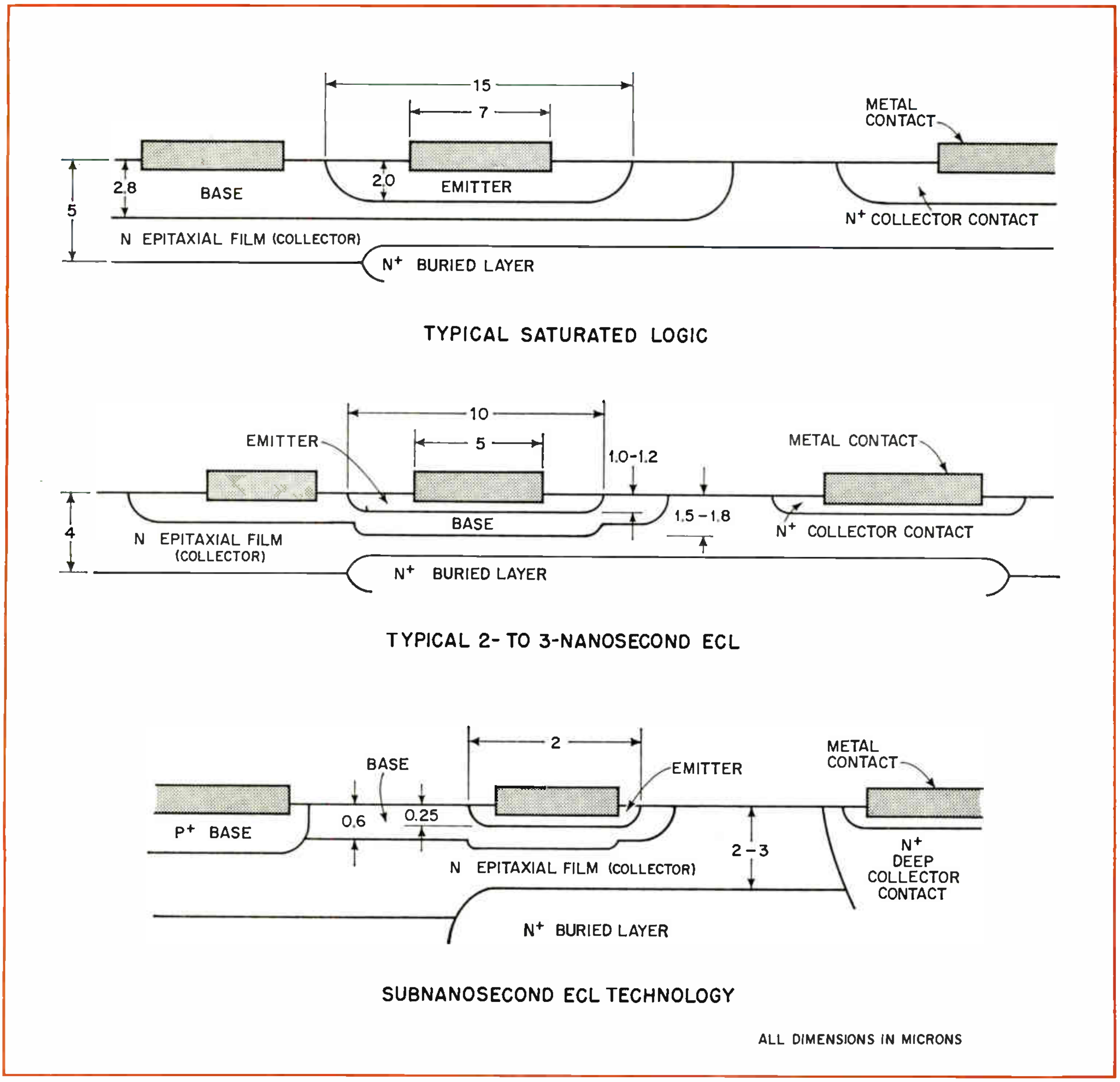
Typical dimensions of ordinary ECL, which switches in 2 to 3 nanoseconds, are rather smaller than those of circuits like TTL, shown directly opposite. The dimensions of subnanosecond ECL are smaller still. Repeatedly reducing these dimensions, even without changing doping concentrations, tends to decrease the capacitance associated with the semiconductor junctions, which in turn decreases the time constant of the transistor and its switching time—up to the point at which photographic technology and the properties of the material make further size reductions impractical.

Beyond this point, the capacitance can be decreased by using a more lightly doped p-type base material and a more lightly doped n-type material for the epitaxial film, in which the collector is formed. The base resistance is reduced by adding a p+ base contact, and the saturation resistance is kept low by an n+ collector contact that is diffused deep into the n+ buried layer.

This deep collector diffusion also prevents saturation in a current-source transistor, which sometimes replaces the resistor connected to —4 volts in the circuit diagramed in the panel on page 52. It's also valuable in circuits that are to be used in a high-temperature environment. Most significantly, perhaps, it permits the epitaxial film to be made with a higher resistivity; as a result, though total resistance increases to a degree, the collector-base capacitance decreases to a still greater degree, and overall the time constant also decreases.

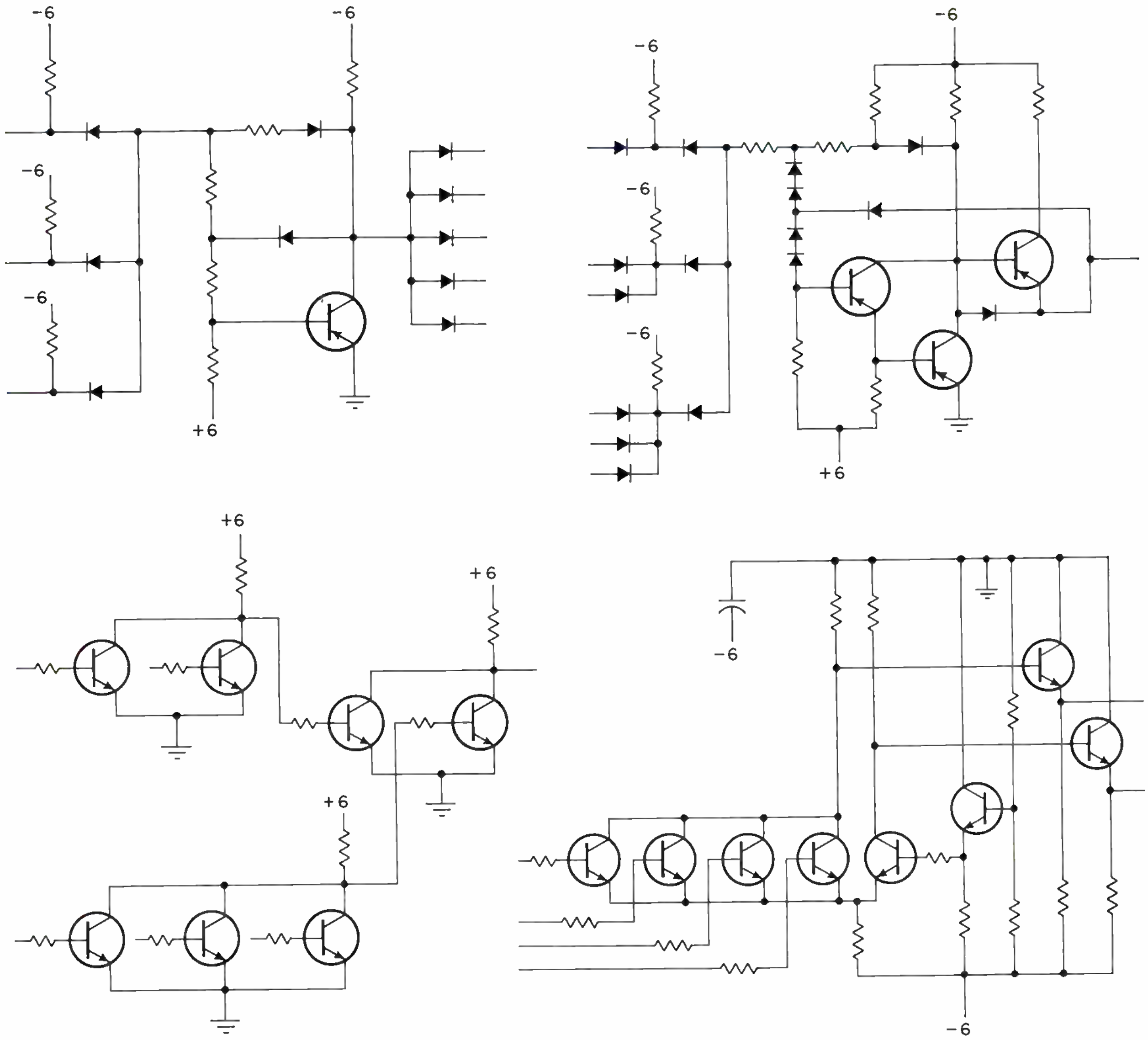
Such small dimensions and such refined diffusions, however, entail reduced yield. Wafer defects vitiate the diffusion profiles. The small dimensions make photographic alignment, etching, and alloy techniques more difficult and surface cleanliness more critical. (But it should be noted that these same small dimensions do enable significantly more logic decisions to be packed onto a chip of a given size, and this offsets the lower yields a little.)

Another effect of reduced sizes is metal migration, induced by higher current densities. Near the emitter contact, for example, nearly a million amperes per square centimeter are quite likely. At densities like this, the electrons in the interconnection metalization are so active that they dislodge the metallic atoms one by one until the entire metalization path actually slides along the surface of the chip in the di-



Technology comparison. Even the simplest ECL circuits require shallower diffusions and narrower depositions (middle diagram) than do such conventional saturated logic circuits as TTL (top). Subnanosecond circuits involve even finer control (bottom).

How supercomputers get faster



Whenever major computer designs have been undertaken at Control Data Corporation, the emphasis has always been on throughput—and throughput directly reflects the performance of the circuitry used.

The first two major systems, the CDC 1604 and the Series 3000, were built with modified diode-transistor logic circuits, like those shown at top. Later, to meet the design goals of one to three million instructions per second for the CDC 6600, a modified direct-coupled transistor logic (DCTL) circuit, shown at bottom left, was developed, which required a new silicon transistor; under loaded conditions the circuit achieved delay times as short as 4 to 6 nanoseconds.

All these circuits were built out of discrete components, because the integrated-circuit industry at that time was judged not mature enough to produce what Control Data required. Because the components were discrete, the circuits in many cases were complex, requiring feedback loops in every logic block to achieve the necessary performance.

For the CDC 7600 computer, which was to have four times the throughput of the 6600, a new transistor was again developed, for use in a new, simpler, discrete circuit configuration, ECL. There are two forms of the circuit, referred to as ECL and E²CL; the former is used when driver and loads are on the same card, and the latter when they are on different cards.

The same DCTL and ECL circuits are used in the new Cyber 70 series recently announced by Control Data, in part to help achieve compatibility with the 6000 series and the 7600, which the series is replacing.

In the meantime, for still more advanced computers, including the STAR-100 now being built and the CDC 3500, a custom ECL family has been developed. This circuit, at bottom right, is also known as a transistor current switch, or TCS. It is very nearly the same as the discrete-component version of ECL, except for an internally generated reference voltage. It is also used in the CDC 733, the high-speed batch station that is part of the Cyber 70 series.

rection of electron flow—sometimes far enough to create an open circuit. (Though there are metalization processes that can withstand the high current densities without suffering from metal migration, they are complicated and expensive.)

Once a suitable ECL circuit family has been developed within these restraints and tradeoffs, its designer must determine the proper utilization of the new circuits. For example, appropriate circuit packages must be defined. Interconnection distances between logic elements create time delays that are significant in ECL designs. Impedance mismatches can occur between modules, between printed circuit boards, or at connectors, if these elements are not properly designed. The large spaces needed for the passage of cooling air must not unnecessarily increase the length of transmission lines between logic elements.

The high performance expected of ECL tends to create significant voltage and current transients. To overcome them the designer must lay out his printed circuit boards to include microstrip transmission lines, and must make sure the circuits are properly grounded—although sometimes he may try to live with the transients, or try to control them with simple diode clamps.

The temptation to resort to such brute-force techniques is great, because transmission lines are affected by so many variables—the size of the board, the number of layers in the board, the characteristic impedance of these layers, to cite just a few. And, because the propagation delay along the transmission line is proportional to the square root of the board material's dielectric constant, this constant is the most important variable of all. Materials also vary in dimensional stability and lamination adhesion qualities, not to mention cost. Different manufacturers may use different materials in their boards; each material has its advantages and disadvantages, but a particular manufacturer may resist pressures to use a material with which he is not familiar because of the skills of his personnel, the investment in his present equipment or the investment in new equipment he might require.

Transient currents can be kept low if the transmission line's characteristic impedance is high—and a high characteristic impedance requires a thin, narrow microstrip widely separated from its ground plane by a material with a low dielectric constant. But even with a low constant, impedances over 50 to 100 ohms would need inconveniently thick boards and etched conductors so narrow as to be hard to work with. These considerations limit the designer to a rather narrow "window" with 50 to 100 ohms at its center.

Another problem with ECL concerns the power dissipation per logical decision, which depends on the required performance level and the available technology. For a given transistor, the external circuitry can be optimized to achieve some desired combination of power and performance; when better transistors become available, the performance can be improved while the previous level of power dissipation is retained, or the power can be reduced while the previous level of performance is retained, or both power dissipation and performance can be improved to a lesser degree.

Further, the board material and size can also be important if power is dissipated by conduction into a cold plate—they're less important with forced-air convection cooling.

A second thermal consideration is the operating junction temperature. Its specification affects reliability, cost, performance, and semiconductor processing techniques. For every increase of a stated number of degrees in junction temperature, the failure rate of integrated circuits doubles. And metal migration, besides being directly proportional to current density, is also proportional to the fourth power of the junction temperature in degrees Kelvin. In addition, when the junction temperature increases, the saturation voltage moves closer to zero. Thus saturation can be a serious problem when junction temperature is not controlled. Keeping all junction temperatures as nearly equal as possible significantly improves system operation.

But thermal resistances vary in different parts of a large system, due to differences in materials and mechanical tolerances, and the circuit designer may choose to incorporate additional electrical resistances between the power bus and ground on certain chips to insure that each chip dissipates the same amount of power and therefore operates at the same junction temperature.

However, these parasitic resistances increase the system's total power requirement. Moreover, the merit of this "power balancing" technique is open to question, because it doesn't take into account the temperature gradient that may exist within a chip, or even different definitions of the junction temperature itself. In either case, not using power balancing requires greater care in chip layout.

ECL as a technology of the future is getting a boost from a number of both vendors and users.

Motorola, the original vendor of ECL, now has several complete product lines in the family it calls MECL. These include 20 types of the original MECL line, 24 in MECL 2, with propagation delays ranging from 3 to 8 ns, and 12 in the MECL 3, 1.1-to-1.6-ns line. Also it has recently announced the MECL 10,000 series, a new low-power family with 2- to 2.5-ns delays that is competitive in both performance and power with the new Schottky barrier TTL circuits.

Texas Instruments, the other big ECL house, has a full family of device types with propagation delays averaging 2 to 3 ns, and is expected to bring out a new line of 1.2- 1.5-ns logic [*Electronics,* March 1, p. 69].

Fairchild Semiconductor announced a family of circuits with 2- to 2.5-ns delays within the past year; these designs are unique in incorporating temperature compensation.

For several years RCA has marketed circuits in the 3- to 5-ns range and is coming out with new ones at 1.4 to 2.0 ns and at 1 to 1.3 ns.

And from Japan comes Hitachi Ltd., with two families, called "High Speed ECL" and "Ultra High Speed ECL." Their switching speeds are 2 to 3 nano-

Inside the circuit

In ECL, at top below, the three input signals A, B, C can be at either −0.8 volt or −1.7 volt. Only when all three of them are at −1.7 v can the reference transistor, Q_4, conduct—at which time its collector voltage drops to about −3.3 v, from near ground. The emitter follower stage, Q_6, returns these levels to those of the inputs, so that the circuit can drive another like it.

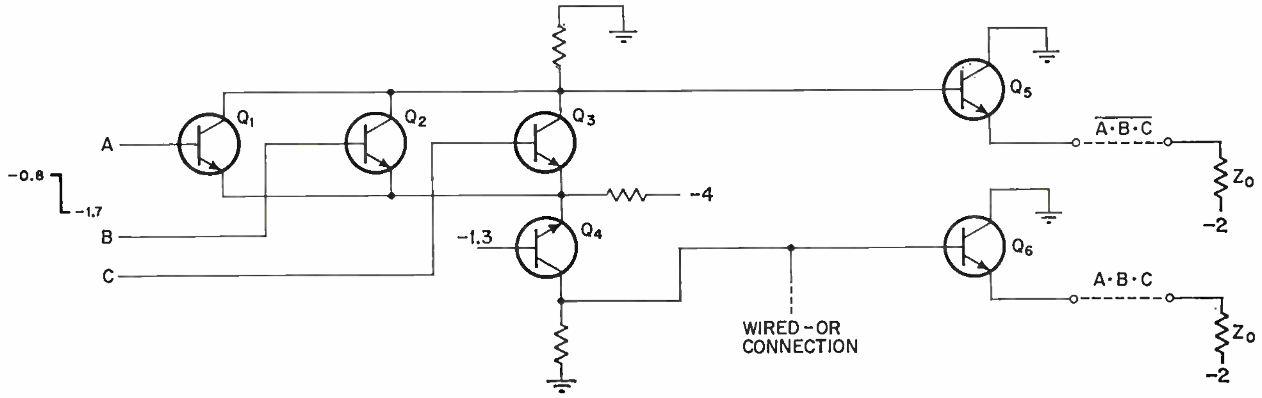
At the same time, the collectors of the input transistors, electrically common, are complementary to the reference transistor's collector. Another emitter follower provides normal signal levels from this point. Thus the circuit has two outputs that are always complementary except at the moment of transition. At no time is any conducting transistor saturated—which accounts for ECL's speed capability.

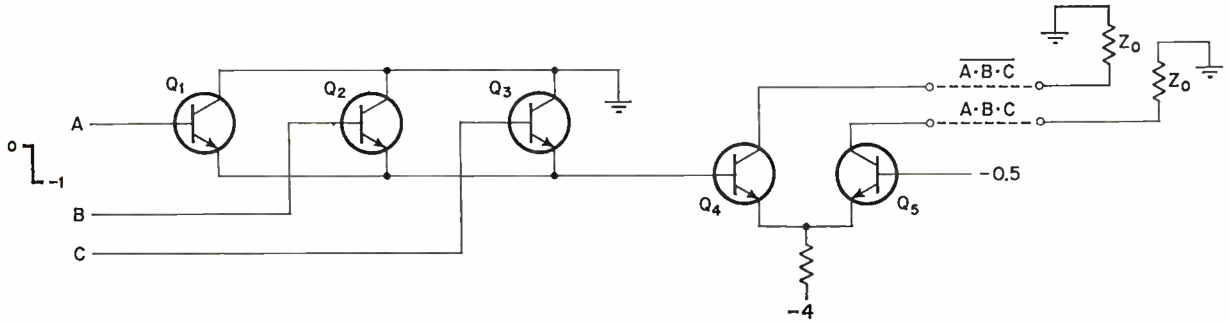
With the convention that −0.8 v represents a binary 0, and −1.7 v a 1, this circuit performs the AND/NAND function—AND from the output at Q_6 and NAND, or NOT-AND, from Q_5. The OR function is obtained by connecting the emitter-follower inputs to similar points in another circuit.

No inverters are needed when ECL circuits are used, because the logic block that produces any given function also produces its complement. And both emitter follower outputs can be designed to drive as many similar circuits as desired, reducing the need for special power and line drivers that other logic families often require.

The operation of E^{2}CL (bottom diagram) is similar, except that the reference transistor, Q_5, is part of a differential circuit. Because the emitters are electrically common in both the differential pair and the input transistors, the configuration is called E^{2}CL. In this circuit, the level shift between logic blocks is performed at the input rather than at the output, by the same transistors that perform the logic function, so no output emitter follower circuits are necessary; and the remote load resistors return to ground instead of to a voltage, making off-card loading simpler.

Although the signal swings of ECL and E^{2}CL are slightly different, they are easily converted from one to the other—from ECL to E^{2}CL by driving the load directly from the collector output instead of through the emitter follower, and from E^{2}CL to ECL by adding an emitter follower to the load resistance at the end of the transmission line.





seconds and 1.1 to 1.3 nanoseconds respectively.

Stewart-Warner Corp. and Signetics Corp. are the only second sources for ECL at the present time, having announced versions of Motorola's MECL. But Raytheon Co. will probably soon announce its own line of ECL as a second source of either Fairchild's or Motorola's circuits.

Several of the major computer manufacturers, both in the United States and abroad, are reported to be readying new machines using ECL [*Electronics*, March 1, p. 71]. Although users of other circuit families may be tempted to stay with higher-performance TTL, including the Schottky-barrier families, eventually they'll discover that where truly high system throughput is required, ECL is the only reasonable choice.

Meanwhile Control Data's successful experience with ECL in the 7600 and the STAR-100 computers illustrates the technology's value; it will probably be the major circuit family to be used at CDC for some time to come. □

You and your career: help us find out what's on EEs' minds

Many electronics engineers are faced with uncertainty and insecurity about their careers. Unemployment and shifting national priorities, as well as rapidly changing technology, are some of the factors that are converging to create an unprecedented wave of soul-searching among EEs of all ages and at all levels.

How do engineers feel about their careers under these circumstances? How can engineers reconcile their desire for professional status against the need for job security? How is the design function changing under the impact of new components and computer-aided design? How is the methodology of engineering changing, and what will an EE of the Seventies be like?

The editors of *Electronics* invite you to participate in a special project to help determine the answers to these questions. The questionnaire on this page is aimed at finding out what you and other engineers think about your careers. We urge you to fill it out and return it to the address below no later than May 15. The results will be published in a forthcoming issue.

How to enter your opinions

Clip the completed questionnaire and mail to:

Editor, Code Q
Electronics
330 W. 42nd St.
New York, N.Y. 10036

We welcome any additional comments on engineering as a career. Simply attach them to the questionnaire.

Career questionnaire

1. Your job:

Do you use a computer in your engineering work?
Yes____ No____

In an average month, how is your time allotted? Give % of time.

a. Design and analysis____
b. Preparing reports____
c. Breadboarding and testing____
d. Hardware evaluation____
e. Internal technical discussions____
f. Reading____
g. Other____

2. Your goals:

What would you like to be doing five years from now?

a. Engineering____ b. Management____
c. Head own business____ d. Leave engineering____
e. Other____

3. Your education:

What additional training are you taking?

a. Advanced degree____
b. Correspondence course____
c. Company courses____ d. Other____

4. Your opinions:

a. If you had it to do over would you be an EE?
Yes____ No____

b. Would you want your children to be EEs?
Yes____ No____ No opinion____

c. It has been suggested that the Federal Government help provide more engineering jobs by shifting priorities from military to urban problems. Do you ____agree ____disagree?

d. Check below the one area you consider the number-one national priority:
1. Space exploration____ 2. Power generation____
3. Clean environment____ 4. Support of education____ 5. Health care____ 6. Transportation____
7. Other____

Comments

____

____

Title and function____
Highest degree____ Age____
Total years in engineering____
Your company's (or division's) main products____

____

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Designer's casebook

Hitch in time saves gates in 12-hour digital clock

by Vernon R. Clark
Applied Automation, Inc., Bartlesville, Okla.

The trickiest task in designing a 12-hour digital clock is decoding the hours-counter outputs. As the truth table shows, a binary number sequence cannot directly control this section.

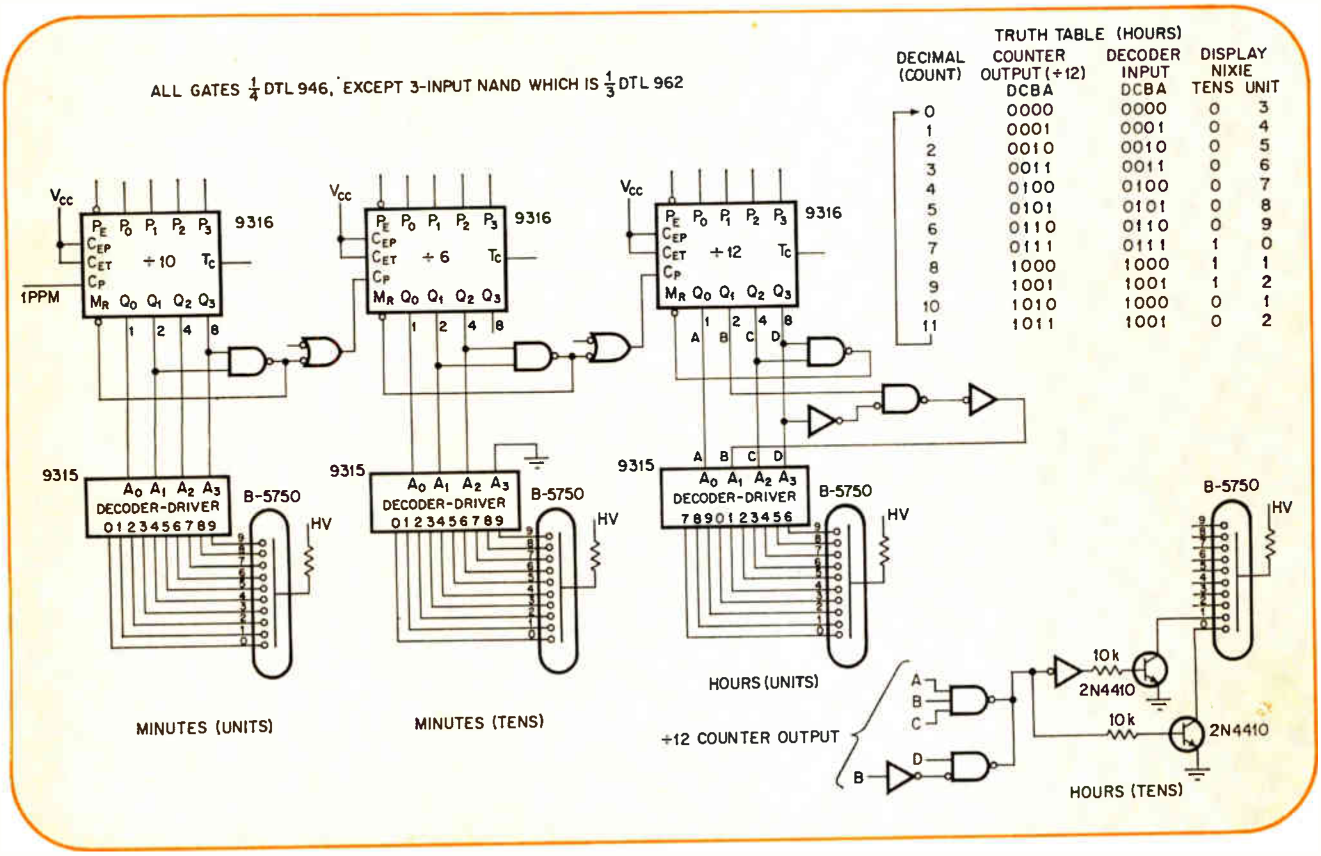
The hours (units) logic can be unsnarled with only three gates—three-fourths of a DTL 946 quad NAND package—after rearrangement of the Nixie tube connections to the third decoder-driver.

To advance the counter output by three hours, decoder output 0 is connected to cathode 3, output 1 to cathode 4, etc. Then the three gates can make the decoder's B input go low by inhibiting B whenever D is high. The decoder reads counts 10 and 11 as 8 and 9 counts, so the hours (units) cathodes light in 1, 2, 1, 2, order before the counter resets and the clock goes to 3 o'clock.

Decoding the hours (tens) merely requires gating that enables cathode 1 of the hours (tens) Nixie when counter outputs ABC = 111 while D is low, and when D is high then B is low. The 2N4410 transistors are high-voltage drivers for the hours (tens) Nixie. The 900 DTL cannot drive the cathodes directly because their output transistors can't handle the high voltage.

The 12-hour digital clock was designed for a computer application and is applicable to other timing functions as well as timepieces. To tick off seconds, two more 9316s, connected like the minutes counters but with a one pulse per second input, can be added at the left. The divide by 6 and 10 counters could have been used to divide down from a 60-hertz reference source. Parallel setting and resetting, and a.m. and p.m. indication also can be worked in.

Ten equals 12 hours. Rearranging the hours-display connections simplifies hours decoding. The gating makes hours 1 and 2 repeat by holding decoder input B low when input D is high, as shown in the truth table. Hours tens are decoded by sensing when D is high and B is low, or when D is low and ABC are high.



TRUTH TABLE (HOURS)

DECIMAL (COUNT)	COUNTER OUTPUT (÷12) DCBA	DECODER INPUT DCBA	DISPLAY NIXIE TENS	UNIT
0	0000	0000	0	3
1	0001	0001	0	4
2	0010	0010	0	5
3	0011	0011	0	6
4	0100	0100	0	7
5	0101	0101	0	8
6	0110	0110	0	9
7	0111	0111	1	0
8	1000	1000	1	1
9	1001	1001	1	2
10	1010	1000	0	1
11	1011	1001	0	2

Low-cost exclusive-OR needs no power supply

by K.D. Dighe
K & M Electronics Co., Baltimore, Md.

An exclusive-OR gate with three resistors, two low-power, small-signal npn transistors, and no external power supply could hardly be simpler. And by adding an inverter, the exclusive-OR gate becomes a coincidence detector.

Conventional exclusive-ORs take four or five gates and a logic supply. Other discrete-component designs with fewer than four or five gates require positive and negative supplies or circuitry to split a single supply.

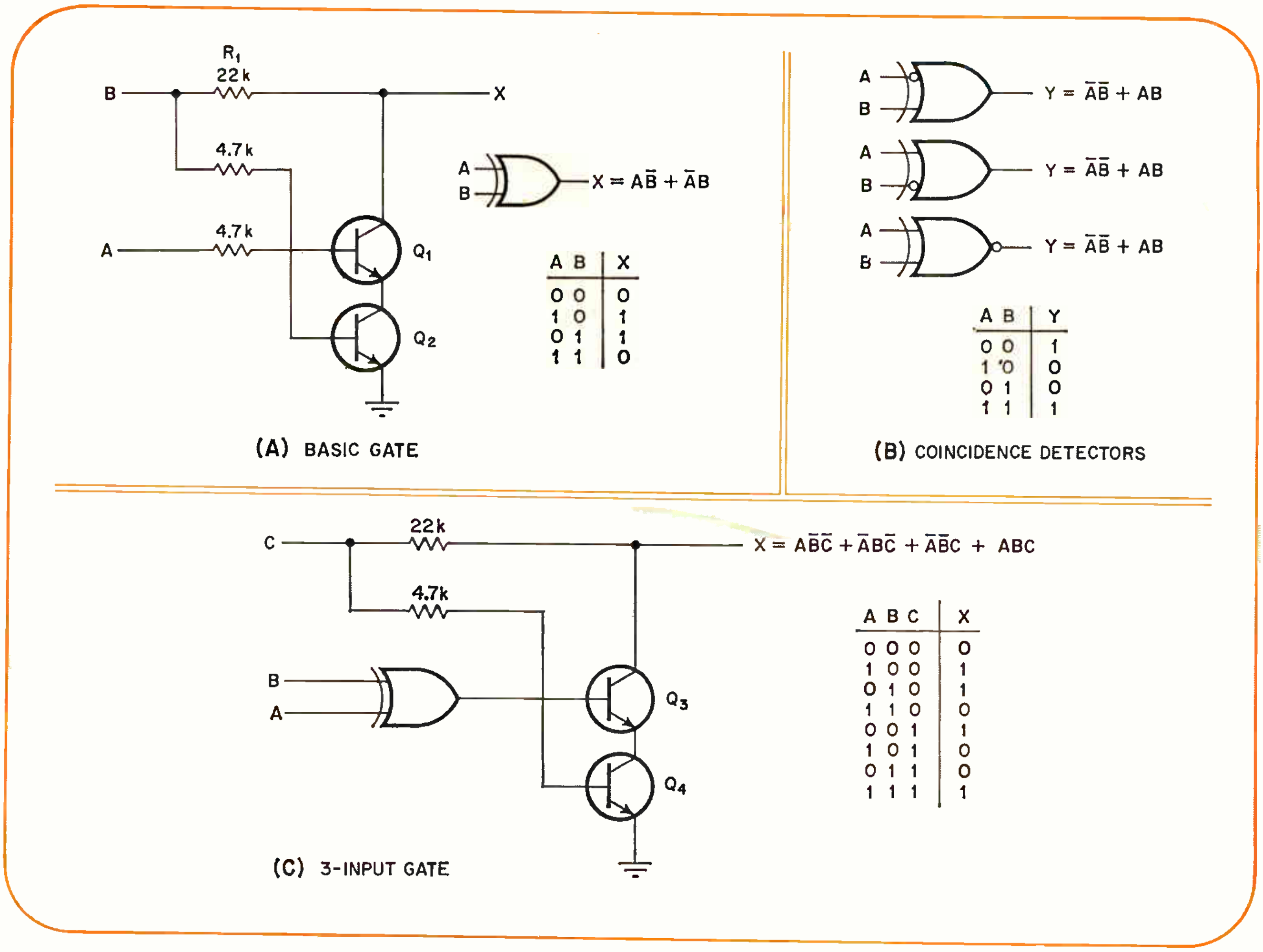
However, in this circuit, input signals operate the gate and drive the load. When low-voltage signals are applied to both of the basic gate inputs, both transistors are off and the output is low. A high voltage on both inputs turns both transistors on, but the output is still low because the two saturation drops pull Q_1's collector down to 0.4 volt.

If input A is high and B is low, Q_1's base-emitter diode opens and its base-collector junction is forward-biased. The output is high and the load is driven through the latter junction. When A is low and B is high, the load is driven by the voltage through resistor R_1. Now the base-emitter junction of Q_2 is forward-biased, but Q_1 is off and does not draw current.

Therefore, the exclusive-OR function $X = A\overline{B} + \overline{A}B$ is provided with positive logic assignments to the inputs and output (low voltage is 0 and high voltage is 1). Mixed positive and negative inputs or inversions as in diagram B change the gate to a coincidence detector with the function $Y = \overline{A}\overline{B} + AB$.

Extended with a second stage (diagram C), the gate provides $X = A\overline{B}\overline{C} + \overline{A}B\overline{C} + \overline{A}\overline{B}C + ABC$. Or with an inverter, the output becomes $Y = \overline{A}\overline{B}\overline{C} + AB\overline{C} + A\overline{B}C + \overline{A}BC$. Configuration C gives a high output when any one or all of its inputs are high. For any other condition, the output is low.

Signal-powered logic. A high logic signal on the A or B input drives the load through Q_1 or R_1. Two low inputs or two high inputs hold the output low. So the basic gate (A) is an exclusive-OR. An inverter makes it a coincidence detector (B). Two stages can handle three inputs (C).



High-voltage amplifier offers high frequency, too

by Walter A. Cooke
Lockheed Missiles & Space Co., Sunnyvale, Calif.

Both high voltage and high frequency are hard to obtain in one amplifier. But if a common-base voltage amplifier is added to a low-voltage operational amplifier, both features can be achieved—and with excellent stability. The circuit can be used as a CRT cathode driver that delivers 50 volts, peak-to-peak, has a response of 10 megahertz, and is stable beyond 100 MHz.

Ordinarily, the high junction capacitance of a device with a high breakdown voltage imposes a low frequency response. But because of the common-base connection of the output stage, the design does not have to fight both the laws of solid state physics and Nyquist's response rules.

A common-base transistor gives only voltage gain, not current gain, and can operate with a small collector resistor. Its response is high because frequency rolloff is inversely proportional to collector resistance. And additional help is provided by the higher collector current, which raises cutoff frequency, up to a point.

The first stage is a high-frequency, high-current, hybrid amplifier, A_1. It must handle the load current, but its output need swing only 2.5 V pk-pk, at midfrequency since the common-base stage's gain is nearly 20.

A_1's inner-loop capacitance, C_1, is adjusted for system stability. It should roll off A_1's gain by 20 decibels per decade from dc to 10 MHz. Gain is then unity until rolloff resumes again at about 350 MHz. Making R_1 equal to R_2 balances the output swings of A_1.

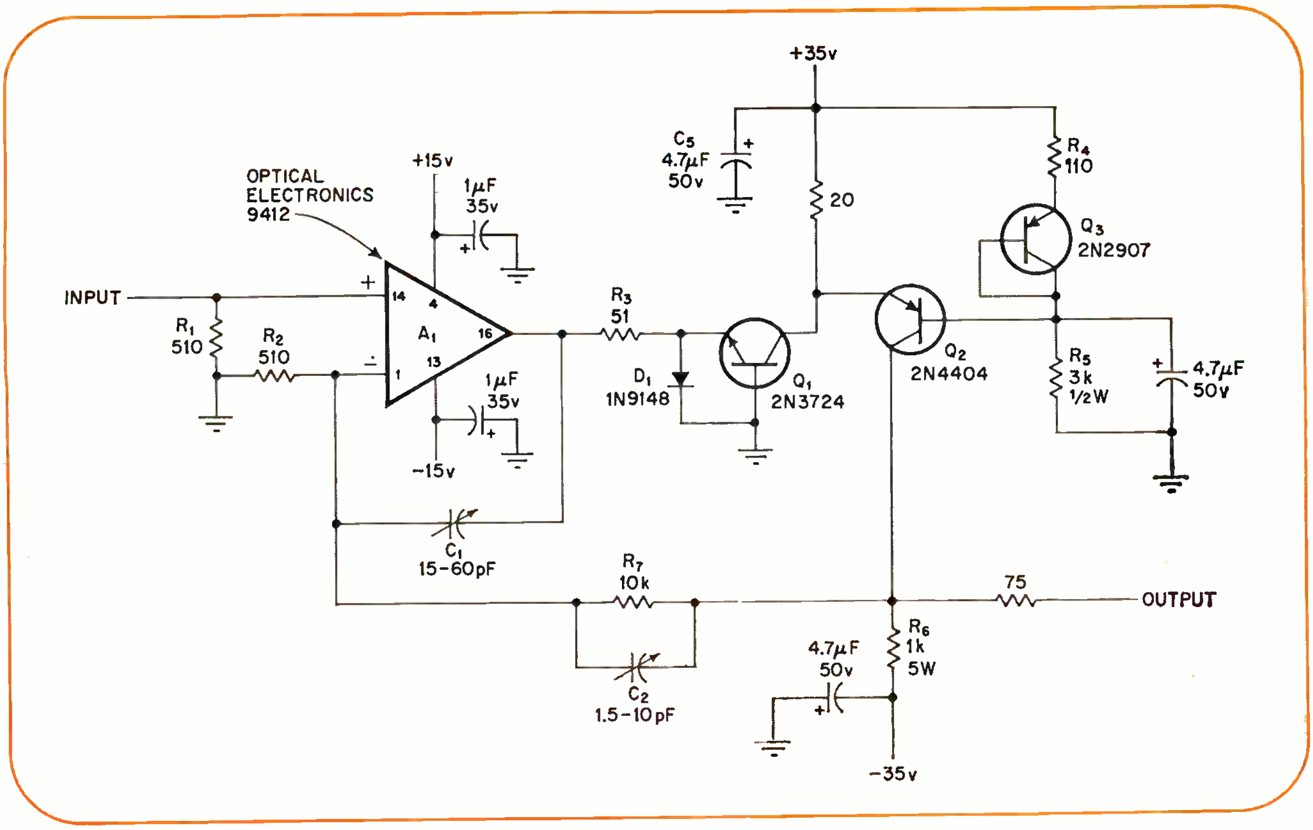
The amplifier's output controls Q_1 through resistor R_3 and diode D_1. Q_1 then translates this output up to the emitter of Q_2, which is biased near the + 35-V supply by R_4, R_5, and Q_3. The circuit's output swings symmetrically about the ground reference.

Second-stage voltage gain is approximately R_6/R_3 (19.6 for this case) from dc to 10 MHz. Rolloff to this point is controlled by A_1. At about 10 MHz, R_6 and Q_2's collector-to-base capacitance take over, also rolling off gain at 20 dB/decade.

Composite closed-loop gain is flat to 10 MHz; gain is about $1 + R_7/R_2$. Since A_1 inverts, making R_7/R_2 equal to R_6/R_3 keeps output overshoot small. Any overshoot can be damped by adjusting C_2. Open-loop gain is 77 dB from dc to about 30 kilohertz. It then rolls off at 20 dB/decade to zero crossover at 200 MHz, assuring closed-loop stability.

Q_1 and Q_2 must be heat-sinked and Q_3 should be thermally coupled to Q_2 to maintain the operating point during temperature changes.

Two-stage rolloff. Common-base connection of Q_2 allows its collector resistor, R_6, to be small. This prevents collector-to-base capacitance from rolling off voltage gain until signal frequency is 10 MHz. Below 10 MHz, the first stage rolls off until A_1 becomes a unity-gain amplifier. The two-stage rolloff keeps the entire amplifier stable.



Active RC network has two movable zeros, fixed poles

by Robert D. Guyton
Mississippi State University, State College, Miss.

An active RC network allows its zero locations to be placed anywhere in the complex plane, including positions on the positive real axis. Zero-pair locations can be moved over a circular path in the plane by varying the feedback resistance, R_f. The pole-pair position, however, remains fixed because, as the network's transfer function shows, it does not depend on R_f.

The basic circuit can be easily modified and adjusted for specific filter applications and also can be used as a compensating network in feedback systems—for example, the 60-hertz notch filter shown has a rejection of more than 70 decibels. Its zero-pair motions with variations in R_f can be seen in the pole-zero plot.

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas and solutions to design problems. Descriptions should be brief. We'll pay $50 for each item published.

That the zeros will move as shown is clear from the general form of the transfer function:

$$\frac{E_2}{E_1} = \frac{R_3}{R_2 + R_3}\left[\frac{1 + s(R_1C_1 + R_2C_2 - R_2R_fC_1/R_3) + s^2R_1R_2C_1C_2}{(1 + sR_1C_1)[1 + sR_2C_2R_3/(R_2 + R_3)]}\right]$$

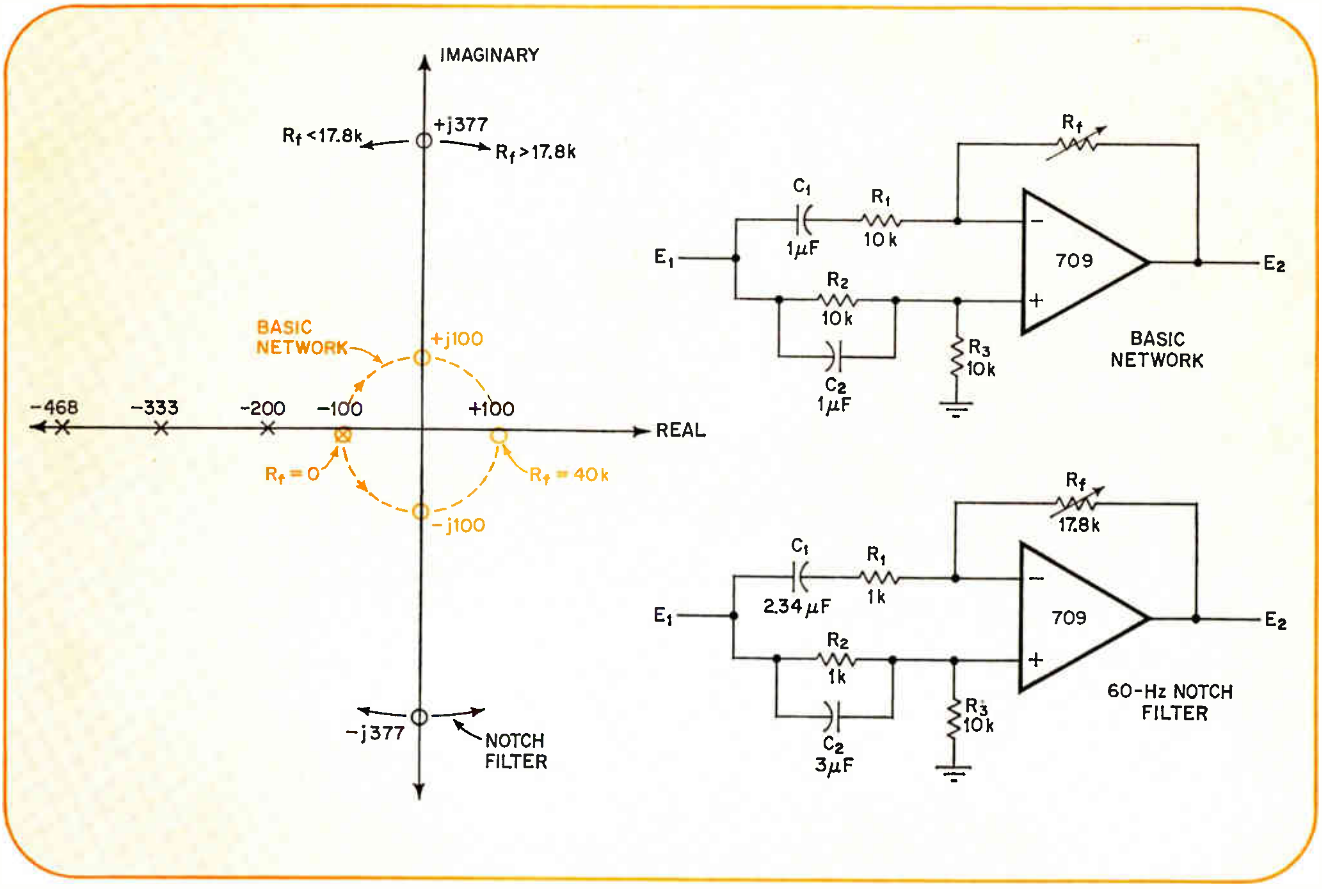
For the basic network, with R_f in megohms, the function reduces to:

$$\frac{E_2}{E_1} = \frac{1}{2}\left[\frac{1 + s(0.02 - R_f) + s^2 \times 10^{-4}}{(1 + 0.01s)(1 + 0.005s)}\right]$$

At $R_f = 0$, the two zeros are on the negative real axis at −100. As R_f increases to 20 kilohms and then to 40 kilohms, the zeros move to a complex pair at ±j100 and then a pair on the positive real axis at +100. The poles remain fixed and real at −100 and −200.

Changing the fixed RC values will alter the path radius. The 60-Hz notch filter has a complex pair of zeros at ±j377 with a nominal R_f of 17.8 kilohms. The value of R_f is determined by experimental adjustment. The poles, in this case, remain fixed at −333 and −468.

Variable filter. Pole-zero plot shows circular motion of zero pair in an active RC circuit with variations in the feedback resistance, R_f. The circuit can perform a specific filtering function or can act as a compensating network in feedback systems. Basic network motion is in color and adjustment of notch filter is in black.



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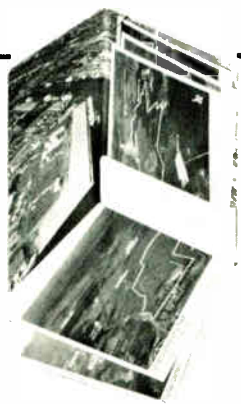

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Designing out the problems of wide-angle color TV tubes

110° deflection angle means slimmer color TV, but presents higher voltage requirements plus misconvergence and distortion; they're controlled—without additional circuitry—by redesigning yoke and gun

by Walter D. Masterton and Robert L. Barbin, *RCA Electronic Components, Lancaster, Pa.*

☐ Slimming down a color television receiver by increasing picture tube deflection angle from 90° to 110° sounds like just a small change. But to achieve the 4-inch, or 22%, reduction in the length of an 18-inch-viewable picture tube (see Fig. 1), some knotty design problems had to be solved. These included minimizing the increased voltage demands of the 110° tube; designing a new deflection yoke; adjusting for misconvergence caused by the wider angle of the new tube; controlling higher distortion; and controlling astigmatism at the yoke.

More voltage is required for 110° deflection because, in theory, the power for a uniform deflecting field increases as the square of the sine of the deflection half-angle. In practice, the deflection-yoke power increase is larger. For example, from 90° to 110° the power increases by approximately 50% instead of 43% for horizontal deflection and by 65% instead of 53% for the vertical deflection. Since a yoke designed for a 90° tube cannot be used with a 110° deflection angle, a recontoured yoke and tube were designed; they're shown in Fig. 2. But these changes, by themselves, would double the deflection power requirement for the 110° tube.

Another important design consideration was convergence. For proper focus, the three electron beams that excite the red, green, and blue phosphors must converge to a common point at the screen in order to superimpose this video information. As in the 90° tube, use of dynamic convergence waveforms, in which the trajectories of the three electron beams are selectively altered prior to entry into the deflecting field, aided convergence along the horizontal and vertical center lines of the picture tube screen.

The deflecting-field design controls convergence over the rest of the screen. The increase in the deflection angle and the shorter gun-to-screen deflection field in the new tube caused misconvergence at the edge of the screen. As a result, dynamic convergence waveforms larger than in the 90° tube were required to eliminate it. But in so doing, it was important to avoid additional circuitry. By retaining on-axis dynamic convergence nearly identical to that used in the 90° system, circuitry—and costs—could be reduced vis-a-vis the large-neck, large-screen tubes made in Europe.

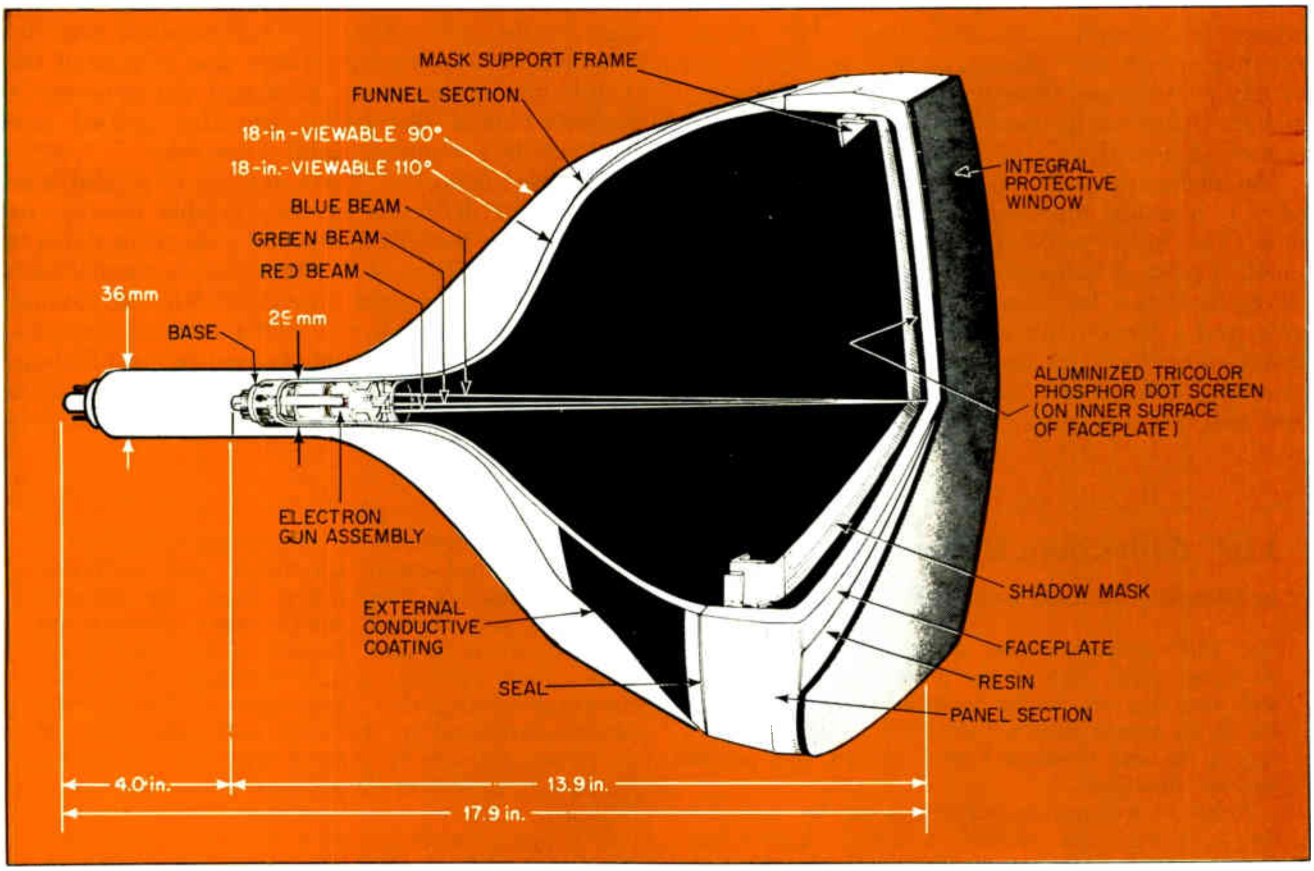
Happily, the problems of increased deflection power and misconvergence—and their solutions—were interrelated. Both were minimized by using a smaller-diameter tube neck and an electron gun in which the three electron beams are positioned closer together than in the 90° models. Because neck diameter of the 110° tube is 29 millimeters, compared with 36 mm for the 90° color tubes, the yoke diameter was reduced enough to obtain a 30% savings in deflection power. And thanks to its shorter electron gun diameter, the distance of each beam from the axis of the 110° tube at the deflection plane is 0.07 in. shorter than in the 90° types. In designing the gun to shorten the gun-to-screen distance, spacing between the beams on the screen was reduced by 35% so that convergence is virtually equal to that of the 90° systems.

Thanks also to the closer spacing, the beams pass through a more uniform portion of the yoke's magnetic field. The result is reduced yoke and tube convergence variations. With the smaller electron gun and the new deflecting yoke, very good convergence over the entire screen area was achieved without the need for the complicated and expensive corner-convergence circuitry found on large-screen, large-neck 110° tubes.

A further problem caused by the wider deflection angle was increased distortion of the triangular arrangement formed on the screen by the three electron beams that pass through a common aperture-mask hole. The ideal electron-spot configuration is equilateral triangles equally spaced over the screen.

However, two factors prevented achievement of the ideal condition. One, the error caused by the electron beam hitting the curved tube surface at an angle, called obliquity, depends solely on the deflection angle of the electron beam and the curvature of the screen. This error factor causes the shape of the electron-spot trio to be shortened in the direction of the deflection. As a consequence this distortion increases from a maximum shortening in the corners of the screen of approximately 20% for 90° systems to 30% for 110°. The second factor in this type of distortion is astigmatism of the deflecting yoke field, generally the same polarity as obliquity.

The error was solved by designing a more accurate lens and tightening control of the phosphor-dot manufacturing process. Astigmatism cannot be eliminated without causing serious convergence problems, but



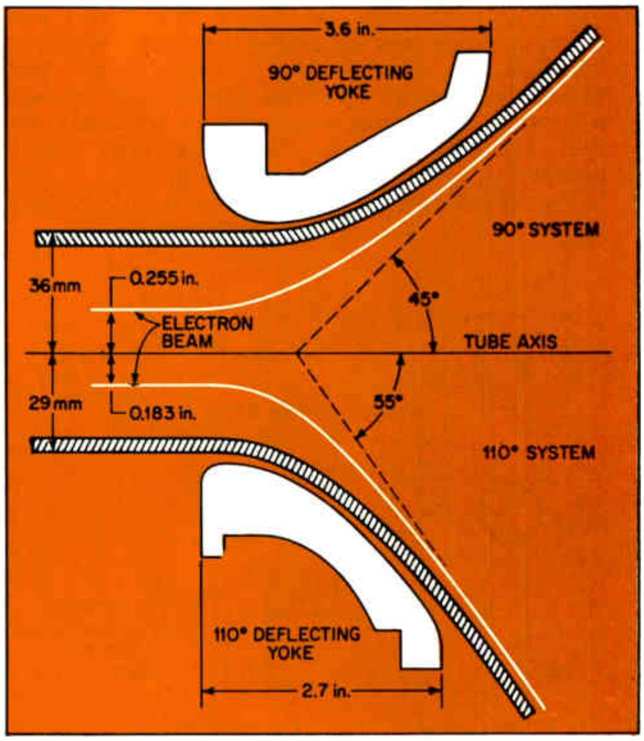
1. Long and short of it. Comparison of the 90° and 110° tubes shows the slimmer profile of the 110° model as well as the thinner tube neck. To maintain picture quality in the 110° tube, changes were necessary in the yoke, tube, and neck.

by changing the yoke field shape, it can be apportioned to screen areas where it will be noticed least. For example, it can be distributed with the new yoke so as to cause a maximum radial shortening of the electron spot trio of 11% at the extreme top and bottom of the screen, 7% at the ends of the horizontal center line, and essentially none in the corners. In addition, the improved lens design and phosphor-dot printing methods helped compensate for this astigmatism.

One more result of the wider deflection angle is distortion of the shape of the raster. This pincushion distortion increases approximately as the square of the tangent of the deflection half-angle. It means that lines near the edge of the screen in the 110° tube have a radius of curvature of about 35 in., against 75 in. for the 90° unit. Thus, pincushion distortion is much greater in the 110° tube than in the 90° version.

This distortion, illustrated in Fig. 3, was corrected by modulating the scanning current so that less current is applied to the horizontal and vertical yoke coils during deflection to the corners than the center lines.

It's also possible to reduce pincushion distortion by altering the design of the yoke magnetic field distribution—at the expense of a distorted electron-spot pattern. However pincushion-corrected yokes suffer from more astigmatism in the horizontal coils, further distorting the electron-spot trio at the ends of the horizontal center lines. That's why it was decided to



2. Playing angles. Because of the 110° tube's new contour, a smaller yoke had to be designed to accommodate the wider electron beam angle.

design the recently announced 18-in., 110° system to provide best convergence, purity, and white uniformity possible and then to correct the resulting pincushion distortion by modulating the yoke scanning current afterward.

The deflecting yoke for both the 18- and 19-in. tubes is a saddle type similar to most yokes in 90° units. The basic parts of the yoke design include matched pairs of horizontal and vertical coils, molded plastic insulation between the horizontal and vertical coils, and a ferrite core that provides a high-permeability return path for the magnetic field lines. Coil-wire distribution shapes the electromagnetic deflection field and, consequently, the electro-optical performance of the yoke. The coil configuration was determined by a computer, which also calculated the distribution of turns and predicted performance. A geodesic-shaped distribution provides optimal performance in a windable saddle-type yoke.

Increased deflection power and use of a solid state thyristor for deflection in one portable receiver required paring the yoke horizontal inductance down to 0.2 millihenry. To achieve this value, horizontal coils were wound with eight strands of wire in parallel. Vertical windings follow a bifilar configuration; impedance, shown in Fig. 4, is the conventional 8 ohms.

Since the 110° tube's wider deflection angle causes increased convergence variations when deflection field

110° deflection, German style

by Michael F. Koubek, Siemens AG, Munich, Germany

The 110° deflection tube is available in Europe in all screen sizes. Though the problems of convergence and distortion are similar to those of the U.S. tubes, the larger screen sizes required redesigning one existing circuit and developing new circuits that provide unusual functions.

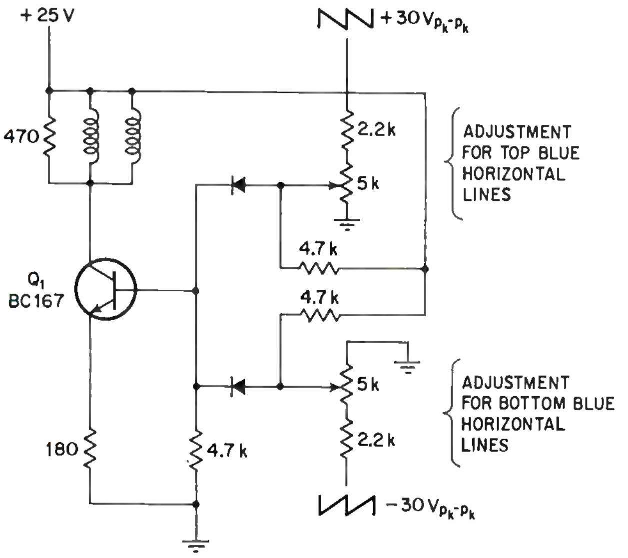
Although well-proven techniques can be applied to the horizontal and vertical deflection, high-voltage, and pincushion-correcting circuits, an entirely new design idea was required to obtain proper registration and beam landing. This principle is called active convergence. Different circuits had to be designed for vertical, horizontal, and corner convergence because each section of the tube has different error parameters.

With a small-screen, small-neck tube, corner convergence errors may be minimized with changes in the deflection yoke. But for a large, 26-inch tube with a large neck, additional circuits are necessary to provide independent adjustment for horizontal, vertical, and corner errors. The design even permits variable correction for the four corners.

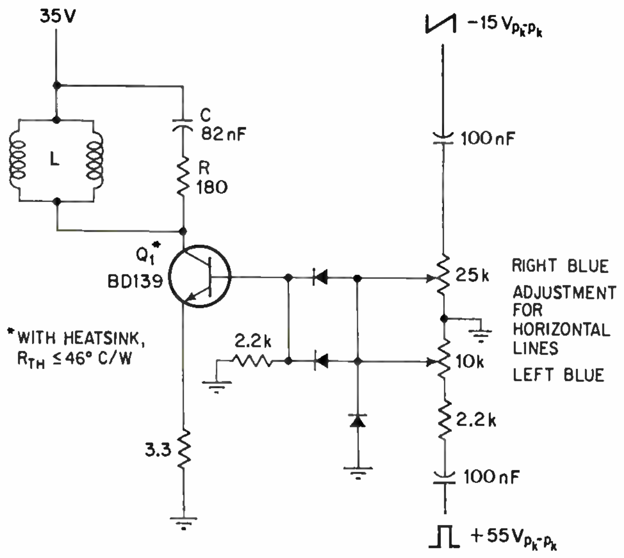
For vertical convergence (shown in the blue circuit), two sawtooth waveforms of opposite polarity are taken from the vertical output transformer and readjusted by potentiometers. Two diodes block the negative portion of the sawtooth signals while allowing the positive portion to pass. Present at the base of Q_1 is an almost parabolic signal, composed of the two positive sawtooth parts. The two parts of the parabolic current correspond to the lower and upper areas of the picture and can be adjusted separately. This same principle is applied to the red and green convergence as well.

Only one sawtooth waveform is needed as the main driving source for the horizontal convergence, although a positive pulse is used for slight corrections. Only the positive part of the sawtooth, corresponding to the right portion of the picture, is used as a driving signal. In this case the transistor generates the proper convergence current during the second half of the line reception period. The transistor is cut off during the first half of the next line period.

But some energy still is stored in the convergence coil at the switching point. This energy will cause a nonresonant current to flow through the series combination of resistor R and capacitor C, which are in parallel with convergence coil L. As a result, with a relatively high value of C, a decreasing convergence



VERTICAL CONVERGENCE CIRCUIT, BLUE



HORIZONTAL CONVERGENCE CIRCUIT, BLUE

shape changes, tighter controls were required in the yoke manufacturing process. One approach was the use of taps in the coil; these allowed slight, selective modifications in the coil-turn distribution. A small section of the winding near the middle of the horizontal coil was bypassed using the taps so that it does not carry any current and thus does not contribute to the magnetic field. Its location can be varied to correct for small construction variations so that the 110° yoke achieves the same convergence as its 90° counterpart without additional circuitry.

The electron gun configuration for the 110° tubes is similar to that developed in 1962 for the round-face 90° deflection tube. However, size was reduced to fit into the 29-mm-diameter neck. The smaller gun permits a smaller-diameter yoke and a consequent increase in scanning efficiency and convergence accuracy. To accommodate the decrease in beam separation, mask transmission, and hence light output, had to be reduced.

The shorter gun-to-tube-screen distance of the 110° tube more than compensated for the higher lens aberrations of the smaller gun optics. Thus, higher beam currents were possible with the same beam spot width, so there was no loss in resolution and the brightness is maintained comparable to that of a 90° tube with its larger gun. Also, by changing the electron optics, beam diameter was reduced, concentrating the elec-

current will result, falling with a time constant of L/R.

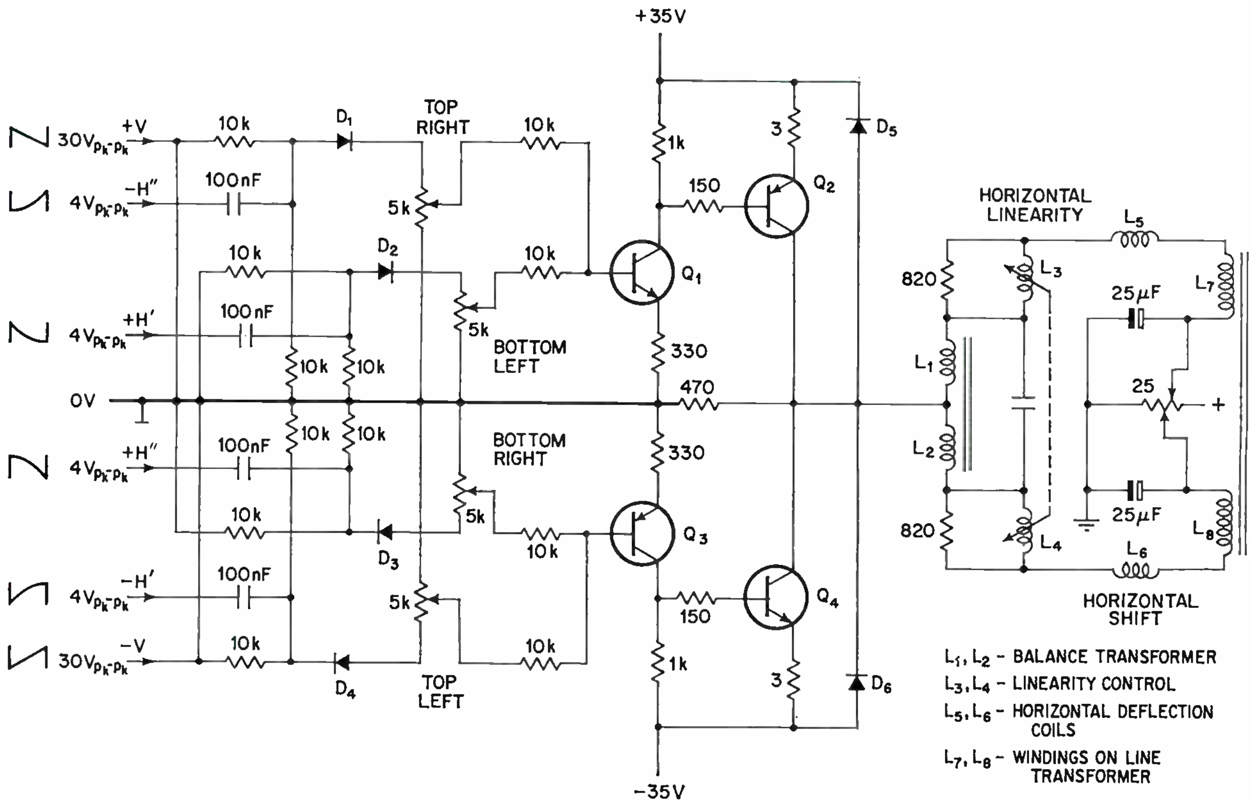
The initial adjustment is for the right part of the picture; this must be corrected before the left side is because the error on the left is affected by the right-side correction. The red-and-green horizontal convergence circuit requires the same two-step correction procedure as did the blue.

Corner convergence correction requires a more elaborate circuit because the requirements for each corner are different. Thus, separate adjustment of each part of the driving current is necessary. Since positive and negative current must be provided, a complementary amplifier arrangement is used. In addition, driving voltages for the amplifier have to be generated individually for each corner. Generally, this can be done by superimposing appropriate horizontal and vertical sawtooth signals and clipping off the negative or positive parts of the mixture as needed.

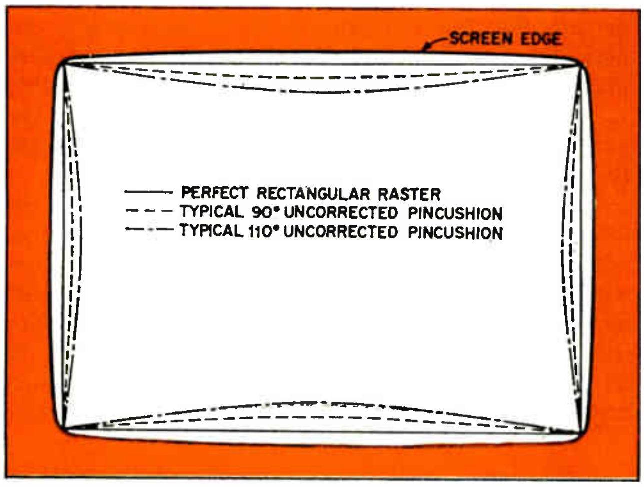
For example, in the upper right-hand corner, the rising portion of the sawtooth curve is used for the horizontal, the falling for the vertical, and the clipping is negative. In the upper left, the horizontal and vertical both employ the rising portion of the curve, and clipping is positive.

The lower right has falling curve portions for both horizontal and vertical, with positive clipping. And the lower left corner has a falling horizontal, a rising vertical, and negative clipping.

Diode D_1 through D_4 are used for clipping, while diodes D_5 and D_6 serve as flashover protection to prevent a high inverse voltage from breaking down output transistors Q_2 and Q_4.



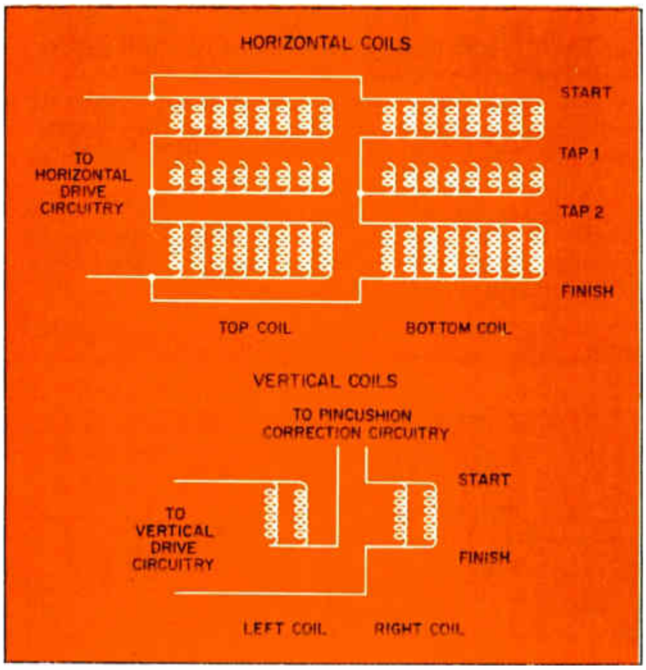
CORNER CONVERGENCE CIRCUIT



3. Distorted picture. Pincushion distortion was greater for the 110° tube than for the 90° type until corrected by modulating the scanning currents.

Sizing up the 110° and 90° tubes

	18-in., 90°	18-in., 110°	19-in., 90°	19-in., 110°
Overall length (in.)	17.056	13.872	18.047	14.061
Neck length (in.)	6.693	5.538	6.693	5.538
Minimum screen area (in. 2)	180	180	185	185
Screen diagonal (in.)	18.075	18.075	18.897	18.897
Screen width (in.)	15.585	15.585	15.922	15.922
Screen height (in.)	12.185	12.185	11.941	11.941
Aspect ratio	3.14:4	3.14:4	3:4	3:4
Deflection angles: diagonal	89°	110°	90°	110°
vertical	63°	80°	60°	77°
horizontal	78°	98°	78°	97°
Neck outside diameter (in.)	1.438	1.146	1.438	1.146
Weight (approx. lb)	23.5	22.5	25	24



4. Coils on tap. To correct for pincushion distortion in the 110° yoke, the taps on the horizontal and vertical coils permit fine adjustments in drive circuitry.

tron energy into a smaller area on the phosphor dot.

A nonceramic cathode structure was used in the cathode and heater design. The cathode was insulated from the grids by glass support beads. This nonceramic design eliminated thermal conductance variations characteristic of ceramic and ceramic-to-metal joints, and also provided complete mechanical rigidity. The three heaters were connected in series in order to allow strong connecting wire and were adequately supported by metal tabs. In addition, a small Nichrome sleeve thermally isolated the active portion of the cathode from the support mechanism. The resulting reduction in input power to the heater caused by thermal isolation resulted in a cooler-running stem and less heat to the adjacent gun parts. Thus, parts movement caused by thermal expansion was reduced, minimizing misconvergence.

Another feature of the small-neck tube is a new base-and-socket design. This was required because the smaller tube size requires smaller, more fragile contacts. Instead of the conventional arrangement, in which the leads protrude freely, the leads lay against the periphery of the base. The base is a hollow cylindrical insulator; its external longitudinal grooves support the inner sides of the stem leads. The socket also is a hollow cylindrical insulator; its ribs slide in the grooves of the base and spring contacts engage the outer sides of the stem leads.

Another manufacturing problem that had to be overcome was that the increased deflection angle in the 110° tube causes about a 50% increase in the aperture mask's sensitivity to thermal motion with respect to the phosphor-dot array (Fig. 1). This condition usually shows up as higher sensitivity to any mask/faceplate instability during thermal processing cycles of the screen, and as a need to adjust a temperature-compensated mask-frame system to maintain beam-to-phosphor-dot register for color purity as the tube warms up. The problem was solved with a four-point support system that provides increased rigidity and shock resistance.

Initially, the 110° technology is being applied to tubes with 18- and 19-in. viewable areas. The 18-in. version is the first 110° color TV on the market in this country; it's 4 in. shorter than corresponding 18-in., 90° picture tubes, permitting a more compact cabinet for bookshelf and portable models.

A 19-in. version featuring a more rectangular-shaped screen than the 18-in. unit will be available later. Performance of the 19-in. 110° tube is comparable to that of the 90° type for brightness, purity, and uniformity. This tube has a maximum anode-voltage rating of 27.5 kilovolts, the same as for the 90° type. For other comparisons, see table. □

Part Two
System designers eye multichip LSI packages

Developments in ceramics, beam leads and LSI testing appear to be making a practical proposition of the multilayer, multichip package

by Stephen E. Scrupski, *Packaging and Production editor*

☐ Amid all the controversy about the price, quality and respective merits of ceramic and plastic LSI packages, there is no dispute that putting a single 200-mil square chip in its own 2-inch-long package is extravagant in terms of space—and often in terms of cost also. Many system designers are therefore taking a new look at multichip packages with interconnections made on multiple layers of ceramic.

Although such packages aren't as yet popular enough to be attractively priced, recent developments by package suppliers suggest lower costs may be in the offing. Equipment designers may also benefit from developments in beam leads and multichip packages that semiconductor suppliers themselves are making.

Faced with growing competition from plastic encapsulation and overcapacity in house, ceramic package suppliers are hunting for new ways to reduce costs—and these same innovations may apply as much to multichip as to individual packages. Suppliers are also trying to develop new packaging concepts based on ceramic technology—of which lower-cost multilayer ceramics will probably be part.

The new connection methods, like beam leads and solder bumps, with which semiconductor companies are hoping to eliminate the high labor costs of wire bonding, would be equally suitable for multichip packages. (In fact, the availability of a wider variety of beam lead chips may be crucial to the use of multilayer substrates, suggests William Everitt, product sales manager at Coors Porcelain Co., Golden, Colo.) Going still further, semiconductor producers are also developing their own multichip packages for semiconductor memories—and these, too, may be useful to the system designer, even though memories tend to require more regular and simpler wiring patterns than random logic does.

Moreover, in being concerned about the problems in LSI chip testing, the same companies may indirectly be helping the designer in a third way. Whereas individually packaged chips that failed could be removed from a pc board, the risk of sealing a bad chip into a multichip package carries a heavier penalty. So the recent developments in LSI testing should diminish this risk.

Multichip memories are attractive on several counts, says Jerry Moffitt, manager of logic and memory functions at Texas Instruments, Houston. He notes that they allow mixing of MOS and bipolar chips, have lower-cost interconnects, and, because the chips can be more firmly interconnected, also offer higher reliability. TI is now offering a 2,048-bit random access memory consisting of 15 beam-leaded (eight MOS and seven bipolar) chips that include peripheral functions.

Some, however, think the multichip approach to memories is only a temporary measure. For instance, Glen Madland, president of Integrated Circuits Engineering Corp., Phoenix, Ariz., feels that such approaches will be continually upstaged by improving yields in large chips, and the extra problems of thermal dissipation in a smaller space might be more easily solved with separate packages.

System designers, however, are more interested in multichip random logic circuits. One product design engineer at a major computer house says that he, "like everyone else," is working on multichip packages for the next generation of computers. However, he sees two problem areas still requiring work. Gang bonding techniques, such as beam leads, solder reflow and ultrasonic flip chip bonding, are still not at an "engineering stage" of development, he feels, since each suffers from low bond yields, while ceramic modules themselves still are not good enough, he says.

Solder reflow, however, has been proven in the automated production of multichip circuit modules (monolithic system technology—MST) for IBM Corp.'s System 370 computers. Now Cogar Corp., Wappingers Falls, N.Y., and Semiconductor Electronic Memories Inc., Phoenix, Ariz., also are using the process for memories with chips having 24 or more contact pads each.

Ceramic package quality, of course, affects yield, and yield and cost are inseparable. Benjamin Ranan, president of Frenchtown CFI, Frenchtown, N.J., a ceramic package supplier, points out that cost is high at present mainly because of the yield problems, while fixed costs for materials and overhead aren't all that low either. Right now, he says, a typical industry yield for a laminated, three-layer, single-device package is about 50% to 55%, but it's much lower for multilayer packages, where yield losses have many more causes. The first step, making the tape in the green state that will later be laminated, is running "pretty well now," he says, but all the subsequent steps—screening, punching, laminating, and firing—still need work. In particular, punching the small holes and getting conductive material down into them to interconnect the layers is a difficult task.

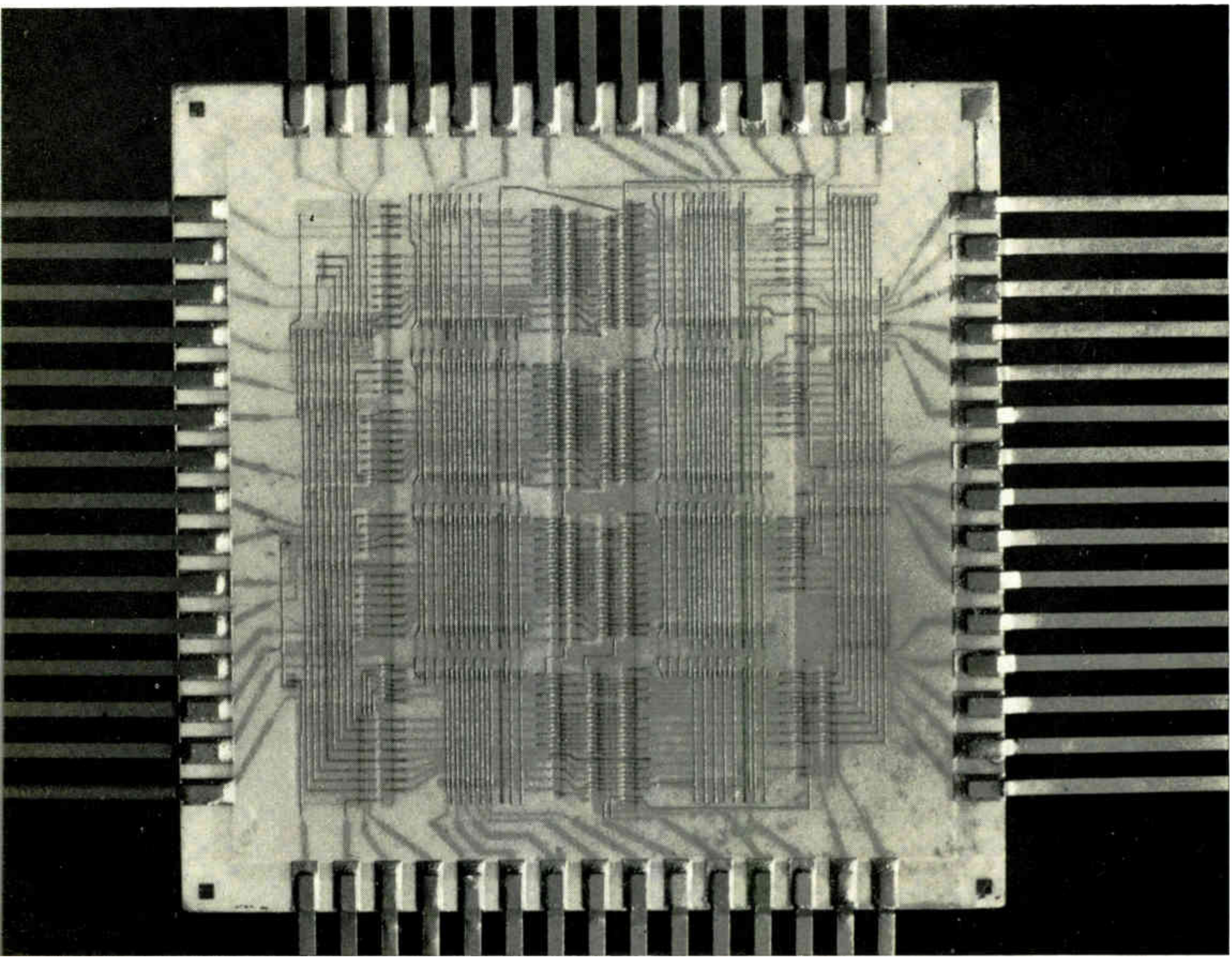
Another major contributor to cost is that the top layer of ceramic must be extremely flat to accept beam leads and the sealing ring, and this flatness is made harder to achieve by the relatively large area of the multilayer package. Coors' Everitt says that most makers now grind it down to the necessary flatness, an extra step that further raises the price.

The conductive pattern on the top layer must also be flat where it meets the beam leads. Normal screened lines tend to be domed or oval in cross-section, which makes it difficult to bond a beam lead to one, since it may touch only the top of the dome or may slide down the side. (On this point, Ranan says that Frenchtown has developed its own screening equipment to produce flat enough lines.)

The flatter, photo-etched circuits may be another answer. Also, with their finer conductor lines they yield higher-density packages. According to Frank Rydwansky, applications engineering manager at Metalized Ceramics Inc., Providence, R.I., lines 3 mils wide with 3-mil spaces are "duck soup" with photo-etching right now, while the best that screening can normally do is only 5-mil lines with 5-mil spaces (although this can end up as 4-mil lines and 4-mil spaces, since screening is done in the green state and material shrinkage is an advantage in this case). Etched lines 1 mil wide with 1-mil spaces are next.

Another advantage of etch is that, with the whole conductor area plated before etching, it's possible to have isolated plated interconnects. With screened patterns, it's necessary to bring all plated interconnects out on an external lead for connection in the electroplating process.

1. **Mnemonic.** Eight beam-lead MOS memory chips on a multilayer ceramic substrate form a 2,048-bit memory now being produced by Texas Instruments. Two layers of metal are used, plus a layer of screened dielectric for insulator. Etched lines have 3-mil widths and 3-mil spaces.



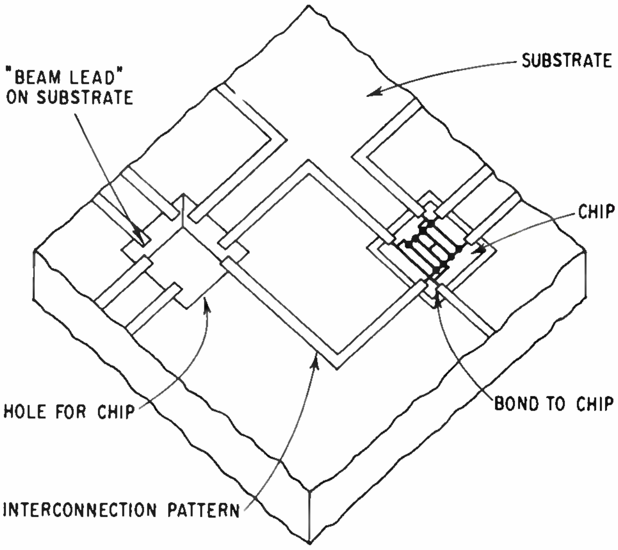
Where beam-lead substrates are at

A beam-lead substrate packaging idea developed at MIT Lincoln Laboratory [*Electronics*, March 30, 1970, p. 126] by Robert McMahon is still evolving. The substrate has holes in it for chip insertion, and the interconnection pattern extends over the holes. Because the substrate and not the chip carries the beam leads, any standard chip can be used.

McMahon is presently looking into a substrate system that employs a carefully controlled thickness of aluminum oxide as the dielectric. A sheet of aluminum, coated on one side with aluminum oxide, is etched to create the interconnection pattern and the beam leads, leaving the oxide as the substrate. Such a device would yield controlled transmission line impedances for microwave and high-speed digital systems.

McMahon also says the process for making ceramic beam-lead substrates has been simplified. He has developed a method for using water glass as a filler in the holes during the formation of the beam leads. Formerly, after the chip holes had been punched out of the ceramic and the substrate fired, the holes were filled with low-melting-point glass, polyvinyl chloride, or another material, to support the leads then laid down.

"But there were always problems with these systems—either there was a crack between the ceramic and the surrounding filler, or one had to grind or etch or do something else messy to get rid of the materials and leave the leads and the substrate," McMahon comments. "Now, we just put the substrate face down in a mold, pour in the water glass, let it harden, deposit our leads, and wash away the water glass. There are no cracks, and no messy removal processes to deal with." McMahon credits workers at Sanders Associates Microwave division in Nashua, N.H., with thinking of water glass for this purpose.



Regardless of yield and cost problems, ceramic producers say that they see interest stirring among system designers. Multilayer edge mounts, for example, now are being shipped by Dielectric Systems Inc., San Diego, Calif., according to vice president Yung Tao, while Metceram's Frank Rydwansky says that in a three-week period last month he received six requests for quotes on multichip packages, apparently based on "real program needs." Each was for multilayer units holding upwards of 20 chips for computer mass memories and telephone system memories.

Metceram is able to supply about 50,000 photoetched, 1-by-1-inch substrates a week right now, or about 200,000 substrates measuring 0.4 by 0.6 inch (the smaller the area, the more can be produced).

One systems house package designer who is well pleased with the multichip approach for military applications is Allen B. Chertoff, assistant chief engineer for microminiaturization at Loral Electronic Systems, Bronx, N.Y. The 1.5-by-1.5-inch multilayer-ceramic "Lisa" (Loral integrated subassembly) packages, which accommodate up to 25 chips, are now being produced for high-density, high-speed display systems for airborne equipment. To date, Loral has used over 5,000 multilayer substrates, made by several suppliers.

The substrates are produced by the co-fired, laminated-tape process, and instead of a lead frame have 100 pins for connection to the pc board. The pins help dissipate heat to the board and, because ceramic is used instead of a metal can, the underside of the package is accessible for testing. Chertoff adds that Loral recently completed equipment that die-attaches, wire-bonds, and tests at the same station. He adds that the latest packages use conductive epoxy for die attach rather than wire bonding because it is an easier process and also avoids high temperatures.

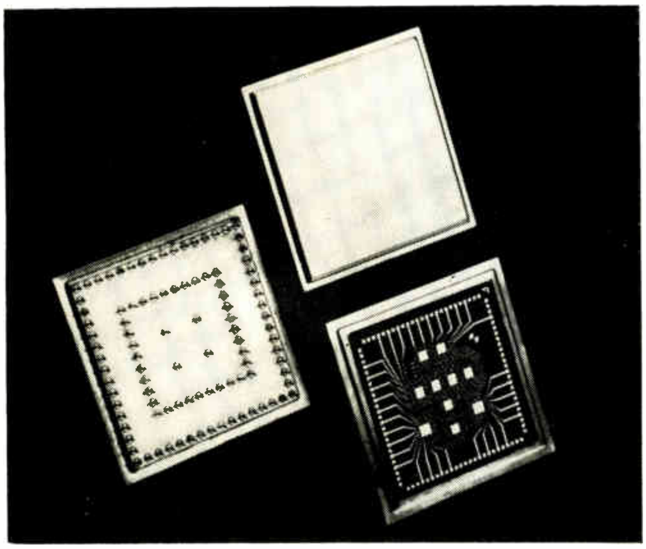
Comparing the mechanical reliability of his approach to a system using individually packaged circuits, he notes that the total package pin count is reduced by two thirds, although the same number of wire bonds is used. There is no longer a separate soldered connection between individual package lead frame and conductor pattern—this connection is merged into the conductors deposited on the package.

One other aspect, which he says has been hotly debated for some time, is the hermeticity of a large package. Chertoff says that the Lisa is within the leak rates specified in Mil Std 883 yet eliminates 95% of the hermetic seals.

Robert Applewhite, sales supervisor at American Lava Corp., Chattanooga, Tenn., says that his company is one of those supplying the ceramic packages to Loral for the Lisa. As to what's limiting their wider use, he says it's "just an educational problem—system designers have to learn what can be done in the way of line widths and spacing, number of planes, plane-to-plane interconnects, and the like."

Applewhite says that Lava has been producing the modules, which he calls composites, for over five years and that they actually preceded the company's line of single-device packages.

To get system designers thinking in terms of multi-



2. Pin up. As many as 100 pins may be used on the Dielectric Systems Century packages. The substrate, which can have from two to 10 layers, measures 1.6 by 1.6 inches. The 15-mil Kovar pins are sealed only to the lower ceramic layer and do not reach the top layer. The cap is welded for seal.

chip packages, E.I. du Pont de Nemours Inc., Wilmington, Del., recently introduced a multilayer package for use with up to 12 chips, of 48 leads each, as a standard item. With leads on standard dual in-line 100-mil spacing, the du Pont package has six insulated conductive layers. Of these, the top layer has the chip bonding pads, along with the top surfaces of the conductive risers or vias that bring all internal wiring paths to the top.

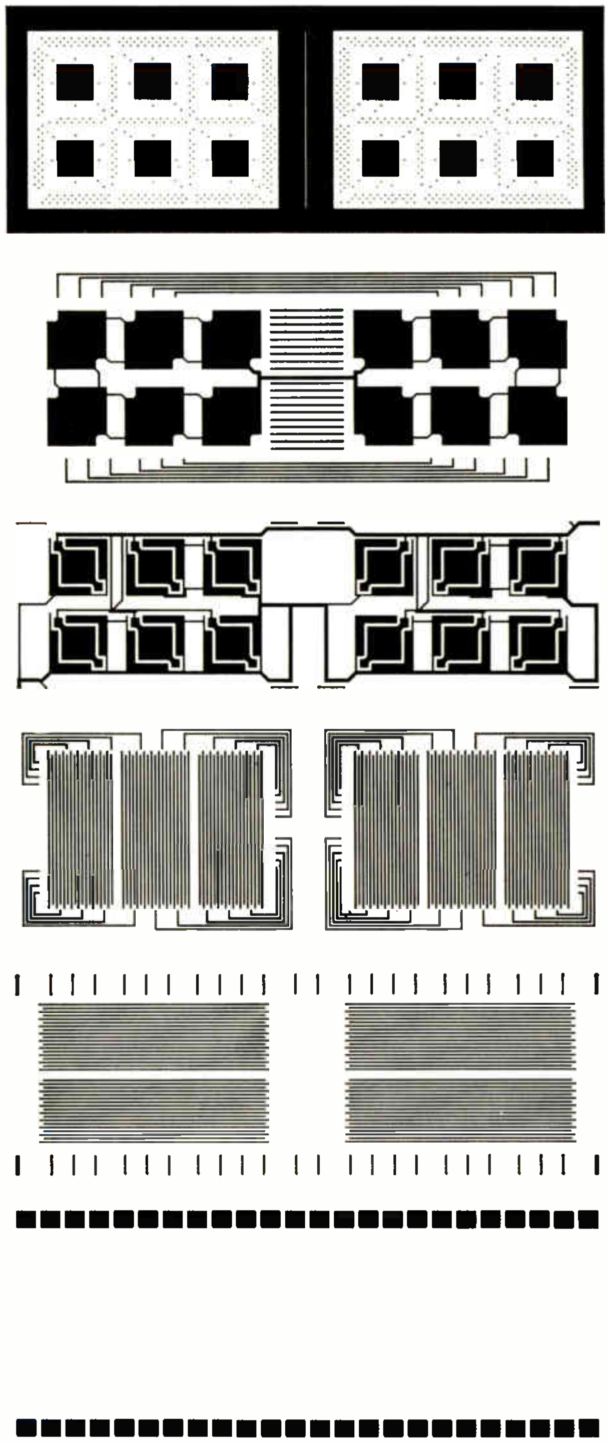
On the top surface, the user would wire-bond the chips to their adjacent wiring pads and then interconnect the internal metalization paths with wire bonds to the tops of the vias. Jack Cox, program manager, says that du Pont offers a computer program that arranges the wire-bond sequence so that the user can avoid any that would have to cross over one another. Moreover, once the user has completed his circuit and fully checked it out, du Pont promises to convert the pattern to a screened interconnection mask for the top surface. The chips themselves may still be wire-bonded, but such wiring could also be eliminated if beam leads or flip chips were used. Cox says that the wire bonding would also be done under computer control if the wire bonder is x-y programable. □

The first part of this two-part special report appeared in the previous issue. Reprints of the entire report will be available for $3 a copy. Prices for quantity order on request. Address all orders to Electronics Reprint Department, P.O. Box 669, Hightstown, N.J. 08520.

Addenda: In the list of ceramic package suppliers in Part I, one company was omitted, and another was given an incorrect address:

NTK Ceramics division
NGK Spark Plugs (U.S.A.), Inc.
4010 Sawtelle Blvd.
Los Angeles, Calif. 90066
213-397-8184

Dielectric Systems Inc.
3422 Tripp Court
San Diego, Calif. 92121
714-459-2935



3. Stack up. The du Pont multichip package is made with six layers of metalization, using the masks shown. The first layer (bottom) carries the bonding pads for the lead frame. The next four layers are the x-direction, y-direction, ground plane and power plane wiring respectively. Finally the uppermost layer has die-attached pads and the tops of all the conductive risers that interconnect the layers. Wire bonding on this layer completes the circuit. Once determined, the wire-bounding pattern could be converted to a screening mask.

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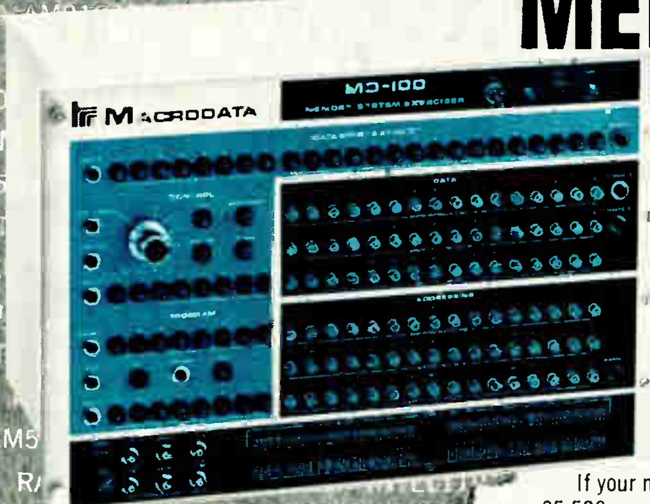

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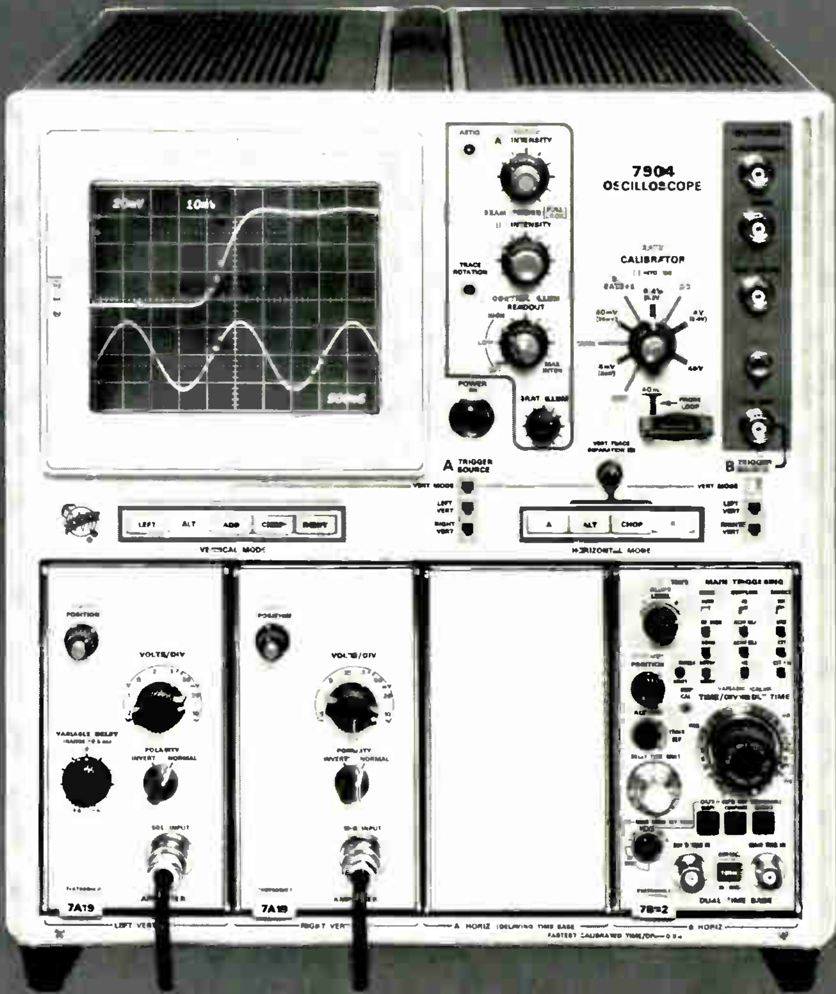

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Circle 70 on reader service card

Singapore raises sights

Turning its back on assembly-only plants, the island republic is seeking full-scale manufacturing and the importation of advanced technology

by Tony Polsky, McGraw-Hill World News

It doesn't boast the lowest wages in Southeast Asia, it's taking a tougher line now on tax breaks for foreign investors, and it wants to be more than just an "assembly of assemblers." Yet Singapore continues to draw U.S. and other foreign companies to its shores with such strong attractions as a government that cuts through red tape in record time and a work force that speaks English.

With its business growing fast—thanks to its earlier success in luring foreign investment—the Singapore government is no longer interested just in attracting electronics assembly plants. Now foreign enterprises must show a clear promise of switching over to "genuine" manufacturing, higher utilization of local materials, and more sophisticated technology. "The industry has yet to prove itself in terms of importing or disseminating skill and technology to Singaporeans," notes a recent report from the Singapore National Productivity Centre. "As it stands today, it is an assembly of assemblers conglomerated on the island."

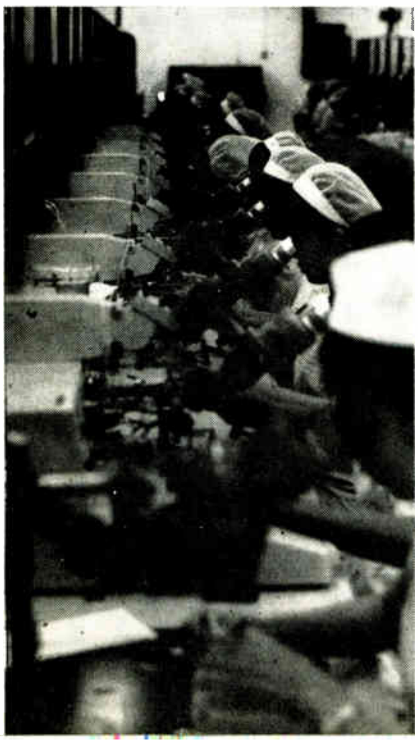
As a result of its evolving attitude on foreign investment, Singapore has recently tightened up its relatively generous tax benefits and other inducements to potential investors. Some latecomers have complained, but foreign companies whose business promises to upgrade the island's technology still get the fullest cooperation from the government.

Among the first to recognize the republic's attractions for foreign investment were U.S. electronics firms. The Singapore National Productivity Centre study, released last September, listed half of the 43 electronics manufacturers on the island as American owned or as joint American-Singapore ventures. American capital investment in electronics assembly operations topped $20 million as of July 1970, says the study. At that time 11,649 people were employed in Singapore's electronics industry, 86.1 percent of them females.

Largest American employer is Texas Instruments Inc., with other big manufacturers including Fairchild Semiconductor division, Hewlett Packard Co., National Semiconductor Inc., General Electric Co., Intersil Inc., Electronic Memories & Magnetics Corp., and Litton Industries Inc.

Texas Instruments is also one of the most enthusiastic. Back in November 1968, a TI management team negotiating in Taiwan to set up an assembly plant found that "the red tape was terrible, and so were the delays," according to a senior Dallas-based TI executive. "So part of our team hived off and came down to Singapore for a look." Fifty days after they arrived, TI had an electronics assembly plant in operation in Singapore. It had chartered two DC 8 cargo jets and flown the necessary equipment straight from Dallas to the island.

Evolution. Singapore wants to grow out of assembly operation stage.



Much of the credit for this quick turnaround goes to the Economic Development Board, a government agency that has high decision-making authority. Not only does the board work to attract investors and help train workers for new plants, but it performs the vital function of coordinating a wide variety of agencies and ministries during negotiations with foreign companies. Thus, it protects the investor from the welter of conflicting and competing agencies that so often plague him in other Asian countries.

Singapore's foreign investment program stems from the efforts of Prime Minister Lee Kuan Yew, a Cambridge University honors graduate, and associates such as Dr. Goh Keng Swee, a London-trained economist who is generally credited with being the principal architect of the island's economic boom.

The republic turned to foreign investors after a series of crises threatened to disrupt the economy and produce widespread unemployment. First of these came in the early 1960s when Indonesia, under its former president, Sukarno, disrupted the vital sea trade that had been the source of the island's wealth. Next, Singapore was expelled from the Malaysian Federation in 1965 after a brief marriage marked by much political acrimony across the causeway linking the two countries. Finally, the British Labour government in 1968 announced that it would shut down all its bases on the island by 1971. At one time these bases had contributed almost 25% of the republic's gross national product.

The solution for the Singapore government was to look for foreign labor-intensive industries with a technological base—industries that later could be upgraded. Electronic product assembly was thought to be an ideal, interim solution.

As a start, the government began building "flatted factories" at sites adjacent to apartments put up under its public housing programs. The five- to 10-story buildings contain space for ready-made factories, with only minor alterations required by the tenants, and they are designed for light industrial operations. And the nearby "housing estates" provided a vast reservoir of relatively unskilled labor, particularly the young girls required for a semiconductor industry.

Under Prime Minister Lee's tight rule, labor unrest has been kept to a minimum in recent years, but now his nominally Socialist government recognizes that some worker demands simply will have to be met. Thus wage scales are expected to rise about 10% this year. On the average, the women employed in electronics companies as semi-skilled assemblers get between $35 and $45 a month for a 44-hour work week. Fringe benefits can add as much as 33% to gross pay.

Labor turnover, initially a problem because most of the girls had never held jobs before, has stabilized as workers adjust to working on shifts. And though productivity and work discipline are perhaps not up to Japanese standards yet, they are much higher than in many other countries around, say U.S. company spokesmen.

Many of the American investors say the fact that workers speak English has turned out to be an even bigger advantage than first imagined. "Our girls and the rest of our local professional employees can follow circuitry diagrams much easier than a worker can in a place like Hong Kong," says one executive.

The first electronics firm to hit the island—in November 1968—was National Semiconductor. After a dip during last summer's depressed U.S. economy, it now has about 1,600 employees. The company is very sensitive to the government's interest in bringing more advanced technology to the island. "Actually, we are trying to convince the Singapore government there is an extremely high degree of technology involved in making our products," relates R.B. Mollerstuen, head of National's Singapore operation. "And, as we have developed our local operation, the head office has been pushing more and more items—which means more elaborate equipment," he says. "We have even started some basic research in our engineering section, and are doing things now that two years ago we couldn't have touched. But our local engineers now have the experience."

Essentially, though, most of the American electronics firms still run assembly operations. Most of the raw and semifinished materials are imported, and most of the components are shipped to the U.S.

"Our real problem is the Japanese penetration and competition in the American domestic market. We're here to be competitive. It is 10 to 15% cheaper to make our radios in Singapore than in the States," says a GE executive. GE subsidiaries on the island are making vacuum tubes, radios, timing devices, and wound coils.

"Our output is split between the U.S., Britain, and Europe, with about 60% of our current IC and transistor output now going back to the States," reports Charles Anders, who heads TI's assembly plant on the island. After a summer downturn, TI, like most of the companies, seems to have bounced back. It is in the process of passing its peak employment level and now has about 1,800 employees. The company is building its own plant on a 10-acre site near the present flatted factory it is using, and over the next two years it plans to employ up to 3,000 people. □

Government

Nixon + David = new science policy

Electronics companies can expect a host of different guidelines, some hard to take, as White House works to shift direction of Federal R&D funding

by Wil Lepkowski, McGraw-Hill World News, and Ray Connolly, Washington bureau manager

Federal support of technology for defense and space programs is designed to solve specific problems, and President Nixon has made it clear that he wants funds for all domestic R&D redirected toward precise goals. Though the President's men responsible for implementing this pragmatic approach to national needs are still struggling with the technological priorities, a new pattern for funding them is beginning to emerge. For electronics companies, it will require some sobering reappraisals as the Administration considers replacing the spoon-fed progress payments that characterize defense and space programs with unknown quantities, such as tax writeoffs for new industrial R&D initiatives in the domestic market.

A major force behind the new approach is Edward E. David Jr., now in his seventh month as Science Adviser to the President. Operating with a comparatively small staff of 25 and a budget a bit above $2 million, David is still a long way from bringing a new look to the Federal research program. Nevertheless, there is evidence that the former Bell Laboratories engineer and executive is making progress. For example he is credited with helping pin down $100 million increases for biomedical research and for the National Science Foundation in the fiscal 1972 budget, though he had been on the job less than three months.

But whether David's Office of Science and Technology is progressing fast enough for engineers in electronics companies—which laid off 107,000 persons last year—is another matter. Confronted by a sluggish economy and a nation divided on priorities and the ability of technology to meet society's needs, David's group is moving with understandable caution, trying to remain as flexible as possible.

"It's very clear," said David shortly after his arrival in Washington, "that if we're to successfully continue industrial and technological progress in this country, we must develop a technique for assuring the public that its concerns are being duly considered."

One of the techniques David is counting on is to push the private sector of the economy to do more on its own in responding to society's demands, generating its own new markets for technology rather than depending on federal funds.

Though this will take time and is unlikely to produce many new jobs for unemployed defense electronics and aerospace specialists in the short term, the 46-year-old science adviser does not favor Federal make-work programs for the interim. Instead, David subscribes to a mild form of social Darwinism, characteristic of the Nixon Administration at large, in leaving the fate of the engineer to the marketplace.

"I don't see any fundamental bar to the absorption of these people back in jobs," he explains. "There may very well be a large number of jobs in other areas, such as environmental fields, transportation systems, new housing technology, information systems, health care systems. Some of the money will be publicly generated, but it won't come unless we can create viable industries."

Adviser. Industry should create new technology markets, says David.

David's list is likely to be expanded in May when the President puts out his first annual report on the status of American science and technology. And the Administration's approach will show up clearer when the science office completes its list of national technological goals as a base for new R&D strategies. This report presumably will draw on a contract study by Mitre Corp.'s McLean, Va., division assessing technology and its impact on society.

But the study that should put it all together is one shepherded by Texas Instruments' Patrick Haggerty for the President's Science Advisory Committee (PSAC). That report will relate the future of U.S. technology to such economic considerations as barriers to innovation, industrial research, manpower, productivity, and the balance of trade—a currently negative

Priorities. Health care is something David usually cites first.

balance. In 1970, for example, electronics imports exceeded exports by $266 million, an increase of nearly 600% in five years.

David, not just waiting for these reports to emerge, is considering ways and means of stimulating fresh applications of technology in research-oriented industries, such as electronics. Possible corporate incentives include tax credits of up to two-thirds of the collective salaries of R&D personnel, a number of tax rebate concepts based on the level of R&D investment, and extension of the Pentagon's independent R&D reimbursement approach to other agencies and a larger number of industries.

It will be some time before any of these plans, if implemented, will have visible impact on profits from technology—or on jobs. Indeed, David notes that "it may turn out that a number of people who call themselves scientists and engineers may in the interim take jobs outside of engineering and science."

A hint as to how upcoming Nixon Administration reports will rank technological priorities and their potential for electronics can be gleaned from David's own remarks. Health care, for example, is something he usually mentions first, noting that medical costs continue to rise while the delivery system remains antiquated. How innovation in this field will be financed is still open to question. "We're just at the point of making a decision on a number of these issues," he says.

David also talks readily of environmental control, a popular issue. "We're asking such questions as to whether there should be a national environmental monitoring system. That would require a good deal of research and technology."

David is also reported to have suggested that it may be time to update a 1966 PSAC report to the President on the potential use of computers in schools and colleges, a report developed by a panel headed by his former Bell Labs colleague, John R. Pierce.

To rank these and other social needs, David and his staff are looking for novel ways to measure them and a new mix of technical manpower to achieve them. Technology assessment is one measure, of course, but the degree to which it should be applied requires answers to harder, more subjective questions. How fast, for example, does high-speed ground transport need to be? And what is the best mix of rail and highway systems?

The new manpower mix, says David's deputy Hubert Heffner, will require engineers whose special expertise is balanced by a sharp social awareness to identify needs and move with change. A certain amount of management training should help them achieve this blend, says Heffner. Tomorrow's engineer, it is said, may work on development of transportation systems for a few years before moving on to public safety or environmental measurement and control. In public service, that same engineer could serve as technical adviser to a governor, mayor, or legislative body—groups badly in need of technical expertise.

For the long term, David's office is pushing for new educational curricula, funded through the National Science Foundation, to produce a more flexible engineer, as well as Federal grants to industry for on-the-job retraining of engineers willing to learn the new technologies.

How successful the new science adviser is in carrying out his ideas will be determined largely in the coming months as he begins a lengthy testimony before a hostile Congress where he must justify the President's programs. □

Aerospace

Europe hits back at Aerosat decision

ESRO is rushing to design a rival aeronautical services satellite system to force the White House to permit European participation in U.S. program

by *Stewart Toy, McGraw-Hill World News*

Blocked by the White House Office of Telecommunications Policy from participating in the development of aeronautical services satellites for the Atlantic and Pacific [*Electronics*, Feb. 1, 1971], Europe has decided to fight back by designing its own system. The European tactic is bold and direct: by racing ahead with a competitive satellite that can be launched at the same time it feels the first U.S. Aerosat will be orbited, the European Space Research Organization hopes to force the Americans back into the cooperative development plan that was quashed in January.

But if the U.S. stands firm, ESRO insists it will launch its own system. And it says it will recruit partners, such as Canada, Japan, and Australia, to assure navigational and telephone coverage for aircraft over both oceans.

Though the European move may contain a good measure of bluff, ESRO is serious enough about the project to have set aside $5 million to spend on it this year alone.

The decision to go ahead was taken just last month, following a visit to the U.S. by Dieter Lennertz, ESRO's director of the new project, to sound out the latest American thinking. Lennertz says he sensed a possible shift back toward cooperation with Europe. He notes that the latest White House office's Aerosat plan, issued March 19, makes a dozen references to international coöperation, and that the Department of Transportation and the Federal Aviation Administration have agreed to join ESRO in testing antennas for the L-band systems being designed in both the U.S. and Europe. The two agencies will participate in a series of 15 balloon-to-airplane transmissions to be held next September in southern France.

Meanwhile, ESRO is racing to design a competing system. In fact, to hasten its progress, it has taken the unusual step of bypassing competitive bidding and has awarded three noncompetitive system study contracts.

These time-saving contracts are essential to the European strategy. Though the U.S. timetable calls for a preoperational satellite to be launched over the Pacific in 1973, Lennertz believes this schedule cannot possibly be met. The U.S., he feels, will not be able to call for bids before the fall, so that a contract could be let only by the first of next year, delaying the actual launch until 1974—the target date for ESRO's orbiting of its own preoperational Atlantic satellite.

The study contracts which are worth $600,000 each, were awarded to three European industrial consortia, each with an American minority partner. The consortia are called Cosmos, headed by Germany's Messerschmitt-Bolkow-Blohm and including Boeing Co. and General Electric Co.; Mesh, led by France's Matra with TRW Inc.; and Star, with British Aircraft Corp. at the helm and Hughes Aircraft Co. as its partner.

These groups will look at existing hardware and try to match it with what they consider system needs. ESRO emphasizes that "Project Dioscures," an L-band system proposed by the French and the basis for most prior ESRO work in the field, will not be the takeoff point for new studies. "We want to look at everything available, including American designs," says Lennertz.

In addition, ESRO is awarding its own hardware development contracts for several critical satellite

Europe's big hope: slippage

Though U.S. officials hate to admit it, the guidelines for European cooperation in the U.S. aeronautical services satellite system are vague at best. The official word from the White House Office of Telecommunications Policy is that Europeans may participate financially in the system as long as such an arrangement does not slow down the fast pace being set by the office.

The schedule calls for the Federal Aviation Administration to draft a detailed national satellite plan by June, leading to deployment in the fall of 1973. Many predict, however, that the FAA will not be able to live up to the timetable. "If they have a satellite up in 1973, it will be one minute before New Year's," quips one highly placed source, "and even that's awfully ambitious."

If, as the Europeans and others predict, these slippages do occur, the White House guidelines will fall apart. And that means that the State Department, which fears a stormy diplomatic battle with the Europeans over this issue, and industry and agency officials, who are opposed to any loss of the U.S. space monopoly, will have to fight it out to decide the question of European participation.

Probing the news

components. Orders already have been let covering mechanically despun devices, power supply systems that include flexible solar-cell arrays, and attitude sensing and control devices. And a $500,000 contract to design a satellite antenna will be awarded soon.

Antenna gain will get particular attention. Texas Instruments Inc. and France's Elecma have designed 10-decibel antennas. However, says Lennertz, "we are not yet convinced that 10 dB is the most attractive solution." Coverage will be another major question—whether a single dish or whether spot beams should be used.

Once the tradeoffs are made, ESRO will choose two or three of the most promising systems and the consortia will study them in depth, doing preliminary designs. By September, ESRO expects to have in hand one or two system proposals, which it will present at November's meeting of the International Civil Aviation Organization. ESRO hopes to get the Americans to agree at this meeting to collaborate on one preoperational system.

The Europeans will start lobbying sooner, however. A negotiating group to be formed by early May will make frequent trips to Washington this summer to work on the State Department and the Department of Transportation. And ESRO plans to use the swift pace of its independent work as a lever.

Lennertz says that ESRO's pressure on Washington should help simplify the American political tangle that's complicating the entire Aerosat program. For example, he notes that U.S. airlines are less than delighted at the prospect of having to partially finance the current American project; they should welcome the ESRO move, he feels. The Europeans, he maintains, are ready to pay for half of the estimated $100 to $140 million cost of the Atlantic and Pacific systems. But though European governments have approved both a joint and a unilateral system, prying sizable appropriations out of member countries may not prove that easy. □

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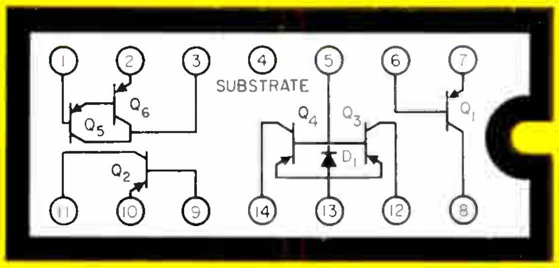
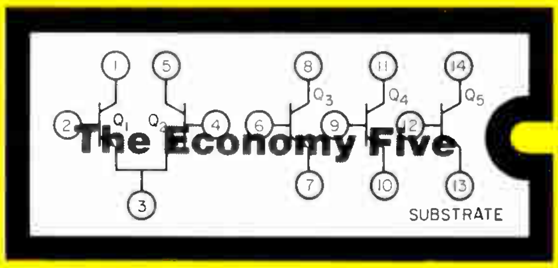
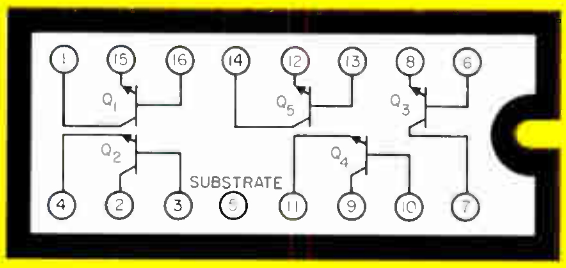


CA3084



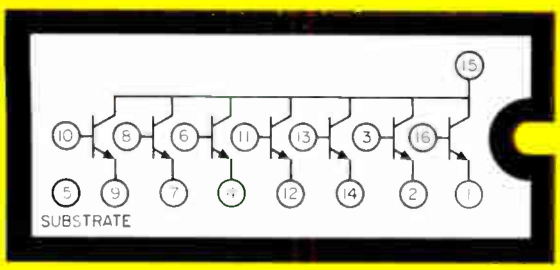
CA3086

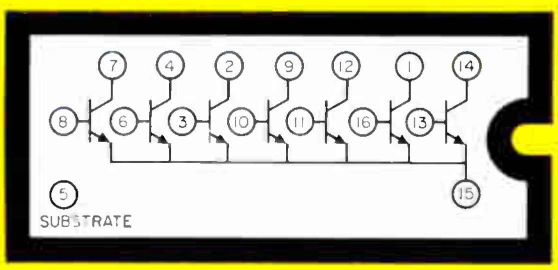
Type	Package	Description	Technical Bulletin File No.	Price (1000-unit level)
CA3086	14-lead DIP	The economy five	483	.49
CA3084	14-lead DIP	P-n-p array	482	1.79
CA3083	16-lead DIP	Five independent 100-mA n-p-n transistors, with V_{CEO} = 15 V(Q_1 and Q_2 are matched at low currents, i.e. 1 mA)	481	1.69
CA3082	14-lead DIP	Seven 100-mA transistors with V_{CEO} = 16 V (common-collector array)	480	1.89
CA3081	16-lead DIP	Seven 100-mA transistors with V_{CEO} = 16 V (common-emitter array)	480	1.89



CA3083

CA3082





CA3081

RCA Solid State

Circle 77 on reader service card

Mobility. New fm transceivers can be carried, mounted in automobiles.

Consumer

Ham gear gets a boost

Solid state cuts costs, reduces size of 2-meter sets; makers use ICs, squeeze performance out of a few parts

by Paul Franson, Dallas bureau manager

Static for the past ten years, ham radio is beginning to show signs of growth again, and its vitality stems largely from a new type of product, the solid-state fm transceiver. Not only has solid state lowered costs, but it also has made the units compact enough to fit into any car or even be carried around, thus encouraging hams to use the transceivers for "walkie-talkie" style, local communications. And prices are continuing to drop as the Japanese, who started the rush to these sets, and the Americans are designing in low-cost ICs, ceramic filters, and other new developments.

Sales of the new transceivers are, and probably will continue to be, modest—about 10% of the $30 million amateur radio market. But the features of the new transceivers have generated a great deal of interest among hams—many of them electronics engineers—and some dozen manufacturers and importers are fighting over their share of the pie.

"I like the standing-wave-ratio-type overload protection in most of the new units," reports one such engineer at Collins Radio Co., Dallas. "I used to have a transistor citizens-band transceiver of about the same power level, and I kept losing the output transistor, once by transmitting when the whip was touching a telephone pole guy wire, and once when somebody stole my antenna, and I didn't know it."

The market for 2-meter fm sets began a few years ago when hams started buying up used tube-type commercial sets that had been obsoleted by new FCC requirements. Once the supply of sets was exhausted, the Japanese jumped in to fill the void and began exporting low-priced, solid state units. The first U.S. company to import the sets was Varitronics, Inc. in Phoenix, which sold a transceiver for $350. Other companies— such as R.L. Drake Co., Miamisburg, Ohio; Swan Electronics Corp., Oceanside, Calif.; and Standard Communications Corp., Wilmington, Calif.— soon followed suit.

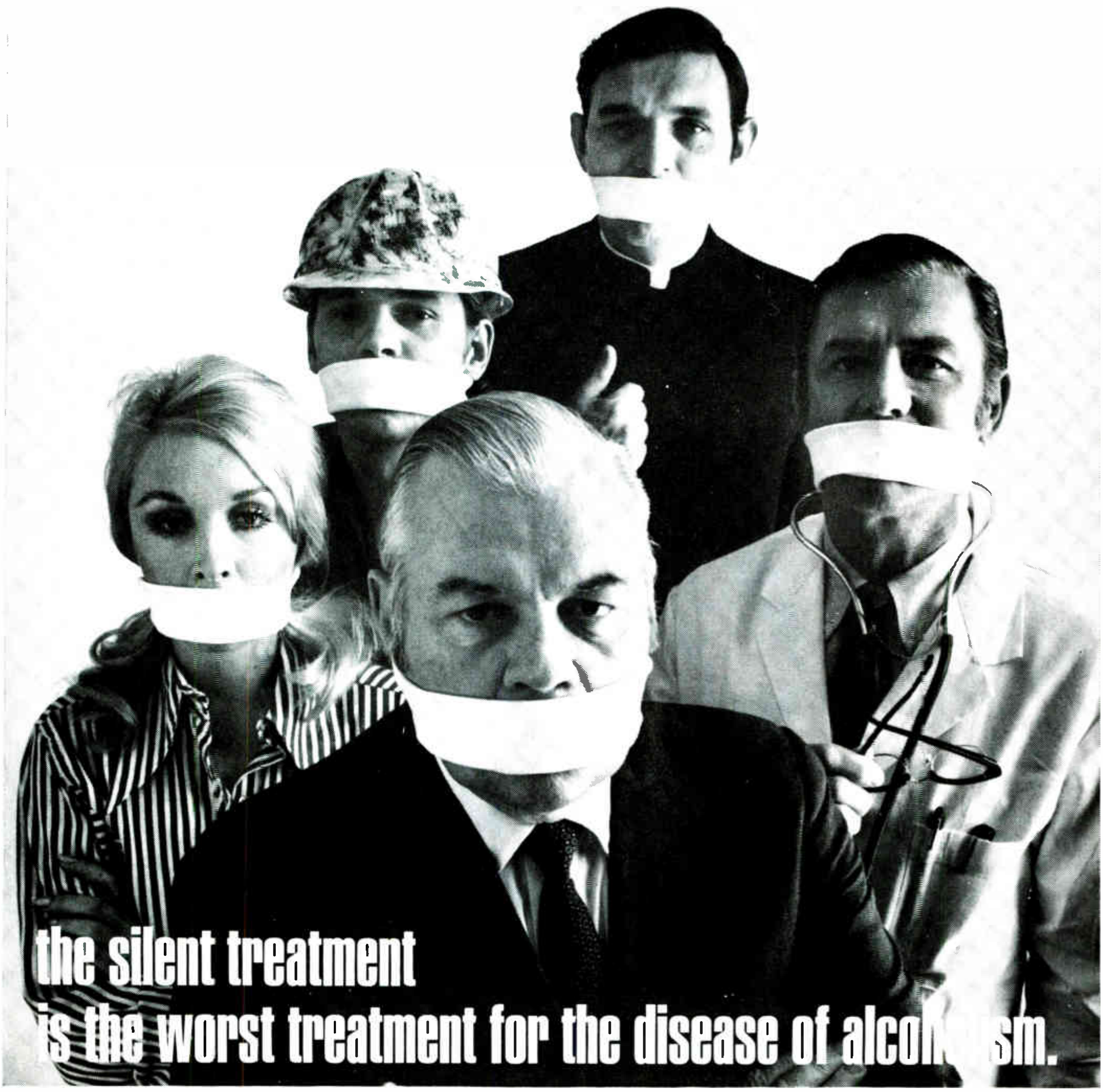
Many of the imports at first were modified "FCC-type-accepted units," and their design and construction were fairly conventional, with relatively little apparent attempt to squeeze the highest performance out of a few parts. That's changing now, though, because of tough competition posed by U.S.-made sets, which exhibit careful attention to cost-effective design.

The first American-made fm transceiver came to market with a pricetag of about $200, much less than the cost of Japanese-made units at the time. It was made by Galaxy Electronics, now a division of Hy-Gain Electronics of Lincoln, Neb.

Last summer, another company, Regency Electronics Inc. of Indianapolis, introduced a $229 U.S.-made unit that uses two ICs in the receiver portion, one as a mixer and i-f amplifier, the other as an fm detector. The set uses a minimum number of stages and takes advantage of new, relatively low-cost parts. One is a 455-kilohertz ceramic filter that provides 32 kHz selectivity at 6 decibels. Another is a first mixer that uses a field effect transistor and provides overload resistance. Two balanced-emitter power transistors are used in the transmitter portion.

Though Swan doesn't see a huge future for amateur fm, it's selling the 2-meter transceivers now "to make more money," according to H. T. Henley, sales manager. "This is a hot item right now, so we would be fools not to get into it." Henley feels that the market will reach saturation in two or three years. "All 2-meter fm amounts to is a citizen's band radio for local communications, whereas most hams are interested in long range, high-frequency communications," he says. However, many amateurs are using the transceivers over ranges up to 150 miles, boosting their signals in mountain-top repeaters, designed, built, and maintained by hams in most areas.

More bullish about the prospects for the solid state 2-meter transceivers is Stanley Reubenstein, sales manager for Standard's amateur radio division. "Fm transceivers have given a real shot in the arm to the ham radio business," he says. He expects sales of these units to continue strong because of the many inactive hams who will start buying again, thanks to the sets' low price and mobility. □

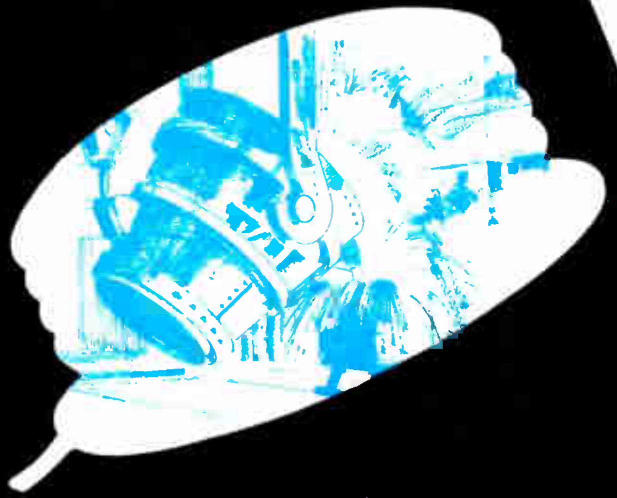


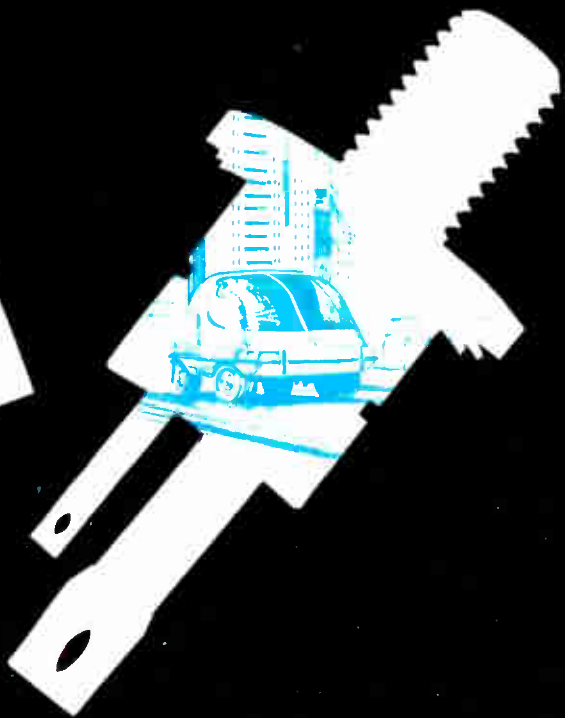
When one out of 20 employees in America—including executives—has alcoholism, it's time for some plain talk about alcoholism. The alcoholic's family, friends and employer may mean well, but the silent treatment is no way to treat a disease. And alcoholism is a disease from which recovery is possible, rather than a moral weakness for which the alcoholic should be pitied—or fired. It's a disease which ranks with heart disease, cancer and severe mental disorders as a public health menace.

The National Council on Alcoholism has pioneered in setting up joint union-management alcoholism programs. In these programs, industry is achieving *recovery rates averaging 60 to 70 percent.* Management profits by retaining its experienced employees and regaining lost productivity—estimated at six billion dollars. Unions profit by increasing health and welfare protection for members and keeping them in the active work force.

If you think alcoholism is affecting your business, **talk it over with the Director of Labor Management Services, National Council on Alcoholism, 2 Park Avenue, New York, N.Y. 10016.**

National Council on Alcoholism inc.





LSI tester aimed at design needs

Clock and word generators offered separately; system handles static, functional checkout of bipolar and MOS

While most testers for large-scale integrated circuits are high-priced, computer-controlled units that are at home on a production line, a new system from Comaltest Inc. is intended for the design engineer. The unit checks out almost any type of device—bipolar and p- and n-channel MOS—with up to 50 pins. Both static and functional tests can be run; programing is done via front-panel switches and a matrix board.

The system also has a feature that should appeal to designers who don't need a full-blown test setup: its key components—a word generator and a four-phase clock tester—are being offered as separate products. The clock generator, says Comaltest vice president John Cocking, is unique in that it has three, not two, operating modes—with adjustable-frequency, adjustable-clock-widths, and adjustable-delay being the third.

Working together in the system, the two generators provide a frequency range of 100 hertz to 12 megahertz. The generators, along with three adjustable power supplies, deliver signals to the device under test via the system's 20-by-50-pin programable matrix board. Signal amplitudes from the two generators are variable over ranges of 0 to +12 volts, and 0 to —30 V. Rise time at peak amplitude is 20 nanoseconds, and offset level is adjustable between —5 and +5 V.

The four-phase clock generator, says Cocking, has been specifically designed to test and characterize MOS circuits. The word generator puts out up to 12 channels of data, with word lengths of eight, 12, or 16 bits. Alternatively, channels can be connected serially to form words up to 192 bits long. Interface circuits with the word generator permit it to be driven with a PDP-8, PDP-11, or Nova minicomputer.

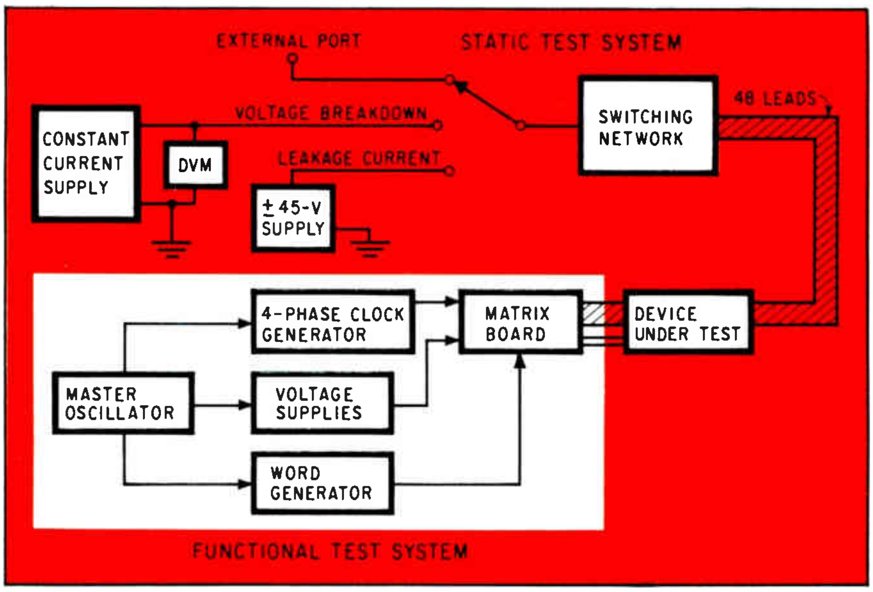
In its most flexible mode, the clock puts out four sets of pulses with independently adjustable widths. The delay of clocks 2, 3, and 4 also are adjustable relative to clock 1. This mode is used for a wide variety of tests. Clock frequency also is adjustable.

In mode 2, the clock pulse delays are fixed. Pulses from 1 and 2 occur at the beginning of a period, while those from 3 and 4 occur in the middle. Frequency and clock widths are variable. This mode is used for measuring the frequency response of circuits requiring fixed clock widths.

In mode 3, clock widths and delays are fixed ratios of the clock period; only frequency is adjustable. In this mode, the low- and high-frequency cutoffs of dynamic shift registers and memories can be measured.

Working in the static mode, the

Two ways. Simplified block diagram shows how LSI tester for the design engineer runs either static or high-speed functional tests. Matrix board is used for programing the functional tests.



system can measure leakage over a range of 100 picoamperes to 100 milliamperes and breakdown voltages up to 200 V.

Rise and fall times are independently adjustable between 30 ns and 300 ns. Widths and delays are variable between 30 ns and 18 milliseconds for duty cycles up to 90%.

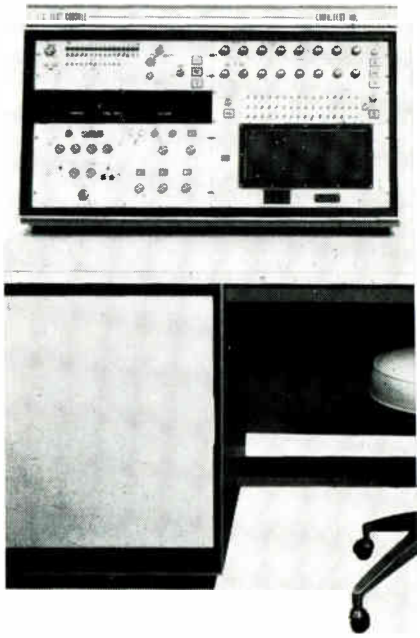
The specific pin to be checked for any tests is selected with one of 48 toggle switches. The remainder of the pins then can be grounded or one other pin can be selected for pin-to-pin measurements. Results are displayed by digital meters.

The three power supplies are used to provide two separate voltages to an MOS chip and a ground return which can be offset ± 5 volts. The offset feature is included because a permissible offset voltage is frequently specified on MOS chips.

The total system is priced at \$20,000; for the word generator and the clock generator, the prices are \$3,000 and \$2,500, respectively.

Comaltest Inc., 124 South Eighth St., New Hyde Park, N. Y. 11040 [338]

Test console. System tests and characterizes complex ICs, including high-speed logic circuits.



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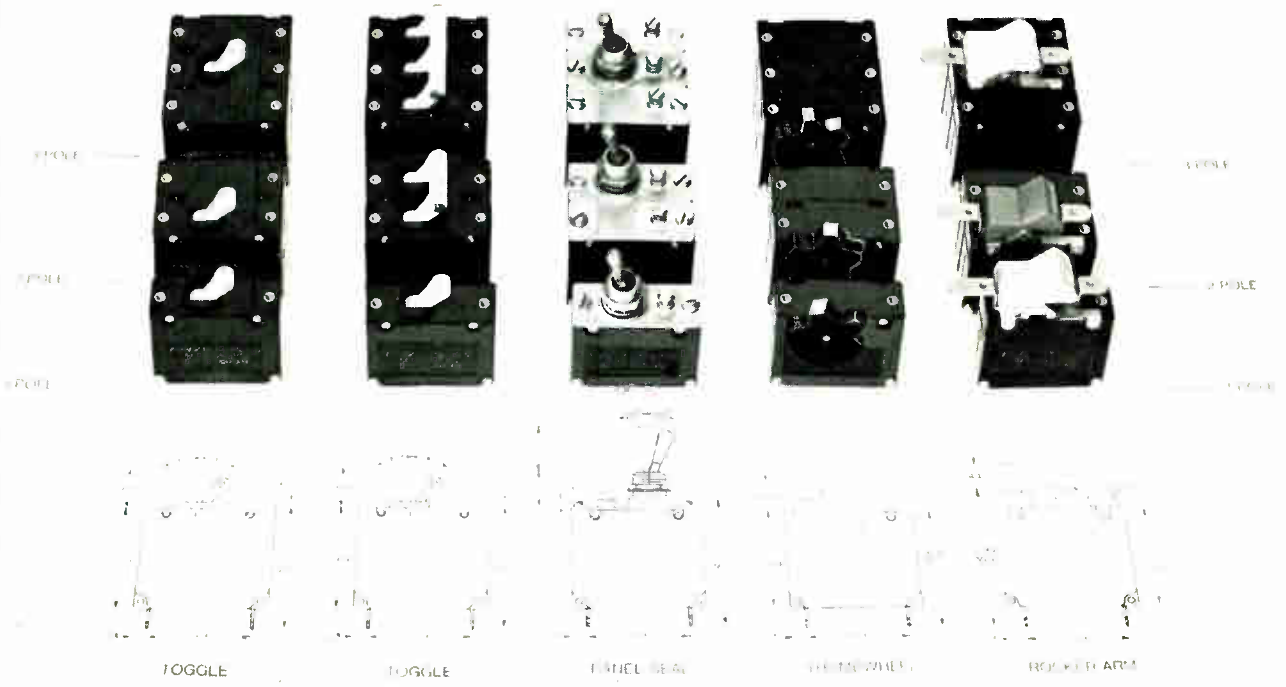

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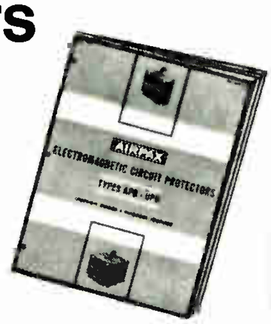

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Components

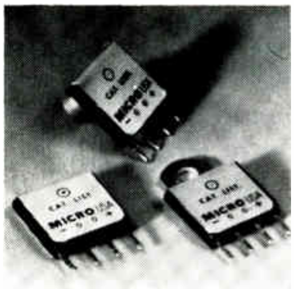
Power klystron is air-cooled

S-band tube for airport surveillance radar puts out 2 megawatts of pulsed power

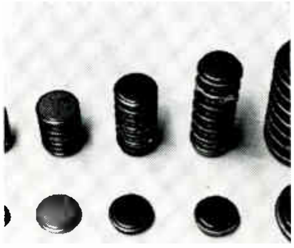
A target-cluttered radar display screen is difficult enough to read, but if any system noise is present, the screen can become totally illegible. Part of the problem, according to Richard T. Schumacher, product manager for super-power tubes at Varian Associates, is that airport radars use magnetrons as a power source. These suffer from phase shift—their frequency tends to change from pulse to pulse, which introduces additional noise. Klystrons, on the other hand, are more stable but they've been limited by low efficiency and water-cooling problems. Varian's answer was to design an efficient klystron that can be air-cooled.

Designed specially for airport surveillance radar systems, the new tube, called the VA-87E, is capable of producing 2 megawatts of pulsed power in the 2.7-to-2.9-gigahertz (S-band) range with an efficiency of about 50%. Integrated random noise and peak spurious output are about 70 decibels below the carrier level; saturation gain is 50 dB or more.

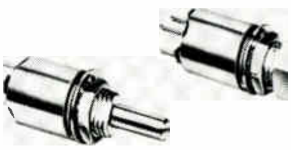
Airports have been slow in switching to klystrons, says Schumacher, because of their cost and the fact that magnetrons have been good enough. Although more susceptible to clutter, magnetrons operate on lower voltages than klystrons and can be air-cooled, whereas the less-efficient conventional klystrons had to be water-cooled. "The new klystron," says Schumacher, "is more efficient and



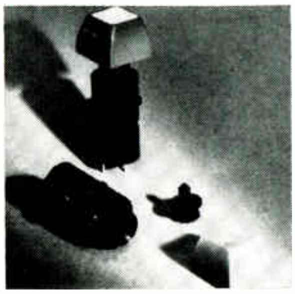
Hall-effect switches, models 1SS2, 3, and 4, have magnetic flux concentrators that allow operation at greater distances than before. Units switch at up to 10,000 cycles/s. Output level is 0.3 V dc max in low state, 3 V minimum when magnetic field is applied. Micro Switch, 11 W. Spring St., Freeport, Ill. [341]



Sealed, non-gassing mercuric oxide cadmium batteries have shelf life of 5-10 years and operational temperature capability of −65° to 164° F. They are available in five capacities from 500 mA/hr to 12 A/hr. Voltage can be any multiple of 0.9 V. Elca Battery Co., 1140 W. Evelyn Ave., Sunnyvale, Calif. [342]

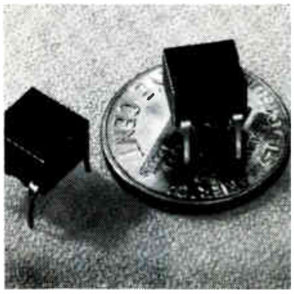


Miniature cermet variable resistor type SP, with ⅜-in. diameter, is for small panel spaces. The potentiometer is stable under severe conditions, dissipates 1 W at 70°C, and has resistance range from 50 ohms to 1 megohm. Rotational life is 25,000 cycles. Allen-Bradley Co., 1301 S. Second St., Milwaukee, Wis. 53204 [343]

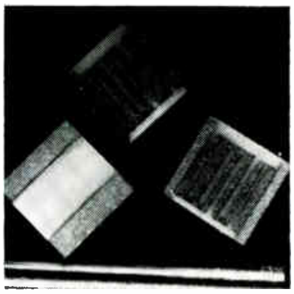


Keyboard switch model S830 features momentary and alternate action. Five snap-on adapters mate with most keytops. Designed for interchange with other switch types, unit is rated at 100 million operations at logic levels. Keytops are available in seven shapes. C. P. Clare and Co., Pratt Ave., Chicago, Ill. [344]

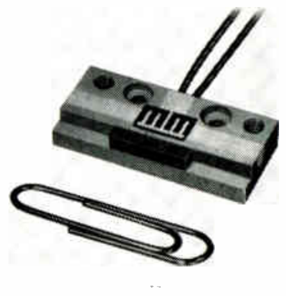
Thin film resistors are designed for microwave applications. Film is deposited by pyrolytic carbon process. Substrate is aluminum or beryllium oxide. Temperature coefficient of resistance is 250 ppm/°C, and standard resistance tolerance is 1%. Midwest Microwave Inc., 3800 Packard Rd., Ann Arbor, Mich. [345]



Square-style film element trimmers designed for automatic packaging come in single-turn (type 87) and 12-turn (type 85) series. Pin spacing is compatible with DIP machinery, and sealed cases withstand soldering. Units are rated at 0.5 W at room temperature. Dale Electronics Inc., P.O. Box 609, Columbus, Neb. [346]



Metal film chip resistors offer good stability and low resistance values. They measure 50 and 75 mils square and have gold terminations for bonding to film conductor patterns. Resistance range is 1 to 100 ohms, coefficient of resistance less than 100 ppm/°C. Airco Speer Electronics, St. Mary's, Pa. [347]



Ferrous-operated proximity reed switch, model 26-23, for industrial control is highly stable unit with 2-millisecond response. Actuation range is .075 to 0.150 in. in .025-in. steps. Initial contact resistance at 25 mA is 0.5 ohm max for laboratory grade. McClintock Matrixes Inc., Woodbury, Conn. [348]

Circle 85 on reader service card→

it can be air-cooled."

Schumacher says that many of the calculations used in designing a klystron involve nonlinear relationships and that, because of the large number of variables, the designer's experience was brought into play in selecting some preliminary numbers. "But now we have a program that can predict tube efficiency as a function of internal dimensions," he adds.

Delivery time is six months, and prices range from $15,000 to $5,000 depending on quantity.

Varian, Palo Alto Tube Division, 611 Hansen Way, Palo Alto, Calif. 94303 **[349]**

Ultraminiature trimmer pots are only a quarter-inch high

Over the past ten years, the application of monolithic technology has shrunk nearly everything in electronics. But simply because a human being must adjust it, industry has yet to produce a monolithic potentiometer.

Now comes the KVSF10 series of 15 ultraminiature—though not monolithic—trim pots from Trans National Electronics Inc., Marblehead, Mass.

One of the larger models in this line is five-eighths of an inch high—including the length of the pins which attach it to a printed circuit board.

The smaller units are less than a half-inch in their largest dimension. And a horizontally mounted version rises less than a quarter-inch above the printed circuit board after installation.

All are carbon film pots with type B linear tapers. Since their maximum working voltage is 100 volts, and they can dissipate 0.1 watt, they are suited to low-power, low-volume applications. Some have already been sampled by makers of consumer products like high fidelity equipment and small tape recorders.

Standard resistance value range and tolerance for the tiny devices is 500 ohms to 1 megohm, ±20%. Burn-in characteristics show some drift: about 5% over a 5-hour 70°C burn-in—but this can apparently then be trimmed out.

Since these pots will find themselves on the inside of most components, rotational life isn't too important a spec. But for such a tiny pot it's fairly respectable at ±10% total change after 100 of its 200° to 270° rotation sweeps.

The maker has even included a moisture resistance spec, although these devices are not for mil-spec use. After about 350 hours at 90 to 95% relative humidity, total resistance change should be within ±20%.

Price in lots of 25,000 ranges from 6.5 to about 8 cents each, in 1,000-unit lots from about 10 to 12 cents each. Delivery time is 45 to 60 days.

Trans National Electronics Inc., Marblehead, Mass. **[350]**

Tiny LED numeric readout aimed at calculators, probes

After going to market with one of the largest light-emitting-diode numeric displays [*Electronics*, Feb. 1, p. 93], Litronix Inc. is now offering one of the smallest—a 0.1-inch numeric for calculators, hand-held instruments, and probes.

The unit, called the Data-Lit 300, is a seven-segment, gallium-arsenide-phosphide red readout. The character size, power requirements, and package design are also suited to field test sets, bench instruments, point-of-sale machines, and other peripheral terminals.

The unit dissipates only 160 milliwatts at 25°C. In addition, it has a mounting density of 10 digits per square inch and a low-cost frame lead construction.

Storage and operating temperature of the display ranges from −20°C to 100°C; total continuous forward current is 80 milliamperes. Forward current is 10 mA per segment and decimal, and peak inverse voltage is 3 volts.

The Data-Lit 300 will sell for under $7. Delivery is from stock.

Litronix Inc., 10440 North Tantua Ave., Cupertino, Calif. 95014 **[351]**

New products

Semiconductors

Op amp error cut to 15 pA

Monolithic IC's input stage uses super-gain Darlington transistors instead of FETs

Monolithic operational amplifier precision now can be as tight as tens of picoamperes, thanks to a new input stage design for IC amplifiers. Developed at National Semiconductor, the device incorporating this design limits input offset currents to as little as 15 pA over a wide temperature range, while input bias currents are cut down to 50 pA.

The new input stage employs super-gain bipolar transistors in a Darlington configuration instead of the field effect transistors used in some low-leakage op amps.

According to Robert Dobkin, manager of advanced linears at National, "with FETs, the input current doubles with every 10° increase in temperature." Thus an amplifier specified at 10 pA at room temperature will have an input current of 10 nanoamperes at 125°C.

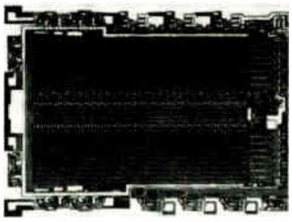
But in the new design, input error currents change only a few picoamperes with temperature. Operating at gains of several thousand and zero collector-base voltage, the bipolar inputs virtually eliminate high-temperature leakage.

Another problem with FETs is that they are hard to match, making offset voltage a problem. But this doesn't trouble bipolar transistors.

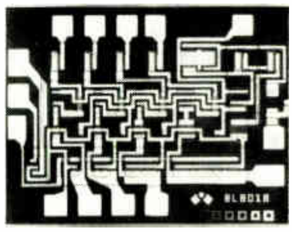
The first op amp to use the new design is the LM216, an internally compensated device. Dobkin says that the low-error inputs make practical many circuits that could never be built before with ICs,

Small-chip, plastic-packaged static RAM is low-cost version of 256-bit silicon gate MOS memory. Designated type P1101A, it is fully decoded and interfaces directly with DTL and TTL. Prices range from $24 to $12.80 in quantity. Ceramic package is also available. Intel Corp., Middlefield Rd., Mountain View, Calif. [436]

High-Q, voltage-variable-capacitance diodes in ceramic pill-type cases can operate up to 2 GHz. These Varactron diodes feature minimum Q (at 4 v dc) as high as 350, and reverse breakdown rating of 60 v. Price is $8 to $12 in quantity. Teledyne Crystalonics, 147 Sherman St., Cambridge, Mass. 02140 [437]

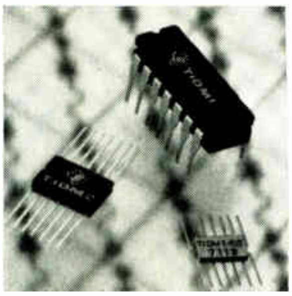


Bipolar ROM is a 4,096-bit integrated circuit with access time of 55 ns and dissipation of 125 microwatts per bit. Bipolar performance is combined with MOS densities and power levels. High speed is attained by clamping transistors with Schottky barrier diodes. Signetics Memory Systems, 740 Kifer Rd., Sunnyvale, Calif. [438]



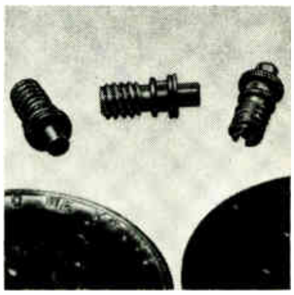
High-speed, precision current switches for digital-to-analog conversion feature 12-bit accuracy, 100-ns switching speed, and a wide power range. Units consist of four switches and a reference device on a single chip. Price is $36 to $7.20 in quantity. Intersil, 10900 N. Tantau Ave., Cupertino, Calif. [439]

Active crosspoint for TV crossbar distributors is monolithic switching unit with small dimensions and low power requirement. Circuit of the P1 consists of two emitter followers, between which signal path is either through-connected or blocked by diodes. Siemens Corp., 186 Wood Ave. So., Iselin, N.J. 08830 [440]



Programable monolithic logic diode matrices are fabricated by epitaxial techniques. Units in TIDM1 group have reverse recovery time of 10 ns when static forward current is 10 ma; in TIDM2, 25 ns. Prices range from $5.25 to $6.60. Texas Instruments Inc., P.O. Box 5012, Dallas, Texas 75222 [441]

Transistor chain can take 250 mw and amplify to 140 w. Power level is achieved with five transistors of single-chip construction, each having a 5.5- to 10-dB power gain figure. Main device is a 70-w, 12-v VHF transistor called the B70-12. Communications Transistor Co., 301 Industrial Way, San Carlos, Calif. [442]



Gunn diodes operate over X band from 8.2 to 12.4 GHz. Minimum outputs of 10 and 25 mw are available in standard units priced at $33 and $49, respectively. Output of 100 mw also is available in this series. Fairchild Microwave & Optoelectronics Div., 2513 Charleston Rd., Mountain View, Calif. [443]

and obviate the need for choppers, input buffers, and complex bias networks in high-accuracy work.

Small capacitors, for instance, will store charges indefinitely in sample-and-hold, integrator, and delay circuits. Transducer amplifiers and similar circuits can use input and feedback resistances of thousands of megohms, adds Dobkin; the ICs themselves have input resistances of gigohms.

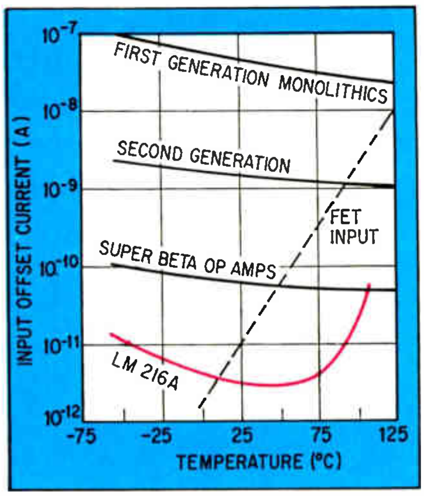
Combinations of large resistors and small capacitors may be used to reduce bulk and cost, and to stretch the RC time constants of circuits such as very-low frequency active filters and oscillators.

The high-performance LM216 (—25°C to 85°C) and LM316 (0°C to 55°C) have input offset currents of 15 to 30 pA. Maximums for the LM216 and LM316 are 50 to 100 pA.

A 100-kilohm potentiometer will balance offset. Standard compensation is a 30-pF MOS capacitor built into the IC and protected from supply spikes by an internal zener diode. The amplifier also may be externally overcompensated—for example, to drive high-capacity loads. Supply range is ±3 volts to ±20 V; and supply current is only 300 μA at ±20 V.

Prices range from $9.95 to $40 for units in the TO-5 package. Flat-packs and dual in-line packages are also available.

National Semiconductor Inc., 2900 Semiconductor Drive, Santa Clara, Calif. 95051 **[444]**



Packaging and production

Pin prevents pc card damage

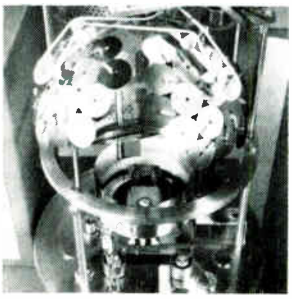
Rolled-barrel spring contact for through-holes permits repeated use of boards

Fitting square pins into round holes has been a common practice in electronic assembly work, particularly in staking contact posts into printed circuit boards. But now Winchester Electronics is coming to the aid of packagers with a contact pin that doesn't damage the sidewalls of a plated-through hole when pushed into or removed from it.

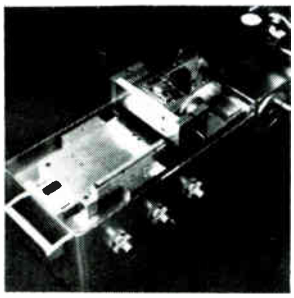
The interconnection, called Wedglok, is a small, rolled-barrel spring that when inserted expands evenly to put pressure radially on the sides of the hole. Staking equipment is also available. Unlike other pins, the Wedglok requires no soldering and is designed to leave both hole and plating undamaged. As a result, pc boards can be reused and circuits replaced in the field.

The company says that a retention force of 40 pounds is achieved and that the contact covers more than 90% of the inside surface of the hole, making a metal-to-metal, gas-tight seal that preserves the shape and condition of the hole.

Gas tightness was tested by subjecting the Wedglok-hole interface to a sulfur dioxide atmosphere for 24 hours, with no apparent contamination of the connection area resulting. Hole deterioration was checked by inserting new contacts in the same hole several times, with negligible change in the diameter of the hole after 10 cycles. Stresses on the hole area were monitored through high-low tempera-



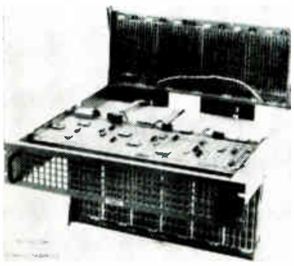
Vacuum coating system has a satellite unit that doubles production rate while requiring only a 60% addition of equipment. Master system includes satellite controls, and it has a high-speed six-inch diffusion pump and automatic deposition control. Norton Co., 160 Charlemont St., Newton, Mass. [421]



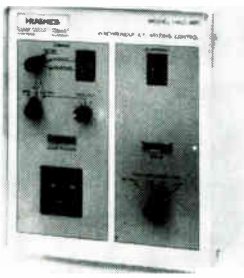
Lead-integrity and bond-strength tester, model 601, checks tension, bending, fatigue and torque of package leads and wire interconnections for ceramic microcircuit packages. Tester fulfills Mil-Std 883 requirements. Kurt Manufacturing Inc., 226 Via del Monte, Oceanside, Calif. 92054 [422]

MOS/LSI tester model 1036 handles arrays up to 79 pins. System is built around the PDP-8 computers with 4K to 32K of core available. Automatic prober interface is available for major wafer probers, also automatic device handlers. Basic price is $63,400. LSI Testing Inc., 2280 S. Main St., Salt Lake City, Utah [423]

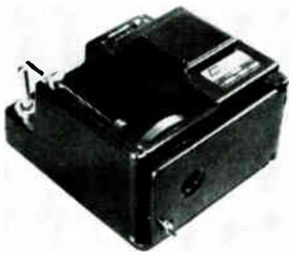
IC analyzer model IC590 is a portable, battery-operated static and dynamic tester of 14- and 16-pin dual in-line modules of DTL and TTL families. Flat pack and TO-5 modules can be handled with the same machine by using adapters. Price is $169.95. Kurz-Kasch Inc., 1421 S. Broadway, Dayton, Ohio 45401 [424]



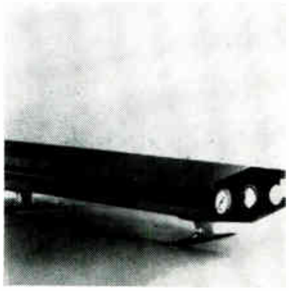
Drawer assembly contains 8316-P series high-density packaging panels for DIP integrated circuits. It is designed for 19-inch rack mounting. Price is $32 to $51 depending on quantity, and $14.50 to $23 for panel frame containing IC socket patterns. Augat Inc., 33 Perry Ave., Attleboro, Mass. 02703 [425]



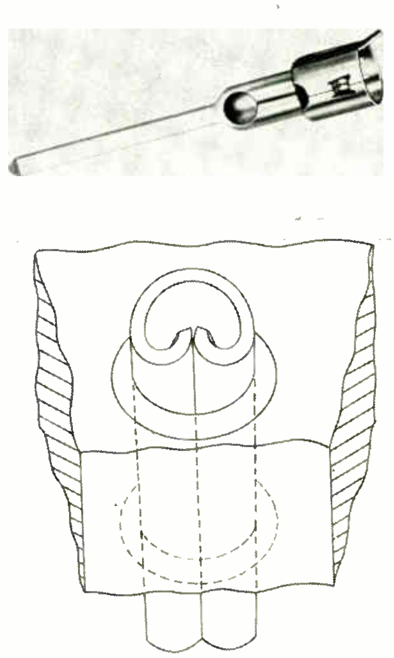
Welding control model HAC-460 is designed for precision work in resistance welding, brazing and reflow soldering. Solid state control is available with 7.5, 15, or 30 kVA external pulse transformer. Price is $1,075. Hughes Welders, 2020 Oceanside Blvd., Oceanside, Calif. 92054 [426]



Rotary wire stripper model 72 is a twin-swing blade machine that strips wires up to 0.750 in. diameter. It is suitable for thick or thin walled insulations, solid or stranded wires, multiple constructions, and coax cable. Unit measures 5x8x9 in. Carpenter Mfg. Co., Fairgrounds Dr., Manlius, N.Y. 13104 [427]



Air-operated shock testers for electron devices cover a size range from TO-18 cans to 1½-in.-diameter units. Included are complete instrumentation and a nomograph relating parameters. Price is $525 to $1,500; delivery time, 2 to 4 weeks. Mechanization Associates, 140 S. Whisman Rd., Mountain View, Calif. [428]



Tight fit. Wedglok, bottom, expands against hole sides. DIP socket and wirewrapping tail can be added, top.

ture cycling of an assembly, which showed only slight change in push-out forces. Elevated temperature and humidity tests also produced negligible change in the interface, Winchester engineers report.

For different applications, the connection comes in two versions. Constructing a cantilever beam on one end of the Wedglok section and using it in conjunction with a molding results in a mother-daughter back panel. Alternatively, a spring socket section can be fabricated into the Wedglok section for use with packages such as 14-pin DIP modules.

A major application, the company says, will be as dual in-line sockets with wire-wrapping tails. This fabrication method is growing in usage as designers seek flexibility in changing interconnections. Winchester will supply boards, with Wedgloks inserted, and with printed wiring.

The price, including board, will be 5 to 8 cents a pin, depending on quantity and circuit complexity.

Winchester Electronics Division of Litton Industries, Main St. and Hillside Ave., Oakville, Conn. **[429]**

Epitaxial silicon wafers use new gaseous source

Each of the sources of silicon for epitaxial deposition has had its own problems—silane (SiH_4) is slow in deposition rate; silicon tetrachloride ($SiCl_4$), the most widely used material, is a liquid and requires high temperatures in the chamber; and trichlorsilane ($SiHCl_3$), is more temperature sensitive than the others. Now, following Union Carbide's introduction of a new source, dichlorsilane (SiH_2Cl_2), Applied Materials Technology Inc. is offering epitaxial wafers made with the material. Wafers up to 3 inches in diameter are available, and AMT will also deposit films on the customer's silicon substrates.

Working under an agreement with Union Carbide, AMT has been studying the process for the new source and, according to Walter Benzing, AMT vice president and technical director, has found that dischlorsilane has many advantages over the previously used materials. Benzing says that his studies show that dichlorsilane has a high deposition rate (2 or more microns per minute) and, with a low temperature coefficient of deposition, is much easier to control than the other materials. He also notes that at a temperature of 1,050°C, dichlorsilane gives a crystal quality that's equivalent to that obtained with silicon tetrachloride or trichlorsilane working at deposition temperatures of 1,150°C. The growth rate for the new material is about 30% higher than for silicon tetrachloride and, as a gas, the dichlorsilane is easier to handle.

The lower deposition temperature also results in less auto-doping (impurities from the substrate being carried by the gas to the expitaxial film) and sharper junctions, he adds. And, since the deposition rates are stable with changes in temperature, Benzing says that thickness variations are reduced.

Applied Materials Technology, Inc., 2999 San Ysidro Way, Santa Clara, Calif. 95051 **[430]**

Instruments

Magnetic field spots faulty IC

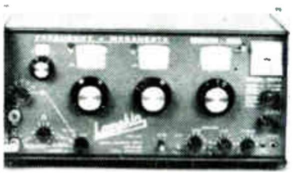
Transmitter/receiver/meter for testing logic circuits saves circuit-board rework

Sensing current flow through a wire by detecting the magnetic field it generates isn't a new concept. But a relatively new Los Angeles company, Concept Electronics Corp., has put the principle to work in what the developers maintain is a unique product—an integrated-circuit fault locator.

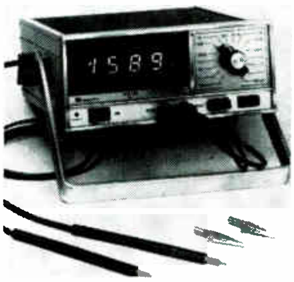
Robert Oberdiear, Concept's director of operations, says the trick in applying the principle to locating faulty packaged ICs and discrete semiconductors that are already plugged into a circuit board is to develop a receiver sensitive enough to detect the low-level signals encountered—as low as 50 microamperes in MOS devices. Concept has done that in a transmitter/receiver/meter combination, called the model CL-1, which should save IC users considerable rework on circuit boards, Oberdiear says.

He explains that more than 90% of IC failures can be traced to a condition in which the outputs remain in a high or low clamped condition. He uses a wired-OR circuit to illustrate the problem. If 10 packaged ICs make up the circuit and the output fails to go high, an oscilloscope will tell how low it is, or if there's a complete open or a direct short to ground. "The technician then has to start snipping leads on the ICs until the line goes high, and he may destroy nine devices before he finds the bad one," Oberdiear continues. "We're not primarily interested in saving those chip costs, but we are

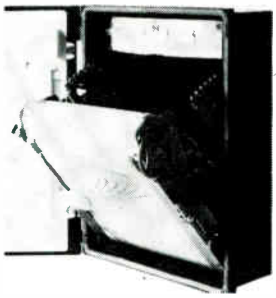
Ac panel meter type 2330 features an average-responding ac converter and a three-pole active filter, providing fast response. It offers digital display of ac voltages or currents from 40 Hz to 100 kHz. Input resistance is 22 megohms, with 30 pF input capacitance. Price is $199. Digilin Inc., 1007 Air Way, Glendale, Calif. [361]



Digital frequency meter/synthesizer/signal generator is primarily for mobile radio maintenance, also for labs and production work. Solid state unit measures carrier frequencies, provides modulated signals. It operates from 12 v dc or 115 v ac. Price is $2,150. Lampkin Laboratories, 8400 Ninth Ave., Bradenton, Fla. [362]



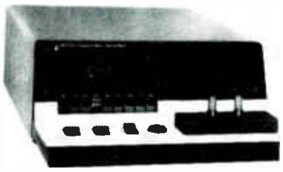
Digital volt-ohm-milliammeter model 8035 can be used as a portable test instrument or be rack-mounted. A chopper-stabilized amplifier provides input resistance of 10 megohms on all ac and dc ranges, and unit has drift-free stability circuitry, also a tube display. Price is $385. Triplett Corp., Bluffton, Ohio 45817 [363]



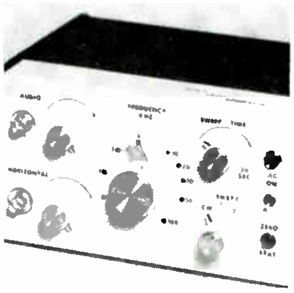
Galvanometer model A144 records humidity, pressure, flow, temperature and other transducer outputs. It plots up to six curves, each in a different color, without inks, on a four-in.-wide strip chart. It can provide sensitivities of 2 mv full scale. Kimberly James Inc., Box D, Smedley Lane, Newtown Sq., Pa. [364]

Function generator model FG-2 is a general purpose test instrument for industrial, research, and educational labs. It has frequency range of 0.005 Hz to 1 MHz in decade steps, a voltage control range in excess of 1000:1, and a ramp output. Price is $390. EL Instruments Inc., 61 1st St., Derby, Conn. 06418 [365]

Wideband wattmeter model WX-1A is designed to determine real power with arbitrary waveshapes. Voltage and current inputs are isolated. Voltage input ranges are 1 v and a choice of 100 or 200 v. Current ranges are 1 v and a choice of 100 v or 200 v. Halmar Electronics Inc., 1544 W. Mound St., Columbus, Ohio 43223 [366]



Digital impedance meter model 1684 combines low cost with automatic operation in a universal bridge. Unit makes up to four measurements per second with 1% accuracy and displays four digits of R,L,C and dissipation factor. Prices start at $1,050. General Radio, Baker Ave., Concord, Mass. [367]



Audio sweep/signal generator model ASG-1 displays response characteristics of active or passive circuits on standard scope. Swept and cw operating modes are provided and sweep width is variable from a few Hz to 100 kHz. Price is $195. Rameco Corp., P.O. Box 580, Deerfield Beach, Fla. 33441 [368] interested in saving board rework expenses. It costs $9 or $10 in labor to replace one chip."

Concept's solution has been to take advantage of the magnetic field generated by a faulty IC that's drawing current. The CL-1 consists of a transmitter, signal injector probe, signal pickup probe, receiver and field-strength meter. In operation, the common junction of the faulty circuit configuration is located on the circuit board, and normal power is applied to the board. The transmitter signal injector probe is connected to the clamped junction. The pickup probe is connected to the receiver, and the receiver gain control is set to the proper level for the logic type.

The receiver signal probe is brought near the tops of the IC packages and rotated slightly. If the field strength meter on the receiver panel deflects the full scale, the faulty device has been found because satisfactory devices don't present a low impedance to the clamped junction and will not trigger a meter deflection.

The receiver pickup probe is detecting the radiation induced in the faulty device—through any kind of package medium—by the radio-frequency signal injected by the transmitter. The 1-volt, very-low frequency (1.5-kilohertz) signal won't damage good devices in the circuit. The CL-1 will also locate leaky devices causing partial clamps or "hogging" of the common line. For this condition a higher signal is provided to override the hogged level and make current flow.

The unit can reject unwanted signals (common mode rejection is 36 decibels) and still sense the minute flux fields generated by current flow through a carrier. The receiver, which is shielded, uses differential amplifiers and op amps in a proprietary, cascaded arrangement that allows detection and amplification of the low-level signals.

The CL-1's price is approximately $700, depending on options. One option provides electronics for fault location on MOS devices.

Concept Electronics Corp., 8402 Osage Ave., Los Angeles, Calif. 90045 [370]

Pulse code modulation used in precision voltage source

Voltage calibration equipment is either very expensive or not very accurate. But by applying a communications technique—pulse code modulation—in a power supply design, engineers at Alpha Scientific have developed a precision voltage source with an accuracy of 0.003% at a price under $2,000.

Called the Alpha M106, the precision voltage source can supply from zero to 1,000 volts dc in four ranges, each with full six-digit resolution and readout. Twenty-four-hour stability is 0.001%, line and load regulation is 0.0002% of full scale. Maximum output current is 50 milliamps from 0 to 100 V and 5 mA from 100 to 1,000 V.

According to Thomas Morgan, engineering manager at Alpha, the problem with most other voltage references is errors due to switch contact variations. "We find that dust, oil, and contact wear causes changes in resistance and therefore inaccuracies. But in the M106, the only switches that are used are for selecting the desired voltage range; the actual voltage is selected digitally with integrated circuits in a pulse-width modulation scheme."

When the desired voltage is selected by means of front panel push buttons or a rear panel BCD connector, a timing sequence is set up. This divides a reference voltage and produces a signal that is some fraction of the total signal. The output voltage depends on what portion of the timing period is occupied by the word length input. For example, if the timing period is one millisecond and the input "word length" is 500 microseconds, then the output voltage is one-half: on the 10-to-100 V range, this would produce a 50-V output signal. If the word length is increased to 750-μs, then the output voltage will be 75 V.

Price for the Alpha M106 is $1,750, and delivery takes six weeks.

Alpha Scientific, Box 2044, Oakland, Calif. 94606 [369]

Data handling

Recorder vies with cassettes

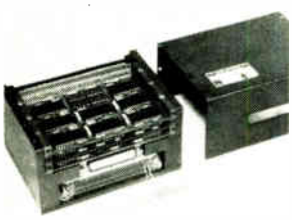
Instrumentation tape unit features speed, density, ruggedness for digital jobs

In some data processing applications, millisecond access times are not critical, so it's not necessary to use disk recording. In these cases, say engineers at Borg-Warner Corp.'s Control division, instrumentation-type recorders have significant advantages in speed and durability over cassette units. That's why they developed the Acculog model 525.

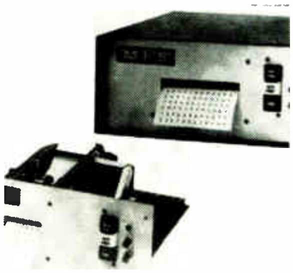
John Coolidge, vice president for tape recorders at the division, sees initial markets in credit card verification systems, small hotel reservation networks, and in customer billing for cable television services. Coolidge says that millisecond access times aren't vital in these applications, and the 525's access time of about 5 seconds maximum to retrieve any data from the tape will make it useful because it's faster than tape transports, although not as speedy as disks.

Other advantages cited are use of 1.5-mil-thick computer-grade tape for longer life than the 0.5-mil-thick cassette tape; speeds up to 400 inches per second vs 120 in./s for casettes; and the ability to start and reach 120 in./s in 20 milliseconds (and stop in 20 ms), vs seconds for cassettes.

Cassette tape is also narrower, and hence provides fewer tracks, than the ¼-in.-wide tape Borg-Warner is using. Further, Coolidge says the tape guides in a cassette aren't the same quality as the unit in the model 525, additionally reducing the number of tracks be-



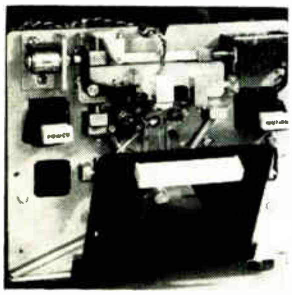
Severe - environment memory called Sems 8 is a nonvolatile ferrite core system organized in a 3-wire, -3D configuration with capacities of 4096 words of up to 32 bits and 8192 words of up to 16 bits. Access time is 450 ns and cycle time is 1.2 μs. Electronic Memories, 12621 Chadron Ave., Hawthorne, Calif. [401]



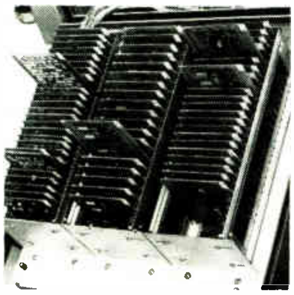
Digital drum printer converts BCD input into print on paper tape, punched cards, tickets and pressure-sensitive labels. Up to four copies can be printed at a rate of 2.5 lines per second. Price of printing mechanism starts at $72. Mechanics for Electronics Inc., 340 Fordham Rd., Wilmington, Mass. [402]

Data transmission system 7260 DTS offers receive time recovery and up to eight full-duplex FSK channels operating at rates up to 1200 bits/s. It can provide multiple input/output transmission. System price starts at $600 per full-duplex channel. Tele-Dynamics, 525 Virginia Dr., Ft. Washington, Pa. [403]

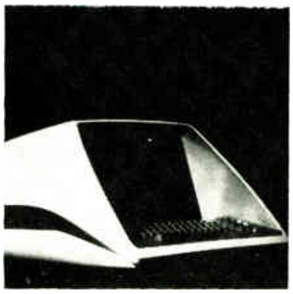
Disk memory system with a head-per-track configuration provides an average access time of 8.7 ms and eliminates electromechanical retraction devices. Model M-2000D offers storage capacity from 400,000 to 6,400,000 bits. Prices start at $4,055. Applied Magnetics Corp., 75 Robin Hill Rd., Goleta, Calif. 93017 [404]



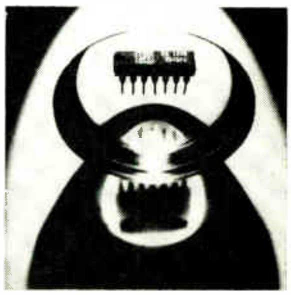
Digital cassette transport model TT 120 for OEM applications features synchronous and asynchronous operation within the same unit. Direct access allows any block of data to be located at 120 in./s. Price is less than $500 in OEM quantities. Sykes Datatronics Inc., 375 Orchard St., Rochester, N. Y. [405]



Industrial logic line, series CP, uses high-density, plug-in, 5 x 7 in. cards. Fundamental logic, timers, sequences and memory plug-in cards are available, all using 12-v DTL circuits on glass boards with gold-plated connectors. Training handbook is available. Jordan Controls, W. Douglas Ave., Milwaukee, Wis. [406]



Display terminal can be substituted for a teletypewriter as an input/output device to any computer using ASCII code. The terminal displays 72 characters per line with a capacity of 20 lines on its 12-in. screen. Price starts at $1,995 in quantities of 100. Digital Equipment Corp., Maynard, Mass. [407]



MOS shift registers in silicone molded packages include a quad 32-bit, a variable length, a 256-bit and a 512-bit unit, all dynamic; and a dual 100-bit static register. All conform to Mil Std 883 requirements. Prices range from $4.40 to $6.35 in 100 lots. Electronic Arrays, 501 Ellis St., Mountain View, Calif. [408]

Introducing

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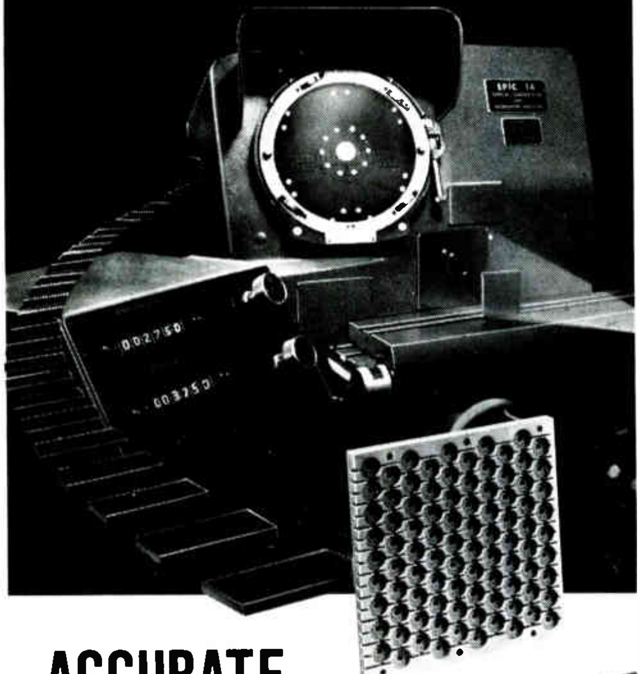

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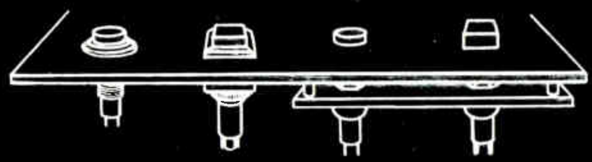

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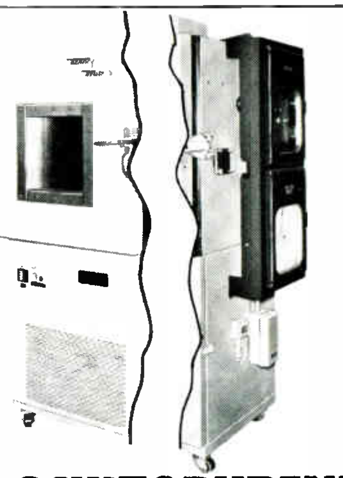

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607

Circle 111 on reader service card

New products

cause of the need to compensate for skew in the guides.

The design is especially well suited for high-density digital recording. With standard ½-in.-wide computer peripheral tape, a very good transport is required to get the equivalent of 14,000 bits per inch on nine tracks, each with 1,600 bits/in. Without the high-quality transport, valuable data may be lost. With the model 525, however, Borg-Warner can achieve the same density with only one dropout in 10^7 bits.

The model 525 will sell for an estimated $1,200 and $1,300 each in quantities of 1,000.

Borg-Warner Corp., Controls division, 3300 S. Halladay St., Santa Ana, Calif. 92702 **[409]**

MOS dynamic shift registers have clock rate of 5 MHz

Designed for low-cost buffer memories and sequential access memories, two dual 100-bit dynamic shift registers developed by Signetics operate at a clock rate of 5 megahertz.

The relatively high rate, Signetics says, is due to the use of low-threshold silicon gate MOS technology, which permitted power dissipation and clock input capacitance to be held to low levels. Power dissipation at 1 MHz is 400 microwatts per bit, and clock capacitance is less than 40 picofarads.

The clock and signal inputs of the registers, designated the 2506 and 2507, can be driven directly by standard TTL and DTL logic or by MOS circuits. The 2506 outputs contain 7.5 kilohm pull-down resistors for interfacing with other MOS circuitry. Output impedance is typically 300 ohms.

Both units are available in an eight-pin TO-5 package and an eight-lead silicone dual in-line package. Prices are the same for both types: $3.70 each for 100-999 lots.

Signetics Corp., subsidiary of Corning Glass Works, 811 E. Arques Ave., Sunnyvale, Calif. 94086 **[410]**

New literature

Calculators. Wang Laboratories Inc., 836 North St., Tewksbury, Mass. 01876. Model 500 calculators, with scientific notation of floating decimal display and a learn mode for programing directly from the keyboard, are described in a four-page brochure.
Circle **446** on reader service card

Graphic input device. Science Accessories Corp., 65 Station St., Southport, Conn. 06490. A four-page brochure presents a graphic data input device that uses sound to determine the position of a hand-held pen for the purpose of digitizing information. **[447]**

Plug-in reed relays. Computer Components Inc., 88-06 Van Wyck Expressway, Jamaica, N.Y. 11418. A four-page brochure covers a line of low-profile, plug-in reed relays with replaceable switches. **[448]**

Semiconductor dice and wafers. Intersil Inc., 10900 N. Tantau Ave., Cupertino, Calif. 95014, has published a 16-page brochure describing quality control procedures, assembly and packaging techniques, and the company's complete line of discrete dice and wafers. **[449]**

Voltage regulator. Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94040. Characteristics of the 723 voltage regulator for both military and commercial temperature ranges are described in a seven-page data sheet. **[450]**

Stepping switches. Oak Mfg. Co., Crystal Lake, Ill. 60014. Stepping switches for military and other applications requiring performance under severe environmental conditions are described in technical bulletin SP-365. **[451]**

X-Y recorders. Bolt Beranek and Newman Inc., 1762 McGaw Ave., Santa Ana, Calif. 92705, offers a bulletin containing information about two new low-cost, 11 x 17 in. X-Y recorders, the Plotamatic 805 and 815. **[452]**

Data transmission system. Lenkurt Electric Co., 1105 County Rd., San Carlos, Calif. 94070, offers a 12-page brochure describing the type 25B data transmission system, which provides speeds from 75 to 600 b/s on a standard voice-grade telephone circuit. **[453]**

Proximity frequency transducer. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343. A catalog sheet covers the series 496 solid state proximity frequency transducer. **[454]**

Timers. General Time Corp., Rte. 8, Torrington, Conn. 06790 offers a catalog providing descriptions and application information on timers and elapsed time indicators. **[455]**

Sorensen's new SRL power supply has a great thing going for it.

Built-in overvoltage protection that can be quickly set and instantly checked even under full load.

SRL is a new low voltage, regulated DC power supply for systems and laboratory applications. We designed it by asking power supply users what they liked and didn't like, the features they wanted or needed. Features like exclusive front panel monitoring and adjustment of overvoltage setpoint without removing the load.

SRL comes in 14 models: 4 voltage ranges to 60 VDC, 4 power levels to 2000 watts. It offers higher power density, low ripple and noise, fast response time over full load range, operation to 71°C, IC reliability.

Check out SRL. Or any of the hundreds of other Sorensen power supplies with output voltages from 3 to 150,000 VDC, output currents from 1.5mA to 1000 A. They are all listed, with prices, in the Sorensen catalog. Write for your free copy to Raytheon Company, Sorensen Power Supplies, 676 Island Pond Road, Manchester, New Hampshire 03103. Tel: 603-668-1600.

	Output Power			
	Voltage	Current (ADC)		
Model	(VDC)	55°C	60°C	71°C
SRL 10-25	0-10	25	22	16.7
50		50	44	33.5
100		100	88	67
SRL 20-12	0-20	12	10.5	8
25		25	22	16.7
50		50	44	33.5
SRL 40- 6	0-40	6	5.3	4
12		12	10.5	8
25		25	22	16.7
50		50	44	33.5
SRL 60- 4	0-60	4	3.5	2.68
8		8	7	5.36
17		17	14.9	11.4
35		35	31	23.4

Sorensen
POWER SUPPLIES

Circle 96 on reader service card

International Newsletter

April 26, 1971

USSR to orbit three new communications satellites . . .

The Soviet Union is expected to launch three Molniya 2 communications satellites into synchronous orbit this year to replace the outmoded Molniya 1 series, according to estimates by the U.S. Department of Defense. The new satellites, operating on the 4- to 6-gigahertz international frequency band also used by Comsat, are expected to increase the USSR's communications channels and provide for multiple access, so that several ground stations in Russia's 25-site antenna net can use one satellite simultaneously. Of the 17 Molniya 1 satellites placed in highly elliptical orbits, the Department of Defense estimates that "about five are considered still active."

. . . while continuing its manned space platform effort

The Russians show no signs of slackening in their push to orbit a working manned space station. Their latest space platform, called Salut, apparently has testing of a new docking system and the transfer of men from one vehicle to another as part of the agenda. In Russia's first such experiment, flown in October 1969, three spacecraft with seven crewmen aboard successfully tested antonomous navigation and control of joint flights.

Mitsubishi to sell 300-ampere triac

Mitsubishi Electric Corp. in July will start marketing what it calls the world's largest triac, a 300-ampere unit. The device is available with blocking voltages as high as 1,200 volts, opening applications for controlling equipment running off 440-V ac lines. And since the triac is rated for use with inductive loads, it can be used to control motors, as well as noninductive-loading heaters and lamps.

A new triac will cost roughly as much as the two back-to-back silicon-controlled rectifiers it will replace in some applications. But since the triac will eliminate a second heat sink that must be insulated from the first, and an additional trigger circuit that would be needed for the second silicon-controlled rectifier, it's felt that substantial cost and size savings might result.

Yellow LED made by British firm

A small British research company, Phosphor Products Co. Ltd., has developed an experimental yellow light-emitting diode display using zinc sulphide. The company employs its own manganese- and copper-doped zinc sulphide phosphor powder in a layer about 50 microns thick that's sandwiched between a vacuum-deposited metal cathode on the rear and a transparent conducting glass anode, etched to the character shape, on the front.

There's a big snag—the material requires a 100-volt supply, against only 2 or 3 V for established LED materials. But on the other hand, it requires less than five milliamperes dc per square centimeter to yield 100 foot-lamberts of brightness at 5,800 angstroms, a wavelength that's quite close to the eye's peak sensitivity. Typical operating lifetimes so far are a few hundred hours to half-brightness from 100 foot-lamberts start. The company claims that with its powder technique, ZnS lamps are potentially economically viable vis-a-vis U.S. experiments several years ago that used expensive thin film deposition and achieved lives of only a few hours.

International Newsletter

AEG-Telefunken wins second contract for satellite station

AEG-Telefunken has landed a $2 million contract to put up a ground terminal for "Symphonie," the communications satellite being built jointly by France and Germany. **This makes the second major contract the West German company has received within the last few months for a ground station.** The first—for a 12-gigahertz installation near Frankfurt—was awarded late last year.

The latest project, in which West Germany's Friedrich Krupp GmbH, France's Laboratoire Central de Telecommunications, and Belgium's Bell-Telephone Manufacturing Co. are participating as subcontractors, is a transmitter and receiver terminal operating at the 4- and 6-GHz ranges. The terminal, to be put up at Raisting, Bavaria, **also will be provided with superhigh-frequency telemetry and telecommand equipment for satellite monitoring and control, as well as a 50-foot-diameter Cassegrain antenna dish.** One special feature of the new terminal will be its transportability—it can be dismantled and reinstalled without any welding.

U.S., Canada plan joint communications satellite effort

Extending low-cost communications services to sparsely populated areas will be the aim of a joint Canadian-U.S. experimental satellite system to be launched by NASA in 1974. Called Cooperative Applications Satellite C, **it will be built under a joint agreement whereby Canada will design and manufacture the spacecraft and the U.S. will develop key components and launch services.** Important requirements include an unfurlable solar array capable of a 1-kilowatt output, low-cost 12- and 13-gigahertz ground terminals, and a traveling wave tube amplifier that operates at more than 50% efficiency with an output of 200 watts.

GI in Britain signs MOS second-source pact with Ferranti

The latest second-source pairing in the European integrated circuit industry is General Instrument Microelectronics Ltd., a subsidiary of GI in the U.S., and the Semiconductor division of Ferranti Ltd. **The companies have "aligned" their very similar low-threshold nitride MOS processes so that about 20 established devices—and perhaps more—can be dual-sourced.** Both companies seek a marketing lever throughout the European Free Trade Area; one spur is the British government's increased insistence that devices used in publicly owned equipment be dual-sourced. In addition, GI's experience on standard MOS products should help Ferranti's transition from custom design if and when the market for standard RAMs, ROMs, and long shift registers booms. For its part, GI believes Ferranti's plastic encapsulation process and large assembly capacity may be useful.

Calculator price hits new low

The latest price cut in the hot electronic desk calculator battle was announced by Omron Tateishi Electronic Co., which will start selling an eight-digit unit for $138 in Japan next month. The previous low was Sharp Corp.'s $236 ELSI-8 [*Electronics*, Feb. 1, p. 6E]. **The new machine will be sold in the U.S. by Commodore for $199.95.**

The new calculator, designed for line operation only, is larger than Sharp's unit but performs the same basic functions. **It's built around three MOS/LSI chips that Omron Tateishi claims were designed by its California subsidiary, Omron R&D, and fabricated by an undisclosed U.S. IC manufacturer.**

Diffusion method flashes green light for green LEDs

While quantum efficiency is still low, Ferranti devices turn out 500 foot-lamberts from 5 milliamps at 2 volts

Through work in red light-emitting diodes far outshines development efforts in green units, the latter can be highly useful in certain applications. For example, in airplane cockpits, red indicators are used to signify dangerous situations, so their deployment for displays and other normal functions must be carefully restricted. The big problem in fabricating green gallium phosphide LEDs has been doping—zinc must be used to form the p region in the n-type GaP. Zinc is very difficult to control by planar diffusion, and since the big market for solid state lamps is for arrays, planar processing is likely to be the most economical approach.

Now Ferranti Ltd. has developed a method of diffusing zinc into expitaxial GaP that produces well-defined arrays. The shade is slightly lighter than emerald green but is free from yellow degradation. It's also bright—about 500 foot-lamberts from 5 milliamps at 2 volts—though the quantum efficiency is only around 0.1%. The company's first offerings will be individual diodes and dot-matrix binary arrays intended for marking digital information on film. Seven-segment numerics and 35-diode alphanumerics will follow, probably in about six months. The film markers have priority because that's where Tony Peaker, who's in charge of GaP work at Ferranti, sees the company's biggest market.

Like the human eye, film is much more sensitive to green than to red—in fact, some films are a million times more sensitive to green than red. Hence, with green markers, lamp size, current, and exposure time can all be cut. For example, Peaker says that if red and green lamps of similar marking intensity are used on panchromatic film, a red lamp will require about 100 mA and a 1-millisecond exposure, against 1 mA and 10 microseconds for the green unit. These advantages, he says, can be used to increase information density per unit area and simplify driving circuitry by driving directly from integrated circuitry without intermediate amplifiers.

Peaker says there were two major difficulties in developing his planar diffusion process. First, and most difficult, the normal mask materials let the zinc through, so that proper diode separation was not possible. His team has solved this by making the mask as a three-layer sandwich—silicon dioxide topped by silicon nitride topped by another layer of silicon dioxide. Total thickness is about 6,000 angstroms.

Second, since gallium phosphide is an indirect band-gap material, the gradient of the impurity concentration at the junction is critical for high efficiency. To obtain the proper gradient, the team had to develop a special diffusion technique, consisting basically of zinc vapor diffusion followed by a complex annealing process. The phosphide layer is about 2 mils thick, topped by sulphur doped to a concentration of 10^{16} atoms per cubic centimeter and nitrogen graded with maximum concentration. It is produced by liquid epitaxy on a Czochralski-grown substrate.

Peaker won't comment on yield levels, but says he sees no reason why they should not be at least as good as GaAsP when the process is fully developed. At present a major limitation is that only 1-inch-diameter crystals are available—he says costs could be reduced sharply with larger-diameter substrates.

The planned size of the seven-segment numeric is 0.08-inch high and will use a special IC drive-through similar to present seven-segment numeric drivers. The 35-diode alphanumeric arrays will be made in two standard sizes, 0.06 inch and 0.12 inch, and possibly up to 0.2 in. for special orders. Peaker thinks the 0.2 in. probably will be the economic size limit. He speculates that the price of the 0.12-in. array will be about $15-$20 without drive circuitry. The biggest array actually being considered at the moment is a 0.16-in. display for aircraft cockpits.

Initially, Ferranti probably will build alphanumeric drive units out of four or five bipolar ICs, but eventually may make a special MOS chip. "Gallium phosphide and, hence, green lamp technology," says Peaker, "has a big potential advantage over present red gallium arsenide phosphide technology in that the drive current required is so small it should be possible to drive arrays directly from MOS circuitry. This should do a lot in the long run to bring down the high cost of an alphanumeric driver."

Services Electronics Research Laboratory, a government establishment, is developing a GaP double epitaxy green LED process. SERL uses tellurium for the n-dopant and zinc for the p-dopant, and introduces nitrogen to the junction region by adding 0.1% ammonia to the inert gas that flows through the epitaxial growth apparatus. This process is at present producing diodes of 0.05% typical quantum efficiency and a luminous efficiency around 0.3 lumens per watt. Arrays are made by bonding diodes to a ceramic substrate. SERL men hope this will make larger arrays more economically viable than is likely by planar diffusion.

The Netherlands

Philips IC process puts film in starring role

In recent months, a spate of new techniques have cropped up for putting integrated circuits in their place—a lead frame tucked into a package with connections to the outside world.

With yields on chips generally so high there's little room for improvement, semiconductor makers have been concentrating on packaging as the surest way of cutting costs. Out of the efforts have come, among others, Fairchild's Unibond, Motorola's Spiderbond, and General Electric's Multibond.

Now it's time to add to the list a European entry, the ICs-on-film technique worked out by the Eindhoven research labs of Philips' Gloeilampenfabrieken. So far, the semiconductor producing arms of the giant Dutch company haven't set a date for adopting the technique on their packaging lines.

That most likely won't happen until the European IC market, currently having hard times, starts to look better. But when the film mountings do reach the market they'll be much cheaper than conventional plastic dual in-lines, insists W. G. Gelling, the Philips researcher who spearheaded the development. What's more, the technique makes possible a substantial improvement in heat dissipation. The cost-dissipation combination, of course, makes the technique a natural for power-handling linear ICs in entertainment and industrial gear.

General Electric's Minimod package [*Electronics*, Feb. 1, p. 44] comes to mind when there's a mention of chips on film. Both techniques, in fact, are based on the same film—the polyimide Kapton. But the differences far outnumber the similarities. For one thing, GE's reels of sprocketed IC-carrying film are intended principally for automatic insertion into printed circuit cards. Philips' film-mounted ICs can be bonded directly onto a specially designed small pc card, however the film is much narrower than Minimod's 35 millimeters—and has no sprockets. The main use of the Philips mounting figures to be in conjunction with a special carrier that doubles the dissipation for the circuit, compared to a plastic dual in-line package. A second doubling is possible if an extra heat sink is added.

Another key difference is the way the lead-frame patterns are put on the film. GE laminates a copper sheet onto the Kapton and then etches that. Philips starts with a photographic process to obtain a thin silver pattern, which is plated with copper and then topped by nickel and gold finishes.

Philips produces the film mountings on rolls 12 inches wide and packs in 5,000 frames per running meter of 12-inch strip. After metalization, the individual strips are cut apart and the ICs bonded to them.

The chips are special. They have solder bumps 40 microns high and 100 microns in diameter atop the contact pads. For the soldering, Philips blows hot gas onto the chip for about 1 second after it has been aligned with the contact pattern. So far the chip bonding process is partly automated; 500 chips can be bonded to film strips per hour. Gelling says it would be easy to step that up to between 1,200 and 1,500 per hour.

Once the solder bonds have been made, the chips and film are coated with a special plastic which "cements" the two together. The strip then is ready to pass through an automatic tester, and after that the good circuits can be directly mounted on a pc board or soldered to a special carrier.

France

A bridge between cores and semiconductor memories

Whenever designers of computer memories get together, they almost always split into two contending groups. The semiconductor men insist they're on the verge of condemning magnetic core memories to obsolescence. The core people, on the other hand, insist that their arrays will best semiconductor memories on a cost-performance basis for a long time to come.

Michel Carbonel sides with neither group. Carbonel heads the integrated magnetics laboratory at Thomson-CSF's Corbeville research facility and one of his teams has come up with a magnetic memory fabricated by production techniques used with semiconductor making. Rather than semiconductors, these integrated magnetic memories may turn out to be the successors to core arrays as the mainstay memory type, Carbonel contends.

The Thomson-CSF group already has proved out the technology in the laboratory and is currently working with the Compagnie Internationale pour l'Informatique, France's native computer producer, to develop industrial versions. There's a chance, Carbonel thinks, of getting a 300,000-bit memory stack on the market by 1972. The price will be about 0.09 cents per bit. Four or five people can produce about 2 million bits per day with the technique, says Carbonel.

The integrated magnetic memory first scheduled to hit the market will be made up of 256-word-by-72-

bit planes, with a packing density of 550 bits per square centimeter. Cycle time depends on the drive current: for a stack with 10^5 bits, the cycle time is 200 nanoseconds with 850-milliamps. For a 10^8 stack, typical figures can be 4 microseconds and 50 mA.

Although a density of 550 bits per cm^2 is perfectly respectable, the Corbeville crew sees it as just a beginning. They're already at work on a 256-by-72 plane with the bits packed in 3,300 per cm^2. Their long-range goal is a density of 100,000 bits per cm^2. That would make for a very fast cycle time at very low current—50 nanoseconds at 40 mA.

The high packing densities stem from the integrated circuit fabrication techniques used to produce the planes. Instead of ferrite cores threaded with three wires, the integrated memory is made up of permalloy elements, each with three holes—for the bit, word line, and sense conductors. The permalloy pattern, with provision for the holes, is deposited on the substrate. After the holes are etched, a gold connector pattern is laid down over a resist on both sides of the substrate. The resist, in turn, is removed by etching, and copper is deposited under the gold. The end result is a pattern of 18,000-plus three-hole permalloy elements with conductor patterns looped around each hole.

Soldering with power transistors

The heat generated by power transistors is a nuisance for most electronics designers. But it warms the heart of French inventor Maurice Pilato, who believes semiconductors are among nature's most efficient heat producers.

Pilato has invented a soldering iron heated by a transistor. He has also designed a transistorized baby bottle warmer, and he thinks semiconductors may one day heat houses. The semiconductor is the perfect heater, he says. And it can be easily designed into tools and

Hot item. Waste heat from power transistor runs French soldering iron.

products that need a point source of heat.

A classic soldering iron must be heated to 400° in order to have 200° at its tip, Pilato says. Large amounts of power are wasted just heating the air. Pilato's invention, the Transifer, has instead a tiny, pointed copper tip with a standard Texas Instruments 100-watt silicon transistor mounted inside. The transistor is run at 60 W, but once heated it needs only 4 W to stay hot. A regular iron needs 60 W constantly.

When solder touches the Transifer, a thermistor automatically increases current flow to keep heat constant. This ease of temperature control explains why Pilato sees promise in transistor-heated toasters, household irons and radiators, as well as in the bottle warmer, the design of which he has sold to a French company.

Pilato has also sold the soldering iron design to a new French firm named Micronex, based in Grenoble. The firm plans to license manufacturers elsewhere. Micronex has orders for several thousand 24-volt irons, at $9 each, from a French telephone equipment maker. The company plans to market a mini-iron with a pinpoint tip for the jewelry industry. France's Sescosem is designing a $1 heating transistor to be mounted, chip-only, in this and other small devices, according to Pilato.

The French inventor sees several applications for semiconductor heat in automobiles. Transistors could warm cooling water in cold countries to help engines start, and they could also heat gasoline before it hits the carburetor to give better fuel economy.

Japan

RAM gets a leg up in MOS speed competition

Putting itself right at the leading edge of MOS technology, an IC research group at the Electrical Communication lab of the Nippon Telegraph and Telephone Public Corp. has made a 1-kilobyte prototype random access memory. Fabricated according to the group's design by Nippon Electric Co. Ltd., the MOS memory is superfast—access time is 30 nanoseconds and cycle time is 35 nanoseconds—and the group says even higher-speed memories may be made in the future.

Speedup of the MOS memory began with the design of a basic static flip-flop cell with eight transistors, two of which are used for the sense output. Since sense output from the cell is separated from the digit line to which a large-amplitude pulse is applied, readout is possible immediately after writing, instead of having to wait for a dummy cycle that usually follows a write cycle. Because fairly large transistors are used to obtain high transconductance, the basic cell requires about 30% more area than previous designs.

The basic MOS field effect transistors are n-channel depletion types; the substrate is biased to convert them to the enhancement mode, which gives the higher speed of n-channel operation without the danger of reducing speed, which often occurs when doping the channel to obtain true enhancement operation. Other advantages of the biasing scheme are reduced circuit capacitances; the ability to obtain optimum threshold by changing bias, if device threshold does not coincide with design center; and relative insensitivity to circuit voltages.

Device configuration is 64 basic cells arranged on a single chip measuring 0.15-inch square. Each chip has four pairs of digit lines for writing and 16 word lines for reading and writing. It also has four sense outputs for reading. Anodized aluminum passivation is used to eliminate the need for sealing, while beam lead terminals ease attachment of the many leads to the substrate.

The ceramic substrate measures 1.2 x 1 inches, and has two layers of wiring. It mounts eight chips—together with an X-Y matrix and sense amplifiers—to give a hybrid LSI circuit with a 512-bit capacity. Four bipolar chips form an X-Y selection matrix to convert the eight-by-eight-word inputs into 64 word driving outputs. The matrix is driven by an external driver, included in the decoder, which converts the current mode logic input level to the higher level needed to drive the MOS circuits.

Power drain for the memory is about 7.5 milliwatts per bit, of which about 0.7 mW goes to the MOS memory cell. During standby, drain per bit is about 1.7 mW, of which 0.7 mW goes to the MOS memory cell and about 1 mW to the sense amplifier.

Because the external decoding and driver circuits are off-the-shelf current-mode logic devices that were not optimized for this application, NTT men feel that an improvement in the driver circuits could give a large increase in speed.

West Germany

Surface doping achieved by implanting cesium ions

If semiconductor doping could be restricted to a thin surface layer—rather than added to the bulk of the semiconductor—the range of device applications could be extended. Researchers have tried using sodium ions for surface doping because they produce electron accumulation at silicon surfaces. But because of instabilities caused by the high mobility of sodium such ions end up as a contaminant rather than a dopant.

Using cesium, another alkali metal, researchers at the Institute for Applied Solid State Physics at Freiburg have opened the way to considerable improvement in the performance of existing devices. For example, with MOS transistors the threshold voltages can not only be made higher but can be held stable at that higher level. The technique thus overcomes voltage drift, a common problem with MOS devices. What's more, with the new method threshold voltages can be adjusted to different values at different locations on a silicon surface.

The new doping technique, developed by Gert Sixt and Adolf Goetzberger, who heads the institute, also allows making the inactive, nonmetallized areas of ICs immune to surface inversion. In conventional devices, surface inversion sometimes causes the formation of undesired p-type zones on n-type crystals, which can lead to unwanted short circuits.

A stable positive surface charge is obtained by applying the cesium by ion implantation. The cesium ions remain on that surface even after the subsequent oxidation step. As Goetzberger, a former Bell Labs scientist and associate of transistor inventor William Shockley, points out, the easiest way of surface doping would seem to be to implant the ions in the oxide film covering the silicon layer. But this would lead to radiation damages and deterioration of the film's electrical characteristics. To correct for the radiation damages, the semiconductor material would then have to be annealed at high temperatures, which again might lead to oxide surface contamination. All these difficulties are sidestepped by implanting into a pure silicon surface before silicon dioxide is grown.

Experiments at the institute have attained a high degree of device stability. For example, with MOS components a flat-band voltage of 72 volts is obtainable. This voltage decreases by only 2 V when the device is subjected to a field strength of 1 million V per centimeter applied for 30 minutes at an ambient temperature of 430°C.

Plastic potentiometer offers high precision for $50

A practically infinite resolution and a linearity of better than 0.3% are the prime features of a new low-cost precision potentiometer that a small West German components maker is about to put on the market. Developed by the Stuttgart-based firm Novotechnik KG, the pot uses a conductive-plastic material as its resistive element.

The new device, the first plastic-element potentiometer made by a European firm, is designated Dinopot and is having its debut at the current Hanover Fair. The new pot will be delivered to potential customers starting next month.

To be sure, conductive-plastic precision pots have already been made in the United States. But the U.S. versions, the German firm says, are expensive, ranging anywhere between $40 and $350, depending on quality, with pots having a 0.3% standard linearity at the upper end of the range. Novotechnik, on the other hand, will offers its Dinopots "for around $50." "It's because of such price advantage that we feel we can put up stiff competition in the precision potentiometer market," says Volker Allgoewer, Novotechnik's commercial director.

Other features besides high linearity and resolution are the potentiometer's long operating life, high rotational speed characteristics, and low noise level. This level is only around 50 millivolts and remains virtually constant at that value for the pot's entire operating life. Novotechnik guarantees a lifetime of at least 20 million shaft revolutions for its Dinopot and specifies its rotational speed at 400 revolutions per minute, a value which conforms to U.S. military standards. The pot's power-handling capacity within a −55° to +60°C range is about 2 watts, and the maximum ambient temperature at which very low voltages can still be applied is +120°C.

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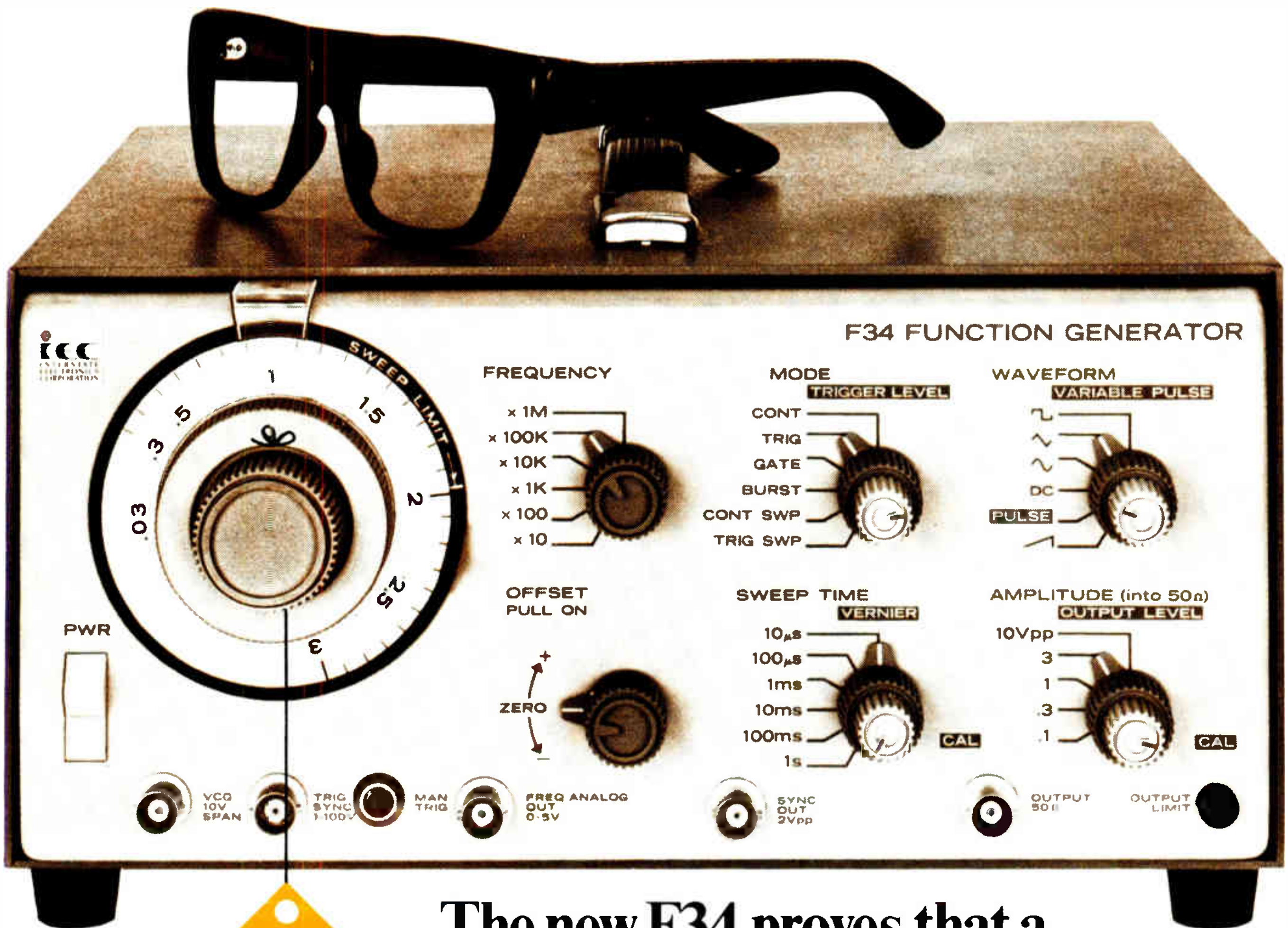

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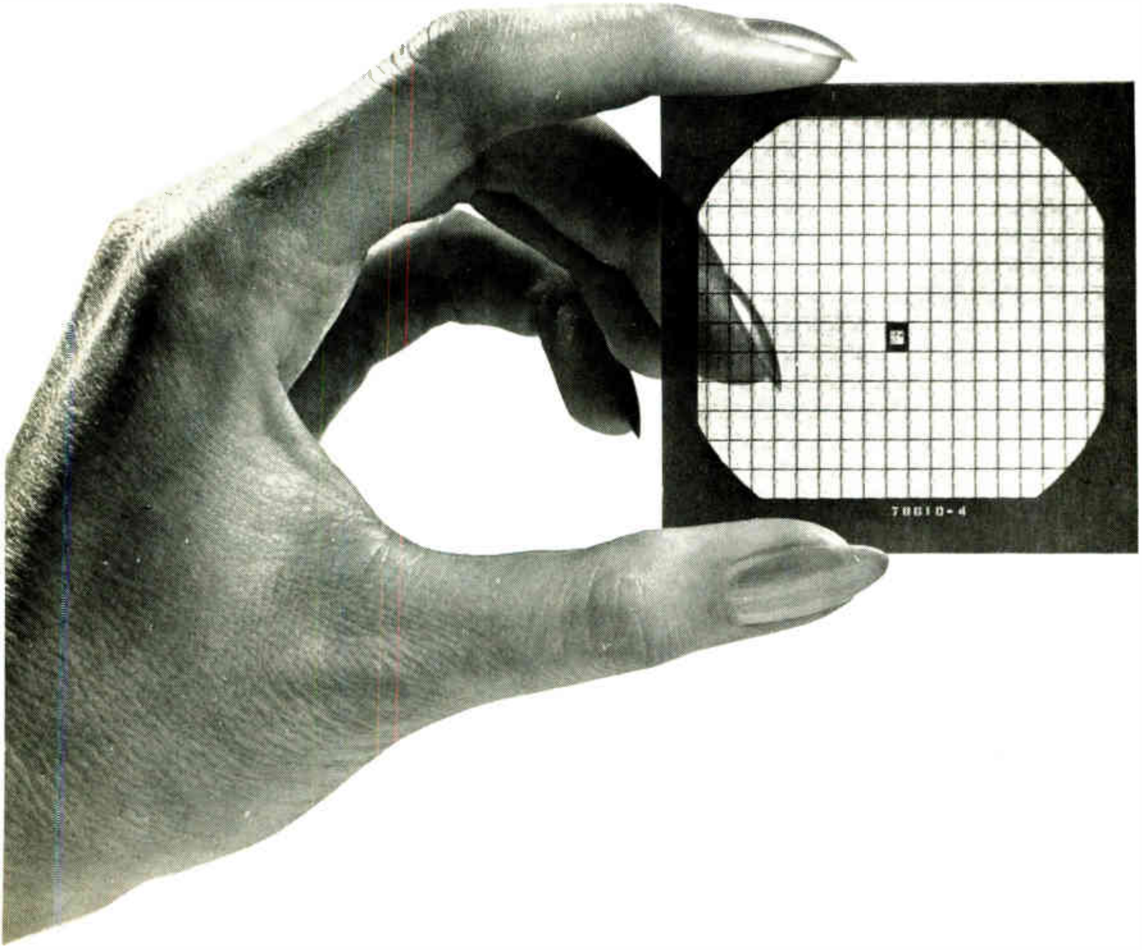

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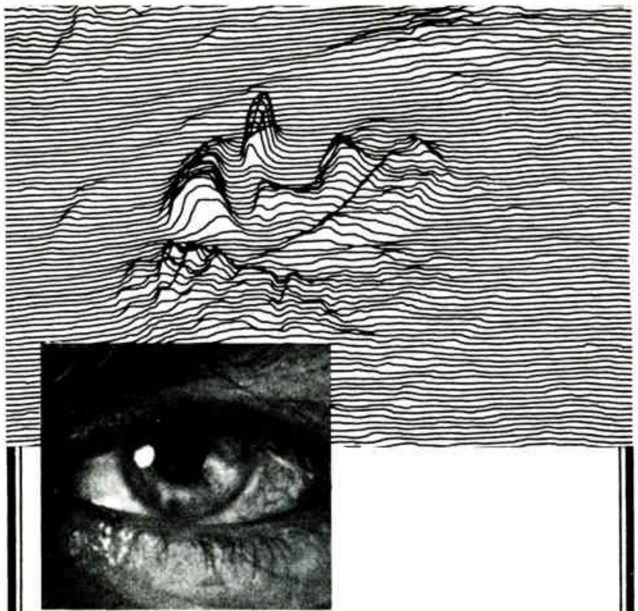

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Twenty years ago, circuit designers began to replace hot, limited-life vacuum tubes with cool, highly reliable, low voltage solid state devices.

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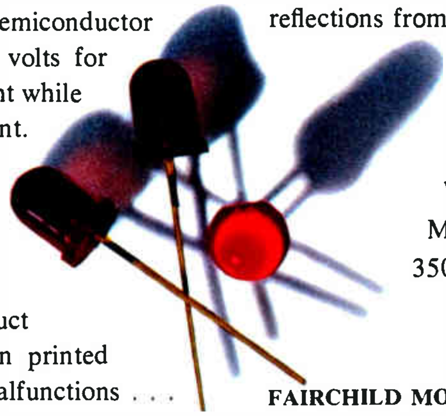

Solid state lamps open up new product design concepts: visible indicators on printed circuit boards to show component malfunctions . . . on cameras and other battery-operated equipment where low power consumption is a must . . . on instruments, control systems, computer peripherals and communications gear . . . wherever a visual status indicator is required.

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And now, Fairchild's prices on production quantities make tomorrow's designs practical today.

Write on your letterhead to Fairchild Microwave and Optoelectronics Division, 3500 Deer Creek Road, Palo Alto, Ca 94303 for a sample of the "new solid state lamp" or call our distributor in your area:

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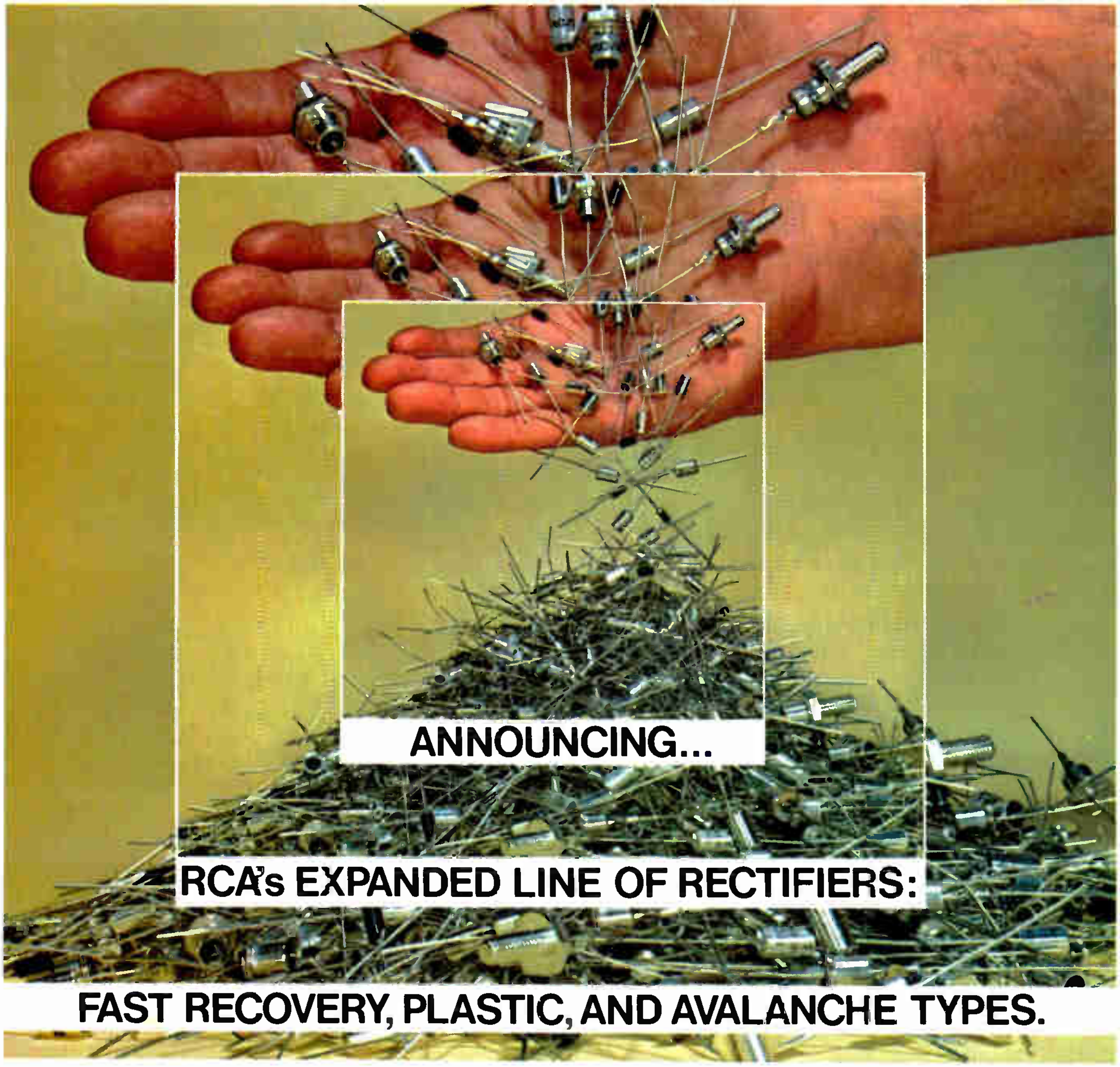

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Rectifier	Max. Repetitive Peak Reverse Voltage (V_{RRM}) (V)	Maximum Forward Current Avg. (I_0) (A)	(RMS) (A)	Peak Surge** Non-Repetitive I_{FSM} (A)	Reverse Recovery Time (t_{rr}) (μs)	Package	Capability
TA7892-TA7895*	200-800	1.0	1.5	35	0.5	DO-26	fast recovery
TA7898-TA7901	200-800	3.0	4.5	75	0.5	modified DO-4	fast recovery
TA7996, TA7802-TA7806*	100-1,000	1.0		35		plastic DO-15	general-purpose
1N5391-1N5399	50-1,000	1.5		50		plastic DO-15	general-purpose
40808	600	.5		35		DO-26	controlled avalanche (700-1100 V)
40809	800	.5		35		DO-26	controlled avalanche (900-1300 V)

*RCA Developmental types

**For one-half cycle of applied voltage (f = 60 Hz)

RCA Solid State

Circle 902 on reader service card