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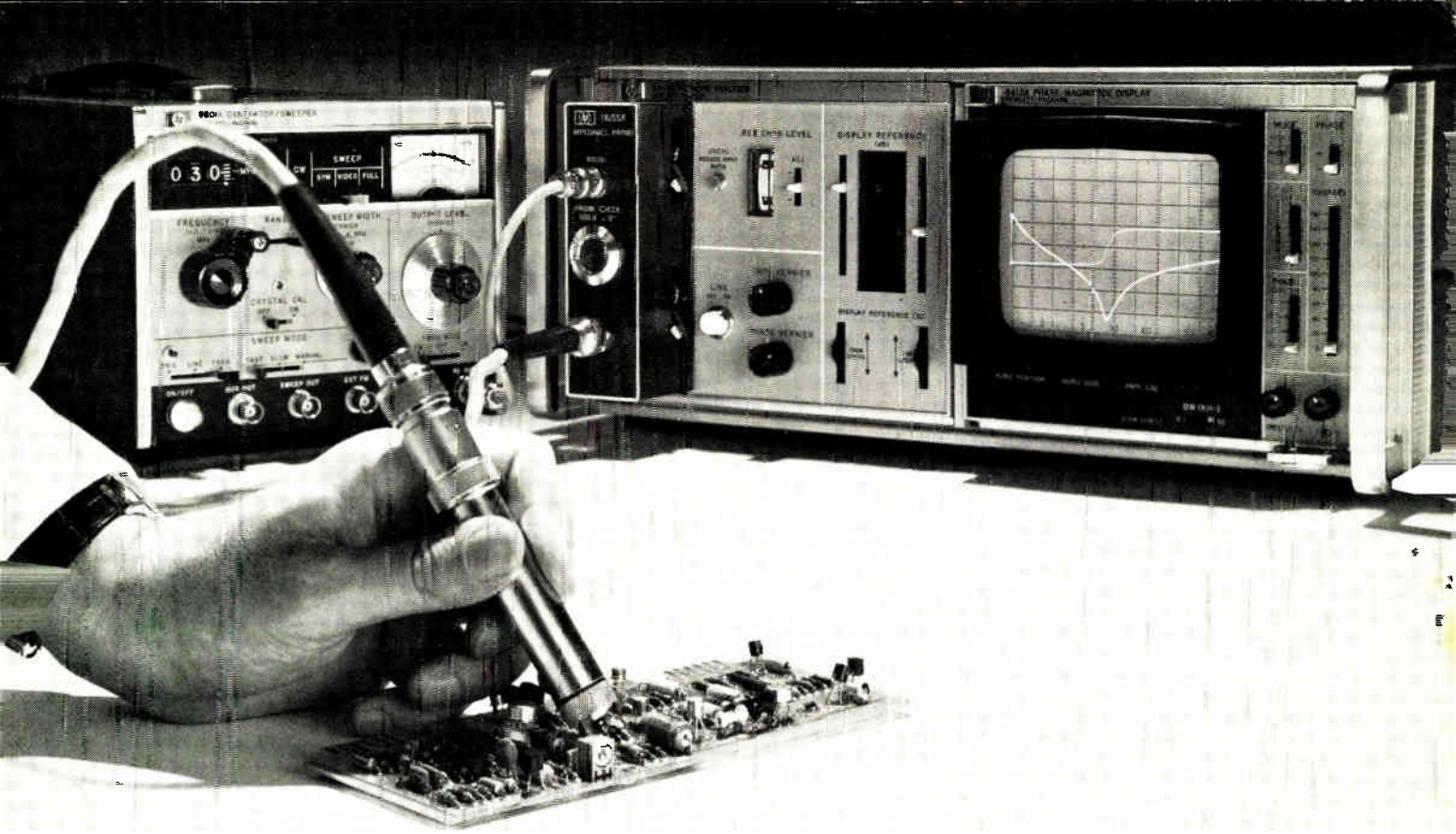

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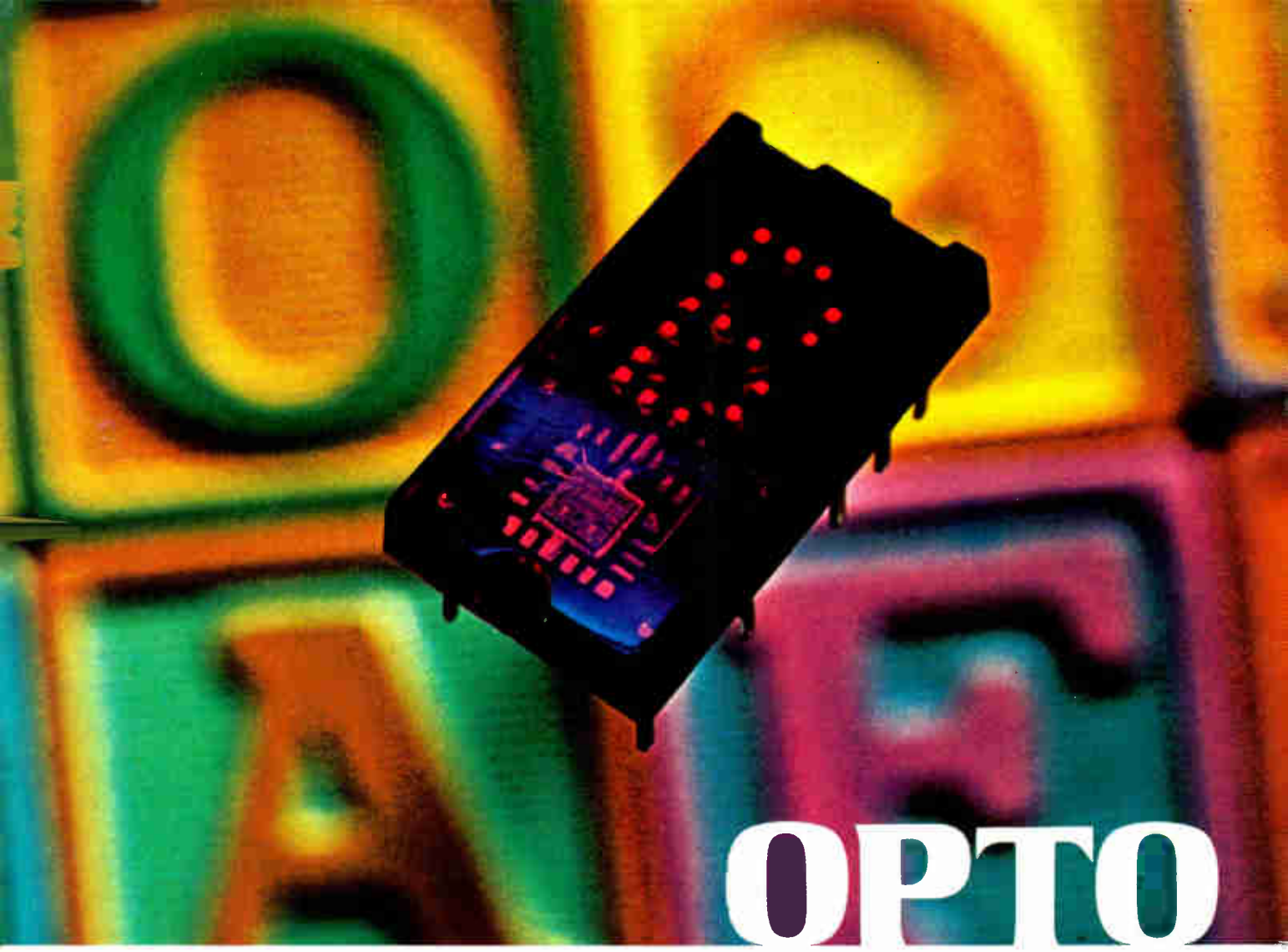

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Newest of the displays-with-logic is the TIL311, a hexadecimal LED display with an internal TTL/MSI logic chip providing latch, decoder and driver. It accepts 8-4-2-1 data and displays 0 through 9 and A through F with both right and left decimal points.

Other TI displays-with-logic include a 7-segment with latch, decoder and driver and a 7-segment with decade counter, latch, decoder and driver. Both have left and right decimal point versions.

For data sheets on the entire TI hybrid display line, plus applications information, circle 245 on the Reader Service Card. Or for Opto Packet 245 write Texas Instruments Incorporated, M/S 308, P. O. Box 5012, Dallas, Texas 75222.

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Electronics

The International Magazine of Electronics Technology

July 17, 1972

 Volume 45, Number 15

Highlights

Government aid for electronics exports sought, 53
Why doesn't the U.S. behave more like Japan and other countries that give tax incentives for commercial electronics exports and/or R&D? That was the major complaint of 30 U.S. electronics companies whose views the Commerce Department canvassed for a report commissioned by the White House.

A new high in bipolar LSI performance, 65
The 1,024-bit V-ATE random-access memory wastes a minimum of space on device isolation—each cell on the chip is surrounded by a narrow air-filled notch. Bit-density is significantly increased at no sacrifice in speed.

What to look out for in digital panel meters, 77
The surge in DPM sales has also multiplied the problems that confront DPM buyers. Here a path is traced for the design engineer through the maze of overlapping specifications, and an analysis is made of interdependent DPM parameters.

Face to face with optical isolation, 103
No longer exotic, untried novelties, the optical couplers now in production may cost as little as $1 each in quantity. TTL-compatible at input and output, they're being most widely used as interface circuits in data communications.

. . . and in the next issue
Special report on peripherals . . . start of a new series of thermal design articles . . . a low-power LSI logic circuit . . . application tips on the integrated Schmitt trigger.

The cover
Set of microphotographs shows the air-filled notches used for isolation on a V-ATE memory chip from Raytheon.

Electronics

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Publisher's letter

It's something of a cliche among newsgatherers that the story you start out to get often turns into something different. But that difference is usually a matter of emphasis, rather than a completely different story.

However, our Washington bureau manager, Ray Connolly, did manage to come up with something totally different when he literally uncovered a Commerce Department confidential survey of electronics manufacturers. The subject: what they believe is needed by way of Federal support to retain a world leadership role (see Probing the News, p. 53).

Connolly turned up a copy of the survey in the office of an industry source with whom he had scheduled an interview on a completely unrelated subject, a military program. But once he spotted the survey, the original story gave way and is now scheduled for a later issue.

The crucial issue of world trade in electronics—and the U.S. role—is a subject the Washington bureau has now probed three times this year. While of critical importance to the health of the electronics industry, it does not yet shape up as a major issue in a Presidential election year, Connolly says.

"But it is getting there. The Commerce working paper contains just about every industry viewpoint imaginable on the subject. That should help the Government come up with a policy, which it does not have. What is probably most surprising about the manufacturers' comments is that so many of them seem to prefer direct aid, in the form of Federal support for export efforts, over international political pressure to open up foreign markets to American electronics goods."

The escalation of commercial aircraft skyjacking for ransom has everyone tense and most people confused about how to stop it (see Probing the News, p. 56). But one uptight group that exhibits no uncertainty about what should be done is the Air Line Pilots Association.

As Jack Bavis, ALPA executive administrator, put it to our aerospace editor, Bill Arnold, "We need nonlethal weapons, such as electronic devices, for crews. We need a whole system including ground security, in-flight security—a protected environment for the crew—and international agreements." Bavis, an Eastern Air Lines pilot, says ALPA also wants a single Federal agency to coordinate a program and says "hell, no, to local control."

"Everybody's passing the buck and the pilots are in the middle," Bavis contends. He says there are both confusion and contradiction within the airlines and the Federal Aviation Administration on the issue. For example, he says, "The FAA tells us that pilots should resist skyjackers more. Then some airline managements put out a notice, which the FAA approves, telling us not to resist."

Bavis says the pilots believe the lawmakers are moving too slowly, and the pilots, themselves, could move more quickly. "We may run a boycott on our own."

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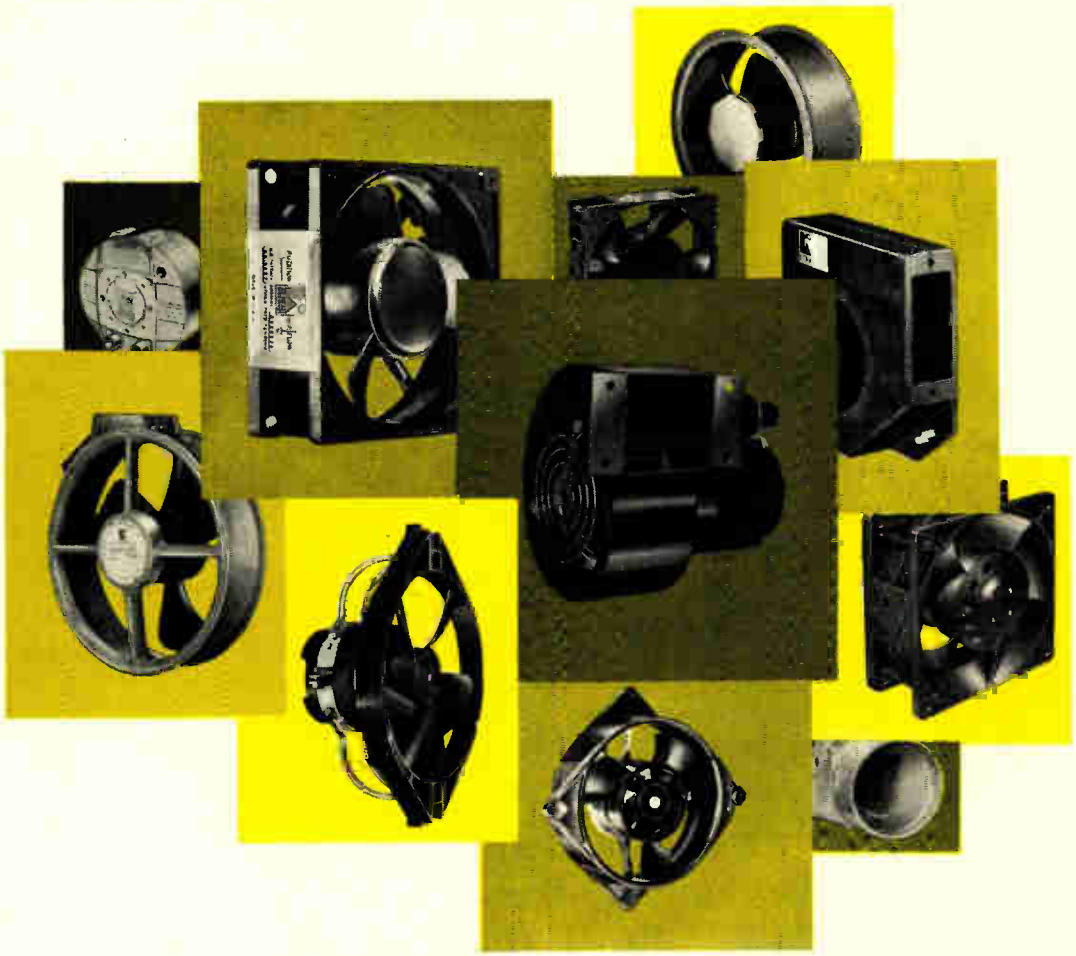

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Readers comment

Testing by hand

To the Editor: In your article, "Low-priced German wire tester uses operator's finger as probe," [*Electronics*, May 22, p. 53], in which the human hand is the contact instead of wires, you state that "the measuring voltage is 24 volts dc—a harmless level for a human being."

Only if the area of skin contact is small will 24 volts dc be harmless. Typical dry human skin resistance is about 100 kilohms per square centimeter, so that two contacts on opposite sides of the body, each only 8 square centimeters in area, will produce a current of 1 milliampere, which is lethal. If the skin is wet, or worse, perspiring, the area needed for lethal contact is reduced.

I realize that the area of contact is intended to be small. However, there is no excuse for stating that 24 volts dc is harmless. It is only harmless when precautions are taken.

Jim Bradley
Northern Electric Research Ltd.
Ottawa, Ont., Canada

■ *The currents involved are negligibly small—in the range of microamperes or nanoamperes. The resistance in the wrist strap and the tester are in the order of megohms. Putting the low resistance (say 10 or 20 ohms) presented by wet ground or water in which the operator may be standing in series with that low resistance doesn't change the circuit's over-all resistance much.*

If that resistance is 50 megohms, then with a test voltage of 24 volts, the current through the body would be less than half a microampere. Because the tester is so inherently safe, it does not require approval by the VDE (Germany's equivalent of Underwriters' Laboratories).

Costs favor ceramics

To the Editor: Your article, "Package cost," [*Electronics*, May 8, p. 44] contained this statement on over-all costs of ceramic and plastic-packaged integrated circuits: "If the cost is, say, $30 per repair in a small system, the buyer is spending twice as much for the glass ceramic package as for the plastic package."

This statement does not appear to back up the premise stated in the opening paragraph that, when costs of maintenance and replacement are considered, the economics favors ceramic. We believe the statement should have read, ". . . the buyer *can afford* to spend twice as much for glass ceramic packages. . . ." The reason for the economy is, of course, ceramic's much lower failure rate.

Donald Towse
Owens-Illinois Inc.
Toledo, Ohio

■ *Reader Towse is correct. In editing, the meaning was inadvertently changed.*

A matter of license

To the Editor: We very much enjoyed William F. Arnold's article, "Will solar cells shine on earth?" [*Electronics*, May 22, p. 67]. We would, however, like to correct a minor error relating to our work on the edge-defined film-fed growth process for silicon ribbon.

Dow-Corning Corp. is not a licensee of Tyco for the use of this process. Perhaps the confusion arises from the fact that Corning Glass Works is a licensee of Tyco for the application of EFG to the growth of sapphire tubes for high-pressure sodium vapor arc lamps.

A. I. Mlavsky, Director
Tyco Corporate Technology Center
Waltham, Mass.

The nanofarad—why not?

To the Editor: I am all for the nanofarad, as proposed in "What happened to the nanofarad?" [*Electronics*, Engineer's Newsletter, May 8, p. 131]. But why not further improvements? As the ohm symbol is omitted on schematics, why not write only 1n next to the capacitor symbol, instead of the customary 1,000 pF? Needed explanations could be included in notes. Furthermore, the prefix could mark the decimal place: instead of 4,700 pF, 4n7; instead of 1.8k, 1k8. Thirdly, I would like to see more uniform labeling by capacitor manufacturers. Why can't they stick to standard metric prefixes?

Perr Cardestan
University of Hawaii
Honolulu

40 years ago

From the pages of Electronics, July 1932

When the Chicago World's Fair of 1933 opens next June, its lighting circuits will be switched on by light from the star Arcturus, gathered in the great Yerkes telescope, focused on a photocell, and amplified for transmission to relay switches at Chicago. The light used left Arcturus 40 years before, at the time of the Chicago World's Fair of 1893.

On-time performance of tows of the privately owned Mississippi Valley Barge Line Co., operating between Cincinnati and New Orleans, is facilitated by the system of radio reports recently installed by the company.

Every three hours the company's four towboats report their positions to the central station in Cincinnati, and communication is established between the various boats.

Measurements of lightning involve time in microseconds, volts in millions, amperes in hundreds of thousands, and horsepower in millions. So rapidly does the flash come and go, that its rise and fall can be indicated only by a cathode-ray stream of electrons.

With the recently developed cathode-ray oscillograph, which records extremely brief phenomena by a pencil of electrons, it has been possible to secure records of natural lightning waves on lines, and to reproduce these in the laboratory.

Every man interested in electronics repeatedly finds himself faced with the question: "If your electric eyes and vacuum tubes are replacing human labor and throwing men out of work, what real advantage are they to society as now constituted? Are not your inventions a menace rather than a boon to mankind?"

This puts a puzzling query up to all invention and all scientific progress. But one thing is certain. Invention is bound to go on. And a way must be found so that society as a whole benefits rather than suffers from labor-saving devices.

In the ultimate, electronic devices must be used to make the world a happier place for all.

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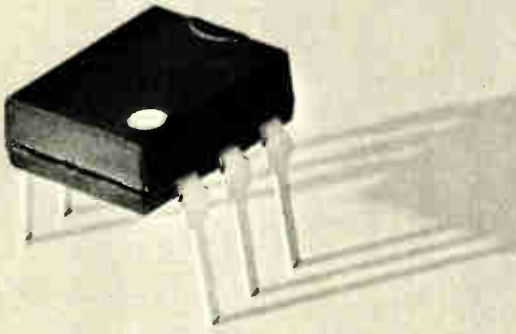

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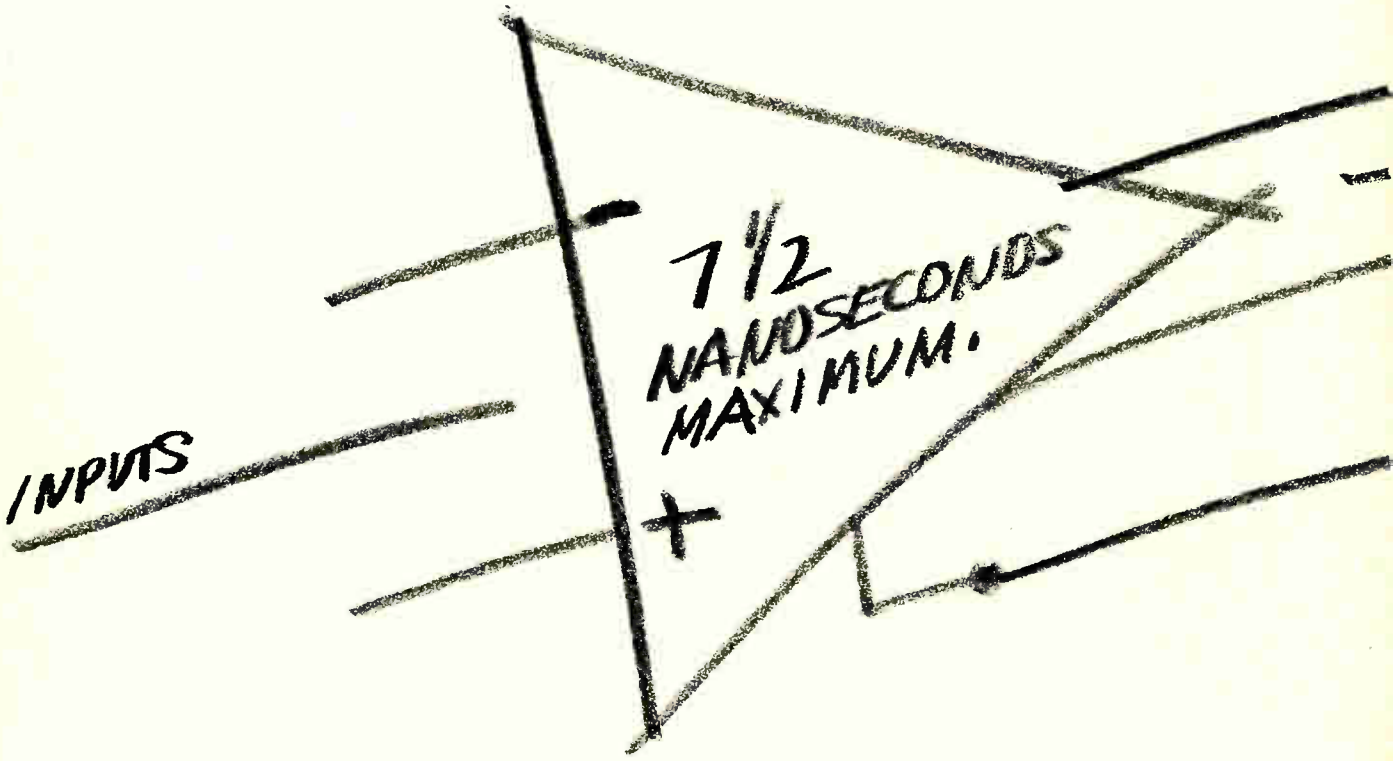

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People

Role of engineering grows in consumer products

Engineering in consumer electronics will no longer be shoved into the back seat when it comes to advancing technology if George A. Schupp, newly promoted vice president and chief engineer for color TV products at Zenith Radio Corp., has any say.

The 48-year-old Schupp, who has been in consumer electronics since 1948, attributes the existence of his present job to the explosion of new products and advanced applications within the consumer sector.

His main responsibility will be to convert fast-moving technical development into products. One of the most challenging aspects of this role, he feels, is smoothing Zenith's own entry into the home video player competition—with a disk said to use a different approach from one being developed in Europe.

Schupp: Zenith will have home video player.

"When the market's ready, we'll be there," Schupp promises. While he anticipates a reasonable volume of home players by 1975, he expects growth will be limited by competing, noncompatible systems.

"There is room for a cartridge player-recorder and a disk player, but not for two or three of each," he points out. "We don't need another 45 versus 33⅓ problem, but I expect there will be one."

The application of linear integrated circuits to TV receivers is another fast-moving aspect of the consumer electronics business. And Zenith is now deeply involved in expanding IC applications. "I think we've always had the engineering talent to move quickly from tubes to solid state to ICs, but it has been a question of directing this talent into new technology," Schupp observes. "Outstanding product developments in the practical business world are what we need."

Look westward, says Tanaka of Calcomp

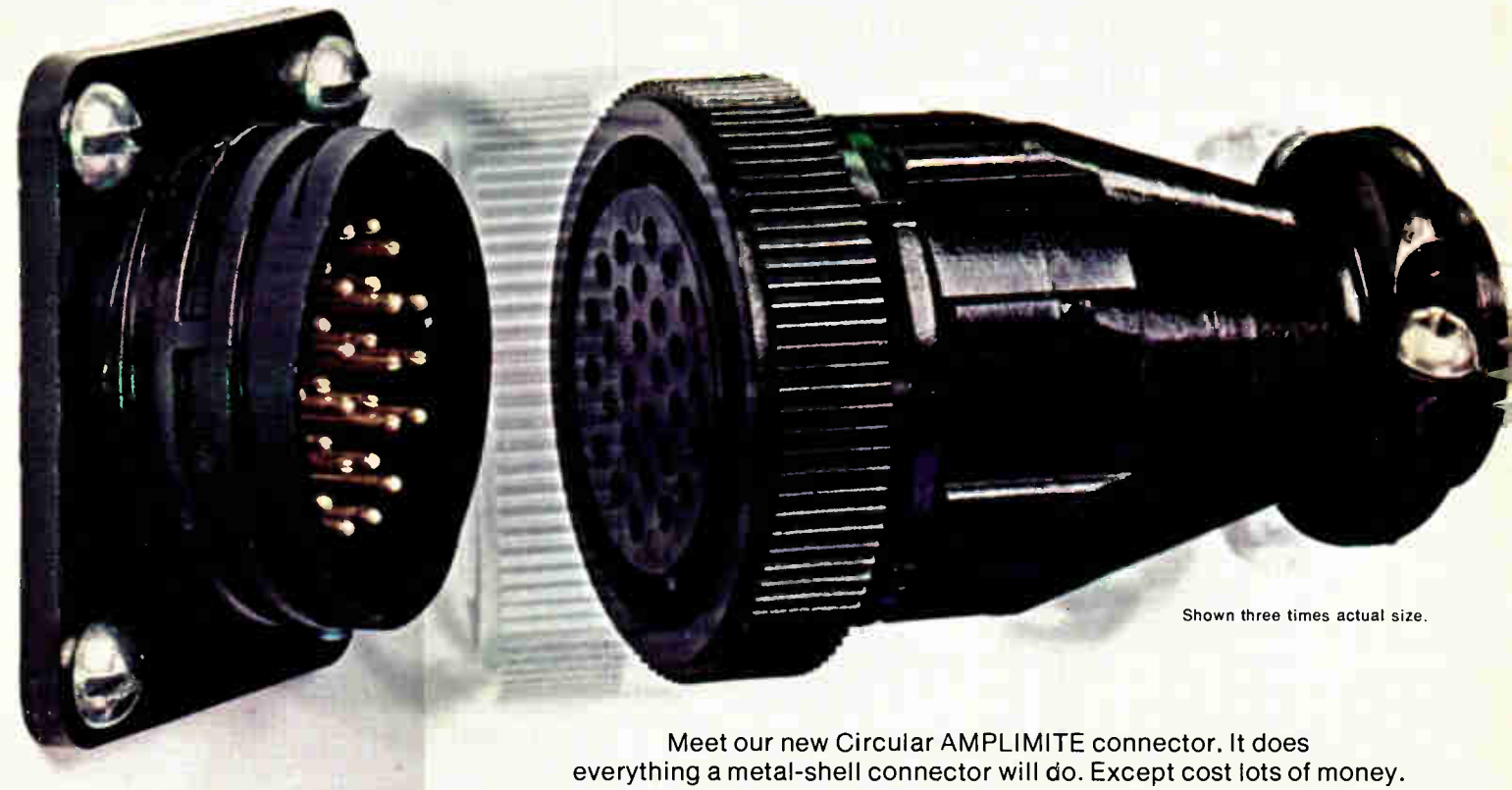
Many U.S. data-processing companies are ignoring a vital market. That market, says Richard I. Tanaka, senior vice president at California Computer Products Inc., is the international one—or, more specifically, Japan. And Tanaka should know, because his Anaheim, Calif., company derives half its revenue from business outside the U.S.

Tanaka feels that the first annual U.S.-Japan Computer Conference, to be held in Tokyo, Oct. 3–5, is a tremendous opportunity for American industry to learn about what's happening in Japan. Tanaka is an honorary co-chairman of the conference, which is sponsored by the American Federation of Information Processing Societies (AFIPS) and the Information Processing Society of Japan. Exhibit space for the nonprofit meeting, which is split between Japanese and U.S. companies, has been sold out.

One might think that California-born Tanaka, 43, is particularly interested in the conference because of his Japanese background, but it turns out that he didn't learn to speak Japanese until he started going to Japan on business about five years ago. "I've learned as much Japanese as possible because there's a much better rapport with people when you can talk to them directly." He suspects, though, that if his job were liaison with Japanese companies, his background would be a liability.

As it is, Tanaka is responsible for engineering, manufacturing, and marketing development at Calcomp. He has a Ph.D. in electrical engineering and physics from Caltech, plus his BSEE and MSEE .

Nylon. A new twist in cutting circular connector costs.



Shown three times actual size.

Meet our new Circular AMPLIMITE connector. It does everything a metal-shell connector will do. Except cost lots of money. We make it of high-strength, glass-filled nylon. So it's just as rugged . . . but lighter, nonconducting and less expensive.

Circular AMPLIMITE connectors cost less to buy. And less to use . . . because you can terminate their pin and socket contacts on our high-speed, automated, customer-provided machines. And load only the contacts you need.

We make this new nylon connector in most popular sizes, including 63-position, 1 7/16-inch O.D.; 28-position, 1 1/16-inch O.D.; and 8-position, 11/16-inch O.D. Mountable or free-hanging. Standard or splashproof. Rated 7.5 to 15 amp.

Ready for a new twist in circular connectors? Write for details to **AMP Incorporated, Industrial Division, Harrisburg, Pa. 17105.**

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Circle 13 on reader service card

Meetings

Joint Automatic Control Conference: AIAA, IEEE, et al., Stanford University, Palo Alto, Calif., Aug. 16-18.

Western Electronic Show & Convention (Wescon): WEMA, Convention Center, Los Angeles, Sept. 19-22.

Engineering in Medicine and Biology: IEEE, Americana, Bal Harbour, Fla., Oct. 1-5.

International Symposium on Remote Sensing of Environment: U. of Michigan, Willow Run Labs, Ann Arbor, Oct. 2-6.

U.S.A. & Japan Computer Conf.: AFIPS, IPSJ, Tokyo, Oct. 3-5.

Ultrasonics Symposium: IEEE, Statler Hilton, Boston, Oct. 4-6.

National Electronics Conf.: NEC, Regency Hyatt O'Hare, Chicago, Oct. 9-11.

International Conference on Cybernetics and Society: IEEE, Sheraton, Washington, D.C. Oct. 9-12.

Conference on Display Devices: IEEE, United Engineering Center, New York, Oct. 11-12.

Eascon: IEEE, Marriott Twin Bridges, Washington, D.C., Oct. 16-18.

The Business Equipment Show: McCormick Place, Chicago, Oct. 16-20

International Conference on Computer Communications: IEEE, ACM, Hilton, Washington, D.C., Oct. 24-26.

Nerem: IEEE, John B. Hynes Civic Auditorium, Boston, Nov. 1-3.

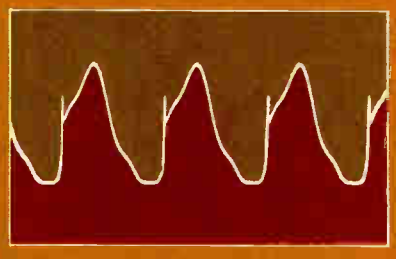
International Conference on Magnetism and Magnetic Materials: AIP, IEEE, et al., Hilton, Denver, Nov. 28-Dec. 1.

International Electron Devices Meeting: IEEE, Washington Hilton, Washington, D.C., Dec. 4-6

Fluke problem solvers

Plug in true rms... at the lowest price available!

These new Fluke plug-in options let you add true rms capability to Fluke 8200A and 8400A DVMs. Take the measure of non-sinusoidal waveforms in 500 ms. Get accurate readings from 1 mv to 1000V rms.



Now you can put true rms to work in your Fluke 8200A for just $595, and for only $750 in the 8400A. These are the lowest prices offered for true rms in 4½ and 5½ digit DVMs.

But price is only part of our story. Even at an unexcelled low price, we offer performance the others don't even begin to match.

For instance, we measure low levels that competitive units can't touch. Why? Because we use an exclusive converter technique which doesn't have square law response limitations of thermal rms converters.

This same technique allows us to measure waveforms that quasi-rms or distortion insensitive converters can't handle. And, we can do it up to five times faster than thermal converters. Mid-band accuracy (50 Hz to 10 kHz) is 0.1%.

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These options are field installable. All other features and specs are those of the respective instrument. The Model 8200A is a high-speed 0.01% 4½ digit voltmeter with 60% overranging, auto polarity, and auto ranging on all functions. It features switched input filter, full 1000 volt guarding. Full multimeter and systems options are available. Base price is $995.

Fluke's Model 8400A is the ultimate bench and systems DVM. It features an accuracy of 0.002%, 1 microvolt resolution, resistance measurements down to 100 micro ohms, auto polarity and auto ranging. For $2450 you get five ranges of DC from 0.1V full scale to 1000 volts with 20% overrange. The switched filter provides better than 65 dB noise rejection for DC, AC, resistance and ratio.

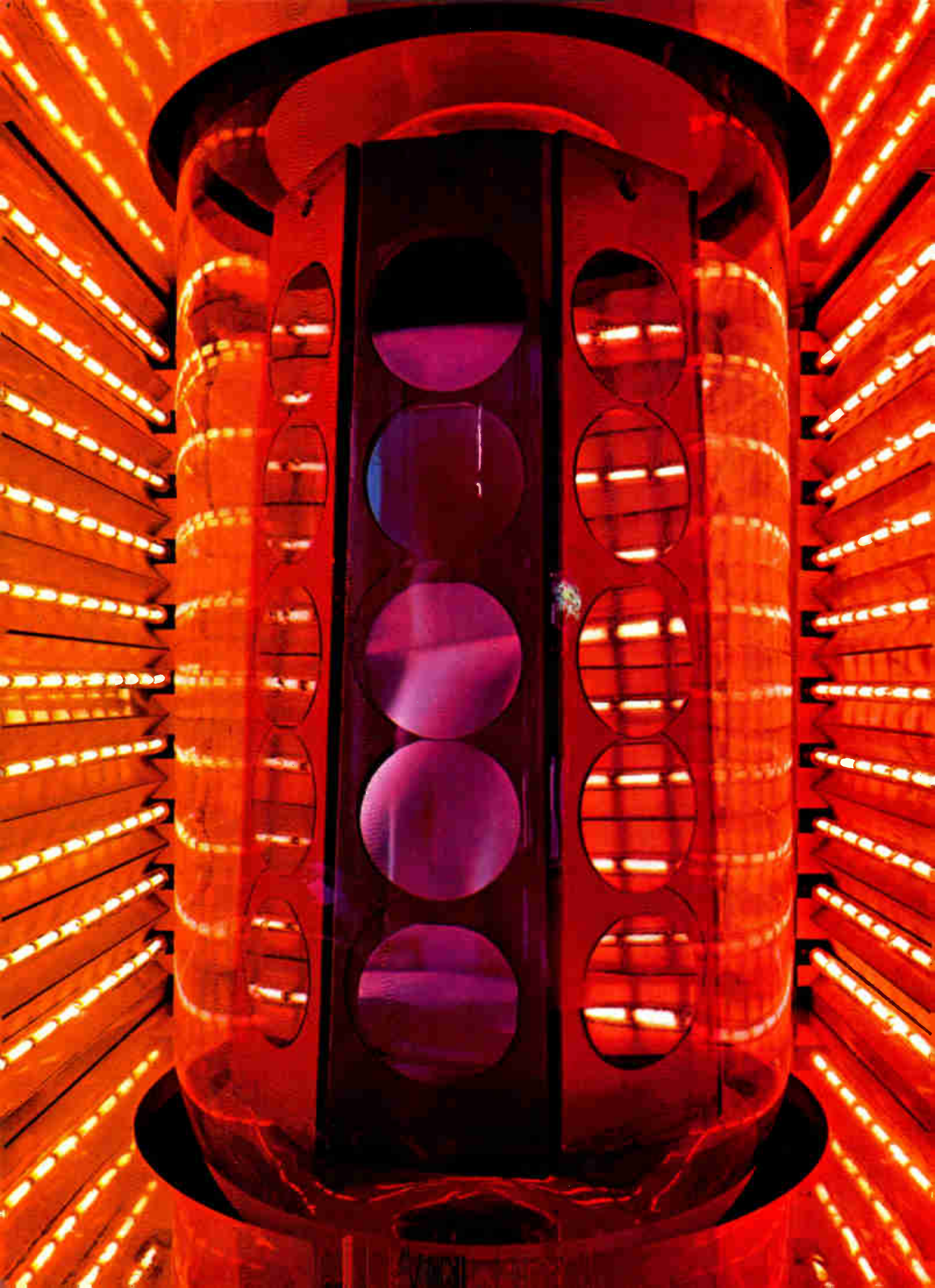
Both DVMs feature 1500V peak overload protection and the ability to meet tough environmental specs.

For full details, call your nearby Fluke sales engineer or contact us directly.

Fluke, Box 7428, Seattle, Washington 98133. Phone: (206) 774-2211. TWX: 910-449-2850/In Europe, address Fluke Nederland (N.V.), P.O. Box 5053, Tilburg, Holland. Phone: (04250) 70130. Telex: 884-52337/In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2, 4TT. Phone: Watford, 33066. Telex: 934583.

FLUKE

Circle 15 on reader service card



Radiant Heating keeps your slip from showing.

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The new AMN 730-Nitrox™ Reactor for greater flexibility; profiles temperature electronically so you can deposit multi-layer structures in a single run, without opening the reactor. That counts when you're processing SiO_2, Si_3N_4, Al_2O_3, polysilicon, or refractory metals.

The new AMH-704 Mini-Reactor™, an economical system for precise thin film deposition in the lab. Small in size, big on capability.

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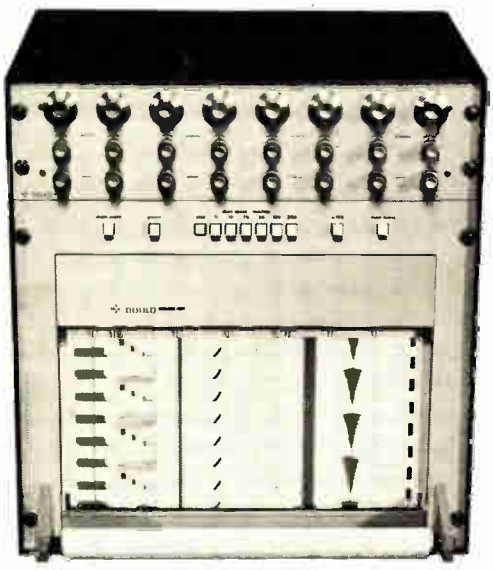
applied materials
radiant heating

*Applied Materials Technology Inc. U.S. Patent No. 3,623,212

New. 8-channel recorder with preamps in a single box.



It's the Brush 481. For about $1000 less than the same components bought separately.

It gives you Brush quality. And Brush innovations. For example: pressurized inking system that writes dry and eliminates smudging, puddling and priming. And Metrisite® non-contact servo-loop feedback device that guarantees 99.5% linearity.

You also get 12 pushbutton chart speeds, from 0.05 to 200mm/second. 40 Hz full scale frequency response. And the built-in preamps provide a measurement range of 1mV/div to 500 V d-c full scale. With differential, balanced and floating inputs and high common mode rejection.

Finally, you get your choice of either a compact portable or rack mounted version—and accessories like chart take-up reel and Z-folder.

The only thing missing: the problems of separate preamps.

You'll certainly want more information. So contact Gould Inc., Instrument Systems Division, 3631 Perkins Avenue, Cleveland, Ohio 44114. Or Rue Van Boeckel 38, Brussels 1140 Belgium.

BRUSH INSTRUMENTS

GOULD

Electronics newsletter

Signetics builds static n-MOS RAM

Signetics Corp. has developed what it believes to be the first ion-implanted, n-MOS, 1,024-bit random-access memory that's completely static. It requires no clocks and is completely DTL/TTL-compatible, operating from +5 volts and ground. Ion implantation is used to get both depletion and enhancement mode MOS transistors, which makes for a low-power design.

The TTL compatibility in both logic levels and power supply, plus the device's low power dissipation of only 200 milliwatts, makes it a candidate for minicomputer main memories and peripheral equipment storage. **The price will also be attractive—about 1 cent per bit in quantities of 100.** Samples are expected later this month.

Two versions are being planned. The standard part will have an access and read cycle time of about 1 microsecond, while the higher-speed part will operate at 500 nanoseconds. Write cycle time for both will be 500 ns.

Larson to head IEEE's Intercon and Wescon . . .

An agreement between IEEE and Wescon has put the direction of Intercon and Wescon under one man, Donald Larson, previously general manager of Wescon only. **This move was prompted by the resignation of William J. Hilty as director of IEEE Convention and Publishing Services** to accept a similar position with the Society of Manufacturing Engineers.

Besides filling IEEE's need for a replacement for Hilty, the combined arrangement should facilitate idea-swapping between the East and West Coast shows, according to Donald G. Fink, IEEE general manager.

. . . as IEEE maps plan to draw semiconductor folk

One of the first orders of business for Donald Larson will be to put together Intercon's planned celebration of the 25th anniversary of the transistor. **IEEE hopes this program will bring the semiconductor exhibitors back to the 1973 Intercon next March in New York. The program will be repeated at the 1973 Wescon.** A letter addressed to all semiconductor houses outlining the elaborate preparations for this celebration has received seven favorable responses, none of them, however, from Texas Instruments, Motorola, or Fairchild.

Foremost in the planning will be a promotion effort to bring non-electronics attendees to the exhibits. The theme, "Solid State Shapes the Future," will be embodied in **an applications center showing the use of semiconductors in food processing, automobile, chemical, and other manufacturing enterprises.**

Ampex developing low-cost system for video retrieval

Ampex is believed to be working on a new automatic video document storage and retrieval system for small- or medium-size organizations. The company already has a larger system—Videofile—that's aimed at insurance companies, hospitals, law enforcement agencies, and other groups with similar needs.

The new system, as yet unnamed, is based on a new high-bandwidth video recorder/reproducer, and a program control unit. A version of the system was delivered to North American Rockwell earlier this year.

Electronics newsletter

Hitachi develops new ceramic board

A significant price advantage is promised by a new process developed by Hitachi's Semiconductor and IC division for making multilayer ceramic boards for multichip and single-device packages. **Reduced costs of firing and automated continuous-strip production methods promise lower prices than previous methods.** The new SMC (for Screened Multilayer Ceramic) process is based on alternate screening and drying steps of conductive and dielectric layers on "green" (unfired) ceramic tape, followed by a single firing. This avoids costs of alignment and punching, as well as the costs and time associated with tooling that are involved in laminated processes, and the costs of repeated firings if a prefired substrate is used.

Conductors are molybdenum-manganese or tungsten and the dielectric is a special screenable alumina paste. **The alumina paste is the key to the system,** according to Takahiko Ihochi, IC packaging group leader at Hitachi. The paste's shrinkage rate is matched to that of the green ceramic and metalized conductors, and its viscosity is such that close tolerances can be held on via holes.

Teradyne delivers 20-MHz tester for bipolar RAMs

As the demand for bipolar reed-only memories expands [*Electronics*, July 3, p. 65], test equipment for the parts is close behind. Following quickly the announcement of Macrodata's 10-megahertz MD-104, hometown rival Teradyne Dynamics—both are in Chetsworth, Calif.—says that **it has delivered its first 20-MHz H484 memory exerciser to a semiconductor manufacturer and has four other units on order.**

Unlike the Macrodate unit, which is a stand-alone tester, the Teradyne instrument is designed to be used with systems such as the Teradyne J283 LSI test system. The $15,000 instrument tests 4,096 by 4 bits, expandable by 4 bits. It offers the standard patterns, plus a special combination of read-modify-write and address complement that Teradyne says can substantially reduce test time, yet detect most failures.

Garrett calculator also tells time

As calculator prices drop below $100, manufacturers are starting to come up with new features to attract customers. **Garrett Comtronics of San Diego has designed an MOS chip, to be built by National Semiconductor, that also can be used as a digital clock.**

The calculator itself, to be announced at the end of the month, will initially be a standard eight-digit unit. As the company's entry into the home and executive market, it features walnut insets and brushed aluminum panels. Later, the company will introduce models with additional features, such as timekeeping. Garrett Comtronics is the spin-off that remained when Burroughs acquired most of Garrett's MOS group.

Addenda

The Treasury Department has found what it terms reasonable grounds for believing that Japanese color TV tube makers are dumping their products in the U.S. at prices below those paid in Japan. **What the action does, in effect, is to stop the placement of new orders.** . . . Sen. Kennedy's bill to create a Civil Science Systems Administration to accelerate technology application to social goals and retrain jobless engineers seems likely to get through the Senate, but appears doomed in the House. **With it will die Sen. Javits' amendment to make pension portability part of Federal procurement rules.**

nuts

Their book, ironically symptomatic of minicomputer technology itself, was good as far as it went but didn't go far enough. Significantly absent was any reference to the only *really* new and different concept for systems computers in years: functional minicomputers using a universal bus system.

And that's a damned relevant topic to be leaving out!

GRI's Functional Minicomputers* are integrated into system environments with unheard of simplicity. You won't find out what that means for the systems designer or end user—not in their book. That's why we wrote *our* book.

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Discover the minicomputers that can be fully integrated with your system and completely debugged in the time it takes to write the program for many others. That's relevancy! *That's a lot of time, money and manpower saved.* Multiply that savings by the number of systems you plan to build—can you afford not to check out the GRI story?

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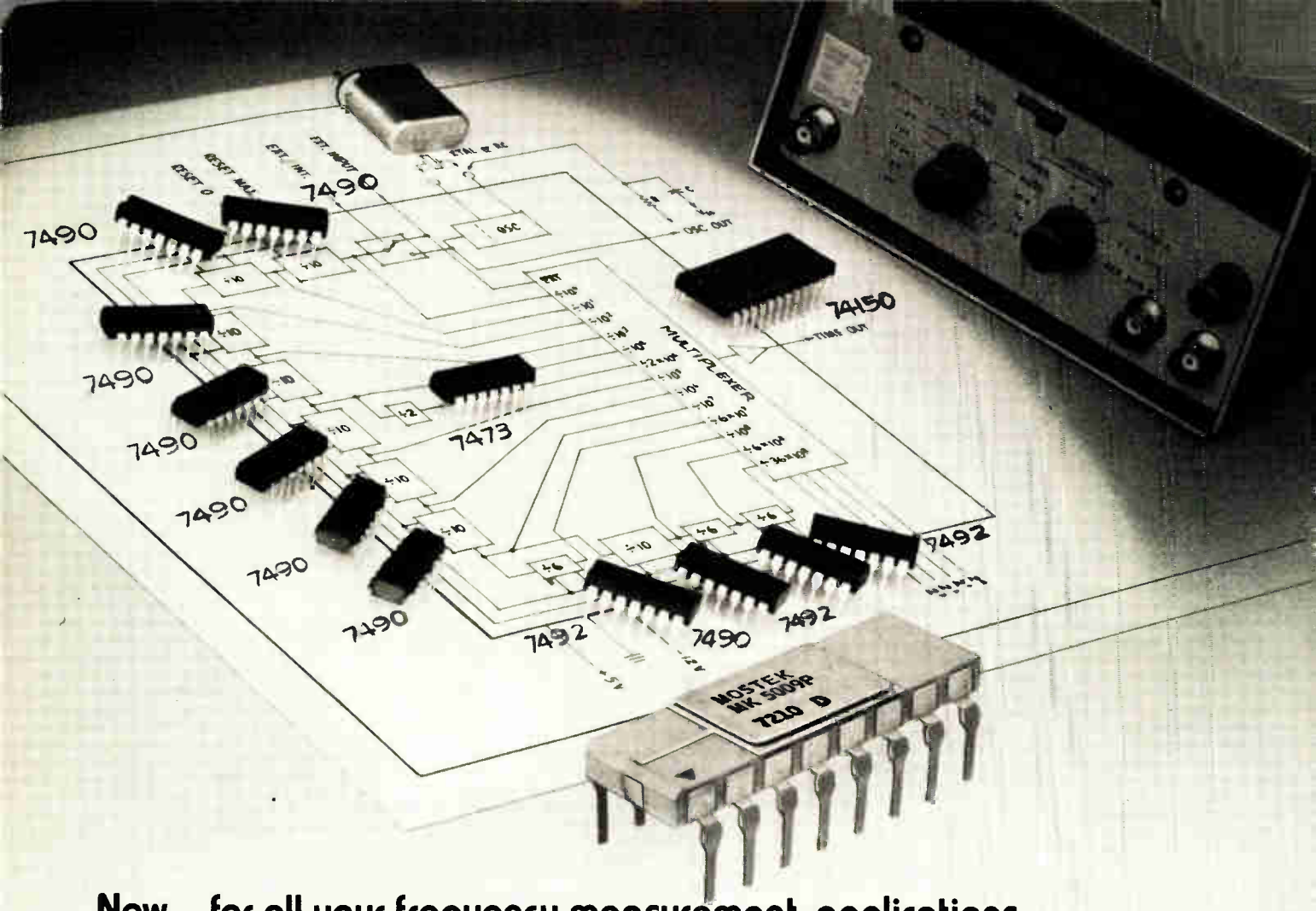

Now...for all your frequency measurement applications

the universal time-base circuit

MOSTEK is now offering a new MOS chip—the MK 5009 P—to solve a host of timing and counting applications at low cost. With this versatile new circuit you can replace seven or eight TTL packages usually employed and enjoy a 94% saving in power required (80 mW for the 5009 compared with 1.3W for eight TTL decade counters!).

For flexibility, the 5009 is designed to operate from any of three frequency sources: internal oscillator with external RC combination; internal oscillator with external crystal; or externally applied TTL signal. Other features? Check these:

- "Reset to 9" and "Reset to 0" features are included to facilitate initiation of time base periods.
- Separate oscillator output is available for use with other equipment.
- BCD selection of time base periods facilitates automatic ranging of time base with addition of simple counter.
- Inputs and time output are TTL compatible.
- Frequency division ratios of from 1 to 36 x 10^8 are available.

With a 1 MHz input frequency or crystal, the 5009 provides the basic time periods necessary for most frequency measuring instruments—1 μs through 100 secs. Also available for other applications: 1 min., 10 min., and 1 hour periods using a 1 MHz input, and 50 or 60 Hz output with a 1 or 1.2 MHz input.

Pair the 5009 with MOSTEK's MK 5002 P or new MK 5007 P counter/display circuits (the 5007 features a 16-pin package containing four decades of counting storage and BCD output) and you've got a perfect low power "duo" for frequency counters, tachs or time interval measuring equipment.

When counting/timing are important requirements, call MOSTEK or one of the distributors or representatives listed here. We make MOS with your needs in mind!

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Circle 22 on reader service card

Military to get $21 billion for fiscal '73 shopping

Election-year pruning to trim 9% from Pentagon's requests; some electronics-laden programs are sliced

Military procurement for the fiscal year that began July 1 is expected to fall slightly below $21 billion—but not before a vigorous election-year floor fight in the Senate after the political conventions in Florida. The forecast figure—a compromise between the House-passed $21.3 billion measure and the $20.6 billion authorization approved by the Senate Armed Services Committee— is a 9% cut from the $22.8 billion Pentagon request, some in programs heavy with electronics.

SALT cuts. House officials, acknowledging that defense spending will be a major campaign issue this year, point out that most of the committee cuts came as a result of the Strategic Arms Limitation Talks and in programs with large controversial cost overruns, rather than in some new programs still in R&D.

"The jobs issue is uppermost in the minds of most members, and all of them are standing for reelection," observed one House staffer, explaining the lack of major cutbacks. On the Senate side, more cuts could be made on the floor, although some of these could be restored in the subsequent House-Senate conference.

Both House and Senate measures approved the full $444.5 million for Air Force R&D on the B-1 strategic bomber at North American Rockwell, as well as most of the $926.4 million sought for R&D and long-lead-time procurement on the Navy's new Trident long-range missile submarine. Defense Secretary Melvin Laird had conditioned his approval of the U. S.-Soviet SALT agreement on Congressional approval of the two programs.

Money for the Army's Safeguard antiballistic missile system was approved in both houses, but with sharp cuts motivated by the SALT agreement limiting the U. S. to one 100-missile site for ICBM defense and another for the national capital. Of the $800.1 million sought by the Pentagon, the Senate approved only $561.5 million for the Grand Forks, N.D., site procurement and continuing R&D. But the committee took no action on another $110 million for accelerated post-SALT weapons RDT&E sought by Laird.

While approvals came in both chambers for a variety of aircraft and ship programs with heavy electronics content, funds for many were frequently cut or restricted in their usage. Key actions included:

- The Navy's DD-963 destroyer program, hurt by delays and cost overruns in another Litton Industries ship program, was cut $363 million in both houses from the $610 million sought for seven additional ships. The $247 million remaining is authorized for long-lead-time items.
- The Navy's CVN-70 Nimitz-class carrier, however, won approval of all $299 million for long-lead-time items. This is expected to produce a floor fight because Government reports indicate final cost of the ship, its planes, and other hardware contracted separately could push the price to nearly $2 billion—almost double the cost of the vessel itself. Secondarily, the Congress questioned if recent experiences with contractors such as Litton don't con-

FISCAL 1973 DOD AUTHORIZATION
(IN MILLIONS)

PROCUREMENT	REQUEST	HOUSE ACTION	REDUCTION
Aircraft	5,962	5,744	218
Missiles	3,717	3,452	265
Vessels	3,564	3,201	363
Tracked vehicles	251	251	0
Torpedoes	194	194	0
Other weapons	97	97	0
Subtotal	13,787	12,941	846
RDT & E			
Army	2,097	1,997	100
Navy	2,797	2,661	135
Defense agencies	520	494	26
Emergency	50	50	0
Subtotal	8,696	8,372	324
Safeguard ABM			
Construction	387	0	387
Housing	12	6	6
Subtotal	399	6	393
BILL TOTAL	22,881	21,318	1,562

Totals may not add due to rounding

tradict earlier arguments that Navy shipyard costs are higher than those of private industry.

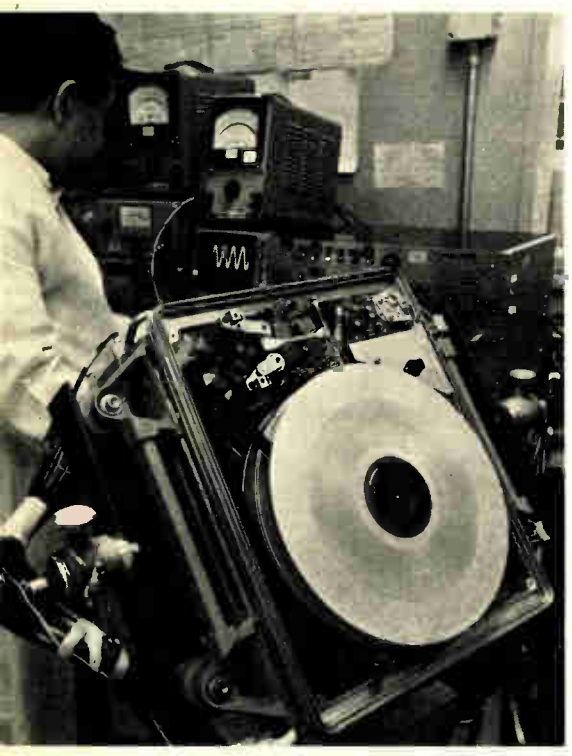
- The Air Force's Advanced Airborne National Command Post (AANCP) and Airborne Warning and Control System (AWACS) got limited approval. The Senate cut the AANCP to $100 million for procurement of four Boeing 747s, plus $20 million for R&D—reductions from requests for $224.8 million and $32 million respectively. The AWACS request for $470 million was cut by nearly $227 million in the House, which denied any procurement funds for another year, keeping the project in R&D.
- The Army's SAM-D air-defense missile program at Raytheon Co. received Senate approval of its total $171.4-million R&D request, despite program slippage and the Pentagon's questions about the program's cost prospects.
- The Navy's F-14 fighter, under contract to Grumman Aerospace, and the Air Force F-15, recently rolled out at McDonnell Douglas, both won funding approval. However, the F-14 budget of $732.7 million in the House and $734.8 in the Senate contained limitations that the $407 million procurement money be conditioned on company acceptance of a contract for 48 planes in the fifth lot.

R&D took the biggest percentage cut overall, as indicated in the House bill, on which a final appropriation is based (see table). □

Space electronics

Skylab tape recorder replaces telemetry to record 'tremendous' volume of data

As space missions get more and more complicated with additional experiments, wider-bandwidth communications links are required to get the data back to earth. But on Skylab, the first stage of which is scheduled for launch in April 1973, there will be no telemetry downlink for experimental data; instead, NASA is relying on a tape recorder and an astronaut.



Space tape. Ampex AR-728 tape recorder, to fly aboard Skylabs, is checked out in clean room. Data-filled tapes will be carried back to earth by one of astronauts.

In the words of R.H. Webster, Skylab program manager at the Instrumentation division of the Ampex Corp., Redwood City, Calif., "The volume of data accumulated from the Skylab experiments will be tremendous. [The three Skylab space stations are designed to test man's ability to stay in space for long periods.] So to save weight and money—by eliminating telemetry equipment and its associated antennas—NASA went to tape."

Two modified Ampex AR-700 airborne digital recorders, one online and one backup, will fly in the multiple docking adapter section of the space station. The standard AR-700, a 14-track machine, will be converted to 28 tracks and will be called the AR-728. Also, since Skylab is a manned program, potentially toxic or flammable components will be replaced.

Packed in. "Essentially what was done," says Webster, "was to take what is normally packed into a six-foot-high rack and reduce it to a 100% reliable 1.5-foot cube." This, adds Webster, was difficult; in fact, about two years will have passed from the time Ampex got the contract until the first two of four machines (two flight, and two ground preflight backups) will be delivered to Martin Marietta Corp., the prime contractor, later this month.

Since there is no telemetry, the only way to get experimental data back to earth is to have one of the astronauts bring the tape when there is a change in crew. That's the reason for going from 14 to 28 tracks—the astronaut won't have too many reels of tape to carry. In fact, only 10 reels will be needed to record all the data from the complete year-long mission.

Each 7,200-foot reel is to have not more than five errors in 1 million bits of data; the recorder is capable of recording 1 million bits per second per track, and the capacity per reel is almost 50 billion bits. If someone other than NASA needs that kind of density, Webster says that Ampex will sell an AR-728 for $30,000 to $60,000, depending on options—"as long as it doesn't have to meet NASA's manned space flight requirements." □

Displays

Toshiba light valve has no moving parts

Large-screen television doesn't necessarily require large components. A light-valve tube being developed for projection TV by Tokyo Shibaura Electric Co. (Toshiba) uses IC fabrication techniques to get small size. The development team, headed by Shunichi Sano, hopes to complete its work in less than a year.

Many of the basic principles are

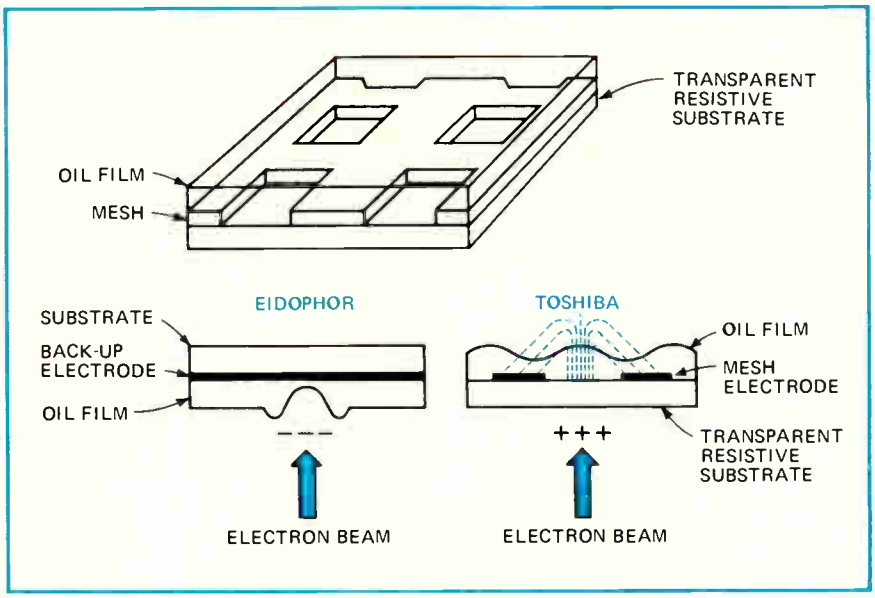
similar to those of the Eidophor projection system—but the new light valve is a small, sealed tube, rather than the large tube with internal moving parts and a vacuum pump in the Eidophor. Another difference is that the Eidophor tube works by reflection, while the new tube is a transmission-type light valve.

Bright light. Basically, both systems consist of an intense light source—typically a xenon arc lamp—plus a light-valve tube and the associated optics of a schlieren optical system. The tube's face is coated with oil, the surface of which is deformed by electrons representing picture elements. The deformities vary the refraction and also slightly vary the diffraction of light hitting them, thus controlling the amount of light passing through.

Several problems inherent in the original Eidophor system are eliminated by the Toshiba light valve. The Eidophor valve has an accelerated stream of electrons strike the oil surface. This degrades the oil, so that it must periodically be replaced, and requires control of the resistivity of the oil, so that the charges can leak away. Also, the electron beam sweep and intensity-modulation circuits must produce a charge distribution that periodically undulates the oil's surface. Such circuits are more complex than those used in TV receivers.

Slick. With the Toshiba light valve, oil doesn't degrade, and resistivity of the oil needn't be controlled. That is because the electron beam strikes the thin film of controlled-resistivity glass of the type used in image orthicons, and the charges leak off to a metal ring around the glass film. It's also unnecessary to vary the intensity or sweep rate of the electron beam because an evaporated aluminum mesh is photo-etched on the surface of the glass, where no electrons impinge.

The side of the glass film with the aluminum mesh (which has 4-micrometer lines about 25 micrometers apart) is covered with oil. This film is thick enough and has enough surface tension so that it is planar. Although called "oil," the material is a silicon-based polymer that is a hybrid between oil and highly resilient rubber. In more than a year the Toshiba material has shown negligible flow or droop.



Picture this. Top drawing shows light valve in Toshiba's tube. Bottom drawings compare Toshiba and Eidophor light valves. In the Toshiba model, the oil doesn't degrade.

In operation, picture information is written on the surface opposite the film by an electron beam that is swept and intensity-modulated like the beam in a conventional picture tube. The charge on the surface of the glass film opposite the aperture in the mesh extends through the glass film, through the oil in the aperture, and then bends around to strike the mesh. This charge distorts the film, and the mesh provides required variations in distortion.

The schlieren optical system has a series of slits between the light source and the light valve, and a target mask is placed between the light valve and projection lens. The target mask has slits similar to those in the mask near the light source, but when the film is undistorted, the light passing through the slits in the first mask is focused on the solid regions between the slits in the target mask. Deformation causes refraction of that light, which passes through the slits in the target mask and is focused on the viewing screen.

Color TV would require three light sources, three light valves, and associated color filters. Toshiba engineers don't consider commercial movie theaters with giant screens as ultimate users of their tube. Rather, they envision applications where the screen size would be more moderate, as in classrooms and small auditoriums. □

Consumer electronics

Bipolar chip contains radio

The first commercial radio on a single chip has been developed by Ferranti Ltd. of Manchester, England, by using collector diffusion isolation techniques [*Electronics* July 3, p. 96]. Researchers at Ferranti have managed to provide a complete a-m radio circuit on a small monolithic bipolar chip that requires only battery, earphones, and antenna, plus a few capacitors for tuning and decoupling to complete the package. What's more, the audio output is 3 milliwatts.

Part. Bryan Down, marketing specialist for Ferranti, predicts that the IC will lead to production of low-priced pocket radios and may well be incorporated into television sets, tape recorders, calculators, and coffee pots. Although the chip is still

in the evaluation stage, Down stresses that it will be in production in two to three months.

The tuned a-m circuit is a tuned rf receiver in a proprietary space-saving design that allows the chip to fit into a standard three-lead TO-9 plastic transistor package. By addition of a single-stage power amplifier, the chip can be used with a standard loudspeaker. Only one 1.3-volt battery is required, and under normal operating conditions, the quiescent current typically is only 1 milliampere.

The radio is tuned by the external variable capacitor; automatic gain control is built into the design. Ferranti's Down emphasizes that CDI techniques make possible a superheterodyne IC, but additional external components would be required to accomplish this. □

Avionics

Phased-array radar for light planes

Virtually all commercial rader systems for airplanes still use mechanically driven scanning-dish antennas. Jetliners have room in the nose for antennas, but there's much less room in general aviation aircraft and none at all in single-engine planes.

Now, a 20-pound phased-array weather radar system for general aviation has been developed by Aradar Corp., Blue Bell, Pa. It has a 90° beam scanning angle and an estimated production cost of $5,000, less than half that of comparable mechanical systems. Called Airadar, the system's antenna will fit in a light-plane wing and give a range of 90 nautical miles, reports David L. Stanislaw, project engineer.

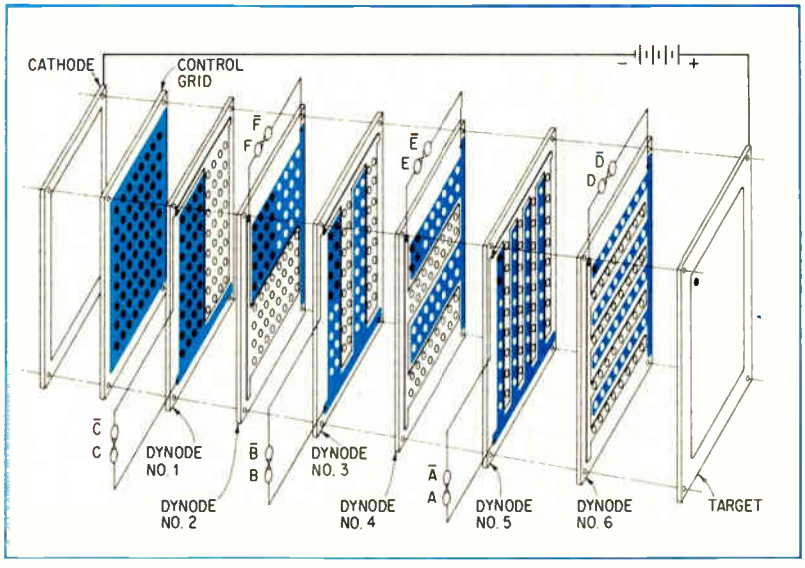
Key to the solid-state antenna system is the use of ferrite phase shifters. "They are inexpensive, compared with semiconductors," Stanislaw says, "and take less electronics to drive them." And, at less than a dollar apiece, the ferrite phase shifters are about 1/20th the

Digisplay, the flat-screen image sandwich, poised for commercial debut as peripheral

When the Northrop Corp. won contracts from the Army and Air Force to show how its Digisplay flat-screen image tube was better than bulky CRTs, the military-oriented company also had ideas about licensing commercial manufacturers. Northrop felt that Digisplay showed promise for such commercial and industrial applications as a computer terminal display [*Electronics*, June 21, 1971, p.30].

Now GTE Sylvania is planning to make an alphanumeric display with the Northrop tube at a price described as competitive with conventional CRT systems. Edmond N. Elowe, Sylvania's project manager, says samples will be available in 90 to 120 days, and the price eventually will be in the range of $50 to $150. In recent meetings with prospective customers, Sylvania said it may also supply drivers for the Digisplay tube, or even complete terminals.

The main effort now is readying the tube for high-speed production at the Electron Tube division in Seneca Falls, N.Y., says Elowe, and the company has "sizable and significant resources" committed. Northrop is also developing the tube further, emphasizing advanced



work toward military and special-purpose applications.

Harper Q. North, manager of Northrop's Electron Optics department, says that a proposal is before the military for a ruggedized version of the tube, and the company has a contract for a 40-beam version for incorporation into a 40-sensor forward-looking infrared system. The company has already shown the Army Electronics Command a 32-by-16-character tube with a resolution of 80 lines per inch, and an 8-by-10-in. tube with a 55-line resolution per inch and gray-scale capability. North's group has also made a color version and is developing TV and graphic-type displays as well as storage tubes.

The tube that Sylvania recently showed is the FTA-512, a flat alphanumeric display that shows 512 5-by 7-segment characters 0.18 in.

cost of semiconductors, he says. "It's the first application of ferrites at these power levels (8 kilowatts) at X band."

For a typical single-engine installation, the array would consist of 17 radiators, each a vertical array of eight dipoles. Each array is fed through a ferrite phase shifter that has its electromagnetic state controlled by transistor drivers. A solid-state logic system controls the drivers, causing the microwave energy to be phase shifted in 16 discrete steps across the array. The number of vertical arrays can be changed slightly to conform with the wing size.

The unit also is relatively easy to produce, says Stanislaw. The 17 antenna arrays are identical printed boards, which means "you just photograph it and print and print and print." The feed, phase shifters, and all other microwave parts are on one other printed board. Moreover, the unit has neither moving parts to wear out, nor waveguides.

A subsidiary benefit of the phased array is that the scanning rate is faster than the flicker rate of the eye, Stanislaw explains, thus giving a steadier, clearer picture than conventional radars, which show bright scanning beams. Tube phosphors are brighter and don't burn, he says. Nearly any small television receiver can serve as the unit's viewing screen.

Five years in the making, the unit was developed by A. Rufus Applegarth, a co-founder of Narco Avionics, a general aviation equipment manufacturer, and Syracuse University Research Corp. Aradar is talking to several avionics manufacturers for production, starting next year.

That $5,000 price, say industry sources, is high for single-engine planes but seems about right for light executive craft and larger. □

high in a 5.4- by 3.8-inch viewing area. The tube is digitally addressed without deflection circuitry; hence, it is convenient for digital applications. Since it has random-scan capability, the time required to change the beam position does not depend on the distance between beam positions.

The Digisplay has certain similarities to a cathode-ray tube. An evacuated glass chamber contains a thermionic emitter and a phosphor target operated at about 9 kilovolts. There the similarity stops, however. A large-area cathode produces electrons over a large surface, with a number of metallized glass plates for focusing and selection of display. The tube is analogous to a CRT with 512 times 5 times 7 guns, with each gun selectable digitally.

It would seem that selection of specific bits to be illuminated could be a formidable problem; however, the FTA-512 requires only 63 connections. The four selector plates are a row-selector, a column selector, a row-bit selector, and a column-bit selector. These plates, along with the cathode and beam-forming and beam-focusing plates, form a rigid glass sandwich. The number of switching plates is a compromise between the number of connections and desired writing rate, plus other factors. For switching the selectors, either a positive voltage, which permits the electron beam to pass, or a negative voltage, which deflects the electrons, is applied to the plates. The tube is rated at −50 and +150 volts, but the tube demonstrated actually used −20 and +30. Power required is 25 watts for the filament and about 5 w for switching. Any type of CRT phosphor can be used.

Elowe points out that the tube wi" have to be cost-competitive v other displays, including the his own division makes, to h cessful in the long run. Lic ting diodes and liquid cryst to be out of the running f cations requiring large nun characters, he says. The obstacle to commercial seems to be convincing users to abandon the lo CRTs for the lighter and mc pact Digisplay.

Medical electronics

Computer is key to health tester

Contrary to popular opinion, Americans are far from the healthiest people on earth. Poor eating habits, little or no exercise, high-pressure working conditions—and most important, almost no preventive medicine—take a staggering toll of men at the prime of their lives.

The seeds of a solution to the problem are being sown, and electronics plays a key role. The outgrowth will be new ways to deliver eventive medicine, with the comter the tool to make it work.

Doing it. Earlier this month, the merican Health Foundation pened its Health Maintenance enter in New York City. The emasis is on the practice, rather than e preaching, of preventive medine, emphasizes Dr. Ernest L. Wyner, president of the foundation and iedical director of the new center.

Basically, the center, a multiphaic testing facility, is set up to idenify high-risk factors in the people creened there. The computer has at least two important functions in this system, and it will probably be used for several others as well.

First, the computer reviews the patient's medical history, which he prepares when he fills out a 400-question machine-readable questionnaire. After verifying that the questionnaire has been filled out properly, the computer modifies the standard battery of tests.

The machine's second task is to

Like it is. Patient presents questionnaire at initial interview. Responses are entered into CDC 1700 in 90 seconds, which validates questionnaire and specifies test branching.

modify the test procedure on the basis of data obtained from the test results themselves. To make this almost-real-time procedure feasible, the screening begins with blood and urine analyses, because these chemical tests are time consuming. Electrocardiography, pre-glaucoma tonometry, audio and visual testing, and other tests are conducted later because their results become available quickly.

Doctor. The last step is an interview and examination by a physician. By the time the doctor is ready to conduct his examination (about an hour after the testing begins) the computer has provided him a printout of all test results, highlighting any abnormalities.

In addition to its role in determining first- and second-order branching of the screening procedure, the computer can perform several other functions. For example, it can analyze an electrocardiogram (EKG) in real-time, although the current procedure is to rely on a standard strip-chart record. All EKGs are actually examined twice at the center—once by the computer, and again by a cardiologist.

To prepare EKG data for computer evaluation, an a-d converter samples the analog signals at a 500-hertz rate and encodes the data into 10-bit digital words. The automated procedure can thus provide better frequency response and resolution than the strip chart.

An additional function that the computer will no doubt perform in the future is trend analysis. As patients are reexamined, any changes in their test results, as well as the results themselves, will be taken into account in arriving at diagnoses.

While the medical side of the Health Maintenance Center, which will charge about $80 per physical, is operated under the auspices of the nonprofit American Health Foundation, the business side is run by the profit-oriented American Health Corp. This corporation is a joint venture of six companies—Control Data Corp. (the center's computer is a CDC 1700), Eastman Kodak Co., Northwestern Mutual Life Insurance Co., Norton Simon Inc., Time Inc., and Bradford Computer & Systems Inc. □

Government electronics

Coast Guard funds navigation contracts

In pursuit of equipment that will let ships maneuver freely in foul weather and at night, the Coast Guard has awarded three parallel development contracts for short-range, shipboard harbor navigation systems. Collins Radio Co., Cedar Rapids, Iowa; RCA Corp., Camden, N.J.; and Tracor Inc., Austin, Texas, has each received a nine-month study contract for a total of $350,000 to define the technical aspects of their competing systems. The systems include on-shore transmitters.

The awards are the first part of a three-year, four-phase $5.2 million R&D effort leading to an operational system that the "Coast Guard can set up and evaluate," says Comdr. Robert L. Cook, project officer for the River and Harbor Aid to Navigation System (Rihans). From that evaluation the Coast Guard will decide when and in which harbors to install the systems—an undertaking that "could amount to many megabucks," he says.

Aim of the system is to enable pleasure craft and ocean-going vessels to pinpoint accurately their locations with respect to shoals, bridges, and other harbor obstacles, Cook says. Under terms of the development, cost of the receivers would be $250 for pleasure craft and $5,000 for large vessels. Respective accuracies would be within ±125 and ±50 feet, or "far in excess, on a total system and cost basis, of any other being used to do the job."

Could be required. Although the Coast Guard has no intention at present of making such receivers mandatory, it could do so when the systems become operational in harbors and waterways. The receivers, called position-determining equipment, will give a continuous display of a ship's current position, updated every three seconds in the case of large vessel receivers. Unlike San Francisco's Marine Traffic System, which is a traffic control system, Rihans "lets the guy himself know just where he is."

The three companies are taking different tacks in meeting the Coast Guard's tough requirements. Collins proposes a time-multiplexed, short-pulse microwave beacon system, in which a series of primary and secondary transmitting shore stations would beam time-coded double pulses to shipboard receivers in a hyperbolic format. With modular additions, Collins says, the unit could lead to an automated way-

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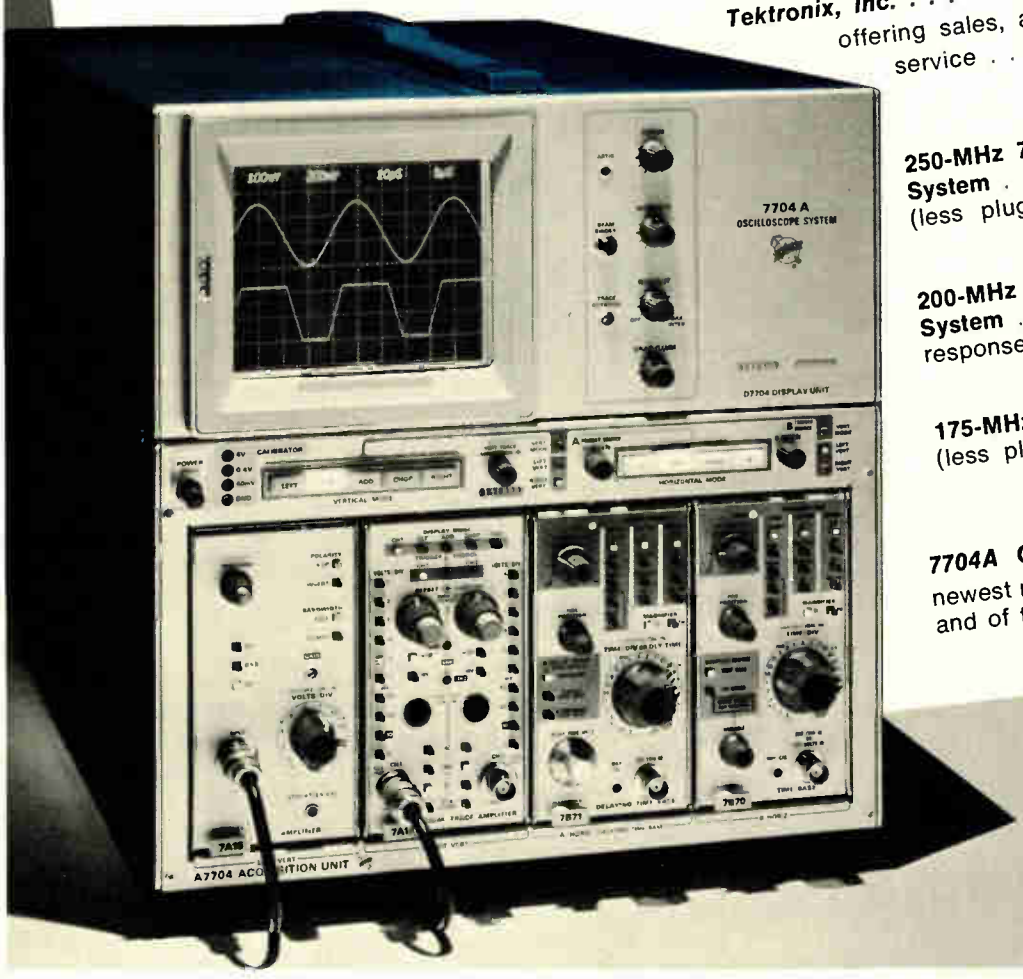

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point navigation system translating time differences into latitude-longitude coordinates.

RCA wants to use a derivation of its Secant airborne collision avoidance system [*Electronics,* Dec. 20, 1971, p. 69]. Each ship would be equipped with an interrogator-receiver that would continuously receive microwave signals from transponders in fixed shore stations. The vessel would interrogate a transponder with time-jittered pulses on one of two frequencies, and the transponder would send back navigation data by frequency-shift-keying the return pulses to give range lines of position.

Tracor proposes a low- and multi-frequency format using phase-measurement techniques in what it calls a "modified Omega" approach. Omega is a vlf radio-navigation aid. The company says the system would use simultaneous transmission of three frequencies, time-multiplexed from a network of transmitting antennas to shipboard receivers.

"Everybody is going to have some trouble with the requirements," Cook says, who expects one or two companies to drop out before the development project is over. □

Contracts

Army testing Sony cartridge television

The Japanese have won the first skirmish in the battle to sell cartridge television to the military—though the advantage may be temporary. The Army Audio Visual Agency is testing the Sony ¾-inch video player that could establish an Army standard. John O'Brien, communications manager specialist for the agency, says that Sony was chosen because it has the only commercially feasible unit available. And sources say, too, that the Army was dissatisfied with the Ampex 1-in. machines it previously used.

O'Brien adds, however, "It is too early to zero in on a standard now. When equipment using the EIAJ ½-in. standard becomes available, there will be an advantage in the greater interface of systems." However, in the interim, more Sony units will be added to the 500 or 600 the armed forces now have.

Look-see. The Army, in its search for a standard cartridge television player, is testing this Sony U-Matic. It was chosen, says Army, because it's only commercially feasible unit.

Waiting. Spokesmen for the Navy and Air Force say that the Army has been suggesting a standard within the services to facilitate the exchange of information. Both branches have been testing Sony equipment, but are not anxious to follow the Army's suit. The reasons: applications are different and, mainly, criticism that the Army is not buying American. Both Navy and Air Force have been using Ampex and other 1-in. units.

Comment from other cartridge television manufacturers on the Army-Sony marriage is unanimously unworried. As one insider put it; "The Army is polygamous. Any action the Army takes now doesn't preclude us in the future." As for Sony itself, all questions are referred to the Army. □

Integrated electronics

Signetics implants arsenic in wafer

Many semiconductor researchers are working with arsenic as a dopant in bipolar structures to increase device speed; but Signetics Corp. has added something new. Instead of diffusing the arsenic into the IC wafer in a furnace, researchers at the Sunnyvale, Calif., company are using an ion implantation machine. The work is similar to that reported last fall by IBM Corp., but Signetics says it's the first commercial house to disclose such research. However, semiconductor industry insiders disclose that other bipolar makers are experimenting with implanted arsenic, among them Hewlett-Packard Associates.

High energy. James A. Marley, manager of solid state research at Signetics, says, "While most people are implanting boron and phosphorous, we wanted to have the capability of working with arsenic also." The problem is that, since arsenic is a heavier ion, higher implantation voltages are required [*Electronics*, June 19, 1972, p. 69]. That's why the Signetics R&D implanter is a 400 kiloelectronvolt machine, and the production machine on order from Extrion Inc. will be a 200 keV machine. Several other Bay Area semiconductor makers have ordered the 150 keV model, but "we don't want to be energy-limited," says Marley.

Why is arsenic a better dopant than boron or phosphorous? Marley says, "There are problems with phosphorous that can be eliminated by going to arsenic." It gives a sharper diffusion profile, permitting a shallower emitter and a narrower base—the two layers being doped in the Signetics experiment. Also, since

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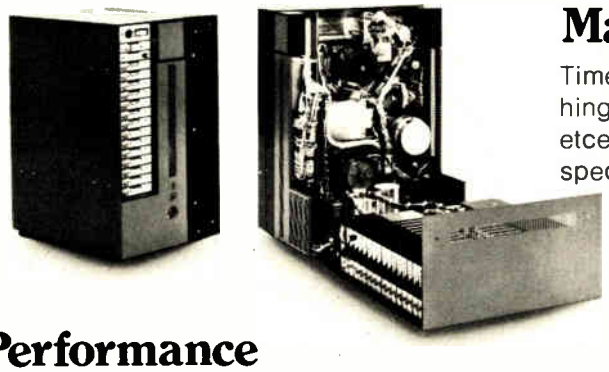

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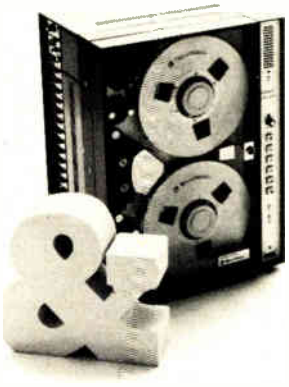

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arsenic is a heavier ion, it tends to stay after it has been implanted—no matter what is done to the wafer afterwards. Marley adds that arsenic "is a better Group V dopant in that it offers a better lattice fit with silicon and, since it has a diffusion coefficient that is an order of magnitude lower than that of phosphorous, it's more controllable."

While the benefits of arsenic can be gained by conventional furnace processing, the wafers must be diffused at 1,200°C, which is higher than normal, and they must be processed in sealed quartz tubes, which, says Marley, tend to "sag at 1,200°. But with ion implantation, you just need higher voltage."

Experimental results thus far indicate that arsenic produces a more step-like junction than other processes. "It's more square," says Marley, "and it remains square. We can get narrower base regions, and this means more efficient current injection from the emitter to the base and into the collector, even with present masks." What will come from all of this, he won't say, but faster, denser random-access memories are at the top of the list. □

Communications

Telephone test unit market seen soaring as phone companies update equipment

Manufacturers of electronic test equipment for telephone communications networks are gleefully forecasting a burgeoning market for such precision items as phase-jitter meters, spectrum analyzers, and psophometers—which measure noise and transmission characteristics. Although company spokesmen are unable to peg dollar volume, they predict rising sales because the market, which is worth hundreds of millions of dollars, is changing. This is caused by several significant trends, among which, they report:

- More sophisticated test equipment is needed because telephone companies are updating their equipment in response to public demand for better service.
- Western Electric Co., Bell Telephone's equipment-manufacturing arm, is reportedly concentrating on high-volume gear and leaving lower volume, but high-cost, items of phone test equipment for outside companies to manufacture.
- Cable-television, microwave, and other data-transmission networks are growing, and they use much of the same test equipment to monitor performance in their stations, cables, and lines.
- The number of telephones and users is rising as the population increases, thus creating a bigger demand for equipment.

The rate of market increase may not top 9%, but "the base is so large that the total increase is high," says Jack T. Evans, marketing manager for Hewlett-Packard's Delcon division, Mountain View, Calif. "You're talking about very large numbers." Since telephone companies' profits are Government-regulated, these utilities are pouring a lot of money back into equipment and facilities, he points out.

Upgrading of equipment is generating a market for new semiautomated and automated test equipment, as well as portable and smaller items. Industry spokesmen say that New York Telephone plans to spend $1 billion a year in New York City alone. About $26 million is pegged for automated gear, and the company will need lots more portable equipment to locate 50,000 idle lines it's unable to connect, they say.

Customers. "The phone companies aren't the only buyers," says Charles V. Parker, vice president of Northeast Electronics Corp., Concord, N.H. "Nonphone carriers need them, too."

Walter Mack, staff engineer at tiny Hekimian Laboratories Inc., Rockville, Md., says the market for phase-jitter meters is coming out just the reverse of what one might expect. Modem manufacturers started buying first, then data-line users, and finally the phone companies are coming around, he says.

Big and small companies alike joust for parts of the highly competitive field, and some are reluctant to discuss contracts or business. Among those also making equipment are General Radio Co., Concord, Mass.; and such California companies as Cushman Electronics Inc., Telephone Technology Inc., Pacific Plantronics, and Wiltron Co.

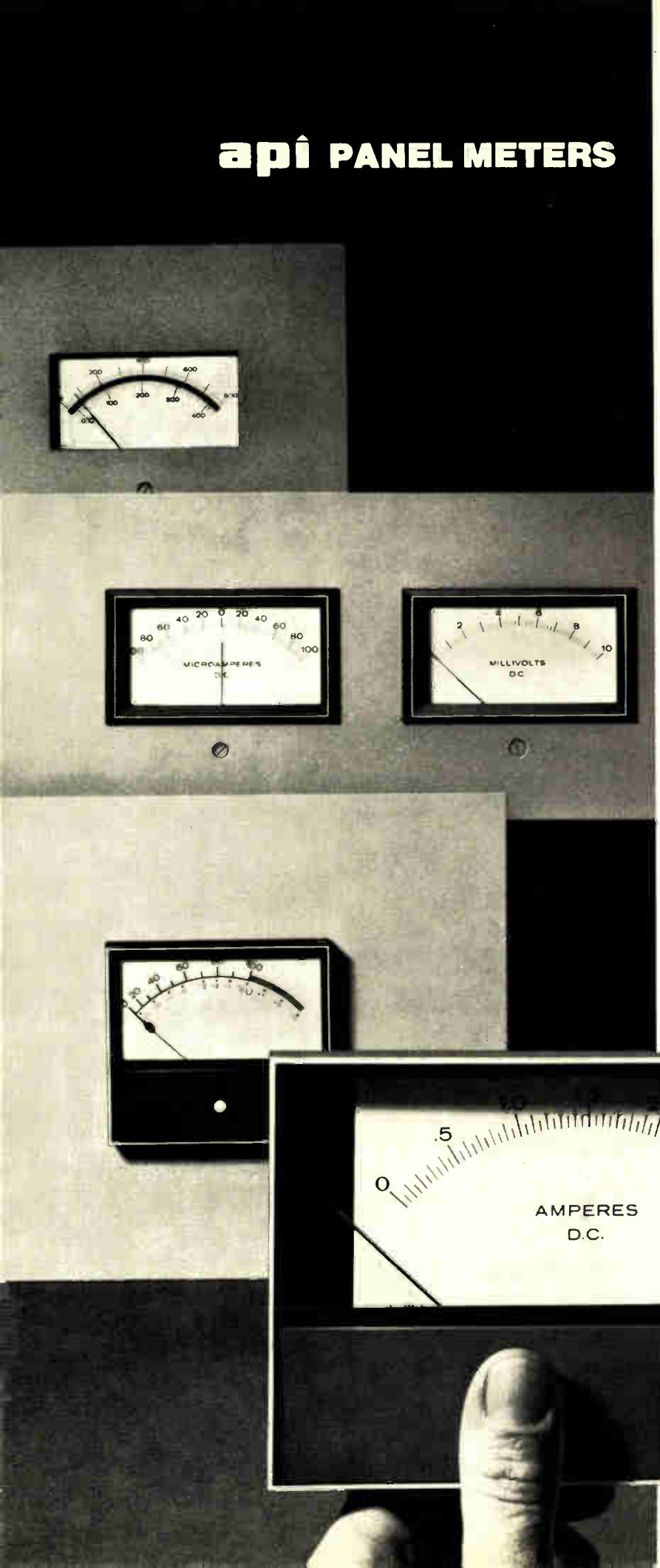
The big-ticket test-equipment market is diverse. Hewlett-Packard, for example, makes $600-$800 psophometers, as well as $1,775 TV waveform analyzers and $8,000-$12,000 microwave-line testers. Hekimian sells its phase-jitter meters for $1,000 to $3,000. Northeast markets 120 items over a broad price range. □

Air traffic control

Boeing approaches decision on ILS

The Boeing Co. is completing tests of a new type of low-cost microwave instrument landing system, designed for remote airfield operations requiring low-cost installations. Initial prototype projections call for the ground equipment to cost about $20,000 and the aircraft gear about $4,000. The solid-state terminal navigation aid, developed by Boeing Electronic Products, is under test in Alaska and Washington state.

Boeing is using data from the tests to make a decision on production. "A decision on marketing the system worldwide is imminent," an official said. If a production go-ahead for the microwave ILS is authorized, Boeing officials predict that the system will benefit airlines worldwide that must fly to airfields now requiring only visual flight rules. The company describes the development as a microwave



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equivalent of conventional low-frequency ILS.

The ground unit, located near the runway, generates glide slope and localizer information and transmits a fixed microwave beam. Insignificant attenuation has been experienced, Boeing reports.

An aircraft picks up and follows the beam to a point near the runway. The receiver in the airplane detects the microwave energy and converts it to a standard vhf/uhf ILS signal. This allows use of the microwave landing system and the standard vhf/uhf instrument landing system on the same aircraft with no change in the cockpit displays.

A prototype of the landing system was installed in January at the Deadhorse, Alaska, field that serves Prudhoe Bay and the North Slope petroleum activities. In a cooperative program with Wien Consolidated Airlines of Alaska, successful landings have been made by means of the prototype. The system has operated without fault throughout the winter at temperatures reaching -60°F. □

USAF "initiatives" require $428 million

Electronics accounts for eight of 12 new Air Force research and development programs scheduled for fiscal 1973 funding. According to military appropriations testimony released on Capitol Hill, the service's "new initiatives" in electron-

For the record

Liquid crystals next?
Now that RCA's Solid State division has cut the prices of its entire line of commercial complementary MOS devices, observers are awaiting a promised reduction in liquid-crystal display prices. As for C-MOS, RCA says that 180 standard ICs are involved, with new prices averaging about 25% lower for plastic-packaged devices, 20% for dual in-line and flatpack ceramic, 50% for chips.

A spokesman says that continuing product modifications have kept RCA from announcing liquid-crystal price cuts. These include a different digit shape and the addition of a ground at each digit to permit multiplexing.

NR to buy Unicom
North American Rockwell Corp. will acquire Unicom Systems Inc. from American Micro-systems Inc. under a recent agreement. Unicom, now 88% owned by MOS-maker AMI, designs and distributes electronic office equipment, including calculators. This is NR's first venture into the retail distribution and service area.

Unicom, only a few years old, distributes lines from two Japanese and one U.S. company. NR says that, initially at least, Unicom will retain its identity. In particular, it won't have any special relationship with North American Rockwell Microelectronics Co., a major manufacturer of calculator MOS chips.

GSA rebuilds EDP setup
The General Services Administration, the nation's largest civilian computer customer, has restructured its Government-wide EDP operations and enlarged them.

The new Automated Data Processing and Communications Service (ADPACS) implements in part a report by Fry Consultants, of Chicago, that recommended improvements in the management of GSA's computer and related services, which now cost between $6 billion and $8 billion. Acting commissioner of the new ADPACS is Ted Trimmer, GSA assistant administrator.

GE gets ARPS work
General Electric's Aircraft Equipment division, Utica, N.Y., has a new $3 million-plus award from Grumman Aerospace Corp., Bethpage, N.Y., for design and development of two Advanced Radar Processing Systems (ARPS). The award is a follow-on to the AN/APS-120 program, under which six prototypes were turned out over the past three years for the Navy's E-2C.

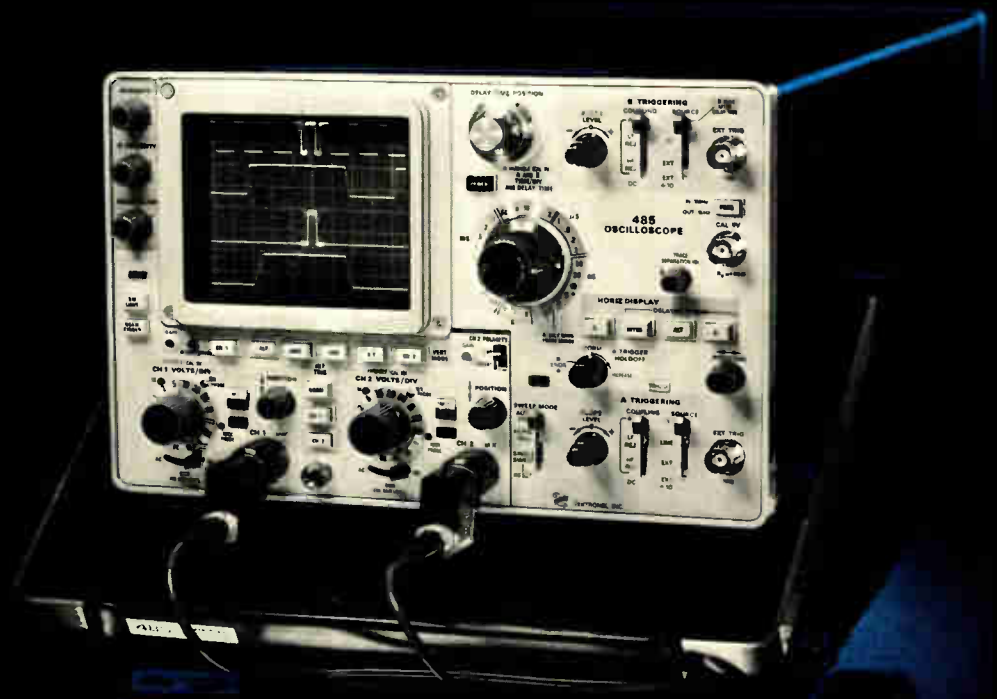
Radar to map winds
The Naval Research Laboratory says it has come up with an operational breakthrough that enables high-frequency radar to map winds of a storm at long range—500 to 1,000 nautical miles. The lab's radar men say the short time response of the sea surface to local winds may be mapped by the analysis of a matrix of range-azimuth records containing frequency-power spectra of high-frequency signals backscattered from the sea surface via the ionosphere. While the potential has been demonstrated in the past, the technology hasn't been used.

Electric winds
The Army's Mobility Equipment Research and Development Center (MERDC), Ft. Belvoir, Va., is pushing development of a soundless air-moving device with no moving parts and none of the characteristics of a conventional fan. Long interested in research on silent systems—an effort spurred by the Vietnam War—MERDC calls its program ionic airflow.

While working on another program, MERDC researchers found that air could be forced to flow at velocities in excess of 2,000 feet per minute—more than twice the velocity of conventional heating or air-conditioning systems. Further research showed, the Army says, that a static, or no-flow, pressure could be produced.

Ionic airflow is achieved by activating positive and negative ionized molecules in air by a dc charge impressed across an airspace between the ends of two conductors. The air ions are accelerated to the electric field poles of opposite charge, with the velocity dependent on shape of the pole ends, distance between them, and the voltage. Ionic airflow is generated at the expense of the kinetic and electrical charge energy of the accelerated ions, which collide with electrically neutral molecules and propel them toward the conductor poles. Thus, the majority of the mass flow is electrically neutral.

350 MHz



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ics—a concept pushed throughout the military by DOD's John S. Foster Jr., research and engineering director—will require $428.1 million in total funds, including $73.1 million programed for the next 12 months.

ECM chunk. Biggest single increment will be $25 million to be spent this fiscal year on a four-part effort to develop prototype tactical electronic countermeasures (ECM) systems for jamming. Total development cost is expected to reach $73.3 million, the service says. One part of the effort will be to interface McDonnell Douglas Corp.'s AN/APR-38 ECM hardware on the F-4D Wild Weasel countermeasures planes with higher-power AN/ALQ-99 jamming pods developed by Raytheon Co. and Airborne Instrument Laboratories Inc. to achieve "frequency set-on and antenna steering control" for jammers.

The tactical jamming program's second effort will be to develop small, disposable jammers with dispensers and delivery systems. Third will be design of a countermeasures package for a recoverable drone aircraft. Finally, the program will develop and test a low-cost ECM drone for ground launching; the aim is a unit cost below $50,000.

Location. Second largest budget is $12 million to be spent this year out of an $86 million total for development of a Precision Emitter Location System, a combination of aircraft and remotely piloted vehicles using time-of-arrival techniques to permit location of enemy emitters in a high-density ECM environment.

A new program known as EAR (for Electronically Agile Radar) will get $6.1 million of an estimated $48.6 million in program costs to develop a modular airborne radar able to simultaneously operate in air-to-air, air-to-ground, and terrain-following and avoidance modes.

A $27.4 million program to build a large electromagnetic pulse simulator to measure the vulnerability of avionics in aircraft as big as a C-5A supertransport will receive $8.3 million in fiscal 1973.

Upgrading the Strategic Air Command's Automated Total Information network (Satin) by replacing obsolete electromechanical hardware with large-scale IC technology will receive $1.7 million of an estimated $5.6 million total cost. Known as Satin IV, the program will tie SAC into the Defense Satellite and Fleet Satellite Communications Systems, the Advanced Airborne National Command Post, and the Worldwide Military Command and Control System.

Another $2 million will be spent this year to complete development of a 35-pound polar uhf satellite for tactical forces.

First try. A major aircraft electronics effort calls for $38.8 million, including $7.4 million to be spent in fiscal 1973, to develop and outfit two F-111As with a multisensor package that will permit attacks on targets during the first pass in bad weather. The Air Force says the prototype (known as Scana for Self-Contained Adverse weather/Night Attack) must be pursued with "a high sense of urgency."

A three-part project called MAWA for Missile Attack Warning and Assessment is scheduled for $10.6 million in FY 73 out of an estimated total development cost of $148.2 million. Its components represent system improvements, rather than new R&D efforts. First, for example, is the service's support of DOD's missile launch warning system, using satellites to improve "credibility and accuracy" of sensor data. The Air Force will get $79.7 million, including $5 million this fiscal year, to develop hardware, software, communications and displays.

Reporter. The MAWA program also calls for development of a low-cost, easily deployable and survivable nuclear detection and reporting system. Its total development cost is estimated at $29.5 million, including $3.5 million for studies and hardware in the coming year. Final increment of the program is for an attack assessment system designed to accelerate information flow and display options to the National Command Authority in the event of Soviet nuclear attacks. It is budgeted this year for $6.6 million of an estimated $39 million cost. □

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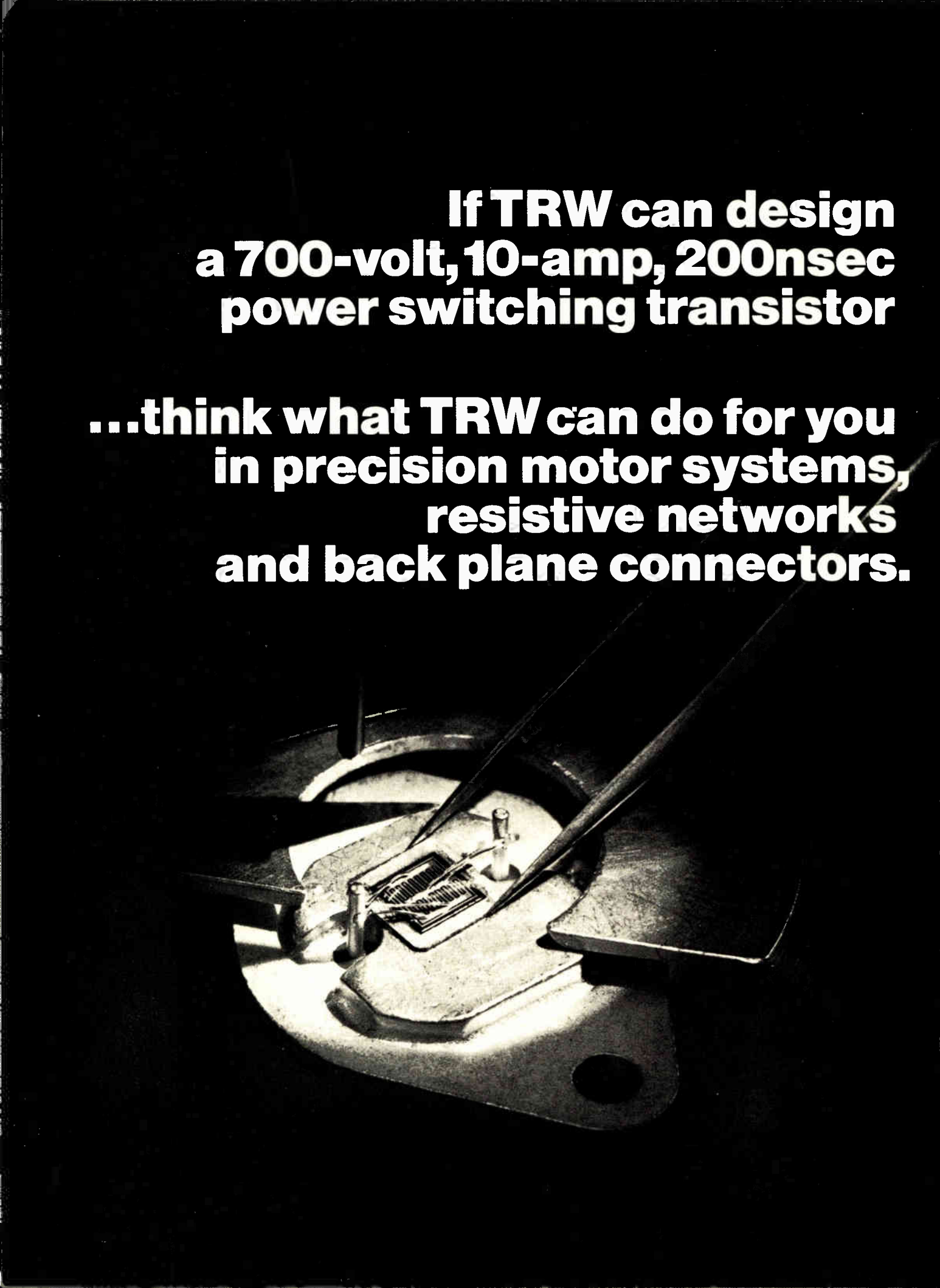

TRW's SVT 7000 Series power switching transistors have a pulse energy rating of 4.5 KW for 100μsec. They make significant size, weight and cost savings possible in such designs as off-line power supplies and power modulators. Microwave and mobile transistors, hybrids, high speed diodes and microelectronic power amplifiers are some other areas of TRW's advanced semiconductor technology. (For more information, circle 214 on the reader service card.)

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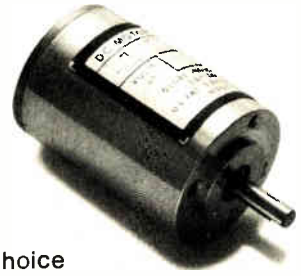

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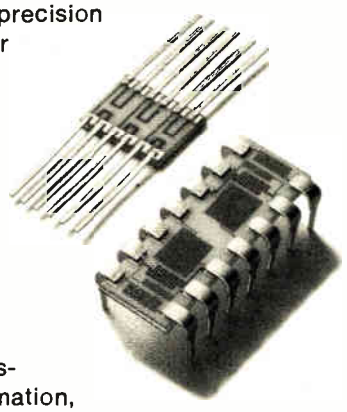

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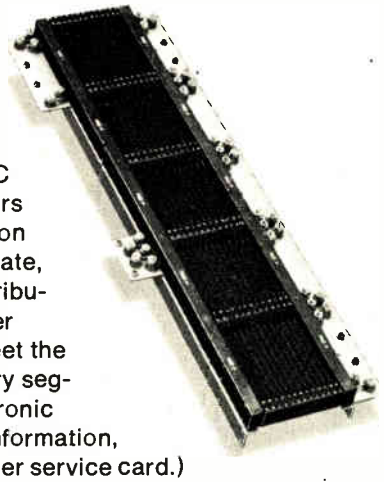

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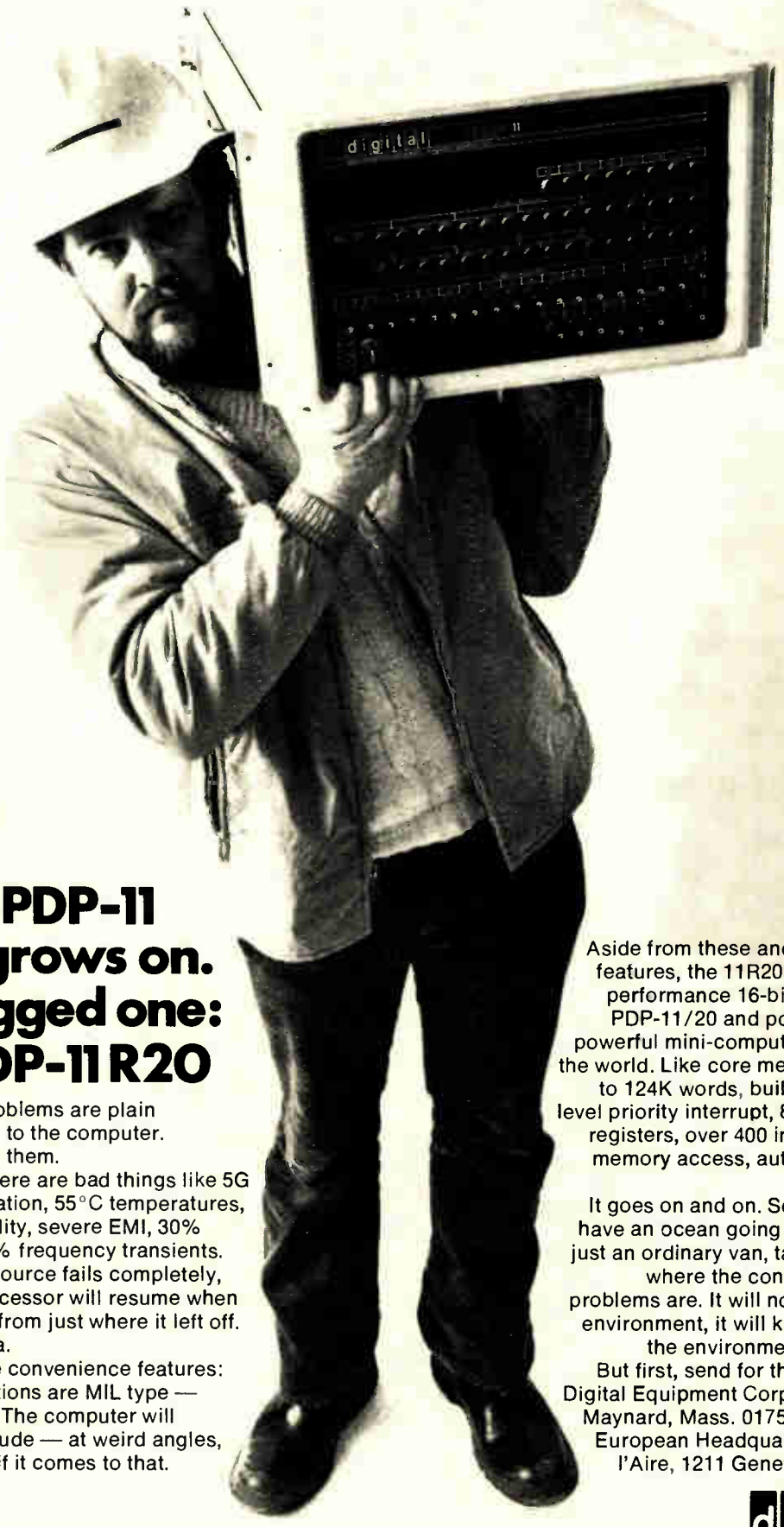

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digital

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Washington newsletter

Laird lays the groundwork for new F-14 contract

Defense Secretary Melvin **Laird has given the first public hint that the Pentagon will rewrite Grumman Aerospace Corp.'s controversial contract for the Navy's F-14** Tomcat fighter, confirming lower-level defense reports [*Electronics*, April 10, p. 57]. Laird says he will wait until final appropriations action in the House and Senate and then write the conference committee. which was set up to adjust differences in the two bills, asking for **removal of the present contract's requirement for the purchase of 48 more planes.** At the same time, Grumman sources say the company will back off a bit from its refusal to accept a new award under the existing terms [*Electronics*, March 27, p. 48].

These actions are seen in Washington as paving the way for a rewritten contract authorizing fewer planes at a higher unit price. **Also expected is a switch to the F-14B model** based on the more powerful engine that McDonnell Douglas uses for the Air Force F-15.

FAA and Raytheon both attacked over en-route ATC

The Federal Aviation Administration is under Congressional fire again for its $117 million purchase of Raytheon Co. display equipment for the en-route air-traffic control system, and both may face grilling in public hearings over the matter. Jack Brooks (D., Texas), chairman of the House Government activities subcommittee and a frequent critic of the FAA, **charges that "Raytheon has yet to provide the Government with a completely acceptable production model** of the unit" and "despite Raytheon's bad performance, the FAA has awarded the company additional contracts for display units." **The FAA contends the program is now up to snuff after some delays** [*Electronics*, April 24, p. 74]. Raytheon officials could not be reached for comment.

White House study backs aerospace development

Avionics and airframe manufacturers would get a boost from proposals in a White House study that recommends bolstering the sagging aerospace industry against increasing foreign competition with Government-backed development and production money. Expected out by the end of the year, **one proposal would aim to make funds available for the increasingly expensive development of new airliners** to compete with foreign Government-financed craft. A large U.S. share of new airliners **would help domestic avionics companies.** Among the ideas being studied are a Government loan agency, Government-guaranteed loans, or investment credits.

French missile licensed for U.S. production by NR

Chances that the French air defense missile Crotale will enter the Army inventory have been enhanced by the licensing of North American Rockwell Corp. as U.S. manufacturer by Thomson-CSF, the missile's developer. Crotale has successfully completed one round of Army tests. following a Defense Department mandate to search for economies by looking at already developed foreign technologies before undertaking new domestic R&D programs [*Electronics*, Dec. 21, 1970, p. 39]. Crotale is **one of three European tactical air defense missiles being evaluated by DOD.** The others include the British Aircraft Corp.'s Rapier. for which United Aircraft is U.S. licensee, and the West German Nord combine's Roland [*Electronics*, March 29, 1971, p. 31].

The changing pattern of world competition

Significant changes in the way the American electronics industry conducts its business are brewing in the capital. And they all involve more Federal support instead of more free enterprise.

None of the changes will come overnight, but they are worth noting here because their very consideration by a group of about 30 major manufacturers surveyed by the Department of Commerce reflects some remarkable shifts in management thinking. With the industry running scared as its share of an expanding world market declines in the face of tough competition from the likes of Japan and West Germany, American manufacturers are anxiously looking for ways to improve their exports, their technology, their productivity and, of course, their profits. The Nixon Administration is searching, too. And that is what the Commerce Department's confidential survey is all about (see p. 53).

Praise for the stew

The document's all-inclusive nature has drawn both praise and criticism from those in industry who have seen it. But considering that it professes to be nothing more than a "working draft," a base on which to build something more solid, it deserves more of praise. Beyond analyzing the state of the U.S. communications and electronics industries, their relationships with the Government and a wide sweep of manufacturers' opinions thereon, the report also summarizes well the policies of Japan, West Germany, France, Canada, and the United Kingdom, which support their domestic electronics and telecommunications industries. "It's a bit like putting together a good stew," observed one company man of the Commerce Department's problem in preparing the report. "They have assembled all the right ingredients: everything that can be said about the subject of communications and electronics and world trade is there. The only things anyone can quarrel with are the proportions."

What comes through most strongly from the report, however, is the call by the manufacturers surveyed for direct and indirect Federal support of commercial research and development to bolster lagging electronics exports. In communications and electronics other than computers, the U.S. has seen its annual trade balance erode from a $161 million surplus in 1967 to a $571 million deficit in 1971. And though imports rose from 4.3% to 9.5% of U.S. consumption in the same period, exports continued to grow through 1970. It was at that point—when exports slipped $111 million in 1971 to $1.5 billion and when telephone and telegraph equipment recorded its first negative trade balance—that industry began to respond to Government's inquiries and search for solutions.

Changing priorities

With the Federal Government now apparently responsive to the need for development of a U.S. "game plan" for trade in electronics and other high technology industries, it is intriguing to see the Commerce Department now conceding that much of America's problem lies with its heavy investment of its best technical talent in defense and space programs at the expense of commercial and industrial systems.

The view at Commerce is that the U.S. needs "to increase both the quantity and quality of commercial product development, rather than accelerate pooling of research and development" as in Europe. What the agency suggests instead are more stimuli such as "tax writeoffs, tax rebates, development loans, industry development associations" for competition overseas and similar supports.

The pace of change

Manufacturers not only support these goals, but a surprising number of them also recognizes that the U.S. no longer has a monopoly on useful technology—and they suggest that companies can profitably license more foreign technology for domestic consumption. Beyond licensing, however, the pace of change is likely to be slow when it comes to all the legislative and attitudinal changes that would be required to produce the large-scale Government and industry cooperation envisioned in the Commerce Department paper. Indeed, that hurdle is acknowledged to be the biggest by the Commerce Department itself, and indicates why its efforts at deriving a new national policy are still in the working paper stage.

The broad scope of changes suggested by manufacturers—particularly those urging direct support of commercial product R&D—run contrary to what most of the public believes has long been the pattern of national industrial development in the U.S. Nevertheless, such changes were effected in the defense and space industries some time ago. Whether or not they can be carried further is still to be determined, of course, but in any event they are not likely to come quickly.

—Ray Connolly

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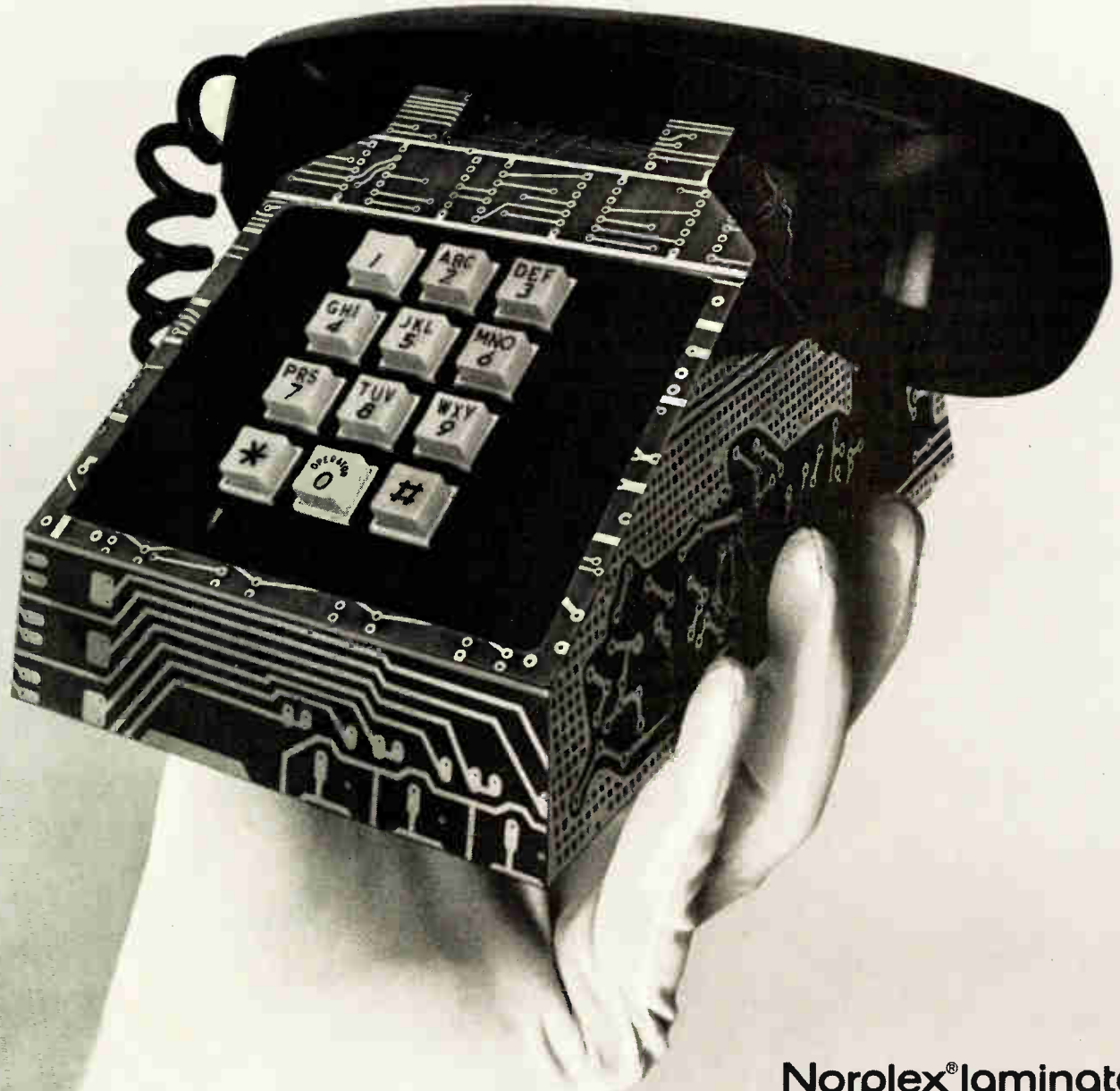

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Japanese companies work on TV slide transmission systems

Several Japanese electronics manufacturers are developing equipment to expand the utility of home television receivers by transmitting single-frame still pictures—in series, if desired. A station established to broadcast slides could offer tens of channels to provide a variety of information services, such as a continuously updated newspaper, with a column being transmitted over each channel employed.

Although efficient transmission of slides presents no great obstacles, further work may be needed to obtain the low cost and high reliability necessary in home receiver adapters. Government licensing of such broadcasts, of course, is also a necessity.

Thus far, Sony Corp. has developed and patented a slide transmitting and receiving system. Matsushita Electrical Industrial Co. has a system for transmitting individual pictures over telephone lines. Sanyo Electric Co. claims to be working on a system to display still color pictures. Hitachi Ltd. plans to start marketing a black-and-white system in August.

NHK System. Now, the Technical Research Laboratory of Nippon Hoso Kyokai (NHK), Japan's public-service broadcasting company, has developed an experimental system that relies on a plastic disk at the receiver.

Since the Japanese and American standard TV stations transmit 30 frames a second, 30 separate slides can be broadcast in one second. But even one second is too short a time to comprehend a slide; 10 seconds is a more reasonable period for viewing, and this is sufficient time for transmission of 300 slides.

The experimental NHK system uses a 10-second repetition rate, with approximately one-third of the time used for transmission of slides and two thirds for transmission of voice. This gives a theoretical capacity of 100 separate channels for slides, but researchers opted for wide buffer margins and thus set a capacity of about 80 slide channels. For the remainder of the two-thirds of each 10-second period, voice to go with individual channels is transmitted by four-level pulse-code modulation.

The most important component in the receiver adapter is a magnetic memory with a capacity of one or more TV frames. A rotating disk memory with a capacity of one frame would be sufficient to record one of the picture channels and display it continuously for 10 seconds until the next frame is transmitted. The experimental disk unit developed by NHK uses a plastic disk plated with cobalt-based magnetic alloy and a magnetic head that floats a fraction of a micrometer above the disk. □

Sweden

Mobile radio moves around

A mobile-radio transceiver that's really mobile has been introduced by Sweden's AGA. The compact radio, which weighs only 3 pounds, plugs into a variety of support units without removing screws or connections. Thus, the radio can be shifted from one vehicle to another in a fleet—or even turned into a portable by being slipped into a 14-lb carrying case, which holds battery, speaker, microphone, and antenna.

Despite the radio's compactness, AGA says, it contains most of the advanced features available in mobile radios. It offers 6 or 12 channels, in a frequency range of 68.0 to 87.5 megahertz. Maximum bandwidth is 1.2 MHz. The entire IC circuitry is on one circuit board, but there is space in the unit for additional "systems circuits," which can be ordered as optional.

These optional features include one that will automatically switch off the regular fm radio signals—received from the Swedish Broadcasting Co.—to allow a voice call to come through. It also offers a semi-automatic or automatic channel selection.

The radio operates from 10.8 to 33 volts; it needs 80 milliamperes for receiving and 1.8 amperes for transmission. The radio has a standard 10-watt output, but it can be equipped with an extra amplifier, intended primarily for use when carried outside, that can increase this to 50 W. Because of the broad operational voltage range—there's even an attachment for use in 6-V systems—the unit can easily be transferred from one vehicle to another. □

Modular. Mobile radio can be removed from vehicle, slipped into portable 14-lb power and support pack.

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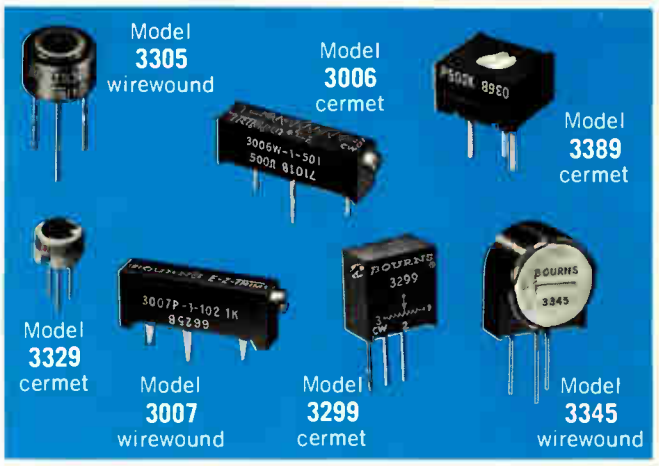

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International newsletter

ICL to get $35 million in Government support

The British government will pump $35 million into International Computers Ltd. in the 18 months ending in September next year. **The funds will support R&D work connected with ICL's new computer range, due for announcement within the next two years.** This is nearly 2.5 times the average annual rate of direct government support for ICL's R&D over the last four years, and probably about 35% of ICL's expected R&D investment in the 18-month period. Though a smaller sum than many had expected, **it indicates that the government intends to see the new range properly launched.** Providing further support is something the government will decide when the time comes.

The government's obvious seriousness throws cold water on the tentative plans of Burroughs Corp. to bid for control of ICL in the open market—the government holds 10% of ICL stock and the right to veto foreign control. However, it does not rule out a substantial minority holding in ICL by a U.S. company—an idea being developed by Univac—provided control remains in Britain. The big attraction of ICL is its sizeable market base—it holds about 38% of the British domestic computer market. Several years of talking with Continental computer makers has done almost nothing to make ICL part of a pan-European computer industry. **Thus the government seems to be looking more seriously at the possibility of linking the company with an American or even a Japanese computer maker** as a means of expanding ICL's world market—and phasing out continuous government support.

European sharing in post-Apollo is in doubt

Chances of European nations taking up NASA's invitation to take part in post-Apollo space work are growing very thin. European enthusiasm has dwindled as NASA has spelled out what it would want Europeans to do, which is—to quote British Prime Minister Edward Heath—"limited to what one might describe as normal technology." **Without a significant share of the advanced work, European governments find it difficult to justify the expenditure of public money.** In a last effort to retrieve the situation, new talks with NASA will be held and the outcome considered at a meeting of European space ministers in September—this meeting replacing last week's cancelled meeting in Brussels.

$66—a new low calculator price

A Japanese supermarket chain, Dai'ei Inc., has just started selling a personal eight-digit, no-memory calculator with a price tag of $66. a new low. The calculator, made by Crown Radio Corp. uses a single LSI chip from Texas Instruments. The extremely fast pace of price cuts is shown by comparison with a similar Crown eight-digit, no-memory calculator, also using a TI LSI chip. Dai'ei started selling that one in February for $89.33.

Dai'ei, though, has not been all alone in pushing down the price of calculators. For the past several months the lowest-priced calculator on the market has been a private-brand model made by Sharp Corp., and sold under the Kokuyo brand. It was introduced in June at a list price of $81.67. This calculator uses a one-chip standard LSI made by Hitachi Ltd. **Meanwhile, Ricoh Co. has started selling a 10-digit calculator with memory and printer for $199.33, which is a new low for calculators with printers.**

International newsletter

Boom times start again in West Germany

After a lackluster 1971, West Germany's electronics industry is bouncing back with a strength reminiscent of the boom years during the late 1960s. The star performer is the communications sector, which, according to the industry association, scored a 31% growth in production during the first quarter of this year compared with the same period last year. The growth figure for the data processing sector is 20% and that for consumer electronics 12.5%. As a result, plants around the country are working at near capacity. **Incoming orders, a leading indicator of prospective activities, are also on the upswing,** suggesting that production will continue strong throughout the year. Especially optimistic are color TV set makers, who expect production this year to climb to 1.1 million units, an increase of more than 25% over 1972.

Japanese plan to restrict calculator exports

Calculator exports to Europe during the year that started July 1 will be limited to a 20% increase over calendar 1971. This restriction will apply to all exporters, not only to members of the Japan Machinery Exporters Association. Actual control will be maintained by the Ministry of International Trade and Industry. Licenses for export of personal calculators—those without memories or with 12 or fewer digits—will be issued to exporters on the basis of their exports during the 1971 base year. Licenses for business calculators will be granted on a first-come, first-served basis.

Meanwhile, members of the Japan Machinery Exporters Association say they will try to hold exports of calculators to a 40% rise over calendar 1971—on a voluntary basis. They will also try to hold the line on prices, but one manufacturer says prices will probably be allowed to float for a while, and then restricted at a lower level.

Britain replacing VOR beacons

Britain's Civil Aviation Authority will start replacing the 43 conventional VOR beacons in the U.K. by doppler-VORs in the fall. The doppler-VORs are less site sensitive, appreciably improve angular accuracy and bearing stability, and require much less inspection and maintenance, which it's expected will more than compensate for their higher initial cost. The first five systems will be supplied by West Germany's Standard Electrik Lorenz and the next 10 by Plessey Co. to a new design. All are solid state, and the SEL equipment is alternate sideband, the Plessey gear double sideband with a capability of including an fm reference as well as the normal am reference. **In addition to the replacement program, some new sites will be added, making about 50.**

Bosch ignition systems hit million-unit sales

Initial problems with reliability notwithstanding, the electronic fuel injection system marketed by West Germany's Robert Bosch GmbH in 1967 is proving quite a success. **Since that time, the Stuttgart-based automotive accessory maker has built 1 million of its Jetronic systems for the world market.** The firm expects sales to accelerate as more and more car makers introduce it on their new lines.

So far, 17 car models by nine European automobile manufacturers are Jetronic-equipped. The first cars to use the system were Volkswagen 1600 models destined for exports to the U.S. The developers say the exhaust-gas standards that can be obtained with the system are far better than the minimum limits legally set forth in the U.S. and Europe.

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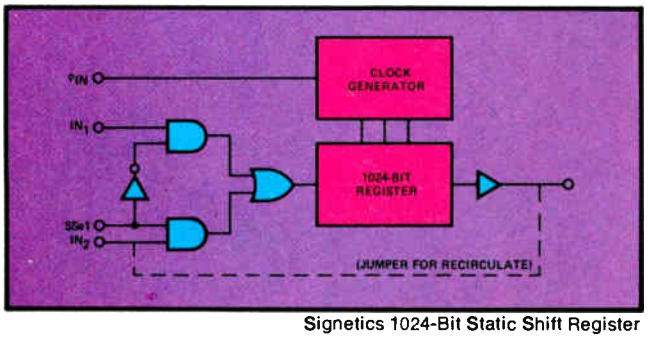

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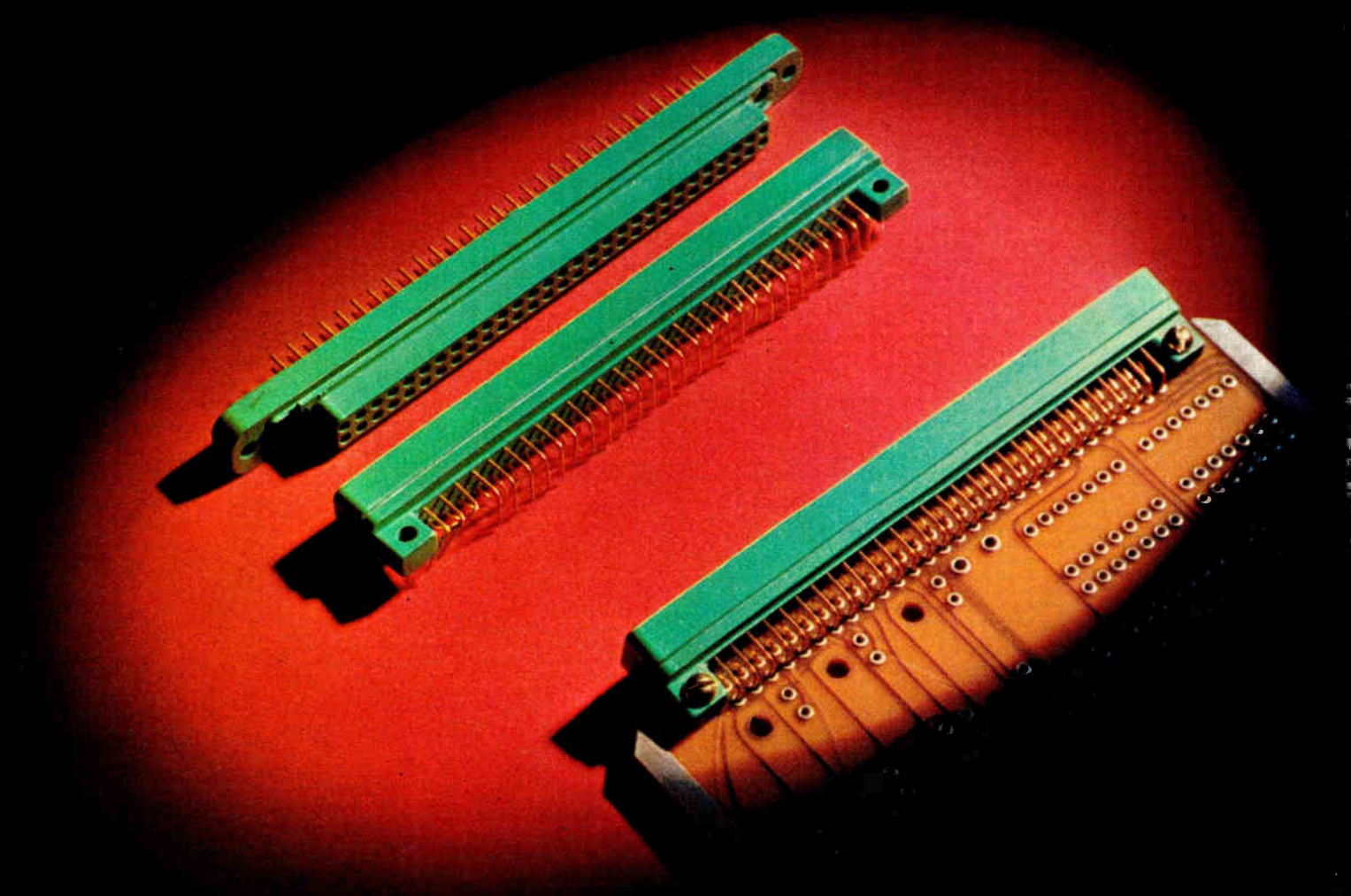

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Industry asks Federal export aid

A confidential Commerce Department survey highlights requests for commercial R&D support and tax laws that will promote sales abroad

by Ray Connolly, Washington bureau manager

If the United States expects its electronics industry to retain world leadership and effectively compete for commercial communications and electronics business, the Federal Government is going to have to pay for it. This is the conclusion to be drawn from a confidential Commerce Department working paper based on a survey of 30 of the largest American electronics companies.

Twenty percent of those companies rate "more Government funding and incentives for commercial product research and development" as industry's most significant need. The second most significant need, according to 15%, is "tax laws and regulations to provide more financial incentives for industrial modernization and exports" from domestic plants. Also stressed were: easier antitrust regulations to permit joint corporate efforts in overseas sales through establishment of consortiums; less Federal emphasis on small business support of non-competitive companies; increased subsidies and grants; plus development of a "national 'game plan' for electronics and telecommunications industrial development and world competition."

The 72-page study was drafted by the department's Bureau of Domestic Commerce "at the request of the President's Adviser on Technology," explains a cover statement. Titled "International Export, Technology and Productivity Enhancement Programs and Policies," the "working draft" was prepared by the bureau's Communications-Electronics division, which is headed by Thomas Z. Corless.

Corless says the study was completed about mid-May and is being updated regularly for the office of Presidential adviser William Magruder. He explains that the 30-company survey was made possible by the assistance of the telecommunications committee of the National Export Expansion Council, a Government advisory group made up of top industry executives. No substantial changes have been made since the document was prepared.

Big firms chosen. "The companies selected," says the report, "were

Ma Bell at home—and abroad?

Western Electric Co., AT&T's captive manufacturing arm, "with a capacity to outproduce any foreign manufacturer at competitive prices, should be encouraged to enter the export field." That is one controversial U.S. industry recommendation contained in the Commerce Department survey to develop views on how the country's communications-electronics industries can better compete abroad.

When asked about the recommendation, an AT&T spokesman said the company's top management is unaware of the report and could not comment. However, he added that he was puzzled by the report's failure to indicate how the company could compete overseas without violating a 1956 consent decree with the Justice Department. AT&T at that time agreed not to sell equipment to companies outside the Bell System.

"Bell Telephone Laboratories, the world's largest telecommunications R&D facility, make their findings available to all nations at the same time," observes an unidentified U.S. company in the study. "Thus the availability of U.S. R&D to other nations and their rationalization programs permits them to concentrate on selected segments of our markets, both in and outside the Bell System. This is particularly apparent in switching and specialized microwave areas where foreign interests have established U.S. assembly facilities during the past year."

In 1971, the U.S. posted its first trade deficit in telephone and telegraph equipment, recording a negative balance of $18 million as imports rose to $79 million on increased imports from Japan while exports dropped $14 million to a level of $61 million. The 1970 surplus was nearly $20 million [*Electronics*, June 5, p.52].

Perhaps, for example, Western Electric Co. participation in a U.S. consortium might have bettered American chances of winning a Venezuelan telecommunications system bid if the company could have provided the 170,000 handsets needed, noted one industry source commenting on the report. On the other hand, he added, "If Western were able to move into the export market and tried to do so, I suspect they would have every public utilities commission in the country on their back, complaining that they have no right to export when they are having trouble meeting domestic demands." Nevertheless, the industry recommendations in the draft document confirm reports that the National Export Expansion Council will push allowing the AT&T manufacturing arm to compete abroad [Electronics, June 5, p. 57].

predominantly large U.S. international corporations with extensive experience in foreign production and trade, chosen to provide a good product mix" in communications and electronics other than computers. The participants were not identified. Though noting that industry cooperation was "excellent," the report tries to soften its conclusions by adding that "there was a considerable divergence of opinion in their evaluation of foreign technology and productivity measures, the effectiveness of present U.S. programs, and what additional actions the U.S. Government should take" to increase American industry's competitiveness. Nevertheless, the agency said its assessment of industry's views is "a consensus with an occasional 'minority opinion.' "

American industry's biggest problem is not technology or its dissemination, says the document, but the "translation into relatively mundane commercial products at competitive prices." Japan, it notes, achieved its great consumer product success "based on relatively simple technology." Yet the study also cites another industry need—Federal support for export promotion that is "equal or better" than that of competitor nations.

An American MITI? Japan comes in for the heaviest emphasis in the report, because its government-industry electronics programs have been "far more successful," and because that country "appears to pose the greatest long-term competitive threat" to the U.S. In fact, the overall tone of the study "sounds like it wants to fight fire with fire and counter Japan by setting up our own MITI," comments one industry official who has seen the document and its detailed treatment of Japan, its Ministry of International Trade and Industry (MITI), and national electronic industries development statutes such as Law 17 [*Electronics*, May 8, p. 29].

Other sources concur in this view, despite the caveat in the study that it is "totally impractical in the U.S." to achieve the close government direction and control of industry that exists in Japan. Indeed, that disclaimer is itself rather halfhearted, for it is followed by the observation that some of Japan's economic incentives for electronics development—tax write-offs, rebates, development loans, and industry teaming—might be employed by the U.S. if it could get "substantial changes in legislation, including antitrust; national priorities, business attitudes and practices; and Government-industry relations." The report does conclude that "greater Government tolerance of industry mergers to remain internationally competitive might be in order."

Besides focusing on Japan, the study is believed the first to describe and contrast in a single document the government-industry relationships in electronics practiced in France, West Germany, Canada, and the United Kingdom.

Comments attributed in the report to "the president of a large U.S. electronics firm" contend that Japanese and European policies are very similar. They "preserve for their domestic [electronics] industries maximum access to demand within their countries to support full production . . .; augment the production stability of home industries through significant export incentives in the form of total remission of internal taxes; strengthen the competitive appeal of their products in export trade through government subsidization; weaken the U.S. industry by a rapid penetration of the U.S. market . . .; and systematically use unfair methods of pricing" their exports to the U.S. in the knowledge that countervailing duty and antidumping statutes are seldom enforced.

Impediments. Asked to comment on U.S. policies and recommend changes, companies responded vigorously. Varied industry recommendations dealt with in the report included:

- Commercial R&D. Without a program of tax credits or outright grants leading to hardware "or a resurgence in the NASA or DOD programs, the U.S. will soon (within three years) cease to be the source of advanced technology."
- Standards. Increase Federal support of U.S. voluntary standards activities as other nations do, and strive to achieve compatibility between the International Telecommunications Union standards and those of the Bell System so that the U.S. doesn't cut itself off from the world telecommunications market. "The cost of this changeover is enormous and needs Government support" if the U.S. is to compete successfully in expanding world markets.
- U.S. planning. "Most Federal programs try to satisfy too many goals with the same program"—they may try to increase exports, cut unemployment, and aid small business and underdeveloped nations all at the same time. Another criticism noted that American assistance to industry is "too often reactive rather than positive," as in nations like Japan.
- Restrictions on exports. Complaints were made about unilateral controls on exports to Communist Bloc countries and Pentagon sales from stockpiles that compete with U.S. companies, plus overly strict interpretation of military content of hardware for joint civilian/military uses such as air traffic control systems. The State Department's foreign service was criticized for failure to support overseas sales efforts. And Governmental failure to negotiate nontariff barriers to U.S. products was mentioned, as well as its noncompetitive financing arrangements for exports—again as compared with aid provided by competing governments to their industries.

Divided mind. Reaction to new U.S. programs such as the Joint Export Association and formation of domestic international sales corporations (DISCs) was mixed. The DISC concept [*Electronics*, May 8, p. 65] only "helps large exporters," according to one industry view quoted. "Lots of paperwork and monitoring reduces practical benefits to most companies."

On the other hand, comments on the JEA program urged its orientation to "emphasize large projects" for large returns; "help large companies who can significantly expand exports, not small firms who could triple their volume and not have large volume." How best to help the large companies? "Give grants, not loans," says a manufacturer quoted in the report. □

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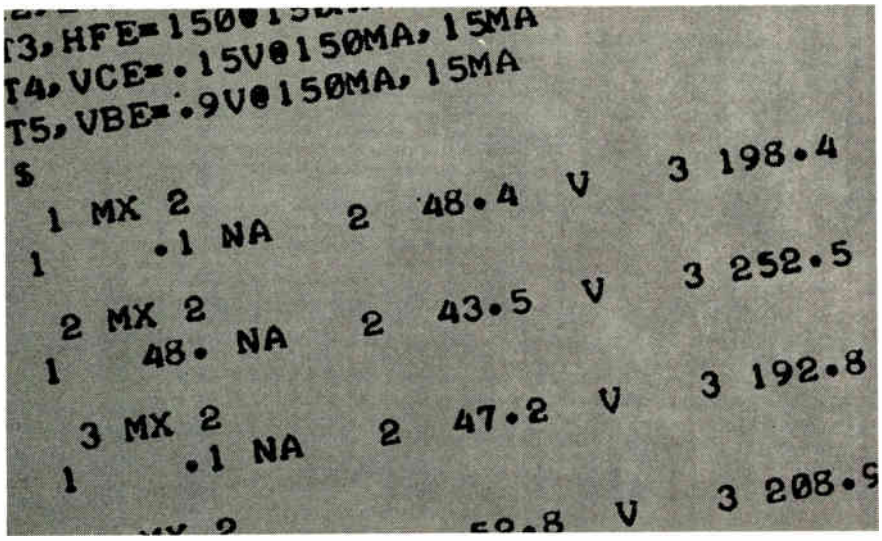

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Government

Anti-skyjacking effort held up

Who enforces and who pays for equipment—the airlines or the Federal Government—is hotly argued as funding of effective countermeasures drags

by William F. Arnold, Aerospace Editor

Arguing by the airlines and Federal Government over who's responsible for preventing skyjacking is diverting a national program from its goal: a quick halt to air piracy. But as the wave of skyjacks has escalated into high ransoms and high-flying political acts, there's a push to put that program rapidly on course. And electronic gear is being advocated—by equipment makers and potential buyers—as part of a solution.

The big disagreements are over who should direct the necessary law enforcement and who should pay for the electronic detection gear. What's more, a truly national program can't get off the ground until some airlines abandon their "it can't happen to me" attitude.

Who's responsible? J. Floyd Andrews, president of Pacific Southwest Airways, San Diego, Calif., believes the Federal Government should take responsibility for airport security. PSA was victimized twice earlier this month by skyjackers. Two were shot to death by FBI agents in a July 5 attempt and a passenger also died in the shootout.

John Shields, who runs Eastern Airlines' successful anti-skyjacking program as manager of operational safety, agrees with Andrews. "The Federal Government should take over total law enforcement support on the ground," says Shields, a former Marine Corps colonel. He urges that the Federal Aviation Administration formulate the policies, the Justice Department enforce them, and the Government buy the needed electronic equipment, an idea shared throughout the airline industry.

The Government contends otherwise, however. "The present Administration would like to back off as much as possible from law enforcement," says one official charged with stopping skyjacking. He adds that "the FAA can set up specifications for the types of equipment, but it's up to the airlines to screen their own passengers and operate the equipment at their own gates."

Since most airports are under local law enforcement control, the official continues, airline passengers "should get the same police protection that citizens downtown get going to a concert." The airlines contend that Federal law enforcement officers are better trained than local police.

As this impasse has developed, the character of skyjacking has changed from "a free ride to Cuba to extortion and cold-blooded political tactics," in the words of James P. Jaquet, vice president of Infinetics Inc., Wilmington, Del. His company and Schonstedt Instrument Co., Reston, Va., sell most of the magnetometers to airlines. Besides hitting at the FAA, airlines have asked Congress for money because "the biggest problem is the lack of equipment," Jaquet says.

Congress is deliberating between spending $2 million or $3.5 million to buy 800 more magnetometers to augment the some 350 already in use and reimburse airlines that already have purchased them. Both Infinetics and Schonstedt estimate that this will saturate the country.

Overall, though, Congress hasn't paid much attention to the skyjacking problem because "Congressmen assume that the appropriate committees and agencies are doing the job," says one key Capitol Hill staffer. Two bills to require—and fund—passenger screening devices at all airport gates are tied up in committees with little action imminent. Furthermore, the aide says, FAA administrator John H. Shaffer "has told Congress that he's not in favor of the Government buying the equipment."

Some action. Spurred by the recent wave of skyjackings, the FAA plans a crackdown where security is lax (see panel).

James T. Murphy, the agency's director of air transportation secur-

Probing look. Contents of attaché case are viewed on TV display of X-ray picture taken by Bendix machine. FAA plans more rigid baggage screening as part of crackdown.

Carry-on luggage ban hinted

To check the chances of guns or bombs being carried aboard airplanes, the FAA is turning tiger over carry-on baggage. In mid-June it asked the airlines' trade group, the Air Transport Association, to "immediately and effectively" take steps to ban the use of carry-on luggage by skyjackers.

"If they don't, we'll regulate it," says James T. Murphy, the agency's air transportation security director, sternly hinting that the agency might ban carry-on luggage altogether. Murphy insists that, at the very least, any bags carried onboard will have to be individually inspected and sealed, and unsealed onboard only in the presence of a flight attendant. He says carry-on baggage was used to conceal weapons in over one-third of the skyjacking attempts in the last three years.

Moreover, the FAA is going to "start slapping fines on airlines that don't screen properly," says Lowell L. Davis, civil aviation security chief for the Department of Transportation. By "properly," Davis says he means "every flight, every gate, 24 hours a day."

Further, the agency is turning to new technology for improved screening of passengers and baggage, says FAA's William C. Richardson, chief of the Airport Systems Development Branch. The agency is testing a Westinghouse Electric Corp. computer-assisted active-field weapons detector at Dulles International Airport near Washington, D.C. Two contracts also will be let for two X-ray baggage inspectors, one using gamma-ray backscatter and the other using fluorescence. The agency is also looking into explosive vapor detectors [*Electronics*, Feb. 28, p. 34], but Richardson says his entire R&D budget is only $350,000 a year.

ity, details the FAA's current but enlarging security measures. All passengers—"every shift, every flight"—will be screened at the nation's 531 airports. Security will be tightened at the 87 airports which handle 90% of all air passengers.

But, the Federal role is declining, he says. The number of customs agents will decline from 1,500 to 625. As to actually supplying equipment, the agency's basic position hasn't changed. However, it will "pay for developing the technology and carry the weight of the research and development," says Murphy.

First steps first. Government and private security men agree that the potential skyjacker must be stopped from getting on the plane in the first place. To do this, three elements are needed: the use of psychological profiles to spot a potential skyjacker, electronic detection equipment to pinpoint guns or bombs, and quick law enforcement reaction to apprehend the suspect, once discovered. To this proven formula, the FAA's new security regulations also charge the airlines and airports with baggage, cargo, and aircraft security.

The formula works. Murphy says that 2,000 people have been stopped from boarding during the first four months of this year. Eastern Airlines stringently applied the formula earlier, spending $2.6 million on magnetometers and law enforcement. In 1969, the airline had one-third of all skyjackings; this year it has had only one out of more than a score.

And, "the technology is there" for more accurate and more automated systems, says a spokesman for Pan American World Airways, which spends $1.5 million a year for its successful anti-skyjacking program. "Some pretty sophisticated devices can be made available, but they're expensive," he says. He puts fluoroscopic devices high on his list and says six would cover Pan Am's terminal at New York's John F. Kennedy International Airport.

A sizable market could well develop in advanced techniques to screen passengers and baggage. American Science and Engineering Inc., Bendix Corp., North American Philips Corp., and Raytheon Co. are developing X-ray and fluoroscopic inspection devices.

Just how fast these newer devices will appear is uncertain, however, because the big problem is money, security executives agree. Harry Murphy, security official for the Air Transport Association, the airlines' trade group, says "The airlines' position is that the cost of this equipment should come out of the Federal Airport Trust Fund." □

Consumer electronics

Discord in four-channel audio

Because of lack of standardization, equipment makers must build systems that can accommodate both discrete and matrix recording

by Gerald M. Walker, Consumer Editor

Audio equipment manufacturers have been forced to hedge their bets on the three-way battle being waged by two domestic industry heavyweights and one Japanese challenger because of the lack of a standard method of four-channel disk recording. The main antagonists are those traditional rivals in recording and playback—CBS/Columbia group, which is supporting a matrix system called SQ, and RCA Corp., which is backing its yet-to-be-marketed discrete approach. Electro-Voice, Buchanan, Mich., was in the four-channel race first, but has been overshadowed since the two giants entered. The Japanese incompatible is Sansui Electronics Corp., already marketing its equipment, built with a QS matrix technique.

All four are recruiting their own licensees while spreading confusion among dealers and prospective buyers of sound equipment. Caught in the technical crossfire are most audio component manufacturers.

Essentially, the discrete disk carries four channels of information in the record groove, so that sound remains separated from original source to reproduction. In matrixing, the rear-channel information is encoded onto the two front channels as subcarriers, then decoded back to four channels when reproduced. Both attempt to "fold" the rear channels into the front channels when in the two-channel stereo mode. The argument has raged over which system provides better sound, which retains two-channel compatibility more effectively, and which is more economical.

There is no problem with tape players, which are all going to four discrete channels. But for disks, confusion over which of the competing systems will prevail has forced manufacturers to hedge, so that amplifiers and tuners announced for this fall are ready for two-channel or four-channel matrix, and, in addition, are "adaptable" to four-channel discrete equipment.

The confusion extends to the recording industry as well. Columbia, in announcing the SQ recording equipment developed by CBS Laboratories, insisted that two inventories be maintained—one for two- and another for four-channel—and that the new four-channel disks sell for a dollar more than the stereo versions. But RCA officials have said that their discrete records will carry no premium price and that the same record will play on either stereo or four-channel with the aid of a specially designed cartridge.

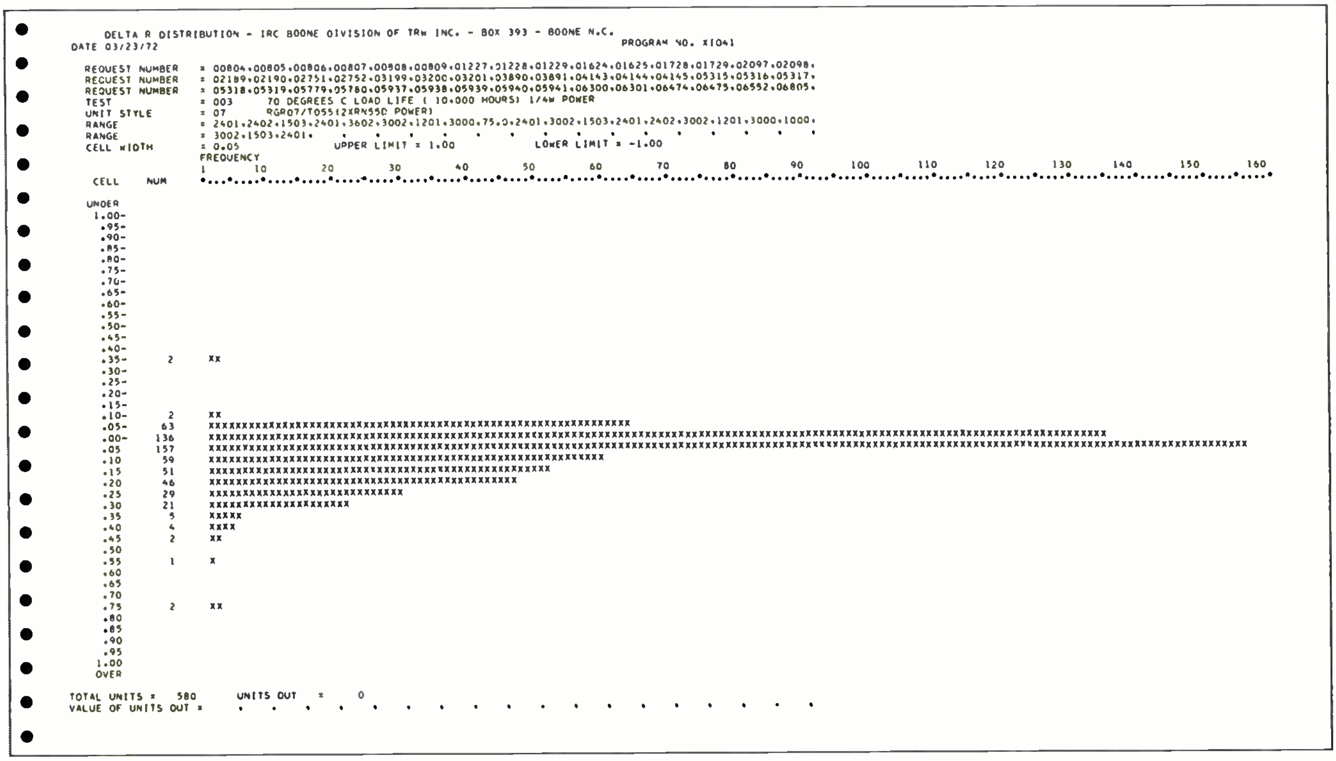
To make matters worse, no one in the components or record industry holds out much hope for standardization, although CBS and rival matrix supporter, Electro-Voice division of Gulton Industries Inc., recently agreed to exchange patent rights and technology, for a show of unity on the matrix side of the fence.

Confusion reigns. All of these factors reached a peak at the recent Consumer Electronics Show in Chicago, where the rivals squabbled publicly over who is to blame for the confusion. Manufacturers showed equipment designed to be all things to all audio buffs, and dealers moaned about their tribulations in trying to persuade consumers to buy now and play later. The lack of compatibility prompted one irate manufacturer at the show to vent his frustration: "They [RCA and CBS] ought to be locked in a room and kept on bread and water until they come out with an agreement."

There's apparent agreement that four-channel is here to stay, despite the confusion. While one major New York City hi-fi dealer has

Both worlds. Fisher's new Model 404 two/four-channel convertible a-m/fm receiver provides full-rated power from all four amplifiers in both the two- and four-channel modes.

Metal Glaze™ resistors don't drift.



The best place to control downstream circuit drift is at the design stage. Specify IRC Metal Glaze resistors. They benefit the designer and everybody else by providing six specific kinds of protection:

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claimed that 50% of his sales are already in four-channel, most industry observers estimated that quadraphonic gear will account for 10% of retail sales this year.

The consumer show underscored a new mixture of enthusiasm and caution. In 1971, the approach was to sell the consumer quadraphonic sound—twin amplifiers, four speakers, and all. This year, the angle is to sell equipment to the consumer—if he's not ready for four-channel, he plays two-channel disks and waits. As a consequence, the equipment maker has a foot planted in the two- and four-channel matrix camps and may need a third to cover both four-channel formats. And two-channel record collections will be protected, at least until enough four-channel programing is available.

Hardware hedging. A sampling of the new lines shows how cautious the companies have become. For example, after much design analysis, Fisher Radio division of Emerson Electric Co., Long Island City, N.Y., introduced its 04 line of receivers, which features a "strapping" system to make possible the use of full-rated power in either two or four channels [*Electronics,* June 19, p.36]. Thus, the user can hook up the amplifier, priced to compete with two-channel-only equipment, and hold off on jumping into four-channel gear. To ease this decision, there's a switch mounted on the front panel of each model that shifts from two- to four-channel. The line has a built-in CBS SQ matrix decoder circuit and an fm tuner featuring a new MOS FET phase-locked loop.

Concerning this "convertible" 04 line, Joseph L. Behr, Fisher's vice president for research and development, comments, "I don't know of any other design here that was studied and debated as long and as hard as this one."

Harmon Kardon, Plainview, N.Y., also has a new line of receivers that uses what it calls a "bridging" circuit to tie the front and back amplifiers together when played in the two-channel mode. The new configuration distributes the load equally to four output transistors connected as a bridge. Therefore the amplifiers had to be balanced perfectly in relationship to each other to deliver full power to the two stereo speakers. Each of the Twinpower Multichannel Models 75, 100, and 150 has a switch in the back to convert from two to four channels. This line also has an SQ matrix decoder, and all three have sound field-balance joysticks on the front panels to "place" the listener in an optimum listening position, no matter where he is seated.

The version produced by Marantz Co., Sun Valley, Calif., is called Quadradial 4. It includes two a-m/fm stereo receivers, two console amplifiers, and an adaptor-amplifier. The company is also bringing out the RC-4 remote control unit ($39.95) that plugs into the four-channel equipment by a 15-foot cord to control speaker balance, volume and on-off switching from the listening position.

Aerospace and computer-circuit-board techniques are the latest selling points in the receiver line from H.H. Scott Inc., Maynard, Mass. The two/four-channel Model 554, using the Modutron concept, straps the front and rear amplifiers in the stereo mode similar to the way Fisher and Harmon Kardon do it. As for the circuit-board concept, Scott claims that the use of individual function modules plugged into a "masterboard" that forms the floor of the chassis eliminates 95% of the discrete point-to-point wiring, reducing assembly costs through mechanization yet permitting new features to be added as the four-channel controversy is sorted out.

The big guns. Even the console stereos have moved into the four-channel scramble. Motorola Consumer Products division in Chicago, for one, has introduced a line that features four speakers mounted in single cabinets in widths from 42 to 76⅛ inches. Two-range speakers are angled upward and outward from the back or wall side of the console cabinet. If the cabinet is placed two to three inches from the wall, these speakers tend to bounce the rear channel sound off the wall and back to the listener. Rear-channel bass comes from woofers mounted to fire from the sides of the console unit. The front speakers perform as usual. The console's receiver section will accept adaptors for four-channel discrete fm and disks if and when they become available.

Nor has the stereo earphone business been overlooked in the now-you-hear-it-now-you-don't game. Koss Corp., Milwaukee, has added three new two-channel stereo/four-channel earphones to the one introduced last year. All four have two- or four-mode switches and individual volume-and-balance controls. These headsets have two drivers for rear-channel information, but when switched for stereo, the drivers are connected in parallel, doubling the bass radiating area. □

Listening to the user

Recording artists have begun to study how best to use the new sound of four-channel for both pop and classical music. One pioneer in recorded sound, Enoch Light, who heads Project 3 Records, has released records using the CBS SQ and the Sansui QS and eagerly awaits the arrival of RCA's discrete four-disk system.

His interest in four-channel goes back to 1963, when an equipment manufacturer asked him to evaluate a prototype tape player. Today, thanks to quadraphonics, Light feels that recording artists can reach the peak of reproducing sound as close to the original as possible. "I don't see how we can get much better, in a practical sense," he says.

However, like everyone else, he hopes for an early solution to the incompatibility of disks. After that, he observes, "we need a lot of cooperation between the hardware engineers and the record companies. If the engineers would just contact someone in the recording business to fool around with new equipment before it is ready for the market, to find out how it performs, and to learn how to use its best features, we could make four-channel a lot more exciting to the average listener.

"Maybe," he adds, "engineers become too interested in the specifications and not enough in what people will actually be listening to on the equipment. Four-channel requires our best efforts; fakes won't sell."

Commercial electronics

OTB is betting on prosperity

New York City's off-track betting is starting to straighten out after a spate of initial problems; limitless market opening up

by Marilyn Offenheiser, Assistant Editor

Handicapped by contractor delays and equipment malfunctions, New York's Off-Track Betting Corp. left the gate against long odds. The track to the first turn was slow and cluttered with bidders—both winners and also-rans—blaming each other for early problems.

But now the track is clearing. OTB's betting volume vastly exceeds initial estimates—$150 million was bet in the first year, although only $30 million had been expected. With the bankroll generated by that volume and the $700 million "handle" now predicted for fiscal 1972, OTB is adding contractors to extend the services in its 80 shops.

What's more, for electronics suppliers, the market's potential is huge, as officials in other areas of New York—and, when legislation is passed, in other states—approach the off-track starting gate.

Across the board. Originally, after the New York legislature approved off-track betting in 1970, Computer Sciences Corp.'s CSC Systems group, Falls Church, Va., landed the sole OTB contract for 18 initial shops, closing out 13 other bidders. But in 14 of the 18 shops, the system was not ready on opening day, and OTB began to operate manually.

Within two months, Ticketron Inc., New York subsidiary of Control Data Corp., was brought in to supply a parallel system of input terminals. Ticketron had been No. 2 in the bidding and was waiting with a backup system in case CSC had problems. Later, the field was expanded to include the American Totalisator Corp., Towson, Md., which is handling the telephone betting operation, and Conrac Corp., New York, which is putting in displays of up-to-the-minute information.

The OTB system works from a central OTB office that has an IBM 360/50 central processor tied online to terminals in every branch office. Before each race, OTB's betting data—how much bet on which horse—is sent to the tracks via punched tape, and the bets are placed in the pari-mutuel pool.

On the other hand, morning line information from the tracks—on sheets of paper—is distributed to each branch early in the morning. Last-minute changes, such as scratches or jockey replacements, may not become known to the bettor until after a race is over and the race results are posted. When that happens, he receives a refund.

Jerome Paul, vice president of OTB's computer services, says "OTB, unlike the track, is limited because the bettor cannot place his bet and receive information up to running of the race." Conrac's CRT displays in each branch will alleviate most of this problem.

In addition, for a hard-copy record of changes and updated information, OTB is in the final stages of selecting a contractor to set up a facsimile system.

Snafus. Everyone associated with OTB admits that the system was fouled up from the start, but no one is willing to take the blame. Most of the buck has been passed to the city government, with industry insiders quick to accuse the city of being in a rush to get the system started.

The result was that nontechnical people accepted modified equipment that was not really suited to OTB's needs, according to Moses Shapiro, chairman of General Instrument Corp., the parent of American Totalisator. "There should be no technical reason for failure. OTB should have used a modular, not a systems, approach that could handle peaks of work," he adds.

OTB is aware of its problems, and Paul, who has 11 years of IBM experience, including debugging of the American Airlines Sabre reservations project, was brought in last December to put the OTB system into harness. One of his first moves was to make branches compatible. Because of the use of different systems, a bettor often could not collect on a winning ticket purchased in a different shop. Paul's solution was to mix CSC's 453 and Ticketron's 376 terminals in each branch.

Looking toward the future, Paul plans some kind of automatic vendor. "Labor is our biggest economic factor," he says. "Actually the computer constitutes only about 20–30% of expenses." And to speed up operations and decrease the betting cutoff time before a race, Paul is looking into replacing the racetrack/

Race results. Bettors will soon be able to receive current race information on terminals supplied by Conrac Corp.

Probing the news

paper-tape interface with a direct core-to-core computer link. Yet another venture may be establishment of a mobile OTB shop using a mainframe from Wyle Computer Products Inc., El Segundo, Calif., fitted with a CRT terminal from Di/An Controls Inc., Boston, that includes optical character recognition.

But for the long haul, Paul intends to add a few more contractors, and then after the performance returns are in, award a contract for the whole OTB operation to only one.

Meanwhile, contractors are pointing the finger at each other. Ticketron's Jack Lagan, vice president for automated wagering, says AmTote's system is unsuccessful because of too much downtime. AmTote, through GI's Shapiro, says CSC's setup is too slow. CSC, however, does concede trouble: for example, not keeping duplicate files and slow throughput. According to John Young, president of the Custom System division, the company is successfully debugging the system. Nonetheless, CSC recently lost out on the contract for telephone betting, which went to AmTote. AmTote's Varian 620/L computers, with a 16-bit word rate, will interface with the OTB computers and will be able to give credit directly after each race.

Conrac, whose displays will work independently of those in the other OTB systems, thus far has stayed out of the storm. Its $2.8 million contract calls for up to 11 terminals to be installed in each OTB branch by the end of 1972. Conrac won out in the final competition over six other companies.

The long run. What's the growth potential for off-track betting? One industry spokesman says, "I'm afraid to give any numbers; they're so high it scares me."

So far, New York is the only state with off-track betting. Other states—Maryland and Connecticut will probably be next—are sure to go to off-track betting. GI's Shapiro calculates that "for every dollar bet on-track, two are bet off-track. So based on U.S. betting revenues, the potential for off-track betting is at least $12 billion a year." □

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V-ATE memory scores a new high in combining speed and bit density

By etching notches that fill up with one of the best insulators—air—the V-ATE process economizes on isolation space; the result is a bipolar 1,024-bit RAM, with still higher bit-densities expected shortly

by John Mudge and Keith Taft, *Raytheon Co., Semiconductor Div., Mountain View, Calif.*

☐ To get the performance scheduled for the next round of mainframe and minicomputer memories, many system designers would like to turn to bipolar devices because of their speed. But old bipolar processing methods yield arrays that are generally no larger than 256 bits on a chip, so that subsystems built with them cost much more than subsystems built with the 1,024- and 2,048-bit MOS chips.

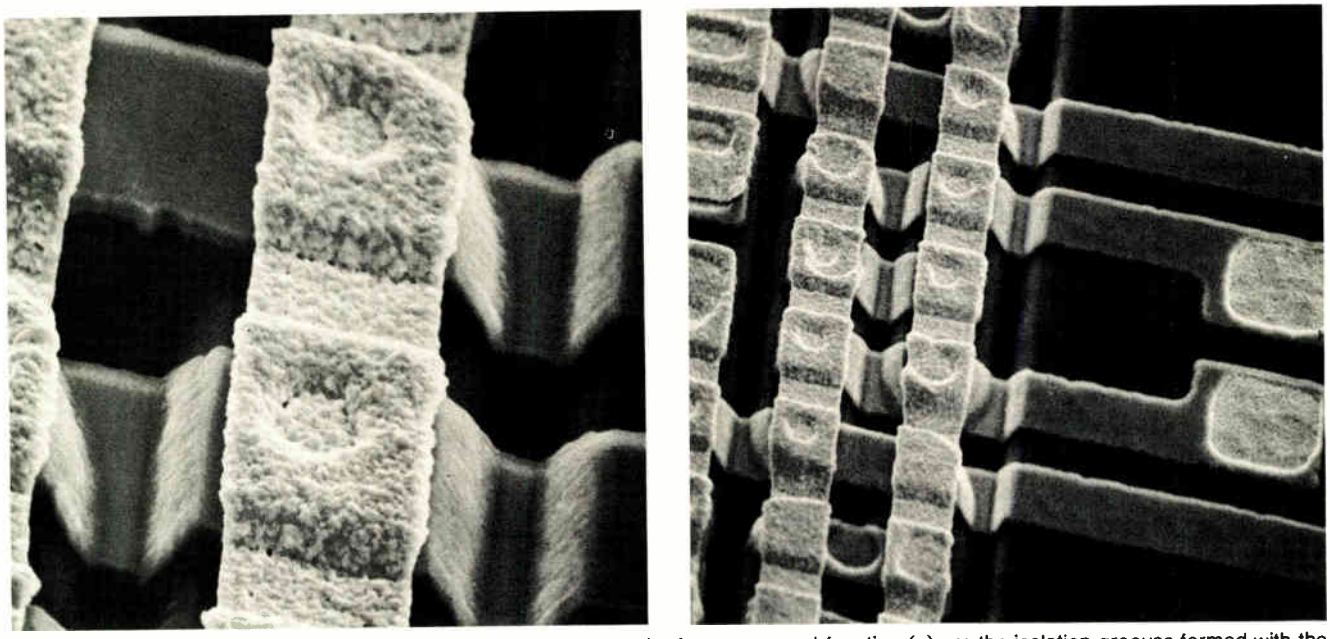
New bipolar methods are changing all this. For instance, the first memory component to go into production with the V-ATE (vertical anisotropic etch) process is a 1,024-bit random-access memory, which boasts an access time of 35 nanoseconds and a power dissipation of only 400 milliwatts. That yields a speed power product better than any similar product.

V-ATE achieves this combination of bit-density and performance essentially by reducing the amount of chip real-estate needed to isolate active devices. In this it resembles such other cell-size reduction approaches as: the oxide isolation of Fairchild's Isoplanar process; the polysilicon isolation of Motorola's VIP process; the nitride isolation used in TI's composed mask process; and Ferranti's collector diffusion isolation method. But V-ATE perhaps goes the furthest of them all in this direction: to separate devices, it relies simply on a narrow air-filled notch (air is an excellent insulator). Thus it reduces cells to about a tenth the size they are on a conventional bipolar chip, where transistors are isolated by extensive p regions.

Trading density against performance

All LSI memory designers face a basic dilemma: increasing circuit complexity always decreases speed. For, as the number of circuits on a chip is increased, the power available to any individual cell or circuit goes down proportionally—and the lower the available cell power, the longer it takes to charge the cell, the slower the cell speed, and therefore the longer the access time of the memory. Likewise, the effects of interconnect and component parasitic capacitance increase with circuit complexity, and make the delay time of the circuit still longer.

This density vs performance relationship is graphically illustrated by recent history. As the bit densities of



1. Groovy. Clearly visible in the scanning electron microphotograph of a memory subfunction (a) are the isolation grooves formed with the V-ATE process. Shown in (b) are strings of cells with double metalization and cross-overs. In the case of the titanium-platinum-gold metallurgy, note the absence of hillocks and bumps that are usually present with conventional aluminum systems.

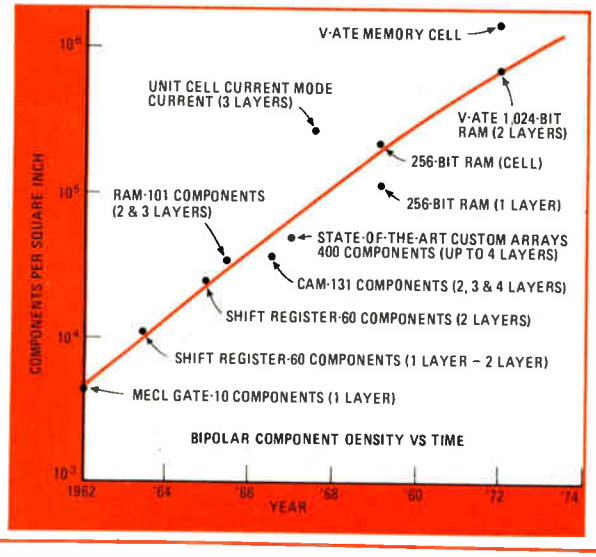
The density game: V-ATE vs MOS

Two factors enter any comparison of V-ATE and MOS memories: chip density, and system density.

Air isolation and a thinner epitaxial layer reduce the size of the bipolar circuits to a point where V-ATE chips, such as the RR5502, are no larger than most MOS memories, such as the 1103, and indeed, the density is limited only by the minimum metal spacing tolerance required to get a reasonable yield. Most important, the peripheral circuits on a V-ATE chip are much simpler than on MOS chips. There are no internal clocks to be generated, and the devices automatically interface with other bipolar circuits. Output devices capable of high fan-out are much smaller and also easy to build.

When bipolar memories are combined into a system, all this adds up to a significant bonus: fewer peripheral circuits; elimination of external clocks, precharge and refresh circuits, and sense amplifiers; and only one power supply needed for a memory system of any capacity.

As for future devices, the graph below shows the steady growth of bipolar device density since 1962.



conventionally built bipolar memories have progressed from 16 to 64 to 256 per chip, their corresponding access times jumped from 20 to 40 to 75 nanoseconds. At the 1,024-bit level, their projected access time would be 150 ns. This figure might be reduced to 100 ns by improved circuit techniques—for example, by using two-layer metalization or Schottky clamps. But even 100 ns is unacceptable for most large-scale memory applications—about 50 ns at the 1,024-bit level is what main-frame designers are now calling for. Clearly improvements in the processing of bipolar memories have been long overdue.

It's in the air

The V-ATE process is one approach to achieving adequate cell resistance and low parasitic capacitance, in addition to small cell size and high chip density. Two innovations enable it to deliver greater chip density—the passive device isolation already mentioned, and high-value resistors that occupy little chip area.

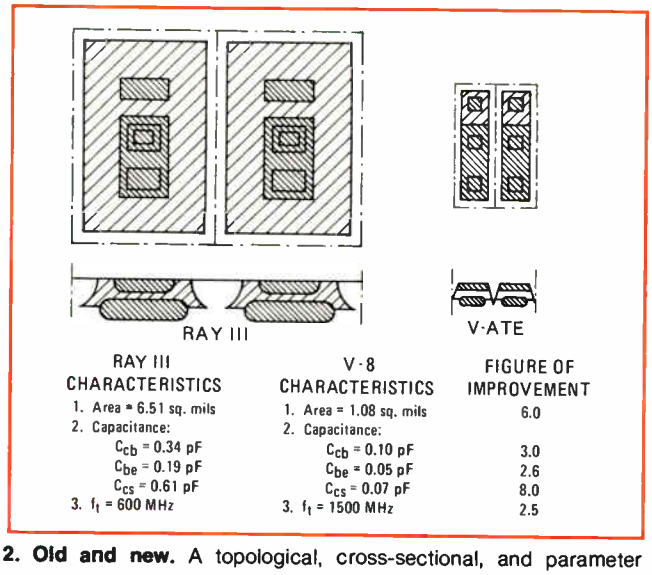
Air isolation between devices, in place of diffused-junction isolation regions, is the more important improvement. In the standard approach, a pϑ diffusion isolates the transistor from neighboring devices. But this blows up the memory cell, consisting of two double-emitter transistors and two diffused resistors, to a size of 30 to 40 square mils. Air, on the other hand, is a good electrical insulator, and also allows passive devices like resistors to be built right to the edge of the air-filled notch.

Almost all the rest of V-ATE's space saving comes from an improved method of building resistors, which in conventional devices can occupy up to 40% of the chip area. Precision etching exposes the epitaxial resistive layer, resulting in tens of kilohms of resistance in a few mils of chip area. This, coupled with the air notch, reduces cell size to only 4.3 mil^2—the equivalent of over one million transistors and resistors per square inch. Oxide isolation, another bipolar memory process that is also gaining popularity, has a cell size of about 6 mil^2 [*Electronics*, June 5, p. 41]).

Finally, another feature of V-ATE construction—two layer-metalization—cuts down on the extra space required when one-layer construction is used, besides eliminating the extra unwanted capacitance and resistance that the single layer causes.

Above standard

Figure 2 compares V-ATE characteristics with conventional bipolar characteristics—here exemplified by Raytheon's RAY III process. In every important device category, V-ATE offers significant improvement: a sixth of the transistor area, more than double the device speed, and a reduction in device parasitics of from over a half to an eighth. Yet RAY III is only a 256-bit technology, while V-ATE is an LSI technology. Indeed, V-ATE, with its two-transistor memory cell of only 4.3 mils^2, allows a fully decoded 1,024-bit bipolar RAM to be placed on a chip 91 by 125 mils—smaller than most of the 256-bit



2. Old and new. A topological, cross-sectional, and parameter comparison of the conventional bipolar technique with V-ATE shows that large areas of wasted space have been eliminated and performance has been improved with the new process.

bipolar circuits and MOS 1,024-bit RAMs now available.

To obtain the best power-delay product for the basic V-ATE design, an emitter-coupled logic was chosen. ECL, of course, does not require gold doping as do some TTL designs, where it serves to decrease the storage time of the device but tends to decrease yields. In addition, ECL makes extremely frugal demands on chip area and switching energy.

The process

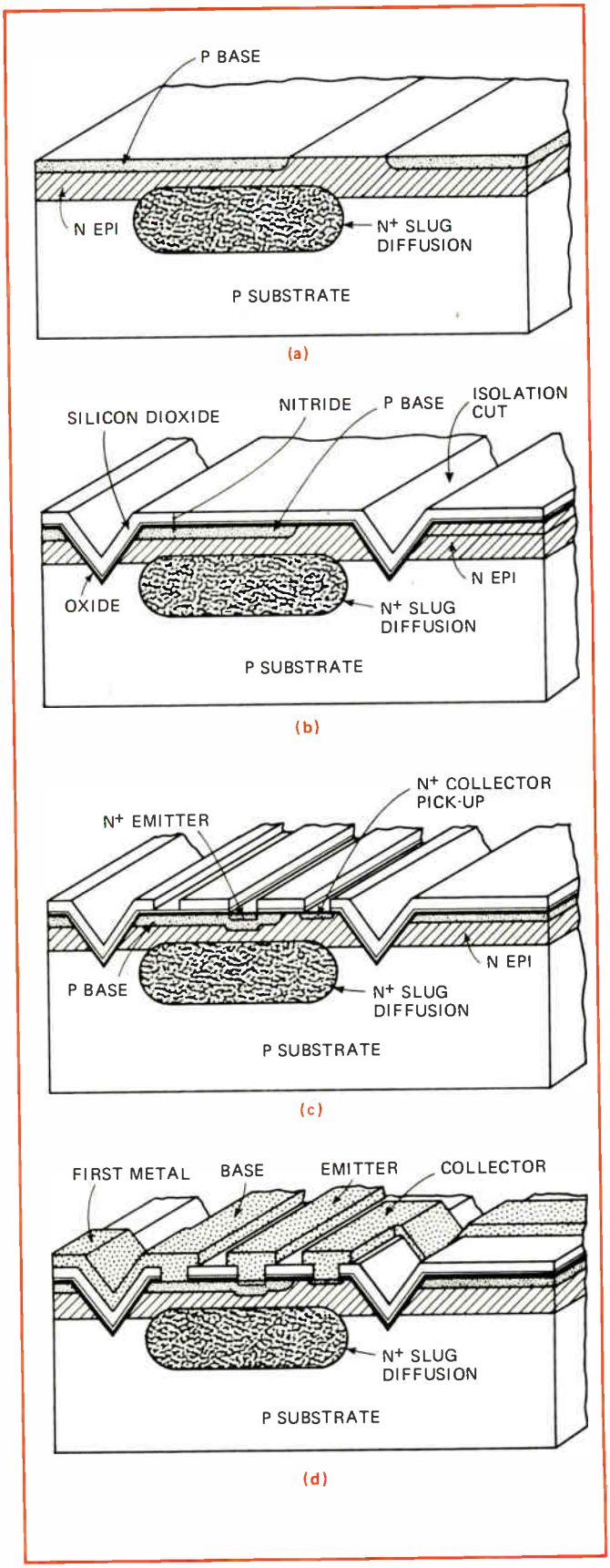
V-ATE fabrication begins conventionally with a p-type 1-0-0-oriented substrate, the first masking step, and an nϑ antimony slug diffused into the substrate. Next an n epitaxial layer is grown on top in the usual manner, except that a silane rather than a silicon tetrachloride system is used. This allows the lower epi-growth temperatures that make high-resistance epi resistors possible. A shallow base diffusion (Fig. 3a) follows, forming the base regions of the transistors and conventional p-type resistors.

An isolation mask is applied, and the pattern etched in the usual protective oxide. It is at this point that the vertical anisotropic etch creates the important isolation. Instead of being isotropic or uniform, the etch rate is anisotropic or preferential to the crystal orientation. It takes place 30 times faster along the 1-0-0 crystal face than along the 1-1-1 face, producing very precise vee-grooves with a 54° angle to the surface. The etch goes down and away from the mask opening, without undercutting. This leaves an air isolation width that is equal to the mask width, and separates adjacent regions with no wasted space.

Next, parts of the oxide are removed, and an oxide-nitride-oxide sandwich is deposited (Fig. 3b). The contact mask is applied, and all of the base, emitter, and collector contacts are opened down to the nitride. The base contacts are covered, and the nitride and oxide are etched from the remaining two contacts. The emitter diffusion (Fig. 3c) takes place in these two regions. Then the nitride and oxide are etched from the base contact so that all transistor contacts are etched down to silicon. Schottky diodes and all other contacts are formed with platinum-silicide as shown in Fig. 3d, completing the structure.

An important innovation in the V-ATE process is the beam-lead metallurgical system. By minimizing interconnect metalization, such a system reduces interconnect capacitance. Originally developed at Bell Laboratories, it consists of layers of titanium, platinum, and gold sputtered onto a substrate sequentially and then delineated into interconnections by sputter etching. This produces a pattern of very fine geometries—the standard metal-to-metal spacing is a mere 0.2 mils—and also reduces interconnect capacitance.

In the version of the beam lead process used in V-ATE, one layer of metalization is deposited, and the dielectric between the two interconnection layers is sputtered on. This produces a high-integrity film of silicon dioxide with superior reliability and low pinhole densities. Via holes are etched through it, and then seed layers of titanium-gold are sputter-deposited, built up by electroplating the surface to twice the thickness of the first layer. This second layer is generally used for larger cur-



3. V-ATE processes. In the earlier steps (a), the epitaxial layer and base diffusion have been completed in readiness for the vee-etch. In (b), the process has been taken through the vee-etch and the oxide-nitride-oxide sandwich, while (c) shows the emitter diffusion. Then in (d), the first layer of metalization is deposited.

rent busses, while the first layer is utilized for fine-line interconnections.

The first V-ATE product is a 1,024-bit random access memory, designated RR5502 (Fig. 4). The specifications of this product bear out the high-performance potential of the V-ATE process. The chip is only 91 by 125 mils, with a packing density 50% better than typical oxide isolation products. Random access time is rated at 50 nanoseconds maximum, but information from customers sampling this product indicates that typical access times are even lower—averaging 30 to 35 ns—making the V-ATE memories the fastest that are presently in production.

Better than ECL

Besides providing fast access, the V-ATE RAM has an excellent power-delay product. A 2-ns propagation delay is realized with a gate current of only 1 milliamperes, representing a power-delay product of 10 picojoules. This is a quarter that of commercially available ECL devices, where 4 mA per gate are needed to achieve 2-ns delays. Significantly, this low power-delay product indicates that 4,096-thousand bit memories are feasible with present V-ATE capability.

The V-ATE RAM also has the advantage of a low input requirement. Because of a pnp input, it needs only a 50-microampere input current, so that special drivers are unnecessary. The output will drive 10 TTL unit loads. In addition, an open collector output and a chip selection provision together allow for easy memory expansion.

Bipolar memories beat MOS memories in two ways. They're easier to use, and they're faster.

As for utility, they interface directly with bipolar logic circuits, eliminating the need for such buffer circuits as level boosters and three-level clock systems. In particular, the RR5502 RAM requires only nine small logic chips, eight resistors (or a resistor chip), and a standard 5-volt supply (Fig. 5). To build an equivalent 4,096-by-8-bit system with 1103-type MOS memories takes approximately 30 to 40 external parts and four power supplies (Fig. 5).

Consequently, the system designer can use more expensive bipolar chips and still have a system that costs less, because he eliminates the extra costs associated with peripheral circuits—larger boards, and component testing, insertion and inventory.

As for access time, in a system using RR5502s the time to access a bit of memory after the submemory block selection (board select) has been made is 25–35 ns. Even when going through the memory address register, accessing totals only 55 ns—15 ns for the address register and 35 ns for the RR5502. With an equivalent MOS system, total access time is 300–400 ns.

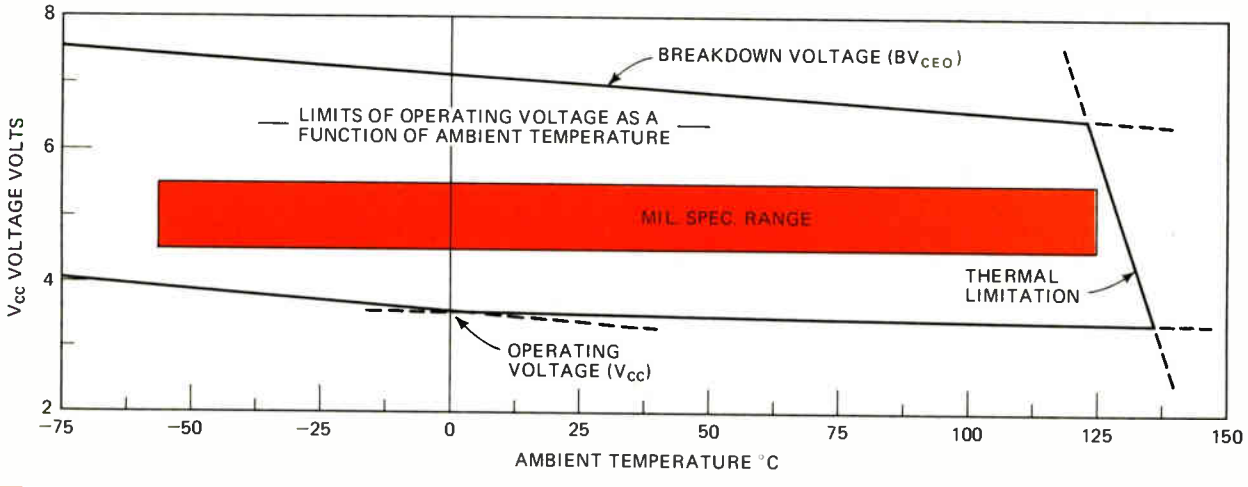
Systems made up of RR5502s also can outperform those composed of typical 256-bit bipolar memories. The RR5502 exceeds their speed, and at the same time reduces the power and space required by a factor of four. Estimating power cost at $2 to $4 per watt, the

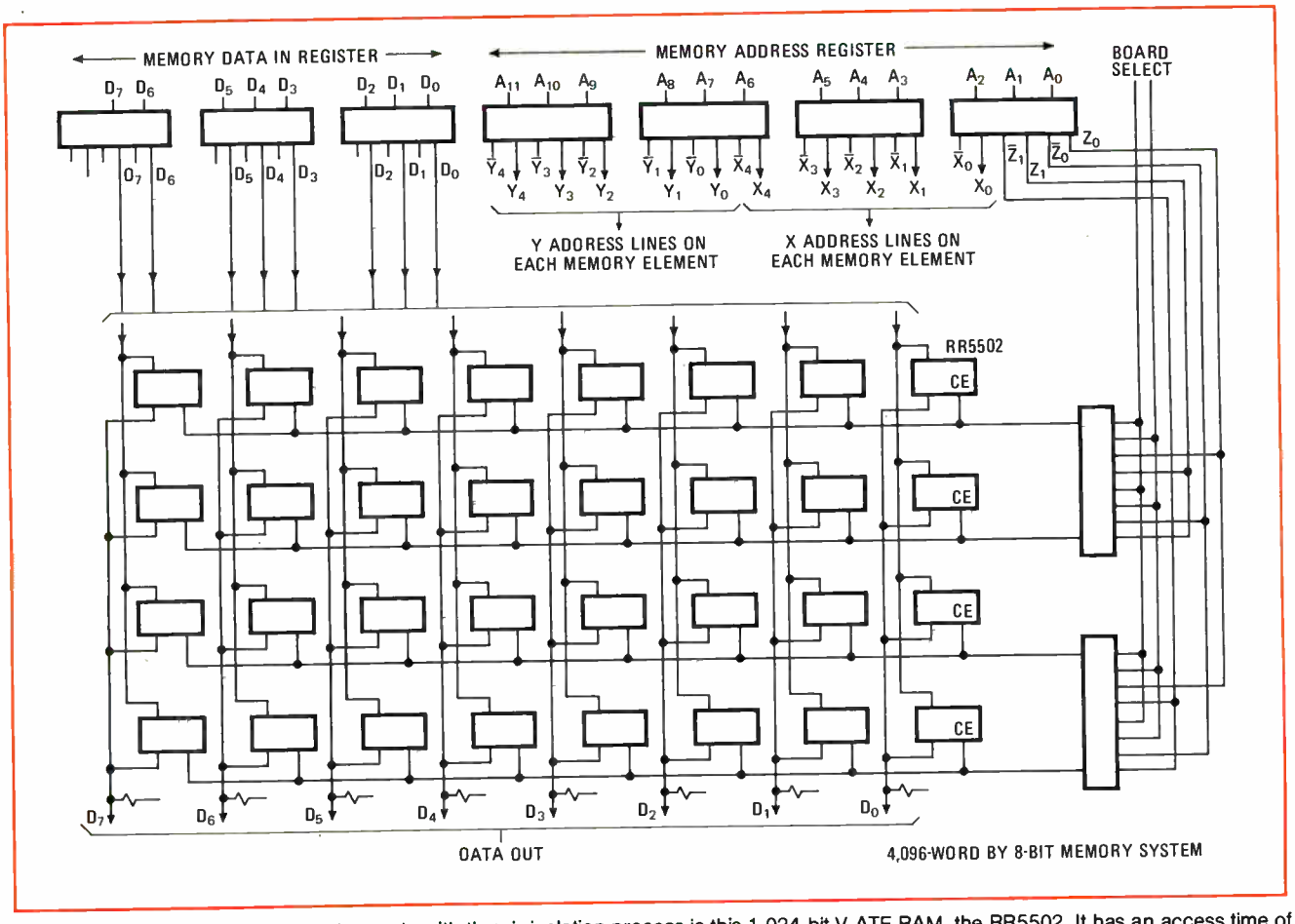
Why ECL?

Speed was not the only reason, although the emitter-coupled logic configuration is the fastest known circuit type. ECL is also more reliable for memory applications because its dc and switching properties are the least sensitive to normal process variations during wafer manufacture. In addition, ECL makes sparing demands on chip area and switching energy. And it is also capable of operating over a wide temperature range and operating voltage V_{cc}.

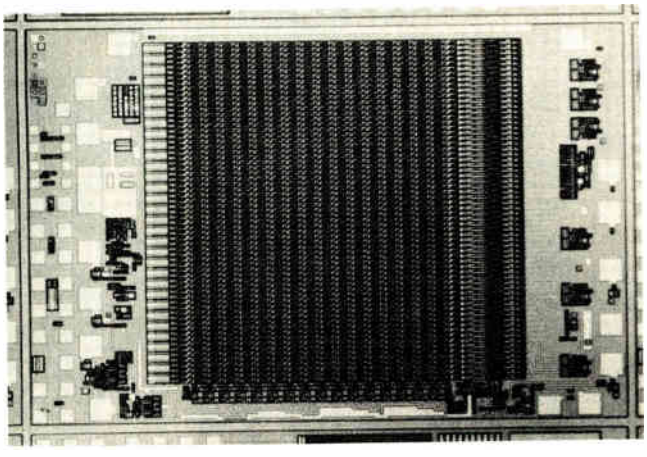
The accompanying graph shows that the breakdown voltage at 7 volts remains well above the operating voltage throughout the Mil Spec temperature range. The low voltage excursion is limited by the forward base-emitter voltage of a conducting transistor at the instant of switch-on. The high voltage is limited by the thermal characteristics and breakdown voltage of the device. Typically, the packaging schemes yield a junction-to-ambient resistance of 100° C per watt, allowing for a maximum junction temperature of 170° C.

It is expected that ECL memory circuit design techniques will become increasingly popular in the design of logic chips as well. Systems using ECL logic and memory will be faster than systems mixing TTL and ECL since the all-ECL system will not require additional on-chip level shifters (which increase delay) to make the ECL circuits compatible with the TTL ones.





4. The payoff. The first product to be made with the air-isolation process is this 1,024-bit V-ATE RAM, the RR5502. It has an access time of less than 50 nanoseconds, a total power dissipation of 400 milliwatts, and chip dimension of 91 by 125 mils.



5. Beating the system. A 4,096-by-8-bit memory system using the V-ATE 1,024-bit RAM (RR5502) requires very few additional packages, unlike MOS systems, and offers access times of 25 to 35 ns from board select to data out. The memory is easily expandable, without extra buffers, because of the low address input currents.

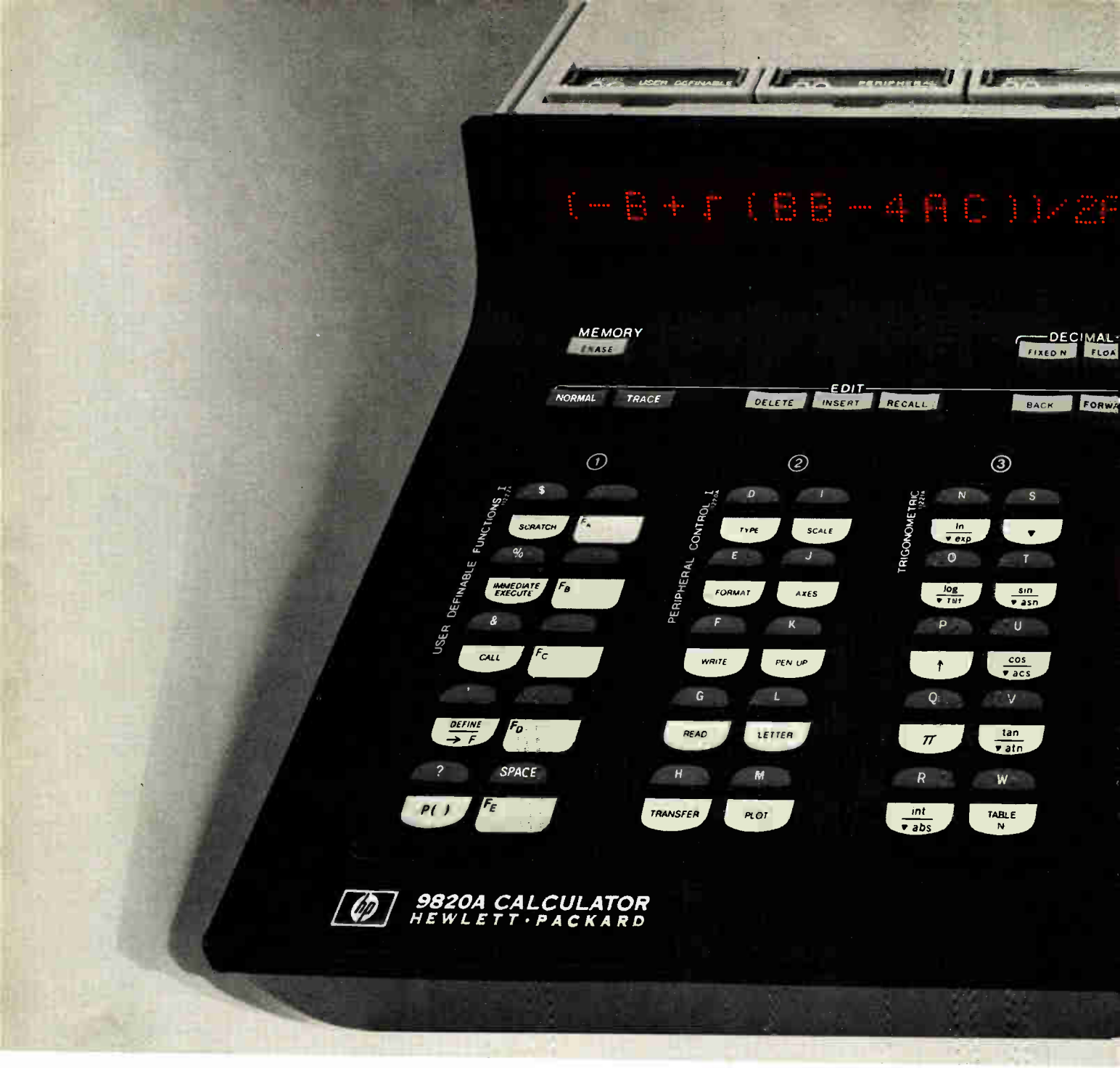
RR5502 operates at only 0.2 to 0.4 cents per bit, whereas the 256-bit memory costs 0.8 to 1.6 cents per bit.

At first, the new bipolar memories will be confined largely to those applications where their high speed is absolutely essential—scratchpad and cache memories in large computers. As for core mainframe memories, the larger computer manufacturers have heavy investments in core production, and they will probably move more slowly toward semiconductor memories, perhaps waiting until the 4,096-bit units become available. The minicomputer manufacturers, on the other hand, who are only now fixing their designs, should find products such as the RR5502 an attractive cost-performance alternative to core.

A fertile future

Fairly soon, however, there should be a natural expansion of V-ATE products, leading to many innovations, such as three-state outputs for ECL applications, ECL options compatible with the more popular TTL families, and a power-down version to allow low standby power when the device is not in use. Most important, because of the low power-delay product available with V-ATE processing, small refinements should lead to a 4,096-bit RAM of reasonable chip size. Read-only memories at that density are already being investigated, and could approach 8,192 bits of 1973.

Outside the memory field, the packing density obtainable with a V-ATE process is applicable to random logic chips as complex as MOS but faster. The average V-ATE gate occupies 12 mils^2, so that more than 500 gates could fit on a chip. In practice, however, interconnection restraints may limit the design to about 300 gates on a 100-mil^2 chip. With these circuits, delay per logic decision would be a low 2.5 ns, at a power dissipation per gate of a very low 1.5 mW. □



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Adapting high-speed logic to data communications

The most desirable properties of microwave and digital technologies are combined to produce data rates as high as 1 gigabit per second; circuit cards provide flexibility to experiment with new concepts

by Pradman Kaul, *Comsat Laboratories, Clarksburg, Md.*, and O. Gene Gabbard, *Digital Communications Corp., Rockville, Md.*

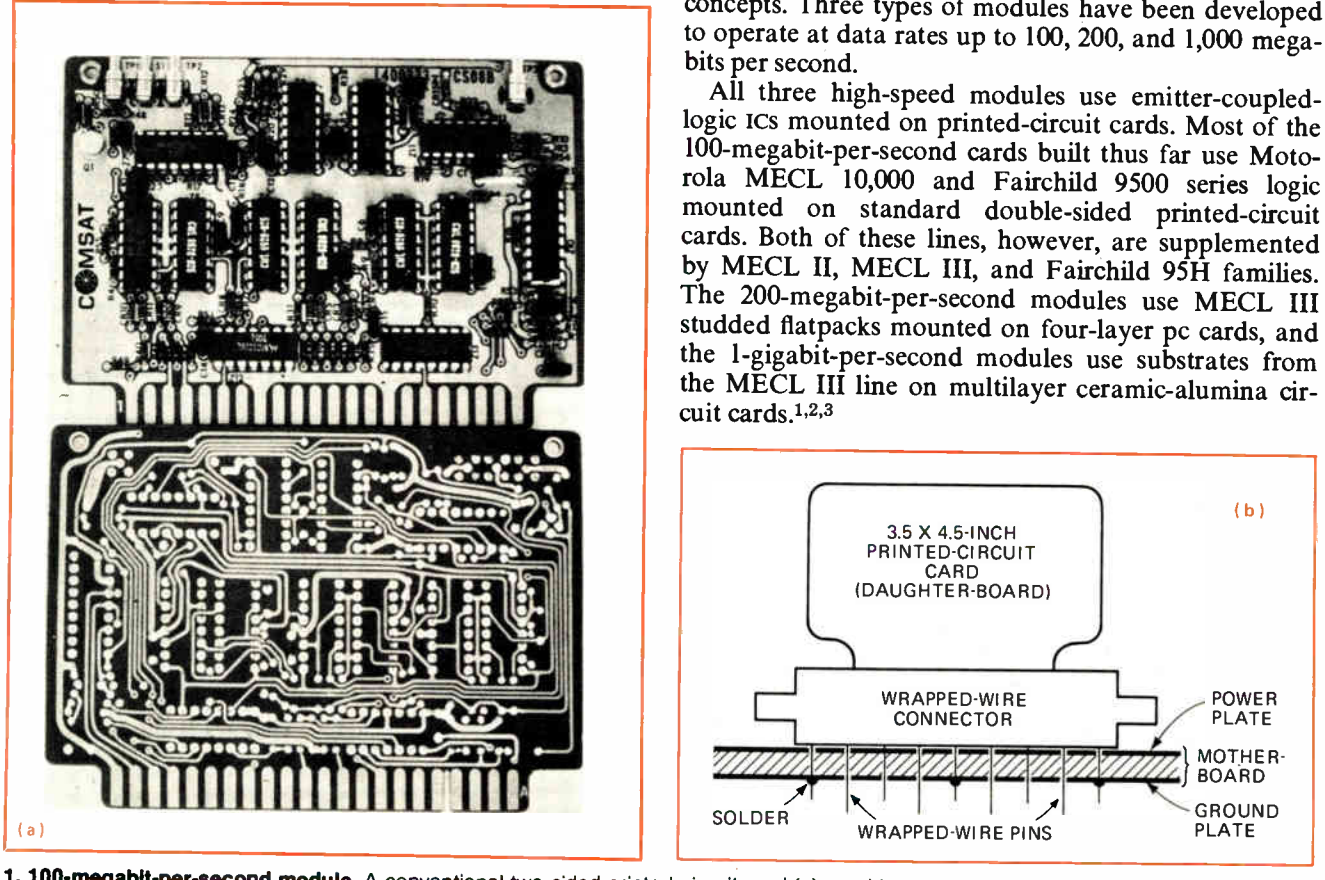
☐ The application of high-speed digital logic to communications is an obvious extension of the powerful semiconductor technology that has been developed for computer system design. For applications in both terrestrial and satellite communications systems, numerous research laboratories are already operating circuits at data rates of several hundred megabits per second. For these and other future requirements up to rates of 1,000 megabits per second, designers are modifying printed-circuit card techniques to take advantage of the high speeds of emitter-coupled logic.

But the transition to microwave data rates is not a simple one. Application of high-speed logic to digital communications requires a judicious combination of microwave and digital technologies. Since digital circuits do not require the high signal fidelity of analog circuits, the designer can sacrifice some degree of sophistication and take design shortcuts. But when borrowing from digital technology, he must not push too far the minimization of logic functions often sought in lower-speed digital hardware.

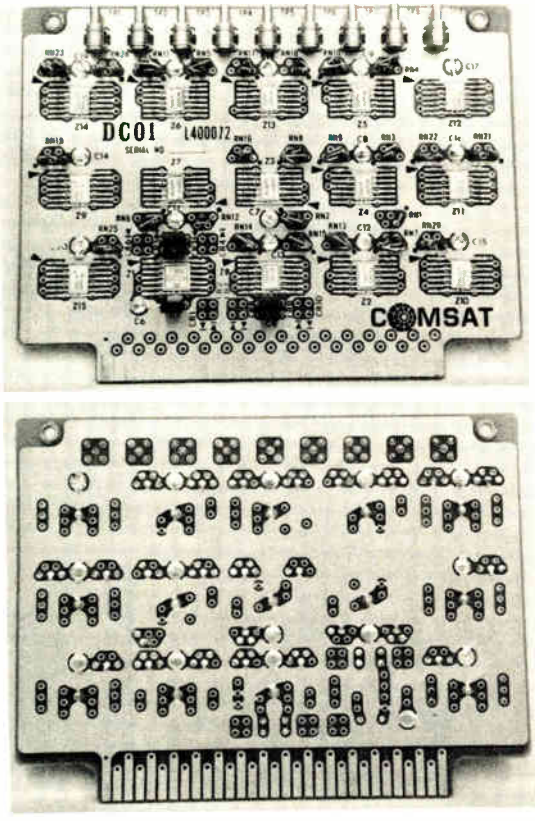
Experience indicates that the most important design problems in high-speed digital systems are packaging, heat control, and distribution of clock signals.

In an effort to overcome these problems, standard families of circuit-card modules have been developed. The modular approach is particularly helpful where new systems concepts are being developed and tested because quick changes can be made in the modules, and standard modules can be assembled quickly to test new concepts. Three types of modules have been developed to operate at data rates up to 100, 200, and 1,000 megabits per second.

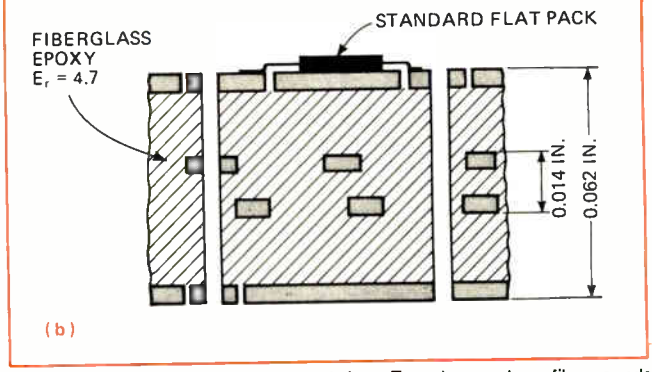
All three high-speed modules use emitter-coupled-logic ICs mounted on printed-circuit cards. Most of the 100-megabit-per-second cards built thus far use Motorola MECL 10,000 and Fairchild 9500 series logic mounted on standard double-sided printed-circuit cards. Both of these lines, however, are supplemented by MECL II, MECL III, and Fairchild 95H families. The 200-megabit-per-second modules use MECL III studded flatpacks mounted on four-layer pc cards, and the 1-gigabit-per-second modules use substrates from the MECL III line on multilayer ceramic-alumina circuit cards.[1,2,3]



1. 100-megabit-per-second module. A conventional two-sided printed-circuit card (a) provides good signal fidelity up to 100 megabits per second. Wrapped-wire connector (b) eases mechanical transition into motherboard and speeds system assembly.



(a)



(b)

2. 200-megabit-per-second modules. Four-layer glass fiber cards (a) serve as the building blocks for circuits operating to 200 megabits per second. Interconnect layers (b) function very much like stripline. Lines in these layers are usually mutually perpendicular, resulting in crosstalk more than 20 dB below signal levels.

A complete equipment rack with multiple drawers and a built-in liquid-cooling system for the 1-gigabit system is now being built. The rack is to be ready for operation later this year

100-megabit-per-second modules

Standard double-sided printed-circuit cards with plated-through holes are used for logic speeds to 125 megabits per second and system speeds to 100 megabits per second (Fig. 1a). Conventional interconnection techniques, such as wrapped wire or point-to-point soldering, may be used within a drawer containing up to 100 logic cards. These cards are interconnected in an 81-position drawer with integral cooling blowers and ac-to-dc power converters.

The ground plane on each card extends into a common ground plane within the drawer. One technique uses a ground (and power) plate (Fig 1b). Here, a two-layer printed-circuit motherboard plate is constructed with holes for all pins of a wrapped-wire connector that interfaces with each pc card, or daughterboard.

The bottom side of the motherboard forms the ground plate. All connector ground pins are connected to this ground layer. A power plate on the top side of the motherboard distributes dc power to the cards.

The clock and all high-speed logic lines are carried between cards via twisted pairs (in a few situations described below, the Schottky-diode termination may be more desirable). Standard 26- or 30-gauge wire suitable for wire wrapping can be used for the twisted pairs. When twisted at about 30 turns per foot, a transmission line made from these wires has an impedance of about 110 ohms. Impedance-controlled pairs specified to impedances of 50, 75, and 120 ohms can be purchased from such manufacturers as W.L. Gore and Associates Inc., Newark, Del.

Coaxial or twin-lead transmission cable is required to interface between drawers.

200-megabit-per-second modules

For logic speeds to 200 megabits per second, a four-layer printed-circuit card has been chosen as the basic building block (Fig. 2). The two layers in the middle are the interconnect layers. The top plane is ground, and the bottom plane supplies the –5.2-volt power. This particular geometry was chosen because it is simple and relatively inexpensive to fabricate.

The active circuits used on the four-layer boards are from Motorola's MECL III family. In many cases, studded flatpacks are mounted to the circuit cards to aid in cooling the ICs. Such typical functions as a decoded decade counter built on these boards have operated at speeds of 275 megabits per second.

Interconnections on the board are made by striplines. The asymmetry of the center conducting lines results in an insignificant change in their characteristic impedance. Measurements show that crosstalk between adjacent lines within the board is less than 5% under worst-case conditions.

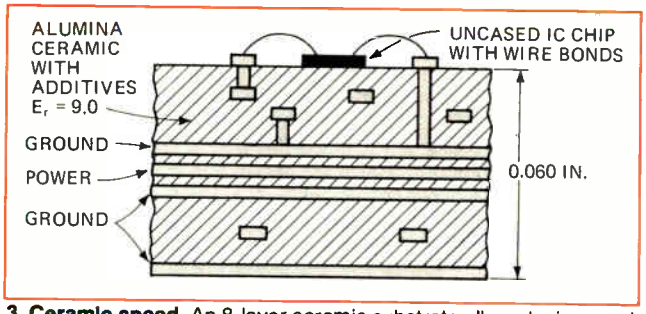
Shielded twisted-pair lines interconnect boards, while coaxial cable is used for connections between drawers. Miniature coax is also used in board-to-board wiring.

Many commercially available connectors meet the requirements of a 200-megabit-per-second signal. The connector should be chosen with a short electrical path length and with a low characteristic impedance between adjacent pins. Present connectors have an electrical length of about 1 nanosecond and a reflection coefficient of about 0.10 with matched 50-ohm cable.

1,000-megabit-per-second modules

For advanced systems requiring data rates above about 200 megabits per second, it was necessary to miniaturize the modules to cope with the effects of propagation delay in the interconnecting transmission lines.

Uncased monolithic ICs are used in the high-speed



3. Ceramic speed. An 8-layer ceramic substrate allows logic speeds up to 1 gigabit per second. Uncased monolithic chips allow required miniaturization and complete the low thermal-resistance path from heat sink, through ceramic, to device junctions.

cards, again to help reduce transmission-line lengths and to provide a lower thermal resistance between the active devices and heat sinks. At present, these logic chips are from Motorola's MECL III family.

Thus, a standard line of eight-layer ceramic alumina cards, shown in Fig. 3, is being developed to operate at speeds at least as high as 1 gigabit per second. To date, these logic card speeds have been limited by the availability of active monolothic chips. Three of the layers are for interconnections—two are embedded microstrip and one is the more conventional stripline.

In addition, there are three ground planes and one power-supply plane. The chips, mounted on the top layer, are bonded to the substrate by a gold-silicon eutectic bond at 385°C. Ultrasonic or thermal-compression ball bonding is used to connect the chips to the external circuits.

The exposed monolithic chips are sealed from outside impurities by using gold-tin or lead-tin solder to attach lids. Because the maximum temperature needed for this bond is only about 280°C, there is no danger to the device's substrate bond.

Ceramic alumina, with a dielectric constant of 9.0, was found to provide the best building-block structure. Ceramic is also a good heat conductor, which is important when trying to cool a small circuit card with densly packed active chips.

Using these cards, a family of ceramic modules is being developed. Each is a basic building block, such as a decoded decade counter, an eight-bit serial-to-parallel shift register, and a pseudorandom number-sequence generator. The 1-inch-square mounting area on each module can accommodate up to 16 monolithic logic chips.

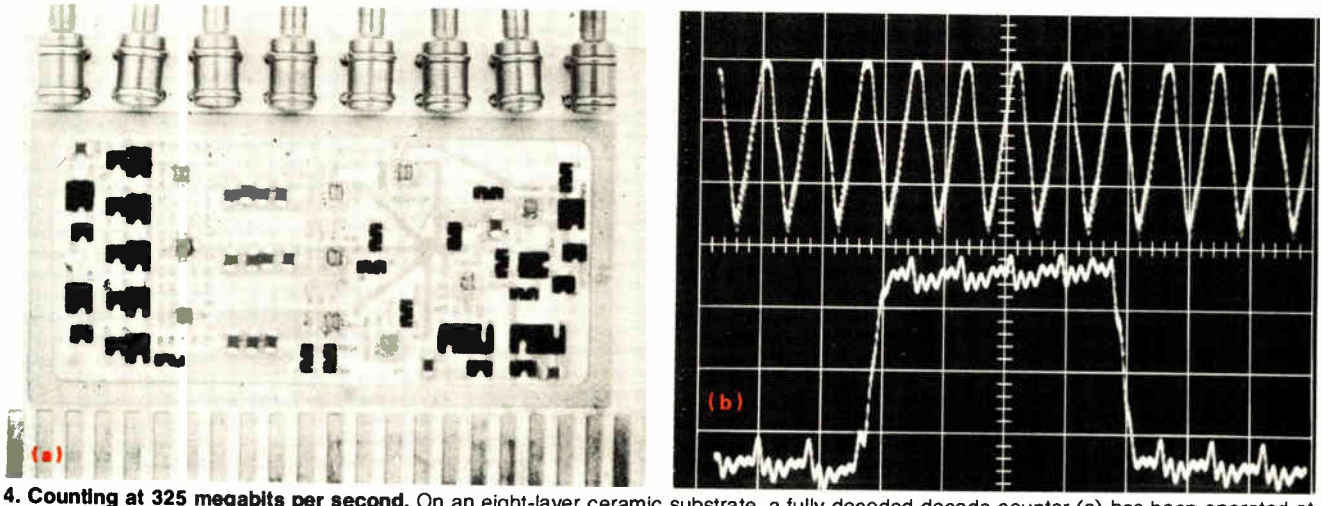
The decoded decade counter of Fig. 4a has been operated at speeds up to 325 megabits per second, the limit determined by the speed of the MECL III logic chips used. A 250-megabit-per-second clock input to the counter and a divide-by-10-output are shown in Fig. 4b.

On this particular substrate, only thick-film resistors were used. On subsequent substrates, these were replaced by thin-film tantalum-nitride-on-silicon resistor chips. The chip, 50 mils square, contains 14 resistors, each with 5% tolerance.

Timing accuracy must be rigorously controlled for successful operation of systems faster than 200 megabits per second. For example, if the system is operating at 500 megabits per second, then the clock period is 2 nanoseconds. A practical limit for clock skew (the mismatch in timing between two inputs to a gate) is ⅛th of a clock period, or 0.25 ns. At a nominal transmission-line propagation speed of 1 ns per 9 inches, all transmission-line lengths must be controlled to an over-all accuracy of within ±2 inches for proper system timing. In addition, factors such as degradation in rise and fall times have to be controlled because they can also contribute to timing errors.

Noise margin is also a critical factor in systems operating at these speeds. Because the voltage swing of high-speed ECL circuits is only about 800 mv, factors that tend to degrade noise margins—such as crosstalk, power supply variations from module to module, and mismatched transmission-line terminations—must be carefully considered.

The module connector must have a characteristic impedance that is closely matched to the transmission lines and must present a very short impedance discountinuity for pulses with rise times as short as 250 picoseconds. Provisions for about 24 signals, including grounds and supply voltages, should be adequate for a standard module. One connector which meets these re-



4. Counting at 325 megabits per second. On an eight-layer ceramic substrate, a fully decoded decade counter (a) has been operated at 325 megabits per second, limited solely by the 10 logic chips. The clock and a divide-by-10 output (b) show binary wave-shapes at 250 megabits per second. Horizontal scale is 5 ns per division; vertical scale is 200 mV per division with logic levels at about −0.8 and −1.7 volts.

Digitizing commercial satellites

The high-speed logic cards being developed at Comsat Corp. are, of course, digital in nature. The digital system is desirable, since it can tolerate smaller signal-to-noise ratios than the analog system can. Also, time-division-multiplexing techniques can be employed, which can lead to much greater spectrum utilization efficiency.

Until now, only analog techniques have been used in satellite communications. A ground station for the first partially digital system is now being installed at the Etam Earth Station in West Virginia for operation with the Intelsat IV satellite. This system (called Spade for single-channel-per-carrier, pulse-code-modulated, multiple-access, demand-assigned equipment) is designed to accommodate light-traffic routes.

Pulse-code-modulated voice signals are transmitted via the 800-channel Spade system at a data rate of only 64 kilobits per second. A common signaling channel operates at 128 kilobits per second. Baseband channels in the Spade system are, however, frequency-division multiplexed together, resulting in relatively low over-all transmission efficiency.

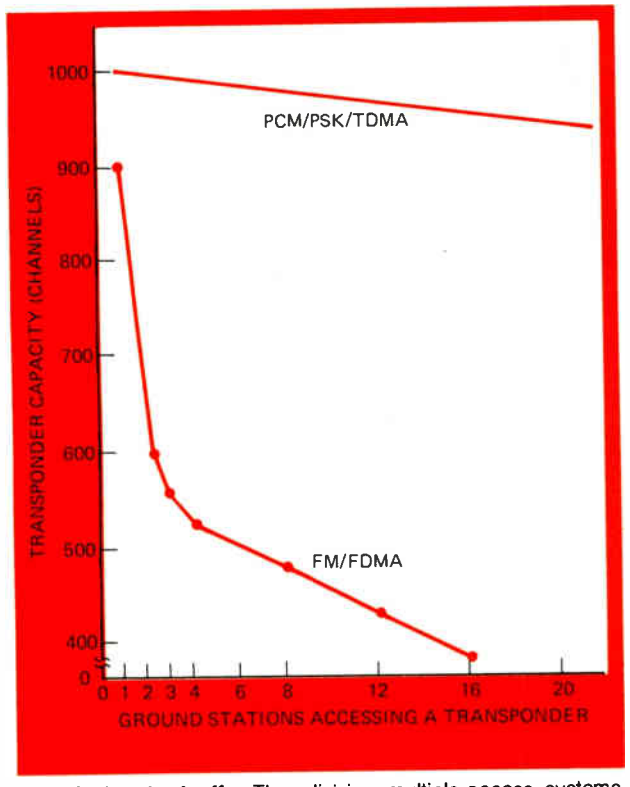
A more efficient method is to pulse-code modulate the voice signals, then employ time-division multiple-access techniques to multiplex the voice channels on a single rf carrier (see graph). For 16 ground stations accessing the same transponder, the channel capacity is increased by a factor of two.

It is also expected that high-speed, all-digital techniques will replace the analog transmission used today for relay of commercial television signals. One full transponder of the Intelsat IV satellite is now needed to transmit one TV signal with acceptable quality. Using digital bandwidth compression, the digital television communications (Ditec) system can send two TV signals through one transponder without any loss in quality, resulting in significant savings in transmission costs.

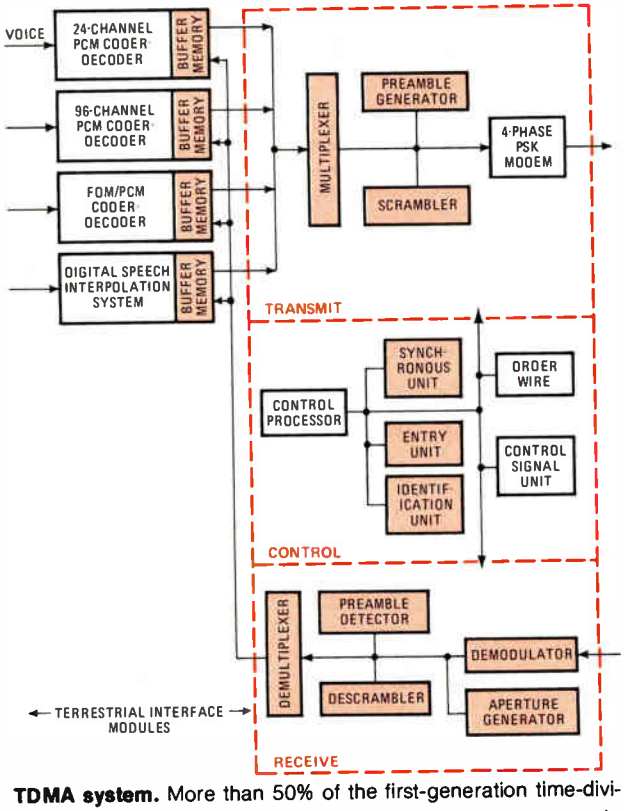
High-speed logic has been used in two key parts of the Ditec system, representing about 75% of the total circuitry. The bandwidth of the standard analog video signal is about 4.5 megahertz for a total display of 525 lines. With eight intensity levels, a data rate of 80 megabits per second is required by the PCM encoder. Also, one of the techniques used to reduce the bit rate is a differential PCM system with a digital feedback loop, which requires a data rate in excess of 100 megabits per second. Future generations of both the PCM encoder and the differential PCM system will operate at speeds requiring ceramic cards.

A general block diagram of a TDMA system is shown. The shaded functional blocks require 100 megabit-per-second circuit cards in the first TDMA system, which was tested in the summer of 1970. The second-generation system with bit rates up to 400 or 500 megabits per second, will use ceramic multilayer cards in the high-speed circuits.

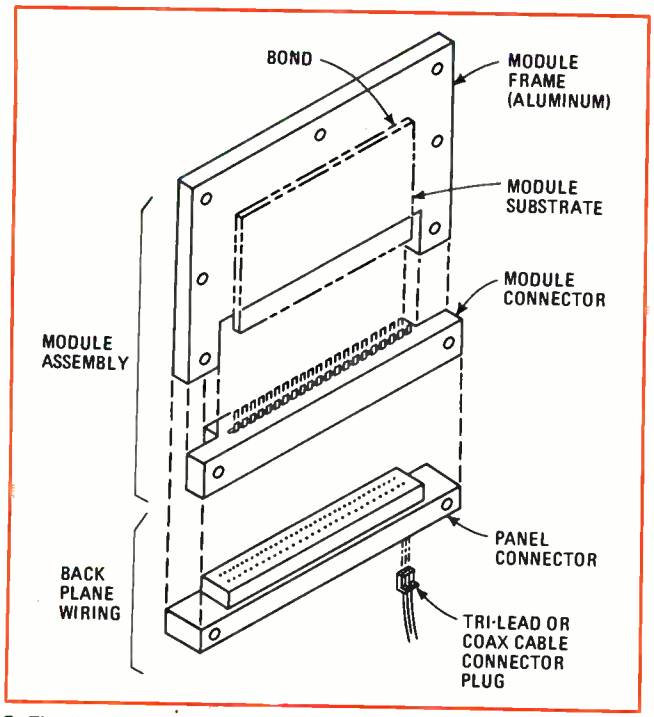
The ground segment is generally implemented with lower-speed logic, except for the input buffer memories, which have to process high-speed data bursts. As can be seen, the major part of the TDMA system requires high-speed logic.



Multiplexing tradeoffs. Time-division multiple-access systems allow much greater voice-channel capacity, especially as number of ground stations wanting to transmit to the transponder increases. This curve is based on the Intelsat IV transponder.



TDMA system. More than 50% of the first-generation time-division multiple-access system is implemented with 100-megabit-per-second cards. Future systems, operating at 400 megabits per second and higher, would use ceramic modules.



5. Flexible interface. Module connector assembly allows complete plug-in capability for the high-speed modules. The panel connector, mounted to the chassis, interfaces with three-conductor cable plugs for matched-impedance tri-lead or coaxial cables.

quirements has recently been developed for Comsat by Microdot Inc.

The resulting interface arrangement (Fig. 5), allows complete plug-in capability for the high-speed modules. The module connector is mounted on the ceramic board, and the electrical connections are soldered. The panel connector, mounted on the chassis, interfaces with three-conductor cable plugs for matched-impedance tri-lead or coaxial cables.

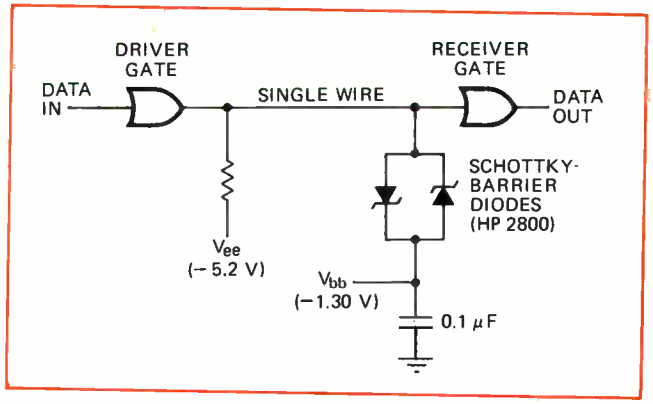
Each module, which dissipates 2 to 10 watts when operating, should be cooled to a case temperature of about 25°C. To reduce over-all system noise margins, it is even more important that case temperature be uniform from module to module.

After an investigation of different cooling methods, it was decided that a liquid-cooled cold-plate system was best for a standard development system. By using an adhesive bond, the ceramic module is attached to a ¼-inch-thick aluminum plate. This is then fixed to a liquid-cooled cold plate.

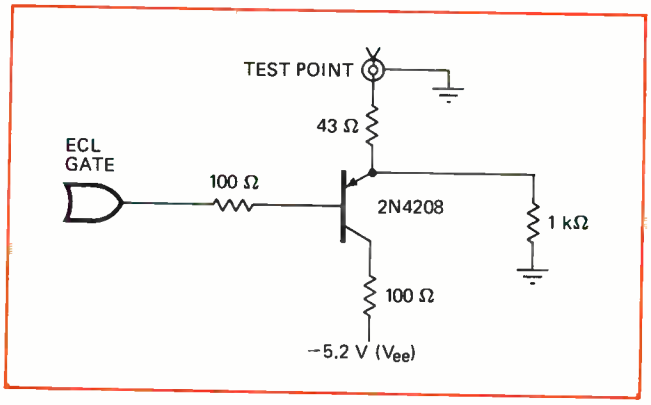
Terminating high-speed logic

The Schottky-diode termination (Fig. 6) can be used to reduce the effects of overshoot caused by a termination mismatch. But the technique's usefulness is limited to bit rates in the 100-200 range, depending on diode quality. The diodes act as dynamic nonlinear resistors. As overshoot tries to occur, one of the diodes will begin to turn on until its resistance approximates the line impedance (the other diode is back-biased). In this manner, the overshoot energy is absorbed, resulting in improved signal fidelity.

To replace twisted pairs, the Schottky-diode termination can be used for single-conductor point-to-point



6. Dynamic duo. A pair of Schottky diodes at the logic gate receiver reduces the effects of overshoot caused by a termination mismatch. The technique, first developed by O.A. Horna at Comsat in 1969, is often used as a dynamic nonlinear termination for long wires.



7. Wideband sync. This single-transistor amplifier makes a good circuit for driving counters and external sync inputs on sampling and other wideband oscilloscopes. Matched to emitter-coupled logic, the circuit produces 400 mV of signal into a 50-ohm load.

wiring for about three feet. While it involves a little added circuitry, the single-conductor line with a diode termination is sometimes necessary if connector pins are limited. This technique can also eliminate the need for an added differential receiver, with associated propagation delay, at the receive end.

Following digital design rules of lower-speed circuits, the more important signals should also be terminated at accessible monitor points. A good circuit for driving counters and external synchronization inputs on sampling and other wideband oscilloscopes is shown in Fig. 7. This circuit provides 400 millivolts of signal into a 50-ohm transmission line and is useful to bit rates well above 1 gigabit per second. The circuit is also short-circuit-proof. A small coaxial connector such as Microdot's Lepracon 141-1005-0001 makes an ideal interface on the printed-circuit card.

In other design techniques, twisted pairs can be used to carry all clock signals between cards; 51-ohm series damping resistors can be used in all output lines leaving any card; and each IC can be filtered with a 0.01 μF high-Q ceramic capacitor. □

REFERENCES
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2. Fairchild Applications Brief App. 157, "9500 System Applications and Wiring Rules."
3. W.R. Blook Jr. et al., "MECL Systems Design Handbook," October 1971.

SPECIAL REPORT

Choosing a digital panel meter is not as easy as it looks

For one thing, different DPM manufacturers often mean different things by the same specification, and for another, key DPM parameters are interdependent; so do your homework—and be prepared to ask questions

by Michael J. Riezenman, *Instrumentation Editor*

☐ If growth is any criterion, digital panel meters appear to be the answer to an instrumentation engineer's prayer. From a ho-hum response to their first appearance in 1967, they have moved up to become a $10 million market, and an increase of 30% is expected next year.

To rack up this steady growth, DPMs must offer the designer some concrete advantages that are worth the extra cost of going digital instead of analog. Three reasons commonly given for going that route are:

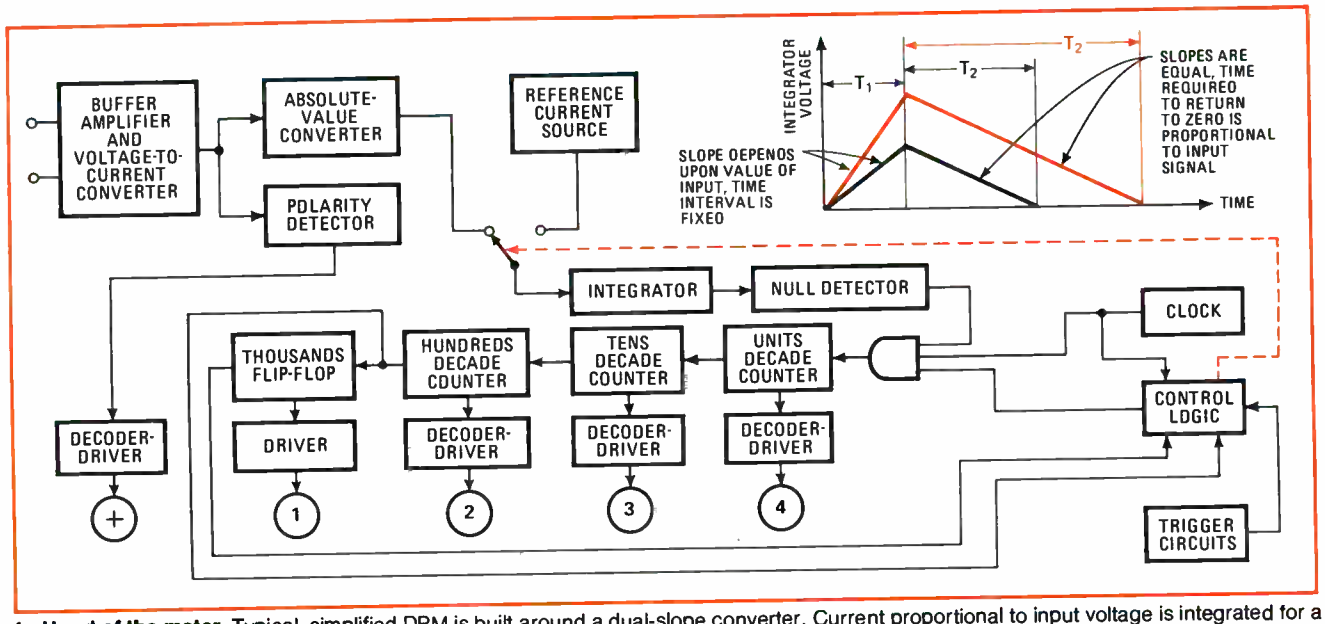
- It's getting to be more of a digital world, and, in addition to digital display, DPMs provide coded outputs that can be used for recording and control.
- It's the most effective way to couple unskilled personnel with production-line instrumentation where precise, repeatable adjustments must be made.
- Some designers just like to try anything new.

Something new isn't necessarily something better for a given purpose, however. If it's reliability you want at low cost, and you can tolerate errors on the order of 1% of full scale, or if you want to monitor an unstable signal, the tried and true d'Arsonval movement is still your best bet. D'Arsonval movement reliability exceeds that of even the best DPMs, and its prices generally begin far below those of even the cheapest digital units.

As yet there are only rare exceptions to this price rule. For example, there is at least one 2½-digit DPM selling at $50 in lots of 100 whose main competitor is a large switch-board-type analog meter selling at about $85. And this price overlap of analog and digital panel meters is expected to increase significantly in the not-too-distant future.

At present, DPMs should be chosen mainly to obtain better resolution, accuracy, and repeatability than an analog meter can provide. Tests conducted by the National Bureau of Standards indicate that the best mirror-scale analog meters cannot be set repeatably with a resolution of better than about 0.5% by several different people. A single careful operator may do much better than this. But if a production-line operation requires that a parameter be set with 0.1% repeatability regardless of who is doing the setting, a simple analog meter will not suffice.

Finally, if you need a capability that only DPMs possess, then analog meters don't even enter the picture. For example, if you require a binary-coded-decimal



1. Heart of the meter. Typical, simplified DPM is built around a dual-slope converter. Current proportional to input voltage is integrated for a fixed length of time, T_1. Integrator is then discharged at fixed rate, set by reference current source. Time needed to reach zero, T_2, is measured by decade counters. Larger signal (shown in color) needs more time to reach zero than smaller one does.

output for operating printers or reading directly into a computer, most DPMs provide it.

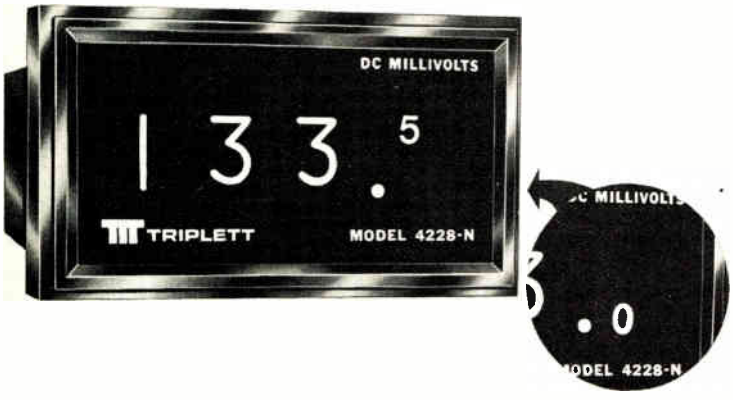
The decision made, you've barely started. At last count there were about 30 manufacturers fighting for pieces of the DPM market, with new ones constantly coming along. Some have been around since the business began in 1967, and others haven't had time for the ink on their letterheads to dry. How, then can you choose between them?

If you've seen one . . .

The main thing you can do is to define carefully the conditions under which you intend to use the meter, and then evaluate the performance of competitive units *under those conditions*, using the manufacturer's spec sheets. This can be an enlightening experience. Several superficially similar meters may turn out to perform quite differently when their behavior is examined under some specific set of conditions.

And at first glance, they all do look pretty much alike. Practically every DPM uses some form of dual-slope integrator (Fig. 1) to convert an analog input signal into a series of digits, and then displays these digits on one of about five different types of displays. Most operate on standard ac line voltage, though the so-called "logic-powered" units (see "What about logic power?") run on 5-volt power supplies. And some specials also can be operated from a ±12-v supply. Many key differences between units, however, only come to light when their specifications are carefully and critically compared.

2. Nomenclature. The 4-¾-digit meter (top) gets its name because it provides 300% overrange. The 2-¾-digit unit (bottom) has 100% overrange and two half digits to double its reading accuracy.



. . . you haven't seen them all

The six most important factors to be considered in evaluating a digital panel meter are generally agreed to be: price, operating temperature range, resolution, accuracy, temperature coefficient, and reliability.

Price is rather easy to evaluate: always seriously consider the lowest-priced unit that will do the job. In other words, don't buy features that you don't really need. For example, if you don't need a bipolar unit, you can generally save about 4% or 5% by going monopolar. Some manufacturers give you an even finer choice: they sell bipolar units whose performance is tightly specified for only one polarity. Inputs of the opposite polarity are measured and displayed, complete with sign, but accuracy is not guaranteed.

On the other hand, a small-quantity user may be willing to pay a modest premium to a manufacturer with an extensive service operation, while a big OEM customer can deal with failures statistically, by simply buying a certain percentage of extra units to replace those that are expected to fail.

Like price, *operating temperature range* is a fairly straightforward consideration, but one that is often overlooked. Before looking at any DPMs, measure the ambient temperature in which they will have to operate, and make sure that the units you are considering can take it. Just about all of the models on the market today have a maximum internal case temperature of 70°C, but to allow for the internal temperature rise, their maximum ambient temperature rating is usually 60°C (140°F). Any rating between 60° and 70° probably means only that the manufacturer has simply allowed less of a safety margin than his competitors.

So what can you do if you want to operate a DPM in a steel mill in an ambient temperature of 150°F? In the words of one manufacturer, "Cool it, or your meter won't last six months."

The specsmanship game

The potential DPM user can be easily confused by *resolution, accuracy,* and *temperature coefficient*—three interrelated parameters that are key to DPM performance. Part of the problem is that it is not easy to tell which of two DPMs is better by simply looking at a couple of numbers. You must sum the various errors contributed by source loading, basic reading error, temperature

drift, display ambiguity, etc., to get a true picture. It's the sum—not any single component—that counts.

Another part of the problem is the lack of any standard method for specifying DPM parameters. One manufacturer specifies accuracy as a percentage of reading; another, as a percentage of full scale. One gives the temperature coefficient in parts per million of reading per degree centigrade; a second talks about percentage of full scale per degree centigrade; and a third simply states that the basic accuracy holds at 25°±10°C.

Finally, many manufacturers omit certain key specs either through oversight, or in the hope that you won't bring up the subject.

Resolution is the easiest member of the triad to define—it's a measure of the fineness with which the unit makes a measurement. A 3-digit machine breaks up its range into 1,000 parts: it can resolve changes as small as 10 millivolts if its full-scale value is 10 V (actually 9.99 V for a 3-digit instrument). Similarly, a 4-digit meter's resolving power is 1 mV on the same 10-V range. Of course this extra resolution comes at a price; a good rule of thumb is that the cost of a given DPM doubles for each full-digit increase in resolution.

This concept of the full digit is unambiguous. But just what is a 2½-digit meter or a 2-¾-digit meter? There is no set standard for these terms. Most manufacturers agree that a 2-digit meter counts up to 99, and that the addition of 100% overranging—so it can count up to 199—makes it a 2½-digit machine. But few agree on the meaning of 2 ¾ digits (Fig. 2). To one company it applies to a 2½-digit meter with an extra 0 and 5 added after the least significant digit. This cuts the meter's ambiguity error from ±1 digit to ±½ digit, but it still counts up to only 199 (or rather 199½). To another company, however, 2 ¾ digits means two digits plus 300% overrange—that is, a maximum count of 399. A third company calls a meter with 300% overrange merely an extended range 2½-digit DPM.

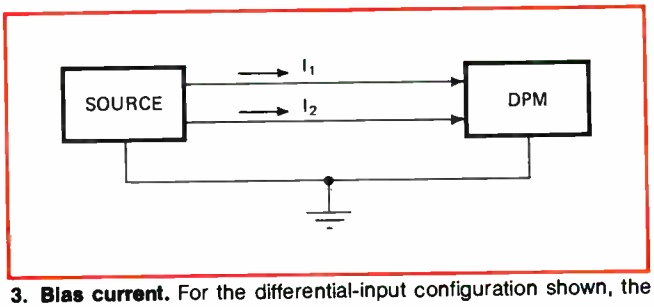
Thus, the most meaningful question to ask when trying to determine the resolution of a DPM is not "How many digits?" but rather, "How many counts?" And to be complete, you should also find out what the ambiguity error is.

That said, you may think that choosing between a 3½-digit meter and a 4½-digit meter is pretty easy. Either you can tolerate the errors of a 3½-digit unit, or you can't. But sometimes it's not so easy to tell. Let's say that you want to be able to set a dc voltage level repeatably to four significant digits. If the voltage is 150 V, a 3½-digit meter is fine. It lets you read 150.0 V. But what if the voltage is 67 V? The 3½-digit unit will only read 67.0, so a 4- or 4½-digit machine is needed. Of course, if the voltage happened to be, say, 35 V, a so-called 3 ¾-digit (4,000-count) DPM would be ideal.

Accuracy: the three significant figures

Being able to read a lot of digits doesn't do you much good unless the digits mean something. The value of the digits you buy is largely determined by the *accuracy* of your DPM. This is a difficult parameter to evaluate since it depends upon how the meter is applied in your circuit as well as how accurate the meter itself is.

The basic accuracy of a DPM is usually described by specifying the maximum error as a percentage of reading. This is a fairly straightforward specification as long as you note that it holds only at a specified temperature or over a specified temperature range. Since digital instruments are subject to ambiguity errors of ±1 least significant digit, this additional error specification is usually tacked onto the percentage of reading figure.



3. Bias current. For the differential-input configuration shown, the bias current is either I_1 or I_2, whichever is greater. The offset current ($I_1 - I_2$) is most important when the source resistances are equal.

Some manufacturers, however, prefer to deal with the ambiguity error by describing it as a percentage of full scale. This raises the interesting question, "What is full scale?" If you have a 3½-digit (2,000-count) meter, do you include the overrange in the description of full scale, or not? Only the manufacturer knows for sure. So if he doesn't say, you'd better ask him, especially if he also specifies temperature coefficient as a percentage of full scale per degree centigrade.

For meters with very high resolution (4 digits and up), it is usually necessary to add a third term to the accuracy statement to take care of errors at the low end of the range. The extra uncertainty can be described directly as a voltage, or as a percentage of full scale.

Thus, a specification might describe the accuracy of a 4½-digit meter as within ±(0.03% of reading + 0.01% of full scale + 1 count). Or, it might be within ±(0.05% of reading + 1 digit + 10 microvolts). These are the actual specifications of two well-known DPMs. Which is more accurate? The answer, which depends upon how the meters are used, is explored in the table.

For maximum cost-effectiveness, the accuracy and resolution of a DPM should be compatible. Fortunately, manufacturers are aware of this, and the two are usually pretty closely related. A 3½-digit (2,000-count) meter

What about 'logic power'?

Some manufacturers are now making so-called "logic-powered" DPMs—units that are powered by 5 volts dc. Since they need no internal power supply they're cheaper too, provided that you already have a 5-V supply from which to operate them.

These meters are an excellent choice for systems with a lot of digital logic circuitry, since the power supply will already be there. But care must be taken to keep the digital signals away from the meter's analog input. A differential front end is almost a necessity in such applications. Meters with single-ended inputs have been successfully used in such situations, but considerable applications sophistication is needed to prevent ground-loop problems.

can resolve 0.05% of full scale. These instruments typically have maximum errors of ±0.05% of reading ±1 digit, or ±0.1% of reading ±1 digit. The manufacturers of the 0.1% units point out that, at half scale (1,000 counts) or below, the meter can't resolve more than 0.1% of reading so there's no point in having better accuracy. Of course, if you're planning to use your meter near the top end, this argument loses much of its force.

More important, perhaps, than these minor differences in accuracy specs are differences in specified *temperature coefficient*. One manufacturer specifies that his 3½-digit unit has a temperature coefficient of error of 50 parts per million of reading per degree centigrade. Another specifies ±(0.005% of reading + 0.01% of full scale)/°C. Since 50 ppm = 0.005%, and 0.01% of full scale is only 0.1 digit (or 0.2 digit depending on the definition of full scale), these two specs are essentially the same. The meter to watch out for is the one whose tempco isn't mentioned.

The important thing to remember about temperature coefficients is that they're not zero. All too often people overlook them, and find out later that temperature-related errors are the dominant ones in their applications.

Incidentally, an extremely important specification that is frequently overlooked is warm-up time. There are digital panel meters on the market that are guaranteed to meet their published specifications as soon as they are turned on. Others need a half-hour warm-up. Still others are described without any reference to warm-up at all. As before, what you don't know will probably hurt you, so ask.

A DPM may function with its specified degree of accuracy in a test situation, however, and still not do as well when incorporated in your circuit. The two factors to watch out for here are input loading and noise.

There are two or three parameters that must be considered when determining the *loading effects* of a DPM on a circuit. These are input bias current, input impedance, and (for differential inputs) offset current.

The bias current (Fig. 3) is the current that the source must supply to the DPM input, at zero input signal, to properly bias the meter. The error voltage developed by the bias current as it flows through the source impedance can be nulled out with the meter's zero control. But the user should bear in mind that the bias current, and hence the offset adjustment, is subject to drift with time and temperature.

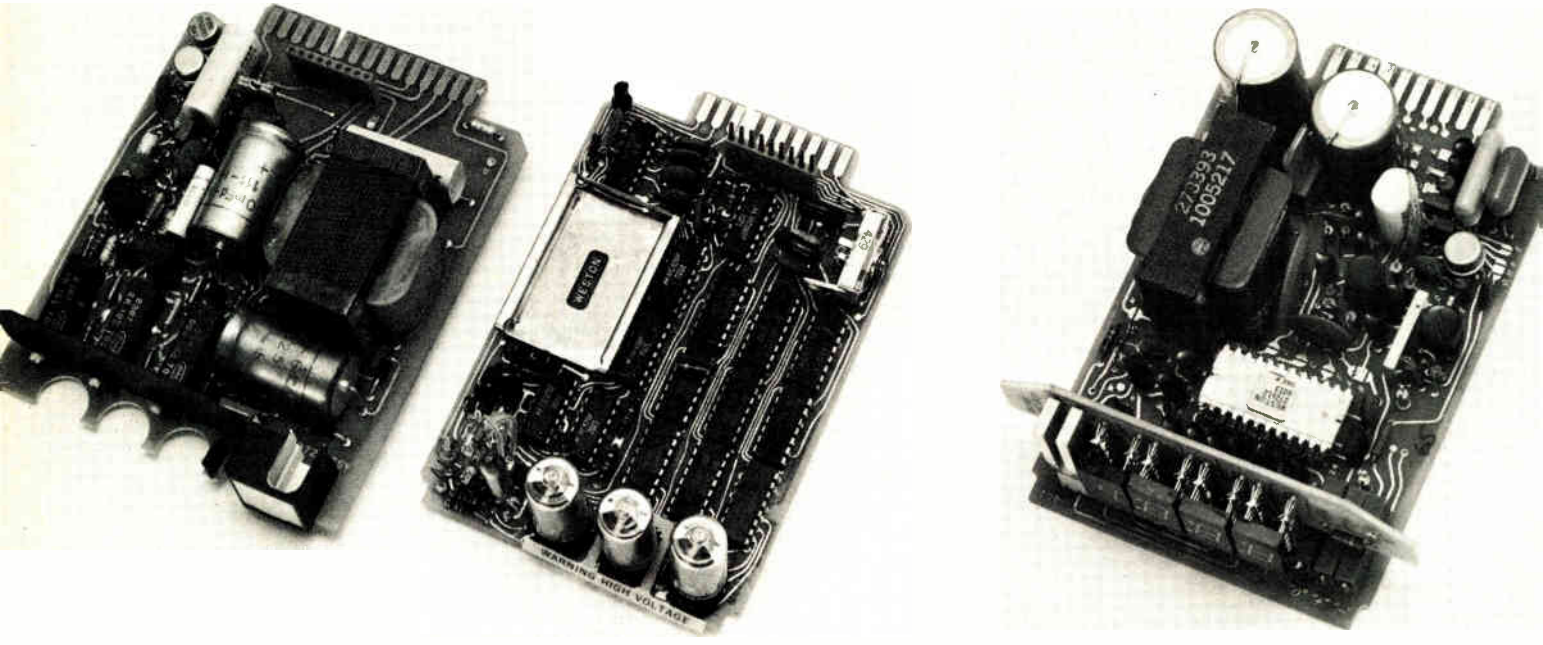
The input impedance of a digital panel meter is the complex ratio of the input signal voltage to the input signal current. This parameter does not take the bias current into account. Thus, the total input current is the sum of the bias current and the current drawn by the meter's input impedance.

Offset current is the difference between the two bias currents of a differential-input DPM. If the voltage source is balanced, this current—not the bias current—may be the only significant source of loading error.

Noise rejection is the other DPM parameter that's important in actual use, but published specs don't tell you very much about it. Typically you are told that the meter in question has a common-mode rejection ratio of X decibels at 60 hertz, and a normal-mode rejection ratio of Y dB also at 60 Hz. But how well will the meter reject the noise in your system? All the experts have the same answer: take a meter, put it in your system, and see.

The common-mode rejection ratio (CMRR) is usually specified for a source imbalance of 1,000 ohms, and, of course, only applies to differential-input devices. It is the ratio, in decibels, of the meter's sensitivity to differential- and common-mode signals.

The normal-mode rejection ratio is a measure of the



4. Looking for reliability. Fewer components mean better reliability. This manufacturer has substituted a single IC for the 14 IC packages required in his older model, has reduced the package design to one circuit board instead of two, and cut the number of connections.

COMPARISON OF ACCURACY SPECS				
	200-V FULL SCALE		200-mV FULL SCALE	
	100-V READING	10-V READING	100-mV READING	10-mV READING
UNIT No. 1 ±(0.03% of reading + 0.01% of full scale + 1 count)	Error = .03 + .02 + .01 = 0.06 V	Error = .003 + .02 + .01 = 0.033 V	Error = .03 + .02 + .01 = 0.06 mV ✓	Error = .003 + .02 + .01 = 0.033 mV
UNIT No. 2 ±(0.05% of reading + 1 digit + 10 μV)	ESSENTIALLY IDENTICAL Error = .05 + .01 + .00001 = 0.06001 V	Error = .005 + .01 + .00001 = 0.01501 V ✓	Error = .05 + .01 + .01 = 0.07 mV	Error = .005 + .01 + .01 = 0.025 mV ✓

Check marks indicate superior accuracy in each case

device's ability to ignore ac signals in series with the dc input. It is usually expressed as the ratio, in decibels, of the actual value of the ac signal to its displayed value.

Both of these noise-rejection specifications are usually specified at line frequency because it is the most common source of input noise. Since these noise-rejection parameters may change rapidly with frequency, they are valid only at the exactly specified frequencies. Generally speaking, for frequencies much above the line frequency, the rejection ratios are improved.

Reliability, the elusive quality

Of all the desirable qualities in a DPM, reliability is simultaneously the most important and the toughest to nail down. If consideration of all other specifications has narrowed your choice of a meter down to three or four candidates, the next logical step is to obtain a sample of each one. These should be tested to see how they work in your system, and then subjected to a reliability analysis. But not every company can spare an engineer to do a proper reliability analysis.

Nevertheless, a rough estimate of reliability can be made by comparing four items in the units under consideration: number of components, number of connections, quality of components, and quality of workmanship (Fig. 4). Sharp-eyed engineers have been known to spot some interesting anomalies by this sort of inspection. For example, if the DPM in question has a rated temperature coefficient of 50 ppm/°C and you know that the reference zener has a tempco of 100 ppm/°C, you have earned the right to ask the vendor some tough questions.

The final piece of reliability advice given by knowledgeable people in the DPM field is: never buy a quantity of meters without first visiting the manufacturer's plant and talking with his engineers. The key things to look for in the plant are an NBS-traceable standards and calibration facility, 100% inspection of incoming semiconductor products and 100% burn-in of all completed DPMs.

So much for the normally invisible aspects of the DPM. What about the displays? At present, in choosing a display for a DPM, the manufacturer has essentially five options:

- The shaped-character glow tube, such as the Burroughs Corp's. Nixie devices.
- The seven-segment planar glow tube, as made, for example, by Sperry.
- The seven-segement planar filament display.
- The seven-segment or dot-matrix light-emitting-diode display.
- The liquid crystal display.

The shaped-character glow tube is the oldest, most throughtly tested horse in the display stable. It has convincingly proven its long-term reliability with a life expectancy that exceeds 100,000 hours. And it's cheap. For these reasons it's the most common display in use today. However, since it's tough to ionize the gas in a glow tube with a 5-V supply, these devices are not generally used in low-voltage meters. Some people also object to the fact that the characters are not in the same plane.

The second objection, but not the first, is met by the planar seven-segment glow tube. Many DPM manufacturers offer a choice between these two displays, with the planar type carrying a higher price tag.

For low-voltage applications, the options are a filament or a LED display. Here, the LED unit usually costs more, if you have a choice. But quite often, the manufacturer offers only one type of low-voltage display, simplifying your decision for you.

One point to bear in mind: if you're planning to use the meter out of doors, make sure you can read the display in bright sunlight. Filament displays are usually better than LED types in this regard.

The liquid crystal diplay is more a creature of the future than of the present. Although one manufacturer does offer a DPM with a liquid crystal display, most makers feel that the display's operating temperature limitations and short lifetime make it an unrealistic choice at this time. But in the future (say, five years from now), the picture will be very different. Liquid crystals, with their low power consumption and potentially very low price, will make cheap, battery-operated portable DPMs a reality.

As liquid crystal displays become more practical, the DPMs themselves will become more reliable, using fewer and better MOS LSI chips. It has been estimated that 80% of the high-quality analog meters in use today (a $45 million market) will be replaced by DPMs in 10 years. Half of this replacement will take place within the next five years. □

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FIFO, as its name implies, operates in a first-in first-out mode. Four bits of input data are clocked into the FIFO device and 'bubble' automatically to the last unoccupied location. Special on-chip input pullup circuits and bipolar compatible output buffers provide direct compatibility with TTL and DTL, without any external components. Control signals make vertical and horizontal expansion easy. 1MHz input/output rate guaranteed.

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Frequency doubler accepts any waveshape

by Donald DeKold
Santa Fe Junior College, Gainesville, Fla.

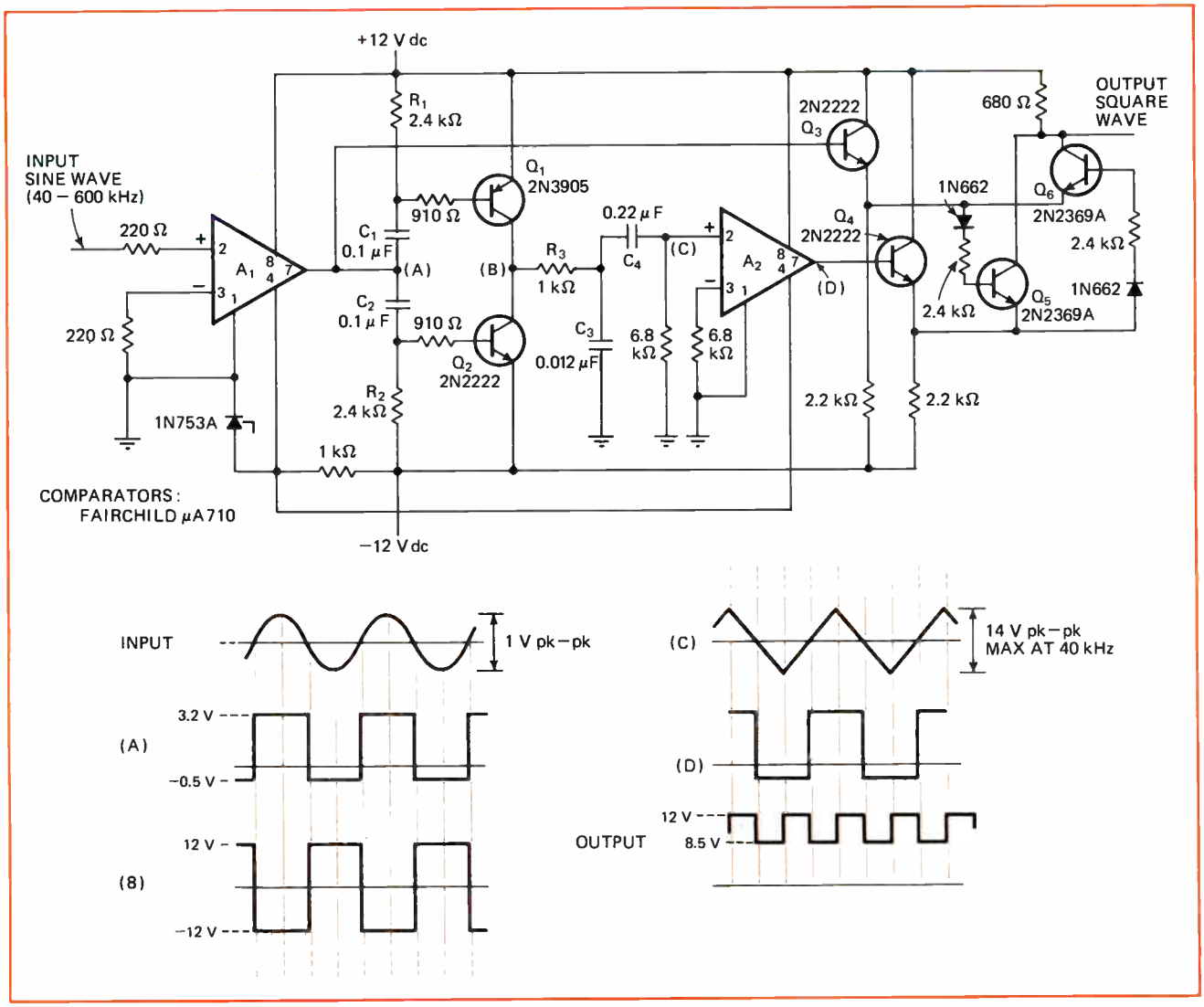
The frequency of nearly any waveform can be doubled by means of quadrature square waves that drive a biconditional logic circuit. Only two restrictions must be imposed on the input to this frequency doubler—the wave form must have a duty cycle of approximately 50% and a peak-to-peak amplitude of at least 0.5 volt.

For the circuit shown, the input is a sine wave that can vary in frequency from 40 to 600 kilohertz. The output is a square wave at twice the input frequency, having a duty cycle of about 38% for the lower-frequency inputs to around 65% for the higher-frequency inputs.

Comparator A_1 operates in its noninverting mode, accepting the input sine wave and producing a square wave at its output. Capacitors C_1 and C_2 couple this square wave to a pair of complementary switches, transistors Q_1 and Q_2. The switches boost the amplitude of the square wave to 24-v pk-pk. Resistors R_1 and R_2 prevent the bases of Q_1 and Q_2 from being clamped to dc voltages that would drive them into cutoff.

Capacitor C_3 is alternately charged and discharged through resistor R_3. When Q_1 is in saturation and Q_2 in cutoff, C_3 exponentially charges towards 12 v dc; with Q_1 cut off and Q_2 saturated, C_3 discharges towards

Frequency times two. Sine-wave input is converted into square wave by comparator A_1. Emitter-followers Q_1 and Q_2 charge and discharge capacitor C_3, producing triangular wave that drives comparator A_2. Resulting square-wave output of A_2 is in quadrature with square-wave output of A_1. Switches Q_5 and Q_6 conduct only when comparator states are different, providing square wave that is twice input frequency.



−12 v dc. When the charging or discharging interval is short compared to the R_3C_3 time constant, the voltage across capacitor C_3 approximates a triangular wave that has its peak value occurring 90° out of phase with the peak amplitude of the input sine wave.

The triangular wave is applied to the noninverting input of comparator A_2 through capacitor C_4. The comparator "squares" the triangular wave about its zero crossings, producing a square wave that is 90° out of phase with the output of the first comparator.

Transistors Q_3 and Q_4 are emitter-followers that act as buffer amplifiers for both comparators and drive a set of nonsaturating switches, transistors Q_5 and Q_6. When comparator states are the same, Q_5 and Q_6 are off; when comparator states differ, Q_5 or Q_6 conducts.

The switching action of transistors Q_5 and Q_6 is equivalent to the biconditional logic function:

$$XY + \overline{X}\overline{Y} = 1$$

which has the effect of doubling the frequency of quadrature square waves. A diode and resistor in each transistor's base-emitter loop prevent false switching when both comparators are in the same state, but may have different output levels.

A square wave with a 50% duty cycle can be realized for a nominal input frequency of 120 kHz. At lower frequencies, the duty cycle is smaller because the triangular wave becomes exponentially rounded. At higher frequencies, the duty cycle is larger, since the amplitude of the triangular wave decreases, thereby shortening the duty cycle of the square wave at the output of the second comparator. Also, circuit delays become significant compared to the period of high-frequency inputs.

The frequency doubler can operate below 40 kHz if higher capacitor values are used throughout the circuit. To operate at higher frequencies, faster switching devices must be used, and transistors Q_1 and Q_2 must not be allowed to saturate.

Since the maximum input voltage for the type μA710 comparator is ±7 v, the amplitude of the triangular wave must not exceed 14 v pk-pk. □

Op amp cancels video switching transients

by Steven E. Holzman
Electromagnetic Systems Laboratories, Sunnyvale, Calif.

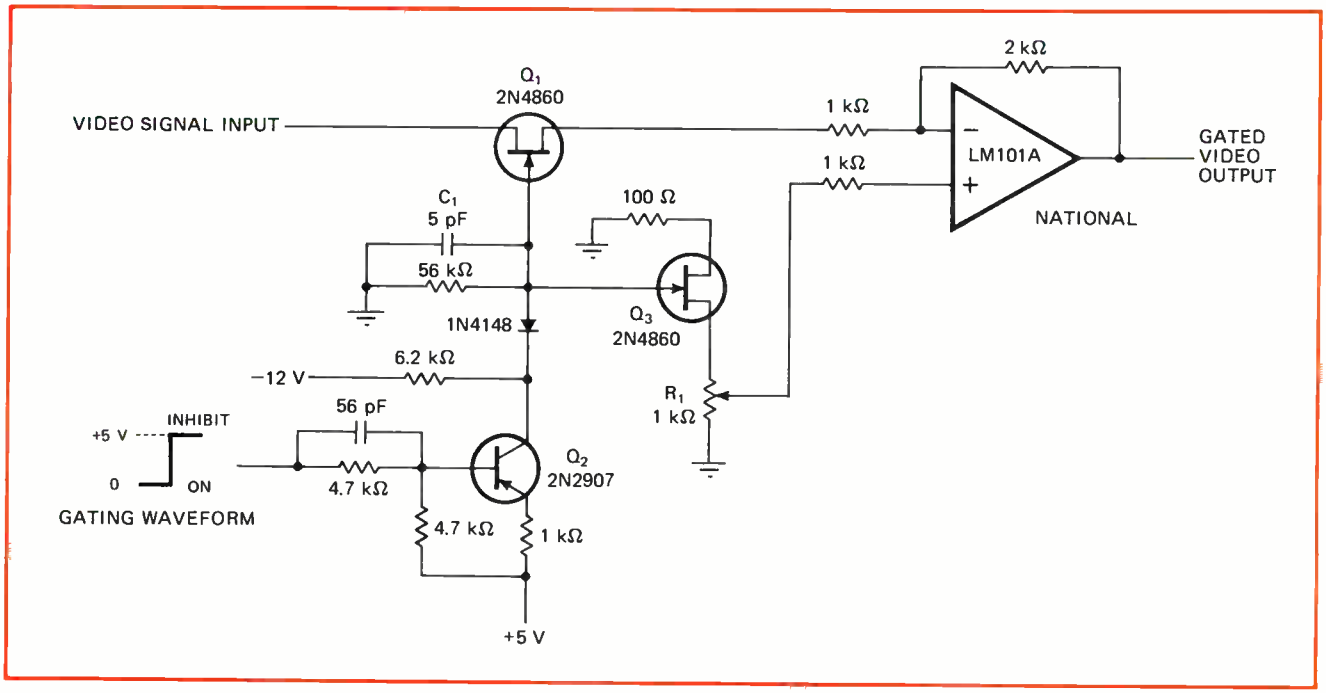
The common-mode rejection of an ordinary operational amplifier can help to minimize switching transients in low-level video gates. The transients are caused by the leading and trailing edges of the switching waveform.

The video gate basically consists of a switching field-effect transistor (Q_1), its associated TTL-compatible driver (bipolar transistor Q_2), and an output op amp. Transients are generated when the switching waveform edges pass through the FET's gate-drain junction.

By adding a second FET (Q_3) and its biasing resistors, the transients can be eliminated by forcing them to cancel through the op amp. Since the transients from transistor Q_1 will be identical to those from transistor Q_3, the op-amp's common-mode rejection stops these unwanted spikes from reaching the output.

Capacitor C_1 helps maintain equal feedthrough char-

Transient-free video gate. Leading and trailing edges of gating waveform create transients when passing through first FET, Q_1. Including a second FET, Q_3, duplicates signal path of Q_1 and permits op-amp common-mode rejection to cancel most transients. Capacitor C_1 equalizes feedthrough characteristics of the two FETs so that matched pair is not necessary. Bipolar transistor Q_2 makes circuit TTL-compatible.



acteristics for both Q_1 and Q_3. This eliminates the need for a matched pair of FETs. By simply adjusting resistor R_1, nearly all of the transients can be cancelled.

In the circuit shown, the amplitude of the switching transients can be reduced to less than 1 millivolt over an operating temperature range of −20 to +60°C. □

Pulse generator accuracy is immune to aging

by Frank Cicchiello
Digilog Systems Inc., Willow Grove, Pa.

This pulse generator for driving digital circuits won't change frequency, even after its components have aged or are replaced. And pulse repetition rate remains stable over a wide temperature range.

If any or all of its active devices are replaced or have aged, the generator exhibits only a 1.5% worst-case variation in rep rate. Replacing or aging any or all of the passive components causes a worst-case change of 1%. Typically, rep rate varies merely 0.5% over a 50°C temperature range, and all variations amount to less than 2% when taken collectively.

When the dc supply voltage (V_{CC}) is turned on, timing capacitor C_1 charges exponentially through resistor R_1 until capacitor voltage reaches the threshold voltage (V_T) of programable unijunction transistor (PUT) Q_1. This triggering level is established by the voltage divider formed by resistors R_2, R_3, and R_4. For optimum temperature stability when the supply is greater than 10 volts:

$$V_T = 0.5V_{CC}$$

Pulse rep rate is determined by:

$$\text{rep rate} = 1/[0.78R_1C_1 + (0.5 \times 10^{-12})R_1C_1]$$

Once its triggering threshold is reached, the PUT switches, causing its gate voltage to swing in the negative direction. This produces a positive-going pulse across cathode resistor R_5, which turns on transistor Q_2 and discharges capacitor C_1.

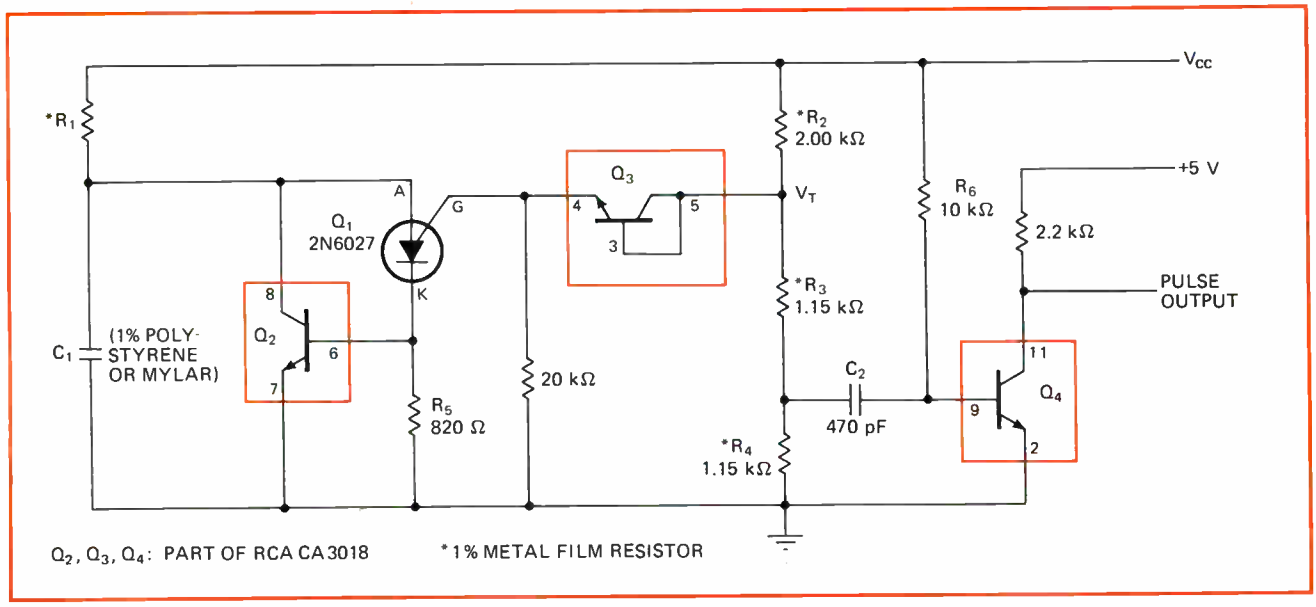
The function of Q_2 is twofold. It rapidly discharges C_1 by passing the discharge current around the anode-cathode junction of the PUT. And it also effectively eliminates the PUT's valley-current offset. This allows timing resistor R_1 to have a value as low as 2 kilohms, rather than a value above 100 kilohms, as normally required. Output pulse rep rate can then vary over a 250:1 range for a given value of C_1 (500 picofarads to 1 microfarad). Output frequency can be up to 1 megahertz.

PUT temperature stability is assured by diode-connected transistor Q_3, which matches the temperature characteristic of the PUT's anode-gate junction, even if current flow is in the microampere region. Although most standard diodes cannot do this, almost any low-leakage diode-connected silicon transistor may be used for Q_3.

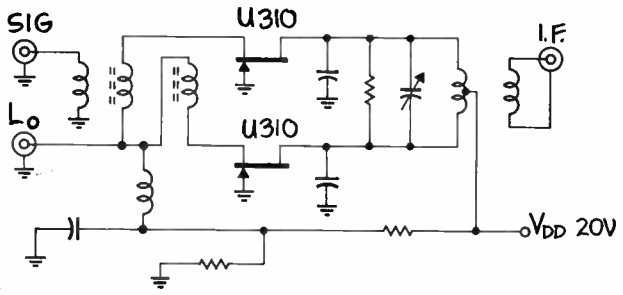
Negative-going pulses from the PUT are directly coupled to the base of transistor Q_4 through transistor Q_3; capacitor C_2 provides ac coupling. If pulses shorter than 4 to 5 microseconds (typical for this circuit) are required, the R_6C_2 time constant of Q_4's input coupling network can be reduced to differentiate the input signal and produce narrower positive-going output pulses. The output pulse train is compatible with both transistor-transistor and diode-transistor logic. □

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

Stable pulse generator. Power supply charges capacitor C_1 until threshold of programable unijunction transistor Q_1 is reached, Q_1 then switches, turning on transistor Q_2, which discharges C_1. Diode-connected transistor Q_3 dc couples resulting pulse to output transistor Q_4. Generator's repetition rate changes only 2% for worst-case variation of all its components, even if they age or are replaced.



to build a better VHF/UHF FET mixer:



Try our U310 junction FET in this balanced mixer and make your own performance comparison. Our results are below. The inherent square-law transfer characteristic of the FET ensures high intermodulation intercept and signal desensitization. The grounded-gate connection is most stable, while source injection of both the signal and local oscillator make easy impedance matching into the FETs. Also, the balanced configuration reduces l.o. radiation from the signal port and suppresses the generation of even harmonics (which helps reduce intermodulation).

How do you select an optimum JFET for a mixer? Low gate capacitance is needed for wide bandwidth – the Siliconix U310 typically has C_{gs} = 4.5 pF and C_{gd} = 1.9 pF. Useful conversion gain comes from high transconductance. Our U310 has typical g_{fs} = 14,000 μmhos. Dynamic range is bracketed by the lowest drain current for an acceptable noise figure and the maximum drain current – typically I_{DSS} = 40 mA for the U310. For an optimum balance, matched pairs are available.

50-250 MHz Mixer Performance Comparison

Characteristic	JFET	Schottky	Bipolar
Intermodulation Intercept Point	+32 dBm	+28 dBm	+12 dBm†
Dynamic Range	100 dB	100 dB	80 dB†
Desensitization Level (the level for an unwanted signal when the desired signal first experiences compression)	+8.5 dBm	+3 dBm	+1 dBm†
Conversion Gain	+3 dB*	−6 dB	+18 dB
Single-sideband Noise Figure	6.5 dB	6.5 dB	6.0 dB

† Estimated * Conservative minimum

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Selecting inputs to test digital circuits on complex IC boards

Choosing excitation codes for inputs to locate faults and troubleshoot them requires judicious decisions on the right combination of fixed and pseudorandom signals that can be reproduced exactly for repetitive checks

by Donald P. Allen and Noel P. Lyons, *Trendar Automatic Corp., Mountain View, Calif.*

☐ Two factors are contributing to the growing difficulty of testing digital circuits: a wide variety of integrated circuits are becoming available for use in many different applications, and the printed-circuit boards holding the ICs are becoming larger as more and more circuits are mounted on them.

Thus, any tester that is intended to be more than a special-purpose unit designed for a particular pc board must not only handle the wide variety of ICs—including multiphase signals for MOS circuits—but also must be able to apply signals to the board that will force the many ICs mounted on it to run through all the possible logic states. (Murphy's law applies to digital-circuit testing—any logic state not checked before the system is assembled will be the one that turns out in the field to be faulty.)

However, simply running the logic through all its states does not guarantee that faults will be discovered—any faults that are in the circuit must be propagated through all the logic stages separating the fault from the board edge connector; this requires care in the choice of test inputs to be applied to the board. Although all three of the major digital circuit test inputs (see "Generating test inputs," p. 90) have their advantages, pseudorandom patterns generally offer better performance at lower cost than truth tables or fixed-pattern excitation.

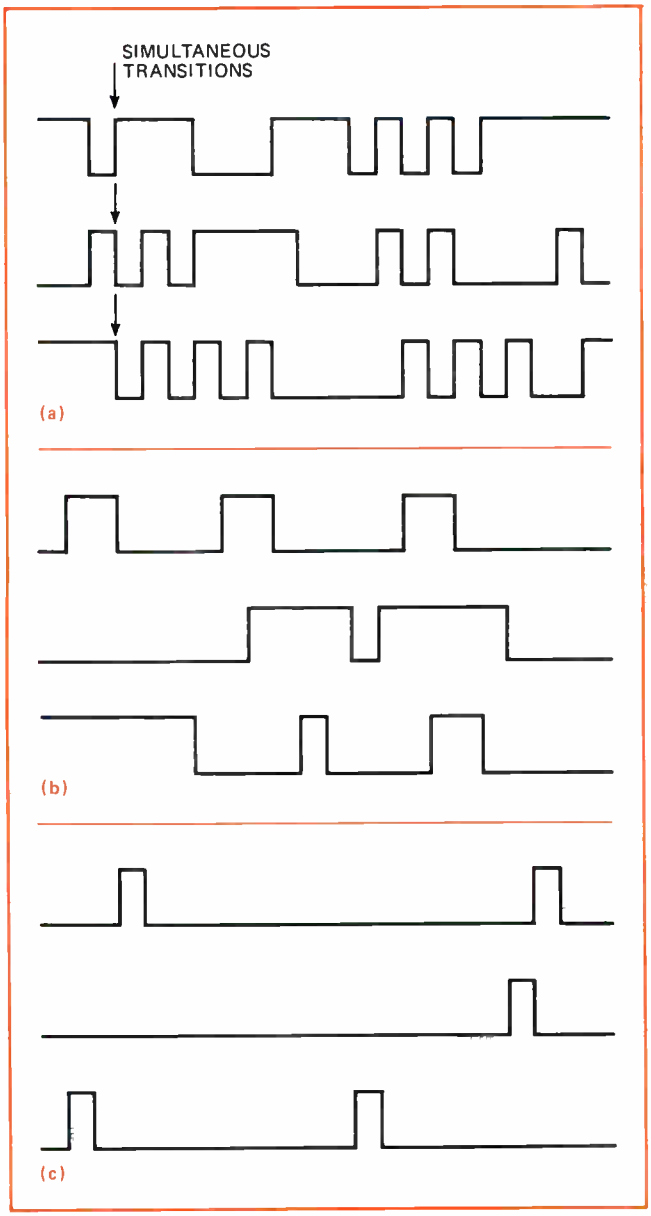
Comparison testing

In comparison testing, where outputs of a board under test and a known good board are matched under the same input excitation, the major problem is in selecting the proper inputs to the two boards; this is the equivalent of the programing process in computer-controlled testers.

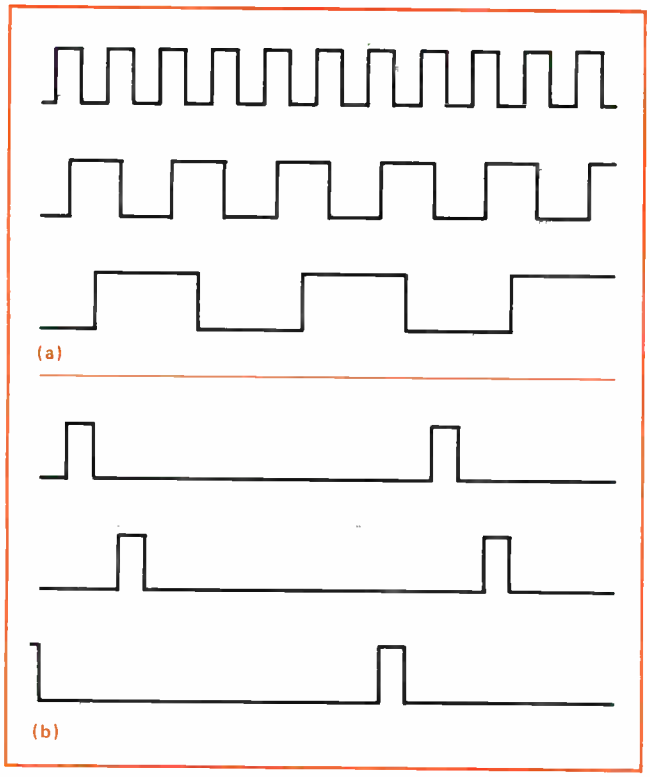
One key to successful comparison testing is to use pseudorandom signals for excitation. These signals appear random to the circuitry, since there is no regular pattern of bit changes, but they can be reset to time zero and then will repeat the same sequence of "random" bit changes.

Such resetting is needed for fault isolation—if the signals were truly random, a fault might be noted, but it would be impossible to duplicate the input pattern as it was at the time the fault appeared at the board edge. Most of the boards now in use can be successfully tested with such pseudorandom signals.

In some cases, however, pseudorandom signals will



1. Pseudorandom patterns. Three types of pseudorandom sources are (a) one that allows transitions on more than one line at a time, the so-called Trendar generator; (b) the pseudo-Gray generator, in which only one line transits at a time; and (c) the 1-of-N generator, in which a pulse appears on only one line at a time. Waveforms are shown for three of 32 available lines in each case.



2. Clock sources. Gray clock generator (a) allows one bit stream to transit at a time (three of 24 bit streams shown). The eight-phase clock generator, useful for MOS circuits, is shown in b.

not suffice, and they must be combined with signals of a particular relative frequency. This is especially true of certain classes of sequential logic, such as cascaded counters and shift registers, to ensure that all the states have been exercised.

However, when combining such inputs with the pseudorandom signals (and also when combining pseudorandom signals), phase relationships must be accounted for to prevent indeterminate circuit action or "race" conditions. This is particularly important where sequential logic clock, set, or reset signals are derived from levels of gating internal to the circuit.

It's also important to observe certain control relationships, such as READ and WRITE commands. Indeterminate circuit action will result if the circuit is asked to do both simultaneously. If two control signals are involved, one can be a pseudorandom "master" control, while the other becomes its complement, thus maintaining exclusive control states. Some exclusive control relationships that are externally related to the end-use system can be ignored in testing the circuit. Here, it is simply required that all internal nodes toggle, since it is mandatory in the comparative technique that sister circuits behave identically under a given sequence of stimuli.

The sequence of stimuli is particularly important in circuits such as those contained in modems and disk controllers, where a specific bit sequence is necessary to compel full exercise of the circuit. For such cases, pseudorandom signals will not be appropriate; instead, programable bit generators that can be loaded with the proper bit sequences are required.

Now in accordance with the preceding general rules, what groups of generators will be required to perform comparison testing? Basically, there must be a group to supply data, a clock group, and a programable group. The data group should be pseudorandom, while the clock group should provide fixed patterns, and the programable group should not only provide programable bit patterns, but also programable clock rates.

Choosing generators

The data group is used to create code sequences, such as 16-bit addresses, ASCII characters, and random control-code changes. Individual bit streams can be used for data, control-state, and clock or command inputs. In a recently developed commercial comparison tester, three types of pseudorandom code generators make up the data group: pseudo-Gray, 1-of-N, and a specially developed set of generators, called, because of their proprietary nature, Trendar code generators. Each of the three provides 32 bit streams on 32 output lines.

The Trendar generator is typically applied to coded data inputs, address inputs, or counter inputs where a particular balance is sought in data rate, clock rate, or reset rate. The patterns (Fig. 1a) include bursts of maximum bit rates, as well as strings of 1s and 0s. The individual bit streams must be used carefully, however, because more than one output can transit at a time.

The pseudo-Gray code generator has practically no restriction on its use. It shares one property with the Gray code: only one bit position changes logic levels at a time (Fig. 1b). However, there is no regular pattern associated with the sequence of bits that make transitions— the one bit making the transition is equally likely to appear on any of the 32 output lines.

Pseudo-Gray patterns can be applied to any combinatorial or sequential logic. Typically, they will drive a data-bus address-select group, control decoder, or data-transfer gating.

The restriction of one bit transiting at a time (only 1 of 32) limits the over-all bit rate of change. The sequence probability of an output-bit position of this generator is identical with that of the Trendar generator, but the bit rate is 64 times slower. Where maximum toggling activity per bit is desired, the Trendar generator is used for pseudorandom input signals, or a Gray clock can provide square-wave input signals.

The 1-of-N pattern

The 1-of-N generator produces a pseudorandom pulse at only one output bit position at a time (Fig. 1c). The pulse will appear at any output an average of 32 times less often than a Trendar transition. Occasionally, multiple pulses will come in close sequence. At other times, longer periods will elapse with no pulse. The generator bit outputs, as a group, can be made normally high or normally low, and the active bit output will pulse to the opposite polarity.

The 1-of-N pattern can be used occasionally to exercise a circuit function of normally limited activity. For example, an inhibit input can be held in the noninhibited state and pulsed to inhibit the circuit periodically. This enables the circuit under test to operate the majority of the time, yet exercises the input. Likewise a strobe to a decoder can be held in the strobed off state (or vice versa), depending upon the test engineer's pref-

erence for amount of relative circuit-activity.

One-of-N signals can periodically set latched control states when the circuit has multiple interlocked controls. Also, this generator is ideal for exercising bus systems that have tri-state logic, which has a high, low, and high-impedance off state. The 1-of-N characteristic ensures that only one circuit is signalled to be active at a time.

Clock signals are generally periodic square-wave or pulse (strobe) functions used to trigger sequential logic or to gate control or data signals. They can be divided to obtain signals of known relative frequencies. In the tester described here, the clock group provides 24 Gray-code clock signal outputs and an eight-phase clock.

The Gray-code generator, with 24 output bit streams (Fig. 2a), is a form of binary divider. The first bit position has the highest frequency; the second runs half as fast; the third runs one-fourth as fast, and so on. Only one transition occurs at a time throughout the 24 Gray-code bits. Gray-code clocks are generally applied to such functions as counter inputs, clock inputs to flip-flops, shift registers, and counters. The phase of this clock generator as a whole is independent of any other pattern-generator source, and the one-transition-at-a-time property ensures that only one clocked activity occurs at a time, thereby preventing race conditions in the circuit.

The eight-phase clock offers eight independent non-overlapping clock phases (Fig. 2b) for circuits that use multiphase clocks. For example, an MOS shift register may require a two-phase clock. The first and fourth clock outputs can be used for this purpose. The event phase of each eight-phase clock transition is independent of other generators. Each of the 8 phases runs at one-eighth maximum Gray-clock frequency.

Programable group

The programable group is used for circuits that require a fixed bit sequence to logically enable parts of the circuitry to accept data signals. In other cases, a given relationship of duty cycle and relative toggling frequency is required between inputs to "open up" the card's internal states. Such special code sequences can be provided by presettable arrays of memory registers having serialized outputs and programable clock rates.

The programable code generators provide eight output bit streams. Each of the eight programable generators is associated with 16 bit positions of one of the other pattern generators. The generators can be used in two ways. They can serially clock out a stored bit sequence of the associated pattern generator, and they can create a fixed code. In the first application, for example, the programable code generator associated with 16 bit positions of a pseudo-Gray generator would serially clock at a programed rate that generator's pseudo-random bit pattern (captured at an instant in time) out to the circuit under test.

The second method is to create a fixed code by using override logic-level switches. Once these switches are set, the programable code generator is loaded, and the switches are returned to allow normal pseudo-Gray operation. The programable generator repeats indefinitely the bit stream thus loaded. Two or more programable code generators can be chained together to produce longer fixed sequences.

Assigning generators

The assignment of pattern generators to specific inputs is the nearest equivalent of programing in a comparison tester. One pitfall in choosing inputs is that highly active toggling on the output line is no guarantee that internal states are being thoroughly exercised. For example, in a push-pop, or last-in/first-out memory stack, it's possible to exercise the upper registers near the input, but to leave the registers farther away untouched.

Another example is in the circuit of Fig. 3, which shows a NAND gate driving a string of counters. The counters have reset inputs which, if pulsed too frequently, will prevent the counters from reaching their full counts. Thus, if the reset pulses are applied at too high a rate compared with the count signals coming from the NAND gate, some sections of the counters will

Generating test inputs

Digital circuit testers generally have used one of three basic approaches to generating inputs for circuit excitation: truth tables, fixed patterns, and random or pseudorandom patterns.

Truth tables, in which the state of every output is known for every possible combination of input states, are generally used in computer-controlled testers. Some testers create the truth table by applying known signals to a known good board and then recording the corresponding outputs; however as board complexity increases, the possible combinations increase rapidly. Software systems are being developed to model the circuits under test and then create the input pattern sequences needed to exercise all the internal states of the circuits. However, this is a complex, costly approach.

Fixed patterns have been used successfully in memory testers and for circuitry of limited complexity. Walking 1s and 0s are sufficient to exercise a random-access memory, but such patterns are too limited for general-purpose applications; they will not usually provide enough toggling action to bring to the edge of the board any logic faults that are several stages removed from the edge (active toggling on an output line does not assure that all internal states are being toggled). One fixed pattern that is useful, when applied with other patterns, is the Gray code. The fact that only one input changes at a time prevents indeterminate timing or "race" conditions. However, the Gray code has a limited number of high-frequency inputs, since each successive bit position toggles at half the rate of the adjacent bit position.

Random patterns have been used as excitation for circuit testers; a white-noise digital pattern generator has been built into a commercial tester. However, the use of white noise suffers from two drawbacks: simultaneous transitions on two or more lines can occur, and truly random signals are not repeatable, which limits fault isolation. Thus, pseudorandom sources, which can be reset to generate the same "random" pattern from time zero, are more useful in actual circuit testing.

never receive the signals to make the check.

It is not necessary to manually program each condition of the state diagram, as with a computer system. On the contrary, the usual procedure is to make an initial pattern assignment and observe the toggling action of each IC. In this manner, inappropriate circuit action, such as a counter string being reset before overflow, can be detected. This is the equivalent of software debugging in computer-controlled testers.

In assigning generators to board inputs, the first step is to assign inputs to independent parts of the circuitry. Next, circuit sections that are interdependent, perhaps including recursive control logic feedback, must be studied to estimate relative frequencies and duty cycles that would yield proper toggling behavior. The test engineer should take advantage of any available data concerning the nature of typical circuit input waveforms to the circuit in question. In this fashion, he can select statistically similar bit streams, thus creating a high probability of active toggling behavior.

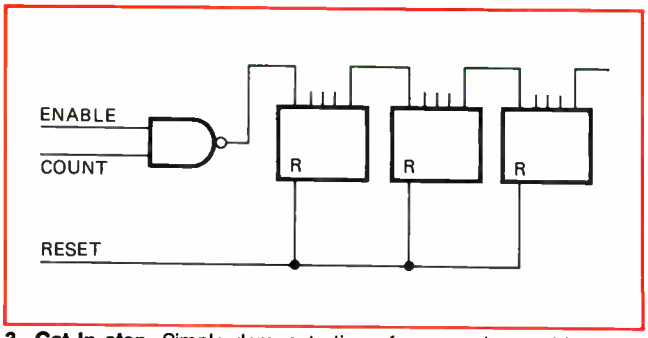
Test illustrated

It would be difficult to present an example that demonstrated all the considerations in choosing excitation sources. However, some of the data and control circuits for a memory system shown in Figs. 4 and 5, do show significant points. The whole board, of which the illustrated circuits are only a part, contains some 50 or more ICs; this has been successfully tested by the comparison method during production.

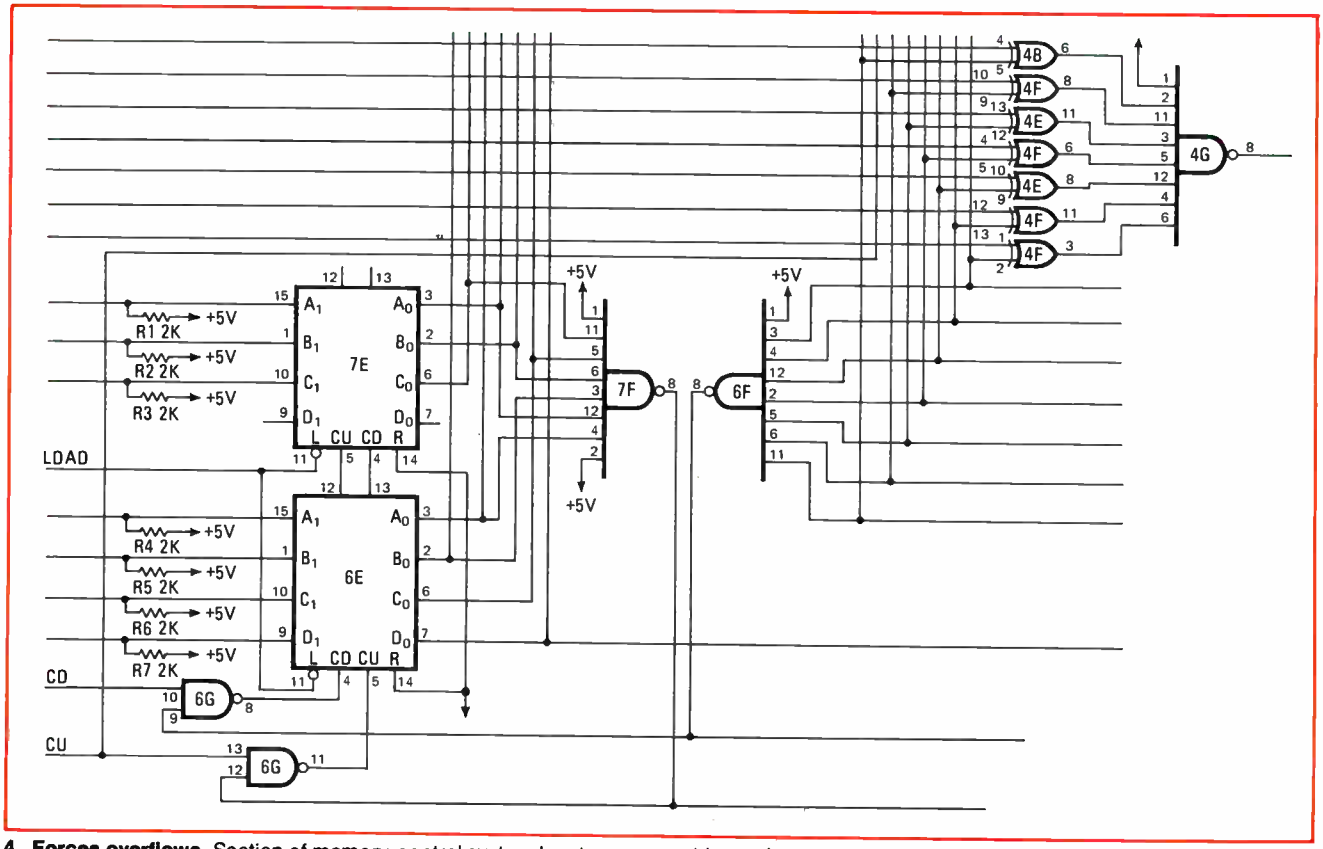
The circuit in Fig. 4 shows two presettable, up-down, four-bit binary counters. Preset data is applied to pins 15, 1, 10 and 9, while the LOAD command is applied to pin 11. COUNT UP commands go to pin 5, COUNT DOWN to pin 4, and four-bit outputs come from pins 3, 2, 6, and 7, with pin 7 the most significant bit.

The preset data words, three bits to 7E and four bits to 6E, can be simulated by pseudorandom signals. In general, it's best to drive sequential logic by pseudo-Gray rather than Trendar generators because of the simultaneous transitions possible with the latter. However, in this case, no action takes place inside the counters until the LOAD pulse is applied, and thus either pseudo-Gray or Trendar generators can be used.

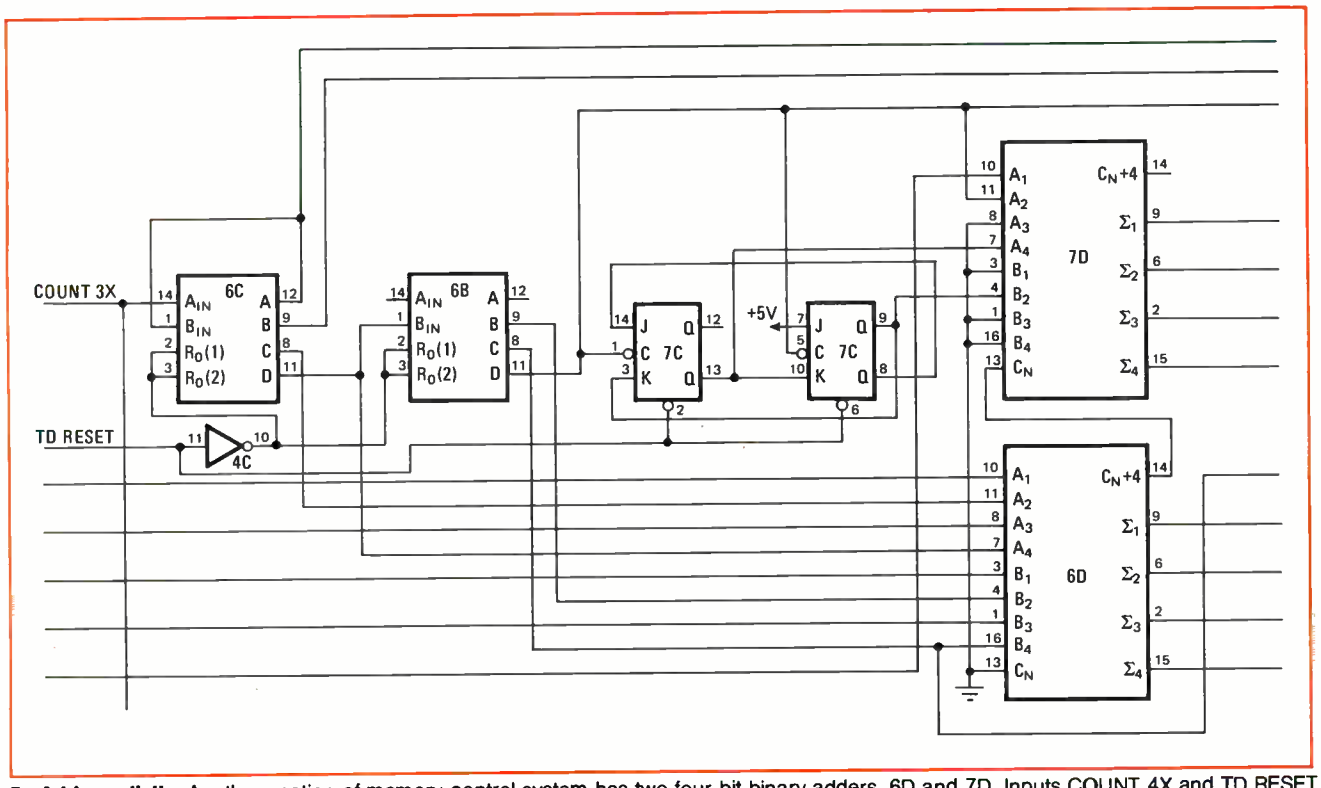
The LOAD input should be driven by a Gray clock square wave that is relatively slow with respect to the COUNT-UP and COUNT-DOWN inputs in order to cause the counter to fully exercise all its states. The 10th Gray



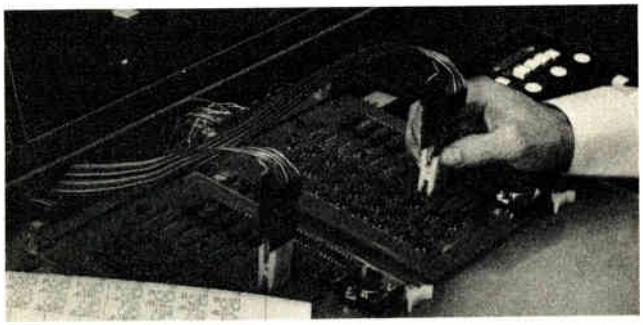
3. Get in step. Simple demonstration of programing problem with comparison tester is logic gate driving three cascaded counters. Inputs to gate must step the counters through all states before reset pulse is applied, or else some states will be untested.



4. Forces overflows. Section of memory-control system has two presettable up-down four-bit binary counters. Preset data words applied to pins 15, 1, 10, and 9 are represented by pseudorandom signals; LOAD input is driven by Gray lock square wave.



5. Adder activity. Another section of memory-control system has two four-bit binary adders, 6D and 7D. Inputs COUNT 4X and TD RESET must toggle J-K flip-flops with enough activity to provide adequate adder inputs before reset. Pseudorandom and Gray clock signals do this.



6. Compare and test. Troubleshooting by comparison tester, once fault is discovered on board under test, is performed with pair of dual in-line package test clips. Fault is traced back from output.

clock stream is a square wave that transits at 2-10 times the frequency of the highest Gray clock, and it will be used for the load input.

In order to exercise all its states, the counter must be driven to overflow and underflow. Choosing a COUNT-UP frequency higher than the COUNT-DOWN frequency will ensure that the counter does overflow periodically. The 11th Gray clock stream can be assigned to count up and count down, and the ninth to count up. Thus, the COUNT-UP input is exercised four times faster than COUNT DOWN.

The other section of the circuit in Fig. 4, the EXCLUSIVE-OR gates are independent of the counting circuits and thus can be adequately exercised with pseudorandom signals.

In Fig. 5, two cascaded four-bit binary counters (6C and 6B) feed two more cascaded J-K flip-flops (7C) all of which provide inputs to the two four-bit full binary adders, 6D and 7D. Here it is important that the inputs COUNT 3X and TD RESET be of such a relative frequency that the counter flip-flop string can provide sufficient activity for the flip-flops and adders. The outputs of flip-flop 7C must provide enough adder inputs before the adders are reset. A number of combinations of inputs can do this.

In particular, a pseudorandom input, such as a Trendar, on the COUNT 3X line and a relatively slow Gray clock (clock 17) on TD RESET will cause resets that occur approximately 64,000 times less frequently than the count input. This is sufficient to allow the divide-by-2^9 action of the counter flip-flop string to actively toggle at the inputs to the adders. Not shown, but also part of the circuit, is a set of MOS shift registers. With the eight-phase clock, the registers can be tested at 2 million to 4 million tests per second with clock frequencies well above the minimum 5 kilohertz required.

The final debugging evaluation would be to actively operate the circuit and check all of the key internal nodes to ensure that active transitions are occurring. With this circuit, it is necessary to ensure that a bad bit entered into the shift register will always find its way to an external comparator as an output fault during the test.

Troubleshooting with a comparison tester can be performed through two logic probes—clips that fit over the dual in-line packages and contact each of the terminals (Fig. 6). When a fault is sensed at an output terminal on the edge connector, the operator resets the test inputs to the same state that existed when the fault was noted. He then traces back through the circuit, comparing the state of each IC in the chain on the board under test with that of the corresponding IC in the known good board until the fault is isolated. □

Computational module stresses applications versatility

by Lew Counts and Fred Pouliot
Analog Devices Inc., Norwood, Mass.

Multiplication, division vector calculations, solving for roots, and finding root-mean-square values are just a few of the jobs that can be done by a recently introduced multifunction module [*Electronics*, May 22, 1972, p. 125]. Sold by Analog Devices for $75 singly, the model 433 uses logarithmic computing techniques, so that its accuracy is maintained even with decreasing signal levels.

The small unit can accept three independent inputs—V_x, V_y, and V_z—of up to 10 volts each. They are related to the output by:

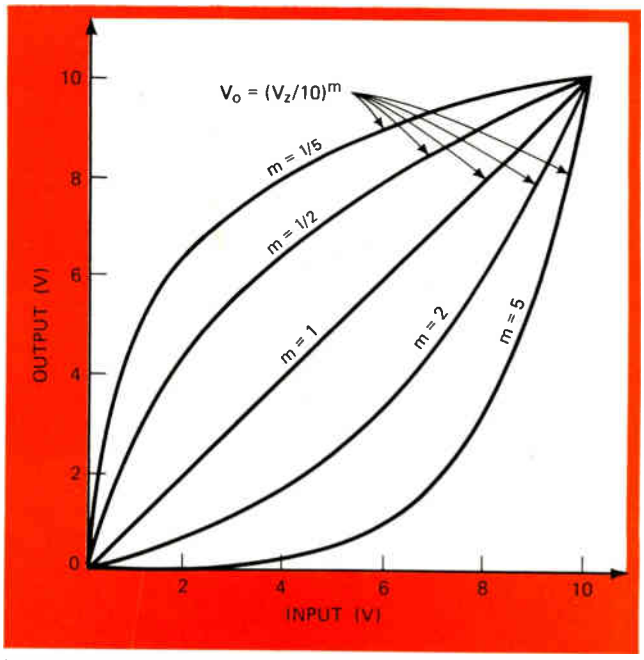
$V_o = V_y(V_z/V_x)^m$

Exponent m is adjustable over a 25:1 range, from 1/5 to 5, by appropriate selection of resistance values in a two-resistor divider network. This is illustrated in the block diagram and in the set of typical transfer functions. Programing resistors are not required for m = 1.0.

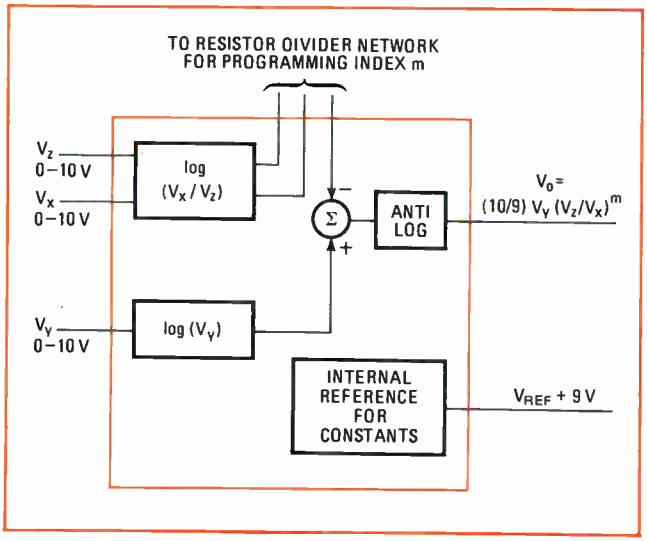
Of course, any conventional analog multiplier may be placed in the external feedback loop of an operational amplifier for use as an analog divider. However, such an arrangement increases error terms associated with the multiplier. Higher noise, offset drift, and over-all error result when the denominator signal decreases, thereby reducing loop gain.

For example, a 0.1% multiplier can operate as a 0.1% divider for a 10-v full-scale denominator input. But if this amplitude drops to 1 v, divider error increases from 0.1% to 1%. When denominator input levels reach 0.1 v, over-all error rises to 10%. In contrast, the model 433 functions as a logarithmic unit, so that errors emerge as a gain error and a fixed offset and are independent of the denominator signal amplitude.

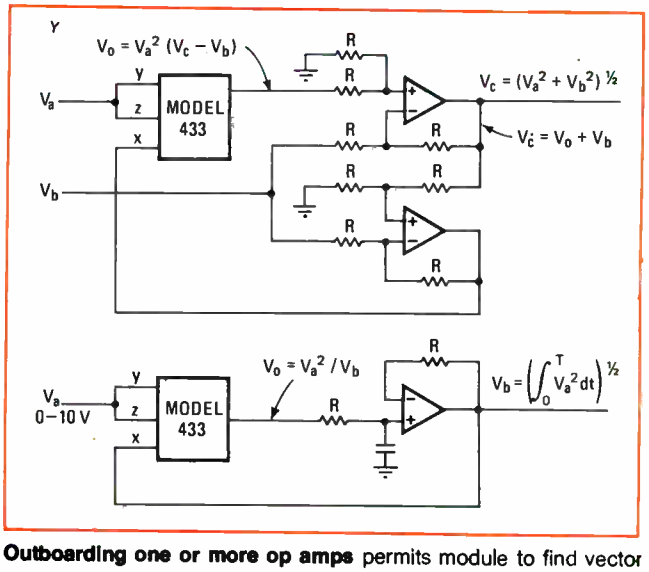
One of the more sophisticated applications for the model 433 is computing the length of a two-dimensional vector. Only two external op amps must be outboarded, and this minimizes accumulated errors from amplifier offset, drift, nonlinearity, and noise. Ordinarily, such a vector computation requires a multiplier to square each input, an amplifier to sum the squared signals, and a multiplier/op-amp combination to extract



Voltage transfer curves show effect of varying index m from 1/5 to 5. Of course, when m = 1, the output is linear.



Handy logarithmic module has output that is function of three inputs: $V_o = V_y(V_z/V_x)^m$. Two resistors set value of exponent m.



Outboarding one or more op amps permits module to find vector length (top) or solve for root-mean-square sygnal values (bottom).

the square root of the sum of the squared signals.

The closed-loop operation of the module's vector circuit broadens input signal dynamic range because circuit equations are solved implicitly, maintaining the output well within the module's operating range. Normally, the equations are solved explicitly, producing signals that quickly exceed a device's capability. Overall circuit accuracy is also improved to within 0.1% by closed-loop operation. When computing vectors, the accuracy of the model 433 depends primarily on the temperature stability of resistors in the external feedback loop and how closely their values are matched.

Another closed-loop application of the model 433 is finding true rms signal values. Here, only a single external op amp must be added. The standard approach requires an analog multiplier to square the input signal, followed by a separate integrator that drives a second multiplier (in an op amp's feedback circuit) that finds the square root for the final output.

As with the vector circuit, closed-loop operation for true rms computations permits a 100:1 input dynamic range to be realized for a 0.1% error. To obtain accurate results, the RC time constant must be large, as compared to the time constant of the input signal. □

Spark gaps can switch as well as protect

by Michael Distefano
General Instrument Corp. Sygnalite division, Neptune, N.J.

A spark gap, or surge arrester, not only protects circuits against sudden voltage overloads, but also acts as a high-energy, voltage-sensitive switch. In this role, it can be used to transfer pulses in such applications as exploding bridge wires or triggering flash tubes, and in capacitive-ignition discharge systems. When a triggering element is added to the two-element spark-gap device, the combination can be used where triggering energy is limited.

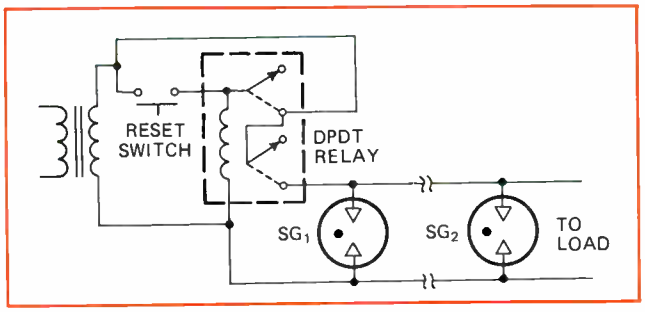
Spark gaps now available can operate with trip voltage ratings from 75 volts to as high as 25,000 v. They are cold-cathode discharge devices that operate as high-energy, short-duration, low-loss switches. Normal operation is in the arc mode, with tube drops (operating voltage during current conduction) on the order of tens of volts for currents of hundreds to thousands of amperes. They present a near-infinite impedance to a circuit while unfired, and a near short when fired.

When the applied voltage is sufficient to ionize the gas in the envelope, a discharge occurs from one electrode to the other. The degree of ionization is determined by the amount of current through the gap during operation—if excessive current flows, the gap will remain ionized even after the transient is removed. Since this current is proportional to the source impedance, the turn-off of the gap also depends on the source impedance—the higher the current level of the previous pulse, the longer the turn-off time.

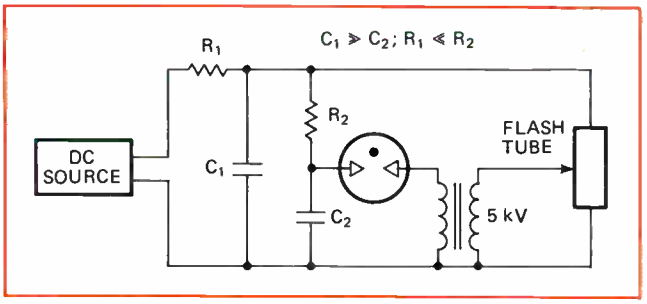
Spark gaps are typically designed for short-term operation, and should not normally be used for long-duty-cycle applications. In a situation where voltage is reapplied quickly, the gap may not be fully de-ionized and would break down at a lower voltage level. If the source

GLOSSARY OF SPARK-GAP TERMS

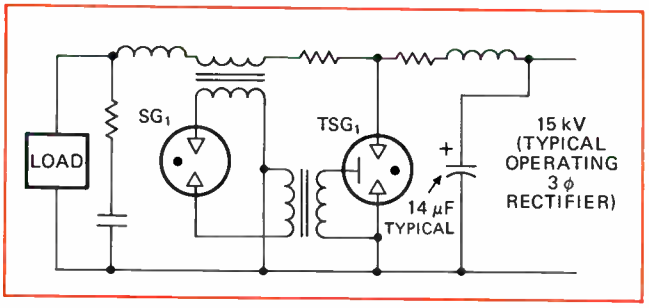
Dc breakdown:	voltage at which ionization occurs when subjected to a slowly rising dc voltage.
Impulse breakdown:	voltage at which ionization occurs when subjected to a fast-rising voltage.
Trip voltage:	voltage at which ionization occurs under any circumstance (also referred to as firing voltage).
Impulse ratio:	ratio of impulse breakdown to dc breakdown.
Tube drop:	operating voltage of device during current conduction.
Follow-on current:	current that flows through ionized arrester from a power source.
Maximum dissipation:	maximum average power device can dissipate during operation while still remaining within published life specifications.
Peak discharge energy:	maximum amount of energy device can withstand during operation without permanent change in breakdown ratings or published life specifications.
Peak current:	maximum amplitude of current ionized device can pass without permanent change in breakdown ratings or published life specifications.
Life:	number of ionizations before a change in dc breakdown rating, pulse breakdown rating, or both, exceeds the initial value by some specified amount.



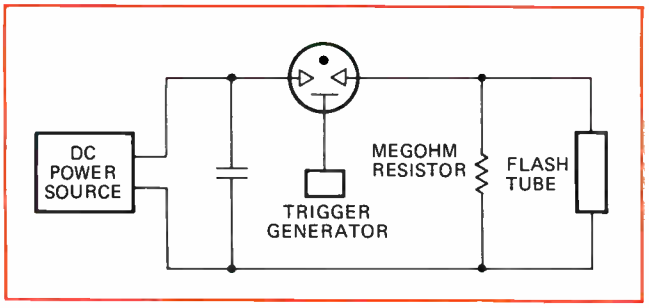
1. Load protection circuit is first reset, energizing relay and connecting load to supply; relay is held energized via its own contact. If transient occurs, SG_1 fires, and its voltage drops below voltage needed to hold relay, opening contacts and disconnecting load. Second spark gap is used if load is connected through long length of line, susceptible to transient pick-up.



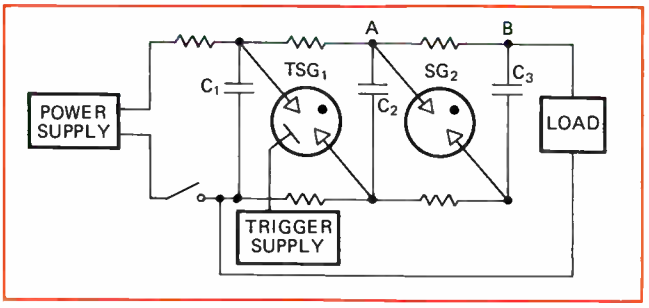
2. Two-terminal spark gap repetitively triggers flash tube when C_2 charges to the gaps breakdown voltage. Capacitor C_1 then releases its charge through the flash tube.



4. Crowbar protection against overcurrent surges is provided by STG_1, set to trigger from the secondary of the series transformer, T_1 and TSG_1, which absorbs overcurrent when triggered.



3. Three-terminal triggered spark gap fires flash tube when pulsed. Megohm resistor provides path for trigger pulse and also for initial rush of current through spark gap.



5. High voltage Marx generator uses triggered spark gap and two-terminal spark gap to place three capacitors in series providing high-voltage pulse to load.

impedance is low enough to maintain conduction through the gap, provision must be made for circuit interruption before excessive energy is dissipated in the gap, ultimately destroying the unit.

A term often used with spark gaps is "impulse ratio." A ratio of unity means that the device will trip at its rated breakdown voltage, regardless of the rate of rise of the wavefront of the transient (breakdown voltage, firing voltage, and trip voltage are synonymous). Impulse ratios greater than 1:1 define the amount of overshoot the gap will permit before tripping when the wavefront is very steep.

Impulse ratio is important when a gap is used to protect sensitive components. For some gaps it can be as damagingly high as 10:1. At that level, spikes with steep wavefronts would bypass the gap before it could go into operation.

Spark gaps can be simply paralleled across an expensive component for protection. Alternatively, two of them can be employed in a more elaborate circuit (see Fig. 1).

A typical circuit using a spark gap as an energy transfer switch is shown in Fig. 2. It repetitively fires a flash tube in a relaxation oscillator circuit. Voltage from the dc source charges capacitor C_1, which will supply the voltage across the flash tube, and also C_2, which fires the spark gap. C_1 charges much faster than C_2. When C_2 charges to the firing point of the spark gap, current flows through the transformer, providing a trigger pulse to the flash tube. C_1 then dumps its charge into the flash tube to fire it, recharges quickly, and holds its charge until the charge on C_2 again reaches the trip voltage of the spark gap.

The three-element triggered spark gap permits high levels of stored energy to be switched in fractions of a microsecond by low-energy control pulses. Triggered gaps require no standby power, are relatively small, and are extremely rugged.

As with the two-element spark gap, the triggered gap presents a near-infinite impedance to the circuit before ionization. Triggering can be done by a transformer, capacitor discharge, or some similar means. When the trigger voltage reaches the gap's breakdown potential, a low-energy discharge occurs between trigger and adjacent electrode. This provokes the high-energy main discharge.

A circuit using the three-element spark gap for triggering flash tubes is shown in Fig. 3. Firing of the spark gap is controlled by the trigger generator, which then permits discharging of the capacitor to activate the flash tube.

When used in a crowbar circuit (Fig. 4), spark gaps can provide fast-acting protection from overcurrents. An arc fault occurring in the load causes excessive current to be drawn from the 14-microfarad supply capacitor, which could destroy the load. Transformer T_1 senses this overcurrent, and pulses the fast-acting triggered spark gap, TSG_1, which then "crowbars" the remaining energy in the capacitor. The two-element spark gap, SG_1, in this circuit acts as a regulator to prevent spurious firing of the triggered gap.

The circuit for a Marx generator, a source of high-voltage low-current pulses, is given in Fig. 5. In operation, all three capacitors are charged in parallel. Then, after switch S_1 is opened, a low-level pulse is applied to the trigger electrode in the triggered spark gap TSG_1. When this gap fires, C_1 and C_2 are placed in series, and the voltage at point A is doubled, providing an overvoltage pulse to the two-element gap SG_2, which then fires. Voltage at point B then is tripled. □

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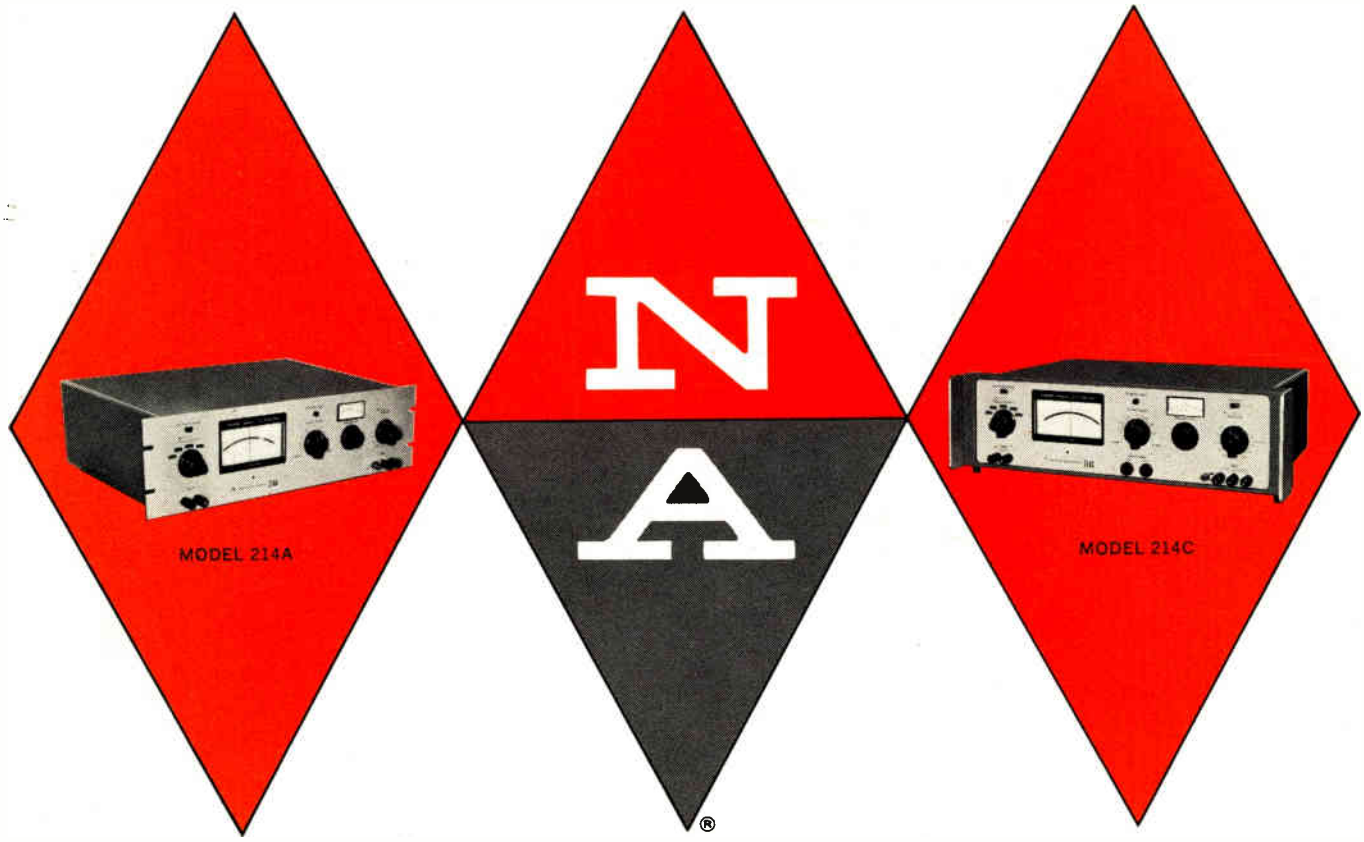

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Engineer's newsletter

SHP modules ride rising military tide

Don't be surprised if the Army and Air Force start asking you to use Navy Standard Hardware Program circuit modules. Until now, SHP modules have been covered by Naval Ordnance Weapons specifications, but **they're now in the process of being converted to the more generally applicable Military Standards and Military Specifications.** Already, some Army and Air Force systems are being built with SHP modules, according to the Naval Avionics Facility in Indianapolis. So far, the modules are found mainly in fire-control and sonar systems, with little usage in radar and communications, primarily because of limitations of the standard connector. However, **NAFI engineers have developed a connector that is good up to 2 gigahertz;** documentation is completed, but the connector hasn't yet gone into production.

Thermal analogs have electrical part versatility

The concept of thermal-electrical analogs is familiar, but the idea has been mainly applied to thermal equivalents of such simple electrical parameters as current, voltage, and resistance. Now, **a company is building thermal equivalents of active circuit components.** With a form of heat-pipe called a Quik-Watt, Noren Products, 846 Blandford Blvd., Redwood City, Calif., is producing thermal analogs of relays to control heat remotely, capacitors to store large amounts of heat in lightweight units, diodes to provide unidirectional heat flow, zener diodes to hold output temperature constant, and trigger diodes that turn on when temperature reaches a certain level. No transistors yet, though.

MOS LSI modem speeds enhance data potential

If you're designing digital communications systems or terminal equipment, **keep your eye on developments in MOS LSI chips for modems.** North American Rockwell Microelectronics Co. has developed a five-chip modem that fits on a single printed-circuit board. The modem operates at 4,800 bits per second, and now NRMEC is working on a 9,600 b/s unit. Faster transmission may lead to an increase in the complexity of terminal equipment. For example, simple credit card verifiers now run at only about 300 b/s, making inquiries of the central computer as to the general status of buyers' credit. But **with 4,800-b/s capability in a small size, these systems may be able to handle much more complex information,** such as actual account balance and other recent purchases.

Addenda

Two booklets recently crossed our desk that may interest you—both from N.V. Philips Gloeilampenfabrieken, Eindhoven, The Netherlands. One is **a rather complete guide to specifying and designing printed circuits,** priced at $3. You may order it from C.D. Elcoma-BA, Printed Circuits Department at Philips. The other is a 50-page, completely worked-out example of computer use in circuit design. **A program is applied to optimizing signal-to-noise ratio in a television camera preamplifier.** The booklet is the April 1972 issue of the company's "Electronic Applications Bulletin" which carries a price tag of $1.75 . . . We're getting interesting results from our employment and job satisfaction questionnaire in the June 19 issue. **Engineers in surprising numbers say they feel underemployed in their present position**—most cite too much clerical work. We'll report fully in the Aug. 28 issue.

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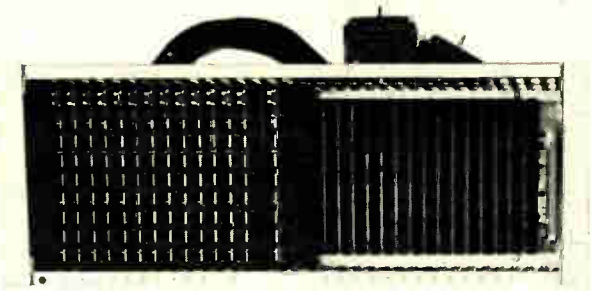

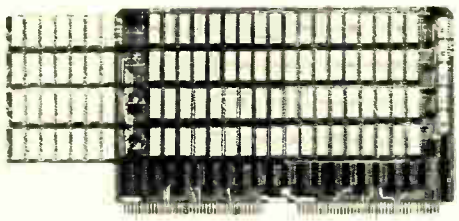

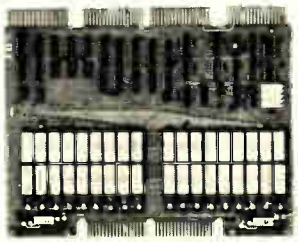

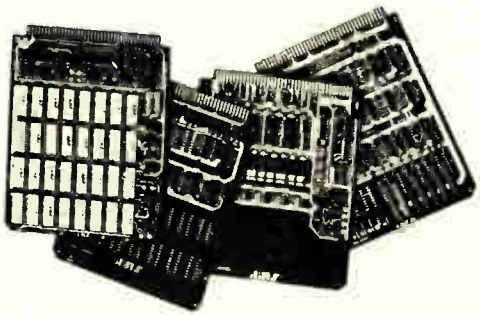

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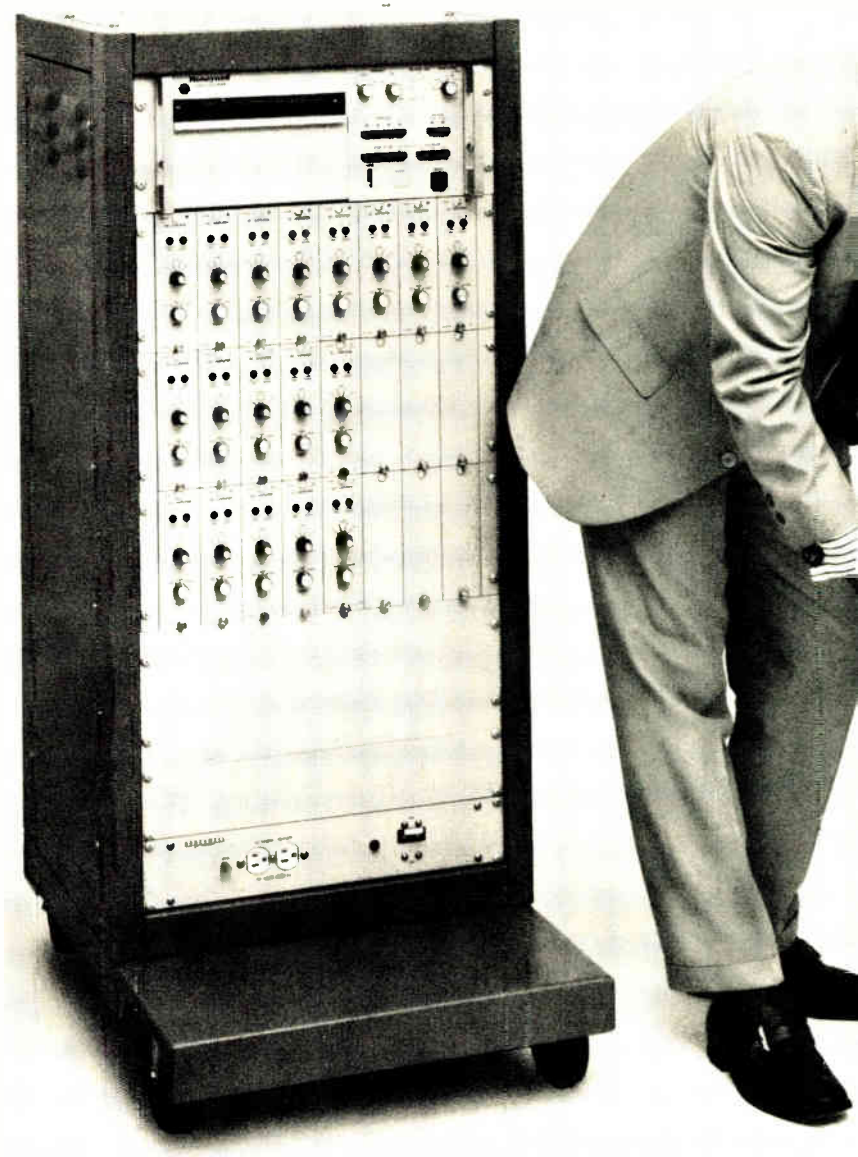

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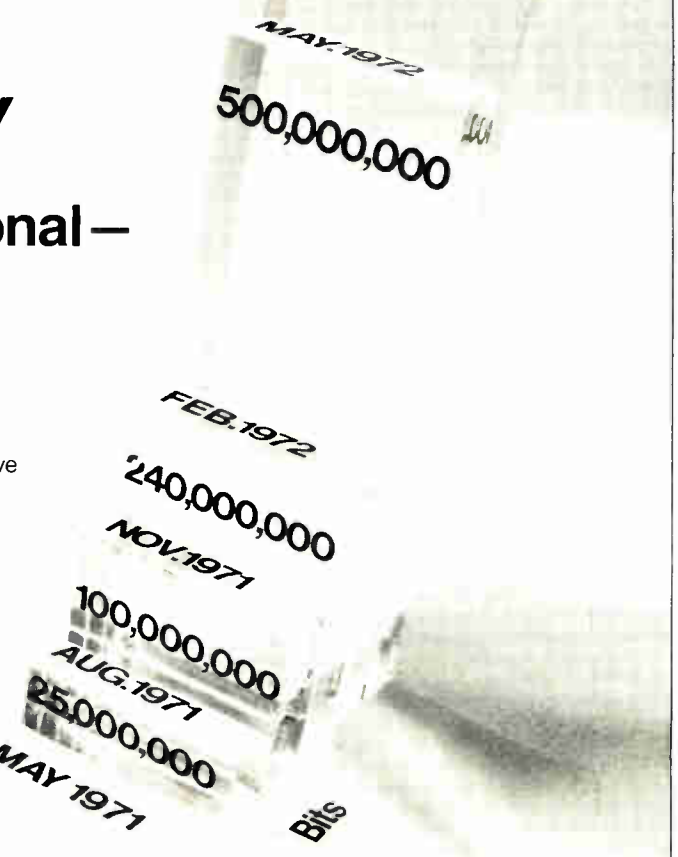

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Optical isolators: outlook is bright

Lower prices and IC compatibility widen use of photon couplers as data communications interface circuits, relays, and limit switches

by Lucinda Mattera, Circuit Design Editor

Technological advances and declining prices are rapidly establishing optical isolators as up-and-coming semiconductor devices. Within the last two years, optical isolators have matured from a toddling business to one of the fastest growing market segments in the electronics industry. Sales are more than doubling from year to year.

Engineers are learning how to design with optical isolators, which are now directly compatible with TTL. Also, isolators are available in IC-type packages, and prices are fast approaching the $1-per-piece figure.

Isolators are still essentially logic-signal switching devices capable of moderate operating speeds and having only limited power transfer efficiency. But manufacturers are developing faster devices with better efficiencies. Air-gap isolators may soon be challenging the proximity or limit-type switches. And solid-state relays face direct competition from more efficient isolators.

The conventional optical isolator, also called an optical coupler or an optically coupled isolator, is an unusual component. Although the unit's heart is optical, its input and output are strictly electronic.

An input signal drives a light-emitting diode that is optically coupled to a light sensor through a light pipe. The entire optical assembly is then placed in a modular package. The LED emitter generally operates in the near-infrared region because this is the optimum spectrum for silicon photodetectors.

The air-gap isolator, on the other hand, is a normally closed type of switch. It operates when an object breaks the light beam that spans the air gap between the emitter and the sensor. It is useful for sensing small parts over small distances.

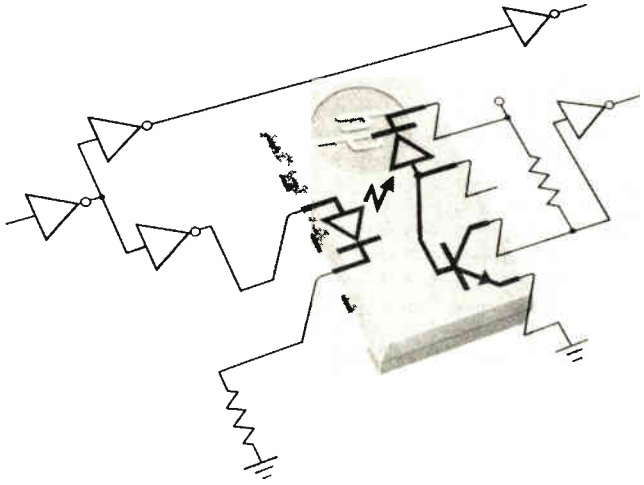
The light sensor can be any one of a number of semiconductor photodevices, such as a phototransistor, a photodiode, a photo-Darlington, or a photo-SCR. The output characteristics of the isolator depend on the type of sensor used. For example, a photodiode output provides the fastest switching speed but the smallest current, while a photo-Darlington output offers a lower operating frequency and a higher output current. A photo-SCR supplies the largest output current.

For the most part, optical isolators are now being used as interface circuits in data communications equipment. Since isolators get rid of unwanted ground loops, they can eliminate the causes of noise when installed at the input and output points of logic systems. Nowadays isolators are being placed between a computer and remote peripherals or telephone lines. Their inherently high isolation voltage, which is on the order of thousands of volts, permits them to interface systems operating at different voltage levels.

In some applications, optical isolators can be used in place of transformers, relays, reed switches, limit switches, or tachometers. A relatively untapped applications market is linear circuits like isolation amplifiers and isolated oscillators.

Recognizing the potential of optical isolators in data communications, Hewlett-Packard Associates of Palo Alto, Calif., is introducing a series of dual-in-line high-speed photodiode devices. Series 5082-4350 units offer a 5-megahertz bandwidth at a current transfer ratio (coupling efficiency) of better than 20% because their photodiode detector is followed by a same-chip high-frequency transistor. Isolation voltage for the family is 2,500 volts; prices range from $2.95–$6.50 in 100-unit quantities. H-P plans to introduce an even faster isolator, a photon-coupled gate, within six weeks. Harvey Gold, product marketing manager for optoelectronics, notes that H-P will an-

Harnessing photons. H-P's opto-isolator has a transistor amplifying its photodiode output.



New products

nounce other high-speed isolators.

Also stepping up its activity in optical isolators is the semiconductor products group of General Electric Co. in Syracuse, N.Y. The company is introducing two series of plastic-DIP isolators, the series H11A with a phototransistor output, and the series H11B with a photo-Darlington output. The units offer a minimum isolation voltage of 1,500 or 2,000 V, and prices range from $3.05–$3.95 for 100-unit quantities. Later on this month, GE will release its series H15 units, which will be housed in modular plastic packages and provide 4,000 V of isolation for $1.50–$1.60 (100 pieces). Randy Wadiak, product planner for optical products, says that at least six more new isolators will be introduced in the next 18 months.

One of the largest suppliers, Monsanto Commercial Products of Cupertino, Calif., is announcing two air-gap type isolators, a reflective optical switch (the MCA7) and a slotted optical switch (the MCA8). Both devices require a drive current of 16 milliamperes and provide an output current of 2 mA. The MCA7 sells for $2.95 in 100-unit quantities; the MCA8 for $3.30. According to Mike Bottini, product manager, Monsanto is concentrating on higher-speed devices, 2–3 megahertz. He says that a product will be ready by the end of 1972.

Ac inputs accepted. Clairex Electronics, Mount Vernon, N.Y., which has been in the light-sensing business for 19 years, has probably the only optical isolator that can accept ac inputs. Labeled the CLI-60 series, the plastic-DIP units have two input LEDs and a photo-Darlington output. Minimum isolation voltage ranges from 1,500–5,000 V, input current is 1 mA, output current is about 6 mA, and cost is $3–$4 in volume. Joe Harris, silicon products engineer, indicates that Clairex will have air-gap isolators in the fall.

Yet another unusual series of isolators is being marketed by Optron Inc. of Carrollton, Texas. The company's type OP1050 devices feature 50,000 V of isolation, a 40-mA input drive current, special packaging, and a choice of a photodiode, phototransistor, or photo-Darlington output. Approximate 100-unit pricing for all the devices is $37.50.

Litronix in Cupertino, Calif., is planning to expand its line of plastic-DIP isolators with two high-speed devices. One unit will be released in about 60 days. It has a Darlington output, a 200-kilohertz gain-bandwidth product, a minimum transfer ratio of 100%, 2,500-V minimum isolation voltage, and is expected to cost around $3.50 in 100-unit quantities. The second isolator, which will be announced in about 90 days, offers a phototransistor output, a gain-bandwidth product of 1 MHz, a typical transfer ratio of 35%, and a minimum isolation of 2,500 V. Its price is also tentatively set at $3.50.

Motorola Semiconductor Products Inc., Phoenix, Ariz., is coming out with its series MOC1000 isolators with phototransistor outputs. Isolation voltage can be as high as 2,500 V with a coupling efficiency of at least 10%. Hundred-unit costs vary from $1.70–$3.60. A photo-Darlington isolator, part of the company's MOC1100 series, is now available for $3.15 each (for 100). It provides 1,500 V of isolation and more than 100% efficiency. Later this month, Motorola will introduce a hermetically sealed series.

On the attack. Planning aggressive marketing of its development-type (not standard commercial product) optical isolators is RCA Electronic Components, Industrial Tube division, Lancaster, Pa. Ted J. Grabowski, the product marketing manager for photodetectors and emitters, says that RCA will be introducing five or six new products in the next 12 months. Currently, RCA is selling phototransistor-output isolators in hermetic TO-5 packages for less than $20 in small quantities.

Texas Instruments, Components Group, Dallas, Texas, hopes to have isolators that can perform more complex logic functions by the close of 1972. TI currently offers a full line of military, industrial, and commercial isolators. Ken Horton, the marketing manager for optical electronic products, predicts that multiple-isolator packages will be available in two to four years.

Minicomputer OEM prices slide

New Interdata model tagged at $2,268 for more than 60 machines; 'mix-or-match' discount schedule is applied to entire series

Down, down, down come minicomputer prices as Interdata Inc. this week announces the fifth member of its New Series of machines—the 16-bit model 74, aimed at original-equipment manufacturers of industrial-control, commercial, and data communications systems. From a unit price of $3,600, the model 74 tag dips down about 40% to $2,268 when more than 60 machines are ordered. And an OEM can get a 15% discount for only one.

Interdata's marketing vice president, Ronald A. Paterson, asserts that the prices set for the Model 74 are "significantly lower than those of competitive machines in the same performance class." Moreover, along with its new machine, Interdata is introducing a "mix-or-match" discount schedule for OEMs that allows a quantity discount on all machines involved in an order, even though the machines are a mix of the five New Series units presently available. In addition to the model 74, these include two general-purpose 16-bit minis—the $6,800 model 70 and the $14,900 model 80—and two data communications processors. "The quantity OEM buyer usually requires a family of minicomputers with varying performance capabilities," points out Interdata's president, Daniel Sinnott.

Far from being a stripped-down or "naked" mini, the new model 74 offers a full complement of features—including multiply/divide, 16 general registers, eight kilobytes of directly addressable core memory (expandable to 64 kilobytes), a large-scale-integrated read-only memory, upward compatibility with the other New Series processors, and up to 255 input/output interrupts, each of which causes the program to branch automatically to a routine to service the interrupt.

The directly addressable main memory in the model 74 is built around core modules with an access time of 300 nanoseconds and a 1.0-microsecond cycle time. Data word length is eight, 16, or 32 bits; instruction word length is 16 or 32 bits; typical execution time is 1.5 μs for a 16-bit add operation. Data transmitted over the multiplexer channel can go to either eight-bit byte-oriented or 16-bit half-word peripheral-device controllers. A programed input-output loop transfers data at 66 kilobytes per second; an optional selector channel makes data transfers at 2,000 kilobytes/s.

The model 74, weighing 70 pounds, is packaged in a standard 7-inch Retma chassis, which houses the power supply, accepting 115 or 230 volts ±10%, 50 or 60 hertz single-phase power at 7 amperes maximum.

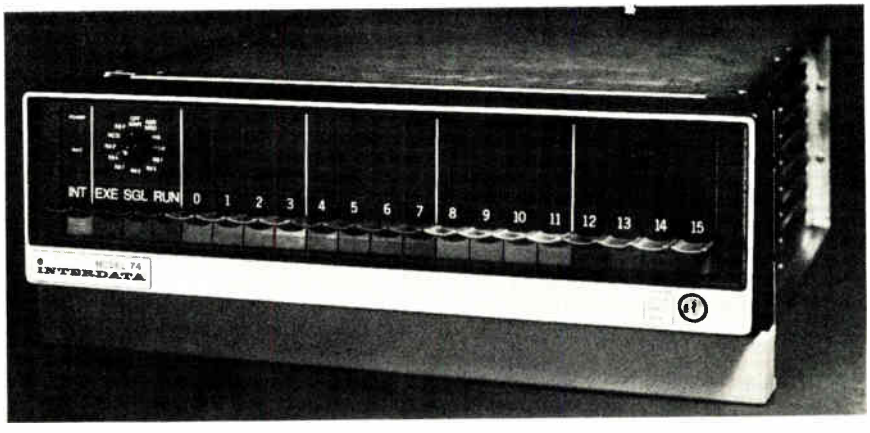
Off-the-shelf software for the model 74 includes the basic operating system, interactive Fortran, symbolic assembler, interactive text editor, interactive debug package, and loaders and subroutines.

Options include memory parity, power-fail-detect/auto restart, selector channel, universal clock, and asynchronous and synchronous data set adapters. Also available is an automatic loader for no-display 74s; a flick of the switch automatically reloads the system.

A newly developed loader storage unit, designed to support and protect remote or unattended systems, can also be used with the model 74. This unit provides an automatic reinitialization of the system in the event of a malfunction. A programable read-only memory stores in a non-volatile form the information needed to restart the system. Price of the loader storage unit is $500, plus $100 for a 128-byte storage module. Deliveries of both it and the model 74 begin in April 1973.

Interdata Inc., 2 Crescent Place, Oceanport, N.J. 07757 [339]

System-priced. The 16-bit Interdate model 74 is a general-purpose minicomputer aimed at quantity OEM buyers. Single-unit price for a no-display version of the 74 is $3,600.



At Last! The Digital Profit Makers!

They're "Money Makers"—

First-class appearance will sell your product, so we designed the NEW 4000 series digital panel meters with big, bright, solid displays that are "No. 1" in national user-preference surveys.

Included is a regulating AC power supply that completely blocks out line transients up to 400 volts peak-to-peak! No more jumpy readings to make you wonder *"—what was that?"*

And extra-low input bias current keeps readings accurate and super-stable, even at the highest operating temperatures.

Give your panel the quality look. Your customers will recognize it— *and buy it, too!*

and "Money Savers," too!

We designed the 4000 series to protect you against profit-robbing failures.

The displays are more reliable (and more readable) because there are no "loose" elements inside.

High quality components, superior workmanship, and wide-safety-margin designs combine to reduce failures, too.

We're so sure we have the answer, we've extended our WARRANTY for **ONE FULL YEAR!**

It won't take you that long to find out how much money you're saving with the 4000 series on your panel.

Don't be fooled by low price tags! This time, buy quality and reliability *right from the start!*

If you have anything left from your last panel meter purchase, give us a call.
If you don't have anything left, call our sales department collect. (714) 546-7160, ext. 567.
We'll understand. That's why we built a totally new kind of DPM—

"the Digital Profit Makers"

Data Technology Corporation
2700 South Fairview Road
Santa Ana, California 92704

Packaging and production

Software eases interconnect job

Program produces inner layers, permits stocking of 'universal' boards

With design changes occurring more often because of the steady stream of new integrated circuits, equipment designers are being faced with tough decisions on when to freeze the design and release the multilayer board to production. To carry them through the prototype and even early production stages, when most design changes occur, they have had to turn to wire-wrapping to interconnect the ICs. Now, Adcor Packaging International has introduced a software package that designs a programable multilayer board. Such a board will accommodate design changes, and so reduce multilayer interconnection costs below those of wire-wrapping. This is true even for just a few boards, says Allen Chertoff, the company's president.

The board has no interconnection profile when produced. The inner layers are etched, but the two outer layers are left as smooth copper. Through-holes are plated. Then, when the circuit is to be interconnected, artwork is prepared for only the two outer layers, and the board is produced with conventional pc production methods. Cost of production at this stage is thus the same as for a two-sided board.

Once it is programed for the size of the board and the location of holes for component mounting, the software will produce interlayer patterns that will provide enough flexibility to allow any connection scheme to be carried out between the ICs. (Simple X-Y patterns on inner layers would not provide this flexibility.)

The method, which is suitable for backplanes as well as ICs, is being licensed on a nonexclusive basis to systems users and to pc board makers. For the first time it gives the board makers a standard product—they can make up the boards and stock them in various sizes. The charge is $5,000, of which $3,000 goes for the software and $2,000 for production of the first board.

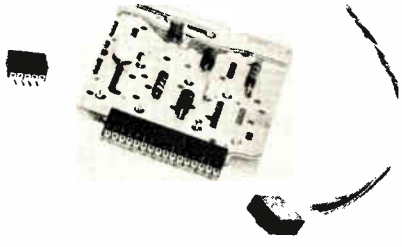
Comparing his approach and wire-wrapping, Chertoff says that total interconnection cost comes out to below $1 per IC. Wire-wrapping, he points out, runs from a minimum of $1.50 to $2 per IC, including the cost of socket board and wrapping.

Chertoff further points out that the Adcor technique allows designers to breadboard equipment using multilayer boards, but paying only for the two-sided etching, and thus to get a better idea of how the board will perform when in actual production.

Adcor Packaging International Inc., 185 West End Ave., New York, N.Y. 10023 [391]

Connector mates with any 0.025-inch-square post

A family of connectors called the Varipost Box mates with any 0.025-inch-square post on the market. The unit features low-insertion-force



contacts with long spring members. Contacts are rated at 3 amperes and 12 milliohms maximum. A cable-to-board type has wire-crimp-removable contacts and a board-to-board version has solder-tail contacts.

Elco Corp., Willow Grove, Pa. 19090 [394]

Socket connectors need no insertion tool

A family of miniature pin and socket connectors offers fingertip contact insertion and rear contact release, eliminating the need for an insertion tool. Several contacts can be put into place in the time usually required to fit one contact onto an insertion tool and then in to the dielectric. The family includes 9-, 15-, 25-, 37-, and 50-contact configurations in choices of screw machine contacts in bulk packaging or stamped contacts on a strip.

Amphenol Industrial Division, 1830 South 54th Ave., Chicago, Ill. 60650 [393]

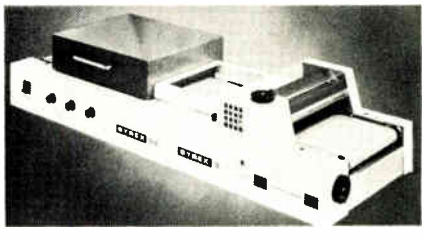
Testers check out linear circuits and memories

Two testers are aimed at high-speed checkout of linear circuits and semiconductor memories. The model 1200 computer-operated linear circuit-test system allows greater throughput to be obtained over multiplexed test systems. Eight programable stations are available, capable of testing simultaneously through time-sharing. The second is the Venture II high-speed functional test system for RAMs, ROMs, and shift registers. It uses ECL levels, a high-speed instrumentation test head, and a test rate of up to 10 MHz. Price of the 1200 with one station is $67,000, with additional stations available at $13,000 each. Price of the Venture II ranges from $40,000 to $60,000, depending on configuration.

Computest Corp., 3 Computer Dr., Cherry Hill, N.J. 08002 [395]

Photoresist coater-dryer delivers uniform films

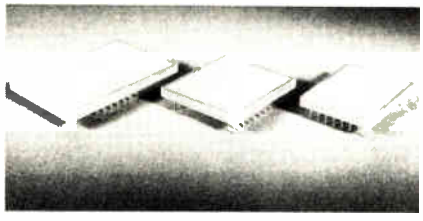
A continuous-process coating and drying system for applying and curing liquid photoresists offers production rates of 8 feet per minute. The system uses a roll technique to



apply 0.5 to 10 micrometers of positive and negative coating resists in a single pass with uniformity within ±10% of the total thickness. An infrared emitter section with high-intensity preheater connects directly to the coater. Price of the model 9 Microcoater with fluid system is $3,445, and the model 92 Microdryer is $1,850. Both are suited to laboratory and production use.
Gyrex Corp., 400 E. Gutierrez St., Santa Barbara, Calif. 93101 [396]

Microcircuit packages eliminate expensive tooling

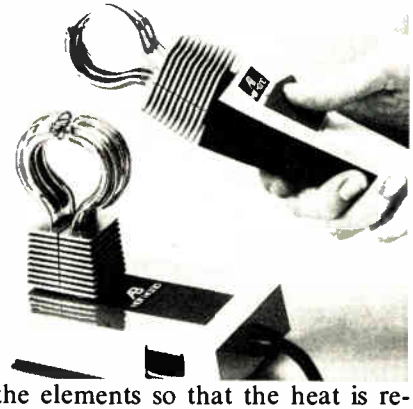
A series of modular sidewall enclosures eliminates the need for expensive tooling and long lead times for making special integrated-circuit package configurations. The units are intended for monolithic and hybrid applications. The cases are formed of Kovar component pieces cut to customer requirements, and standard 14- to 40-lead packages are available with rigid 0.040-inch bases to accommodate substrates from 0.250 by 0.60 inch to 1.47 by 1.27 in. Lids of 0.010 to 0.040 inch may be either braze- or weld-sealed. Round leads with or without nailheads, are available for plug-in or circuit-board mounting.



Tekform Products Co., Subsidiary of Bliss & Laughlin Industries, 2780 Coronado St., Anaheim, Calif. [397]

Tubing shrinker delivers concentrated heat

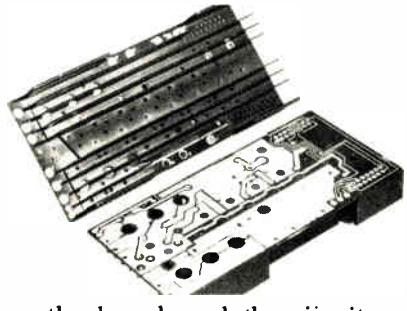
A tubing shrinker that opens and closes to encircle the tubing provides concentrated heat and handles all types of tubing, except Teflon, up to 3 inches outside diameter. A handheld model is for intermittent use while the table model is for continuous operation, manual or automated. Interchangeable plug-in elements of 1-, 2-, and 3-inch diameters are available for all models. Guards surround the outside of the elements so that the heat is reflected inward toward the tubing. The unit can also be used for sweat-soldering tubing and bending PVC pipe and tubing.



American Beauty Division of American Electrical Heater Co., 6110 Cass Ave., Detroit, Mich. 48202 [398]

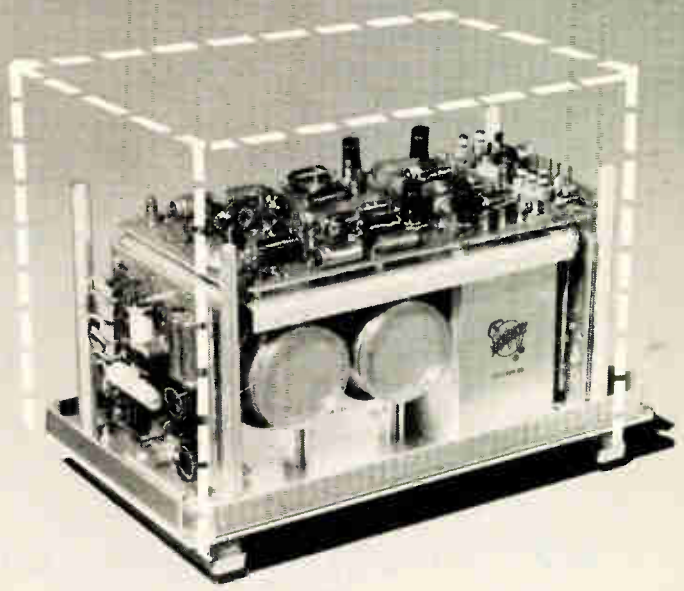
Printed-circuit board is also heat sink, chassis

A chassis-like printed-circuit board combines the functions of heat sink, structural element, and circuit board in a single component. In one application, the components of a high-current power supply were mounted on the board, and the circuit was operated at a power of 170 watts while maintaining a case temperature rise of all semiconductors within acceptable tolerances. The same circuit on a G-10 epoxy board would be able to operate at a power level no higher than 12 watts.



International Electronic Research Corp., 135 W. Magnolia Blvd., Burbank, Calif. [399]

Imagination and Stackpole ferrites can cut a power supply down to size



Tektronix, Inc. uses Ceramag® ferrite materials to achieve efficiency and significant savings.

Conventional power supplies are bulky, heavy and inefficient. Tektronix, Inc. changed all that. With ferrites and a fresh idea.

By rectifying line voltage, converting it to 25kHz and rectifying it again, Tektronix, Inc. engineers produced a power supply that was 50% lighter, over 25% smaller and consumed ⅓ less power. And the overall operating efficiency of 70% is a big improvement over the 50% typical of conventional power supplies.

Ferrites can offer the unique advantages, design freedoms and electronic characteristics that produce exciting new ideas. Stackpole Ceramag ferrites were used throughout the power supply design. Because Stackpole has a wide variety of materials and configurations, designers can unleash their imaginations.

Ceramag 24B

Tektronix, Inc. selected 24B for their "U" and "E" cores. This proven material has seen years of service in flybacks for television. Ideal for power applications, it can be operated at higher frequencies than laminated steel. It is cool running, due to low losses under power conditions and controlled power permeability. Tooling is available for a wide range of "U", "E" and "I" configurations.

Ceramag 24

Toroids of Ceramag 24 were used by Tektronix, Inc. for transformer cores. Again, this is a proven material, widely used by the computer industry for pulse transformer cores. It has a tightly controlled initial permeability, and tooling for a variety of sizes is also available.

Ceramag 7D and 27A

Multiple material selection for coil forms allowed Tektronix, Inc. maximum flexibility and design freedom. Proper inductance values could be achieved in the allotted amount of room. In addition, the high resistance of 7D

material prevents accidental shorting on printed circuit boards.

Great new designs happen when you *start* with the idea of ferrites. Particularly Stackpole Ceramag ferrite components. Why? Because Stackpole offers the variety of materials, numerous tooled configurations and the technical back-up you need. Twenty-four years of television and computer experience makes Stackpole one of the largest and most experienced domestic suppliers of quality ferrites.

Consider ferrites on your next prototype or redesign. But give us a call when you start. Perhaps we (and some Ceramag® ferrites) can help you cut a problem down to size. Stackpole Carbon Company, Electronic Components Division, St. Marys, Pa. 15857. Phone: 814-781-8521. TWX: 510-693-4511.

STACKPOLE
ELECTRONIC COMPONENTS DIVISION

Circle 109 on reader service card

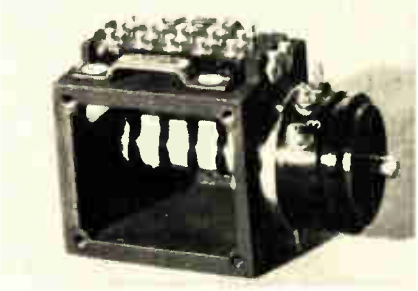
New products

pushbutton is operated, complementary solid-state outputs reverse logic levels, and isolated single-pole double-throw contacts transfer the power load. Contact bounce is eliminated, thus removing the need for buffer circuitry. Price ranges from $9.54 to $17.67, depending on quantity.

Staco Switch Div., Staco Inc., 1139 Baker St., Costa Mesa, Calif. 92626 [345]

Pot-switch module contains up to 5 microswitches

A precision potentiometer-microswitch module features 7-ampere, 250-volt snap action microswitches phased to the ⅞-inch-diameter pot contacts at arbitrary angles. Up to five independently adjustable switches can be incorporated in the

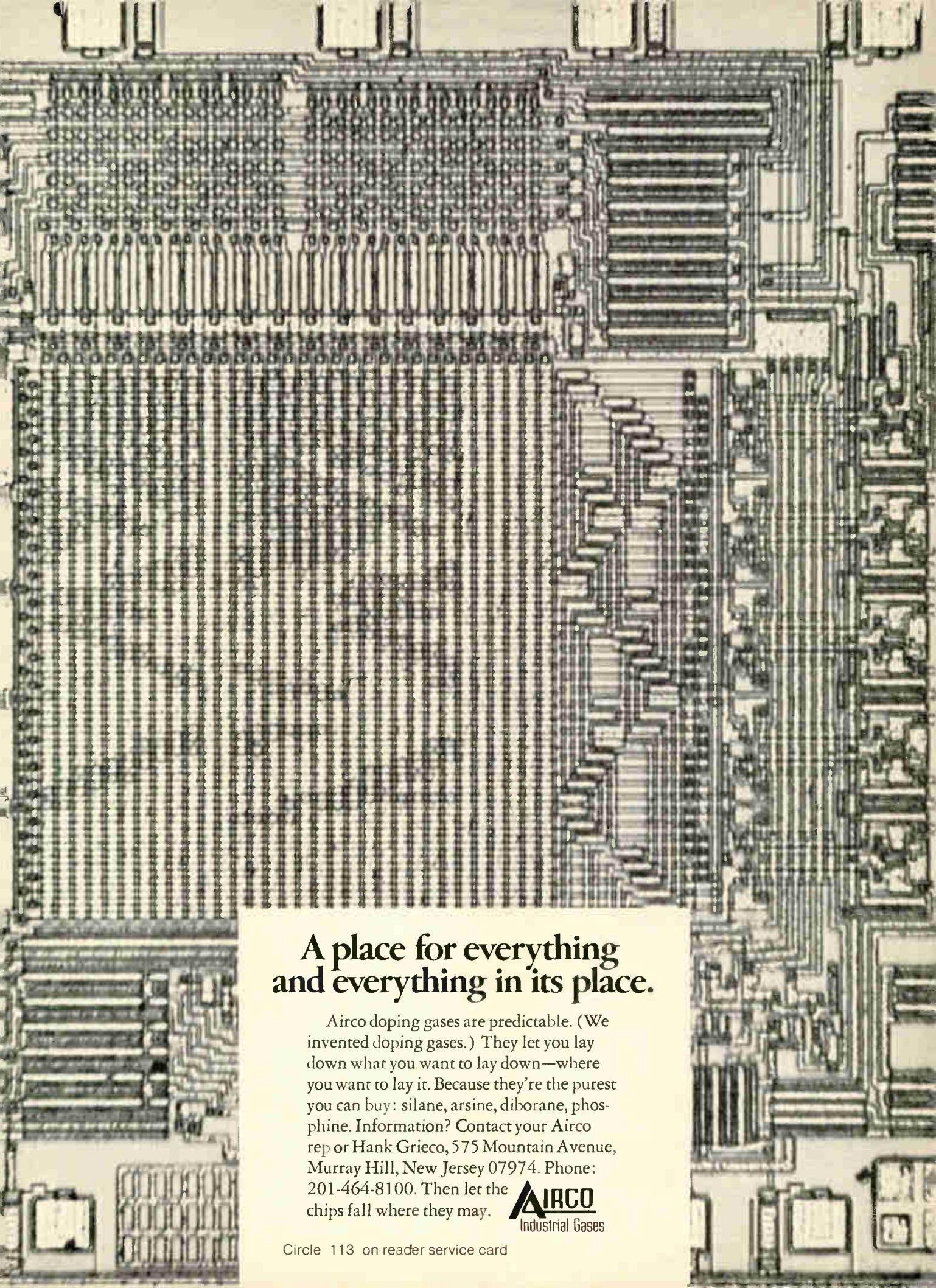


package, and the potentiometer provides linearities to within 0.25% with a resistance range of from 500 to 150 kilohms. Linear or nonlinear functions are available. The pots can be combined with any number of mechanical devices, such as motors, gears, resolvers, and synchros.

New England Instrument Co., 14 Kendall Lane, Natick, Mass. 01760 [347]

Miniature capacitors rated at 50 and 100 Vdc

Miniature metalized polycarbonite capacitors, the MiniMiniature 22 series, are available in a variety of encasement styles and leads. They are rated at 50 and 100 volts dc and range in size from 0.58 inch by 1.16 in. to 0.40 in. by 0.67 in. Capacitance ranges from 0.001 microfarad to 50 microfarads with tolerances to



A place for everything and everything in its place.

Airco doping gases are predictable. (We invented doping gases.) They let you lay down what you want to lay down—where you want to lay it. Because they're the purest you can buy: silane, arsine, diborane, phosphine. Information? Contact your Airco rep or Hank Grieco, 575 Mountain Avenue, Murray Hill, New Jersey 07974. Phone: 201-464-8100. Then let the chips fall where they may.

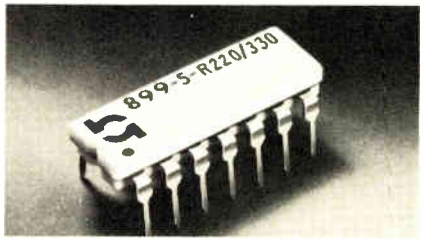
AIRCO
Industrial Gases

Circle 113 on reader service card

±1%. Operating temperature is from −55° to +105°C. Insulation resistance is a minimum 100 gigohms.
S&EI Manufacturing, 18800 Parthenia St., Northridge, Calif. 91324 [348]

Dual in-line networks consist of 28 resistors

The series 899-5 and 898-5 are dual in-line networks, consisting of either 24 or 28 resistors. They are primarily designed for pulse-squaring networks or logic terminators. The resistors are placed in groups of two hooked together in series, having a common line for power and a common line for ground. The center point of each pair is brought out to a separate terminal, giving 12 or 14 center points and two common lines.



Helipot Division, Beckman Instr. Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634 [349]

Capacitors permit wide-range tuning

Ultraminiature trimmer capacitors for microelectronic tuning to beyond the 5-gigahertz range are designated the CP series. The model CP10 has a capacitance from below 0.5 picofarad to above 0.9 pF and a Q factor of above 500 at 250 megahertz. The unit features a stainless steel movable shuttle that permits simplified high-resolution tuning. This avoids product loss caused by irreversible tuning methods such as wire-bonding, scraping, and changing chips. Contact resistance is 5 milliohms, and voltage rating is 150 volts dc. Price is 95 cents each in quantities of 10,000.
Voltronics Corp., West St., Hanover, N.J. 07936 [350]

Data handling

System handles 256 channels

Family of data conversion units aimed at industrial control, signal processing

About the first fact of life a computer maker or user faces is that his digital processor has to operate in an analog world. Nothing in an industrial control application reaches the computer in digital form, and next to nothing can be directly controlled with binary 0s and 1s. It is this which creates a market for the new AN5800 series from Analogic, Wakefield, Mass. The 5800s are called data conversion systems and act as the computer's translator of incoming data and outgoing data and commands.

Analogic's director of marketing, Fred Molinari, says that the AN5800 series of 15-, 14-, and 13-bit conversion systems offer capacity, speed and accuracy. "The 15-bit unit," he points out, "is capable of randomly accessing up to 256 channels if expanded to its largest configuration; our specifications reflect a more normal installation, one with either 64 single-ended or 32 differential analog inputs. Our a-d stage yields a throughput of 40,000 bits per second, and resolution is easily as good as expected from a 15-bit converter at better than one part in 30,000. Linearity is precise at within 0.006%."

At $2,785, the 15-bit system is appropriate for industrial control applications with PDP-11 or Nova-class minicomputers.

The 14- and 13-bit units add a lower-cost end to the line for those who need less resolution or greater speed. Linearity of the 14-bit system is the same as that of the 15-bit 5800, though accuracy is within 0.015% of full scale. Conversion speed is high—system throughput is 80,000 bits per second. This model costs $2,115.

The 13-bit unit, because of its word length and the conversion technique used, is the fastest of the three at 85,000 bits per second. Its full-scale accuracy is within 0.02%, and linearity is within 0.01%. This unit sells for $2,065.

Although linearity and accuracy tend downward with price and word length, the other half of the tradeoff—speed—increases to the point of making the line suited to applications like broadband signal processing, complex waveform digitization, fast data acquisition, and computer control of process values or output devices like CRT displays, oscilloscopes and X-Y recorders. For all three units, output word length before conversion to analog format is 14 bits.

There's lots of flexibility in the 5800 configuration. In the least complex version, an input is fed directly to an a-d converter. But it is possible to add multiplexing, single-ended or differential buffer amps, plus sample-and-hold networks ahead of the conversion stage. In all cases, the 5800's output to the computer is bit-parallel and "justified to the right," that is, the most significant bit is in the right-hand position at the output.

The a-d converter for the 15-bit unit includes a precision referenced supply, d-a conversion circuitry, a low-noise comparator, and a digital programer and registers. Up to eight such converters fit the standard rack-mounted cabinet, and even more can be accommodated. Regardless of the configuration ordered, each 5800 is subjected to computer tests of each multiplex channel. Eventually, to assure monotonic performance, every one of the codes for a given conversion word length is checked—32,768 for a 15-bit system—making sure that the computer gets an accurate digital picture of the analog world.

Analogic, Audubon Rd., Wakefield, Mass. 01880 [361]

Minicomputer is aimed at data communications market

When Texas Instruments introduced the low-priced 960A minicomputer last fall [*Electronics*, Nov. 8, 1971, p. 111], the company's Digital Systems division had a second and similar performer waiting in the wings. This week, TI spotlighted the second one—the 980A, with a $3,475 price for one to 100 that is $655 higher than the first entry.

Though alike in basic design, the machines are aimed at different markets. The 960A was optimized for manufacturing automation and process control. The new 980A has additional features that make it suitable for data communications, front-ending, and scientific and small-business data processing. Whereas the earlier machine has only bit- and word-addressing capabilities, the 980A offers byte and byte-string capabilities as well.

"One of the reasons our cost is low is the commonality between the 980A and the earlier 960A," says Randall J. Gilliam, manager of TI's Computer Equipment Department.

The 980A comes with 4,096 words of 1103-type MOS random-access memory and an internal power supply that will accommodate up to 65,536 internal and external words. Read and write cycle times are 750 nanoseconds, and memory access time is 500 ns.

The basic machine is not discountable for the first 32,768 words of storage. But add-on modules at $1,500 per 4,096 words can be discounted up to 22% on 100-unit orders for the 980A. And with each central processing unit, TI will sell its thermal printer for $2,100 instead of the $3,300 list price.

Besides a full complement of software, standard features of the 980A include: a 98-instruction set, among them about a dozen double-precision instructions; hardware break-

point on the front panel to stop the program at a preset memory address—when debugging hardware and software; a switch-initiated ROM bootstrap loader for fast cold starts; and a store-register file sequence to store all eight addressable registers and the status register in 7 microseconds, thus cutting down overhead in servicing interrupts.

Texas Instruments Digital Systems Division, P.O. Box 1444, Houston, Texas 77001 [362]

Digital tape transport loads, unloads automatically

A digital tape transport offers automatic loading and unloading, vacuum buffering, and a modular capstan assembly that pulls out of the front of the unit and can be replaced without realignment. The model TD 1000 is IBM-compatible, and has bidirectional tape speeds from 25 to 90 inches per second. Bidirectional search speed is 150 inches per second. The unit, housed in a frame measuring 19 by 24 inches, costs less than $4,000.

Tandberg of America, 8 Third Ave., Pelham, N.Y. 10803 [364]

Optical reader accepts handwritten characters

An optical character reader can handle written and printed letters, numerals, and symbols. It accepts subjectmatter ranging from postcard size to letterhead size, and up to 29 lines of characters can be read.

The machine uses a laser beam that passes through a lens onto the surface of the sheet. The reflected beams are received by a photomultiplier tube, and the resultant electrical pulses are then sent to a recognition-logic component. If characters are unrecognizable, the laser beam automatically rescans. If they are still unrecognizable, this is indicated on a CRT display so that correction can be made through a keyboard.

Hitachi America Ltd., 100 California St., San Francisco, Calif. 94111 [365]

Cassette memory built for desktop calculators

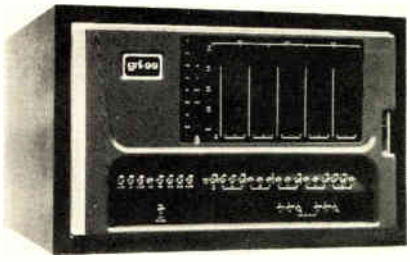
Designed for use with H-P series 9800 calculators, the model 9865A cassette memory adds 6,000 data registers or 48,000 program steps to the calculator memory. Among its capabilities is being able to go directly to files upon identification-number command. Files may be of

different lengths and are located by address without rewinding. The ability to find a file by number also lets the user recall data from that file, modify it, then restore it to the same file without rewriting on a second cassette. Search speed is 130 feet per minute in either direction. Price is $1,750.

Hewlett-Packard Co., 1601 California Ave., Palo Alto, Calif. 94304 [366]

Minicomputer is designed around MSI/LSI functions

A 16-bit minicomputer series, called the GRI-99 and available in three models, is designed around MSI and LSI functions. The unit, with 8,192 16-bit words of core memory is priced at under $3,000 in OEM quantities and is also available with 8,192 16-bit words for as low as $2,500

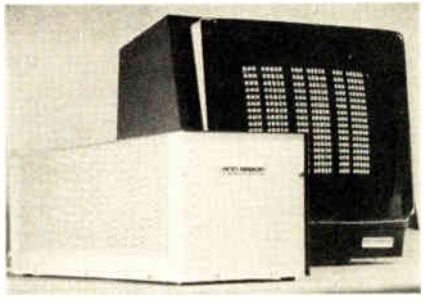


each in quantity. The unit is in a class of general-purpose computers known as direct-function processors, and is aimed at applications requiring wholly dedicated systems. The internal architecture and machine language use a universal bus system.

GRI Computer Corp., 320 Needham St., Newton, Mass. 02164 [367]

Video terminal controller provides high-speed display

The model 204 video terminal controller is intended as a replacement for teleprinters, hard-copy data-capture terminals, and industrial display/controllers. As a replacement for teletypewriters, it provides a soundless high-speed display of data input at asynchronous rates to 1,200 characters per second. As a substi-



tute for display/controllers, it permits software control of data and data format. The model 204 features built-in buffer and refresher memories, and is capable of driving multiple displays which may be either conventional TV sets or 525-line video monitors. Price is $795.

Ann Arbor Terminals Inc., 6107 Jackson Rd., Ann Arbor, Mich. 48103 [369]

Spare the tests... and spoil the board.

If you don't test incoming circuits before wiring in, it's your loss. Literally. Because every defective device that blows on the board is a threat to your profit margin.

In dollars. In expensive man-hours. In discarded equipment. A combined toll usually twice the expense of in-house pre-testing. The question is not *if* you can afford 100% pre-use inspection, but rather, how can you afford not to?

Consider what just one malfunctioning component can cost your plant, over and above replacement price.

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Semiconductors

ICs move into audio front-end

Dual preamplifiers replace discrete transistors without adding unacceptable noise

Many designers in the top-of-the-line audio field have tried using monolithic operational amplifiers as the high-gain first stage in their equipment. But the unwanted noise the devices introduce has forced the designers back to discrete transistor circuits. Two dual audio preamplifiers from National Semiconductor Corp. may change this.

Called the LM381 and LM382, they offer both high gain and low noise, and they operate from a single power supply, which can be from 9 to 40 volts dc. An internal power supply decoupler/regulator provides 120-decibel power-supply rejection in each circuit, both of which also have built-in short-circuit protection.

Joe Byerly, consumer product marketing manager at National, claims that the LM381 offers audio circuit designers the performance of discrete transistor circuits with the cost advantages of integrated circuits. "With the low output level of magnetic tape heads and phonograph cartridges, amplifier noise becomes critical in achieving an acceptable signal-to-noise ratio," says Byerly, adding that "this is the major deficiency of the op amp in this application." Other inadequacies of the op amp, he says, are insufficient power-supply rejection, limited bandwidths, and the need for many external components.

The LM381 has a total equivalent noise input of only 0.5 microvolt rms; this is equal to or better than that of the best discrete circuits found in top-of-the-line stereo equipment. Gain of the LM381 is 112 dB, and the small-signal bandwidth is 15 megahertz; power bandwidth is 75 kilohertz. Other features include a total harmonic distortion of typically 0.1% at the 75-dB gain point, and channel separation of typically 60 dB. Output voltage swing is equal to the power supply voltage minus 2 V, peak to peak.

Besides high-fidelity audio applications, the LM381 can be used in instrumentation tape recorders, hydrophones, and other systems requiring low-noise, high-gain amplification of low-level signals.

The LM382 dual preamp has the same specs as the LM381 except for its total equivalent noise spec of 0.8 microvolt and open loop gain of 100 dB. The major difference between the two is that a resistor matrix is provided on the LM382 chip that allows the user to select a variety of closed-loop-gain options and frequency-response characteristics, such as flat-band, NAB (tape) and RIAA (records) equalization. Both the gain and frequency response are selected by external capacitor connections, and no other external components are needed, except for the input coupling capacitor. Byerly says that with its lower price and its built-in resistor network, the LM382 "is ideal for the auto and home stereo market."

Both dual preamplifiers come in 14-pin dual in-line plastic packages made of National's high-reliability epoxy-B material.

The LM381 sells for $4.95 each in quantities of 100, and the LM382 for $2.25.

National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, Calif. 95051 [411]

Self-scanned linear array designed for page-reading

What is probably the closest thing to a page-reader-on-a-chip has been developed by Reticon Corp., Mountain View, Calif. The RL-512 is a self-scanned linear array of 512 photodiodes, spaced on 1-mil centers. John Rado, Reticon president, claims that the RL-512 is the first commercial solid-state line scanner to give television-type resolution.

The device can be used for film

reading, surveillance, page reading, and other applications. In a page reader, one RL-512 would provide 17-mil resolution over the 8.5-inch width. The 5-to-10-mil resolution required for facsimile transmission, Rado says, can easily be obtained by using two arrays.

The array is self-scanned by the photodiodes and two 256-bit MOS shift registers integrated onto the same silicon chip. Separate output video lines are provided for the odd and even elements, and each shift counter is driven by a pair of complementary square-wave clocks, with a start pulse to initiate each scan. Rado says that, since a new photodiode is accessed on each clock transition, the two shift counters can be run a quarter-cycle out of phase and the two video lines tied together to give 512 elements of continuous video. Or the user can get 256 video elements on 2-mil centers by running only one of the two shift counters, or by running both shift counters in phase.

The RL-512 includes the diode array and the two shift counters in a 18-pin dual in-line ceramic package with a clear quartz lid. To complete the system, the user must add the clocks, the driver, and the video amplifier; or he can purchase these circuits on a printed-circuit card from Reticon. The OEM-quantity price of the RL-512 is $600.

Reticon Corp., 365 Middlefield Rd., Mountain View, Calif. 94040 [412]

Phase-locked loop operates from 0.01 Hz to 25 MHz

Two phase-locked loops give the designer a choice of high- and low-frequency operation. The model 2820 offers a range of 0.01 hertz to 3 megahertz, and the model 2800 version operates to 25 MHz minimum.

New products

Both models feature loops broken between V_{CO} and phase comparators with loop demodulation gains independently variable, making the devices suitable for phase demodulation. In addition, the dc level of demodulated output voltage and/or gain can be selected. Temperature compensation allows the V_{CO} frequency drift with temperature to be 100 ppm/°C. V_{CO} outputs of the 2820 are TTL-compatible, and the 2800 is compatible with either TTL or ECL when used with a logic power supply and negative voltage. Price ranges from $6.35 to $22.65, depending on frequency and temperature range.

Harris Semiconductor, P.O. Box 883, Melbourne, Fla. 32901 [415]

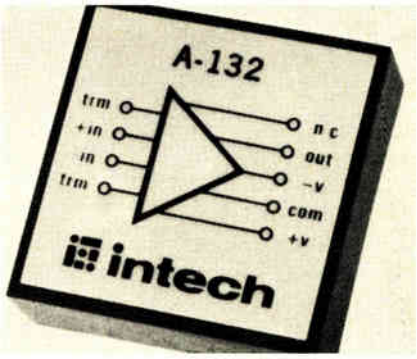
MOS registers offered in commercial, military grades

A six-part MOS shift register group features three devices with 10-megahertz guaranteed frequency operation. These silicon-gate registers are pin-for-pin replacements for Intel and similar circuits, and are available in both commercial and military temperature grades. Power dissipation is 0.1 milliwatt per bit at 1 MHz. All six devices are DTL- and TTL-compatible, and have guaranteed operation as low as 400 hertz. They require two-phase overlapping clocks, and provide a one-bit shift on each clock pulse. They're all available in dice for makers of hybrid circuits. Price ranges from $9.60 to $24.

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086 [417]

FET-input op amp settles in 100 ns

A slew rate of 1,000 volts/microsecond and a settling time to within 0.01% of 200 nanoseconds are guaranteed features of the model A-132 FET-input operational amplifier. Typical slew rate is 1,500 V/μs, and settling time, 100 ns. The unit is suited for high-resolution analog-to-digital applications, sample-and-hold circuits, high-speed buffers or integrators. In addition, low output impedance and good stability permit the unit to drive high-speed



logic, cables, or other capacitive loads to 1,000 picofarads. Open-loop gain is typically 100 decibels, and bandwidth is 20 megahertz minimum. Input bias current is less than 50 pA, and input drift is 50 μ V/°C. Price is $57, and delivery is from stock.

Intech Inc., 1220 Coleman Ave., Santa Clara, Calif. 95050 [416]

White-noise generators cover 10 hertz to 500 MHz

Five white-noise generator diodes called the CND 1000 to CND 4000 and CND 6000 are hermetically sealed silicon devices operating in the avalanche mode. They produce high levels of noise independent of frequency and temperature. Bandwidth ranges from 10 hertz to 500 megahertz, and temperature range is from −55° to +125°C with a maximum noise output variation of ±2 decibels across the frequency spectrum.

Codi Semiconductor Division, Computer Diode Corp., Pollitt Dr. South, Fair Lawn, N.J. 07410 [419]

Silicon-gate RAM has 125-ns access time

A 1,024-bit, n-channel, silicon-gate random-access memory offers a typical access time of 125 nanoseconds and power dissipation of 60 milli-

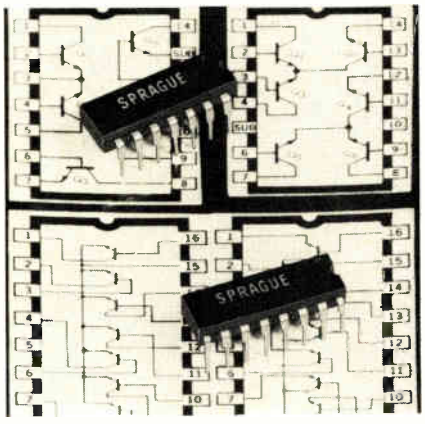
New products

watts. The model EA1501 combines high speed and low power. It operates off a ±12-volt supply and draws 0.01 mW/bit in standby. The memory is organized in a 1,024-by-1 configuration, and 10 address inputs are completely decoded internally to select the addressed word location for operation. A write operation occurs when a write pulse is applied in conjunction with the chip-enable pulse. A read is performed when chip-enable is activated without the write pulse. Price is from $19.50 to $28.50, depending on quantity.

Electronic Arrays, 510 Ellis St., Mountain View, Calif. 94040 [418]

Transistor arrays are for matched thermal applications

Five transistor arrays are monolithic in construction, and combine the attributes of silicon integrated circuits with the design flexibility and accessibility of discrete devices. They are aimed at applications requiring matched thermal and electrical parameters. The models ULS2045H and ULN2046A consist of five npn transistors with two connected as a differential pair; type ULN2054A,



of six npn transistors connected to form two independent differential amplifiers; and types ULN2081A and ULN2082A, each consisting of seven npn transistors connected in the common-emitter and common-collector configuration respectively. Price ranges from $1.05 to $2.25 in 100-lots.

Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247 [420]

New literature

Relays. C.P. Clare & Co., 3101 Pratt Ave., Chicago, Ill. 60645. A 12-page catalog describes general-purpose relay line. Information on contact materials for switching dry circuits is included, as well as a designer's reference guide. Circle 421 on reader service card.

Camera system. A four-page brochure, available from Ampex Corp., 401 Broadway, Redwood City, Calif. 94063, describes features and specifications of the model CC-500 color television camera system, designed for educational, medical, and industrial use. [422]

Transducer calibration system. Dranetz Engineering Laboratories Inc., 2385 S. Clinton Ave., South Plainfield, N.J. 07080, is offering a bulletin detailing the S-7 sonar transducer calibration system, stressing the building-block concept offered by the company. [423]

Communications systems. Capabilities of Xerox Corp., 701 S. Aviation Blvd., El Segundo, Calif., in computer-controlled data communications systems are described in an eight-page brochure that deals with hardware, software, and systems support. [424]

Circuit tester. Teradyne Inc., 183 Essex St., Boston, Mass. 02111, has published a 55-page price list and catalog for the model J133 analogical circuit-test instrument. More than 3,800 digital integrated circuits that can be tested on the unit are listed by manufacturer's part number, along with the stock numbers and prices of the J133 programing boards needed for each IC. [425]

Active filters. Frequency Devices Inc., 25 Locust St., Haverhill. Mass. 01830, is offering a six-page report on active filters that provides systems engineers with data needed for selection of proper filter characteristics. [426]

Potentiometers. An 84-page product catalog describing a line of precision potentiometers and counting dials is available from the Amphenol Connector division Controls Operation, Janesville, Wis. Included are electrical and environmental characteristics, as well as line drawings and selection charts. [427]

Computer. Microdata Corp., 644 E. Young St., Santa Ana, Calif. 92705, has published an 88-page reference manual for the Micro 1600 minicomputer. It includes seven chapters and an appendix, in addition to a reference table and system description. [428]

Switches. Grayhill Inc., 561 Hillgrove Ave., La Grange, Ill. 60525. An engineering catalog contains 104 pages of drawings, dimensions, prices, and operating features of a

line of rotary switches, pushbutton switches, termination hardware, wire ties, and solid-state relays. [401]

Diodes. Diodes and high-frequency transistors available from Hewlett-Packard Co., 1601 California Ave., Palo Alto, Calif. 94304, are described in an eight-page catalog. Listings include a line of Schottky, p-i-n, Impatt, and step-recovery diodes; chip, beam-lead and other configurations for use in hybrid circuit applications are shown. [429]

Modems. Pulse Communications Inc., 5714 Columbia Pike, Falls Church, Va. 22041. A brochure describes a line of low-speed Bell System-compatible data modems, designated the series 4080. [430]

DIP trimmer. A two-page data sheet, available from Spectrol Electronics Corp., 17070 E. Gale Ave., City of Industry, Calif. 91745, describes a low-cost ¾-inch trimmer with dual in-line pin spacing. [431]

D/a converters. A four-page catalog from Micro Networks Corp., 5 Barbara Lane, Worcester, Mass. 01604, provides specifications and pinning information on 24 models of digital-to-analog converters in dual in-line package and module form. [432]

Power supplies. Power supplies available in the EP series from Power Pac Inc., 24 Stage St., Stamford, Conn. 06901, are specified in a brochure that also includes price information. [433]

Power conversion equipment. Topaz Electronics, 3855 Ruffin Rd., San Diego, Calif. 92123, is offering a nine-page bulletin describing a line of solid-state power-conversion systems. These include inverters/converters, ultra-isolation transformers, ac line regulators, and uninterruptible power systems. [434]

Modular oscillator. Fork Standards Inc., 205 Main St., West Chicago, Ill. 60185, has published a 12-page catalog describing a line of modular oscillators. Specifications, including frequency ranges, output waveforms, dimensional and mounting drawings, and terminal layouts, are shown for 18 models of both crystal and tuning-fork units. [435]

Audio-video receiver. Conrac Corp., Conrac division, 600 North Rimsdale Ave., Covina, Calif. 91722. A data sheet outlines the 1000 series audio-video receivers and describes optional modules for professional, closed-circuit, community-antenna and educational applications. [436]

Coaxial load resistors. A short-form catalog from Bird Electronic Corp., 30303 Aurora Rd., Cleveland, Ohio 44139, lists a line of coaxial load resistors, absorption wattmeters, directional wattmeters, rf attentuators, and coax switches. [437]

New books

Systems Programming, John J. Donovan, McGraw-Hill Book Co., pp. 488, $13.95

Digital Computer Fundamentals, Thomas C. Bartee, McGraw-Hill Book Co., pp. 467, $10.95

Basic Principles of Integrated Circuits, R.G. Hibberd, Philosophical Library, pp. 274, $15

Electronic Data Processing, Martin Nussbaum, Vocational Guidance Manuals, pp. 160, $4.95

Superconductivity, E.A. Lynton, Science Paperbacks, pp. 219, $5

From Electrocatalysis to Fuel Cells, G. Sandstede, University of Washington Press, pp. 415, $12.50

The Design of Digital Systems, John B. Peatman, McGraw-Hill Book Co., pp. 457, $15.50

Solid State Electronic Devices, Nick Holonyak Jr., Prentice Hall Inc., pp. 463, $13.95

Electronic Drafting and Design (second edition), Nicholas M. Raskhodoff, pp. 666, $13.50

High-Voltage Measurement Techniques, Adolf J. Schwab, M.I.T. Press, pp. 290, $15.00

Modern Control System Theory and Application, Stanley M. Shinners, Addison Wesley, pp. 528, $14.95

Computer Networks, Randall Rustin, Prentice-Hall Series, pp. 205, $9.95

Theory and Analysis of Phased Array Antennas, Noach Amitay, Victor Galindo and Chen Pang Wu, pp. 443, $22.50

Materials for Semiconductor Functions, E.G. Bylander, Hayden Book Co., pp. 220, $13.50

Materials Science And Technology for Design Engineers, Alex E. Javitz, Hayden Book Co., pp. 560, $23.95

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13	33	53	73	93	113	133	153	173	193	213	233	345	365	385	405	425	445	465	952
14	34	54	74	94	114	134	154	174	194	214	234	346	366	386	406	426	446	466	953
15	35	55	75	95	115	135	155	175	195	215	235	347	367	387	407	427	447	467	954
16	36	56	76	96	116	136	156	176	196	216	236	348	368	388	408	428	448	468	956
17	37	57	77	97	117	137	157	177	197	217	237	349	369	389	409	429	449	469	957
18	38	58	78	98	118	138	158	178	198	218	238	350	370	390	410	430	450	470	958
19	39	59	79	99	119	139	159	179	199	219	239	351	371	391	411	431	451	471	959
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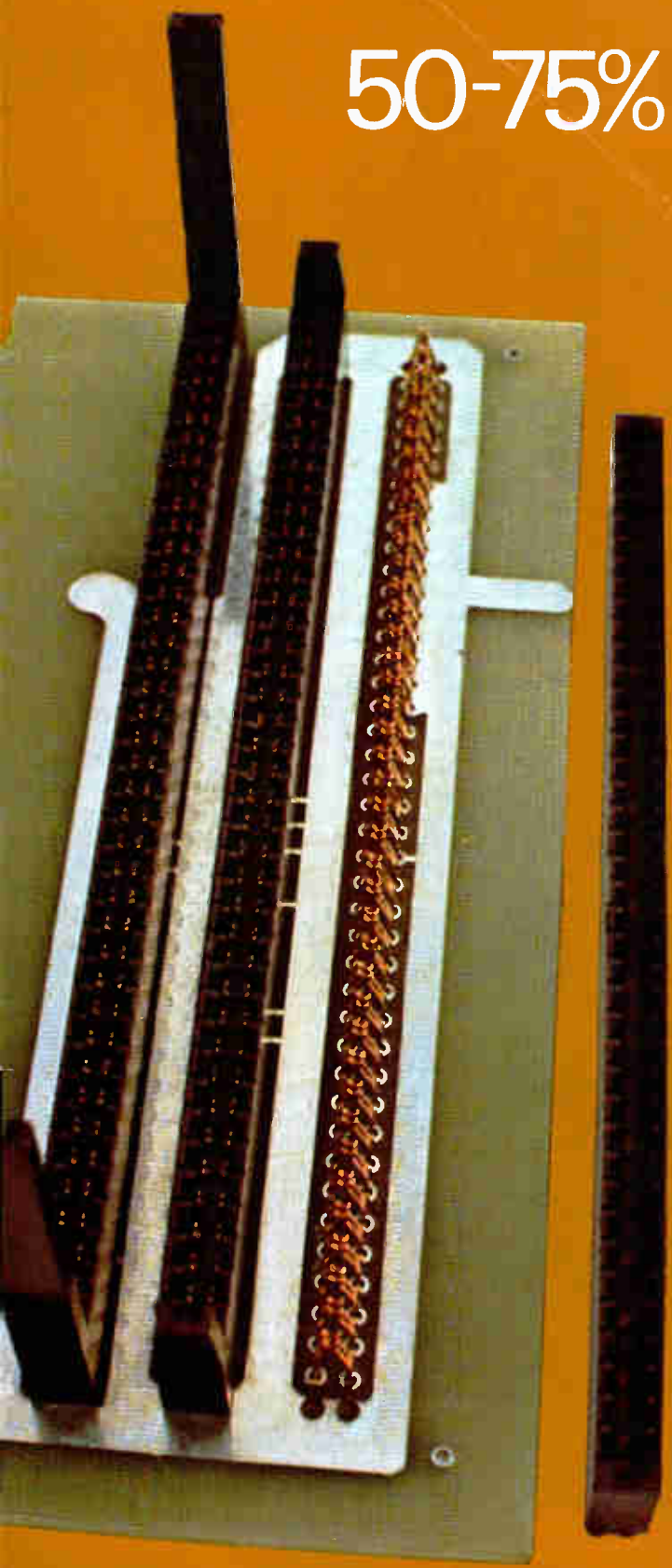

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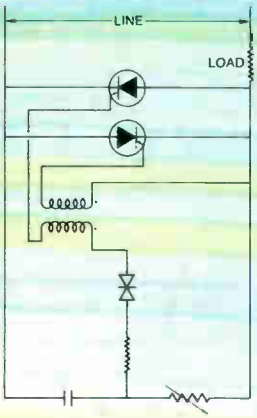

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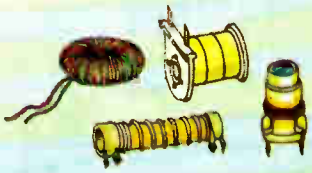

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