January 18, 1971

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Tantalum chip capacitors for hybrid ICs 67

Suppressing circuit noise with ferrite cores 77

The versatile field effect cascode circuit 81

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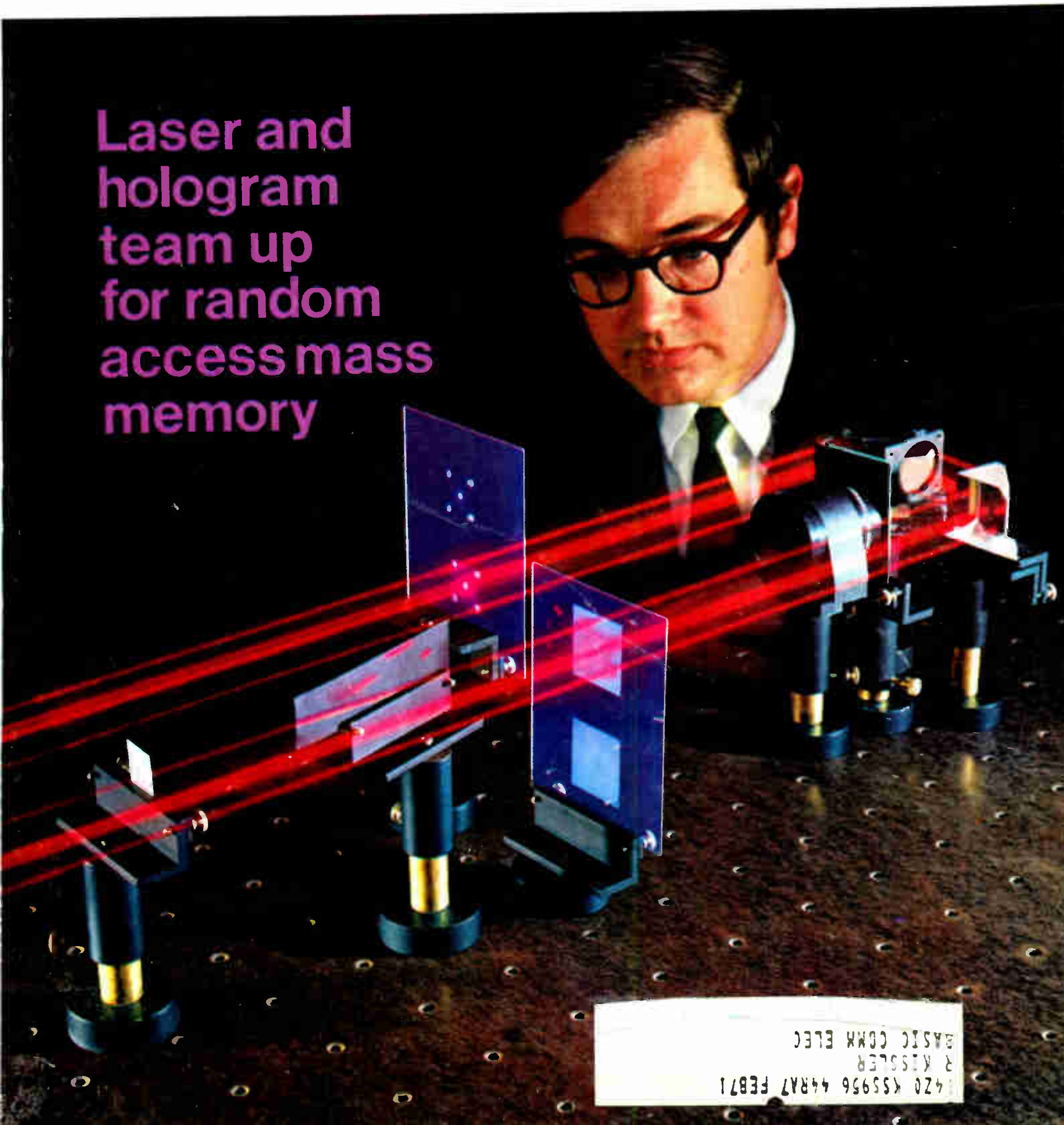
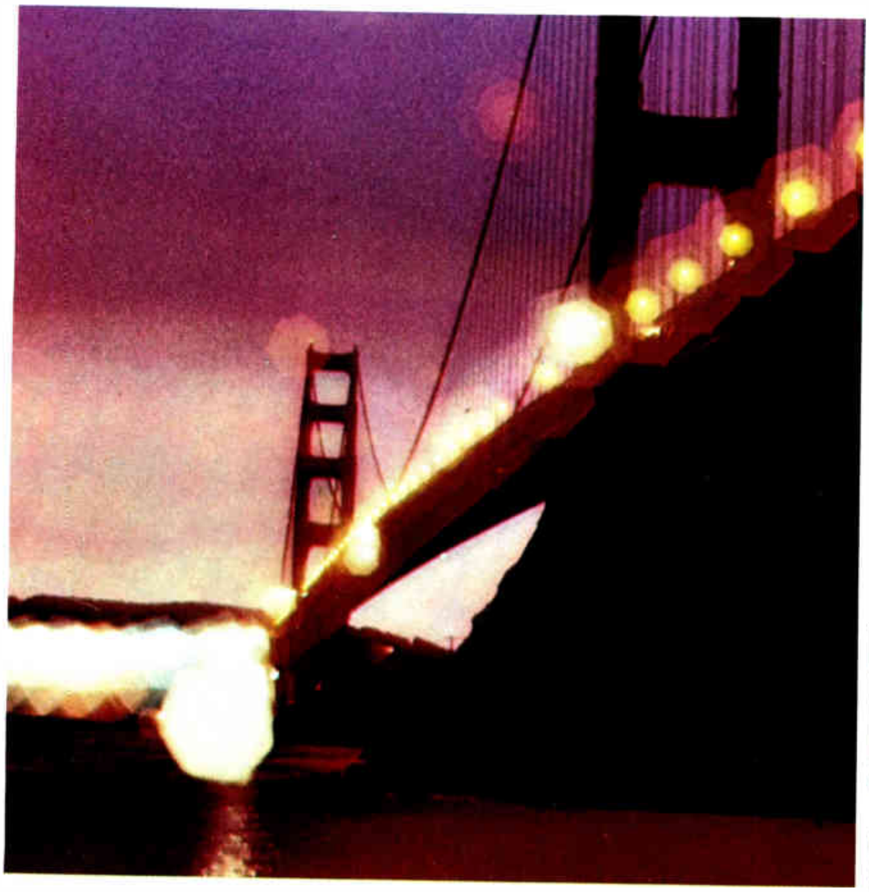
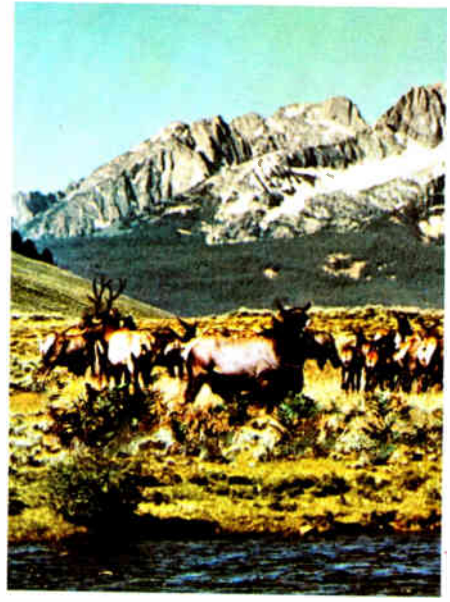
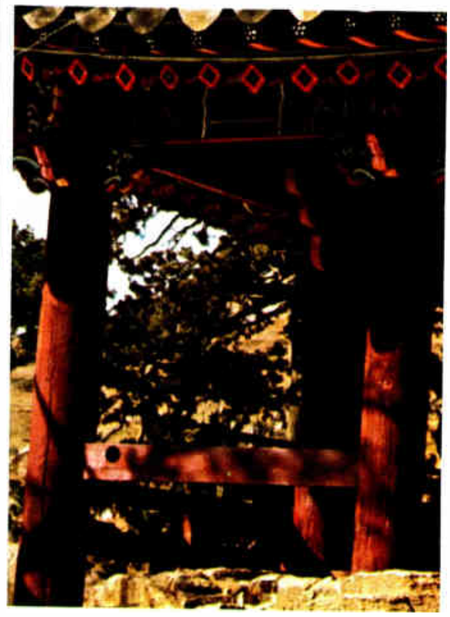


Laser and hologram team up for random access mass memory







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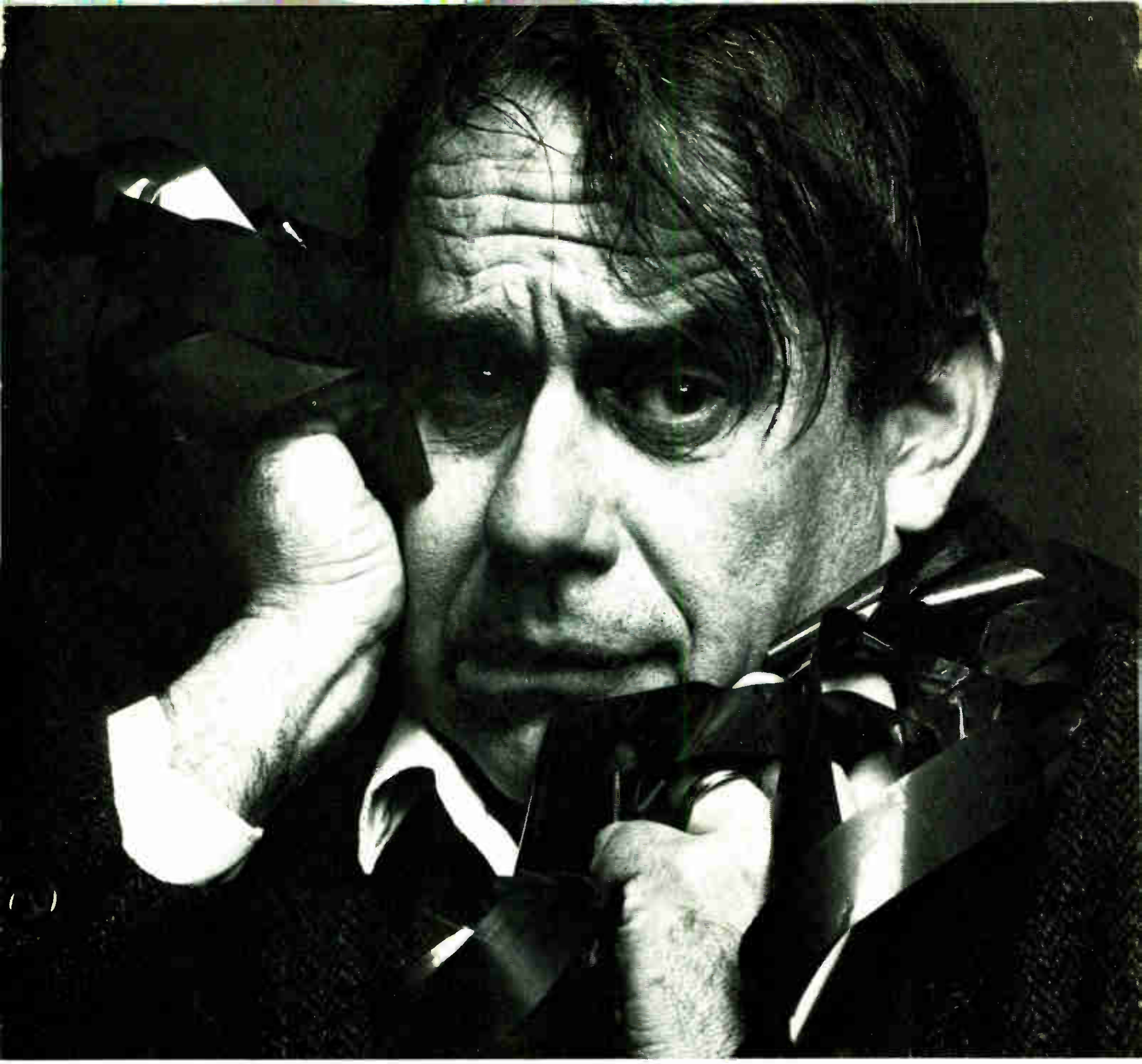

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RECORDING SYSTEMS

Circle 1 on reader service card

Electronics

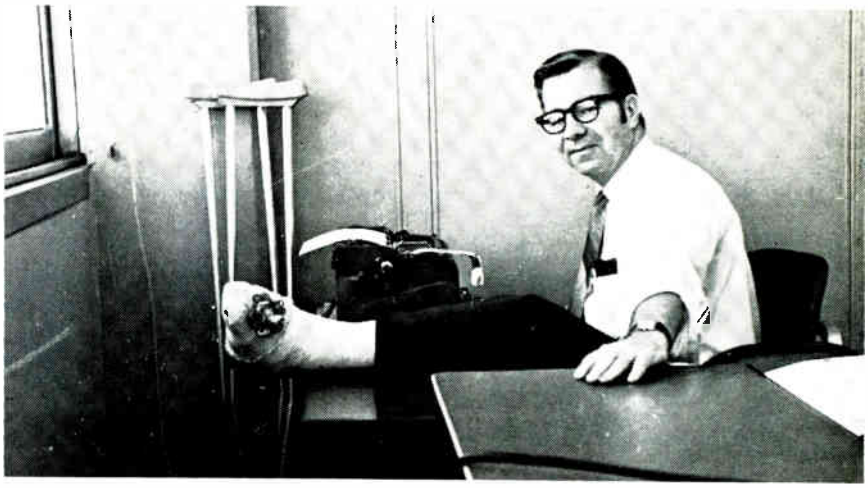
About this issue

Disaster always strikes at the wrong time. For a reporter about the worst time for any personal catastrophe is when he has a heavy schedule of interviews set up. Our Los Angeles bureau chief, Larry Curran, was all set to start reporting the in-depth story on computer-aided design that leads off the Probing the News section (p. 93) when he broke his ankle. He says it happened in a "stupid fall" at home. Crutches were issued, the cast went on, and so did Curran—to get the latest word on how the CAD world is evolving and to explain countless times that he hadn't been skiing when he suffered his injury.

Curran's story updates and expands the special report he did for *Electronics* way back in the Oct. 13, 1969, issue. That's only a little over a year ago, but a lot has happened in the field since then. For one, Curran reports, contrary to the "early" days of CAD, far more emphasis is placed on the word "aided." It turns out that the human designer is still more skillful at manipulating circuit elements than is a computer program. That's the feeling of seven out of the eight leading semiconductor houses using CAD that were covered by Curran and by Paul Franson, who filed the Texas Instruments' side of the CAD story from Dallas.

Last month marked the fourth anniversary of Curran's move to *Electronics* from Washington-based Missiles and Rockets magazine, where he was assistant managing editor. This month marks his eleventh year in business journalism. He is a graduate of Washington and Jefferson College, Washington, Pa.

After covering more than 1,000 miles on crutches to get the CAD story—if you count planes and cars—Curran says, "It was a nice change to have women open doors in deference to my gimpy leg."



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Readers comment

More on ARTS

To the Editor: Overall, the article, "Budget shortages stall ARTS 3 implementation" [Nov. 23, 1970, p. 87], correctly reflects our situation, wherein resource shortages have kept us from making the progress that is needed to keep pace with air traffic growth. However, I believe that a portion of the article was based on a misunderstanding of my discussions with Jim Hardcastle, or perhaps it stemmed from information he received from another source.

I stated that ARTS was a great technical challenge in that it required display of primary and secondary data, as well as high-speed writing of characters during radar system dead time. I indicated that this challenge had been met by Texas Instruments; that it is to TI's credit that the production engineering problems have been largely resolved, with the remaining few to be concluded shortly, even though the cost may have been greater than originally anticipated. I also indicated that one of the strengths of the system's contract was that Univac and TI pursued the problems involved and resolved them with minimum effort on the part of the FAA—an advantage of doing business with companies of their stature.

I also noted an error in the box on "The art of ARTS." I believe that the display subsystem of the original ARTS prototype at Atlanta has been confused with the ARTS 3 production system. The Atlanta configuration uses the TV scan as reflected in the article, whereas the TI subsystem operates in a normal rho/theta manner with brighter output and alphanumeric characters written during radar dead time.

As a matter of overall information, we consider the ARTS 3 production, installation, and implementation program to be moving along satisfactorily.

John C. Mercer
Systems Research and
Development Service
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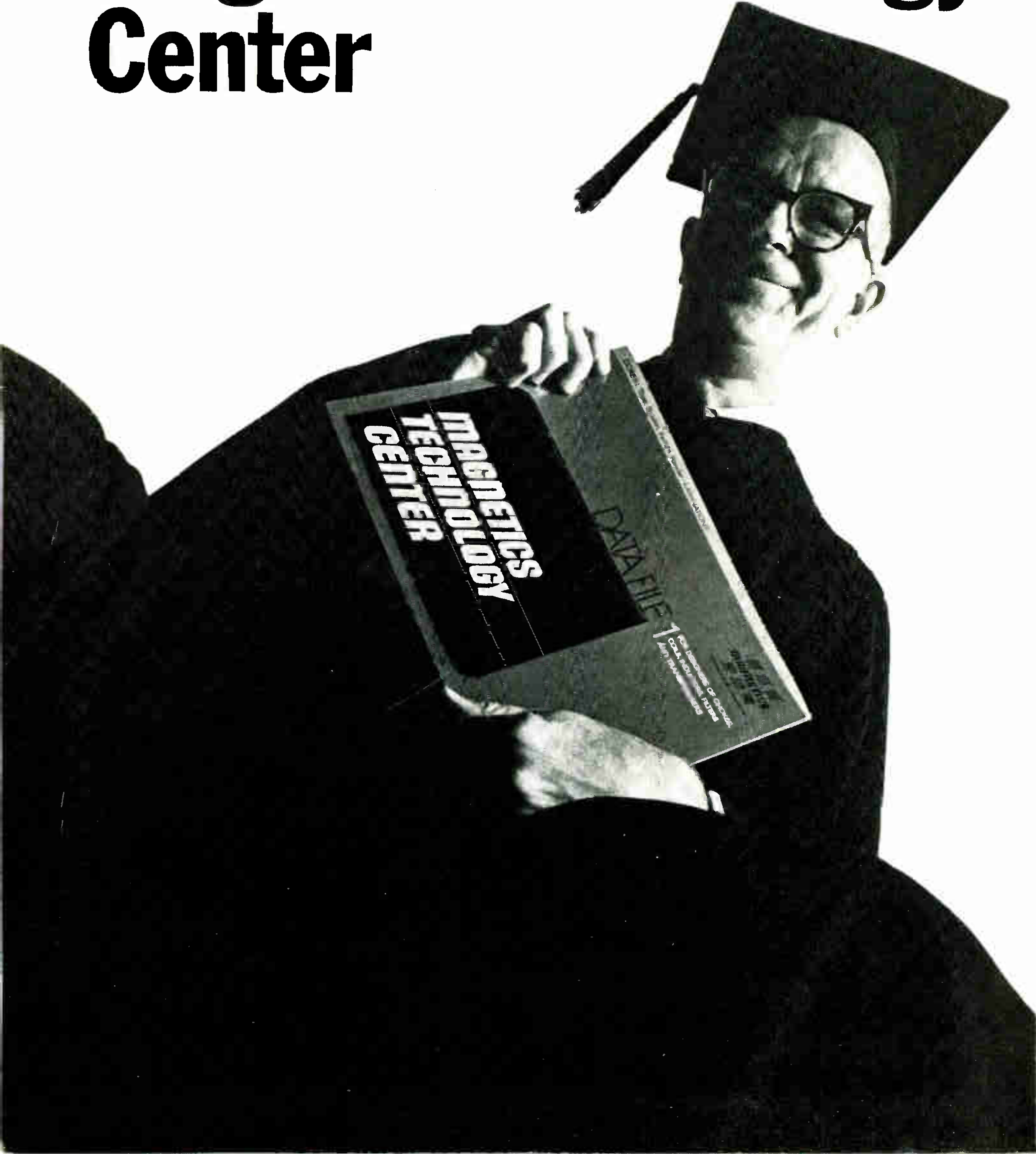

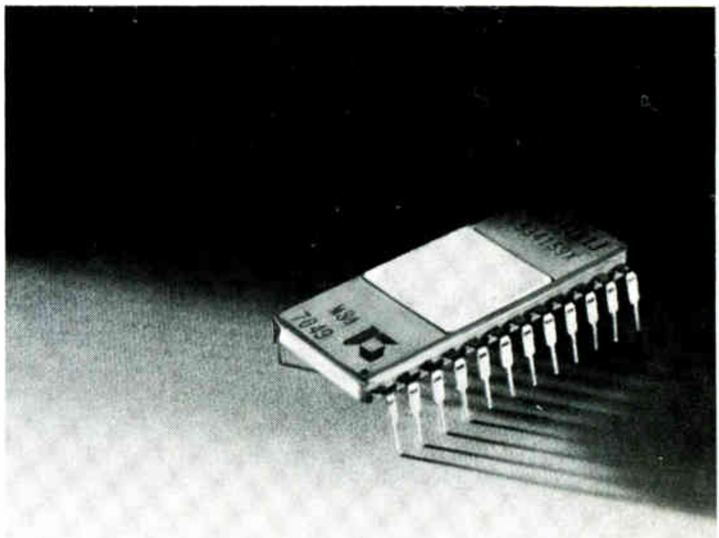

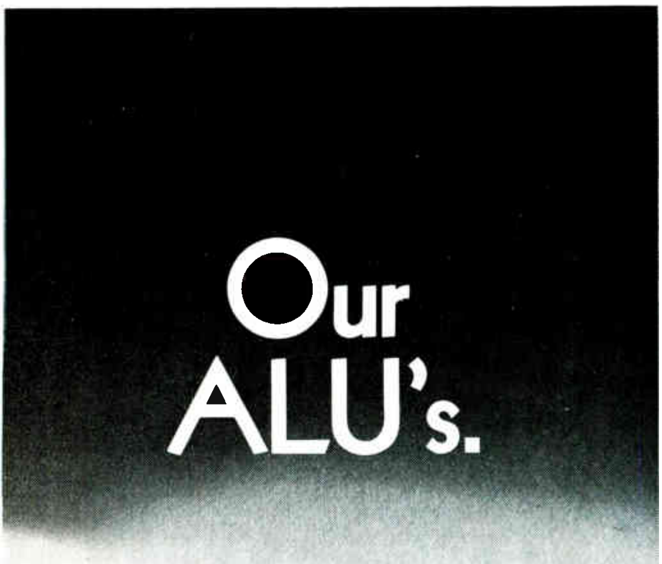

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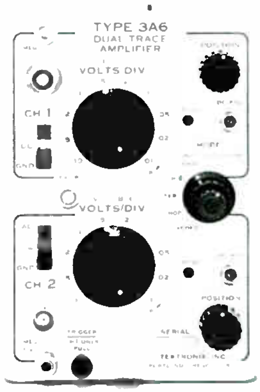

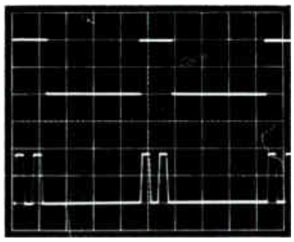

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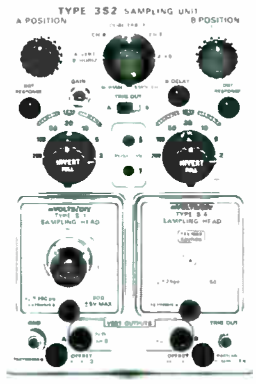

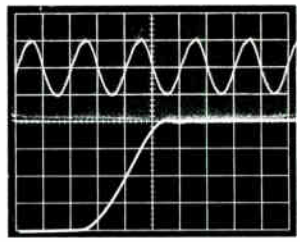

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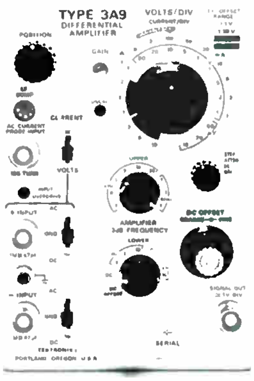

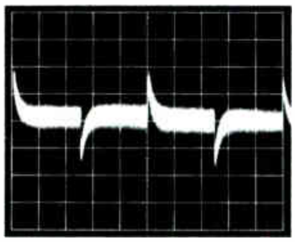

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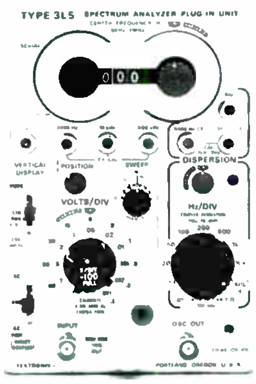

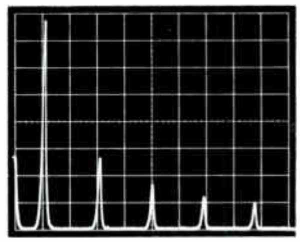

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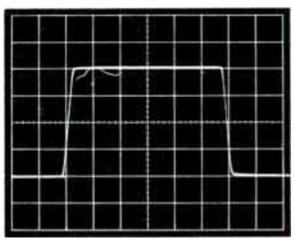

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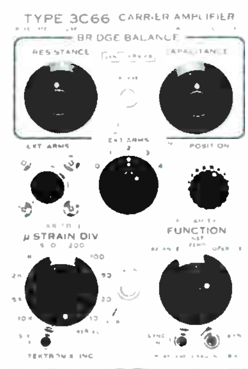

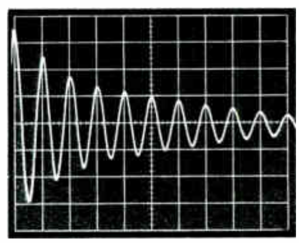

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People

Rosso

"Instrumentation is often used in research—sometimes for a number of years—before it finds a place in routine diagnostic work in a clinical laboratory," Louis Rosso points out. And like that instrumentation, Rosso himself is making the switch from the research to the clinical laboratory. He's the first manager of Beckman Instruments' Clinical Instruments division. He comes over from the head spot at the company's Spinco division, which manufactures medical research equipment.

Big things are expected from the new man and the new division. Beckman president William Ballhaus has already tagged clinical instruments as the company's Number 1 growth area.

The 31-year-old Rosso sees clinical-chemistry equipment as the division's big seller, with most growth taking place in automated gear and in inexpensive benchtop equipment that can do single tests quickly and simply.

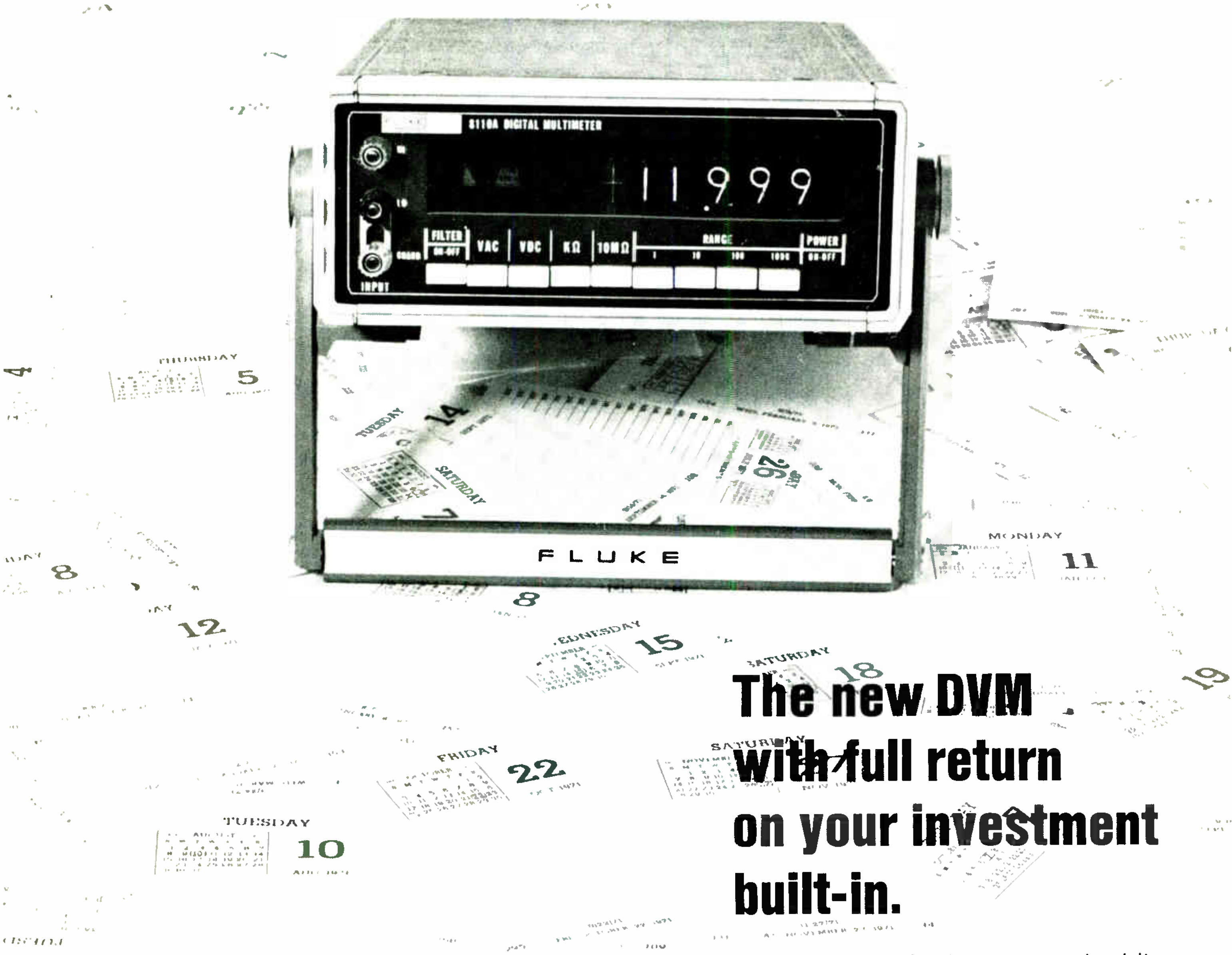
Rosso's division also makes physiological instrumentation. This market has a lot of promise but, says Rosso, "is less well defined and not growing as fast." As an example of the problems, Rosso points to his division's efforts to sell doctors on the telephone transmission and computer analysis of electrocardiograms. "MDs have to want and accept this kind of thing," states Rosso. They don't as yet. "We're in a gestation period," he points out.

Monitoring equipment is also on the division's list of products. However, the concentration is on the relatively new field of infant monitoring. Asked why Beckman isn't moving into the more established field of intensive-care monitoring, Rosso puts it succinctly: "We look for areas where we can be one of the first."

"The traditional engineering divisions are becoming more and more irrelevant," believes Paul E. Gray, 38, new dean of the School of Engineering at MIT. "During the last two decades engineering has seen big-goal-oriented national programs. Now programs are more local, more diffuse, less mission-oriented—like transportation, environmental, and pollution control programs. The old disciplines are not connected in a one-to-one way to the new problems."

With such views it's not surprising that Gray was very much involved in curriculum reform in his former post as associate provost and professor of electrical engineering. His main responsibility was the coordination and development of the undergraduate curriculum, especially the treatment of freshman year work as a coherent whole.

Gray feels that the major change in education in the past few years has been "the focus on the style of the educational encounter rather than the content." MIT now has two school-wide programs which emphasize individual research and an interdisciplinary approach to problems and enroll about 100 freshmen and sophomores, mainly in the School of Science. The question of how such programs relate to the training of engineers is not yet decided, Gray says, but the School of Engineering is studying the programs to determine whether



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they should be made departmental in nature.

One major area of concern for Gray is tight resources, "not just for the School of Engineering but for universities in general. We must use resources in the most efficient and most effective way. I see some courses on a school-wide rather than on a departmental basis." He mentions computation, elementary thermodynamics and fluid mechanics, and some materials courses as subjects that cut across several departments.

For example, at MIT "there are five departments in transportation, none in a majority position," says Gray. "One could conceive of a division with courses, faculty, and students from several departments. The need is clear, but the way to organize the school is less clear; we have just begun to discuss those things."

Gray admits, "I don't have a very good crystal ball" for forecasting future engineer enrollments, but he feels the present recession is the "kind of thing that discourages students. And many young people see engineering as a creator of problems, such as pollution, and stop at that point; but one can't conceive of a solution that isn't technical in nature. I expect that the need for engineers will increase."

Hacking out a share of the European electronic components market for Westinghouse Electric Corp. is a major task facing John C. Marous Jr., new general manager of the firm's electronic components division. He expects increased emphasis on international sales will replace to a considerable extent sales lost to the depressed aerospace and defense markets, and adds, "Our challenge is to develop a worldwide strategy for the division's growth."

To this end, Westinghouse has just established a specialty sales force in Europe, which will sell products manufactured by the firm's electronic tube division in Elmira, N.Y., and will have its headquarters in Frankfurt, Germany.

Moreover, Compagnie des Semiconducteurs Westinghouse (CDSW), at LeMans, France, whose sales force formerly served only the French market, has now expanded it to cover all Europe, with the exception of a few transistors, all semiconductors sold by this group will be manufactured at the French facility. Finally, Marous says his firm is presently investigating the possibility of building a plant in Europe to manufacture electronic transformers.

In addition to expanding overseas sales, Marous believes Westinghouse's semiconductor division in Youngwood, Pa., will grow substantially because of two factors: "We are just beginning to replace electromechanical devices with solid state," and the expanding pollution control and transportation industries offer abundant opportunities for new semiconductor sales directions.

In fact, the semiconductor division, of which Marous was general manager before assuming his new post, is not suffering as badly as the semiconductor industry as a whole, he claims. "We are not in integrated circuits," he points out, "which have been suffering from reduced volume as well as reduced prices."

Marous, who's an avid paddle tennis player, said a rebound in the entertainment market would help the electronic tube division, which makes television picture tubes. But he predicts that that number of sets sold in 1970 will come to less than half of what was projected several years ago.

Marous is quick to emphasize that Westinghouse's efforts to become a worldwide company do not mean it is neglecting the U.S. market. In support, he points to the fact that 18 months ago Westinghouse established specialty sales forces to market the firm's electronic components. Formerly, they were sold by a force handling 13 products.

And after Europe? Marous forecasts Westinghouse's next international targets will be Africa and then the Far East.

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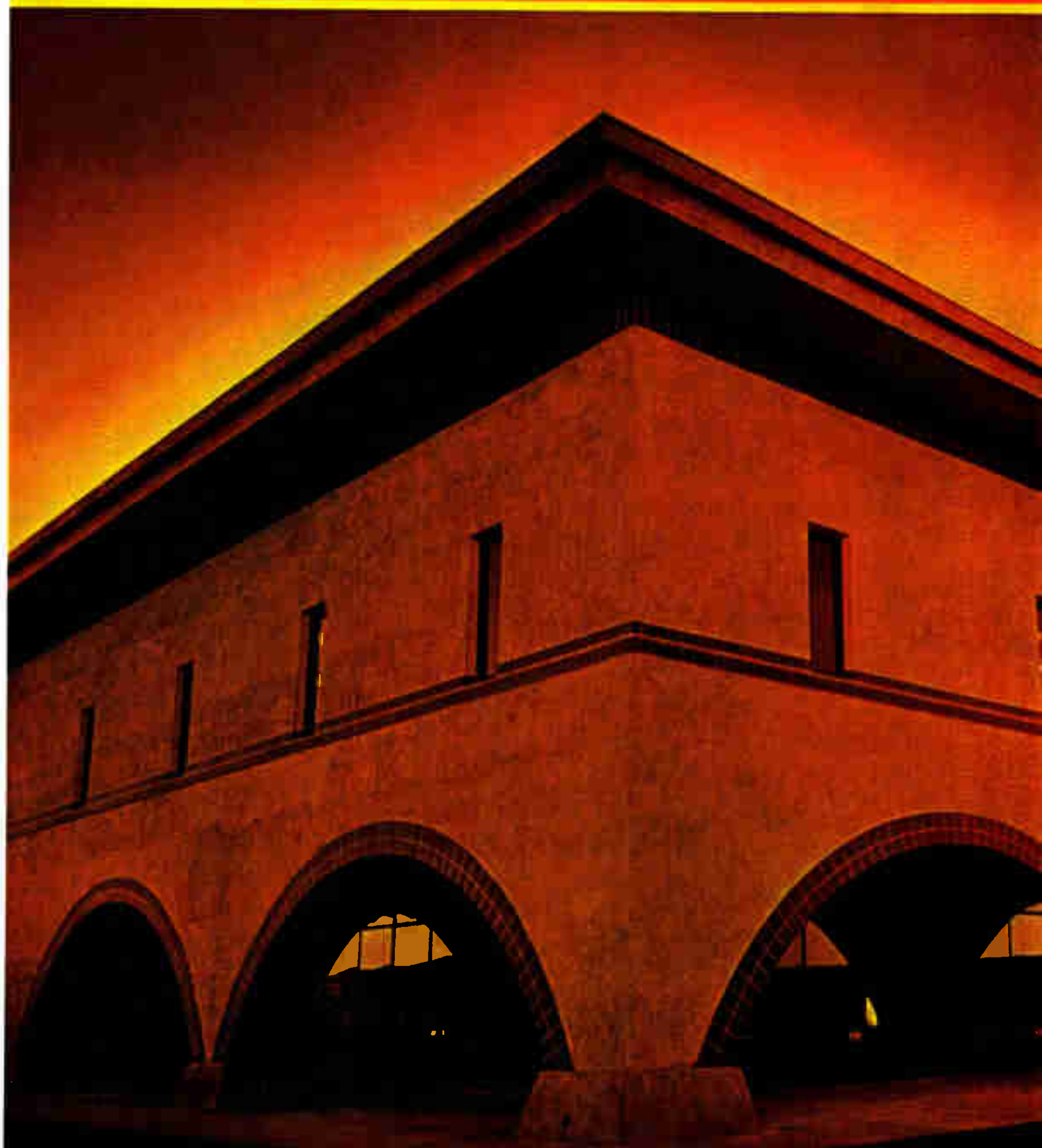

Garrett

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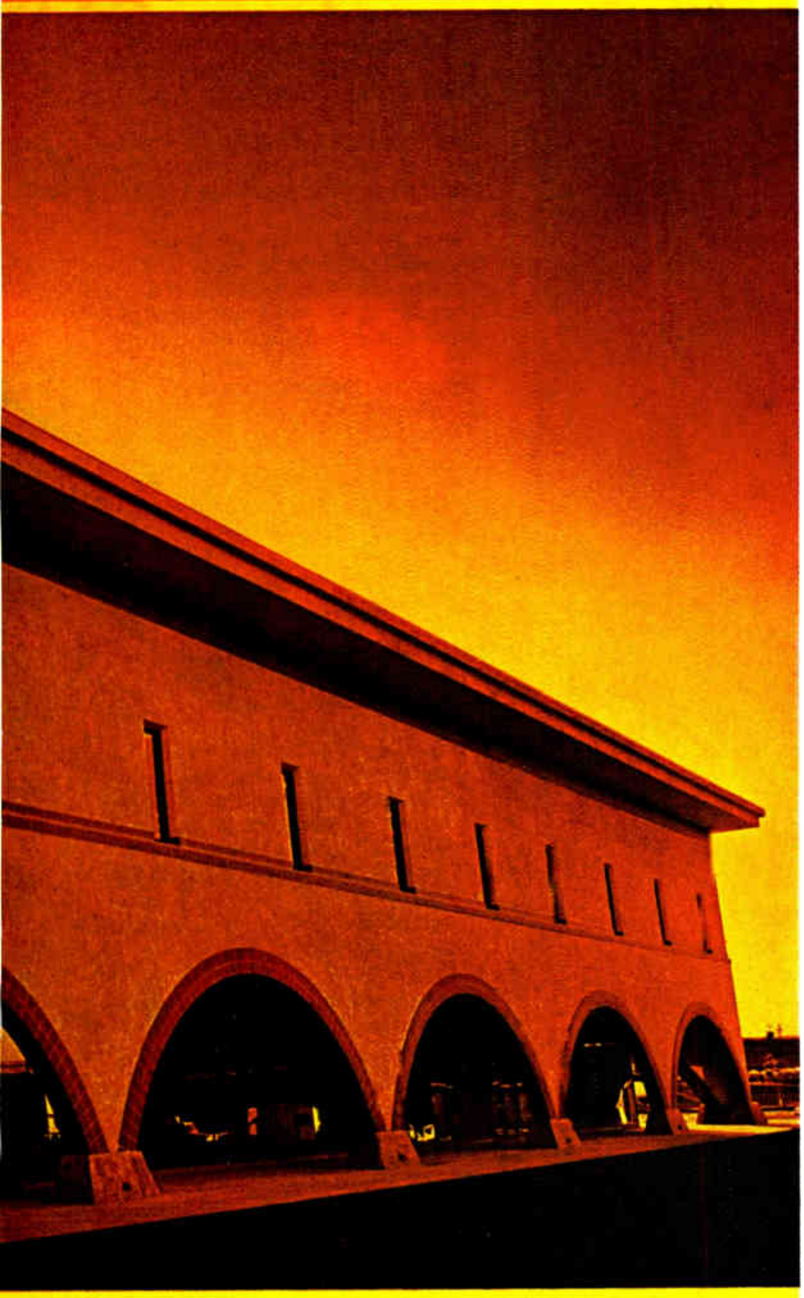

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And we have a temperature control system in critical areas that keeps everything at plus or minus ¼ °F. And a humidity control system that keeps everything at plus or minus 2%.

You name it, we have it. Including a new one-of-a-kind diffusion furnace that has all the controls on the front . . . inside the clean room so operators don't have to enter unclean areas just to turn a couple of knobs.

We are establishing a complete and comprehensive set of computer aids for our design program. One of the benefits resulting from this effort is total and maximum interaction for the designer in all phases, including logic verification, placement and pattern generation.

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And just for the record: every process and piece of equipment we have is devoted exclusively to MOS. Not bipolar *and* MOS. Our commitment to MOS is total. (Our new brochure tells the whole story.)

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Circle 19 on reader service card

Meetings

Calendar

Optics in Microelectronics, Optical Society of America, Stardust Hotel, Las Vegas, **Jan. 25-26.**

Winter Convention on Aerospace and Electronic Systems (WINCON), IEEE; Biltmore Hotel, Los Angeles, **Feb. 9-11.**

International Solid State Circuits Conference, IEEE; Sheraton Hotel, University of Pennsylvania, **Feb. 17-19.**

International Convention & Exhibition, IEEE; Coliseum and New York Hilton Hotel, New York, **March 22-25.**

European Semiconductor Device Research Conference, IEEE, DPG (German physical society), NTG (German communications society); Munich, **March 30-April 2.**

Reliability Physics Symposium, IEEE; Stardust Hotel, Las Vegas, **March 31-April 2.**

USNC/URSI IEEE Spring Meeting, Statler Hilton Hotel, Washington, **April 8-10.**

National Telemetering Conference, IEEE; Washington Hilton Hotel, **April 12-15.**

International Magnetics Conference (Intermag), IEEE; Denver Hilton, Denver, Colo., **April 13-16.**

Conference & Exposition on Electronics in Medicine, Electronics/Management Center, Medical World News, Modern Hospital, Postgraduate Medicine; Sheraton-Boston Hotel and the John B. Hines Civic Auditorium, **April 13-15.**

Off-shore Technology Conference, IEEE, Houston, **April 18-21.**

International Geoscience Electronics Symposium, IEEE; Marriott Twin Bridges Motor Hotel, Washington, **April 18-23.**

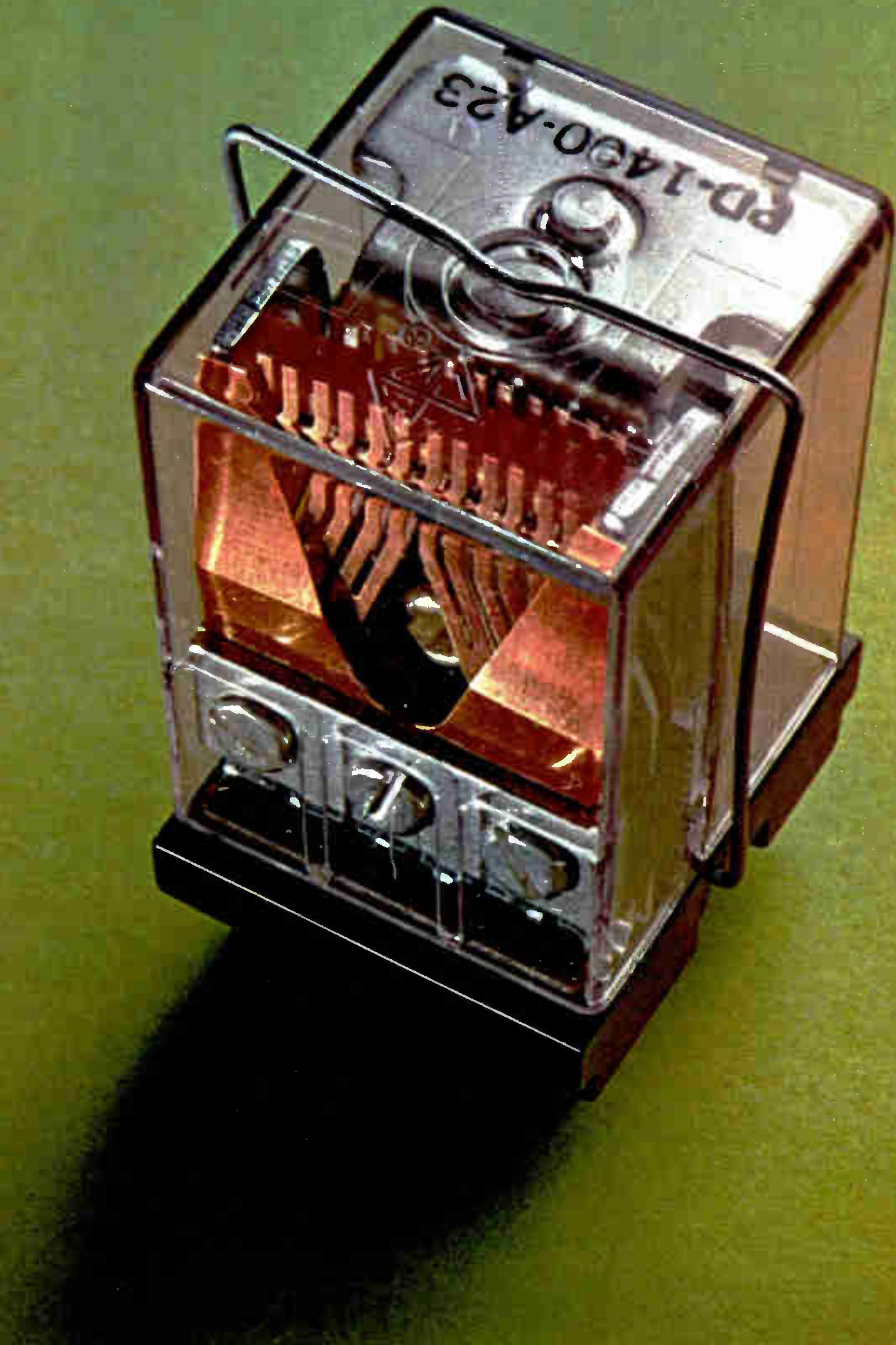
Frequency Control Symposium, U.S. Army Electronics Command; Shelburne Hotel, Atlantic City, N.J., **April 26-28.**

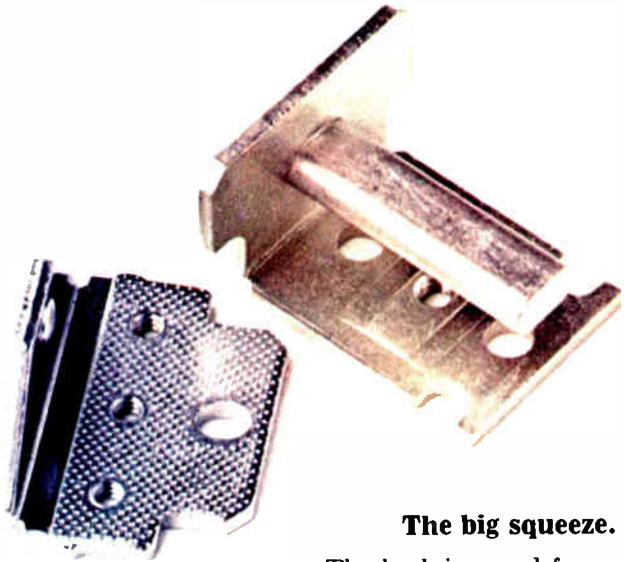
Relay Conference, College of Engineering, Oklahoma State University Extension, National Association of Relay Manufacturers; Stillwater, Okla., **April 27-28.**

Southwestern IEEE Conference and Exhibition, Houston, Texas, **April 25-May 2.**

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

Reliability is 756 little dents and one big one.





The big squeeze.

The heelpiece and frame are the backbone of our Class H relay. The slightest squiggle or shimmy out of either and the whole relay is out of whack.

756 tiny dents on the heelpiece, plus one big one on the frame, make sure this'll never happen.

They're the result of planishing, a big squeeze. Planishing is an extra step we go through in forming the pieces to add strength and stability by relieving surface strain. It also makes the parts extra flat.

This takes the biggest press in the industry and the biggest squeeze. Both exclusively ours.

A different kind of coil.

The heart of a relay is the coil. If ours looks different, it's because we build it around a glass-filled nylon bobbin. It costs us more, but you know how most plastic tends to chip and crack.

Also, moisture and humidity have no effect on glass-filled nylon. No effect means no malfunctions for you to worry about. No current leakage, either.

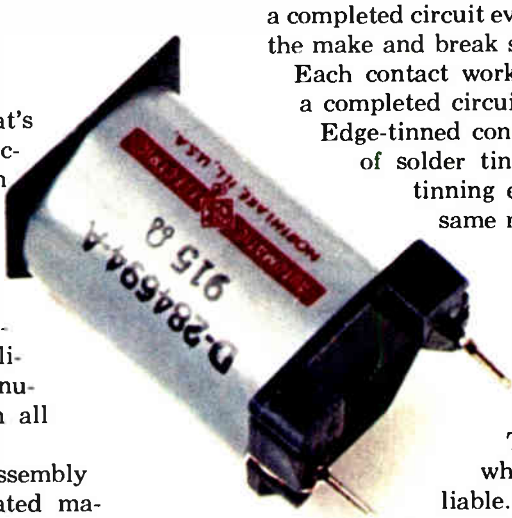
The coil is wound on the bobbin automatically. No chance of human error here.

We didn't forget the solder.

We use a solderless splice. That's because solderless splice connections are sure-fire protection against the coil going open under temperature changes, stress, or electrolysis.

A solderless splice is more expensive to produce, so it's usually found only on the most reliable relays. AE is the only manufacturer to use this method on all of its relays.

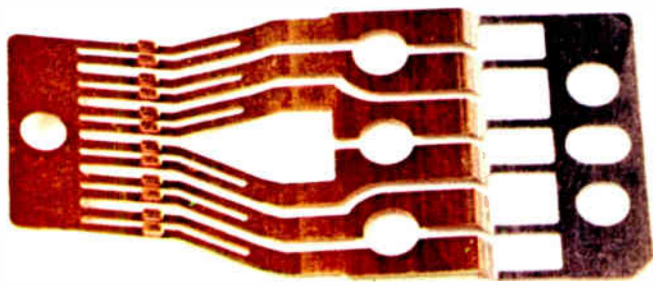
Finally, we wrap the whole assembly with extra-tough, mylar-laminated material. A cover is not really necessary here; but why take chances?



Springs and other things.

We don't take any chances with our contact assembly, either. Even things like the pileup insulators (those little black rectangles) get special attention. We precision mold them. Other manufacturers just punch them out.

It makes a lot of difference. They're stronger, for one thing; and because they're molded, there's no chance of the insulators absorbing even a droplet of harmful moisture. Finally, they'll withstand the high temperatures that knock out punched insulators.



Then there are the contact springs. Ours are phosphor-bronze. Others use nickel-silver. Our lab gave this stuff a thorough check, but found nickel-silver too prone to stress-corrosion. Atmospheric conditions which cause tarnish and ultimately stress corrosion have almost no effect on phosphor-bronze.

Two are better than one.

Our next step was to make sure our contacts give a completed circuit every time. So we bifurcate both the make and break springs.

Each contact works independently to give you a completed circuit every time.

Edge-tinned contact springs save you the job of solder tinning them later. Also, edge-tinning enables you to safely use the same relay with sockets or mounted directly to a printed circuit board. A simple thing, but it takes a big chunk out of the inventory you have to stock.

Etc. Etc. Etc.

There's a lot more to tell about what makes our Class H relay reliable. Now we're waiting to hear from you. Automatic Electric Company, Northlake, Ill. 60164.

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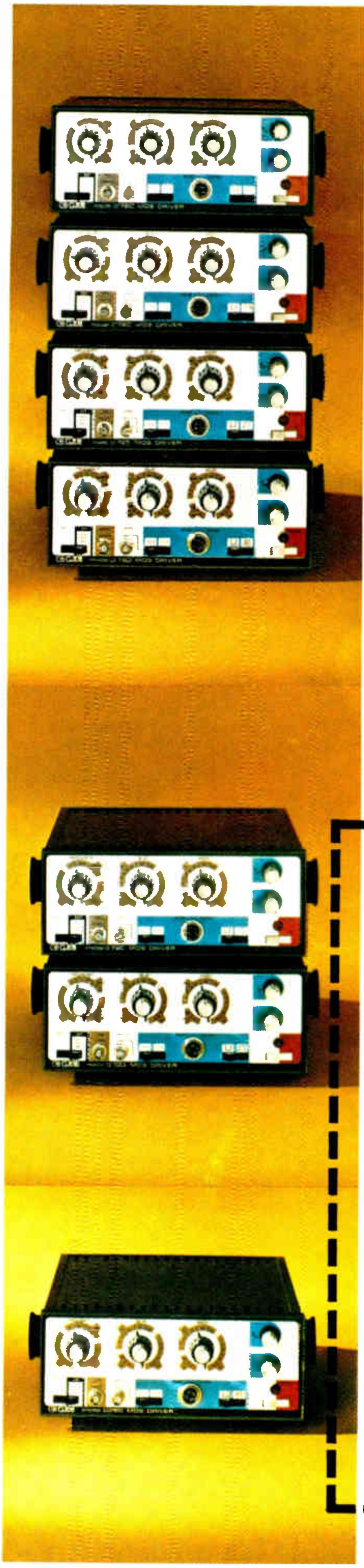
Circle 23 on reader service card



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Electronics Newsletter

January 18, 1971

Laser analyzes each IC component

Scientists at the MIT Lincoln Laboratory are using a laser for analyzing the performance of each individual component in an IC. ICs have been treated like black boxes: their characteristics were measured only at input and output, often making design, quality control, and fault location needlessly difficult.

Lincoln Lab's Robert E. McMahon, group leader and one of the developers, speculates that the technique not only could speed fault isolation, but also permit more accurate measurement of carrier lifetime, resistivity, and surface effects. The work was sponsored by the Air Force.

Now, a helium-neon laser beam 1 or 2 microns wide is scanned raster-fashion across a chip, changing the current flow between power supply input and ground. An oscilloscope synchronized to the laser's x-y scan pattern displays changing current flow across a power-supply load resistor in series with the circuit. A readout shows transistors in the on state as bright areas, and off transistors as black. Isolation regions, resistors, diode junctions, metalization, and bonds all can be observed.

Cogar out to replace 360/65 core memory with MOS modules

Cogar Corp. is bringing out an MOS replacement for the ferrite-core memory of IBM's System 360 model 65. The move could go a long way toward proving the viability of semiconductors as main memories, in volume as well as price.

The Cogar unit, introduced in a burst of ads in such business publications as the Wall Street Journal and Business Week, uses 125-mil-square n-channel chips of 1,024 bits each. It comes in modules of 262,144 bytes, up to four of which can be connected to a single 360/65. Thus, Cogar says it can replace the entire main core memory at the same 750-nanosecond cycle time but at a price 20% below IBM's—$297,000 for Cogar's versus $386,000 for IBM's.

Tests may open phone lines to data

An experimental modem developed at MIT Lincoln Laboratory could allow crowded data communications to be transmitted over phone lines formerly unusable because of their nonlinear phase, amplitude, and frequency response. Using vestigial sideband modulation in a narrow 1.6-kilohertz bandwidth—and TTL logic and MOS shift registers to create an adaptive, 63-tap delay line up to 19.7 milliseconds long—the modem has achieved transmission rates up to 9,600 bits per second.

Duplexed, over a 36-mile dial-up line between MIT's main campus and Lincoln Lab, the modem maintained this bit rate in the face of 3-millisecond delay variations, 13-decibel amplitude variations, 4° phase jitter, and 13-millisecond low-pass impulse response. This poor line quality, according to the modem developers, C.W. Neisson and D.K. Willim, is typical of many voice lines, presently useless for data transmission even at much lower bit rates. Despite the line, error probability measured only 8.5×10^{-5} bits.

IEEE, NSPE agree to join forces

The IEEE has taken steps to make the recession period more tolerable for its members. It has halved dues and fees for unemployed engineers, and has completed an agreement with the National Society of Professional Engineers, subject to approval by the NSPE, that will allow the

Electronics Newsletter

IEEE to answer its members' demands for lobbying and other action without endangering its tax-free status.

Of the two moves, the second is the more important for the long term. The arrangement is said to confer upon IEEE members what amounts to nonvoting membership in NSPE. Thus, IEEE views would be recorded and, it's hoped, acted upon in response to NSPE lobbying.

Mostek MOS/LSI to go into calculator

There appears to be no end to the U.S.-Japanese deals for calculator LSI in which the Americans supply the circuits. Mostek Inc. of Carrollton, Texas, has landed a contract to supply MOS/LSI to an unnamed Japanese manufacturer. At the same time, it's reported that Japan's Nippon Columbia is negotiating a similar deal for Varadyne to supply MOS/LSI calculator circuits.

In the Mostek arrangement, American Micro-systems Inc. of Santa Clara, Calif., would be the second source. The device is Mostek's ion-implanted MK 4006P 1,024-bit random access dynamic memory. Though AMI is the industry's largest supplier of MOS ICs, this is its first ion-implanted device; up to now AMI has supplied conventional high- and low-threshold MOS. Mostek supplied masks for the circuit, which has a top cycle time of 650 nanoseconds; AMI developed the process.

Oven seen as key to quick production

A technique sometimes used to cure lumber could enable process control engineers to speed up production of semiconductors and printed circuits. It also might aid device performance by tightening geometry control. Sage Laboratories of Natick, Mass., is experimenting with a low-power microwave oven for drying the photoresists used on masks, wafers, substrates, and circuit boards. The chief advantage of the technique is speed—photoresist drying time on an IC mask has been cut from an average of 20 minutes or more to 0.6 to 2.0 seconds, reducing the possibility of resist contamination.

Independent experimenters at Bell Labs, Sylvania Semiconductor, Alpha Industries, Crystalonics, as well as resist makers Shipley and Eastman Kodak, report varied, but favorable, results with the oven.

Addenda

Quadraphonic broadcasting may take a giant step shortly when the FCC receives the report on the results of experimental programing over KIOI-FM, a San Francisco station. The four-channel system used was developed by Quadricast Systems of San Mateo, Calif. . . . Hughes Aircraft Co.'s MOS division in Newport Beach, Calif., has been added to the list of semiconductor manufacturers making low-voltage C/MOS circuits for electronic watches [*Electronics*, Dec. 21, 1970, p. 83]. The division is aiming for threshold voltages between 0.5 and 1 volt, using ion implantation to control the threshold level, and has demonstrated working circuits at 1 volt. The monolithic chips include an oscillator, counter and output drivers for a motor. . . . Texas Instruments has confirmed that it's "in the final negotiation state" with Toyota of Japan for joint development of automotive electronic systems. . . . North American Rockwell Microelectronics Co. is offering limited quantities of what it describes as the first commercially available silicon-on-sapphire memory product. The unit is an array of 5,120 diodes that operates at up to 20 megahertz.

Circle 27 on reader service card


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(And, as always, Freedom has its price.)

Two years ago, Electronic Memories announced its entry into the commercial systems business. Ah, the sweet taste of freedom! Freedom from military specs. Freedom to compete on an all-out free enterprise basis. Freedom to supply the major computer manufacturers with the world's best memory systems for high speed main frame applications.

Freedom for a few months. Then three major customers gave us more than twenty million dollars in commercial systems volume—and effectively took our little freedom ride right off the market.

Now, after many months, these same customers are starting to produce their own systems under our non-exclusive license agreements.

Freedom once more.

But—we are told by management—once again this freedom had better be short lived.

So, here we are. Ready to sell ourselves back into slavery. As initial inducement, here are some systems with almost immediate availability:

Our Nanomemory 2600 has 600 ns cycle time and 300 ns access time. Capacity is from 4K or 8K words by 36 bits to 16K words by 18 bits. Our Nanomemory 3650 has a full cycle time of 650 ns and an access time of 350 ns with maximum modular capacities of 16K x 56, 32K x 40 or 64K x 20. The Nanomemory 4850 has an 850 ns cycle time and a 350 ns access time. Its module capacity ranges from 4K words by 8 bits to 32K words by 20 bits. All systems can be expanded to larger capacities by interconnecting modules.

We could go on to talk about the field replacement benefits that result from our unique plug-in stacks, our low power requirements and our low component count. Or customized core. Or stacks for virtually any digital storage application.

But you may have heard all that the last time we announced our freedom. What you haven't heard are some of our current delivery capabilities. Quoted in days rather than months.

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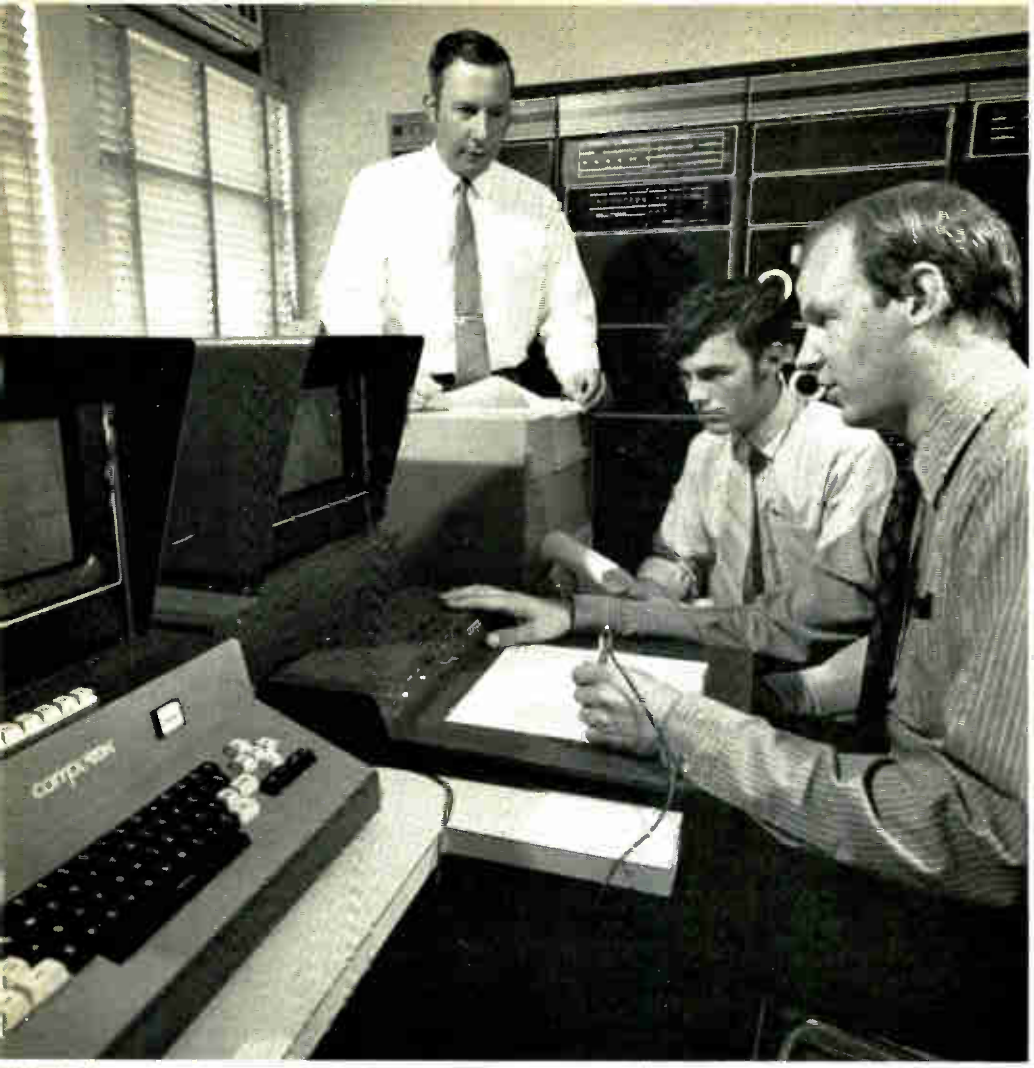

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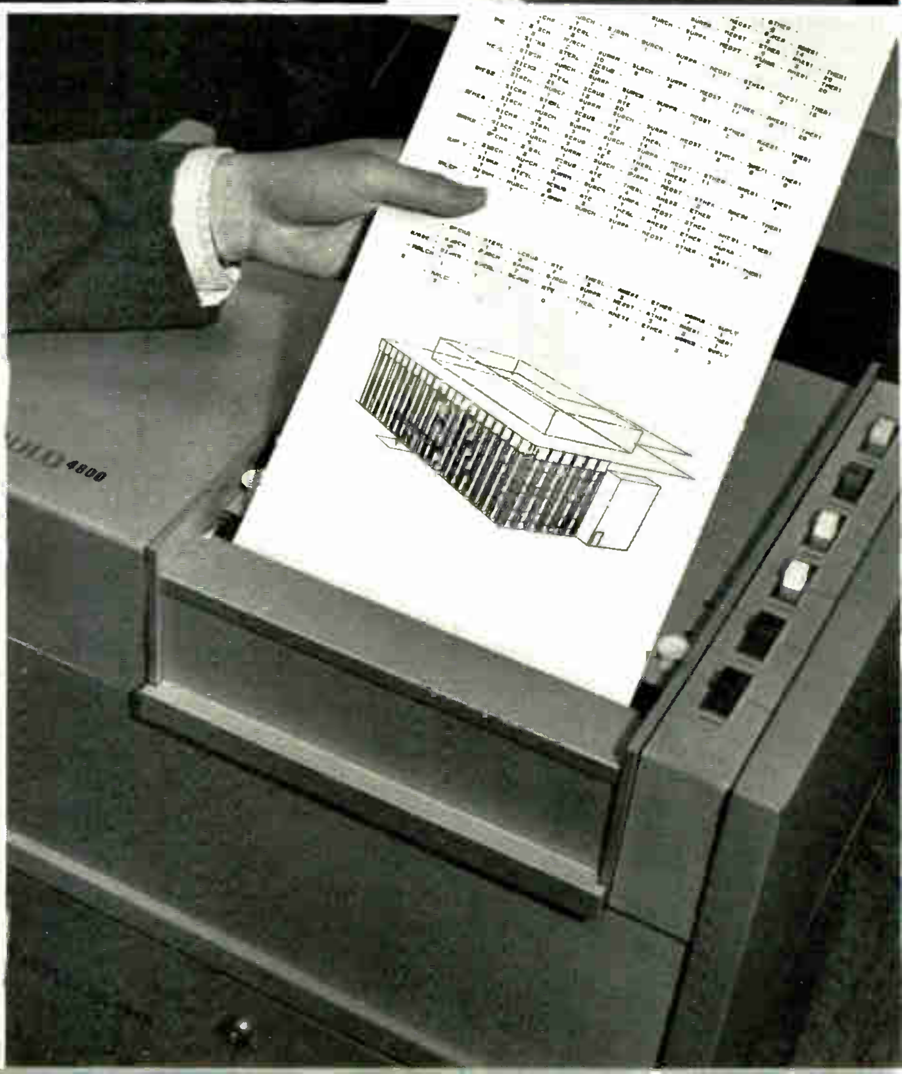

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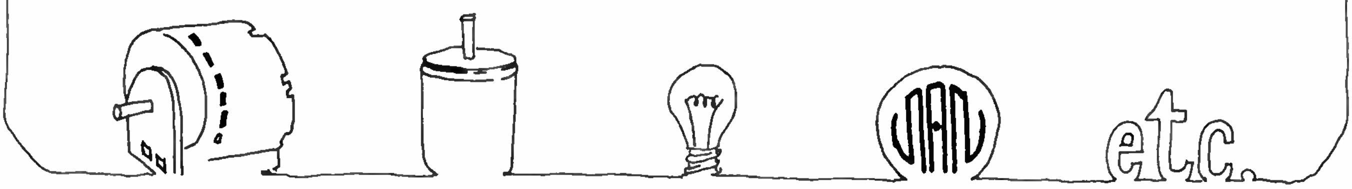

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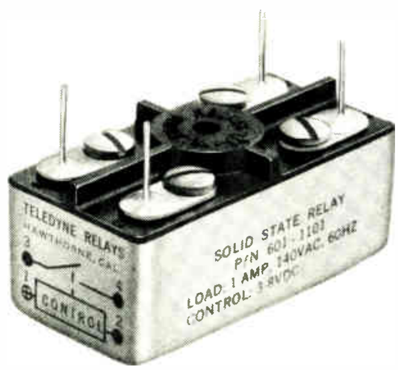

PART NUMBERING (Economy Line)

INPUT (CONTROL) VOLTAGE RANGE	OUTPUT VOLTAGE RATING	OUTPUT (LOAD) CURRENT RATING & PART NUMBERS				
		1 AMP	3 AMP	5 AMP	7 AMP	10 AMP
3-10 VDC	140 VAC	601-1001	601-1002	601-1003	601-1004	601-1005
	280 VAC	601-1006	601-1007	601-1008	601-1009	601-1010
6-32 VDC	140 VAC	601-1011	601-1012	601-1013	601-1014	601-1015
15-45 VAC	280 VAC	601-1016	601-1017	601-1018	601-1019	601-1020
20-75 VDC	140 VAC	601-1021	601-1022	601-1023	601-1024	601-1025
60-140 VAC	280 VAC	601-1026	601-1027	601-1028	601-1029	601-1030
9-15 VAC	140 VAC	601-1031	601-1032	601-1033	601-1034	601-1035
	280 VAC	601-1036	601-1037	601-1038	601-1039	601-1040

NOTE: Add "P" to P/N for printed circuit (pin) mounting only.

ECONOMY LINE PRICE/QUANTITY (Typical)

LOAD	QUANTITY		
Amps @ 140 VAC	10 - 24	100 - 249	1000 - 2499
1	$12.20	$ 8.75	$ 6.65
3	13.50	9.70	7.35
5	15.30	10.60	8.10
7	16.60	11.55	8.80
10	18.45	12.80	9.75

PART NUMBERING (Zero Voltage Turn-On)

INPUT (CONTROL) VOLTAGE RANGE	OUTPUT VOLTAGE RATING	OUTPUT (LOAD) CURRENT RATING & PART NUMBERS				
		1 AMP	3 AMP	5 AMP	7 AMP	10 AMP
3-8 VDC	140 VAC	601-1101	601-1102	601-1103	601-1104	601-1105
	280 VAC	601-1106	601-1107	601-1108	601-1109	601-1110
7-85 VDC	140 VAC	601-1111	601-1112	601-1113	601-1114	601-1115
	280 VAC	601-1116	601-1117	601-1118	601-1119	601-1120
90-280 VAC	140 VAC	601-1121	601-1122	601-1123	601-1124	601-1125
	280 VAC	601-1126	601-1127	601-1128	601-1129	601-1130

ZERO VOLTAGE TURN-ON LINE PRICE/QUANTITY (Typical)

LOAD	QUANTITY		
Amps @ 140 VAC	10 - 24	100 - 249	1000 - 2499
1	$21.60	$15.00	$11.40
3	22.95	15.94	12.11
5	24.30	16.88	12.83
7	25.65	17.81	13.55
10	27.45	19.06	14.50

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MOS technology squeezes its way into surface acoustics

Packaging piezoresistive transistors with other circuitry on a chip costs less than hybrid devices

Surface wave acoustic devices using MOS technology rather than piezoelectric materials have been developed by Texas Instruments engineers working with Southern Methodist University's Electronics Sciences Center. The objective is easier programing, lower cost, and full monolithic integration with drive/control circuitry.

The devices themselves are arrays of long, thin MOS transistors in parallel on a silicon substrate. Signals are coupled into the filter and picked off as required by the transistors. Great versatility is provided by the transistors' gates, which can be turned on in various patterns to form pulse compression filters, tapped delay lines, programable bandpass filters, or decoders for digitally coded signals. The same functions can be achieved with conventional piezoelectric materials, but it would mean expensive hybrid rf construction.

The piezoresistivity of MOS transistors, rather than the piezoelectricity of other surface wave devices, is the key to operation. In the experimental devices, a wedge of piezoelectric glass is used to couple rf signals into the array, but deposited overlay transducers or other approaches probably would be used in production.

In addition to low cost and simple processing, the technique permits gate control circuitry to be integrated on the same chip with the filter. An MOS static shift register could be used to control the filter, for example, with programing instructions tapped into the register. This type of assembly would require no special processing other than the minimal amount needed for the input transducer.

The MOS surface wave acoustic filter presents a few disadvantages, however. It is usable up to 150 megahertz, whereas piezoelectric filters can be used as high as 1 gigahertz. The MOS filter, unlike its piezoelectric counterpart, requires a power supply and has higher insertion loss (technically 50 decibels instead of 30 dB). On the other hand, it does not generate secondary acoustic modes.

The devices were developed by Lewis T. Claiborne, manager of the electronic components branch of TI's Advanced Technology Laboratory; Jack W. Mize, associate professor of electrical engineering at SMU, and Edward Staples.

TI filters wind up in military work

Lewis T. Claiborne's group at Texas Instruments also has developed surface wave filters using more conventional piezoelectric techniques for military projects.

One is a 10.7-megahertz bandpass filter for a pocket-sized, downed-pilot locator incorporated in the PRC-95 field survival radio. The radio is being developed for the Navy on a subcontract from Honeywell. The transponder in the PRC-95 has a 35-mile range. It delivers 20-watt pulses near 1 gigahertz when interrogated by the proper signal from a search plane. The surface wave filter, which uses a quartz substrate, was chosen because its temperature stability is an order of magnitude better than earlier filters; it is small and simple and isn't detuned by strong signals, a problem that plagued earlier L-C filters due to limiting diodes.

The filter has a 3-decibel bandpass of 380 kilohertz and 50-dB adjacent channel rejection at ±1 MHz. Other features of the filter, which measures about 1.5 cm by 0.8 cm, are increased receiver reproducibility, lower insertion loss, wider amplitude and phase response, and greatly reduced cost. The receiver has a 75-dB dynamic range without automatic gain control. The research group experimented with a similar filter in a commercially available quality stereo receiver and claims to have achieved excellent results. TI's components group is producing a small quantity of the transponders for Honeywell and Navy evaluation.

The other project using TI developed surface wave filters is a pulse compression or chip filter for the Rassr developmental phased array radar. Here again, the much lower insertion loss, smaller size, and lower costs spurred the decision to use the surface wave filters.

Claiborne says the surface wave filters are practical over a range of 10 MHz to 1 GHz, with bandwidths of 0.1% to 30%. Insertion loss generally is 6 dB to 15 dB, and amplitude and phase characteristics can be specified within certain limits. He feels that they will find wide use in future production communications and radar systems.

In both these filters, as well as other TI devices such as phase-shift-keying correlators and filters for other applications, TI has concentrated on quartz instead of piezoelectric materials such as lithium niobate.

The reason, says Claiborne, is the desire for rapid development of practical filters that can be used in production. Quartz technology is well developed and Mil Spec materials are readily available from a number of suppliers in many sizes and shapes at low cost. Quartz also provides less electromechanical coupling, permitting less interaction and more stable characteristics with impedance changes. It's also less likely to generate spurious vibration modes.

Memories

Semiconductors program TV color corrector

Semiconductor memories are supposed to revolutionize the computer industry. But, perhaps more significantly, designers of other hardware, who never thought of using any kind of memory at all because of cost or system complexity, are finding the semiconductor versions inviting.

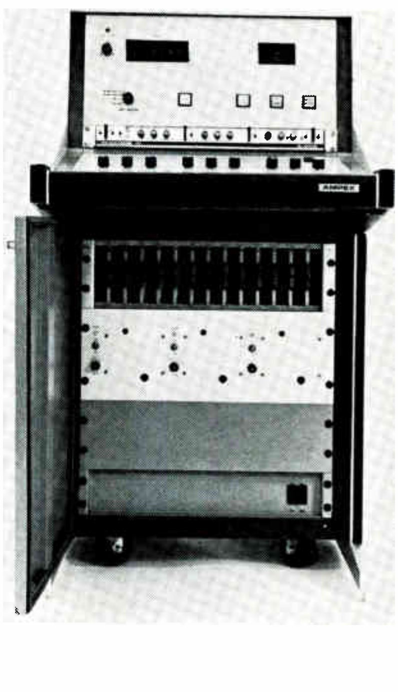
Engineers at the Ampex Corp.'s Special Products division in Redwood City, Calif., for example, were interested in improving on CBS Laboratories' 5500 video-tape color corrector. The system compensates for the color variations caused by unmatched cameras or video tape recorders, or the usual color changes that appear on color film due to processing variations. Its advantage, says Bernard P. Bohunicky, supervisor at the Special Products division, is that with it "we could correct on the air," which is less time-consuming than correcting before the red-green-blue encoding is done. But he and some Ampex customers wanted to correct the signals on master tapes before they went on the air, so that the individual stations would have perfect copies. The answer—a programer for the 5500—required a memory to do the job.

The concept for the programer was fairly straightforward—it would have some means of keeping track of what segment of a film or video tape needed correction and what the correction should be. This information would be stored, and the film or tape would be run through again, except that this time the corrections would be read out from the memory at the proper time for a perfect master tape. The only problem, according to Mark Sanders, the logic design engineer on the project, was what kind of memory to use.

The choice was an Intel 1101 256-bit, fully decoded, static, random access MOS memory. The memory is split into two parts, one for the frame counter and one for the corrections.

"I had five choices," says Sanders. "I could have used a computer to do the storing and controlling, but besides the high cost, this would have meant that the majority of the system would have been bought from the outside (the color corrector itself, which is part of the system, is made by CBS laboratories). Cassettes could have been used, but again, to put together a cassette system would have been expensive." Core memories were also ruled out because of price and because there were no core systems available that had the proper word/bit configuration. About the least expensive memory would have been a punched paper tape system, "but the tape becomes long and somewhat unmanageable for the amount of data that we have to store in the system." The first assembly was delivered earlier this month.

Colorful. Ampex color corrector uses semiconductor memory to correct TV master tapes.



Employment

Jobless form group to help themselves

In the Boston area, where aerospace unemployment is nearing the one-in-five level [*Electronics*, Oct. 26, 1970, p. 46], a new self-help organization is being put together by unemployed scientists and engineers. Called the Economic Action Group, it's headed by Gerald Wallach, a former Itek engineer, and centered in suburban Newton. The group's activities run the gamut from bulk food purchases in an effort to stretch unemployment checks, giving information on the availability of welfare and Food Stamps, to—it's hoped—purchasing group life insurance and medical insurance.

Wallach notes that "we're going to have to bankroll ourselves," even though all potential members are short on funds. But he appears less worried about EAG's financial future than about the morale of the unemployed engineers whom the group seeks to help.

"This has been a very selective recession," he says. "Nearly all the potential members of EAG are middle-class men who retain a strong Protestant ethic, and they now feel like lepers. They are ashamed to

Breeding tigers

"After years of sitting on their tails, the technical organizations are finally doing something," comments a Boston-area engineer. The "something" is a series of three-day workshops for unemployed engineers, sponsored by the IEEE and AIAA, that not only will teach them how to handle their finances while out of work ("Negotiate with your creditors and pay 10% a month . . ."), but make them expert in job interviews ("Don't offer a resume right off the bat, make them ask for it—this gives you a chance to get in again"), and personal selling ("Send letters first on a broadcast basis to the companies that match your likes, then send letters sharply aimed only at those you most would like to work for").

The way the program is set up, the attendee should come out fighting. While the first day is largely devoted to resume writing, how to get bill collectors off one's back, and other general topics, the second two days sound like a combination of psychiatric encounter group sessions and salesmen's pep rallies: "Each class of 150 will break into small groups with individual leaders, and then tear into each other's resumes and interview techniques. They'll feel a little battle-scarred after the second day, but we're hoping for tigers after the third."

be on unemployment, ashamed to be unable to find work, and consequently many of them sit at home in a funk." So he's aiming at getting the depressed engineers and scientists back on the job at the workbench.

"Many of these men once had pet projects that their jobs prevented them from following up," says Wallach. "Now, God knows, they have the time." EAG planners hope to get teams of five to 10 men working in areas like medical electronics, pollution monitoring, and transportation.

Although the group still has to pass the hat, "we have tentative promises of space and equipment from some of the smaller firms in the area," says Wallach. "They can afford to harbor our teams with little risk or overhead, and get high visibility—and maybe new product lines if the teams agree—in exchange."

One thing EAG wants to avoid is what its head calls "WPA work for war; we hope to take the initiative in socially gainful areas of technology." And he adds that EAG teams will ask for government or venture capital support only after they have more or less assured themselves of continuing work in viable sections of technology, "areas less susceptible to defense cuts and more useful to society."

Displays

H-P chases market with $10 LED display

Hewlett-Packard Co. is mounting a major push into the display market now dominated by gas-discharge display tubes. The vehicle is H-P's new light-emitting diode numerics—the 5082-7300 series.

Since they first appeared a few years ago, LED modules have been heirs apparent to digital display tubes. But prices have been high, and application has been limited to military and other jobs where ruggedness or small size rather than low price was the prime requirement. Meanwhile display tubes worth over $10 million a year continued to go into instruments and other high-volume products.

H-P's 7300 numeric is aimed right at this market. "We want to be wherever you see a Nixie tube," says product marketing manager Rick Kniss. The industry commonly says "Nixie" when referring to cold-cathode gas-discharge tubes, though it's a Burroughs Corp. trademark.

In 1,000-unit lots, the 7300 costs $10 a digit and includes a decoder/driver on the same chip as the LEDs. This makes H-P's device the least expensive LED display for its size. Characters are 0.29-inch high.

While the 7300 still costs about twice as much as a tube with its drive circuitry, Kniss feels that $10 is very near the point at which engineers will trade off price for the low-power drain, compactness, and the other LED virtues. Besides, he says, the prices will be dropping. Assuming large orders, 7300 could be selling for as little as $5 within 18 months to two years.

George MacLeod, director of Monsanto Co.'s Electronic Special Products group, thinks prices in the LED industry will fall even faster. He calls $5 a digit a "reachable target" by the end of this year. Monsanto's MAN-1 display, which is roughly the same size as the 7300, sells now for $11 per digit, without decoder/driver.

Aaron Kestenbaum, president of Opcoa of Edison, N.J., says that his company's LED displays could possibly sell for $2 a digit in large quantities. They now sell for $8, without decoder/driver. Unlike H-P and Monsanto, which make diodes from gallium arsenide phosphide, Opcoa uses gallium phosphide, a material of higher efficiency but one that's difficult to handle in production [*Electronics*, Oct. 26, 1970, p. 42].

As for the 7300, it's a hybrid circuit, containing a four-by-seven LED array. On the same substrate as the diodes are a decoder, a driver, and a memory. Package size is 0.55 by 0.39 in.; typical power drain is 380 milliwatts; typical supply current is 75 milliamperes.

Also, by making the decoder/driver an integral part of the numeric, H-P is taking an opposite approach to that of Monsanto's MAN-1, which is just a display. Built-in decoder/driver makes the numerics much easier to use, claims H-P's Kniss. He points out that it takes but four binary-coded-decimal inputs to drive a 7300 numeric. Monsanto's MacLeod, on the other hand, says that customers prefer the freedom of designing their own drive circuits. To illustrate his point, he says he knows a company that has developed a way to operate a MAN-1 display without the standard decoder/driver circuits. He says the 7300 is a very good device, but a bit ahead of its time.

H-P, of course, doesn't think so. Kniss estimates the market for a LED display that can replace tubes at between $20 million and $25 million. To capture this market, says Kniss, H-P spent over $1 million on production equipment. The result is that production of the 7300 is fully automatic from the time it comes out of the reactor till the time its leads are bonded. And "we're working on the lead bonding now," says Kniss.

Production, he predicts, will reach "many thousands of pieces per month" by midsummer. He adds that instrument houses already have committed themselves to using the 7300s in new products. Presumably, some of those houses are H-P divisions.

The company that stands to lose the most if the 7300 is successful is Burroughs. Its Electronic Component division with its Nixies absorbs about 60% of the market for gas-discharge tubes. However, division marketing manager Arthur Chesser professes to be unconcerned: he doesn't think that at $10 apiece the 7300 is price competitive. For displays with many digits, his feelings are much stronger. "Their price is way out of line," he says, pointing to Burroughs' new Panaplex—a multidigit gas-discharge display the price of which, including drive circuitry, averages out to $3 per digit.

Companies

Viatron continues hunt for cash

As sorely beset Viatron Computer Systems sells capital equipment to raise money, the company's future hangs on outcome of two efforts. Says one former employee: "We had almost $3 million worth of MOS production facilities before closedown. Now they're on the block along with everything from desks and typewriters to the pictures on the walls."

As the search for capital goes on, the company is waiting out several events that would improve its cash position. One is final word on its proposed exchange of new stock for outstanding debentures. The other is the start of cash flow from foreign sales on System 21 data-entry consoles. Most former Viatron employees think that overseas sales could be the saving of the firm—if money begins to flow quickly enough. Viatron stopped paying interest on outstanding notes in December—about $500,000 was due then—and both creditors and bondholders could begin legal action as early as February.

One immediate source of anxiety will be lifted from the shoulders of Viatron's new president, Robert Dockser, if the debenture holders take up the company on its offer of 200 new shares for each $1,000 in debenture principal. Legal action from this side would thus be avoided.

Although the final selling price of its United Kingdom manufacturing operations is said to have been about $200,000, plus royalties, Viatron needs more than that. It is estimated that there are parts left for only about three months more production for the income-producing European and Japanese markets. But if Viatron's suppliers are as hard-nosed about new orders as they are about present accounts receivable, Viatron would have to go back to the money markets again—though what it could use as security besides future royalties is uncertain.

The sell-off of equipment began before Dockser became president, apparently at the behest of Exeter International Corp. Exeter lent Viatron almost $500,000 late last summer in exchange for stock and about $1,000 a week in consulting fees.

Only Viatron managers know for sure what's going on, and they aren't talking until the debenture dust settles. The only word from them is that November was a "good" sales month, and January is expected to be one also. But December didn't mark a merry Christmas for Viatron, either in sales or creditor relations.

Computers

Honeywell introduces three small models

Honeywell, the only one of the Big Eight computer manufacturers that did not announce a major new product during 1970, has brought out three small machines. It also confirmed that considerably larger computers will be announced before the end of March [*Electronics*, Jan. 4, p. 39].

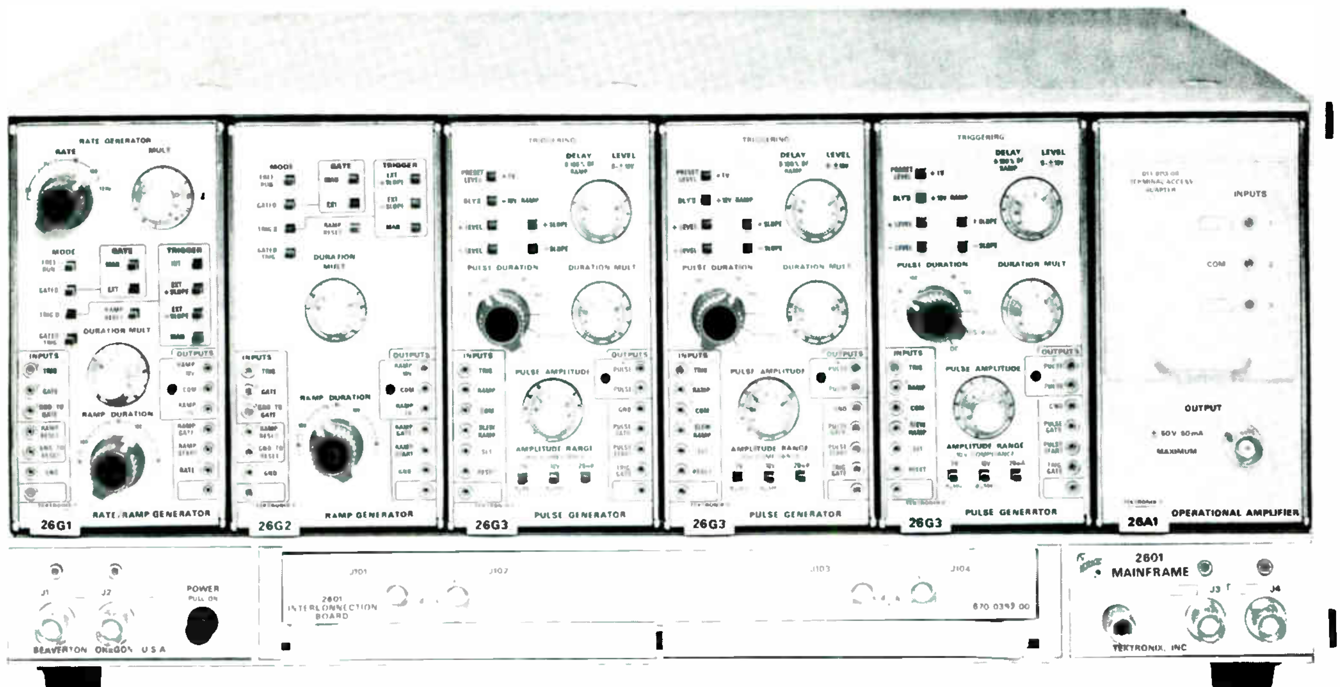
Honeywell Information Systems Inc.'s new 115/2, 1015, and 2015 computers are additions to the company's well established 200 series, which began with the model 200 in 1964 and now comprises 11 machines besides the new models. The latest three are tied rather closely to Honeywell's model 115, announced last year; the four make up a subseries in the 200 line.

The new machines, developed before the GE merger, contain little that is technologically unusual; rather, according to one Honeywell man, they represent an engineering fine tuning of an established design. For example, although the company is known to have a strong interest in the development of MOS memory arrays, they still have the old standby, ferrite cores, in their memories.

While the new machines are the product of a development effort by Honeywell alone, the company has also come up with a marketing plan for the low-cost model 58—which was announced by GE last year and is now a Honeywell product. What's more, the large-scale machines that are about to be announced will be the result of a development program at GE launched well before the merger talks started.

The 115/2 has a basic main memory of 32,768 characters cycling at 2.25 microseconds, three standard input/output channels with automatic interrupt and hard-

you can generate,



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The first modules and mainframes of the 2600 Series generate timing ramps and precise pulses with continuously variable periods from 10 μs to 110 s set by continuously calibrated controls.

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Optional kits and simple modifications adapt the 2600 Series to even more of your applications and an adapter is available for module use in 7000 Series oscilloscope mainframes. This series is compatible with the 601, 602, and 611 Display Monitors.

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the 2600 modular instrument series

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ware multiply and divide instruction; it rents typically for $4,073 per month on a five-year contract.

The 1015 has a basic main memory of 65,536 characters cycling at 1.6 microseconds, 12 standard input/output channels, up to eight of which can operate simultaneously with computation, and a 500-nanosecond control memory; its rent is typically $8,371 per month on a five-year contract.

The 2015 has a basic main memory of 98,304 characters cycling at 1.3 microseconds, 12 standard input/output channels, all of which can operate at once, and a 125-nanosecond control memory, and it typically rents for $12,791 per month on a five-year contract.

Lasers

Power waste cut by double modulation

A great deal of power is required to modulate lasers at high bit rates and it often yields more energy than necessary. Engineers at RCA's Advanced Technology Lab in Camden, N.J., have developed a technique that allows them to extract from the laser cavity only the energy they intend to transmit, a technique they've labeled "double modulation." They are presently pulsing a neodymium yttrium aluminum garnet (NdYAG) laser at 300 megabits per second, and plan to increase that to 500 megabits, the maximum rate the laser can withstand. With optical multiplexing, say the RCA researchers, several laser beams can be combined to yield gigabit-per-second rates.

Using an order of magnitude less power than external modulation schemes, double modulation impresses 100 picosecond pulses every few nanoseconds on the laser beam. This is accomplished by electro-optically modulating a KDP crystal located inside the cavity. The crystal mode locks the laser beam and generates the short pulses so they are in phase with the mode-locked beam. "The pulses actually run back and forth inside the laser," says Donald Herzog, leader of the laser group at the Advanced Technology Lab.

For transmission, the desired pulses are extracted by a lithium niobate crystal also inside the cavity. According to Herzog, it's this that insures extraction of only the energy used. The cavity's response is on the order of 1 megahertz, allowing the energy to be stored for as long as 1 microsecond. "Since there is a modulated pulse for every pulse out of the cavity," says Herzog, "this leads to a natural binary system."

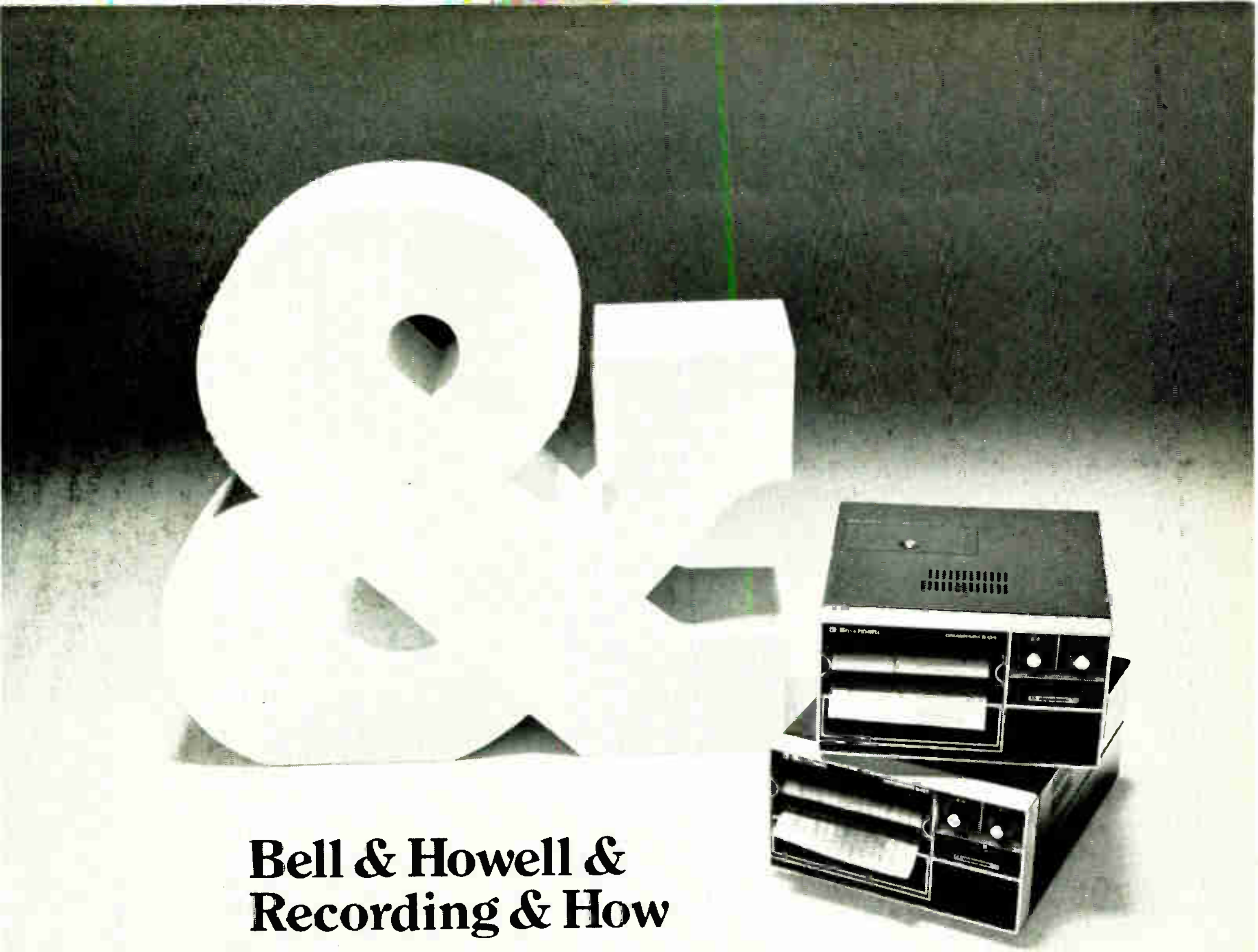
Intended for space communication, the laser with internal modulation requires only a few watts of input power, rather than the hundreds of watts needed for external modulation. In the field, the system will require dynamic gating, but in the lab, RCA engineers don't use any gating—they merely turn the receiver on at the appropriate time to reduce the effects of background noise. The receiver features a planar photodiode detector.

Military electronics

Computer, laser eyed for Army's main tank

A major upgrading of the Army's fleet of 900 M60A tanks may be in the cards if tests of a new fire control computer scheduled to begin in August pan out. For if the computer—made by Hughes Aircraft Co., Culver City, Calif.—passes, it will replace the electromechanical fire control units in the Army's largest tank. And since the hybrid computer is designed to interface with the ruby laser rangefinder developed for another version of the M-60, Army sources say chances are good that laser units will replace the tank's optical rangefinders.

Ira Goldberg, program manager for the fire control system at the Army's Frankford Arsenal, says size and reliability were the major reasons the Army was looking to replace the electromechanical M-16



Bell & Howell & Recording & How

It's done with oscillographs. We have a bunch, but let's talk about these two. They can handle on-line or off-line test and measurement of any physical happening you might have in mind. From pulse flutters during surgery to whether or not you're refining that crude the same way today as last year.

The one on the bottom is the 5-134. It does everything but talk. It writes to 25,000 Hz. (But with all that speed, it has a data accuracy to ±½%.) And can flip into any one of 10 different servo-controlled speeds.

It's modular, of course, with special refinements. Like the timer, servo control board and galvo all plug in. Individual input connectors as standard. An extremely quiet operation. That type of thing.

Here's a couple more exclusives. You don't have to write out timing line rates. With us, that's taken care of automatically. With a timing ID marked on the edge of the paper. Not only that, the rate can be manually selected or can be automatically synced with paper speed.

And it's got a "jog" feature that allows you to move the paper short distances for initial set up—one hold-down button for on/off.

The smaller box is the 5-135. It weighs in at 35 pounds (a real portable) as compared to the other's 50 pounds. Both boxes share pretty much the same components. It's just that the 5-135 has broader application by more industries across the board because it's not quite so fancy (9 channels versus the 5-134's 18, for instance). Even though it's smaller, it doesn't skimp on performance. It has the largest range of input power options of anybody going. And all that at a lot less money. Not bad, huh?

And one more thing. Just in case you're building a system, we've got a range of other new goodies to complement these graphs: 1-172 amplifier, 8-114 bridge excitation/signal conditioner and the 23-111 paper processor.

If anything here piques your curiosity, you can get the full package of specs by writing Bell & Howell, Instruments Division, 360 Sierra Madre Villa, Pasadena, California 91109.

INSTRUMENTS DIVISION

BELL & HOWELL

Electronics review

ballistic computer manufactured by Otis Elevator Co., New York. Reliability of the M-16 was degraded by moisture, Goldberg says. "The troops out in the field don't take very good care of equipment. They wash the mud off the tanks with high-pressure hoses. And moisture has always been a major problem with electromechanical equipment."

The all-electronic XM-21 Hughes is developing under a $15 million contract will get around this problem by being hermetically sealed and filled with nitrogen. "It's also a much smaller unit," Goldberg adds. Higher sophistication is another plus, says Howard W. Boehmer, manager of Hughes' Data Systems divisions. He says it will enable a tank commander to markedly increase the first-round hit capability of the tank's 105-mm gun and to make an instant selection from among the various types of ammunition used by the tank. The XM-21 also will have extensive self-test capabilities. Six of the largely analog computers are to be delivered for the August tests, which should be completed by the summer of 1972.

Medical electronics

Implanted power pack speeds bone healing

First documentation that a small, steady electric current passed through a bone fracture accelerates healing has turned up in a study sponsored by the Office of Naval Research. What's more, by developing a small, skin-implanted power pack, the ONR project also resolved the problem of delivering a constant current to the bone despite steadily increasing tissue resistance. Sealed in an acrylic plastic, the dime-sized package contains a battery, field effect transistors, and resistors that can compensate for tissue resistance; it can deliver a steady 0.01-ampere current to the bone, the Navy says.

The study was conducted by University of Pennsylvania Medical School researchers in conjunction with the Philadelphia Naval Hospital under an ONR contract. In experiments with animals, researchers found fractured leg bones subjected to the current "healed solidly within 18 days" while similar fractures required a much longer time to heal naturally. An ONR official says it is not possible to pinpoint the exact advantage over natural healing rates due to variations in body metabolism, calcium content of bones, and severity of fractures.

Current research may lead to miniaturized power packs implanted entirely under the skin in cases of bone nonunion, a congenital human defect where two ends of the bone have failed to join. The condition normally is corrected by graft surgery. The Philadelphia researchers also are experimenting with variations in electrode placement; they now secure the negative lead directly across the fracture and position the positive electrode nearby.

Industrial electronics

Foxboro to make its own computer

The Foxboro Co., manufacturer of process control instrumentation and systems, is taking the unusual step of building, rather than buying, the digital computer that's at the core of its recently announced process control system, FOX 1. Priced upwards of $150,000, the system also provides the operator with a cathode ray tube console which displays both alphanumerics and graphics. This is also fabricated largely by Foxboro.

Generally, the so-called old-line process control houses like Foxboro, as well as companies such as Leeds and Northrup, have relied on commercially available digital processors.

The company decided to build its own machine, in the class of a General Electric 4020, for two reasons: it considered available machines not reliable enough, and it wanted to have more control over the computer technology going into

its systems. Foxboro has relied on PDP-8 series minicomputers supplied by Digital Equipment Corp. of Maynard, Mass., in, for example, its smaller PCP-88 process control systems. The relationship between the two companies could apparently be smoother. "Every time DEC makes a move to a new computer, everyone rolls around over here, worrying about the effect it will have on our systems," admits a Foxboro executive.

Another greater advantage in designing its own computer—done jointly with GTE Sylvania of Needham, Mass.—was the chance it gave to make tradeoffs between software and hardware as the design progressed, says N. Douglas Payne, manager, computer systems development. To aim the system as much as possible to the needs of the user, Payne says, the software design began even before any attention was paid to hardware.

Instrumentation

Programs in a hurry for automatic testers

Writing programs for computer-controlled testers can take weeks, even months. Engineers at the Vought Aeronautics Co. in Dallas say they can cut the time to a week or less. Their secret is Lasar (Logic Automated Stimulus and Response). This software package analyzes a digital network of almost any complexity, and then turns out the needed test program and fault isolation routine. In addition, Lasar can simulate networks from their schematics, allowing design errors to be caught before prototypes are built.

Developed for the Naval Air Systems Command, Lasar is now being offered commercially. A designer mails schematics of the device to be tested, along with a description of the input format demanded by his test system, to Vought, a division of LTV Aerospace. A week or so later, back come the programs, ready to run. The price varies according to the size and complexity of the network, but is in the $1,000-and-up neighborhood.

Time isn't the only thing saved. Junius Thomas, a senior design engineer at Vought and a Lasar developer, estimates the typical charge for Lasar's preparation of a program to be one-tenth the cost in man-hours for an engineer.

Lasar is the only package, says Thomas, that can automatically handle sequential, as well as combinatorial, logic. That is, Lasar can write programs for circuits with flip-flops and other devices, whose output depends not only on the input they're receiving but also on the information they're storing. "Sequential logic is in 95% of all networks built," states Thomas. Lasar has no trouble with large networks either; it can write programs for circuits having up to 4,000 modes, which is equivalent to 300 flip-flops.

The resolution is high. Lasar-made programs will detect 95% of all detectable failures.

The first step in using Lasar is to model the circuit on punched cards. This can be done in a few hours. Lasar itself is made up of five subprograms—Input, Stimulus Generation, Simulation, Fault Isolation, and Test Program Generation. The model cards are processed by Input, whose main job is to turn the components in the network to be tested into their nand-gate equivalents.

Optoelectronics

Radars used to gang up on hail

Hailstorms, a major agricultural hazard throughout recorded history, soon will come under the scrutiny of a radar now in development at the University of Chicago. The $1-million-plus project is being funded by the National Science Foundation and the Illinois State Water Survey, and is managed by the National Center for Atmospheric Research at Boulder, Colo.

The radar will distinguish hail

from rain and snow by reading hail's differential radar backscatter when illuminated by signals of different frequencies. This difference may be as much as 15 decibels greater for S band than for X band, depending on size of the stones.

The radar will actually be a synchronous system of two radars, one operating in S band, the other in X band, along with a signal processor to normalize and compare their outputs. One is a 3.2-centimeter radar, the M-33 scavenged from the obsolete Nike-Ajax system, and the other is a modified AN/FPS-18 with a new, 28-foot parabolic dish antenna. The antenna is being built by Radiation Systems of McLean, Va., and will have −27 dB first sidelobes at its 10.7-cm operating wavelength.

The signal processor, being made by Control Data Corp.'s Rosemont Laboratories in Pennsylvania, includes a digital preprocessor, a digital doppler analyzer with the equivalent of 500 contiguous filters, and a velocity resolution of 0.1 meter per second for detection of turbulent regions within a storm center, as well as hail-detection circuitry. To further aid discrimination between weather patterns, the processor will take advantage of rain's much stronger backscatter at 3 cm than at 10 cm. First system tests are slated for early summer at ISWS' Urbana, Ill., headquarters, to be followed later in the year by more extensive runs at Boulder.

For the record

Shark shocker. A self-contained electric dart which can paralyze or kill sharks, depending on their size and species, has been invented for the survival kits of naval aviators downed at sea. The dart, which delivers a 30-volt jolt as it penetrates the fleshy part of the shark, consists of a 4-inch, insulated blade attached to a small casing which houses a battery and simple electronic circuitry. As the blade's metal tip penetrates the fish, a switch is thrown which completes the circuit from tip, through shark and sea water, to the second electrode located at the base of the casing. Paralysis is instantaneous, and the shark sinks to the bottom.

Concern spurs sales. As a result of rising concern in Government over mercury contamination of waterways and seafood, sales of equipment for detecting pollution by the metal "have probably doubled in the past few months," says a Westinghouse electric engineer. To meet the demand, Westinghouse's Electronic Tube division at Elmira, N.Y., has come up with a modified hollow cathode line source for use by manufacturers of atomic absorption spectroscopy systems that detect the presence of mercury.

The new line source, designated WL-22847A and priced at about $115 from stock, "provides superior stability of operation with low noise," says Westinghouse. This makes it possible "to establish the presence of mercury down to the 10^{-10} gram level."

Late odds. Systems designers say they were just being "specially cautious" in postponing for at least a week the opening of legalized off-track betting in New York City. It was scheduled for Jan. 11. They want absolutely no technical problems to crop up when the betting begins [*Electronics*, Jan. 4, p. 79]. Therefore, they got more time to carry out the final test and debugging phase of their installation program, says Barry Mindes, vice president of engineering at the New York City Off-Track Betting Corp. The hardware and software themselves present "no inherent problems whatever," he asserts.

Control. Fisher Controls Co. of Marshalltown, Iowa, is about to introduce a digital process control system called dc^2. Using an Interdata minicomputer, the system complements an analog system, ac^2, introduced about a year ago.

Intelsat 4 delayed. Launch of the powerful Intelsat 4 radio relay satellite has been postponed until investigators pinpoint the cause of last November's loss of an orbiting observatory. Engineers believe that explosive bolts used to jettison a protective nose cone did not operate normally. Intelsat has a similar system.

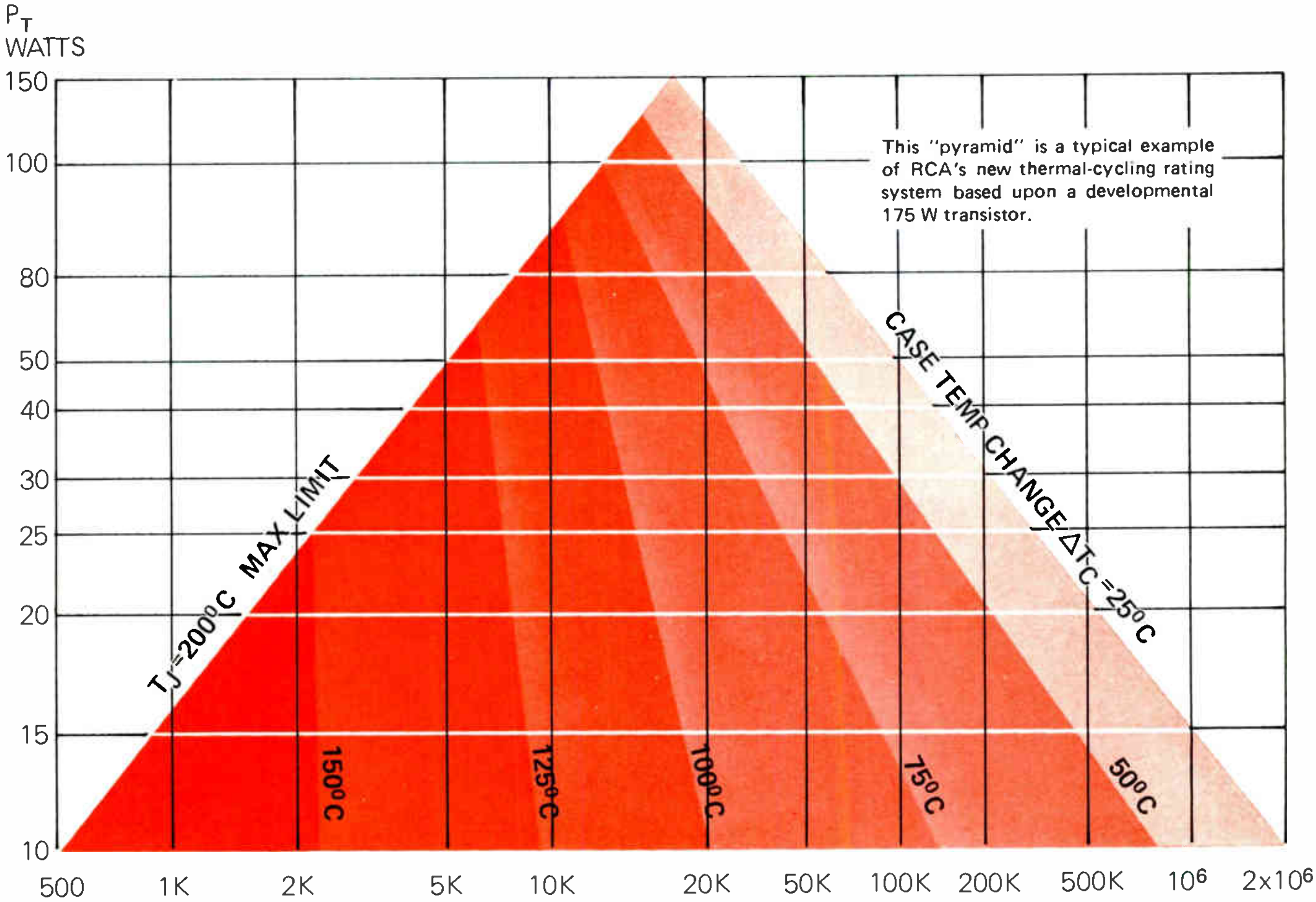
The $18 million communications satellite, however, can be readied within 11 days, and NASA officials hope to schedule the mission before the Jan. 27 launch date of NATO-B, another communications satellite, or the Jan. 31 Apollo 14 moon mission liftoff.

ATC display. Raytheon has won a Federal Aviation Administration contract for up to $463,438 for the installation and checkout of a computer display channel, plus associated radar displays, at FAA's National Aviation Facilities Experimental Center (NAFEC). The equipment, previously purchased from Raytheon as part of a $64 million contract for 16 such systems, will supply air traffic controllers with such information as the identity and altitude of controlled enroute traffic directly on the face of the radar scope. The complete automation system that the FAA is assembling at NAFEC near Atlantic City, N.J., will develop and improve automated air traffic control techniques. At its core are two IBM computer complexes.

Cooperation. The U.S. and U.S.S.R. are getting their heads together in Moscow for discussions on expanded cooperation in space research. Heading the six-man U.S. delegation is George M. Low, acting NASA administrator. Spokesman for the Soviets is M.V. Keldysh, president of the Academy of Sciences of the U.S.S.R. Under discussion is scientific research by satellites in such areas as meteorology, biology, and medicine.

Another opening. SEMI, the Semiconductor Equipment and Materials Institute, has scheduled its first show for May 25-27 in San Mateo, Calif. It will be watched for its effect on the IEEE and Wescon.

RCA Announces the Industry's First Power Transistor Thermal-Cycling Ratings.



The Rating "Pyramid"–built with the help of RCA's Controlled Solder Process.

RCA, the industry leader in over-all silicon resources, introduces a totally new concept in thermal-cycling ratings to help you establish and extend equipment life.

Using these new thermal-cycling ratings, you can tell at a glance the life expectancy of any given RCA power transistor in terms of number of cycles, power dissipation, and case temperature change. A rating chart is being developed for each family of RCA power transistors, and will be included in data sheets as they are completed. RCA's Controlled Solder Process (CSP) has made possible these ratings – the only such ratings in the industry.

Controlled Solder Process is an RCA development. With it, RCA can control the effects of thermal stress between the pellet and mounting base, and thereby extend the number of times a transistor can be cycled thermally. CSP increases the device thermal-cycling capability from five to 20 times. The RCA "pyramid" is the only rating chart yet devised to help you avoid thermal-fatigue failure in the field.

This announcement of thermal-cycling ratings on power transistors is made in the same spirit as RCA's pioneering disclosure in 1964 on Second Breakdown capability. The philosophy, simply, is to continue to provide power transistor users with the best possible tools to achieve the optimum interface between the capabilities of RCA devices and the needs of their applications.

For more information on RCA's new thermal-cycling ratings, consult your local RCA Representative or your RCA Distributor or write:
RCA, Commercial Engineering, Section 70A-18/UT 16, Harrison, N.J. 07029.
International: RCA, 2-4 rue du Lièvre, 1227 Geneva, Switzerland, or P.O. Box 112, Hong Kong.

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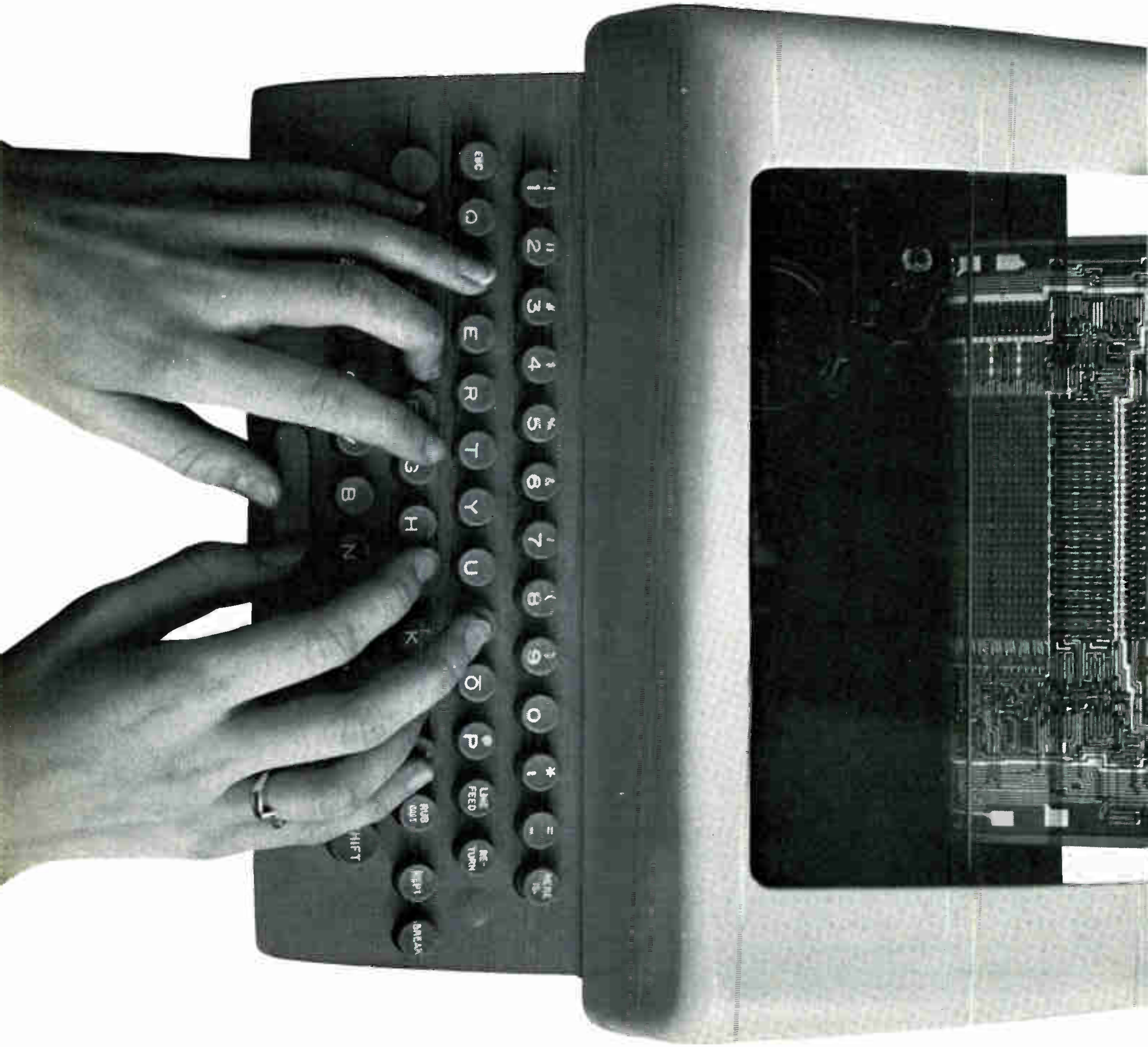
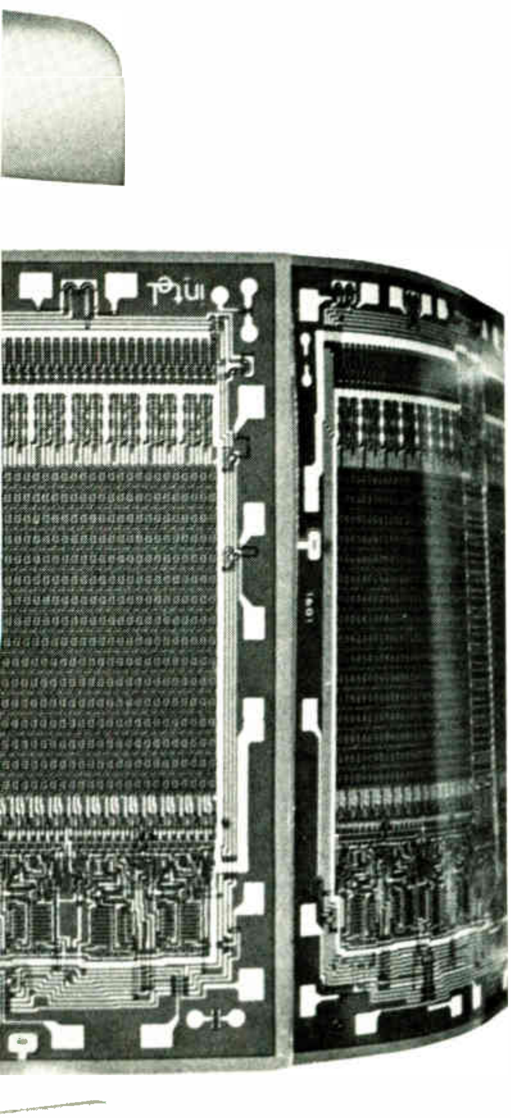


ncing MOS ROM!



Introducing Type 1601, a 2048-bit monolithic MOS ROM that Intel will ship within 24 hours after receiving your custom programming instructions.

Only Intel can deliver MOS ROM's so quickly because only Intel has developed a MOS ROM that's programmed electrically instead of with a mask.

To get custom ROM's fast, you simply transmit to us a teletypewriter tape containing your program instructions. We load the tape in a simple programmer, insert finished 1601's from stock, and push a button to enter your program.

When you're ready for large quantites and want to cut costs, Intel will give you mask-made ROM's, Type 1301, that are operationally identical and plug compatible with your 1601's.

Programming is available at Intel and at many of our distributors and representatives in the U.S., Europe and Japan. Or you can do it yourself with an Intel programmer that costs about $5,000.

Intel 1601's and 1301's are fully decoded, packaged in a 24-lead DIP and interface directly with DTL/TTL logic. Decoded dynamically, they have an access time of 750 nsecs and power dissipation of 0.1 mW/bit. With static decoding, access time is 1 μsec and dissipation is ¼ mW/bit.

Programmed 1601's cost about 3¢ per bit in small quantities. Fixed programmed 1301's cost about 1¢ per bit in quantities of 1000.

For immediate U.S. delivery of Type 1601 programmed for EBCDIC to 8/ASCII-8, phone your local Intel distributor, Cramer Electronics or Hamilton Electro Sales. If your distributor isn't stocked, just call us collect at (415) 961-8080 for same-day shipment.

In Europe contact Intel at Avenue Louise 216, B 1050 Bruxelles, Belgium. Phone 492003. In Japan contact Nippon IC, Inc., Parkside Flat Bldg., No. 4-2-2, Sendagaya, Shibuya Ku, Tokyo 151. Phone 03-403-4747.

Intel Corporation is in high-volume production at 365 Middlefield Rd., Mountain View, California 94040.

intel™ delivers.

Circle 47 on reader service card

Treat yourself to an electronic peripheral package that offers the application simplicity of punched tape with the performance and convenience of "snap-in" magnetic tape cassettes

Philips Professional Cassette system

The inaugurators of the famous Compact Cassette system have pleasure in announcing that a fully-fledged Professional Cassette System, based on the original concepts is now available.

Consisting of a synchronous bi-directional cassette deck and Professional Cassette, the system complies with ECMA standards for the inter-change of digital data on tape cassettes.

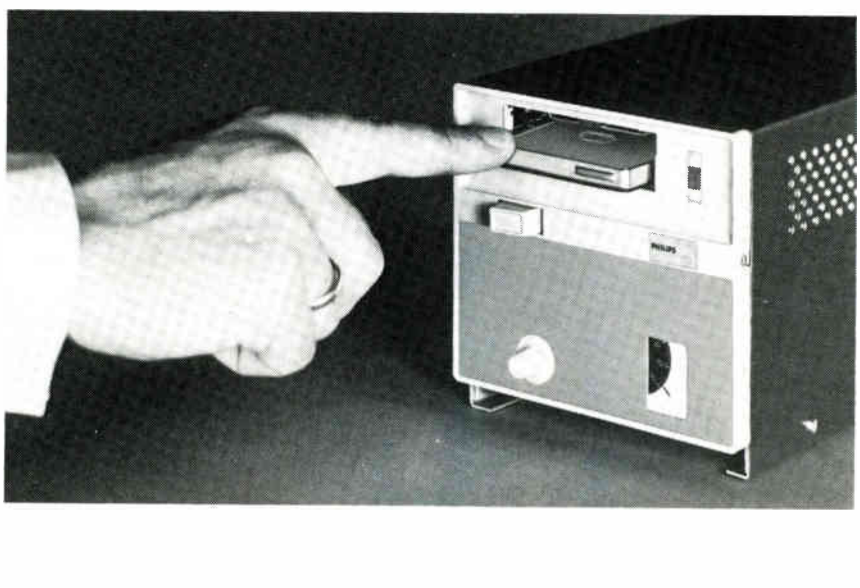
The Professional Cassette is a logical development of the domestic unit and whilst retaining the same dimensions, features completely new materials and a precision of finish to meet the exacting specifications of professional use. It includes a sturdy metal frame to ensure maximum long term stability and to eliminate electro-static build-up.

A highly accurate, friction-free system of tape guides and close tolerance cassette positioning spigots form part of this single frame.

Two holes at the rear of the cassette provide for write enable and, when closed with replaceable plugs, ensure that recorded data is guarded against accidental erasure. A third hole, also at the rear of the cassette, off-set from the cassette centre line, provides track discrimination.

Reliable read after write and bi-directional read operation, is assured by an accurately tensioned, extra-wide pressure pad, which together with full mu-metal screening guarantees clean, close tolerance data handling. The cassette contains 282ft of tape certified for digital data handling.

The cassette deck has been designed with all the features deemed desirable for this particular type of peripheral equipment. It's available as a mechanical tape drive, less electronics, or as a complete digital recorder with function logic and read/write electronics.



The unit is standard for single track bit serial recording at 800 bpi in the P.E. (phase encoding) mode as per ECMA proposed standard.

As the recording method (P.E.) is self-clocking, synchronisation presents no problems. Skew effects are eliminated with the single track recording. The unit is completely electronically controlled and features a "select" function, enabling "unit select" operation in a system of up to four decks. Four decks fit snugly side-by-side in a standard 19" rack. Cassette loading is reduced to just a simple matter of putting the cassette in a slot, the deck automatically takes care of guiding and positioning.

A signal lamp on the deck front panel serves to indicate when lit that a cassette is in position and the deck has been "selected". Percentage of tape used is indicated by an accurate counter, also mounted on the front panel.

Functional specification

Where applicable the system has been designed to meet the ANSI, ECMA and ISO proposed standards' requirements.

The Philips Professional Cassette for digital application, stores a

maximum of over five million bits when recorded at 800 bpi.
The Philips Professional Cassette Deck for digital applications has the following specifications:

Speed: $3^{3}/_{4}$ — $7^{1}/_{2}$ ips ($\pm$ 1%) bi-directional, capstan control.
Short term average bit spacing: $\pm$ 2% of bitcell time.
Rewind speed:
40 sec. for 282ft of tape.
Start time till short term average bit spacing: 15 ms.
Stop time till stand still: 20 ms.
Recording mode: single track half width phase encoding.

Read after write facility with 0.15 inch distance between read and write gap.
Data format:
bit serial, character serial, P.E. recording.
Inter block gap 0.7".
Variable record length.
Bit density 800 bpi (1600 fci).
Data transfer rate:
750 characters per sec.
Operating voltage:
24 V d.c. ($\pm$ 10%).
Electronics:
DTL/T^2L compatible.
Dimensions of the mechanical deck:
front cover: 4.4 x 5 inches.
depth: 7 inches.
Weight of the mechanical deck:
5 lbs.
Operating conditions:
Temperature range: 40-110° F.
Humidity range:
10 - 90% non condensing.

Delivery starts in 1971.

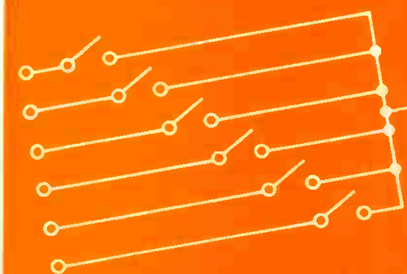
PHILIPS

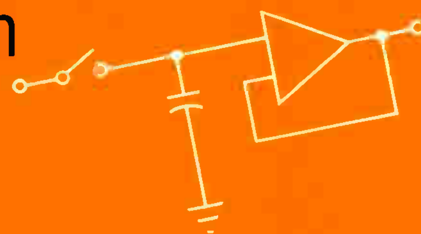
For further details:
N.V. Philips Gloeilampenfabrieken, ELA Digital Recording Division, Eindhoven, The Netherlands.

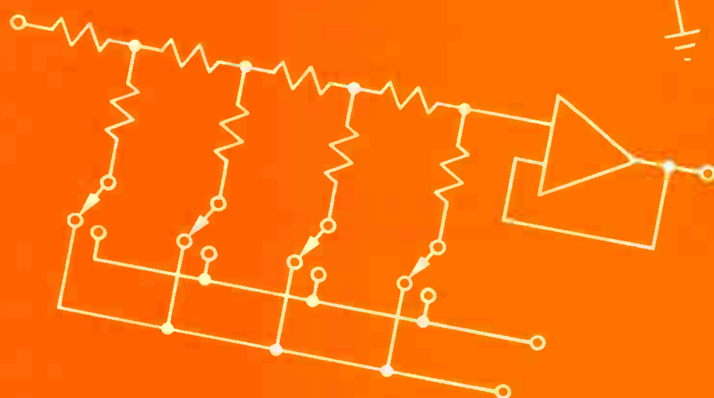
PHILIPS

Circle 49 on reader service card

Monolithic analog switching circuits so cheap you deserve an explanation







There are many reasons. Broad experience in monolithic FET and bipolar circuitry. High reliability (military) experience. Low cost packaging. High yield. Automatic assembly.

Together they explain why only Siliconix can bring you a full line of monolithic analog switching circuits at discrete component prices.

Our 100 piece prices for driver + switch are $3/switch function while quantity prices drop below $2.

The BK line includes 4 and 6 channel MOS switches; 4 and 6 channel switch drivers (4 channel with decode); 2xSPST, 4xSPST, SPDT and DPDT MOS switches with drivers; and 2xSPST and SPDT JFET switches with drivers.

So: whatever your application—multi-channel analog switching, sample and hold, or D/A conversion—we have the low cost monolithic device for you. They're all dual in-line hermetic packages specified over −20 to +85°C range.

For more information on our BK series call any Siliconix sales office.

New York: Sy Levine (516) 796-4680 **New England:** Al La Croix (617) 769-3780 **St. Louis:** Jim Spicer (314) 291-3616 **Minneapolis:** Ed Koelfgen (612) 920-4483 **Southern California:** Dave Ferran (213) 420-1307 **Northern California:** Chuck Brush (408) 246-8000 **In Europe:** Siliconix Limited, Saunders Way, Sketty, Swansea, Great Britain. Siliconix GmbH, 7024 Bernhausen, Postfach 1340, W. Germany. Siliconix 9, Ave d'Arromanches, 94-Saint-Maur, France.

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Washington Newsletter

January 18, 1971

Lockheed unlikely to profit even on S-3A ASW . . .

Lockheed Aircraft Corp. is moving rapidly toward a no-profit position on its $397 million fixed-price incentive development contract for six prototypes of the Navy's S-3A anti-submarine warfare plane. The admission that rising costs could perhaps wipe out Lockheed's 12% profit comes from Lockheed Aircraft chairman Daniel Haughton and S-3A project manager, Capt. Fred Baughman, and confirms a last year's report [*Electronics*, July 6, 1970, p. 33].

The situation had been overlooked in the controversy surrounding the company's claims that the Pentagon reimburse it for overrun costs in other areas: the Air Force's controversial C-5 supertransport; Navy ship programs; the propulsion system for the Air Force Short-Range Attack Missile (SRAM), on which Boeing is prime; and the cancelled Army contract for the AH-56 Cheyenne helicopter. Lockheed has agreed to settle on Deputy Defense Secretary David Packard's terms for the SRAM and Cheyenne programs, but will negotiate the ship settlement and take the biggest, costliest C-5 program to litigation.

. . . possibly because of technology

The reason for the rising S-3A costs may be that Lockheed is running into technological problems with the plane, the most viable of its military aircraft. For when asked about its technological progress, Lockheed chairman Haughton replied, "We've met all the milestones to date." Then he added, "What I mean is that we've met all the major milestones," with emphasis on the "major." He declined further elaboration on the ground that he did not have S-3A program information at hand.

On such profit as might still be extracted from the program, the Navy's Baughman says anything above the $397 million target but under the 130% ceiling will be split 70-30 between the Government and Lockheed, respectively. On reaching the ceiling, Lockheed's profit would be nil.

Navy to benefit most from DDR&E budget boost

The $800 million increase requested for fiscal 1972 by the Directorate of Defense Research and Engineering has cleared the Defense Secretary's office with most of John Foster's "initiatives" projects intact [*Electronics*, Jan. 4, p. 33]. Though they must now survive pruning by the Office of Management and Budget and the President himself, DDR&E sources believe the Navy will emerge as a major beneficiary of the funding increases. The reason: DOD will use Nixon's doctrine of a "low profile" for U.S. forces abroad as the rationale for insuring the Navy's control of the oceans in the face of a Soviet naval buildup. Without assured ocean control to guarantee the passage of weapons, the argument goes, the U.S. has less justification for going to the aid of its allies. As a consequence, anti-submarine warfare programs, among other Navy efforts, will get fresh money, say these sources.

DDR&E's Foster may be succeeded by Rechtin

Confirmation of Eberhardt Rechtin, 44-year-old chief of the Advanced Research Projects Agency, in his position as principal deputy to John Foster in the Directorate of Defense Research and Engineering looks to be another step in his grooming as Foster's successor. Foster is expected to be named to a less controversial policy and administrative

DOD post—Secretary of the Army has been mentioned—before spring.

In the principal deputy's role, Rechtin could profoundly influence the defense establishment. He will have prime responsibility for pushing Foster's R&D "initiatives" programs, most of which consist of adaptations of existing technology and of advanced development projects originated in ARPA.

Most visible of Rechtin's R&D interests are the development of the weapons potential of high-power lasers, improving surface-to-surface missile guidance and navigation to reduce targeting error to nearly zero, upgrading small arms to increase the firepower of foot soldiers, and making air-cushion vehicles effective in the Arctic.

Another of Rechtin's favorite areas is "crisis management systems." He's therefore expected to have an impact on programs for consolidating and then expanding the scattered DOD computerized systems which direct command, control, communications and intelligence functions.

OTP dooms vhf Aerosat

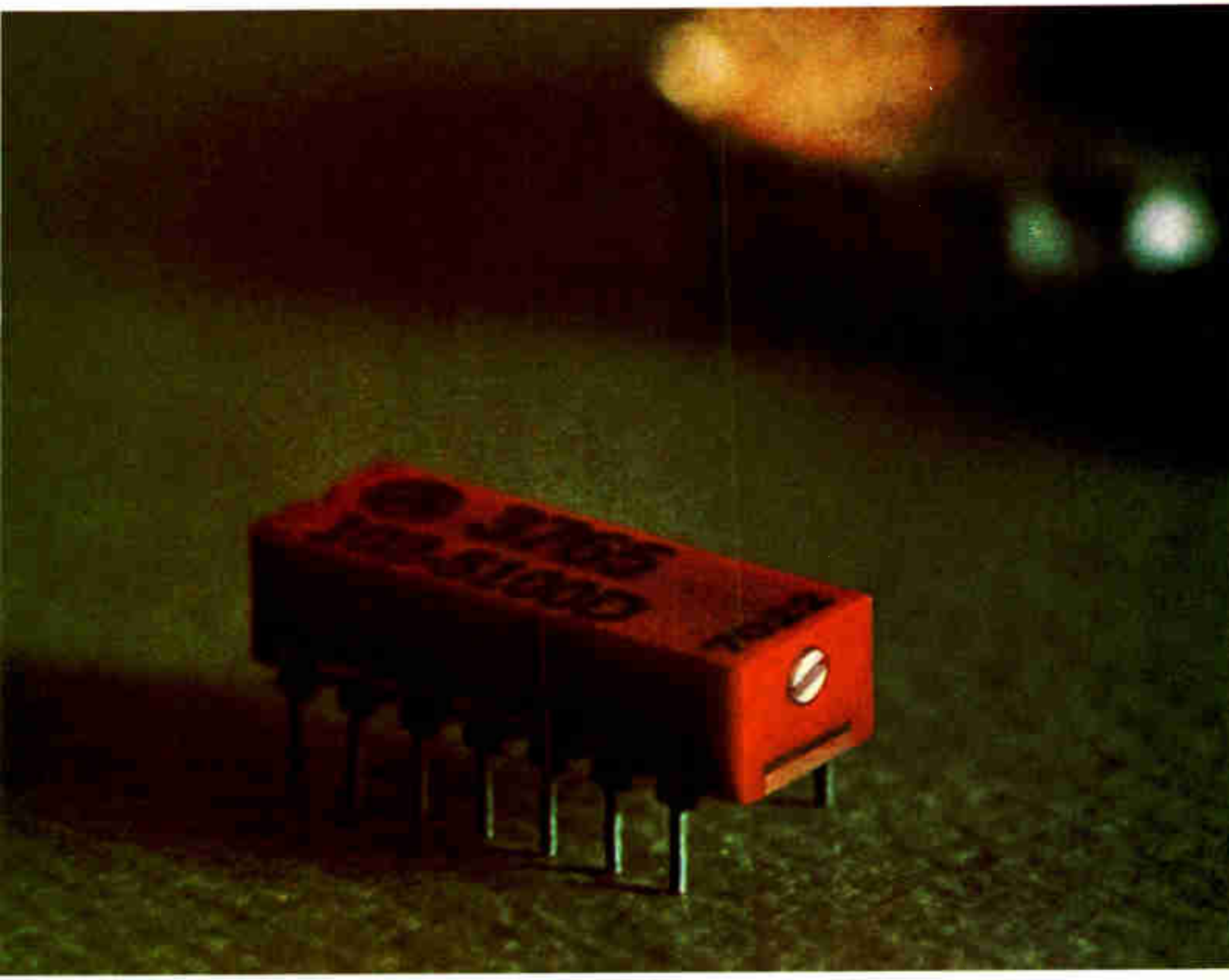
The airline industry is reeling from the White House Office of Telecommunication Policy's decision to back uhf satellites for transoceanic communications. The move, which dooms the industry's five-year development of a vhf specification and forces the development of an uhf specification, came after seven major electronics firms told OTP they could build uhf sets in time for the launch of a leased satellite over the Pacific in 1973.

One OTP source notes, however, that TRW, Hughes Aircraft, Philco-Ford, RCA, GE, Bendix and Collins Radio specified that orders would have to be placed this year if the sets are to be ready for the pre-operational satellite's launch. Airline sources say they will not be able to place orders that soon because of their pinched finances and the fact that the Airline Electronics Engineering Committee, which must approve all airline communications gear, has never been able to develop a specification in less than a year. The airlines are nevertheless grudgingly supporting the OTP position because "at least we have a decision now," one source says. They say that the best chance orders will be placed this year is if the Air Force's Military Airlift Command decides it needs to use the satellite system for its many trans-Pacific flights.

Addenda

Sen. Mike Gravel, Alaska Democrat, will need high-powered support in Congress for a bill that requires common carriers to divest themselves of stock in Communications Satellite Corp. and have no directors on its board. He faces opposition from the White House Office of Telecommunications Policy and from the Federal Communications Commission. . . . Rep. John Davis (D.-Ga.), succeeding Emilio Daddario as chairman of the House subcommittee on science, research and development, plans to make a name for himself with a thoroughgoing examination of the National Bureau of Standards and its role in advancing the state of technology . . . Patent reform will also be an issue in the 92nd Congress and the Administration, as the Government re-examines company patent ownership and licensing manipulation for antitrust violation . . . Salaries in the computer sciences scored the highest percentage increase between 1968 and 1970, rising 17% to $16,500 and giving computer scientists the second highest median salary among U.S. scientific and technical personnel, says the National Science Foundation.

Think of it as a six pack...



one trimmer, five resistors, in one package. That's TRN.

Our new Trimming Resistive Network will cut resistor insertion and preparation cost by at least a 6:1 ratio. In addition it satisfies engineering requirements better than anything on the market. For instance, the TRN provides cermet TCR performance values of 50 or 100 ppm/°C. The one-paste, one-step deposition method that we use allows for uniform, predictable TCR drift within the range of ± 2 ppm/°C of each other for each resistor in the circuit. In addition, the unit features a ratio accuracy with respect to the variable resistor available as low as ± 1%.

All componentry is housed in a single shell, which means that ambient temperature for each resistor in the circuit is the same for all others. Plus, you get versatility of applications, reliable long life and dimensions that are perfect for automatic insertion machines.

Like to know more? Write Bill Dunn. He's at Amphenol Controls Division, 120 S. Main Street, Janesville, Wisconsin 53545.

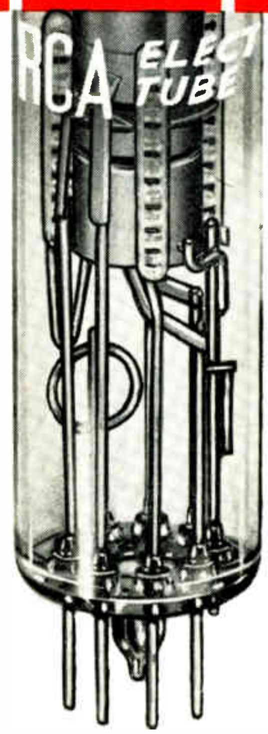
AMPHENOL
THE BUNKER-RAMO CORPORATION

Circle 53 on reader service card

COMPARE! In cost-effectiveness, RCA 1" Vidicons outperform 1" lead-oxide types!

CAMERA USERS' AND DESIGNERS' GUIDE				
Cost-Effective Factors	RCA		Registered Tmk XQ1070 Series	
Tube Type	8507A	7735	16XQ	16XQ-IG
Resolution (MTF at 400 lines)	60%	45%	30%	30%
Sensitivity at 0.1 fc	100 nA	100 nA	100 nA	100 nA
Automatic Sensitivity Control	Yes	Yes	No	No
Gamma Matched to Picture Tube Characteristics	Yes	Yes	No	No
Cost*	$190	$110	$1730	$ 810

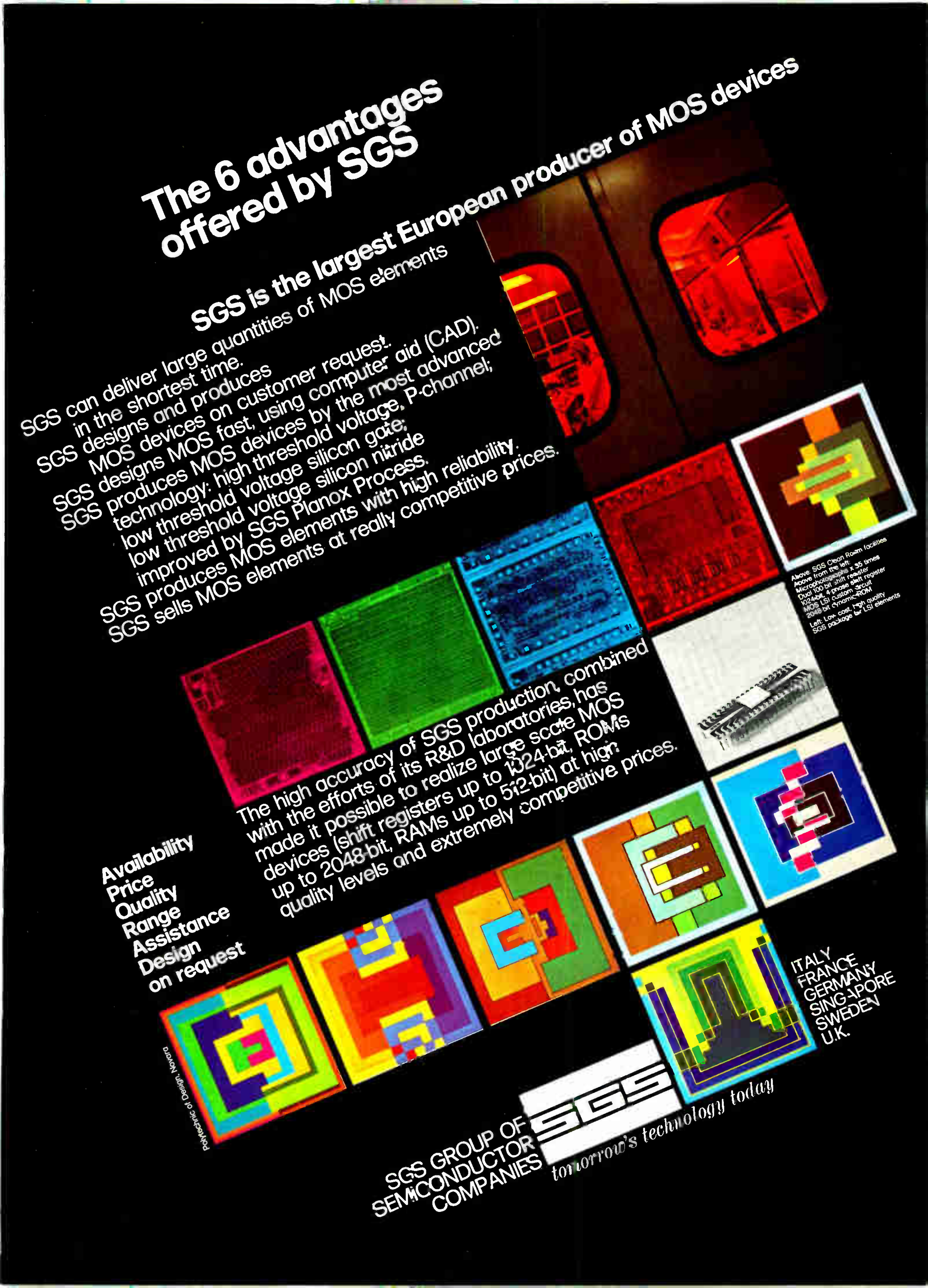
*Optional Distributor Resale Price



Add to this the typical life of 10,000 hours for a Vidicon at a cost of about 2¢ per hour. In educational and industrial CCTV, RCA Vidicons offer a combination of performance, reliability and low cost that lead-oxide types just can't meet. Take a look at the chart. Compare. Make your own decision. For more information on RCA's complete line of long-life Vidicon tubes, see your local RCA Representative or your RCA Industrial Tube Distributor. For additional technical information, write: RCA, Commercial Engineering, Section 70A-18/ZC8, Harrison, N. J. 07029. International: RCA, 2-4 rue du Lièvre, 1227 Geneva, Switzerland, or P.O. Box 112, Hong Kong.

RCA

Circle 55 on reader service card →


The 6 advantages
offered by SGS
SGS is the largest European producer of MOS devices
SGS can deliver large quantities of MOS elements
in the shortest time.
SGS designs and produces
MOS devices on customer request.
SGS designs MOS fast, using computer aid (CAD).
SGS produces MOS devices by the most advanced
technology: high threshold voltage, P-channel;
low threshold voltage silicon gate;
low threshold voltage silicon nitride
improved by SGS Planox Process.
SGS produces MOS elements with high reliability.
SGS sells MOS elements at really competitive prices.
Above: SGS Clean Room facilities
Above from the left:
Microphotographs x 35 times
Dual 100-bit shift register
1024-bit, 4-phase shift register
MOS LSI custom circuit
2048-bit dynamic-ROM
Left: Low cost, high quality
SGS package for LSI elements
The high accuracy of SGS production, combined
with the efforts of its R&D laboratories, has
made it possible to realize large scale MOS
devices (shift registers up to 1024-bit, ROMs
up to 2048-bit, RAMs up to 512-bit) at high
quality levels and extremely competitive prices.
Availability
Price
Quality
Range
Assistance
Design
on request
Polytechnic of Design, Novara
SGS GROUP OF
SEMICONDUCTOR
COMPANIES
SGS
tomorrow's technology today
ITALY
FRANCE
GERMANY
SINGAPORE
SWEDEN
U.K.

MULTI-GENERATOR!

More signal sourcery from Exact

You've come to expect multiple functions from many kinds of instruments. Now Exact is introducing a low-cost waveform generator that will do so many jobs we've decided to call it a "Multigenerator."

The new Model 124 Multigenerator, priced at only $595, produces a variety of *usable* signals previously attainable only by employing several instruments, either separately or in tandem.

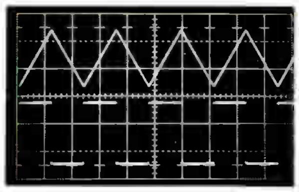
Start with normal sine, square and triangle waveforms. Then add plus-and-minus sine, plus-and-minus square, plus and minus pulse—with both the repetition rate *and* the pulse width controlled internally. You also can generate haversines, gate for burst outputs, trigger for single shot, or sweep symmetrically up and down. The Model 124 will produce offset waveforms and $\sin^2$ pulses without fiddling with DC offset. And you can vary pulse amplitude without affecting DC offset.

The Model 124 has dual output amplifiers—each with individual function selection, 80 db attenuation in 10 db steps, two separate generators, 1000:1 VCF, frequency range from 0.1 Hz to 5 MHz and output voltage of 20 V open circuit (10V into 50 Ω).

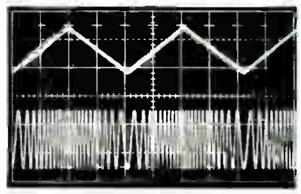
In PULSE, BURST AND SWEEP MODES, the second generator is used to trigger, gate or sweep the frequency, respectively. The second generator can be used to modify the main generator in a number of other ways, opening up almost unlimited waveform possibilities.

The Model 124 is only 3½" high, 12½" wide and 10½" deep. (Small for a waveform generator that will do so much.)

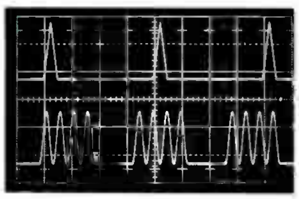
Price $595 ($50 extra for expanded frequency range of .01 Hz to 5MHz on main generator.)



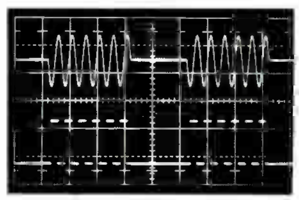
Triangle and square waveforms.



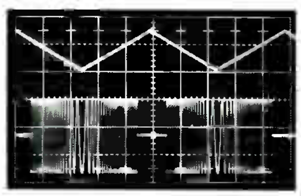
Sweeping up and down with internal triangle.



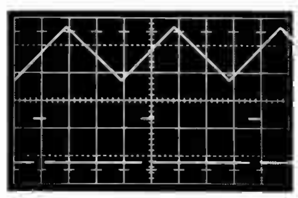
Pulsed havertriangle and $\sin^2$ burst.



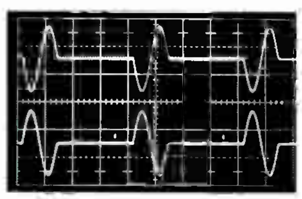
Tone burst and pulse burst.



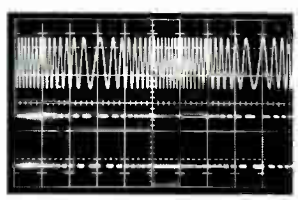
Gated with sweep, internal triangle gates and sweeps main generator.



Pulse mode—pulse delay controlled by internal triangle generator.

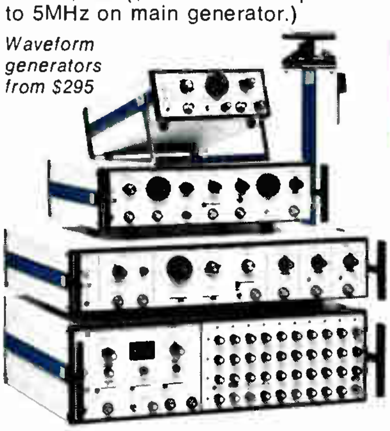


Single shot—sine wave output using pulse mode, start-stop control at 0°. For phase relationship studies.



Sine output from amplifier #1, square output from amplifier #2; both amplifiers swept simultaneously in sweep mode.

Waveform generators from $295



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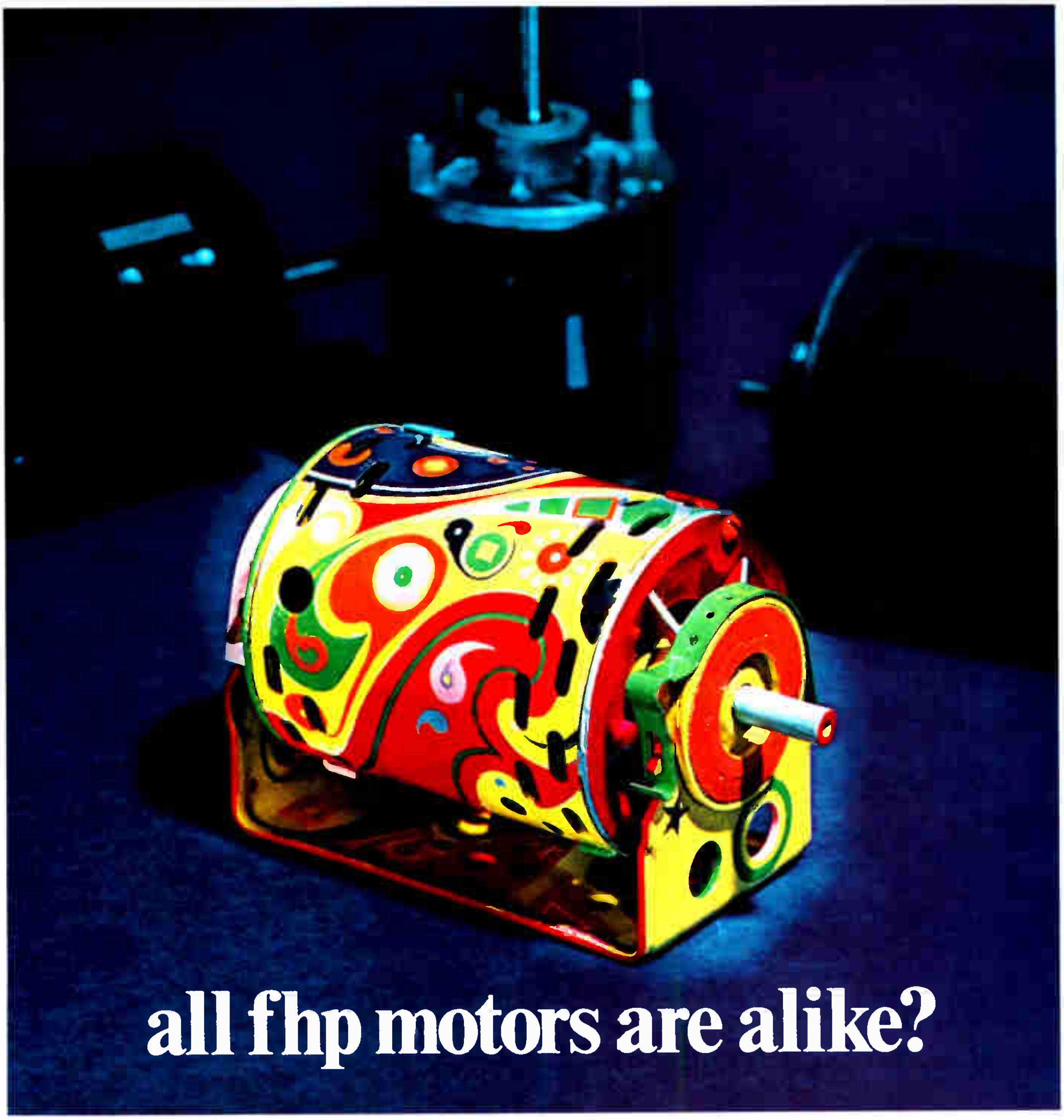

Now that you're surprised at how different this Howard fhp motor looks on the *outside*, let's talk about *output:*

When Howard rates a motor 1/20 hp, we're not about to underpower your system with a 1/25 hp motor. We've always True Rated our fhp motors this way.

Now engineers and designers are finding that a carelessly overrated or underrated motor can cause system problems. And they want no part of either. That's why engineers look to Howard for True Rated fractional horsepower motors. . . . and they get them. Our computer guarantees it. And your products benefit.

Next time you look at the outside of a Howard motor, you won't find mod painting. You will find that if the label says 1/20 hp, we don't mean 1/25 hp. Or 1/15 hp, either.

Get the complete Howard True Rated story. Find out in detail why it makes no difference that all fhp motors *look* alike. It's the output that counts. Write or call Howard for Fractional Horsepower Motor Information Packet E171.

HOWARD

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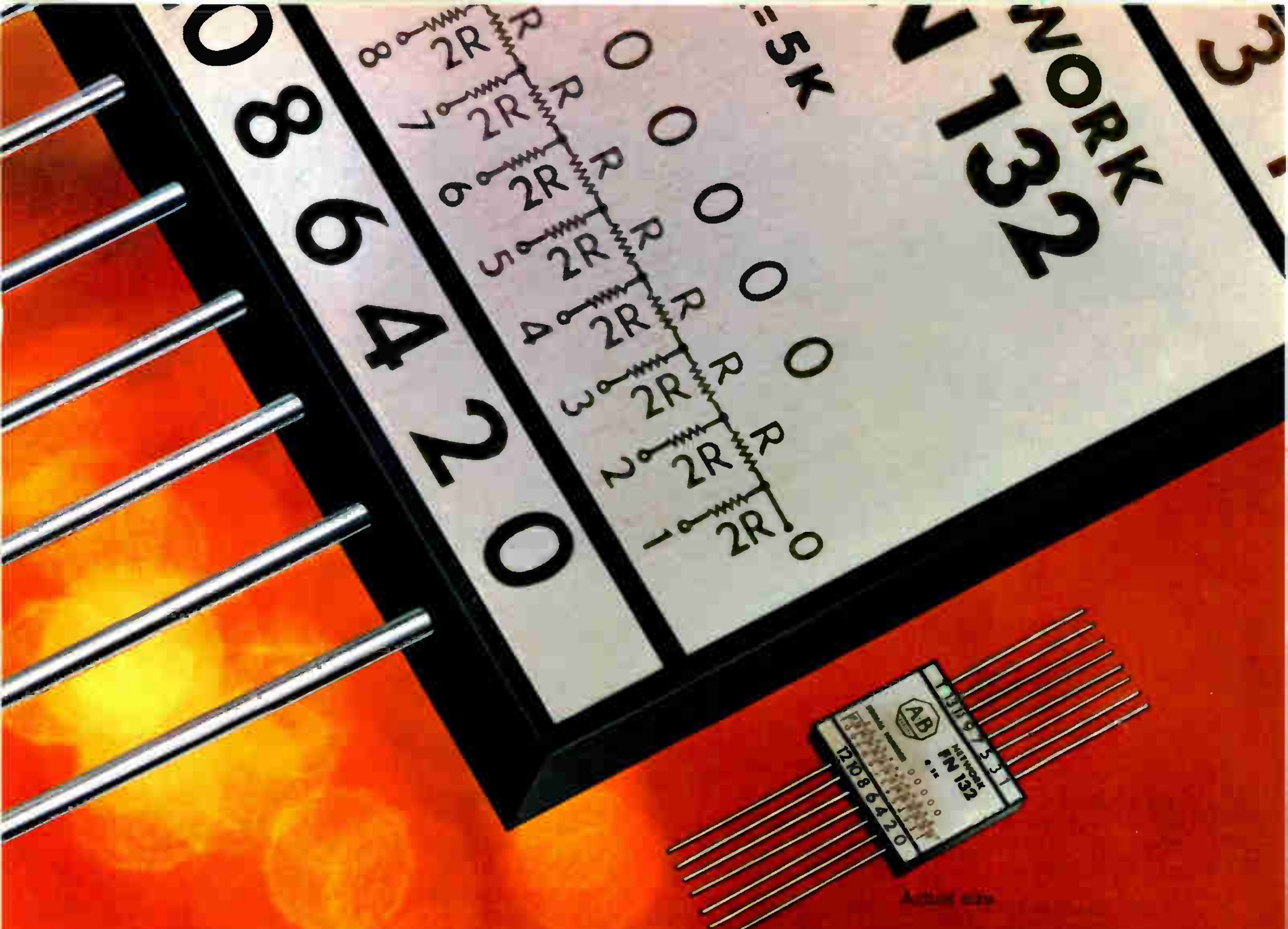
Circle 57 on reader service card



Now true precision in Allen-Bradley thin film networks.

Resistance networks for A/D and D/A conversion, digital volt meters and numerical control systems demand extreme precision. Allen-Bradley can deliver. Precision that starts with a patented chromium-cobalt resistive material vacuum deposited on a substrate made to Allen-Bradley specifications. Precision based on exclusive computer drawn grids. Precision backed by extensive design and testing facilities. Precision on a continuing basis assured by Allen-Bradley's 14 solid years of experience.

Add the reliability of a single substrate, uniform temperature characteristics, much lower attachment costs and you see why Allen-Bradley thin film networks are the logical replacement for discrete precision resistors.

SELECTED SPECIFICATIONS

RESISTANCE RANGE	1K ohms to 2 megs, standard 25 ohms to 50 megs, special (Single substrate range—10,000 to 1)
TCR LEVELS −55°C to +125°C	± 25 ppm/°C ± 10 ppm/°C ± 5 ppm/°C
TCR TRACKING	± 5 ppm/°C standard to ± 1 ppm/°C special
TOLERANCES	Absolute to ± .01% @ +25°C Matching to ± .005% @ +25°C
RESOLUTION	Line width and spacing to .0001 inch
ENDURANCE	Exceeds MIL-R-10509F Characteristic E Procedure. MIL-STD-202D

Investigate the superiority of Allen-Bradley thin film networks. Write: Marketing Department, Electronics Division, Allen-Bradley Co., 1201 South Second Street, Milwaukee, Wisconsin 53204. Export office: 1293 Broad St., Bloomfield, N. J. 07003, U.S.A. In Canada: Allen-Bradley Canada Ltd., 135 Dundas Street, Galt, Ontario. Several standard networks are available through your appointed A-B industrial electronic distributors.

Circle 60 on reader service card

Holographic mass memory's promise: megabits accessible in microseconds

Read/write memory under development combines manganese bismuth magnetic film and new holographic techniques to offer the potential of high-speed, high-density storage for less than a cent per bit

By R. D. Lohman, R. S. Mezrich, and W. C. Stewart, *RCA Laboratories, Princeton, N.J.*

☐ The concept of read/write memories storing hundreds of millions of bits with access times of less than a microsecond sounds like the ideal marriage of core and disk systems. Such a memory now, in general, seems to be feasible; but far from being a combination of these approaches, it uses holographic mass-storage techniques. It's done without the complex wiring required in core systems or the slow and cumbersome mechanical equipment necessary for accessing tape and disk systems. And the optical approach promises costs less than a cent per bit.

The optical read/write memory approach (Fig. 1) has two basic elements: a large central holographic memory that contains the system's total stored information; and an operating memory that at any given time contains a small block or page of the main memory. The central processing unit (CPU), as in any computer, performs the functions of arithmetic, control, etc.

The system operates on commands from the CPU, which orders the operating memory to retrieve a block of data (called a page) from the central holographic memory. Although the holographic storage memory's capacity is very large (say 10^8 bits) and relatively slow (access time of a hundred microseconds), the operating memory is small (10^4 bits), but it has submicrosecond access time to any word residing in the page. Moreover, the operating memory has a read/write capability; it can read the data stored in the holographic memory, or write new data into the memory.

On the cover, checking out components of the memory described in this article, is author Wilber C. Stewart, a member of the technical team put together by Dr. Jan Rajchman, staff vice president for information sciences, at RCA Laboratories to develop his concept for an optical mass memory. Stewart brought to the team a background in thin film memory research, which was matched by the laser and holography expertise of co-author Reuben S. Mezrich. Supervising the project was Robert D. Lohman, a veteran of computer and integrated circuit engineering at RCA, who now heads information sciences systems research.

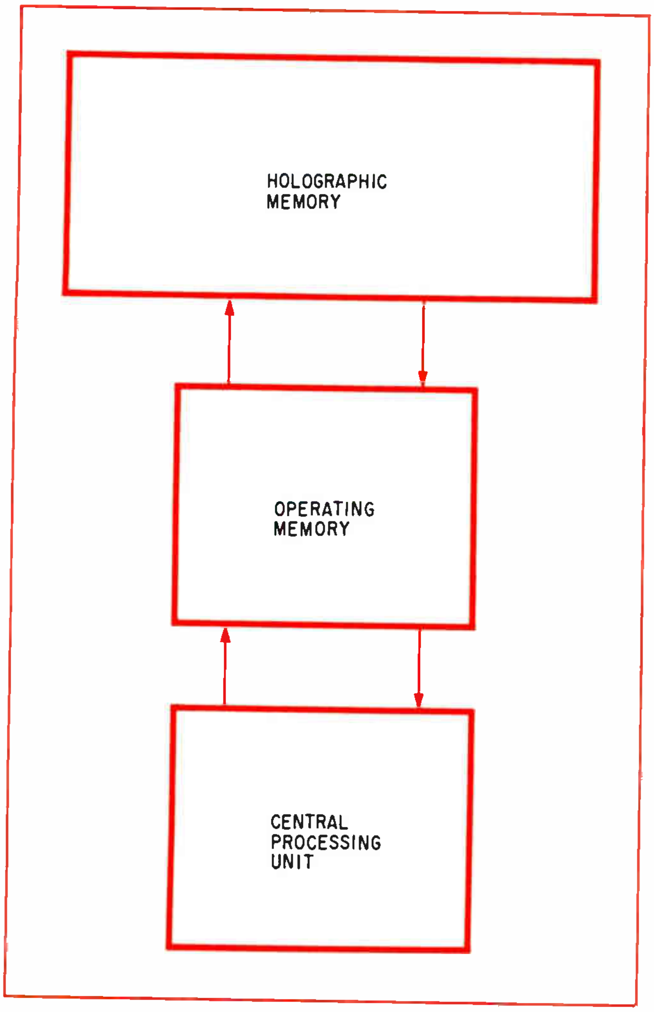
In this setup, pages of data are transferred to and from the operating memory via an optical path to the central holographic memory. The relationship between the two is similar to that of the core memory to the disk memory, but with two major differences: the data path is parallel and optical rather than serial and electronic, and no moving parts are required to access the optical memory.

Key to making the system realizable is the magnetic storage medium, whose ability to store high-density information that is both permanently imprinted but easily erasable offers the flexibility that's essential to success. The medium in this system is a compound composed of manganese bismuth—a ferromagnetic material characterized by a large anisotropy, an easy axis normal to the film surface, and very large magneto-optic effects. Used in a thin (600-angstrom) film, this medium offers high-speed, shows no fatigue or thermal decay, operates at room temperature, and is independent of the frequency of the light used to alter it.

Holograms are made on the MnBi film by Curie-point writing, a process in which light incident on the film is absorbed, raising the local temperature over the Curie point. This temperature rise causes the film, at regions of high light intensity, to become paramagnetic—very weakly magnetic. After the light is removed the film cools and returns to the ferromagnetic, or strongly magnetic state—but with the direction of magnetization reversed by those regions of the film which remain cool. Thus, if the incident light pattern is that of a spot focused on the film, then a corresponding spot, with its magnetization reversed, is written. However, if the incident light is the interference pattern between an object and reference beam, then the corresponding magnetization pattern will be formed and will correspond to the information to be stored.

Using this material, very high resolution can be achieved—greater than 2,000 line pairs per millimeter. In addition, write time is only approximately 20 nanoseconds, while read time is approximately 20 μs.

The read/write operation of the system is illustrated in Fig. 2. During the write cycle a laser beam first



1. Optical route. Holographic memory is coupled to operating memory which functions as a high-speed access for the CPU. Blocks of data are transferred to and from the operating memory via optical paths.

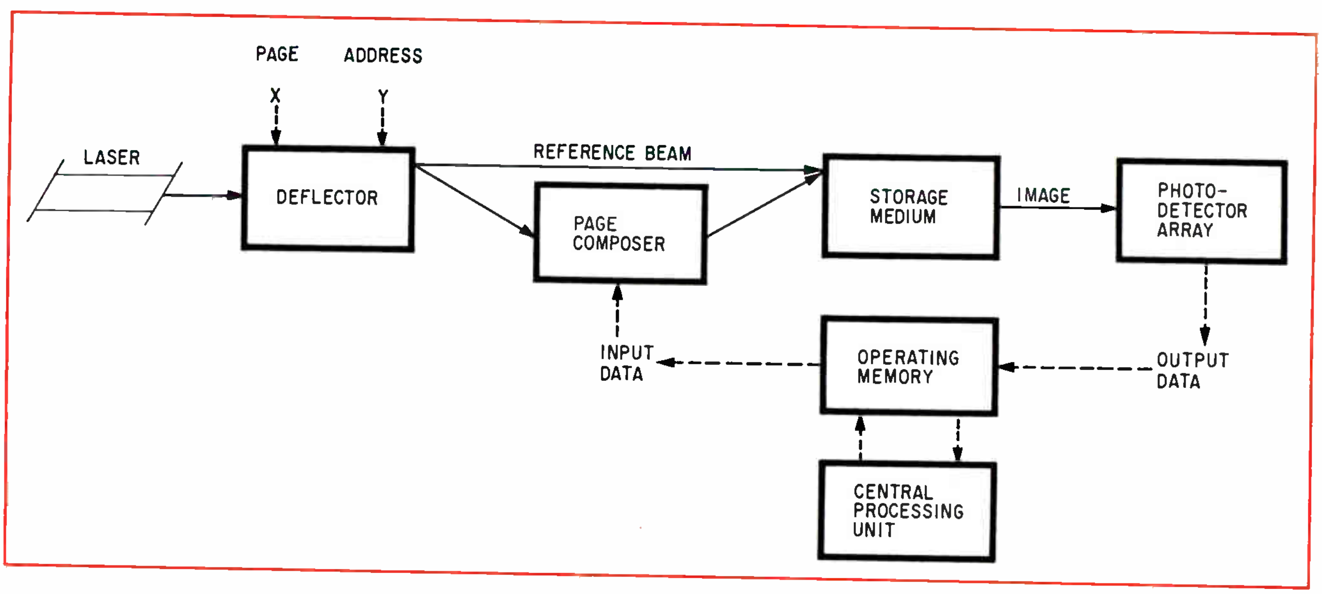
enters a two-dimensional deflector capable of shifting it to any position on a page. Since there are X rows and Y columns, the total number of page positions is X • Y. Each position represents an area on the storage medium containing one hologram. Thus, each hologram can be located by electrically deflecting the beam to that position.

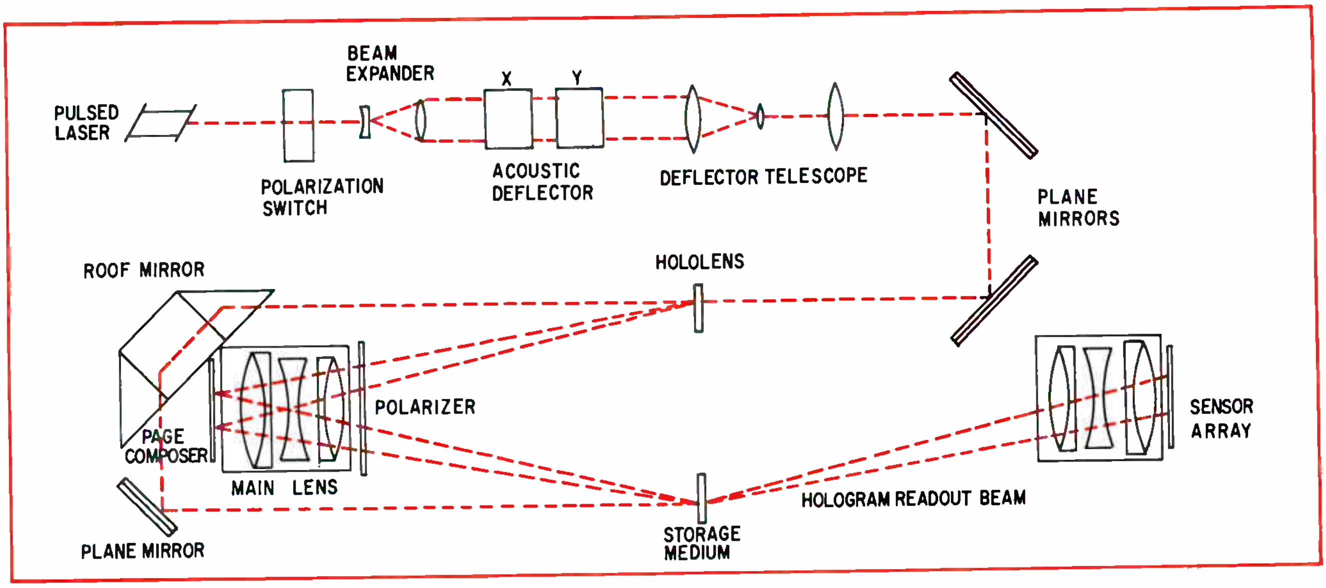
With interference between two coherent beams required to construct a hologram, the deflected beam next is split into two parts. One, the reference beam, is sent directly to the selected page location on the storage medium. The second, the object beam, impinges on a two-dimensional (W•D) array of light modulators, called a page composer, before it reaches the same page location on the storage film. The page composer impresses the information to be stored on the beam. In this capacity it acts as a transducer, converting the electrical input data to spatial variations of intensity or phase of the object light beam.

At the selected page location, the reference and object beams form an interference pattern to produce a hologram of the page, finishing up the write cycle. In addition, since holograms are by nature redundant, (light from each modulator position in the page composer covers the entire hologram area), the storage medium need not be free from random imperfections that would affect the data if it were stored as a direct image of the page composer. Even if part of the holograph is lost, the information can still be accurately reproduced.

To read the data, the selected page of the storage medium is illuminated with a reference beam alone, producing a real image. At this image plane, an array of photodetectors, whose spatial dimensions are the same as those of the page composer, converts the information into electrical signals. These signals, in turn, set the states of flip-flops, one for each photodetector cell. This integrated array, with its addressing

2. System. The components of the holographic memory are the laser (energy source), the beam deflector (addressing mechanism), page composer (data entry), storage medium, and detector (data extraction). Each page of data is stored as a hologram in the storage medium and is read as an image on the photodetector.





3. Reading and writing. The hololens—an array of fixed holograms, one for each deflected beam—splits laser light into an object and a reference beam. The object beam goes to the page composer, then to storage medium. The reference beam bypasses the main lens and combines with the object beam, which contains data from the page composer, to construct the hologram on the storage medium. Data read out by the reference beam, is displayed on the sensor array.

circuitry, comprises the operating memory.

In calculating the memory's capacity, C, note that there are X•Y pages of information, each containing W•D bits. Thus C = X•Y•W•D. However, the number of discrete, nondefective functioning devices required is only 2•W•D, since W•D are needed for the page composer and an additional W•D are used in the detector. Thus, for typical values of the system's parameters, X = Y = W = D = 100; C = 10^8, and N = 2 x 10^4. In other words, the memory attains a very large storage capacity (10^8 bits) with very few discrete elements 2 x (10^4).

A possible configuration for the optical memory is shown in Fig. 3. Here a laser pulse stream is collimated into a narrow beam and is directed toward an electro-optic switch. Since the same beam is used for both reading and writing, during the read cycle, the switch rotates the plane of polarization by 90°, so that during the write cycle the object beam will be blocked by a suitably oriented polarizer further on. When writing, the switch is not energized. Next, a beam-expanding telescope produces a wide collimated beam to fill the aperture of the deflector cells (the number of positions that can be resolved by the deflector is proportional to the square of the diameter of this aperture).

The deflection angle is determined by traveling-acoustic waves introduced into the cells; the deflection angle is proportional to the frequency of the wave. After the beam passes through a three-lens deflector telescope, where its angle is magnified, its diameter reduced, and its axes aligned, the beam is directed by plane mirrors to the holographic portion of the system.

The deflected beam illuminates a small area of an array of fixed holograms, called a hololens. These hololenses, containing one hologram for each deflected beam position, efficiently divide the incident light into an object and a reference beam.

When illuminated by the incident beam, the object beam from the hololens produces a real image of the light modulator arrangement on the page composer. At the same time, the writing reference beam passes undiffracted through the hololens. This beam, in passing the side of the main lens, is reflected once by a 90° roof mirror which inverts the beam position through the plane of the drawing, and once more by a 45° plane mirror. Finally, the undiffracted beam arrives at normal incidence to the storage medium exactly where the object beam arrives, thereby producing the necessary holographic interference pattern used to write the particular page selected in the storage medium.

To read a page of information, only the reference beam need be directed to the storage medium. Transmitted light diffracted from the storage hologram forms a real image at the photosensor array. If the detector array must be identical in size to the page composer array, the readout beam must pass through a lens similar to the main lens. However, a real image of a different size will be formed even without a lens acting on the readout beam.

A major attraction of an optical storage system is the very large potential for bit-packing density. For typical values of wavelength of laser light and lens f-value, densities of approximately 10^6 bits per square centimeter should be feasible. However, if the storage medium were placed at the center of the focal plane, a larger area could be obtained and hence more total storage capacity could be available. This type of configuration, although more complicated, is feasible and might be selected in an actual operational system.

To read the hologram, either the Faraday (transmis-

Holography and mass storage

A hologram is a recording of the optical wavefronts from an illuminated object; subsequent illumination of the recording reconstructs, by diffraction, an image of the original object. To form this image, the wavefronts diffracted by a hologram must reproduce not only the amplitude variations originally present across the plane of the recording, but more importantly, the relative phase variations or wavefront curvatures that existed. The wavefront curvatures, in fact, signify the direction and distance traversed by the light from the object to the hologram. Such recordings can be made by exposing a recording medium to the interference pattern that results from combining the object waves with angularly offset reference waves from a collimated light.

A laser is required for achieving the extended interference fringes of high visibility (contrast). Furthermore, a high-quality holographic image requires resolution in the recording medium sufficient to record the finest detail of the original interference pattern, which is approximately on the order of the wavelength of the light.

Perhaps the principal advantage afforded by holography in mass storage is the ease of achieving redundant recording with no loss in density, since each elemental area of the hologram contributes equally to the entire image and not just to a portion of it. Thus, small random imperfections or dust particles which would obliterate entire bits of information in a directly recorded microimage will merely degrade slightly all the information bits in a holographic image without destroying any. This is accomplished by illuminating the object pattern so that the light from each information bit falls on all parts of the hologram area during recording. A further advantage is that the image from each hologram can be made to fall on a single fixed array of photodetectors without the necessity of moving the storage medium or providing multiple imaging.

sion) or Kerr (reflection) magneto-optic effect is used. Since these phenomena essentially are phase effects, the magnetic hologram will behave as any optical phase hologram: either the real or virtual image of the original object is reconstructed simply by illuminating the hologram.

To erase the hologram, an external magnetic field is applied that's large enough to saturate the film, thus removing the holographic magnetization pattern. Another technique, which allows selective erasure, is to heat an area of the film above the Curie temperature in the presence of an external magnetic field. When the film cools it will again be completely saturated in the proper direction.

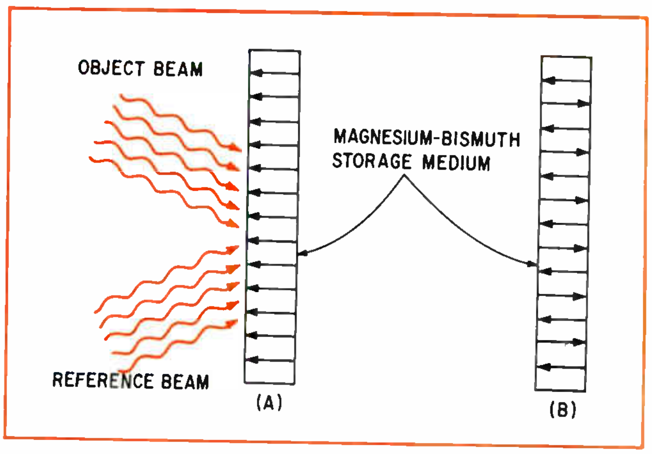
The duration of the light pulse must be short, to preserve the fine detail of the periodic pattern, since long pulses will cause spreading on the film. Also, the light intensity must be sufficient to generate enough heat to reach the Curie temperature of the film. Typically, pulse durations of 20 ns with peak intensities of 10 kilowatts of light are required for an area of 1 mm^2. Although this system, because of the hololens, is more efficient than most, a laser output power of approximately 100 kW is still necessary to produce this power at the MnBi surface due to losses in the deflector, page composer, and various optical components such as lenses, mirrors, etc.

This requirement places severe demands on the laser. In fact, the characteristics required for this application are not available from present lasers. Presently, the only source capable of meeting the peak power requirement is a Q-switched ruby laser, but the repetition rate is much too low for any practical memory system. However, recent developments indicate that a laser with the required peak power and pulse rate is feasible. Particularly promising is the "doubled" YAG laser whose output is in the green light region ($\lambda = 5300Å$). With information-packing density varying inversely as the square of the light wavelength, the doubled YAG is an ideal choice for a memory using MnBi as the storage medium.

The selection of techniques for imprinting the deflector, page composer, and detector is dictated by overall system requirements, compatibility between components, and available technology. For example, the beam deflector must be capable of directing the laser beam precisely and reproducibly to between 10^4 and 10^5 positions in microseconds with high light efficiency. One way to do it is with an acousto-optic deflector, employing a sound wave in a liquid or a crystal to diffract the light. Two acousto-optic cells are needed: one for deflection in the X direction, and one for Y.

Although it's also possible to suitably deflect the light beam using a KDP optoelectric crystal, the acoustic technique is the simpler of the two because

4. Write waves. The interference pattern caused by the combination of object and reference beams (part A) creates temperature variations that duplicate the incident pattern. With this technique, called Curie-point writing, thermal variations can be stored as differences in magnetic domains (part B) in the magnetic MnBi film.



only two active elements instead of 14 elements are required for a 128 x 128 optoelectric deflector. Furthermore, since the precise frequencies for the acousto-optic cells are easier to establish than the exact voltage for the optoelectric cells, acoustic deflection potentially allows greater repeatability at these higher contrast levels.

The page composer is, in essence, a display device that converts electrical data to a spatially modulated light wave. Since in a hologram the entire image to be recorded must be recorded at once, the page composer elements can be one of two types: they can either accept information serially (a word at a time) and store it, or each element must be individually connected to a buffer memory, in which case it acts only as a light modulator.

If the information is entered in serial form, then each element of the page composer must be coincidentally addressable. In this case each bit requires a control wire (totally W•D wires). Likewise, if the elements act as light modulators only, then some way must be found to make the W•D connections from the elements themselves to the buffer memory.

The ferroelectric ceramics, such as lead-zirconium-

The optical ROM: first things first

Although further development of key components still is required before a read/write optical memory becomes practical, read-only optical memories could be built with available technology. Optical ROMS need not have an erasable storage medium, nor do they compose pages in real time, circumventing two technical problems that remain to be solved in the read/write system.

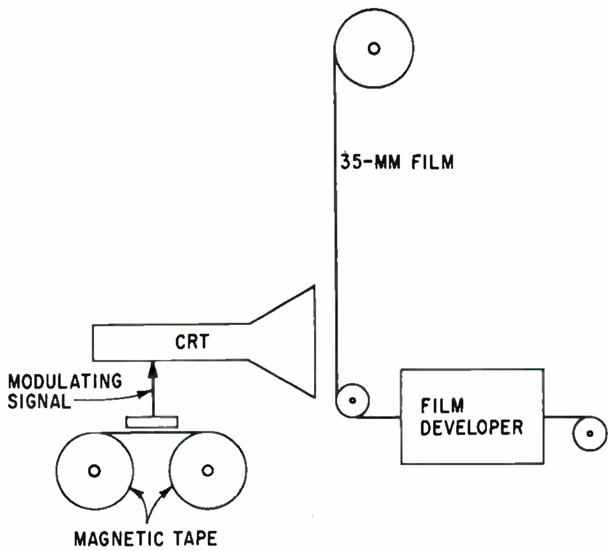
As shown below, the read-only memory comprises a laser, deflector, holographic storage medium, and detector. The page address controls the deflector, which directs the beam to the selected hologram. The image from the hologram is made to fall on the detector array. By selecting one row of this array and reading all the columns simultaneously, the desired information is obtained a word at a time.

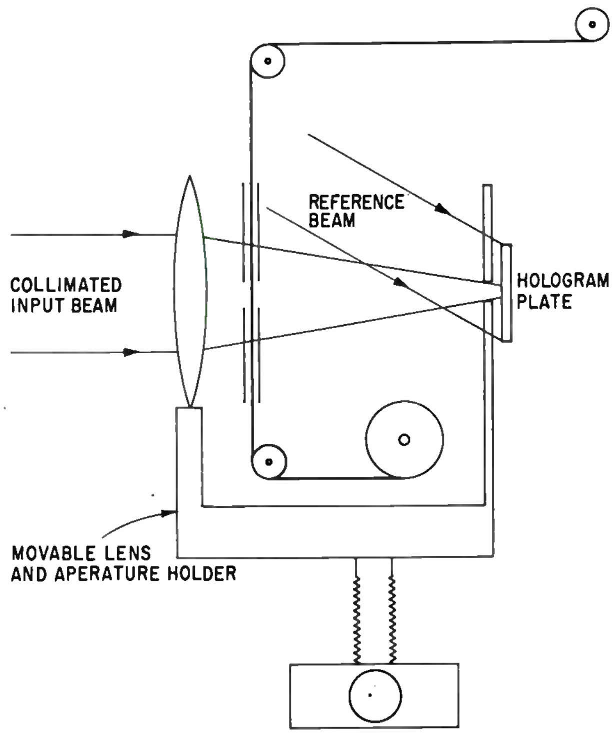
State-of-the-art components could produce a 10- to 100-million-bit memory with a page access time of less than 5 microseconds and a word access time within the page of less than 1 μs. But in order to change the information in just one hologram, a new hologram plate must be made, and this requires some sort of an automated arrangement.

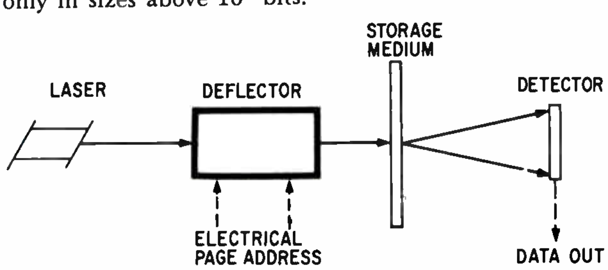
One method, shown at right, requires that the data to be written into the memory first be recorded on magnetic tape. The information then is displayed on a cathode ray tube which is used to expose 35-mm film. Each frame of film corresponds to one page of the memory.

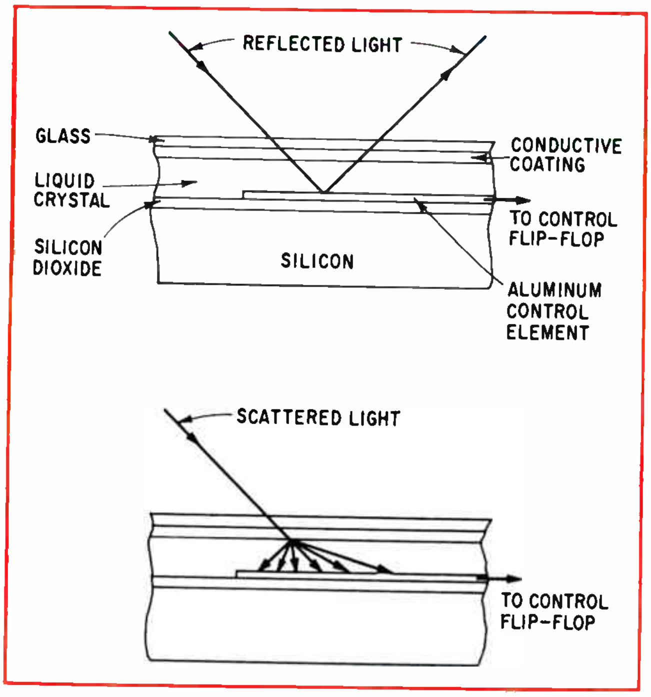
The developed film then serves as the data masks for the hologram plate exposure system. The entire operation can be accomplished in reasonably short times: exposure of a 16 x 10^6 bit memory plate would require approximately 1½ hours.

Although such a memory is technical feasible, the real problem is how to use it. Generally, small ROMS are used now for microprograming or character generation, and usually have capacities of less than 10^6 bits, but holographic optical ROMS are economically attractive only in sizes above 10^7 bits.









5. Liquid modulators. Liquid crystal-silicon sandwich cells could make an ideal page composer, since liquid crystals are nearly perfect light modulators and can be readily connected to the flip-flop controls. However, at present, liquid crystal material is slow—with speeds on the order of milliseconds.

titanate (PZT) appear to be good candidates for page composer elements of the first, or storage, type. The ceramics are both ferroelectric and electro-optic, can be addressed coincidentally, and can store on the basis of electric polarization. Thus it's possible to fabricate a page composer from PZT which would only require placing electrodes on a sheet of the material. Moreover, with this method, the switching time using coincident addressing is only approximately 10 μsec—a 100x100 array can be loaded in only 1 millisecond—with voltage drives easily obtainable from discrete transistors.

However, early PZT samples showed severe electrical and optical degradation. The culprit: fatigue caused by repeated switching. Once the fatigue problem is solved, PZT could become the leading candidate for page composer applications without severe speed requirements.

Another possibility for the page composer is the ferromagnetic equivalent of PZT, gadolinium-iron-garnet. At present, however, it cannot be grown in large-enough crystals—a 10^8 bit optical memory must be approximately 10 cm on a side.

A promising technique for the second type of page composer (requiring a separate memory) uses nematic liquid crystals. These nearly ideal light modulators can yield a high contrast ratio and require very little control power. Since the liquid crystal cells do not store, and cannot be coincidentally addressed, this approach requires W•D connections between the liquid crystal itself and the integrated control circuitry.

A cross-section of a silicon IC-liquid crystal cell that could be used as a page composer is shown in Fig. 5. The IC contains a flip-flop and associated addressing circuitry. An aluminum control electrode, connected to one side of the flip-flop, maintains a potential of either 0 or —20 volts, the liquid-crystal switching voltage. The liquid crystal is poured over the entire circuit; the device then is covered with a piece of glass, whose underside is coated with a transparent conductive material which is grounded. Light striking the device is reflected if the potential between the control electrode and the coating is zero, or is scattered if the potential is —20 V. When viewed from the storage medium, the control electrode appears to be bright in the first case and dark in the second. However, the main disadvantage of liquid crystal devices is their relatively slow operating speed, which is in the millisecond range. This restricted speed is evident at low temperatures—below 0°C, for example. But some new materials becoming available show fast switching over an extended temperature range.

With a slight modification, this arrangement could serve as the detector array as well as the page composer. To serve the detector function, the aluminum control electrode is replaced with the anode of a photodiode, which acts as the reflecting surface. If its anode voltage is controlled by the flip-flop, the anode modulates the light. During the reading function, the image from the storage medium strikes the diode and the resulting photocurrent is used to control the flip-flop. Thus, a single device serves as a page composer and a detector. It is called a light-accessible transistor matrix (latrix).

If a separate detector is used, it could consist of standard photodiodes in combination with flip-flops. In this way the detector array both senses the optical signal from the storage medium, and provides storage for the readout data. Thus it could serve as the computer main memory, or as a buffer for it. In operation, the stage of each flip-flop would be controlled either by external electrical signals or by signals generated optically from the storage medium.

Much remains to be done before holographic optical memories can compete with existing memory technology. Further advancements in lasers and acousto-optic, electro-optic and magneto-optic materials are necessary to provide the required performance. When these occur, optical memories will become an integral part of data processing technology. □

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Tantalum chip capacitors pack high value into hybrid circuits

Fitted with copper electrodes by a plasma process, tantalum chips provide hybrid circuits with capacitances above 1 microfarad; assembly can be automated, and manufacturing costs reduced

By John Piper, *Union Carbide Corp., Components division, Greenville, S.C.*

☐ Ceramic chip capacitors have been a boon to the hybrid circuit designer. They lend themselves to automatic handling, and also are small, economical, and highly reliable. But their cost and size, when a circuit requires capacitance values above a microfarad, may force the designer to turn to discrete, leaded tantalum components. And since he has to attach these outboard of the substrate, he loses much of the convenience and reliability that chips provide.

Tantalum chips would be preferable, but have not been practicable because solid tantalum capacitors cannot tolerate the high temperatures required in various hybrid circuit manufacturing processes. The weak spot is the method of terminating the cathode. But the application of a plasma coating technique, developed for aerospace materials, has made it possible to produce tantalum chips with solid copper terminations, in a form convenient for mass production ("Arc-plasma deposits may yield some big microwave dividends," *Electronics*, Feb. 2, 1970, pp. 108-115).

A typical solid tantalum capacitor consists of a porous pellet of tantalum with a tantalum lead wire that forms the positive plate of the capacitor (Fig. 1). Anodization of the internal and external surface area of the pellet provides a dielectric layer of tantalum pentoxide, Ta_2O_5 that is too thin, typically 2,000 angstroms, to be visible in the photomicrograph. Its thinness is what gives the solid tantalum capacitor a volumetric efficiency seven times that of ceramic capacitors.

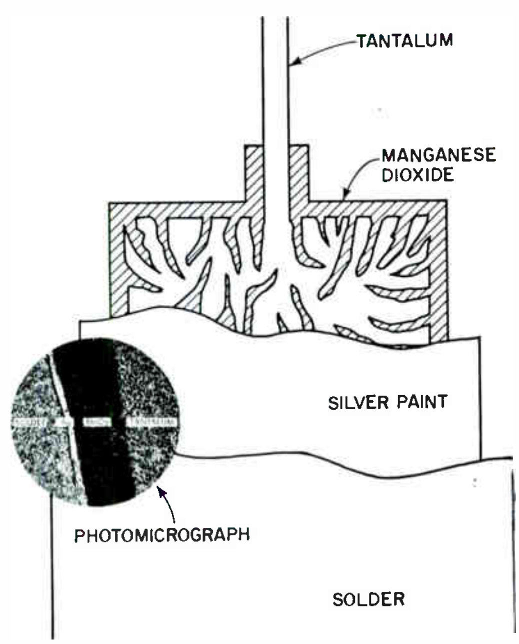
A layer of semiconducting manganese dioxide is used for the negative plate of the capacitor, because of its ability to fill the pores of the anode and, more importantly, "self-heal" the device when it is subjected to excessive voltage or current. A high current density in the MnO_2 near a defect site will cause local heating and decomposition:

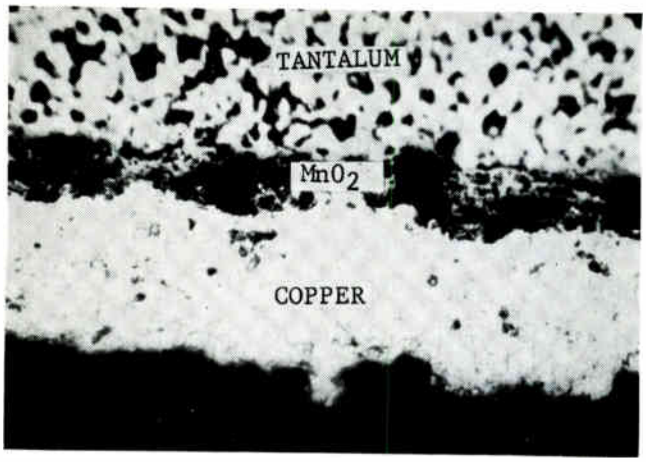
$$4MnO_2 + \text{heat} \longrightarrow 2Mn_2O_3 + O_2$$

thus converting a small volume of the cathode to the high resistivity sesquioxide and releasing oxygen which can then convert any exposed tantalum to an insulating oxide.

However, the rub comes with the conventional cathode termination—a fairly thin layer of a paint composed of silver particles in an organic resin. The basic tantalum capacitor element, the Ta–Ta_2O_5–MnO_2 layers, also has temperature limitations, determined by: the diffusion of oxygen from the tantalum pentoxide into the tantalum at the dielectric-anode interface during exposure to temperatures above about 300°C; the transition from MnO_2 to Mn_2O_3, which occurs at about 450°C; and eventually crystallization of the initially amorphous tantalum pentoxide dielectric. But, in its usual form, the tantalum capacitor never approaches its fundamental temperature capability because above about 200°C the cathode termination starts to degrade, the silver dissolving into the solder and the resin decomposing. Such behavior is clearly unacceptable in hybrid circuit fabrication, where solder reflow, rework, or encapsulating operations

1. Construction. Photomicrograph of typical tantalum chip capacitor shows layers of tantalum, manganese dioxide, and silver. A more advanced version substitutes copper for silver to improve the high temperature capability.





2. **Copper coat.** Photomicrograph shows density of plasma-deposited layer of copper on Ta-MnO_2 chip. Density is 80% of the theoretical maximum.

can require temperatures to 300°C.

To develop a high temperature capability, the silver paint has to be replaced by a more suitable material. Copper is a particularly good choice because it is intrinsically ductile, readily wet by solders, and only slightly soluble in molten, tin-containing alloys. Further, replacement of silver paint by copper results in the body of the capacitor becoming a natural cathode terminal. And removal of an organic resin from the structure lessens the chance for circuit contamination.

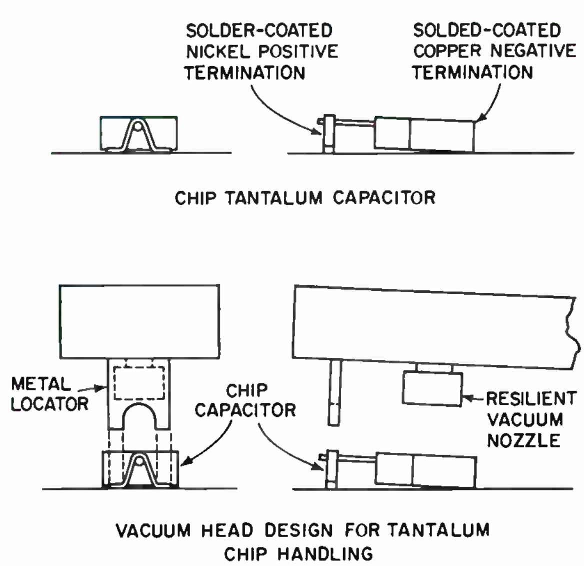
The use of metallic copper instead of silver paint is a significant innovation and is made possible by the technique of plasma deposition. This process has several advantages:

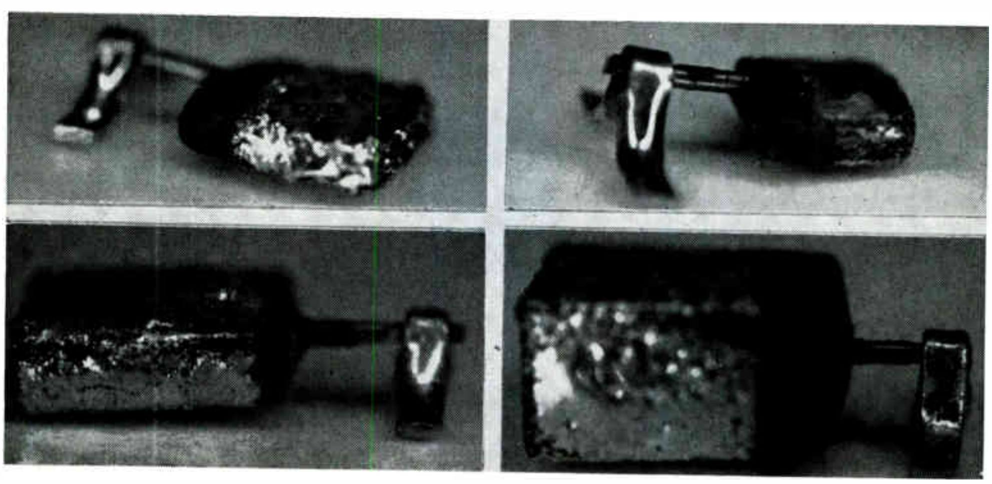
- It yields a solid copper layer, typically 1-mil-thick, and so does away with the need for a binder that would introduce temperature limitations and the possibility of contamination.
- It conformally coats the manganese dioxide surface, so that good electrical contact and mechanical integrity are established.
- It is a clean process that avoids ionic materials, which could affect capacitor performance.
- It allows the placement of the conductive layer to be precisely controlled.
- It is amenable to high volume production.

Figure 2, a photomicrograph of a plasma copper coating, provides evidence of the first two advantages. The copper coating is dense, with greater than 80% of the theoretical density, and it also conforms closely to the manganese dioxide surface.

To deposit the copper, a plasma torch directs a high velocity stream of hot, inert gas at the tantalum chip. The temperature of the gas may be as high as 16,000°C. The copper is introduced in powdered form into the stream, which melts it and accelerates it toward the chip. As the molten specks of metal strike the chip, they form a lamellar structure of flattened, overlapping particles, bonded to each other and interlocking with the chip surface.

A copper-electrode chip designed for easy handling and precision placement is shown in Fig. 3. Such capacitors, under the brand name of Kemet, are being manufactured by Union Carbide Corp. by the plasma deposition process. The positive terminal is made





3. **Chip.** Copper-electrode tantalum chip capacitor is designed for easy pick-up in automatic assembly and positive contact with pads on hybrid substrate. Photos show 33, 68, 150, and 330 microfarad-volt (capacitance-voltage product) units.

Changing values

At less than 1,000 picofarads, thin or thick film capacitors are usually adequate for hybrid circuits. But, though thick film materials are available with efficiencies of up to about 100,000 pF per square inch and tantalum oxide or silicon dioxide thin film techniques can achieve slightly more than 1 microfarad per square inch, they're not very attractive for capacitances above 1,000 pF because of the area they would consume, the unreliability of multilayer thick films, and the increased defect count in thin films.

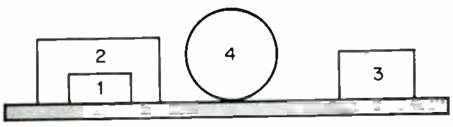
As a result, multilayer, monolithic ceramic capacitors have gained almost universal acceptance for providing hybrid circuits with larger capacitance values. They are used in the form of discrete chips, bonded to the substrate.

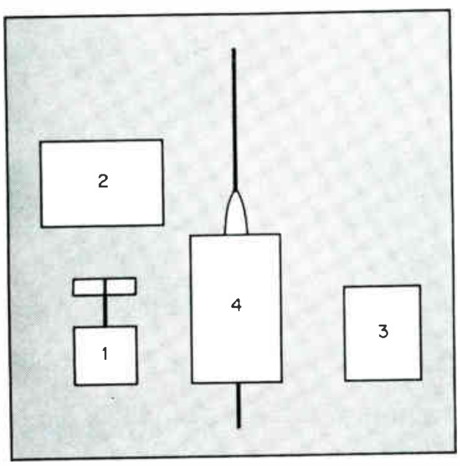
For thick film applications, the shape and construction of such a chip is almost ideal. It is a monolithic ceramic block that withstands high temperatures and has a coefficient of thermal expansion (typically $7 \times 10^{-6}/°C$) close enough to that of alumina substrates (8 or $9 \times 10^{-6}/°C$) to minimize thermal stresses.

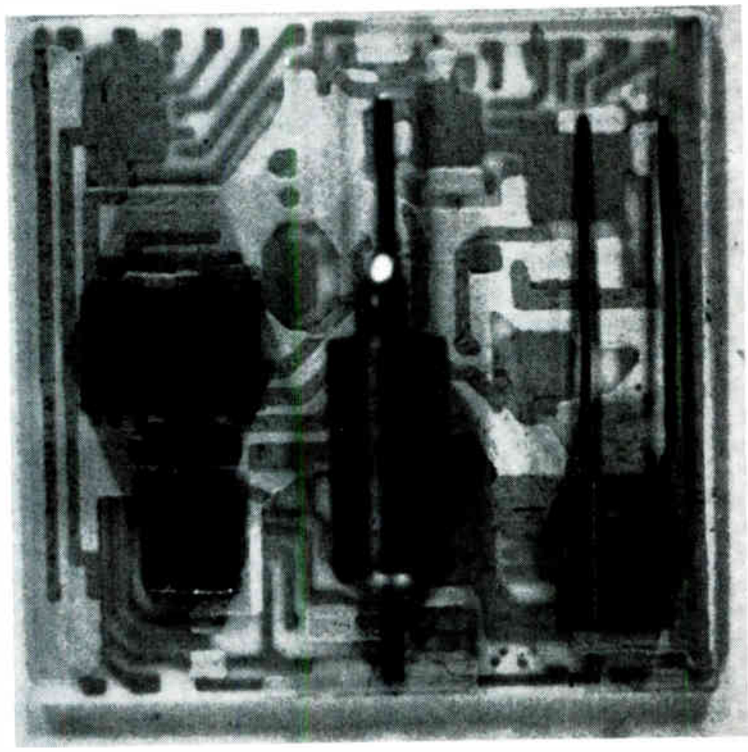
The typical chip's slab configuration is right for automatic handling and loading with vibratory bowl feeders and vacuum pickups. Moreover, the standardized location of electrode terminations on the chip simplifies orientation and aids connection to circuit pads by solder reflow or with conductive epoxy.

In thin film applications, the attractiveness of ceramic chip capacitors may be less apparent, but does exist. These capacitors can accept a broad range of terminal metalizations, suitable for ultrasonic or thermocompression bonding. In addition, their all-inorganic construction minimizes contamination within the thin film module—a feature that is also important in thick film modules, when chemically reducible resistor compositions are employed.

But beyond about 10,000 pF the cost and size of ceramic chip capacitors grow about proportionally with their capacitance value. In the range of 0.1 to 1.0 μF, therefore, the hybrid circuit designer has to turn elsewhere, and either use a solid tantalum chip capacitor, or attach a leaded and encapsulated discrete capacitor. Generally, the first alternative is preferable, because it offers smaller total size, fewer interconnections, and better performance. The size advantage of a tantalum chip capacitor, compared to ceramic chips or leaded tantalum devices of the same value, is shown in the figure below.







Large and small. Four 1-microfarad, 25-volt capacitors on a ceramic substrate illustrate the size advantage of the tantalum chip capacitor (1) over other types of equal value. Compared are: ceramic chip (2), miniature leaded tantalum (3), and military hermetically sealed tantalum capacitors.

with a formed and welded nickel tab on the tantalum lead wire, precisely placed relative to the rest of the device and providing the means of positioning the capacitor on the substrate. The tab configuration forms a bridge, so that conductors can run under it. Unlike the terminals on ceramic chips, the tab on the tantalum component is dimensionally precise, reducing the likelihood of its being short-circuited by wires passing under it. The body of the capacitor makes a slight angle with the horizontal, insuring that the end of the capacitor body will make contact with a circuit pad even when it deviates slightly from a rectangular shape.

To demonstrate that the copper coating performs well as high temperatures, chip capacitors with silver paint and some with copper terminations were immersed in a molten tin bath—an extreme test—at 300°C. After 30 seconds in the bath, the silver had all but dissolved, whereas the copper was virtually unaffected, as Fig. 4 shows. In another demonstration, the constituent layers of two chip capacitors—one with a copper coating, the other with silver paint—were soldered to a substrate and maintained at a high temperature. As Fig. 5 reveals, no degradation of the integrity of the copper coated device is visible after 10 minutes at 250°C, while the silver layer in the other device is already partially decomposed after 5 minutes at 225°C.

The reliability of the tantalum chips is not affected by the replacement of silver paint with plasma-deposited copper, nor is their electrical performance degraded. The copper-coated parts have demonstrated a failure rate of 0.05% per thousand hours at a 60% confidence level.

And tantalum chips in themselves are pretty reliable from a circuit manufacturer's point of view, which is based both on the likelihood of premature failure during or prior to circuit construction problems and on the intrinsic failure rate of the device in service.

The handling, and assembly problems of tantalum chips resemble those of semiconductor chips: with a few rudimentary precautions, each can be successfully introduced into the circuit, with or without pretesting, as desired. The intrinsic failure mechanisms of solid tantalum capacitors have received extensive study. These capacitors have no wear-out mechanism and exhibit a decreasing failure rate with time. Since the time element can be accelerated by applying voltages and temperatures above those for which the device is rated, burn-in can improve failure rate performance. Likewise, added reliability can be obtained in the circuit by appropriate voltage derating of the capacitor in the application.

Chip devices, unlike their leaded counterparts, do not enjoy the built-in stress relief provided by lead wires. But fortunately, the coefficient of thermal expansion for tantalum ($6.7 \times 10^{-6}/°C$) is very low for a metal; it approximates that of ceramics, and so minimizes thermal stresses.

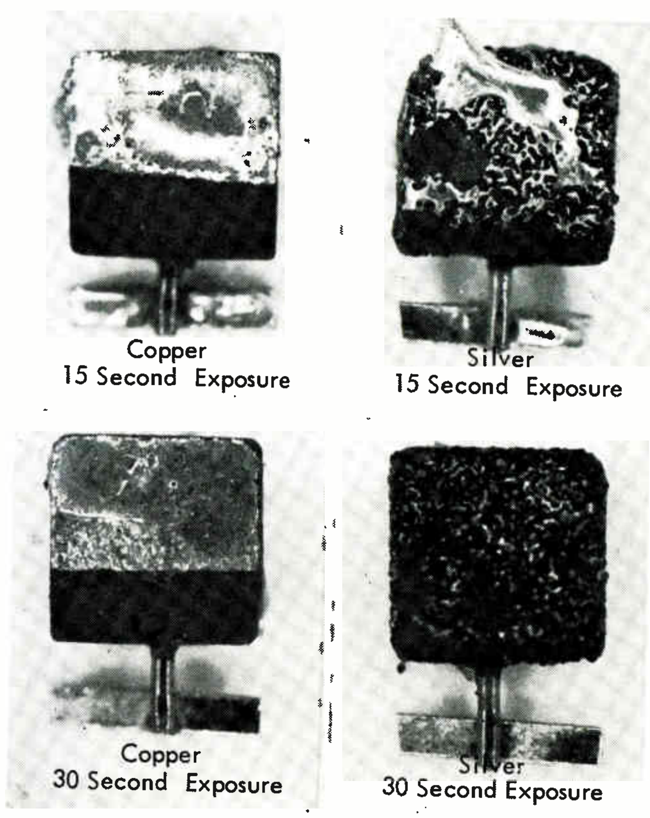
The capacitor user is normally concerned as much with cost as with reliability—not just the cost of the component as delivered, but in-place on the hybrid substrate. Here, the key is automatic handling, and for tantalum chips the approach differs slightly from ceramic capacitor methods.

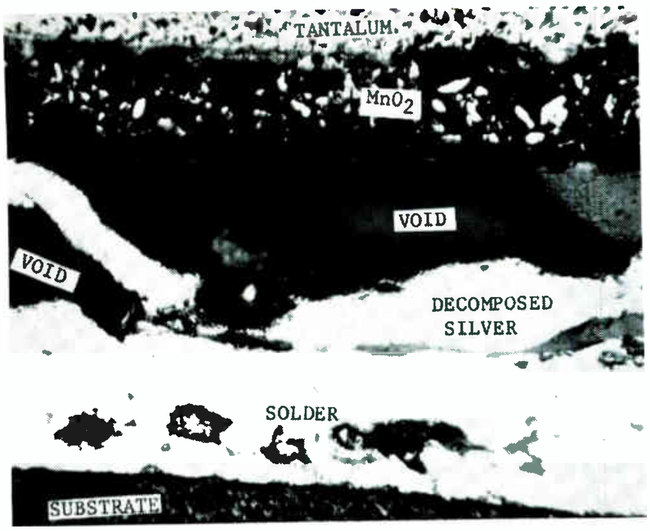
For ceramic chips a vibratory bowl feeder and chute are enough to establish the position and orientation of the device, and the programed motion of say, a vacuum head, positions the chip correctly on the substrate.

However, with tantalum chip capacitors, polarity is important, and a simple vibratory feed won't guarantee the right orientation—specially designed component carriers, like the tantalum chip carriers shown in Fig. 6, must be used, that take advantage of the position of the nickel tabs on the chips. By programed motion of the carrier, the chips can be brought in sequence to a given location and there transferred to the substrate by a vacuum head (Fig. 3). This last step—transferring the part from a given location to the substrate—is the same for both ceramic and tantalum chips.

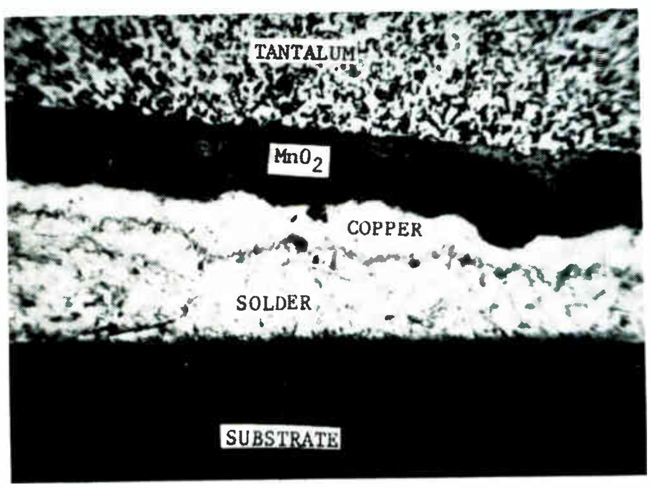
At Union Carbide, a system has been developed for placing tantalum chips on hybrid substrates at a rate of 30 per minute. On command, the vacuum head lowers and places a chip on a prepositioned substrate. The vacuum head then returns to the carrier, picks up the next chip in sequence, and remains poised above the substrate awaiting the next command. It repeats these motions until all carriers have been emptied. If for any reason it fails to pick up a chip, it will automatically recycle.

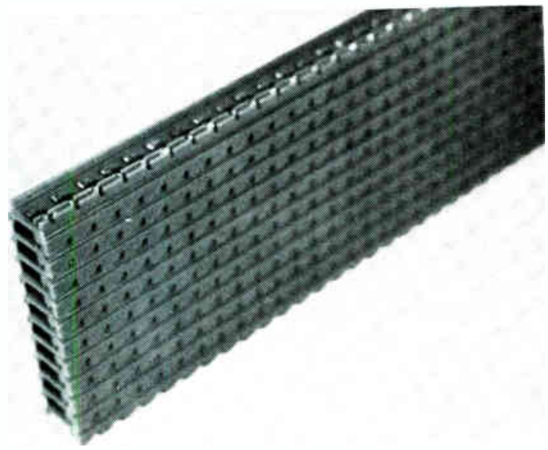
4. Into solution. Electrodes made of silver paint dissolve rapidly in molten solder, whereas copper electrodes are essentially unaffected.

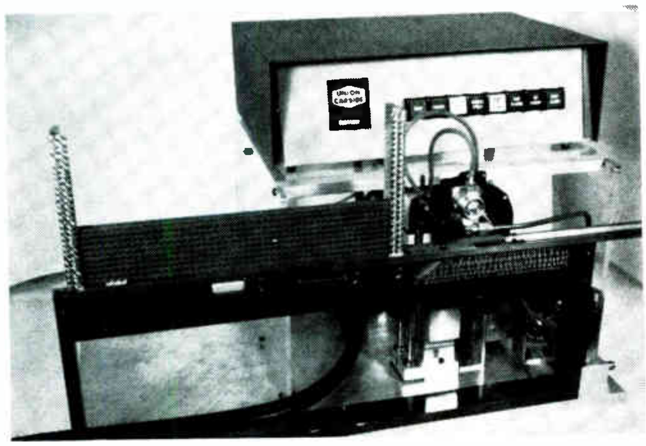




5. Thermal resistance. Lower portion of tantalum chip capacitor is immersed in molten solder. Silver coating on chip degrades at 225°C after only 5 minutes. Copper coating has full integrity after 10 minutes at 250°C.







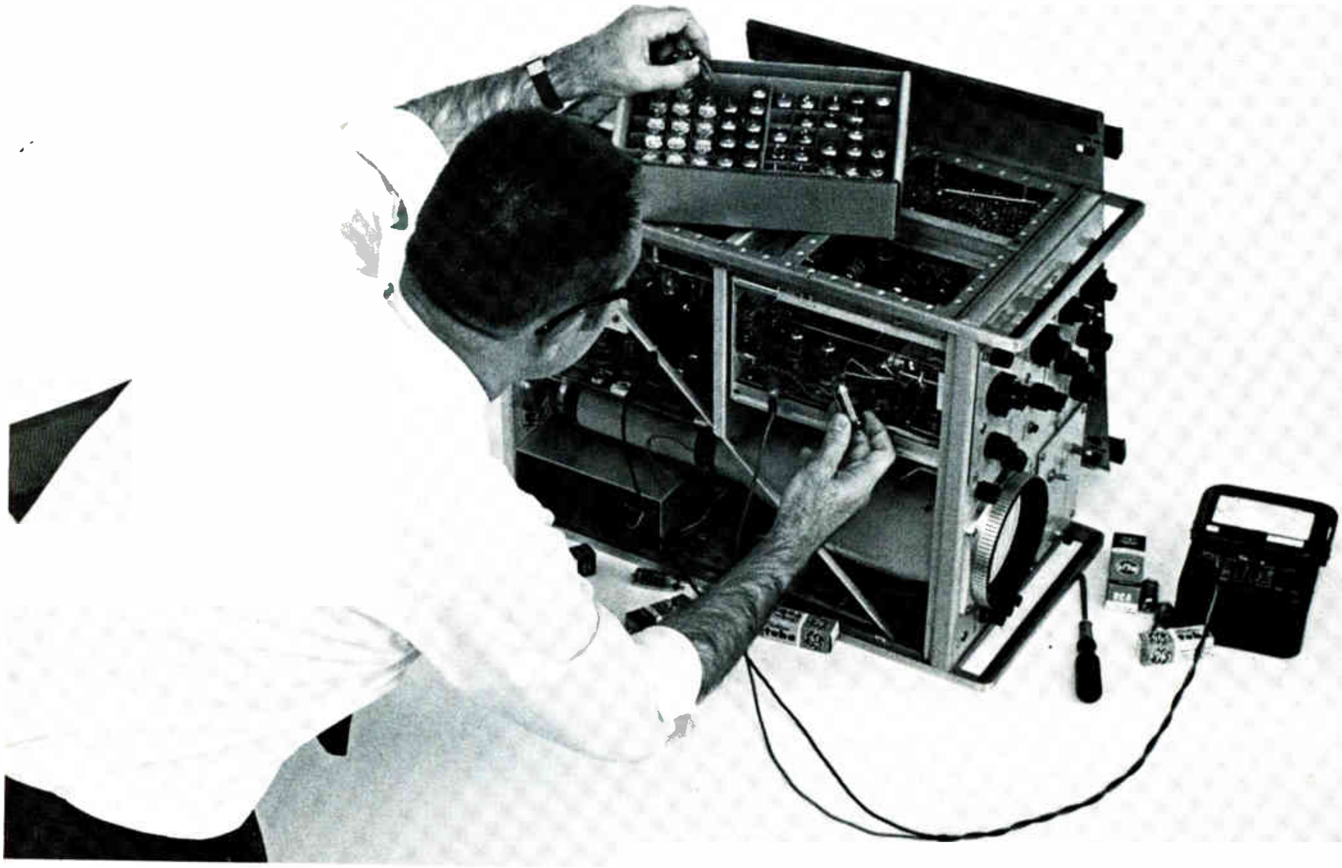
6. Carrier and dispenser. Position of tantalum chip is defined by its index tab and maintained by arrangement of slots and index teeth in the carrier (top). As the carrier is moved by the dispenser (bottom), it brings each capacitor in sequence to the right position for placement on the substrate. The dispenser is programed to place, on demand, 30 tantalum chips a minute on the hybrid substrates.

In addition to the "general-purpose" type designed primarily for thick film substrates and volume users, tantalum chips can be made in a variety of configurations. An example is a disk-type tantalum chip with gold lands for attachment of flying leads, intended for compact, thin film hybrid circuits.

But regardless of their configuration, the various unencapsulated chip forms have certain characteristics in common. First, they are thin film devices and require some care in handling, which the carrier and automatic handling system already described are specifically designed to provide. But if the devices have to be manipulated by hand, they should be picked up by the body with a vacuum pencil or nonmetallic tweezers.

Second, although all tantalum capacitors not hermetically sealed will show a slight variation in capacitance when subjected to moisture, chips show a faster rate of change of capacitance and stabilize sooner than plastic encapsulated devices. Whereas a typical epoxy molded unit may take 50 to 100 hours to become stable after a large change in relative humidity, an equivalent chip capacitor will require only 5 to 10 hours. An excursion of a few percent in capacitance must be expected with extreme changes in humidity.

Third, though an entire hybrid circuit is often packaged by plastic encapsulation or conformal coating, the choice of materials usually disregards the special needs of the tantalum capacitor. For satisfactory capacitor performance, the encapsulating material should be as free as possible of ionic contaminants, which can create electrical leakage paths, and it also should be selected to minimize mechanical stresses after curing and during temperature excursions. Alumina, barium titanate, silicon and tantalum have similar coefficients of thermal expansion that are much smaller than those of most encapsulants. Materials which remain flexible throughout the operating temperature range should be used, or, as a second choice, resins filled with low-expansion additives to reduce the apparent coefficient of expansion. □



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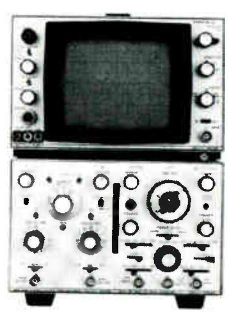

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Designer's casebook

Avalanching transistors speed up high-voltage pulses

By Erwin A. Jung
Argonne National Laboratory, Argonne, Ill.

Many amperes of charging current are required to develop a pulse of a couple of hundred volts across a load with a capacitance of 100 picofarads in only a few nanoseconds. It's difficult to find such pulsers even though they're often necessary in such applications as nuclear instrumentation, cathode ray tube deflection, and photomultiplier tube drivers. However, teaming up a vacuum tube and transistor provides a variable pulse of 200-400 volts with rise and fall times of 30 ns.

In the circuit, the load represents the dynode of a photomultiplier that is to be turned off during an intense illumination of its photocathode. The dynode impedance looks like about 25 kilohms paralleled by about 10 to 20 pF.

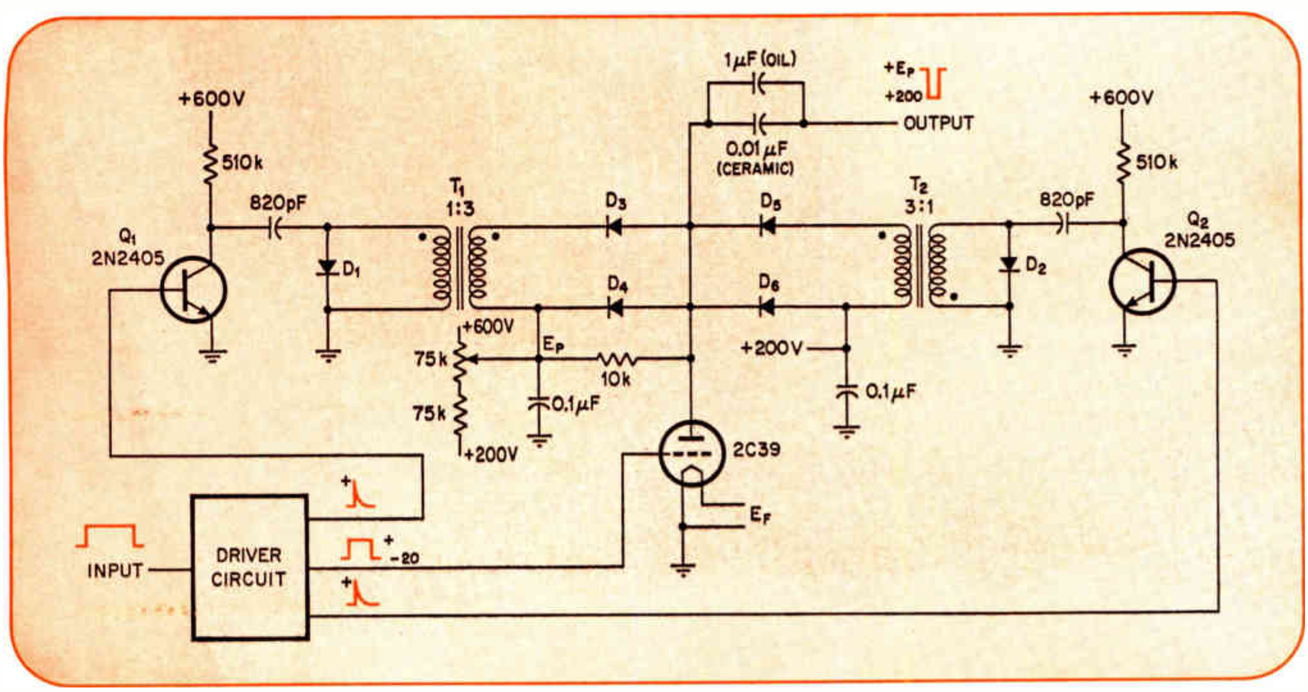
The 2C39 tube is biased at cutoff until the input blanking pulse appears; the tube then begins to conduct. The input pulse also is applied to the base of transistor Q_1, which goes into an avalanche mode. If the tube were acting alone, it would deliver an output pulse, but not fast enough. The avalanche-mode transistor helps speed things up. When the transistor avalanches, it produces a pulse that would reach 600 V at the output of step-up transformer T_1, if the plate voltage were not clamped at 200 V by diode D_6. This high-current, negative-going pulse provides fast charging of the load capacitor (through D_3, the transformer secondary, and then to ground through the filter capacitor on the E_P supply).

During the flat-top portion of the input, the tube serves to clamp the plate voltage at 200 V. The larger output coupling capacitor prevents droop in the output; the smaller assures fast rise and fall times.

At the trailing edge of the input pulse, the opposite occurs: transistor Q_2 avalanches and supplies a positive pulse at its secondary. (Note that the windings have reverse polarity.)

Diodes D_1 and D_2 prevent possible collector triggering of Q_1 and Q_2. Each of the six diodes (D_1-D_6) actually consists of six IN4148s in series. A Q_1 and Q_2 are selected for avalanche voltage greater than 250 and avalanche current greater than 20 milliamperes. Each transformer consists of 10 and 30 turns wound on ferrite toroidal cores. As shown, the circuit can handle a 2-kHz repetition rate at a 1% duty cycle.

Team work. Vacuum tube-transistor combination gives pulses of 200 to 400 volts with rise and fall times of 30 nanoseconds. Input pulse turns on the tube and drives Q_1 into avalanche mode. High current pulse charges load capacitor through T_1 secondary to provide a fast rise time. Similar action assures a fast fall time.



SCR crowbar circuit protects Impatts

By J. Nigrin
University of Alberta, Edmonton, Canada

A sudden surge of current to an Impatt diode from its bias supply can burn it out. Usually, commercially available power supplies don't react fast enough to prevent such damage. Although a resistance higher than about 10 kilohms placed in series with the bias supply would help, it also would degrade an Impatt oscillator's performance. A better solution is to use an inexpensive SCR crowbar circuit that senses the current change and shunts the current around the Impatt before any damage is done due to excessive junction heating.

In the circuit, the bias current is sensed by R_0. If it increases, speed-up capacitor C_s assures that this change quickly fires the SCR. Resistor R_2 sets the voltage and R_1 sets the current, at which the SCR turns on. Since both these resistors influence the SCR gate current, they must be adjusted by a trial method.

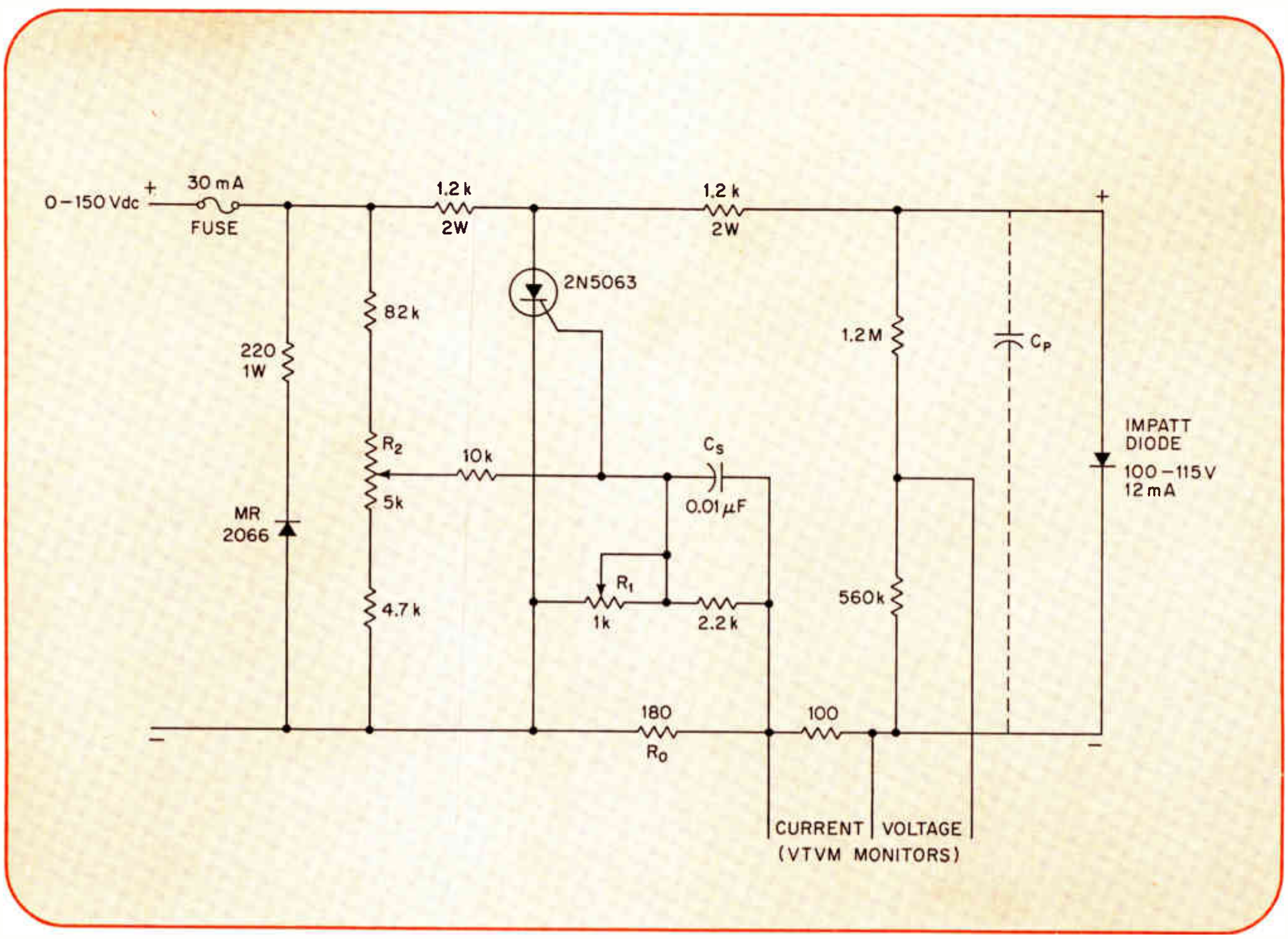
The sensing resistor R_0 can be as much as a few thousand ohms since the output impedance of the bias circuit for Impatts should limit the peak current to a value a few times larger than its maximum dc value.

The circuit uses a 90-cent 2N5063, which will switch off less than 1 microsecond after the output leads have been shorted. A single 0.2-μs current pulse through the sensing resistor, with an amplitude 1.5 times larger than the switch-off current value, will switch the supply from 110 volts at 10 milliamperes to 0.5 V in less than 0.4 μs after the leading edge of the current pulse.

The MR2066 SCR shorts the crowbar input terminals if incorrect polarity is applied to the circuit. The fuse at the input is not really necessary, since the voltage drop across a fired SCR is safe enough (about 0.5 V to 1.5 V) to be handled by the Impatt. However, the fuse does offer extra protection, and requires that the user identify the trouble before replacing it.

The bias-lead capacitance, C_p, should be kept to a minimum because it will discharge directly through the diode. As such, it's best to mount the crowbar circuit inside the oscillator housing.

Blowout-proof. The Impatt diode is protected from current surges by the SCR. Resistor R_0 senses any sudden change in current and couples the surge to the SCR gate through C_s. When the SCR fires, the Impatt voltage drops from about 110 V to 1 V in a fraction of a microsecond. The MR2066 diode assures correct polarity for the Impatt.



Wien bridge oscillator needs only one op amp

By P.C. Lipoma
Lockheed Electronics, Houston, Texas

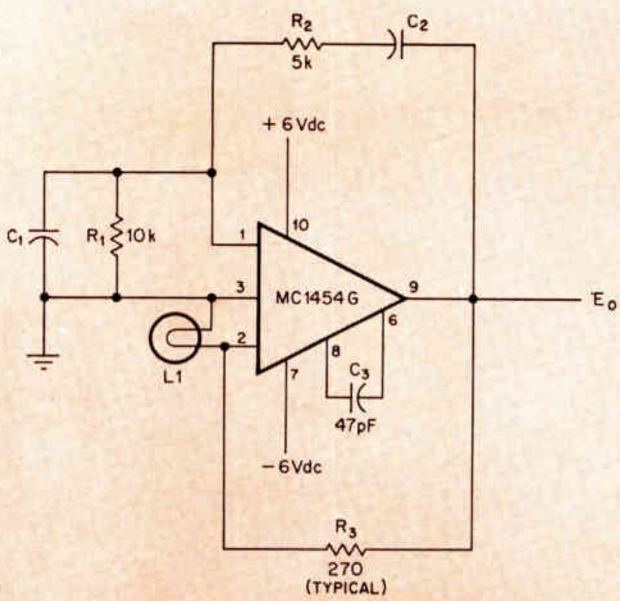
A simple Wien bridge oscillator, with good drive capability, can be built round a single operational amplifier for a cost of less than $5. The circuit consumes little power, and drives both low impedance and highly capacitive loads with low distortion.

The operational amplifier used can drive 8- and 10-ohm loads, and provides an output of from 2 to 8 volts peak-to-peak across a 10-ohm load. Its harmonic distortion is typically less than 0.5% over a frequency range of 1 hertz to 100 kilohertz.

Automatic gain control is provided by the lamp, L_1, which varies in resistance with changes in the output voltage. Resistor R_3 provides the required negative feedback, and, to a limited degree, determines the output signal amplitude. Capacitors C_1 and C_2 form the reactive portion of the positive feedback loop, and are set equal in value. Resistor R_1 is selected so that it's equal in value to the input impedance of the amplifier, while R_2 is half that value (R_1 shunted by the amplifier input impedance). Since both the series and the parallel capacitors and resistors in the positive feedback loop are equal, the frequency of oscillation is simply $1/2\pi R_2C_1$. High-frequency compensation is provided by capacitor C_3.

To turn this circuit into a signal generator, the only addition necessary is a switch section, to alter the values of C_1 and C_2.

Compact. The single-stage Wien bridge oscillator delivers stable output frequencies from 1 Hz to 100 kHz across loads as small as 8 ohms. The lamp, L_1, provides automatic gain control by changing its resistance as the output signal amplitude varies. The chart details the values of C_1 and C_2 required for circuit oscillation at specific frequencies.



FREQUENCY	C_1, C_2
1 Hz	33μF
100 Hz	0.33μF
500 Hz	0.065μF
1 kHz	0.033μF
10 kHz	3,300pF
50 kHz	650pF
100 kHz	330pF

ALL CAPACITORS ARE NON-POLARIZED

L1 = #80 (LAMPS INC. OF GARDENA, CALIFORNIA)

Sequential gate won't chop odd-length pulses

By Björn Kruse
Stockholm, Sweden

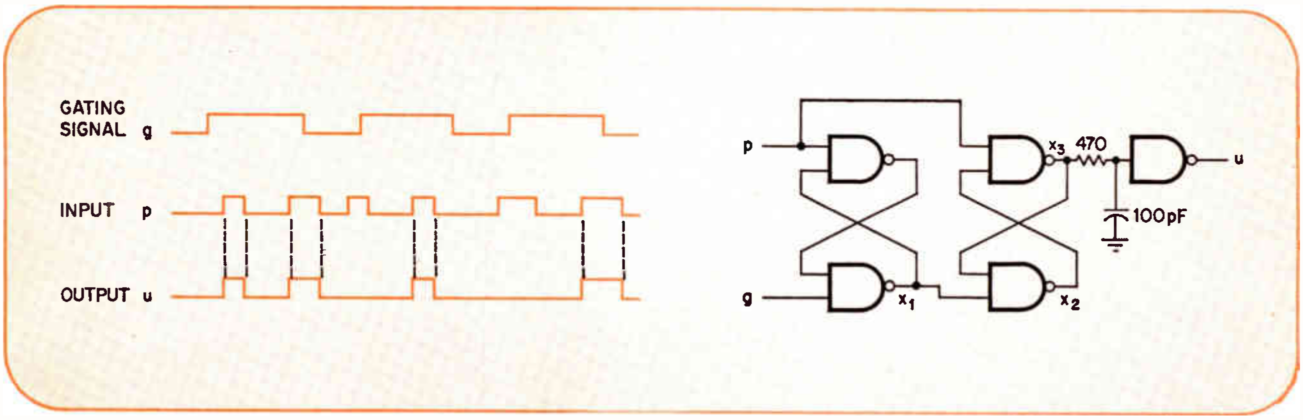
Digital systems that use varying pulse lengths require a gating circuit that won't transfer any part of a pulse unless it is enabled to transfer the whole pulse regardless of the state of the gating-control signal. The gate should turn on before a pulse arrives and not turn off until after it passes through completely.

This type of application calls for an asynchronous, sequential circuit. Fortunately, enough logic to do the job is contained in a quad NAND gate—one integrated circuit package. Connected as two flip-flops, the quad gate meets all the criteria except that it complements the data. An inverter—one-sixth of an IC—makes the output true.

The first flip-flop is reset to $X_1 = 0$ only if pulse $P = 0$ and gating control $G = 1$. With $X_1 = 0$, the second flip-flop is set to $X_2 = 1$. When X_2 is in this true state, $X_3 = 1$ also, unless both P and G are true. Then, X_3 is false, but the data appears at output U.

On the other hand, suppose $P = 1$ and G drops to logical 0. Since $X_3 = 0$ from the previous input, X_2 is still 1. Not until P drops to 0 can X_3 return to 1 and make output U drop to 0. Now the second flip-flop is reset to $X_2 = 0$, so that no pulse can appear at the output unless the first flip-flop is reset.

Door, not gate. Instead of simply gating a pulse train on and off, the circuit lets the pulses hold the gate open. The gate must be enabled before a pulse arrives to transfer a pulse; once enabled, the circuit will not be disabled until a complete pulse is transferred. If used with relatively slow circuitry, the R-C network isn't necessary.



One-shot saves power without losing time

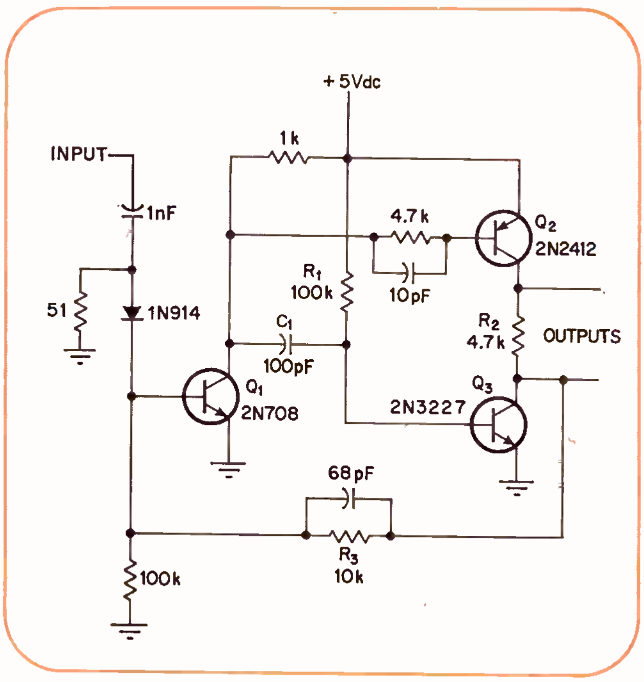
By C.H. Doeller 3rd and Aaron Mall,
Communications division, Bendix Corp., Baltimore, Md.

About 99% of the power wasted by a conventional one-shot can be conserved by using a low-current design which also offers the advantage of timing that does not depend on transistor beta. What's more, two low-impedance outputs are available, one with a positive-going and the other with a ground-going edge.

When a positive pulse is entered, transistors Q_1 and Q_2 turn on, and Q_3 is turned off through capacitor C_1. C_1 and resistor R_1 determine the time during which Q_1 is held on by Q_2 through R_2 and R_3. At the end of the timing cycle, Q_3 turns on again, turning off Q_1 and Q_2.

In the quiescent stage, Q_3 can't waste collector current because Q_2 is off. The only current that flows is that needed to keep Q_3 saturated at the desired load, reducing standby power dissipation to about 1% of the figure for a conventional one-shot.

Output pulse width is directly proportional to R_1C_1, sized here for 8.0 microseconds. Output rise times are less than 20 nanoseconds.



Very quiescent. The only current flowing in the one-shot's normal state is a low standby current through Q_3. Output pulse width is set by R_1 and C_1.

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

The use and misuse of cores to suppress digital system noise

Though ferrite cores are a convenient and inexpensive way of attenuating unwanted high frequency signals, they can compound the problem if not used properly

By Peter W. Grant, *International Business Machines Corp., Systems Development division, Kingston, N.Y.*

□ Ferrite cores are becoming increasingly popular for transient suppression in digital systems—an extension of their use in radio equipment, where small ferrite beads are strung on signal wires to keep noise away from sensitive areas.

However, they're often incorporated into a design on a go/no go basis: either they work or they don't. Worse, when misapplied, they may end up aggravating the problem they're meant to solve, and force the baffled design group to call in an electromagnetic compatibility engineer as a consultant. But if the circuit principles underlying the use of ferrite cores are understood, it's easy to apply them rationally and analytically.

In the role of noise suppressor, ferrites—ceramic ferromagnetic materials—are best thought of as circuit impedances. A ferrite core places a frequency-dependent impedance on a wire passing through its center, and the voltage drop created by the impedance attenuates signals in the wire. The process is more complicated, of course; the voltage drop idea is a condensation of waveguide theory and ignores microscopic magnetic effects within the ferrite. It is, nevertheless, a workable concept for design purposes.

A core may vary from less than ¼ inch in diameter and ¼ inch long, to up to 2 inches long. The impedance may be maximized by lengthening the core, reducing the diameter, or using more turns of wire; but it's not greatly affected by ferrite type, except that some types are more effective at the lower frequencies.

Above about 100 MHz, domain-switching reluctance in the ferrite produces an imaginary component of flux density. This imaginary component manifests itself as a resistance or a real impedance, but long lead wires or winding capacity can make the device look reactive and lower its impedance. If care isn't taken, the cores could, in combination with stray capacitances and other wiring, form an LC tank circuit that would greatly increase the noise on a line by permitting transients to induce ringing.

At low frequencies the effect of a few microhenries of wire inductance on the circuit is not very great. Usually, cores aren't too useful below 1 MHz.

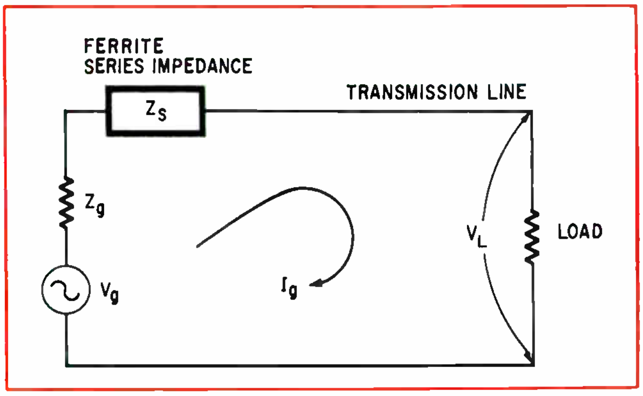
The principles of series impedance attenuation are illustrated by the simple, single-ended, closed-loop system shown in Fig. 1. In this case, the voltage across the load, V_L, is given by

$$V_L = \frac{Z_L}{Z_g + Z_s + Z_L}$$

where V_g is the generator voltage (the signal or noise), Z_g the generator impedance, Z_L the load impedance, and Z_s the series impedance of the wire and core. In a single-ended system, the return may be in the form of a network, with no common-point grounding and with no single identifiable element that totally contains the current I_g developed by the generator. When V_g and Z_L are parts of a larger system, the return line contains current from sources other than V_g, and such a system could no longer be considered single-ended.

The equation shows how the circuit parameters can in general be varied to adjust signal or noise voltages across the load. The higher the core impedance Z_s is, the lower the received voltage becomes. If V_g is a noise source and it is desired to minimize noise across Z_L, then Z_s should be increased and Z_L reduced. If V_g is a signal source and it's desired to maximize the signal, then Z_s

1. Attenuation. Impedance Z_s of ferrite core in a simple single-ended system reduces voltage across the load. If the wanted signal is at a high frequency, as is usually the case in the latest generation of digital systems, it will be attenuated along with the noise.



should be reduced and Z_L increased.

Signals are usually transmitted in the differential mode (DM), in which they are described by the voltage difference between a pair of wires. The current in one member of a pair must be equal and exactly opposite in phase to that in the other. DM transmission is favored over common mode transmission, which is similar to the single-ended circuit, because noise is generally common mode. Since use of a receiver for the transmitted signal that rejects CM signals ideally eliminates noise, DM transmission should suppress noise even without ferrite cores; but in practice, as this article will show, ferrite cores are still needed.

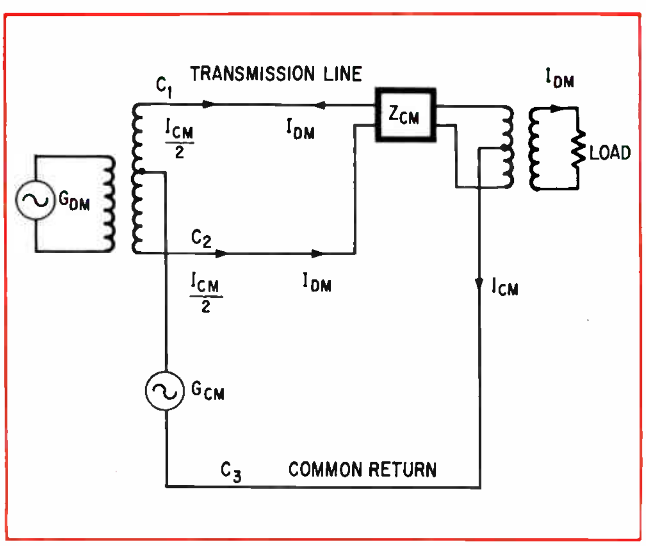
In the single-ended system of Fig. 1, the transmission line and the return line constitute a differential pair. In a typical system, however, the return current is divided among several elements or branches of a common return, no pair contains the total signal, and the arrangement is not a differential mode. Instead, the return elements comprise a CM system, in which the signal is common to two or more conductors.

The double-ended circuit in Fig. 2 is preferable to a single-ended circuit (Fig. 1) because it insures that the wanted signals are always transmitted differentially. Here, currents from the differential mode generator G_{DM} are contained only in lines C_1 and C_2, which constitute a differential pair. In addition, C_1 and C_2 carry common mode current from the common mode generator G_{CM}. The total common mode current I_{CM} is divided equally between C_1 and C_2, flowing in the same direction, and is returned by a common line, C_3.

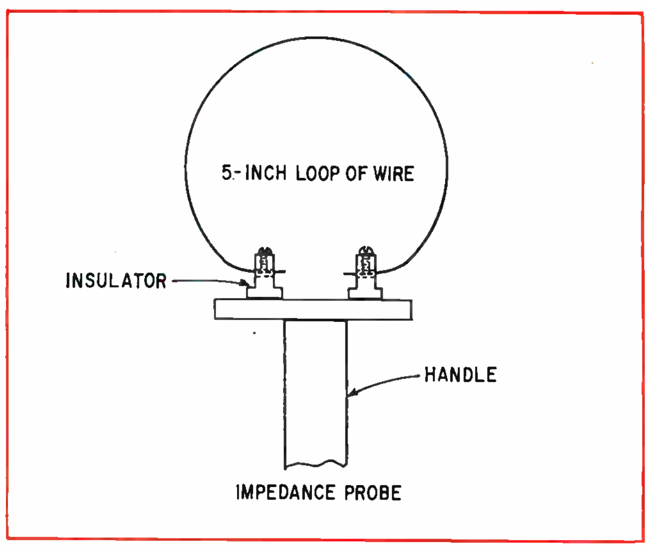
Unfortunately, there is usually some mode transfer in this arrangement—that is, conversion of noise from CM to DM, in which state it can be sensed—and this is where ferrite cores get into the act. Mode transfer, or conversion from common mode transmission to differential mode, and vice versa, results from imperfections in the transmission lines. Ideally, wire diameter and wire spacing are constant. In reality, small changes in dimension or proximity to other metals occur, adding more inductance to one of the wires. These variables produce a phase shift in the signal voltage, resulting in a real component and a quadrature component. A phase difference of only 1° in a CM signal along a pair of transmission lines induces a differential signal with 1/60 the CM amplitude on the pair. In this way, a 10-millivolt DM signal transmitted to a receiver having infinite common mode rejection could be completely hidden by mode conversion of an unwanted 5-volt CM signal on the same line, since 1/60, or 83 mV, would be converted to differential mode.

From a point on an external ground or return path, the voltages on the two wires can seem to have the same absolute value, but slightly different phase angles. This change creates a difference in the real components of the voltages, which becomes a DM signal. If the voltage on line C_1 is 1 V $\angle 0°$ and the voltage on C_2 is 1 V $\angle 1°$, which equals (0.99985 — j0.01745) V, then the resulting DM signal is the difference between these voltages, or (0.00015 — j0.01745) V = 0.017 V $\angle 89.5°$. An amplifier, even with infinite CM rejection, will see at least the 0.00015-volt real component, and may see part of the j component.

However, if a twisted pair carrying a DM signal is threaded through and wrapped around a ferrite core, any CM signal in the wires will be greatly reduced, whereas the DM signal will be unaffected, except by very small leakage inductance. Thus, if the transmission lines C_1 and C_2 in Fig. 2 were a twisted pair, and threaded through and wrapped around a ferrite core, represented by impedance Z_{CM}, the common mode current I_{CM} would be greatly reduced, but the load would see no change in G_{DM}. For CM signals, the twisted pair can be treated as a



2. DM and CM. In a double-ended system, a ferrite core (Z_{CM}) reduces unwanted common mode signals, but does not affect the wanted differential mode signal carried in the twisted-pair transmission lines, C_1 and C_2.



3. Testing. The values in the tables were measured with this impedance probe. Wire lengths ranged from 5 inches to 3 feet, and both a conventional ferrite core and a core specially designed for flat cable were used.

single wire. The propagation delay would be increased proportionally to the longer wire lengths required to wrap the core.

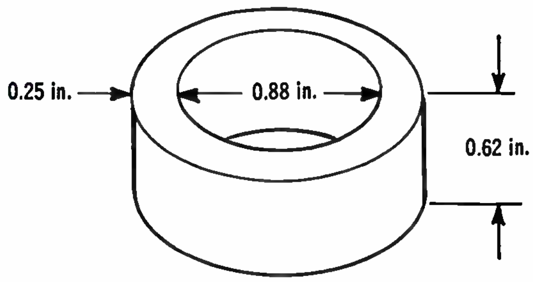
Currents traveling in the same direction at the same time (that is, the CM currents) are reduced in proportion to the number of turns on the core—though there's a limit to the effectiveness, for eventually the core-wire combination has less impedance than the wire alone. Differential mode currents, on the other hand, are affected only by the much smaller leakage inductances of the circuit. This is because the magnetic field produced by DM current in one wire of the pair is opposed by the field from the other, making the net DM field in the core zero, and preventing the core from seeing differential mode current.

As was mentioned earlier, the effect of a core is not predictable if a ground or part of the return network constitutes one lead of a twisted pair. In these circumstances, the core could, as intended, reduce ground loop currents, or it could suppress part of the desired signal. But if attention is paid to mode transfer and retaining the desired signal, the core will eliminate ground loops and not signals.

Tables 1 and 2 are intended to help the designer select a core of the proper size for an application, so as to eliminate both unwanted CM signals and ground loops. They list impedances for various combinations of wire length, core size and shape, wire

TABLE I

IMPEDANCE OF A WIRE PLUS CYLINDRICAL FERRITE CORE



5-inch wire, one turn:

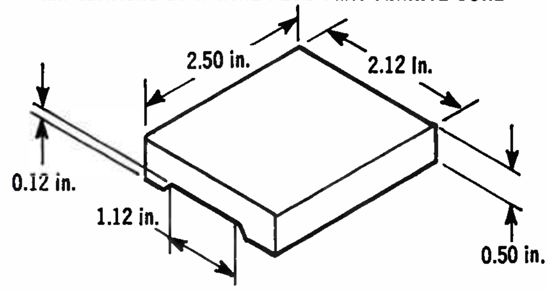
Frequency (MHz)	Z (Wire)		Z (Core & Wire)	
	Mag.	Angle	Mag.	Angle
0.5	0.6	+45°	11	+60°
1.5	1.2	+67°	14	+10°
4.5	3.4	+80°	12	+16°
13.5	10	+86°	16	+45°
35	25	+88°	32	+66°
108	82	+88°	92	+75°

12-inch wire, five turns:

Frequency (MHz)	Z (Wire)		Z (Core & Wire)	
	Mag.	Angle	Mag.	Angle
0.5	2	+75°	390	+60°
1.5	6	+83°	500	+ 8°
4.5	17	+88°	400	+ 2°
13.5	52	+88°	420	+14°
35	145	+88°	680	+18°
108	1,750	+82°	700	−64°

TABLE II

IMPEDANCES OF A WIRE PLUS FLAT FERRITE CORE



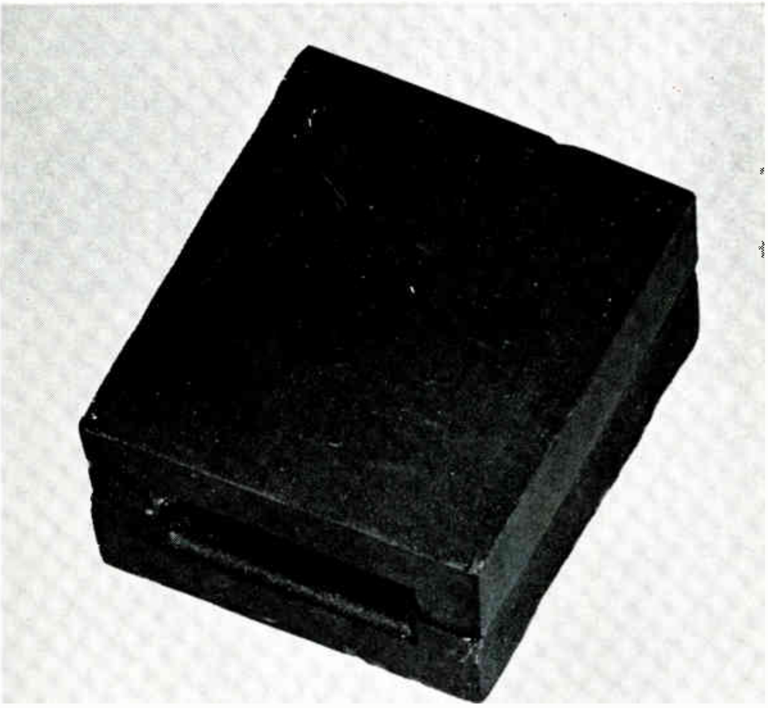
7-inch wire, one turn:

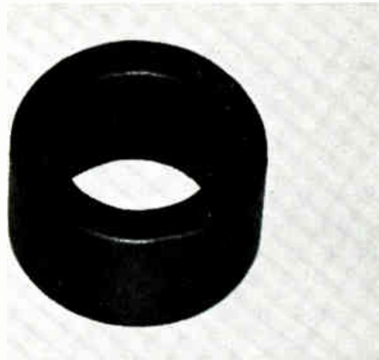
Frequency (MHz)	Z (Wire)		Z (Core & Wire)	
	Mag.	Angle	Mag.	Angle
0.5	0.8	+50°	15.5	+40°
1.5	2	+72°	19	+28°
4.5	5.6	+83°	25	+35°
13.5	16.3	+87°	42	+50°
35	43	+87°	78	+57°
108	150	+86°	210	+54°

3-foot wire, five turns:

Frequency (MHz)	Z (Wire)		Z (Core & Wire)	
	Mag.	Angle	Mag.	Angle
0.5	9.2	+84°	365	+40°
1.5	27.5	+88°	440	+25°
4.5	82	+88°	600	+25°
13.5	275	+88°	1,170	+12°
35	3,400	+83°	830	−70°
108	204	−90°	176	−85°

4. Core variety. Ferrite cores that suppress noise in digital equipment may be conventionally cylindrical, but the rectangular type at left was specially designed for use with flat cable.





turns, and frequencies. Table 1 gives such data for a cylindrical ferrite, and Table 2 gives similar data for a new type of flat ferrite core designed to be clamped around a flat cable.

The values in either table listed under the impedances of the wire alone and of wire plus core indicate whether or not the core is useful. In general, if the magnitude of impedance of the wire isn't increased when the core is added, it not only won't help suppress noise, it may actually make things worse. Thus in Table 1 the drop in impedance of the 5-turn 12-inch coil of wire noted at 108 MHz indicates that adding the core brings the resonant frequency of the combination below 108 MHz and, in this case, the coil alone would have better noise rejection than coil and core together.

The impedance measurements were made with the probe set up shown in Fig. 3.

An example will illustrate both the use of the tables and the general principles of noise minimization. A subassembly of a large electronic machine was found to be a serious generator of noise, causing failures in other parts of the machine. The first approach to correcting the condition was to put a metal shield around the subassembly, and to use feedthrough capacitors for all wires entering the shield. However, the capacitors proved to be unacceptable because they cut down on the speed of data transmission to the subassembly.

The data lines were then brought out of the box simply by passing them through a hole, without the feedthrough capacitors, and with a differential/mode twisted pair for each signal line. The external receivers for these pairs had very high common mode rejection—good to several megahertz, where CMR dropped to a low value. Most of the noise (and signal) was well above several megahertz, but still below 100 MHz.

So noise was still a problem. Low-pass filters on the receivers were not a solution because they, too, slowed the data rate. Moreover, the designer wanted to keep down the cost of the receiver amplifier. Accordingly, he placed round ferrite cores on the twisted pairs. As the requirement was that they provide a 10-to-1 reduction in noise level, each core had to provide at least ten times the CM impedance of the transmission-line receiver. From Table 1, a core with five turns has inadequate impedance when the CM impedance of the receiver is below 100 ohms, in the 13.5 to 108 MHz frequency range. So the cores reduced the problem but did not quite solve it.

Further investigation showed that the twisted pair did not constitute a true differential pair. Some of the information was carried on the system ground, and unwanted noise could easily be added to the signal after the receiver amplifier. To eliminate this noise path, the subassembly was suspended on insulators and kept at least 3 inches away from any other part of the machine to reduce capacitive coupling. In addition, all other wires in the system were run through cores to break the return path for CM noise. The core impedances on these other wires, added to the impedances of the cores on the twisted pairs, were enough to stop the noise problem. □

FET cascode technique optimizes differential amplifier performance

Low-cost FETs afford breakdown voltage protection, while common mode rejection ratio and other circuit parameters can be improved by a factor of 100 without closely matched bipolar transistors or expensive components

By D. C. Wyland, *International Business Machines Corp., San Jose, Calif.*

☐ The usual tradeoffs encountered in low-frequency linear circuit design often result in less-than-satisfactory overall performance. But a self-biasing cascode arrangement, in which an amplifier device is isolated from its load by a depletion-mode field effect transistor, offers an improvement factor of up to 100 in many critical performance characteristics without adversely affecting others. And best of all, the circuit can be constructed using an inexpensive, garden-variety FET.

In the cascode arrangement, the FET carries the burden of the breakdown voltage specification, while the amplifier device itself sees only the much lower operating gate-to-source voltage. The amplifier's output admittance and its feedback ratio in this stage are reduced by a factor equal to the mu of the cascoded FET.

The technique is based on the depletion-mode FET in a grounded gate circuit shown in Fig. 1. The n-channel junction FET, Q_1, is a depletion-mode device, so the source will be more positive than the gate if the current through the device is less than I_{DSS} (drain current with the gate shorted to the source). With signal current I_S on, the FET's gate-to-source voltage will stabilize at a potential between zero and pinch-off, usually 1 or 2 volts.

A feature of the grounded-gate FET circuit is its precise unity current gain. With only a few nanoamperes of gate leakage current, I_{GSS}, flowing through the gate electrode, nearly all the current from source I_S flows through Q_1 into the load resistor, R_L. The result: no error currents. The voltage appearing across the current source is equal to the 1 or 2 volts of operating gate-to-source voltage. But the output voltage appears between the drain and gate of Q_1; it's limited only by the drain-to-gate breakdown voltage of Q_1, which can be as high as 300 V.

Now it's evident that at the cost of introducing an error that is typically less than 1 part per million, the breakdown voltage applied to the current source, I_S, has been reduced to a few volts, while the voltage breakdown capability of the composite current source of I_S and Q_1 has been increased to the breakdown limit of Q_1.

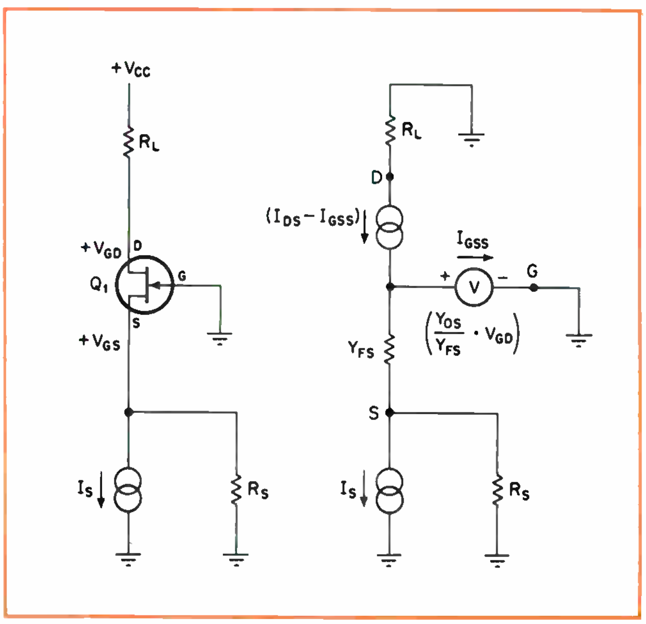
Another advantage is a reduction in the voltage change seen by I_S for a given change in output voltage. This reduction is expressed as

$$\frac{\Delta V_{GS}}{\Delta V_{GD}} = \frac{Y_{OS}}{Y_{FS} + \frac{1}{R_S}} \leqq \frac{Y_{OS}}{Y_{FS}} = \frac{1}{\mu}$$

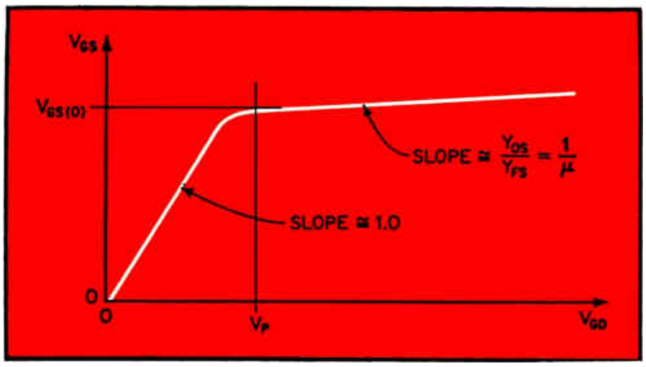
provided that $V_{DG} \geqq V_P$, where V_{GS} is gate-to-source voltage; V_{GD} is drain-to-gate voltage; Y_{FS} is forward transconductance; Y_{OS} is output admittance; R_S is signal current source output impedance $\mu = Y_{FS}/Y_{OS}$, and R_P is pinch-off voltage.

The reduction factor, $\Delta V_{GS}/\Delta V_{GD}$, compares with the ratio of the FET's output admittance to transconductance—typically a factor of 0.01. The result: the small-signal output impedance of the composite current source of I_S and Q_1 is at least 100 times larger

1. Protection. Basis of cascode technique is the grounded-gate FET. Current source I_S is isolated from supply voltage by FET Q_1. Operating gate-to-source voltage of Q_1 usually amounts to only 1 or 2 volts and only voltage change felt by I_S is $(Y_{OS}/Y_{FS})V_{GD}$ or V_{GD}/μ. FET's output voltage is limited by its breakdown characteristics and appears between the gate and drain of Q_1. Leakage current through FET, I_{GSS}, runs to only a few nanoamperes, so almost all the current from I_S flows through Q_1 and R_L.



2. Linear range. Characteristic of a typical FET shows that when drain-to-gate voltage, V_{GD}, falls below pinch-off voltage, V_P, gate-to-source voltage decreases and FET appears as a series resistance. If FET is to act as a linear device and perform desired isolation function, operation must be set at point where slope is $1/\mu = 0.01$.

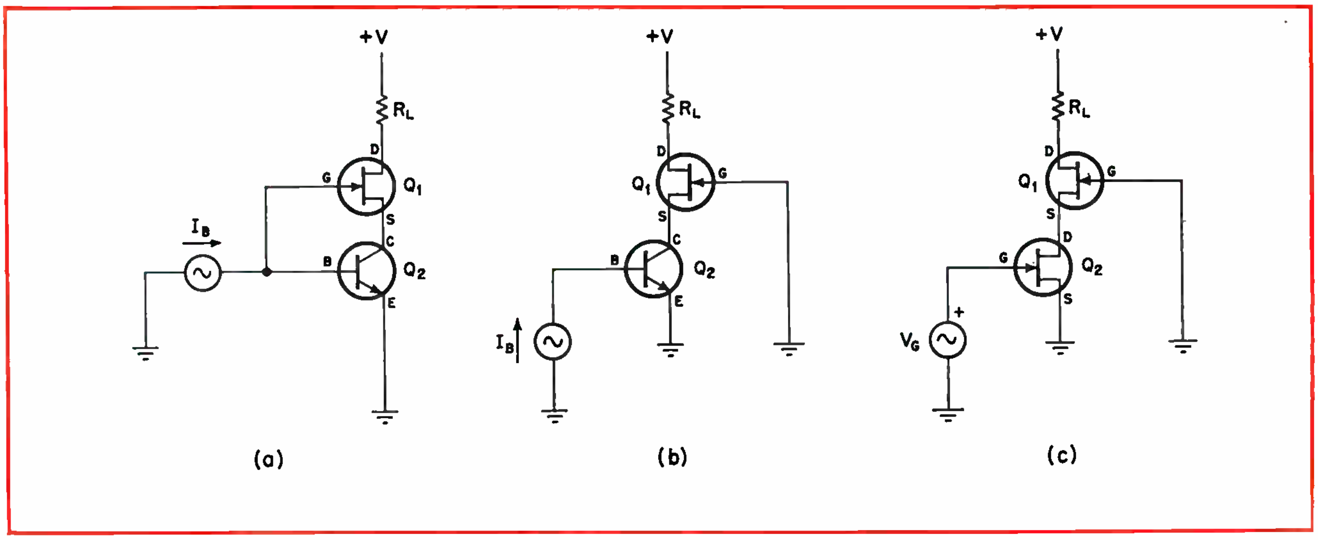


begins to look more like a switch than a linear FET, the improvement ratio will fall toward 1.

The FET cascode technique may be applied to bipolar transistors and FETs, as shown in Fig. 3. The quasi-cascode approach (Fig. 3a) applied to a bipolar transistor with the FET in the gate-base mode works for any combination of bipolar transistor and FET. However, the FET's rated I_{DSS} must exceed the maximum current passing through Q_2.

This method also can be used to improve the bipolar transistor's ac characteristics. Here the FET's gate-to-drain capacitance effectively replaces the bipolar's collector-to-base capacitance. The transistor's actual collector-to-base capacitance is reduced by an amount equal to $1/\mu$. This effect can be used in differential amplifiers to improve their high-frequency common-mode rejection ratio (CMRR).

Similarly, with the true cascode circuit (Fig. 3b) the bipolar transistor's ac characteristics are further



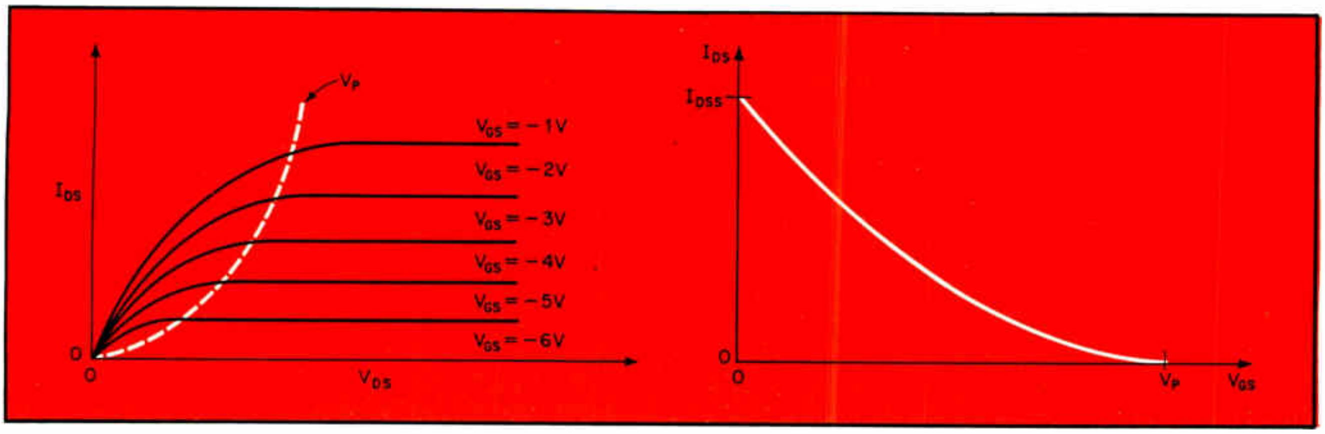
3. Three variations. Quasi-cascode circuit (a) has features of true cascode—bipolar transistor's output is isolated from load by FET. Dc characteristics of bipolar transistor are improved if I_{DSS} of Q_1 exceeds maximum current through it. Bipolar/FET configuration (b) is true cascode—it has grounded-emitter input and grounded-gate output. Collector-to-base capacitance of Q_2 is reduced by improvement factor, $1/\mu$, of Q_1, thereby improving bipolar's ac performance. FET/FET cascode (c) is similar to bipolar/FET cascode since equivalent terminals are connected in a like manner.

than that of I_S alone. If I_S is a FET or a bipolar transistor, the small-signal characteristics related to output voltage change, such as output admittance and feedback ratio, are effectively reduced by a factor of 100.

However, as indicated in the equations, a practical limitation does exist. The dc drain-to-gate voltage of Q_1 must at least equal the pinch-off voltage of Q_1 to achieve the small-signal parameter improvements shown in Fig. 2. If the output voltage falls below this value, Q_1 will enter the resistive region; and, as Q_1 improved, while the same dc improvements are provided in the gate-base model. Likewise, the effective collector-to-base capacitance of the bipolar/FET circuit is reduced as before. There's one consideration, however: Q_1 must be selected for a gate-to-source voltage larger than the emitter-to-base voltage of the bipolar transistor, Q_2, so that Q_2 does not saturate.

The quasi-cascode configuration provides a dc biasing advantage over its true cascode counterpart: in the quasi-cascode setup, any FET will work provided its I_{DSS} is equal to or greater than the current through the bipolar transistor (without considering the gate-to-drain voltage of the FET). In the true cascode circuit, the FET's gate-to-source voltage must be greater than the transistor's base-to-emitter voltage; otherwise the transistor will saturate.

On the other hand, the true cascode circuit offers an ac signal advantage over the quasi-cascode configuration, where a voltage swing across R_L can be coupled through the FET's gate-to-drain capacitance, causing current to flow in the transistor's base. High-frequency gain is reduced because the direction of



4. Finding a FET. Cascode FET for a FET/FET circuit is selected from transfer characteristic curves. Amplifier FET's operating current is chosen first; pinch-off voltage, V_P, then is determined from I_{DS}-V_{DS} curves. Since cascode FET's operating current equals amplifier's, V_{GS} of cascode FET is determined from its I_{DS}-V_{GS} curve; it should exceed pinch-off determined from I_{DS}-V_{DS} curves.

current flow is opposite to that of circuit current. In the true cascode circuit, high-frequency current between the FET's drain and gate flows directly to ground rather than to the transistor's base. What's more, adding the FET reduces the limiting effect of the collector-to-base capacitance of the transistor, resulting in improved high-frequency performance.

The FET/FET cascode circuit (Fig. 3c) is equivalent to the bipolar/FET cascode model. The gate of FET Q_1 is connected to the source of FET Q_2. Q_1's gate-to-source operating voltage should be equal to or greater than the operating pinch-off voltage of Q_2 to assure that Q_2 will remain in the pinch-off region.

In the FET/FET cascode setup, Q_1 can be selected for a given Q_2 by using the voltage-current curves of Fig. 4 (shown here for a typical depletion-mode junction FET). First Q_2's operating current is chosen according to overall circuit requirements, then pinch-off voltage is determined from the I_{DS}-V_{DS} curve. Since Q_1's and Q_2's operating currents are equal, Q_1's operating gate-to-source voltage is determined from the I_{DS}-V_{GS} curves using the value of I_{DS}. The resulting Q_1 gate-to-source voltage should exceed the previously determined Q_2 pinch-off voltage. (It usually will, if the specified maximum V_P or I_{DSS} for Q_1 exceeds those of Q_2.)

Applications, of course, are where circuit designs bear fruit. The differential amplifier circuit shown in Fig. 5 offers a good example. If the mu's of cascode FETs Q_{1A} and Q_{1B} are 200, and they are approximately as well matched as the mu's of the differential amplifier pair, Q_{2A} and Q_{2B}, the circuit CMRR will show an improvement of 40 dB. Even with a minimum amplification factor, (mu of 100 for Q_{1A} and 300 for Q_{1B}) and an initial match of Q_{2A} and Q_{2B} to within 5%, the improvement will be 14 dB.

In a second application shown in Fig. 5, FET Q_3 has been added to the matched-pair bipolar transistor current source Q_{4A} and Q_{4B}. The current source's output impedance is increased by as much as 100. What's more, another source of common-mode error—effect of common-mode voltage on differential amplifier operating current—is greatly reduced by this method.

If FETs Q_{1A}, Q_{1B}, and Q_3 are selected for high voltage (300 V), the differential amplifier can have a common-mode voltage range of ± 100 V with a CMRR typically 10 to 20 dB better than that from the Q_2 pair alone in a conventional low-voltage circuit.

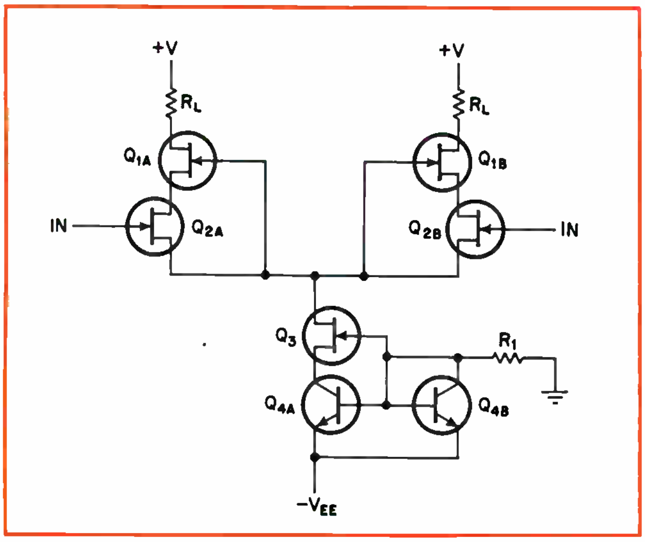
In Fig. 6 a second cascode stage—Q_{5A}, Q_{5B}, and Q_6—is added to the FET/FET cascode differential amplifier shown in Fig. 5. The result: an additional 40 dB of CMRR. However, if FETs Q_{1A} and Q_{1B} have been mismatched, some degradation occurs. Thus, the net improvement is 14 dB from the unbalanced Q_1 and 40 dB from the added Q_5 for a total gain of 54 dB in CMRR over the plain differential amplifier.

In this application transistor Q_5 must be so chosen that its operating gate-to-source voltage exceeds the pinch-off voltage of Q_1, as in the single FET cascode circuit (Fig. 5). In a typical high-voltage differential amplifier, Q_{5A} and Q_{5B} are high-breakdown-voltage FETs, usually with high pinch-off voltages. Thus, Q_{1A} and Q_{1B} are chosen as intermediates between FETs Q_5 and Q_2. Bipolar transistors can be substituted for the differential pair, Q_{2A} and Q_{2B}, with similar results. Enhancement-mode metal oxide semiconductor FETs also can be used in place of Q_{2A} and Q_{2B}.

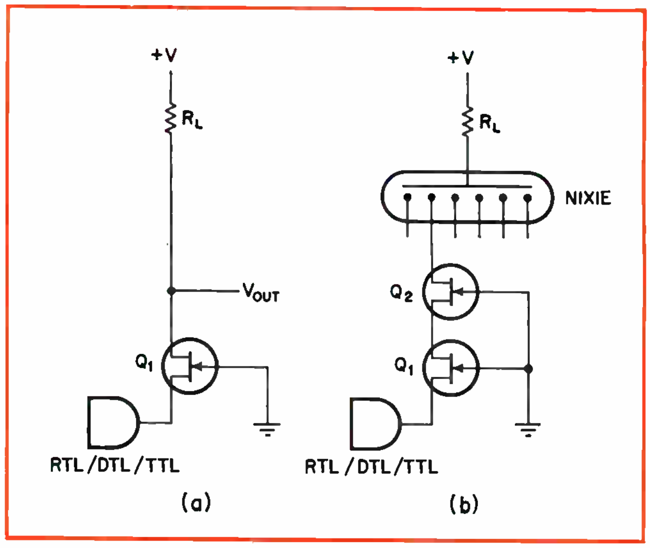
With this approach, the problem of closely matching transistors can be circumvented. But the improvement has its limitations. For instance, a typical bipolar pair has a CMRR of 80 dB. Add a pair of cascoded FETs and the CMRR climbs to 120 dB; with another pair of FETs it's 160 dB. But at this point, other considerations, such as stray capacitance, become limitations, so cascoded FETs cannot be added on indefinitely.

The level converter shown in Fig. 7a is a digital application of the FET cascode approach. Here, FET Q_1 is driven by the output of a logic gate and, in turn, drives a load referenced to a high-voltage supply. This arrangement can be used to interface straight logic with various power supply voltages simply and directly.

Another advantage in this application is that current flow through Q_1 is automatically limited to a value

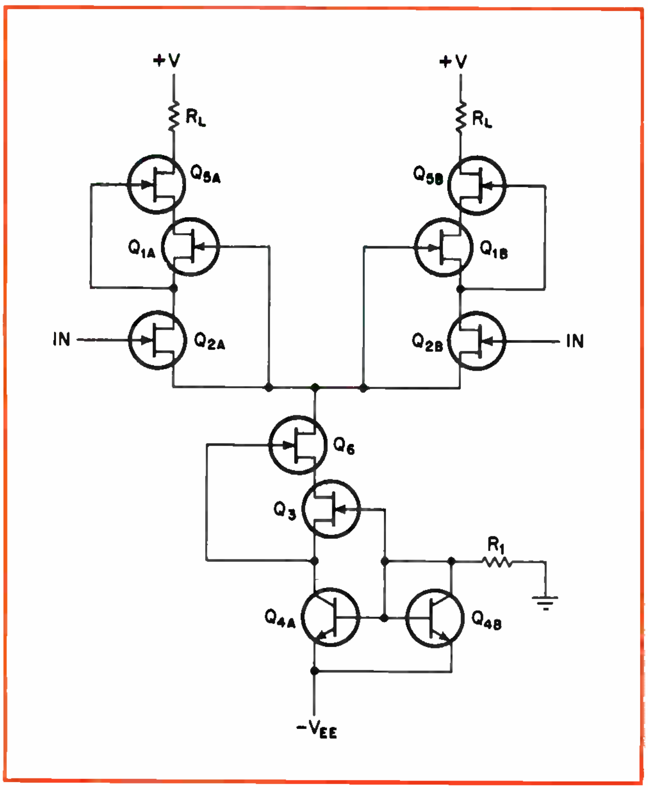


5. Cascode applied. Differential amplifier pair, Q_2, and cascode FETs, Q_1, form FET/FET cascode differential amplifier. Circuit shows significant improvement in CMRR over conventional amplifier. Adding FET Q_3 to matched pair current source Q_4 increases output impedance of Q_4 by a factor of 100. Even if Q_{1A} and Q_{1B} are unbalanced, CMRR still improves by an additional 10 to 20 dB.



7. Digital cascode. FET cascode circuit (a) is level converter that interfaces logic circuits with power supply voltages. Cascode arrangement eliminates high-current spikes and controls peak currents. A variation of this circuit can drive a Nixie tube (b). When logic gate is on, both Q_1 and Q_2 are on, and total resistance is sum of resistances of both FETs. FET Q_2 is a high-voltage type; Q_1 protects logic from high pinch-off voltage of Q_2.

6. Improvements. A second cascode stage, Q_5 and Q_6, improves CMRR another 40 dB. In this multiple FET/FET cascode circuit, Q_5 must be chosen so its V_{GS} exceeds the pinch-off of Q_1; the same is true for Q_6 and Q_3. Bipolar transistors or enhancement-mode MOSFETs can be substituted for Q_2 without affecting circuit performance.

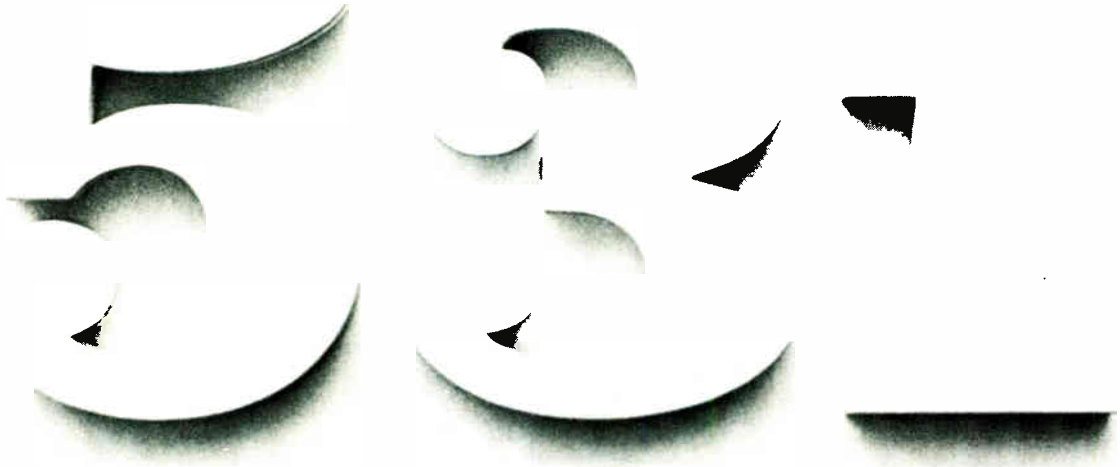


equal to I_{DSS}, useful in interface circuitry to eliminate high-current spikes and to control peak currents. The requirements on Q_1 are sufficient breakdown voltage, I_{DSS} larger than the expected load current, and V_p less than the off voltage of the driving gate.

The technique can also be used to drive a cold-cathode display tube such as the Nixie tube shown in Fig. 7b. Here the circuit calls for a second FET, Q_2, with a high pinch-off voltage. The circuit, in effect, is fail-safe—there is no secondary breakdown, but current limiting is available, an advantage over ordinary Nixie tube drivers. FET Q_1 interfaces between the gate and the high pinch-off voltage of Q_2. When the gate is on, both Q_1 and Q_2 are on; total resistance equals the sum of the on resistance of the two devices. Maximum current is determined by the device with the smallest I_{DSS}.

The cascode technique needn't be costly, even when performance requirements are demanding. For example, in a differential amplifier where the design specifications called for a CMRR of 120 dB and low drift, cost restrictions precluded use of expensive components and trimmer potentiometers. But the circuit requirements were met handily with a pair of 2N4340 FETs in cascode with a standard bipolar dual rated at 80 dB CMRR.

Equally successful was the application to a high-voltage design. With 2N4882s used as cascode FETs, the circuit's CMRR jumped from 94 to 136 dB over a frequency range of dc to 100 hertz. Common-mode voltage range—the maximum voltage that can be applied to the circuit to faithfully reproduce a signal—was improved from ± 20 V to ± 125 V, permitting amplification of small changes in a large voltage. □



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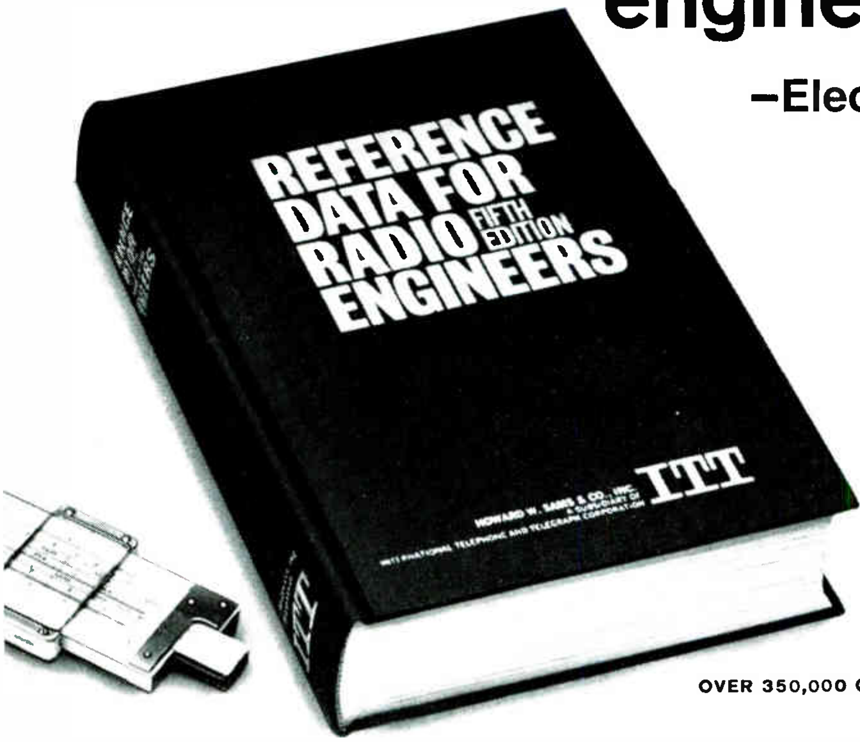

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SINGLE OUTPUT	LXS-B-5-OV	5±5%	5.8	5.0	4.0	3.0	$125
DUAL OUTPUT	[1] LXD-B-152	±15 to	1.6	1.4	1.2	0.7	150
		±12	1.4	1.3	1.1	0.6	

single output
$150
5 volts at 9.0 amps with overvoltage protection built-in

dual output
$160
±12 to ±15 volts at 2.5 amps each

TYPICAL C PACKAGE MODELS	Model	Voltage VDC	Max. Amps. at Ambient of: 40°C	50°C	60°C	71°C	Price[2]
$3\frac{3}{16}" \times 4\frac{15}{16}" \times 9\frac{3}{8}"$							
SINGLE OUTPUT	LXS-C-5-OV	5±5%	9.0	8.0	6.8	5.3	$150
DUAL OUTPUT	[1] LXD-C-152	±15 to	2.5	2.3	1.9	1.5	160
		±12	2.0	1.8	1.5	1.2	

Other models available in:
Single output wide range models
0-7, 0-18, 0-32, 0-60, 0-120 volts—up to 4.5 amps
Single output fixed voltage (±5%) models
5, 6, 12, 15, 20, 24, 28, 36, 48, 100, 120, 150 volts—up to 9 amps

NOTES: (1) Only one overvoltage protector accessory is required for both outputs on LXD series power supplies.
(2) Prices are USA list prices only. FOB Melville, N.Y.; North Hollywood, Calif.; Montreal, Canada. All prices and specifications are subject to change without notice.

Outputs
Single and dual tracking output models

Wide range and fixed voltage models
up to 150 Vdc, up to 9 amperes

Regulation
LC Series: 0.01% + 1 mV line or load
LX Series: 0.1% line or load

Ripple and noise
LC Series: 250 μV RMS; 1 mV pk-pk
LX Series: 1.5 mV RMS; 5 mV pk-pk

Wide input voltage and frequency range
LC Series: 105-132 Vac, 47-440 Hz
LX Series: 105-132 Vac, 47-440 Hz

Wide temperature range
LC Series: −20°C to +71°C
LX Series: 0°C to +71°C

Temperature coefficient
LC Series: (0.01% + 300 μV)/°C external programming resistor
(0.015% + 300 μV)/°C internal programming resistor
LX Series: 0.03%/°C

Convection cooled
no heat sinking or forced air required

Remotely programmable
LC Series: 1000 ohms/V nominal or volt/volt
LX Series: 200 ohms/volt, nominal

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to full performance specifications, includes parts and labor

Other LX/LC single output, fixed voltage models available: up to 150 Vdc, up to 9 amps.

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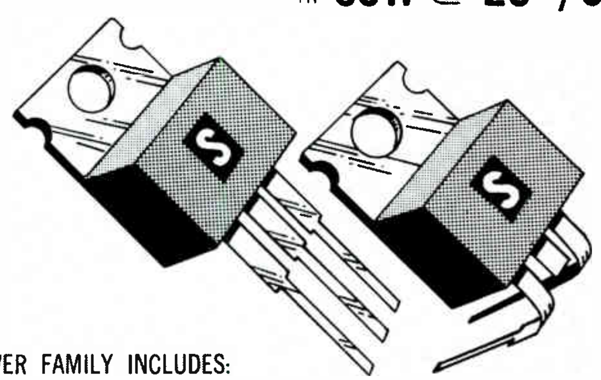

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SPP102	60V	10 min.	5.0A	3.0V	60W
SPP103	50V	15 min.	5.0A	2.5V	60W
SPP104	40V	15 min.	5.0A	2.0V	60W
2N5490	40V	20-100	2.0A	1.0V	50W
2N5491	40V	20-100	2.0A	1.0V	50W
2N5492	55V	20-100	2.5A	1.0V	50W
2N5493	55V	20-100	2.5A	1.0V	50W
2N5494	40V	20-100	3.0A	1.0V	50W
2N5495	40V	20-100	3.0A	1.0V	50W
2N5496	70V	20-100	3.5A	1.0V	50W
2N5497	70V	20-100	3.5A	1.0V	50W
2N5293	70V	30-120	0.5A	0.1V	36W
2N5294	70V	30-120	0.5A	0.1V	36W
2N5295	40V	30-120	1.0A	0.5V	36W
2N5296	40V	30-120	1.0A	0.5V	36W
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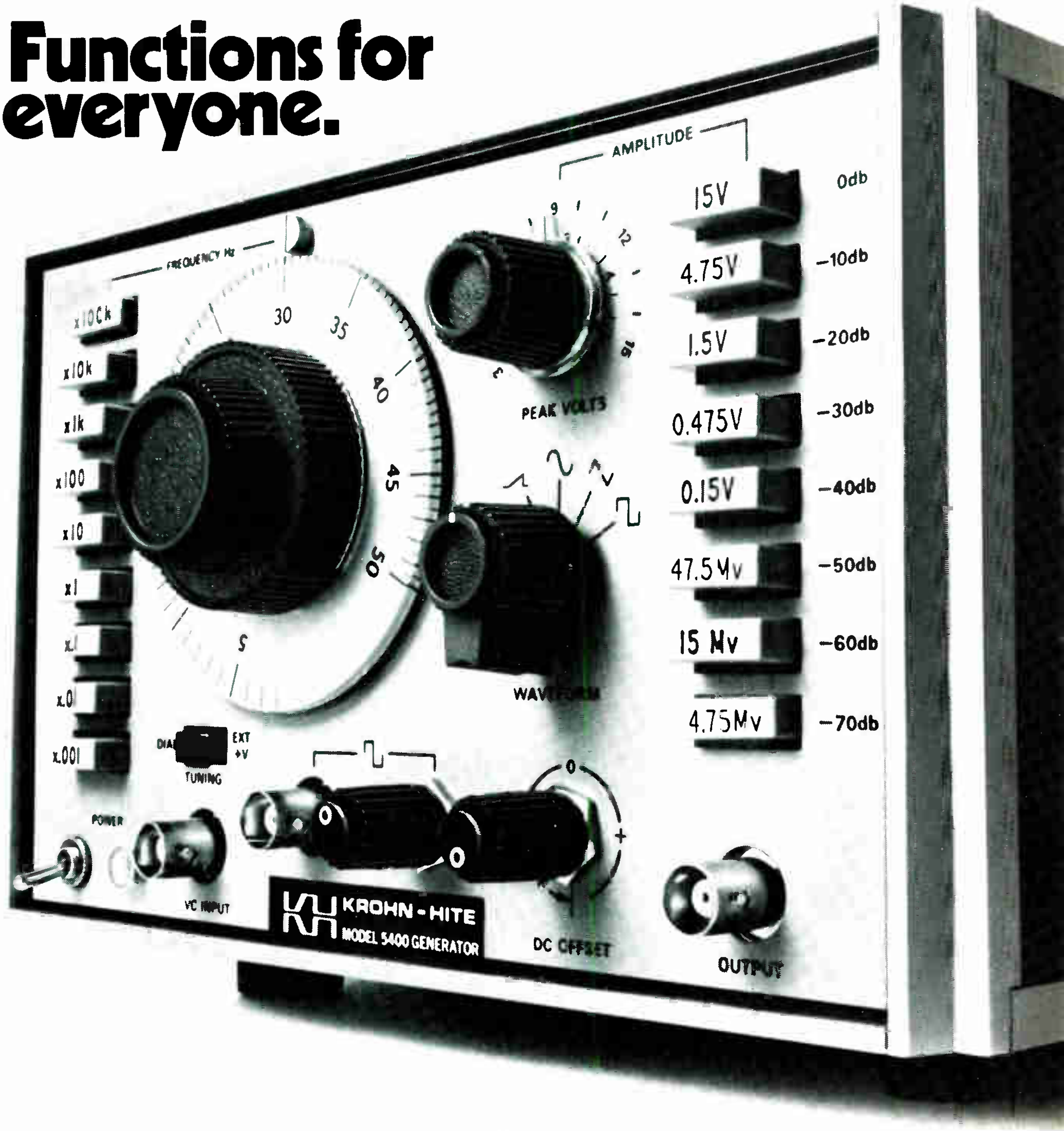

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CAD grows up—fast

Designing custom LSI depends more and more on the computer, but the engineer is still crucial in the design loop

by Lawrence Curran, Los Angeles bureau manager

As computer-aided design usage becomes more widespread, hardware and software limitations have surfaced that show the computer is no panacea. A man still must be plugged into the loop to do layout work that can't be translated into software.

There's no question that CAD has proven it's the only way to go for fast design turnaround in custom LSI—10 to 14 weeks, instead of six months. Yet, since it is a relatively new tool, CAD has plenty of room for improvement. Companies still have to decide on the best method of mask preparation. And service charges for CAD work haven't changed much—they are still high, partly because the expensive facilities required are a long way from paying for themselves. CAD investments range from $250,000 for in-house work to $5 million or more for custom services. Yet companies haven't hesitated to spend the money—CAD is simply too essential a design tool.

"We couldn't be in the custom circuit business without CAD," sums up Howard Bobb, president of American Micro-systems Inc., Santa Clara, Calif. "We need it as an assist, but anyone who depends totally on it can't really be in the business, either." And W.W. Vallandigham, AMI's senior vice president, adds, "If we want minimum size in a volume-production chip, we use our CAD facility as an assist, but we can reduce the chip size by 20% to 40% with human layout."

Putting people back into the loop represents the biggest change in CAD philosophy to emerge with the vendor's maturity, notes Richard Perrin, manager of MOS/LSI design engineering at General Digital Corp., Santa Ana, Calif. "Vendors realize they can't depend on the computer to do the whole design. They first thought the computer could do everything. But this change in philosophy has meant more efficient chip layouts to the user because the man can interface with the machine to get better cell placement," he says. Himself a former CAD user, Perrin was manager of array design at Viatron Computer Systems Corp., Bedford, Mass.

The way in which designers or customers interact with the software can vary. At Texas Instru-

National's CAD route

With its emphasis on standard products rather than custom work, National Semiconductor Corp., Santa Clara, Calif., has a different view of CAD than many of the other semiconductor manufacturers. Floyd Kvamme, microcircuit product manager, emphasizes that "we're a component manufacturer, not a computer house, so we'd rather buy our CAD service outside. We think it's wiser for us to spend the money that might go into a CAD facility on component development, as long as the CAD tools are available outside."

National began working with Macrodata Co. in Chatsworth, Calif., last spring, using that firm's topographical LSI system, and also is working with other CAD companies on the San Francisco Peninsula. Most of its experience to date, however, is with Macrodata.

In the National-Macrodata setup, designers at National create a composite of the chip, usually 400X, and composite data is digitized and checked out by Macrodata for any gross digitizing or format errors. When National corrects the errors, Macrodata does a drum plot containing either its own shorthand symbols for features such as metal lines, transistors, feedthroughs or output pads, or a dimensioned composite. The symbols allow a circuit feature to be located and described simply. National prefers to use the dimensioned composite, which is then overlaid on its own original 400X composite to guard against digitizing errors.

The next step is a feature Macrodata calls critical to the device manufacture—nodal analysis, showing precisely what features are interconnected in the node list that results. Macrodata's software traces all hard-wired connections, shows unconnected metal lines, and also checks that circuit feature spacing follows National's processing rules.

From the nodal analysis, Macrodata creates logic equations taken from the actual circuit geometry—not from National's own equations used to make its composite. This provides a check backward to National's equations, and assures that the digital data base Macrodata has generated thoroughly screens out any human error that may have cropped up in translating those equations into the original composite National produced.

From this data base, Macrodata also provides logic simulation, test sequence tapes, and 100X Gerber-produced plates, from which National makes working plates.

Probing the news

ments, Dallas, for instance, the computer has partner status with the man in designing small- and medium-scale circuits, according to John Hanne, manager of the design automation department. This setup is used mainly for TI circuits; customers don't normally use this interactive system because it requires extensive training and experience, and they don't want terminals, says Hanne. "They want reliable circuits at low cost." TI has other CAD systems—a separate one for discretionary wired LSI, and three others for MOS arrays. Hanne notes that there's no other practical way to make discretionary-wired LSI.

Hanne takes a dim view of trying to get the customer too greatly involved in layouts. The best approach, he feels, is for the customer and vendor to communicate initially via the customer's logic diagram. After TI's simulation programs check its performance, the company performs circuit layout and test sequence generation.

"We've tried to allow the designer to intervene throughout the design to improve it," says Warren Crews, manager of training in the CAD group at Motorola's Semiconductor Products division, Phoenix, Ariz. The polycell program for custom MOS/LSI went on line there last July [*Electronics*, Aug. 3, 1970, p. 26]. Crews says that, while adequate placement and routing programs exist, "the question is how good these programs are, and are they better than doing it another way? We're flexible enough so that the designer stays in charge of the operation and can interrupt an automatic placement and routing program to modify placement," he says.

Similarly, Signetics Corp., Sunnyvale, Calif., is developing a new system that can be stopped to allow an engineer to modify a design. Watching the routing on a cathode ray tube, the engineer can stop the program and change the layout in a given area, and then direct the program to continue from that point. Since Signetics uses CAD primarily for its own standard products, its facility is modest in comparison to customer-oriented operations, consisting of two leased IBM 1130 computers, a flatbed plotter, and a graphics terminal. If the computers were owned, the facility would represent an investment of about $250,000, exclusive of the money spent on a man-year of graphic system development.

By contrast, Fairchild's Semiconductor division in Mountain View, Calif., estimates that the investment over about four years in its CAD facility, including software development, amounts to between $3 million and $5 million. The company recently started mask making on its 100th chip design, all but one of which have been custom units. Most initial cell placement is done manually at the company, reports Robert Walker, manager of micromosaic engineering, but at a point beyond initial layout, hand optimization of the design becomes pointless, he notes. "With custom LSI," he reports, "we're typically in a package with 36 or more pins, so why should we spend much time optimizing the chip if it's only a tenth of the cost of the package?"

At the opposite pole is Collins Radio Co., Newport Beach, Calif. George Grondin, assistant director of engineering in the Solid State Devices division, is still "quite sure" that totally computer-controlled layouts will win out over manual methods, despite a setback Collins suffered in designing chips that were greatly oversize for Viatron more than a year ago.

Using its old layout algorithm and automated techniques, reports Grondin, Collins made a chip that was 2.4 times larger than one made by a vendor to whom it had sent the chip specifications. "We worked on our algorithm for six months and went from a ratio of 2.4 to 1 to 1.5 to 1 compared to the other vendor's chip," he adds. "And the chip we designed worked the first time. We've gone around three times with the other vendor's chip and it still doesn't work. If you pack things in by hand design, you're going to reduce yields," asserts Grondin, "There should be no manual intervention."

Collins also stands alone in advocating customer acceptance of

Probing the news

MOS/LSI design responsibility, even though it's modified that stance recently. After finding little initial enthusiasm for this tack [*Electronics*, Nov. 23, 1970, p. 32], Collins agreed to take on design responsibility at the customer's request. But the company still basically holds with the original approach, maintaining that eventually the customer will have to take on most of the design responsibility because of the finite amount of work the manufacturers' design groups can handle.

Another bone of contention is the ease of correcting errors in mask artwork using rubyliths against the advantages of optical pattern generators—the large cameras that flash rectangles onto plates to turn out mask artwork, usually at 10 times actual size.

With rubyliths, changes or error corrections are simple, points out H. Clair Althouse, AMI's manager of computer systems. Only that part of the mask artwork that's incorrect need be changed, whereas a complete master reticle would have to be discarded with an optical pattern generator, he says.

Signetics' James Kane, head of MOS design, also opts for rubyliths, maintaining that with pattern generators, the plates must be exposed and processed. But with rubyliths, he says, "if there's a design violation, we can quickly alter the artwork with an Xacto knife and a ruler."

Fairchild does both rubylith cutting and peeling, and optical pattern generation. Walker prefers the pattern generator because it eliminates ruby stripping and checking, as well as the copy camera step needed to reduce the ruby artwork from 200 or 250 times actual size. With these steps out of the way, he says, pattern generation can save up to a week in a design.

Peeling of rubyliths is still a problem area because errors can creep into mask artwork. Though ruby cutting is automated on sophisticated flatbed plotters in which cutting tools are substituted for ink pens to generate mask artwork, peeling still must be done manually. Opting for pattern generation is General Digital Corp. Perrin says the newly formed company rejected ruby cutting and peeling because "these are ripe areas for mistakes," especially peeling, where someone may forget to peel at some point or peel inadvertently. Collins uses only optical pattern generation to produce 10-X phototools. Grondin says early problems have been overcome by extensively altering the software and interface electronics that join the camera with the PDP-8 computer that drives it. But Grondin isn't fully satisfied because the optics are limited to chips with a maximum of 160 mils on a side.

Another CAD limitation according to Collins' Grondin is the lack of more varied standard logic cells. His computer designers would like to see more cell sets, Grondin reports. "We should have a set for the minicomputer people, one for telemetry system builders, and another for the telephone companies, for example. Each application area needs a cell set that emphasizes speed, low power, or whatever feature that user needs most."

AMI's Althouse adds that no matter how many standard cells his company has in its catalog, "we always need more for a custom job. We're always designing new cells and they're not standard ones in general logic." But Fairchild's Walker stresses that lack of cells isn't a problem at his division. "If it stands between us and getting a custom contract, we'll make new cells. We usually don't charge for new cell designs."

Grondin also feels his customers should have easy access to Collins' service. One reason more customers haven't used the company's system, he says, is that "we're not reaching the people in, say, Nashua, N.H. We need a fast way of getting three minutes of data into the system." Grondin believes it can be achieved if the customer translates the card deck containing his logic equations into taped data, and then sends that over phone lines to one of six regional centers.

Motorola also is expected to establish regional CAD centers in the U.S. and Europe [*Electronics*,

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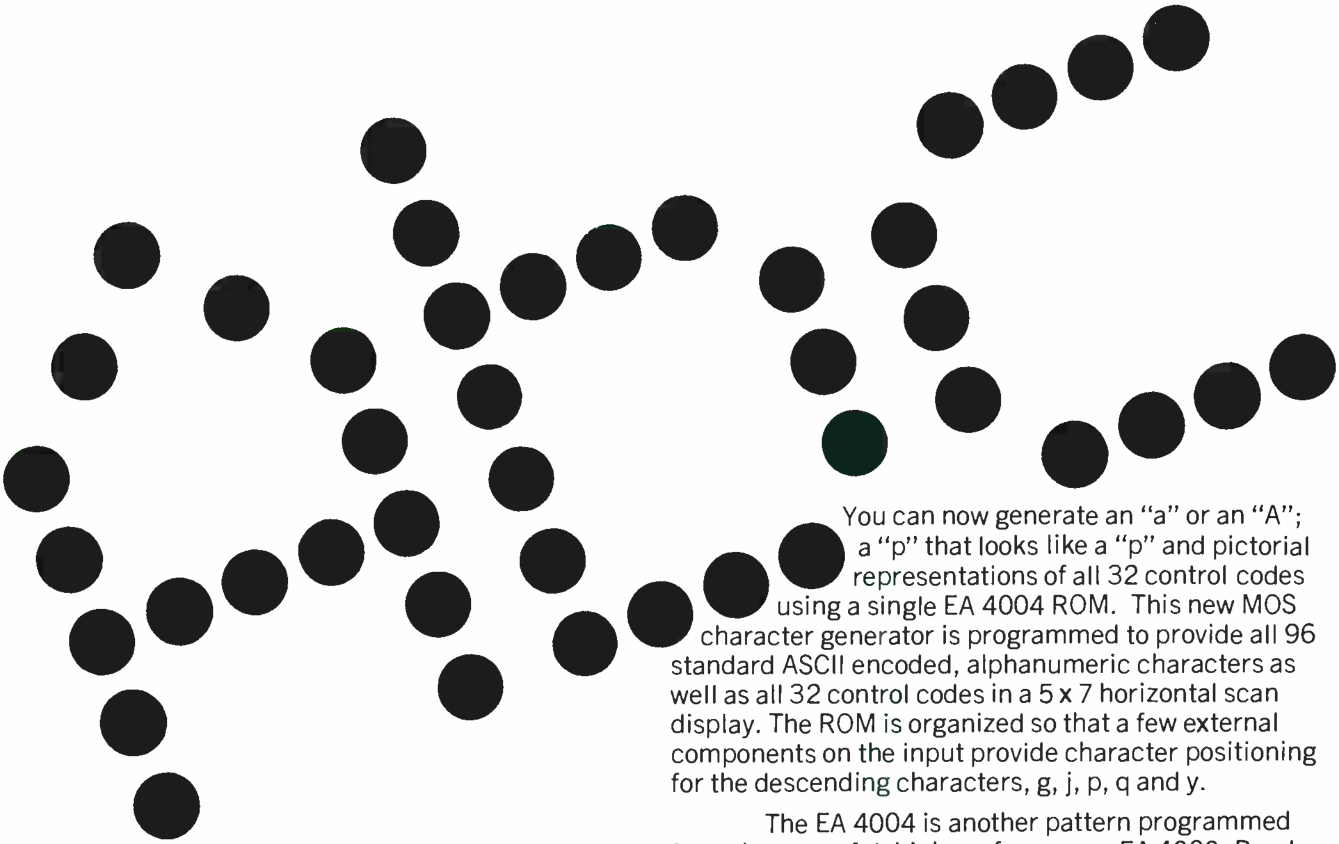

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Dec. 7, 1970, p. 26], though officials won't confirm it. However, most firms seem to shun the regional approach, preferring either to have the customer come to their facility, or send a team to his.

Prices charged by semiconductor manufacturers for custom chip development have changed little in the last year or so, ranging from nothing to about $40,000. Fairchild's Schreiner says that typical chip development costs are $15,000 to $20,000, "but the range is zero to $30,000. We may not want to quarrel about engineering charges if the customer is willing to make a large-volume production commitment," he explains. "But if there's a high risk that the devices will not go into production, we've got to get our engineering costs back right now."

At Motorola, the price range is about $5,000 to $20,000, but the Semiconductor Products division may not make any identifiable engineering charge for large-volume arrays.

TI uses three systems for designing MOS circuitry, each at a different cost. The simplest, for programable logic, has a setup cost of only $5,000 to $10,000, but the circuits are quite limited. As for the other two systems, the row/cell setup is highly automated, but allows interaction as well. It offers low layout cost, $15,000 to $25,000, but not minimum silicon area. Thus it finds greatest use in low-production runs. The manual/interactive system is better for higher-production runs because it provides higher density at the expense of greater set-up charge, typically $20,000 to $40,000.

Perhaps the best summation of LSI manufacturers' pricing views is provided by Fairchild's Walker and Motorola's Crews. Walker says, "If someone gave you the integrated circuits to make a calculator, for example, you still couldn't compete with the price of LSI for doing the same job." Crews comments, "We're interested in the unit cost of the array, and the whole point of the design exercise is to minimize the cost." □

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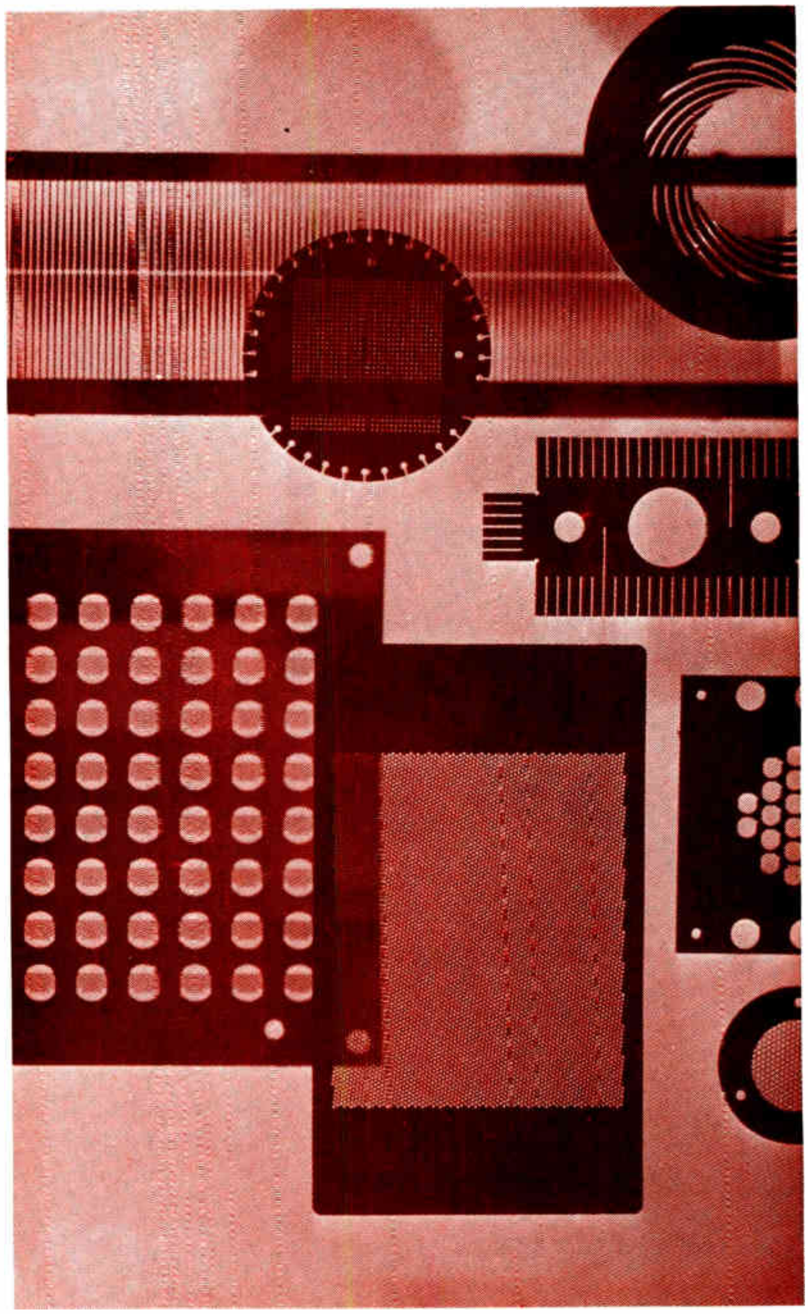

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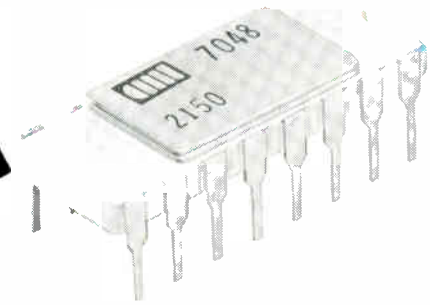

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Memories

Plated wire still holding on

While no one feels the technology will dominate the memory market, some designers find it has its advantages for military, commercial applications

Hailed only a few years ago as the new challenger that would finally dethrone core systems, plated wire memories haven't even become serious contenders. And while cores have continued to hold their own, yet another contestant—semiconductor memories—has come along faster than most believed. As a result, many companies, discouraged by continuing processing problems that have kept yields down and prices up, have scrapped all plated wire work and are ready to count it out. But other firms are insisting that the technology's far from finished; indeed, they say it will eventually carve out a modest but respectable niche in the memory market.

Wherever low power dissipation or nonvolatility is important—in military or machine tool controller applications, for example—plated wire memories still are the best choice, its backers maintain. And implementation continues to grow, albeit slowly, they add. One supporter, Lockheed Electronics Co., estimates last year's plated wire market at 1.5 billion bits and the 1971 market at 2 billion bits or more. In fact, Lockheed predicts that in the next four to five years the market will continue to expand to between 10 billion and 20 billion bits annually.

To date, plated wire has achieved its greatest success in military applications. "You can't really question the technology," says Jerome Sallo, manager for magnetic films at Lockheed Electronics' Data Products division in Los Angeles. "Every Poseidon missile has a plated wire memory for the guidance computer, and so does the Minuteman 3. And plated wire is used in at least two or three portions of the F-15. It's under consideration for use in the Mars lander in the Viking programs," he also notes.

Plated wire memories offer several advantages over other storage media, particularly for military applications, says Sallo. They're faster than cores, with access times of about 75 nanoseconds in read-only memories, and feature a factor-of-two improvement in power dissipation he says. Plated wire also isn't volatile or susceptible to radiation like semiconductor memories Sallo adds.

For commercial applications, Lockheed and others see plated wire being used in electrically alterable read-only memories (Earoms), in computer peripheral controllers, machine tool controllers, and microprogramable minicomputers. According to Ralph Gabai, the division's manager for data storage products, most plated wire ROMs can be general-purpose devices that can be loaded to suit

The outlook abroad: uncertain

Computer makers and memory houses overseas, as in the U.S., disagree on plated wire's prognosis. Some foreign firms feel higher costs can be offset by performance advantages, but others say that plated wire hasn't and won't fulfill its promise.

One firm that's hedging its bets is England's Plessey Co. According to Patrick Calvert, technical executive of the Memories division, which is involved in an extensive plated wire effort, cost and performance consideration will continue to vary sufficiently through the next five years to maintain all three memory technologies.

Right now, Plessey prices its 250-ns plated wire about 10% to 20% higher than its 500-ns cores, estimates Calvert, a small enough price differential to make plated wire's speed a strong selling point. "Plated wire will remain an attractive proposition for main memories for several years —until semiconductor memories really become economical and reliable," he maintains.

In France, however, plated wire has been quietly dropped after several years of a multicompany research program at the French Atomic Energy Commission's Grenoble Electronic Research Center. The reason: "Semiconductor memories are going to be cheaper two years from now, and we don't want to adopt one technology and then drop it for another," asserts Francois Gallet, director of advanced development for Honeywell-Bull, one of the companies involved in the program.

In Japan, Toko Inc. is heavily involved in plated wire work and can produce some 20 million memory bits per month. By this time next year it expects to double this capacity, according to a company spokesman. Main markets are destructive-readout wire memories for minicomputers and control computers, and NDRO memories for the Univac 9000 series medium-scale computer produced by Oki Univac.

The electrical communications operation of the Nippon Telegraph and Telephone Public Corp. is still evaluating plated wire for electronic telephone exchanges [*Electronics*, Jan. 19, 1970, p. 65], and a decision is expected to be made in February. Hitachi Ltd. and Oki Electric Industry Co. made the prototypes being evaluated.

the application, rather than having fixed programs, as with cores.

Similarly, Bruce Kaufman, president of Memory Systems Inc., Hawthorne, Calif., feels it's a mistake to consider only mainframe computer memory applications when comparing the various storage technologies. "For us, the control market for plated wire is attractive because those users are absolutely hysterical about volatility," he notes.

Kaufman says a plated wire Earom would be well suited to communications controllers where the controller performs protocol and instruction routines in a network with dissimilar terminals. "We see a significant multimegabit volume in this kind of application —the relatively small memories, not the monsters," he notes.

Other commercial applications could be for digitizing television data and for telephone switching systems. Nemonic Data Systems Inc., Denver, Colo., for example, is building an Earom that will store subscriber data in a Stromberg Carlson switching system.

Far less optimistic about plated wire's future is another Hawthorne operation, the Electronic Memories division of Electronic Memories and Magnetics Corp., Los Angeles. The division dumped the technology on the basis of market forecasts that prices were unlikely to come down sufficiently to compete with cores and semiconductors.

Plated wire "is the kind of technology in which you need a broad product base—a good proportion of the total memory market because a good deal of tooling and engineering is involved," says Bryan Rickard, manager of product engineering for magnetic products. As an example, he cites the considerable engineering required in the mechanical structures used to hold the plated wire as it's fabricated. What's more, because plated wire memories use a linear select technique, designers can't economize on drive switches and circuits, he adds.

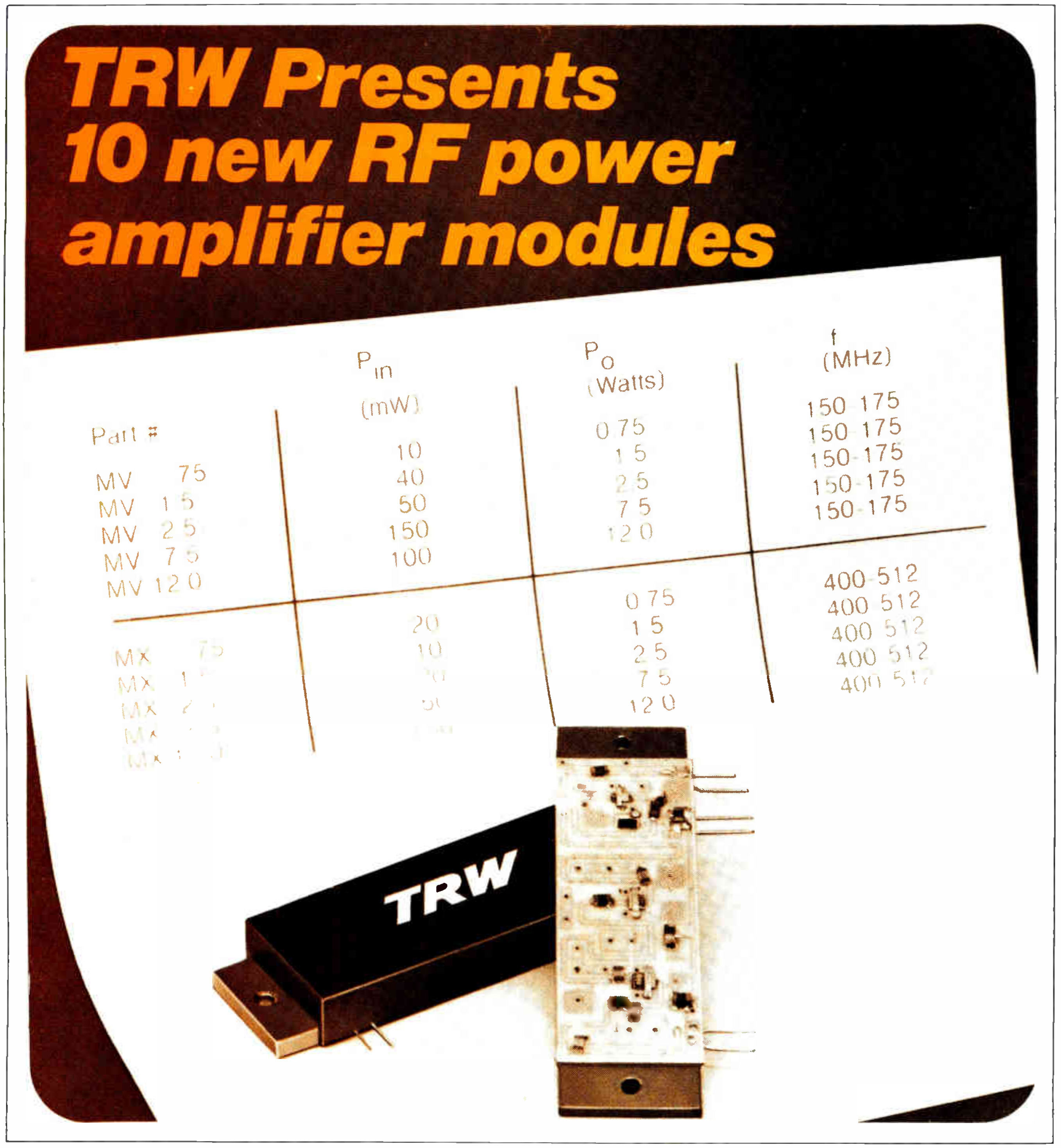
Even more pessimistic is Xerox Data Systems, which dropped its two-year-old plated wire effort last November. "The trend toward semiconductor memories is building faster than expected," says William Gable, vice president for corporate planning at the El Segundo, Calif., firm. "We surveyed semiconductor manufacturers and found higher yields and more bits per chip than anticipated." Computer people generally regarded plated wire as a hedge against the onset of semiconductor memories, he adds; they felt that there was at least a small "window for its exploitation. But the plated wire window is closing," says Gable.

But while Xerox was getting out of plated wire last November, Univac was getting in deeper. Univac, in fact, extended plated wire to large computers when it announced its 1110 processor. Minimum memory size of the 1110 is 98,304, 36-bit words expandable in 32,768-word increments to a maximum of 262,144 words. However, it should be noted that the Sperry Rand division is unique in that it has a heavy investment in plated wire. Back in 1966 it was the first to introduce the technology—in a general-purpose business machine.

As to whether the division stays with plated wire in the future, Frank Lexa, manager of product requirements for major systems, concedes, "We're not committed to plated wires. We're committed to the best technology that meets the requirements for our systems. As far as semiconductor arrays are concerned, we can match their performance, and we're not bothered by volatility in the event of a power failure.

Echoing Lexa, George Fedde, manager of Univac's data processing technology research laboratory, admits to the possibility that plated wire may after all be an interim system for main memory use between cores and semiconductors. He stresses that while the nondestructive readout and nonvolatility aspects of plated wire are important, the ultimate decision rests on speed and cost effectiveness. □

Inputs for this article came from Lawrence Curran in Los Angeles, Peter Schuyten in New York, Charles Cohen in Tokyo, Michael Payne in London, and Stewart Toy of McGraw-Hill World News in Paris.



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Politics stalls post-attack system

DOD decision on highly automated Advanced Airborne National Command Post is up in the air; SAC may lose program if it's upgraded to cover all forces

by Ray Connolly, Washington bureau manager, and Herman Lowenhar, Military/Aerospace editor

Declining military procurements and the politics of military priorities are threatening further delays in the Air Force's Advanced Airborne National Command Post (AANCP). The Air Force already has spent over $2 million on studies and development for the highly automated post-attack system, proposed as an invulnerable command and control center for retaliatory forces surviving an enemy first strike. But despite renewed military and industrial lobbying for the Defense Department to approve AANCP in the fiscal year beginning July 1, the go-ahead is considered a touch-and-go proposition.

Proposed in 1967 as a follow-on to the Strategic Air Command's Post-Attack Command and Control System (PAACS), flown on the EC-135 "looking glass" aircraft, AANCP would rely extensively on computers, displays, and other electronic gear. The system could be worth an estimated $300 million, with much of the cost going for electronics. In the last three fiscal years, the Air Force says it has spent $890,000 with RCA and $998,000 with IBM for studies and development test hardware. In addition, it gave the Mitre Corp. some $150,000 last fiscal year and Hughes Aircraft $51,000.

Some DOD staffers believe that internal approval is languishing because Louis DeRosa, assistant to the Secretary of Defense for Telecommunications, is restructuring and consolidating military communications at all levels—and this would include AANCP. Another impediment is the rising Congressional opposition to large defense budgets. For example, one Senate Appropriations Committee staffer, admittedly opposed to AANCP, notes, "It's not a new idea, and we've managed to get along without it so far. What makes it so important now?" Observations like that leave officials of user commands, such as the Strategic Air Command, speechless; they are dumbfounded that they should be expected to continue with the rapidly obsolescing PACCS (see panel, below). Ironically, a Washington representative of one prospective AANCP contractor sees such a statement as a reflection of an industry-created idea: because technology advances so rapidly, a three-year-old program not yet out of development can become "not a new idea."

Air Force representatives are equally downcast by the failure of AANCP to win strong and unqualified DOD support. The progress of an internal program hinges on the blessing by the Secretary of Defense of a Development Concept Paper, the policy document justifying the need for a new system and its technological feasibility. Air Force sources say the paper for its new airborne command post is "currently being drafted" by the Directorate of Defense Research and Engineering; final action by the secretary's office "is not expected earlier than March 1."

The probability that action will not come until much later is suggested by Air Force officials' comments that choice of an airframe for AANCP again is "being studied in the Office of the Secretary of Defense" on a broadened basis. At the same time, the office is reviewing the possibility of making AANCP much more than just an upgraded SAC command and control system.

This review indicates that the plans of Louis DeRosa's Telecommunications Office are being factored in. As one military source explains, "Post-attack command, control, and communications is

Automating PACCS

The Strategic Air Command has been flying its EC-135 "looking glass" system for Post-Attack Command and Control for nine-and-a-half years, but though it includes 30,000 lb. of airborne PACCS electronics—most of it communications gear—the system is unautomated. The service now envisions PAACS' successor, the Advanced Airborne National Command Post (AANCP), as a self-contained package of computers, keyboards, and displays with a high degree of automation.

Right now, the Air Force is flight-testing an airborne data automation equipment package, which vastly upgrades the original PACCS system. Called PACCS-ADA, it is essentially a prototype to demonstrate feasibility of the more advanced AANCP concept.

The proposed AANCP, for which PACCS-ADA tests are laying the groundwork, now calls for up to 16 interactive displays, a 200- to 500-megabit mass memory, and a computer with a capacity at least double the current 32,000 words. Other hardware envisioned includes several hard-copy printers, and more magnetic tape units, teleprinters, as well as military satellite communications links for worldwide command and control.

more than a SAC problem. If we go with a big kluge for controlling all strike forces, not just SAC's, then we've got a whole new program, of course. If we upgrade SAC's capability alone, then it's not a major level of effort, and funding should be requested accordingly." In fact, the Air Force recognized the possibility that it may lose AANCP to a broader program with its first acknowledgement that the SAC system might be scrapped and a new effort started "if the program is halted for a period of more than a year."

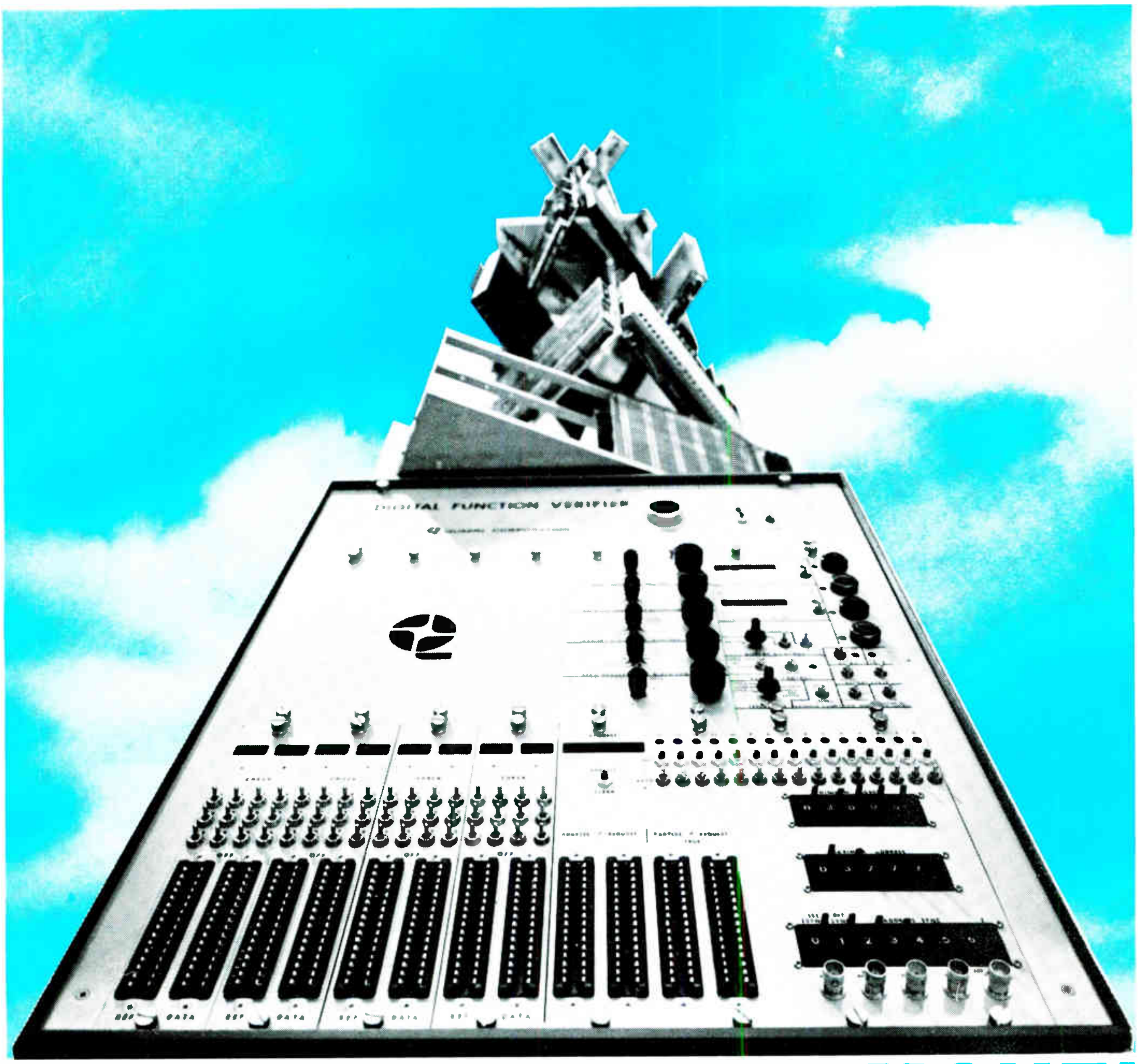
Selection of an AANCP airframe reportedly, was narrowed to the McDonnell Douglas "stretched" DC-8 and the Boeing 747. Now, however, the Air Force says DOD is considering nine aircraft.

For the moment, the Air Force is continuing development flight tests of the airborne data automation version of PAACS, now known as PAACS-ADA [*Electronics*, March 31, 1969, p. 45].

The ADA segment includes a chunky, 4-foot-high, variable instruction computer, developed by RCA under an earlier Air Force contract. In addition, the ADA contains a real-time clock; five RCA data display and keyboard units; a 100-megabit mass memory from General Instrument's Magnahead division; a 300-character thermal printer by National Cash Register; a pair of Ampex magnetic tape units; and a Mitre Corp. teleprinter.

In operation, one of the tape units stores the executive program for the 11-man PACCS battle staff. The other unit stores mission history. Total tape carried on board contains the National War Plan encoded into 80 megabits, which are immediately loaded into the 100-megabit mass memory.

Though the PACCS data must now be manually updated using inputs transmitted via an ARC-89 voice uplink, this is to be automated under a recent $575,000 contract to RCA. The data link, to be flight tested in April, will store, format, and encrypt data for transmission to ADA for automatic entry into the mass memory. □



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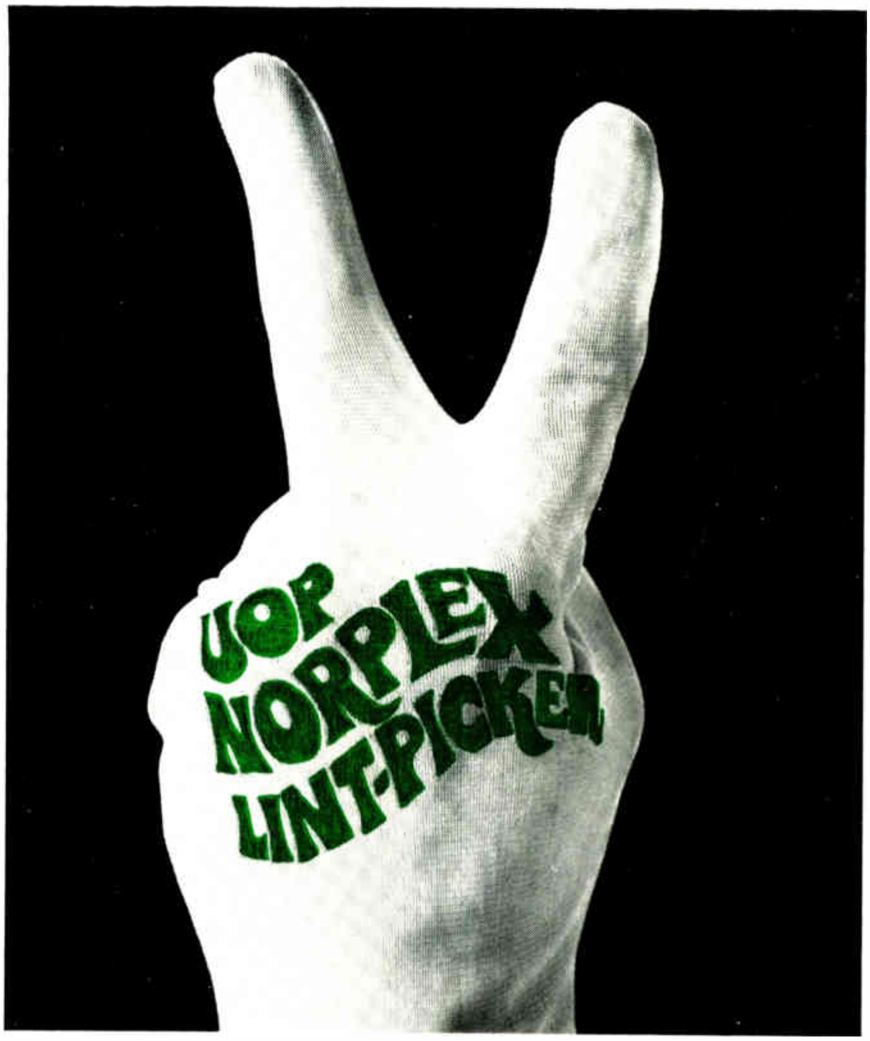

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LSI tester does all things to all arrays

By Stephen Wm. Fields, San Francisco bureau manager

Modular system handles functional, parametric tests of bipolar or MOS circuits under computer control

To make its voice heard over the din surrounding commercial LSI testers [*Electronics*, Dec. 7, 1970, p. 107], E-H Research Laboratories Inc. decided its first move into the test systems business had to be an all-purpose unit, too.

E-H feels that it will be heard because its model 4500 tester was designed to be more than a test system: it is a computer-controlled test facility. Therefore, officials of the West Coast instrument company say they will be marketing a system capability, not just a product. The model 4500 is aimed at testing large-scale integrated circuits, either bipolar or MOS. It can handle all testing procedures in use—including dc parametric, dynamic parametric, functional, and real-time.

Unlike most systems, which are task-oriented, the 4500 is modular in both hardware and software, employing standard E-H subsystems that can be tailored to the application and expanded to meet new requirements. William F. Boggs, systems marketing manager at E-H, says the company eventually would like to install custom-designed systems complete with on-line data analysis. The 4500, it is hoped, will demonstrate the company's capability of building such a system to do a specific test job.

A bare-bones 4500 could make dc measurements only. These tests would include dc voltage from 1 millivolt to 100 volts, and current from one nanoampere to 100 milliamperes. This capability could be extended to 1 A. To supply the dc signal, a programable power supply module is available. It provides six sources, consisting of current supplies, voltage supplies, and a combination of both. Voltage supplies are fully programable, and are current limited. Two types are offered: a dual range (0-2 and 0-20 V) with a 500-mA current capability, and a triple range (0-1, 0-10, and 0-100 V) unit, with a 100-mA rating. The current supply, also fully programable, can source or sink up to 100 mA with 100-V compliance.

For dynamic parametric testing, the 4500 employs an E-H 142 switching time converter and a 153 strobing voltmeter. The 142 measures time interval between a programed voltage level on a waveform and a second programed level on the same waveform. The 153 checks instantaneous waveform amplitude at programed times with respect to the system clock. Both amplitude and time interval measurements are made on a single cycle of the waveform: instead of requiring 1,000 data samples to provide an accurate measurement, as is needed with sampling techniques, only one sample is required. Boggs says that with the 142 and 153, "we can get any information we want about an ac signal, such as propagation delays, rise times, and fall times."

A word generator, a functional test fixture, and a parallel comparator are added for functional testing. This setup can measure not only time and amplitude parameters, but logic operation for proper function as well. Boggs says that while many systems perform functional tests, most are done under static conditions—dc voltages are applied to certain inputs, and dc voltages at the outputs are compared to programed 1 and 0 levels. But this setup doesn't measure output skew at actual operating frequencies, and it doesn't drive the device with signals typical of those encountered in actual use.

"With the 4500," says Boggs, "real-time functional testing ensures that the devices are tested under conditions that approximate those found in actual operation." This functional testing subsystem includes a pulse driver, an impedance converter and a level detector

We've put it all together—that's what its maker says about the LSI test system featured on this page. And each fortnight **Electronics** puts all together in this section a showcase of new products, previewing and featuring those of more than routine significance. Among this issue's features, in addition to the LSI test system: a bipolar memory, which challenges MOS, and two power transistors (Semiconductors, p. 117); a thermal print head and a user-programable read-only memory (Data handling, p. 121); and a line-frequency monitor and a logic-card tester (Instruments, p. 113).

for each pin (up to 40 pins with a 1-nanosecond bandwidth, or 80 or more pins with a 10-ns bandwidth). Pulse driver levels can be specified (by the computer controller) for either MOS or bipolar devices. This subsystem also allows dc testing and dynamic parametric measurements. The word generator can put out words at a 10-megahertz rate—more than enough for MOS memory applications.

The basic test fixture provided with the 4500 can handle 20 pins and is expandable to 40 pins. It includes both an ac and a dc matrix, and employs field effect transistor converters for true high-impedance testing of all device families.

In the dc matrix, each pin has a Kelvin capability which can be extended to a Kelvin socket on the device board. The dc matrix allows each pin to be programed to any forcing function, external line, measurement line, or any combination of these. It is designed to handle currents of approximately 1 A, and signal path isolation is in the area of 1,000 megohms.

The ac matrix is a 6 x 20 array structured with three rf inputs and three rf outputs. The input side of the rf matrix is expanded to accept any three of 12 possible ac stimuli; its output side is expanded to 12 ports which can be either measurement modules or loads. The output matrix is further expanded to accept the FET impedance converters for high-impedance testing.

Tying the whole system together is an IBM 1130 computer, available with or without a disk drive, and a software package developed by E-H.

The software is a three-level system in itself. The first two, called the machine function assigner and the control program generator, allow the test writer to get the maximum out of the system. The test language, called SRV, combines Fortran with a group of special test commands.

The price range is from about $175,000 to $750,000, depending on options.

E-H Research Laboratories Inc., Box 1289, Oakland, Calif. 94604 **[338]**

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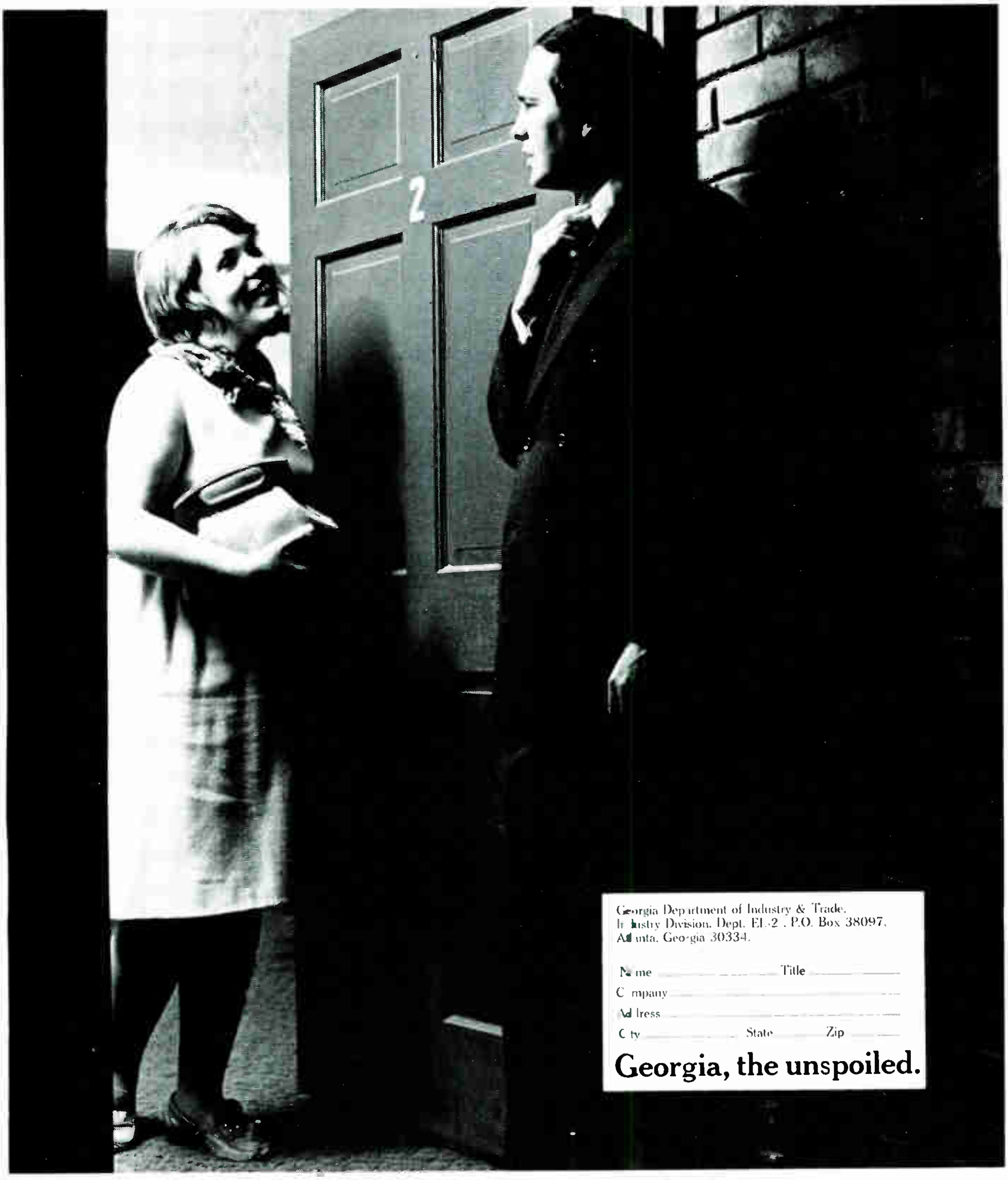

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New products

Instruments

ICs monitor line frequency

Compact sensing unit maintains ± 1% accuracy over temperature extremes

The customary method of monitoring the line frequency of an ac power system is to combine a time reference, a counter, and a crystal or L-C oscillator that serves as the frequency reference. To avoid the problems of bulkiness, environmental effects, and cost that are characteristic of these monitors, Hi-G Inc. has developed a new family of frequency sensors.

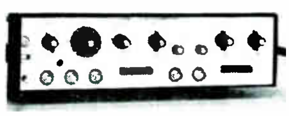
First unit of the new line, called the series 7000, is a compact sensor with an accuracy of ±1%, which it maintains over a temperature range of −55° to +125°C. Packaged in a 2.1-inch cube are sensing circuits, a single-pole, double-throw output relay with 2 contacts, a time delay, and a power supply.

Priced in the range of $75 to $120, the sensor uses integrated circuit digital logic to determine, cycle by cycle, whether a given input signal is within the desired frequency passband. When the frequency deviates beyond preset limits, a normally energized relay becomes de-energized.

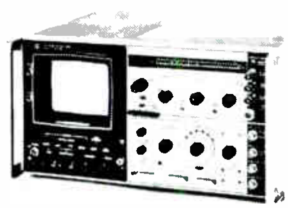
The upper frequency limit is 445 hertz, ±1%, and the lower limit is 375 Hz, ±1%. Other frequencies and tolerances can be supplied. Input signal voltage of 95 to 135 volts rms also operates the built-in power supply.

Sensors without a built-in power supply or time delay are priced as low as $50 each. They require auxiliary power of 18 to 32 volts dc at a maximum current of 100 milliamperes. Size of the stud-

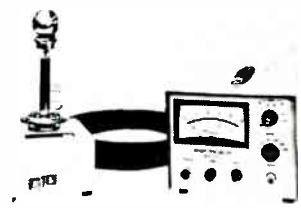
Digital panel meters for use with strain gage transducers are single-range readouts that measure weight, pressure, force, thrust and torque. Transducers with sensitivities to 0.5 mV/V can be used to make measurements with resolution up to 1/12,000 at accuracies of 0.01%. Prices range from $300 to $800. Electro-Numerics Corp., 2961 Corvin Dr., Santa Clara, Calif. [361]



Waveform generator called Multigenerator model 124 features dual output amplifiers—each with individual function selection—80 dB attenuation, two generators, 1000:1 external voltage controlled frequency, and a frequency range from 0.1 Hz to 5 MHz on the primary generator (1 Hz to 1 MHz on the second generator). Exact Electronics Inc., Box 160, Hillsboro, Ore. 97123 [362]



Spectrum analyzer model 8555A is for the range 10 MHz to 18 GHz. It uses thin-film hybrid microcircuitry to attain absolute calibration of the display, from −125 to +10 dBm, and to achieve resolution of 100 Hz. It uses automatic frequency stabilization to cut residual fm to less than 100 Hz on fundamental mixing. Hewlett-Packard Co., 1601 California Ave., Palo Alto, Calif. [363]



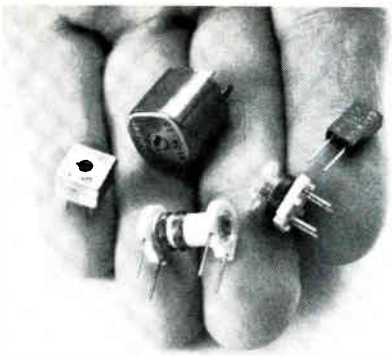
Transient monitor model 5201C-P-30A, utilizing a 30 kV vacuum capacitor divider probe, permits placement of the voltmeter up to 100 feet from the signal measurement source. Bandwidth of the system is 30 Hz to 1 MHz. Transients as short as 1 μs will be detected and peak amplitude held until the instrument is reset. Micro Instrument Co., Crenshaw Blvd., Hawthorne, Calif. [364]

Solid state thermistor thermometers are designated models 251A/551A-1 and 251A/551A-2. These are plug-in modules that combine with the model 251 main frame for temperature measurement using thermilinear thermistor probes. Complete system compatibility is obtained through the use of the 251 main frame. United Systems Corp., 918 Woodley Rd., Dayton, Ohio 45403 [365]

Electronic integrator model 601 is a high speed precision instrument which integrates any voltage signal when applied to its input terminals. Its low cost makes it useful as a fluxmeter, gaussmeter and voltage integrator. It is accurate to 2% of full scale. Its magnetic sensitivity is 300 Maxwell turns per division. LDJ Electronics Inc., 741 Owendale, Troy, Mich. 48084 [366]

Signal source 7100-G is a precision generator that provides unmodulated and pulse modulated output signals within the range of 2,000 MHz to 2,300 MHz. A multiple front panel switching matrix offers instantaneous selection of up to 20 discrete operating channels and combinations of subcarrier modulation formats. Microdyne Corp., Rockville, Md. 20850 [367]

Frequency selective voltmeter model 4200 is a completely portable unit with a six-digit frequency display. A counter mode selector switch allows the user to monitor a tunable preset frequency, or restore the incoming signal to its absolute frequency. Frequency ranges from 20 Hz to 200 kHz. The distortion products are below −70 db. Harmon Electronics Inc., Grain Valley, Mo. [368]



small wonders: big news

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For total circuit reliability – at a small price – it pays to choose CAMBION inductors. They're available in a wide choice of values, sizes, styles and finishes for immediate delivery.

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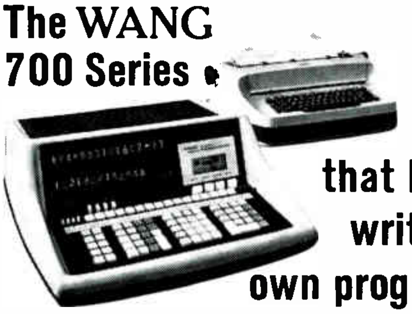
Circle 153 on reader service card

The WANG 700 Series • Now a calculator that lets you write your own programs and store them on a tape cassette



It's easy to store, enter or change programs with a 700 Series and there are no language problems. You already have the knowledge in the math steps you're now using to solve your problems.

With the Wang 700 you'll have more than a calculator. There are 16 special function keys that make it personally yours – you can determine the function each performs. And a choice of typewriter or printer/plotter output turns the 700 Series into a fully programmable calculating system.

And to make it even easier, Wang offers a library of pre-programmed cassettes for the many standard needs. Want a demonstration? Call Mr. Courtney collect at 617-851-7211 or send us the coupon.

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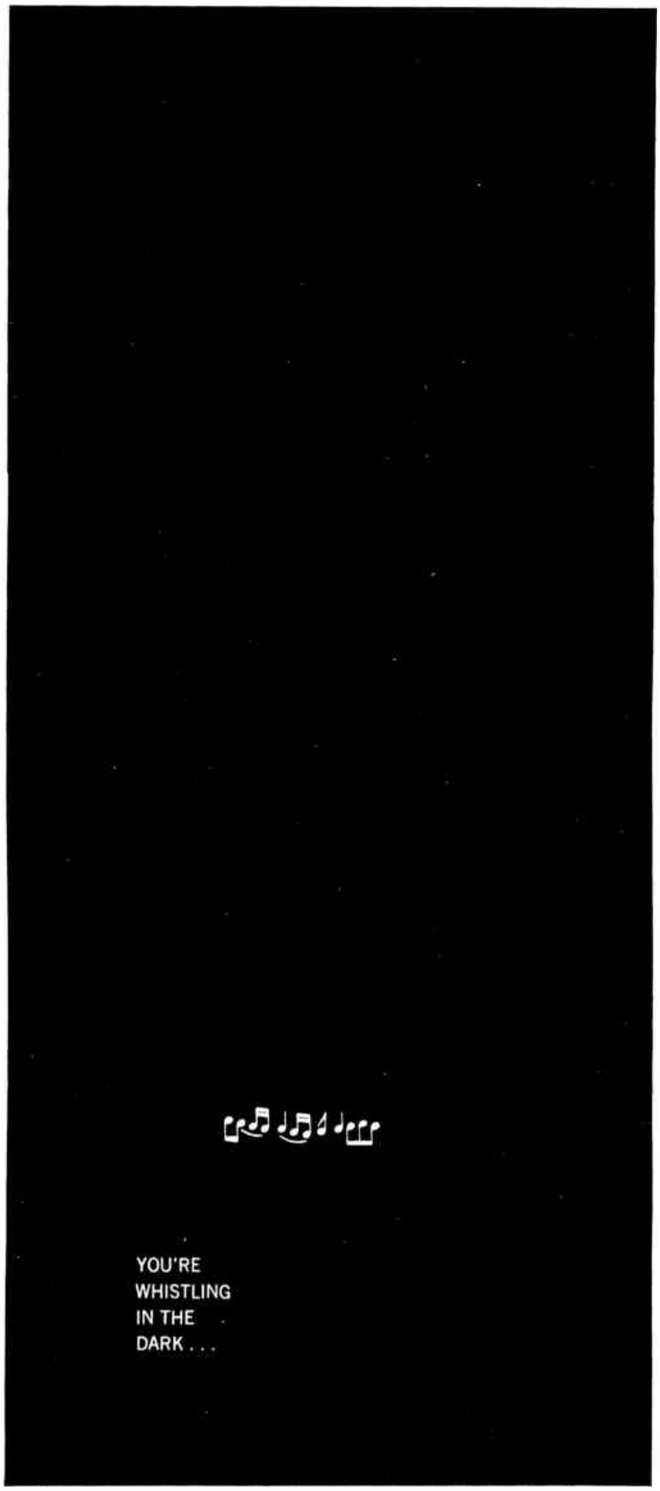
836 North Street, Tewksbury, Mass. 01876
I'd like a 700 demonstration as soon as possible. Call me at ______ for a date.
(Phone number)
Name ______
Company ______
Street ______
City ______ State ______ Zip ______



. . . if you think that heart disease and stroke hit only the other fellow's family. No one is immune. Protect the hearts you love. For authoritative information, ask your Heart Association. For medical advice see your doctor. To safeguard your family . . .

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New products

mounted enclosure for these units is 2.1 by 2.1 by 1.52 inches.

Delivery time is 8 to 10 weeks.

Hi-G Inc., Electronic Products division, Spring St. and Route 75, Windsor Locks, Conn. 06096 [369]

Test station checks out logic modules in small lots

Replacement of bench test rigs, widely used for checking and debugging logic cards in small quantities, is Automation Dynamics' aim in marketing its logic module test station, the QC-560.

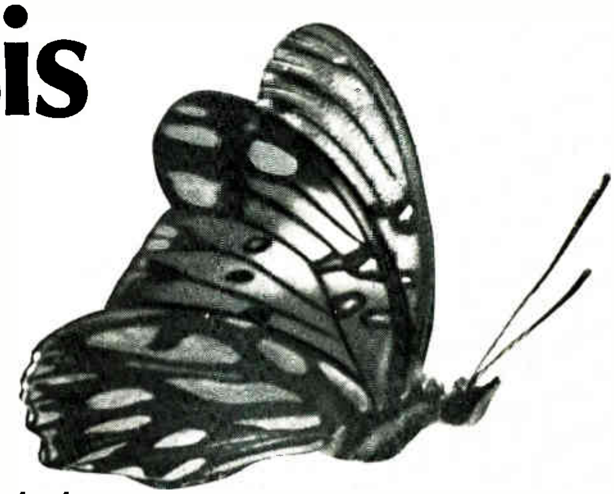
The company says the system can reduce the setup and test time required with bench assemblies by as much as 50%. Priced at $14,000, the QC-560 can perform static and dynamic testing, plus waveform analysis, on most types of printed circuit logic cards.

Automation Dynamics sees applications for the system as a single central test station in engineering departments; in maintenance depots, where there is usually a large mix of logic modules in small lots; and in medium- or small-lot production-line testing.

The QC-560 has programable power supplies for dc tests, and a two-phase clock generator, two pulse sources, and a function generator for dynamic tests.

Automation Dynamics, division of Resalab Inc., 35 Industrial Parkway, Northvale, N.J. [370]

metamorphosis



a great calculator becomes a computer.

But you don't have to become a computer programmer! In fact, you can easily operate this Cintra Calculator and its new Programmer with no knowledge of computer techniques. That's because Cintra instruments observe natural mathematical hierarchy. Operation is as straightforward as running an adding machine.

The Cintra Programmer 926 has an integral storage of 512 steps. 10-block tape cartridges provide for storage of up to 5120 steps.

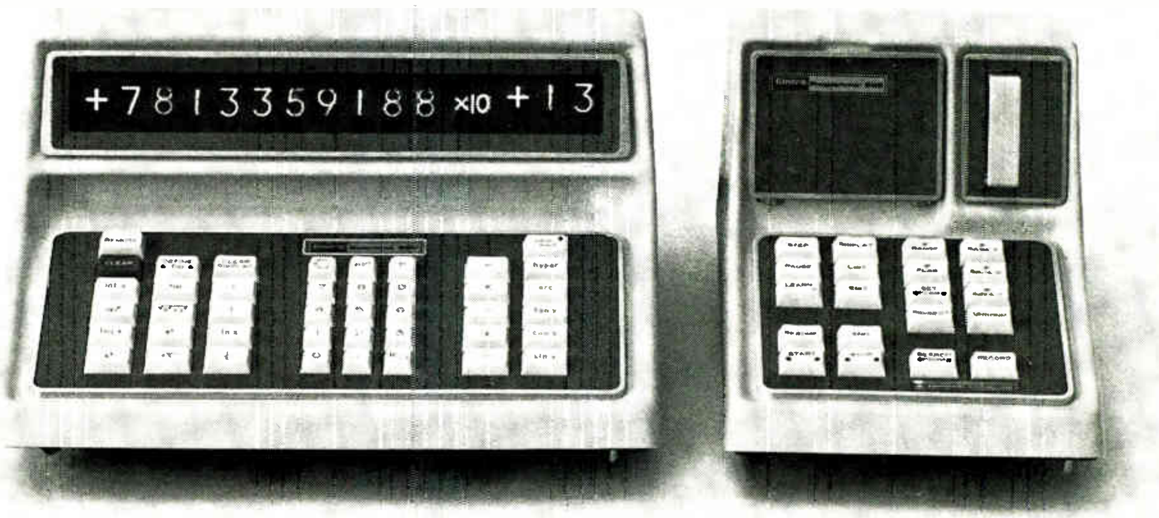
The combination of the Cintra Scientist 909 or Statistician 911 and the Programmer lets you accomplish most tasks that a scientific computer can handle, unless you need extremely large data storage. The Programmer adds looping, branching, and unlimited use of sub-routines (including nesting) to the calculator's capability.

Unique Programmer features include a convenient EDIT key for making rapid program changes. The INDIRECT key allows jumping to an address determined by the program. Any program on the tape can be located in a maximum of 27 seconds; 2.7 seconds from one program to the next! Editable, programmable search permits "chaining" of programs which exceed 512 steps. Price*: Calculator $3,780; Programmer $1,495.

To learn more about the only truly simple, natural desktop computer ready for delivery now, contact: Cintra, Inc., 1089 Morse Avenue, Sunnyvale, CA 94086. Phone (408) 734-3630. In Europe, contact Cintra at Rue Léon Frédéric, 30, 1040 Brussels. Tel: 33 62 63. In Canada, contact Allan Crawford Associates, Ltd.

*slightly higher outside the U.S. and Canada

Cintra
Physics International



Circle 116 on reader service card

Semiconductors

Memory draws little power

Bipolar read-only unit dissipates 0.2 mW per bit, competes with MOS prices

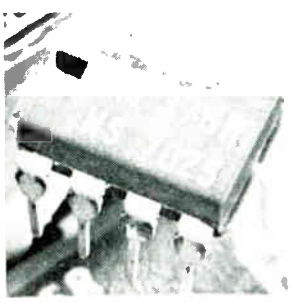
Ever since the first few semiconductor read-only memories were announced, there has been controversy between the bipolar and the MOS camps. MOS advocates pointed to lower power dissipation and thus a greater packing density and a lower price. Bipolar proponents said that the world out there was TTL bipolar, and therefore memories should be bipolar, even if the bipolar speed advantage was offset by the need for big fans and larger power supplies.

Now, however, there is another choice. Monolithic Memories Inc., Sunnyvale, Calif., has introduced a 2,048-bit read-only memory that has a power dissipation of only 0.2 milliwatt per bit—less than half that of other bipolar memories and only slightly more than MOS. And it's priced competitively with MOS.

The memory is organized as 512 words by 4 bits, and offers a typical access time of only 45 nanoseconds. It is a fully decoded memory and can be expanded in either the word or the bit dimension; open collectors are provided for word expansion, and the chip-enable lines can be connected to increase the number of bits per word.

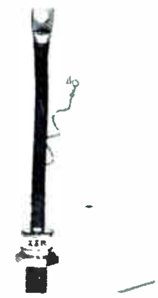
According to Zeev Drori, president of Monolithic Memories, one of the biggest advantages of the unit is that it fits in a standard 16-pin dual in-line package. "This is important for volume users," he says. "They can install it with automatic insertion equipment."

Drori says that one application

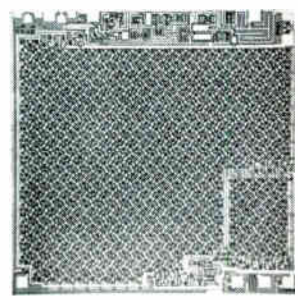


Voltage regulator LM376 fills the need for an economical and reliable IC regulator for consumer product applications. It provides an output voltage range of 5 V to 25 V, output current to 25 mA, and load regulation to 1%. Its eight-pin silicone molded package has a 50% size advantage over the standard 16-pin package. National Semiconductor Corp., Santa Clara, Calif. [436]

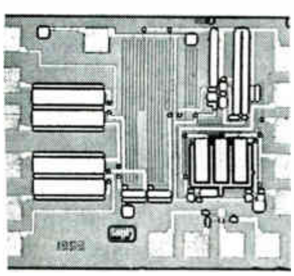
Single phase/controlled avalanche bridge rectifiers series BRE 300 are 50-ampere forward surge current devices. The series includes standard voltage types of 200, 400, 600 and 800 V with a maximum avalanche peak rating of 1,000 W for 20 µs. Price (500-999) ranges from 85 cents to $1. Rectifier Components Corp., 124 Albany Ave., Freeport, N.Y. 11520 [437]



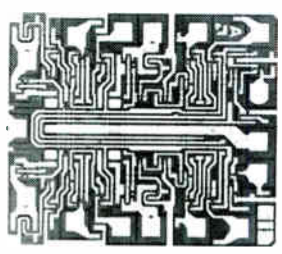
Fast switching, inverter type silicon controlled rectifiers series 151RF meet industrial and commercial demands for a 150 ampere average rated device with a voltage range from 50 to 600 V. Characteristics include di/dt of 300 A/µs, dv/dt of 200 V/µs, and 20 µs turn-off. Units come in JEDEC TO-93 cases. International Rectifier, 233 Kansas St., El Segundo, Calif. [438]



Two-phase MOS/LSI dynamic shift register TMS3401LC is for high-speed operation. It can be programed to accommodate any bit length from 233 to 512 bits. Operating speed is up to 5 MHz. Unit may be used as a refresh memory in computer-terminal and calculator applications. Price (100-249) is under 1 cent per bit. Texas Instruments Inc., Box 5012, M/S 308, Dallas [439]

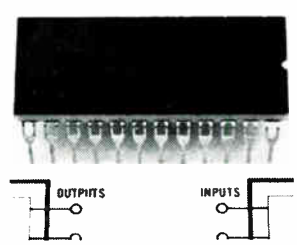


MOS/LSI analog switch provides a TTL compatible dual input OR gate which toggles a dpdt low resistance MOS switch. Positive or negative analog signals up to 10 V may be switched while maintaining a low R_{DS}. Operating temperature range is −55° to +125°C. Unit is available in 14-lead flatpack or dual in-line package. Collins Radio Co., Newport Beach, Calif. 92663 [440]



Multiplexer 9322 is a quad 2-input device. It consists of four individual multiplexing circuits with common select and enable logic. Parallel information is switched from one of the two sets of inputs to the outputs under control of the common select line. Unit offers switching speeds typically below 20 ns. Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. [441]

Plastic encapsulated MTNS (metal thick-nitride silicon) ICs are announced. Silicon nitride is virtually impervious to sodium ion migration, and thus maintains the parametric integrity of the circuit. The first devices available are two dynamic shift registers: the 512 bit BL-7-1512 and the dual 256 bit DL-7-2256. General Instrument Corp., John St., Hicksville, N.Y. [442]



Static read-only memories are designated 3507 and 3580. Each has a storage capability of 2048 bits and a flexibility of design that allows the cascading of eight devices to form an expanded memory without adding external logic components. The 3507 is organized as 256 words by 8 bits; the 3580, as 512 words by 4 bits. Fairchild Semiconductor, Fairchild Dr., Mtn. View, Calif. [443]

for the memory, which is the largest bipolar ROM available, is in microprograming. It could store look-up tables or even logic blocks and, since it operates at bipolar speeds, would keep in step with the processor. "Bipolar ROMs weren't used in this application before," says Drori, "because they just weren't available. Now, they are not only available, but their cost is down to that of MOS units."

For users who have bipolar systems but don't need bipolar speed in a read-only memory, Drori points out that the bipolar ROM interfaces easily with TTL systems. "You don't need the two power supplies that an MOS unit needs, and you get complete decoding on the chip," he adds.

The memory is priced at $40 each in quantities of 100 for the commercial temperature-range device in a ceramic package (model 6205), and $60 for the military unit (model 5205). Delivery takes three weeks after receipt of the bit pattern.

Monolithic Memories Inc., 1165 East Arques Ave., Sunnyvale, Calif. **[444]**

2-GHz transistor in stripline package handles 5 watts

With an eye toward microwave integrated circuit applications, RCA's Solid State division has redesigned two of its coaxial transistors into stripline packages. RCA says the new transistors are the first devices designed to operate at gigahertz frequencies that have emitter ballast resistors. This design allows output impedance mismatches as high as 10:1 at all phase angles at rated power and frequency. Specified for 2- and 5-watt operation at 2 GHz, these cw transistors are exceptionally small—0.20 by 0.17 by 0.16 inch without the mounting flange. The transistors contain their own beryllium oxide heat sinks.

Aimed at applications in telemetry, microwave relay links, phased array radars, aircraft collision avoidance equipment, and electronic countermeasure systems, the transistors are available in two configurations—with or without a mounting flange. In the latter design, the BeO heat sink is metalized, so it can be soldered directly to the circuit. Two flat tabs provide the input and output leads.

Called the TA7993 and TA7994, the epitaxial npn planar overlay transistors, featuring emitter ballasting, offer output powers of 2 and 5 W, respectively. The ceramic-metal construction offers low parasitic inductance providing stable operation in the common-base configuration. Both units are hermetically sealed.

The TA7994 has a power gain of 7 decibels and delivers 5 W with 1 W in at 2 GHz. Efficiency is 35% and input Q is 2 at 2 GHz; the device's impedance is $5 + j\,10$. The TA7993 has a power gain of 8 dB and delivers 2 W out with an efficiency of 35%; input impedance is $5 + j\,30$. Both devices operate at supply voltages of 28 V dc. Collector current of the TA7994 is 1 ampere while that of the TA7993 is 0.275 A. The TA7993 can function as a driver for the TA7994.

While the transistors are specified at 2 GHz, they can operate from 500 megahertz to 2.4 GHz, with some falloff in output power above 2 GHz. For example, the TA7994 can be operated from 1.0 to 1.6 GHz with 10 W of output power. This should be valuable in aircraft distance measuring equipment, which operates at 1.1 GHz, and collision avoidance systems, which perform at 1.6 GHz.

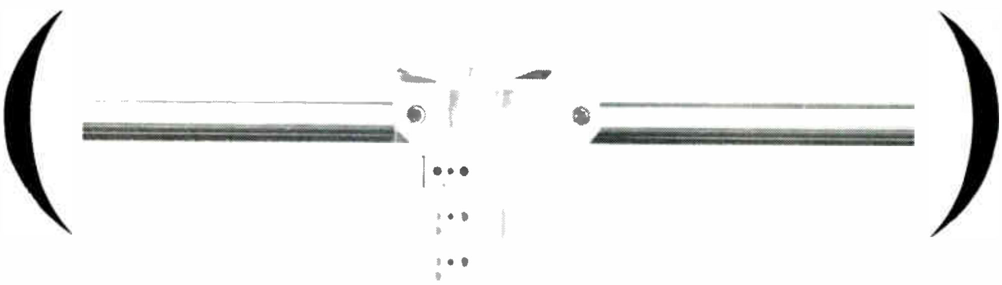
Guaranteed output power, frequency, and power gain are features of the new RCA transistors. "Since the heat sink is an integral part of the package, we can test and guarantee performance of each unit before it's shipped," says George Wood, marketing manager for high-power devices.

The TA7993 is available in quantities from 1 to 99 at a cost of $130.50 each, while the TA7994 costs $181.25, also in small quantities. Both are available from stock.

RCA Solid State division, Somerville, N.J. [445]

Circle 119 on reader service card→

A very uncomplicated new OEM recorder with just one thing going for it...



You'll like what you see in our new approach to dedicated OEM strip chart recorders. First, we eliminated all those complicated moving parts from the writing mechanisms. No more pulleys, cables and slip clutches. Instead, there's just one simple moving part—the slider/pen assembly. That's because a linear servo motor keeps the pen going magnetically . . . and very reliably.

When you see the HP Model 7123, you'll notice how the low power servo system makes the recorder smooth, precise and trouble-free. You could drive it off scale around the clock without noise or danger.

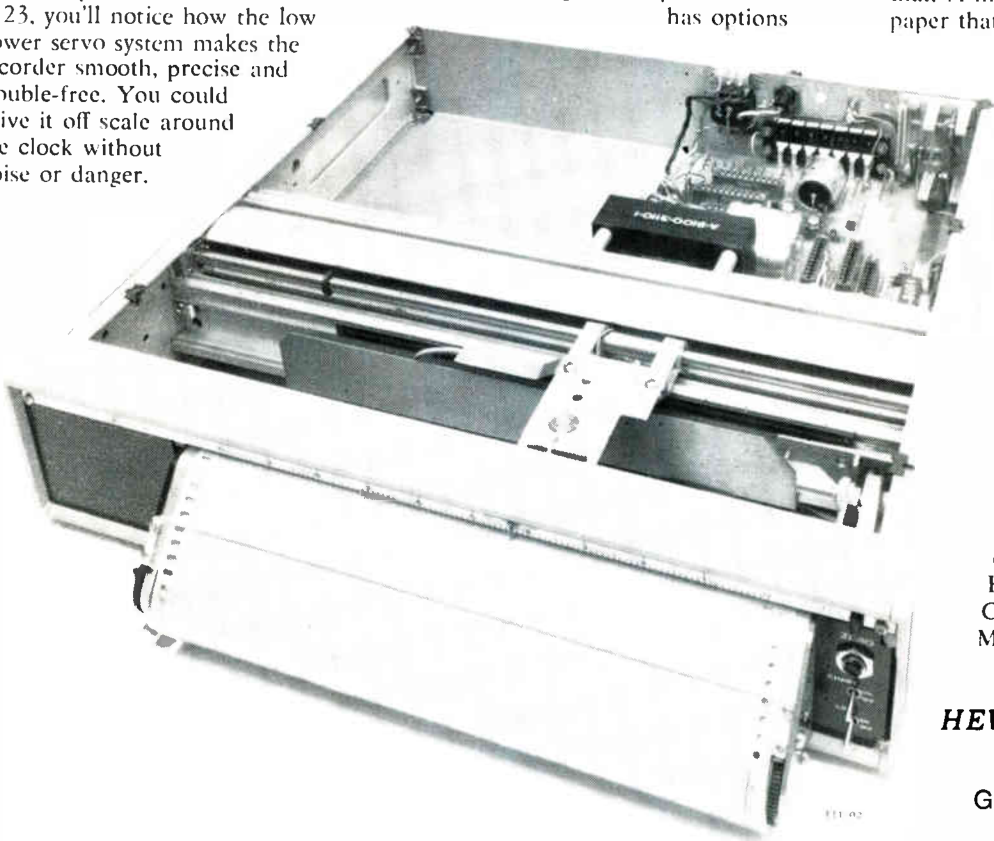
Even with all that, you've got a lot more going for you with the 7123. Like a swing-out chart paper drive for quick reloading and reinking. The viewing/writing area is slanted so you can make notes right at the disposable pen tip. And you can work without worrying about a lot of circuit adjustments. They're simply not needed anymore.

Since it's an OEM machine from the ground up, the 7123 has options for everybody. Select any chart speed and voltage span in English or Metric scaling. In all, nearly 50 options will customize the recorder exactly to a specific application.

You'll probably be most intrigued by an option we call electric writing. Normally, the ink system works like a cartridge fountain pen. But electric writing is designed for people who don't even want to mess around with that. A highly stable electrosensitive paper that gives you a crisp, clear trace without ink.

Available in full rack or half rack versions, the 3½ inch high 7123 makes totally unattended operation a reality. Simplicity, reliability, precision and even electric writing. With all that going for you, you can turn it on Friday and forget about your work all weekend.

To see the uncomplicated new 7123 and its matching price and OEM discount schedule, call your nearest HP sales office. Or write, Hewlett-Packard, Palo Alto, CA 94304; Europe: 1217 Meyrin-Geneva, Switzerland.



HEWLETT hp PACKARD

GRAPHIC RECORDERS

Data handling

Print head is hot and quiet

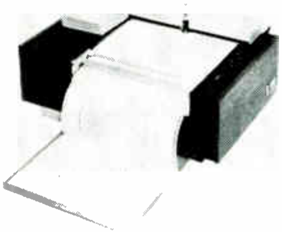
IC matrix provides hard copy on heat-sensitive paper for calculators, terminals

Impact printers are generally considered too noisy, power-hungry, bulky, complicated, and slow for use in the electronic calculators now flooding the market. Yet hard copy is often desired, and it is for this reason that Displaytek, a small company in Dallas, is marketing a thermal print head for use with heat-sensitive paper.

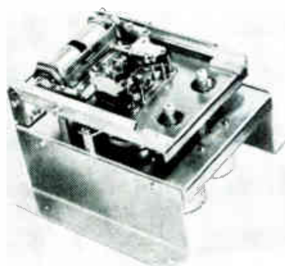
The print head, which Displaytek president Ed Ruggiero expects to be designed into computer terminals, electric typewriters, and strip printers, as well as calculators, is a 150-mil chip mounted by flip-chip techniques on a ceramic substrate. The chip is a silicon integrated circuit consisting of a five-by-seven matrix of dots formed by semiconductor junctions. These can be heated in patterns to form standard ASCII characters 0.1 inch high.

The dots heat in only 8 milliseconds, resulting in a print rate of 30 characters per second. The print head operates from 16 volts, and each dot requires an average current of 100 milliamperes. The silicon chip that contains the matrix, however, also includes drive amplifiers for each dot so that only ½ milliampere of drive current is required, making the device compatible with MOS, as well as with bipolar, ICs.

Though the heat-sensitive paper is in direct contact with the face of the silicon, Ruggiero says that wear on the print head is insignificant. He claims the device is good for 50 million impressions—approximately

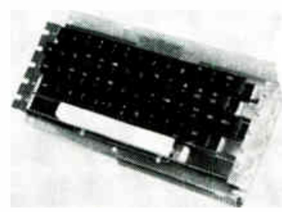


High-speed plotter 230 is designed for the time-share user. It is a self-contained desk-top unit that is capable of direct interface with most keyboard terminals and acoustic or direct couplers. Proprietary data compression techniques allow for maximum plotting speeds in all directions, not limited by transmission rate. Zeta Research Corp., 1043 Stuart St., Lafayette, Calif. [421]



Digital cassette deck CAS-10 features both variable speed and bidirectional read/write under dual capstan control to minimize inter-record gaps. Sensing is done optically, with separate sensors for beginning-of-tape and end-of-tape. Cassette-in-place and file protect sensors are also featured. Auricord Division, Scovill Mfg., 35-41 29th St., Long Island City, N.Y. 11106 [422]

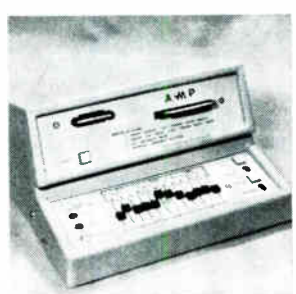
Magnetic tape system model 2045 offers industry-compatible tape recording at tape speeds to 45 in./s and packing densities to 800 b/s (non-return-to-zero, change on ones) and 1,600 b/s (phase-encoded). It features IBM tape interchangeability for either 7- or 9-track recording. Price is between $3,000 and $4,500. Bucode Inc., 175 Engineers Rd., Hauppauge, N.Y. 11787 [423]



Solid state keyboard CDK-3 is for use in applications such as TWX, TTY and other communications systems. It offers the ASR-33 format. Low profile (¾ in.) and light weight (1½ lb) are of particular advantage in portable systems and where it is desired to design the keyboard as an integral part of a work surface. Control Devices Inc., 204 New Boston St., Woburn, Mass. [424]

Digital multiplexer model 263 provides an interface between the outputs of up to eight digital data sources and a single information handling system. It selectively and/or repetitively samples the data present at its input channels and makes the resulting output available at a single connector. Price is $895. Princeton Applied Research Corp., Box 565, Princeton, N.J. [425]

Vhf time code receiver model TCR-145 is designed to provide reliable data synchronization at facilities where standard time formats are transmitted. It is a solid state a-m receiver with fixed tuned, crystal controlled operation over the range from 30 to 400 MHz. An agc system provides an 80-dB dynamic range. Aerospace Research Inc., 130 Lincoln St., Boston, Mass. 02135. [426]



Data collection terminal Syscom is a remote unit for job-cost accounting applications. Incorporating a badge card reader, tabulating card reader, matrix slide switch and matrix rotary switch as input devices, it provides capability of collecting information from badge and tabulating cards plus variable data from the slide switch. AMP Inc., Harrisburg, Pa. [427]

Microfilm retrieval terminal can be used in almost-real-time applications. The device incorporates a new concept in microfilm—roll microfiche—which can carry as many as 45,000 pages of computer print-out on a 100-ft. roll of 105-mm film. Prices will range from $3,750 to $7,000, depending on options. Morgan Information Systems Inc., 3197 Park Blvd., Palo Alto, Calif. [428]

10 years in typical calculator service or one year in computer printout—and he expects to double that figure in the future. The print operation is silent, but, of course, the paper or carriage drive mechanism may not be.

Texas Instruments Incorporated also makes solid state thermal print heads, but they are being supplied only to TI's equipment group for a computer terminal [*Electronics*, May 12, 1969, p. 178], and to Canon for its Pocketronic calculator. TI says it has no plans to market the print head separately. National Cash Register Co. has developed a thin-film print head that is used in some of its equipment.

Price for the Displaytek print head, designated the DC-1157, is in the $20 to $30 range for quantities of 10,000 per year. In the prototype stage is a head with the decoding on the same chip.

Displaytek Corp., 4241 Sigma Road, Dallas, Texas 75240 [429]

PROM uses Schottky diodes, provides three-state output

Flexibility is the principal design feature of a programable read-only memory produced by Harris Semiconductor for use in microprograming computers and process control systems.

Contributing to flexibility are the incorporation of Schottky diodes in the integrated circuit, called the HROM 1256, and provision for a three-state output.

The Schottky diodes act as clamps on transistors in the IC, preventing them from going into saturation. The diodes thus provide a simple and economical way of achieving high speed; the address-to-output propagation delay is at most 50 nanoseconds, and only 25 ns when the chip-enable feature is used.

The circuit has two enable inputs, which are inverted on the chip to give another level of address decoding through the chip-address circuitry. To enable the circuit, both inputs must be at logical 0. The chip-enable feature

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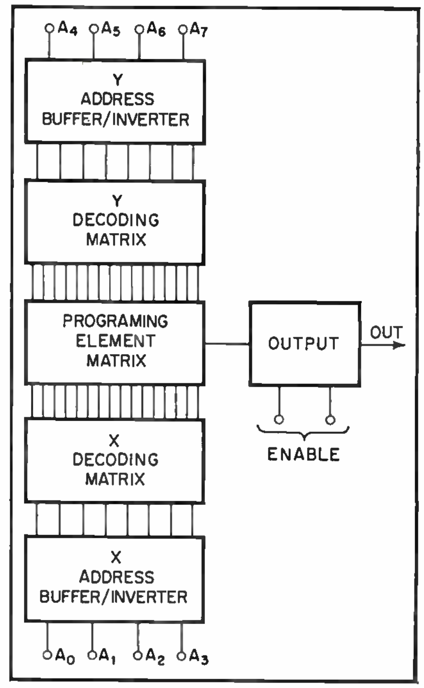

Custom-made. The user programs the memory with electrical pulses.

has a totem pole output, allowing both an OR-tied and an active pull-up output. This gives a wired-OR connection without the degradation in system propagation delay that normally accompanies it. The configuration is similar to the three-state output offered with logic circuits that are designed for bus-oriented systems.

The monolithic bipolar ROM is fully decoded and is organized as 256 words by 1 bit. As in other electrically programable devices, a 0 or 1 is programed into each bit, after the IC package has been hermetically sealed, by applying electrical pulses that fuse links in the nichrome metalization pattern.

The HROM 1256 comes in a hermetically sealed, dual in-line package with 16 pins. Total operating power is 500 milliwatts at 25°C. The IC can sink up to 20 milliamperes of current and is compatible with standard DTL and TTL ICs. Price, in quantities of 100 to 999, is $30.75 for the military version and $23.50 for the commercial version.

Harris Semiconductor, division of Harris-Intertype Corp., Melbourne, Florida 32901 [430]

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Circle 156 on reader service card

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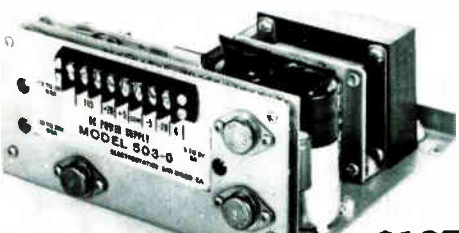

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New products—Materials

Ceramacast 511 is a magnesium-oxide/zircon formulation suitable to 2,300°F. It is a water-mix material which, after mixing, can be poured, dipped or sprayed around components to be potted or end-sealed. The material will set up in 2 hours and is ready for use after a bakeout at 200°F. Dielectric strength is approximately 265 volts per mil at 260°C. Resistivity up to 600°C is 10 x 10^9 ohms; up to 900°C it is 3.7 x 10^7 ohms. Aremco Products Inc., P.O. Box 145, Briarcliff Manor, N.Y. 10510 **[470]**

Silver-filled conductive epoxy AC-2H is designed for use in the 300° to 350°C temperature range. It is effective in replacing conventional soldering techniques in many advanced electronics applications. It has been used to attach transistor chips and leads in hybrid circuits which are exposed to extremely high temperatures. It has a pot life of three hours and will cure in 10 minutes at 120°C to 60 minutes at 80°C. It also has a high tensile shear strength and a shelf life of one year, unopened. Kenics Corp., 1 Southside Rd., Danvers, Mass. 01923 **[471]**

Thin film **etchants** for processing ICs are offered for gold, nickel, nichrome and chromium, with etching rates of 28, 30, 20 and 40 angstroms/s, respectively. Prices range between $7 and $22 per quart, depending on application, and the etchants can be delivered from stock. Transene Co., Route 1, Turnpike, Rowley, Mass. 01969 **[472]**

Soldasip resoldering flux is an activated rosin flux supplied in liquid form and formulated especially for the resoldering of circuit components. Whether using the Soldasip resoldering tip or Soldapullt desoldering tool, the flux will allow faster and safer solder removal than with thicker paste-type fluxes. When resoldering a connection, Soldasip resoldering flux is fast acting; residue is noncorrosive, nonhygroscopic and nonconductive. It is supplied in 4-oz squeeze bottles with metal flux pot included at a price of $1.75, Edsyn Inc., 15954 Arminta St., Van Nuys, Calif. 91406 **[473]**

New literature

Avalanche diode. General ... 316 E. 9th St., Owens... has available a ...te product evaluat...k, literature on ...us-...ies Circle 446 ...

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...ygon Electronics Inc., ... Ave., Roosevelt, N.Y. ...ers a 64-page handbook of ...supplies and power modules for ...ems, laboratory and OEM applica-...ions. [450]

Digital displays. Tung-Sol Division, Wagner Electric Corp., 1 Summer Ave., Newark, N.J. 07104, has published a 12-page catalog on optimum-contrast digital displays. [451]

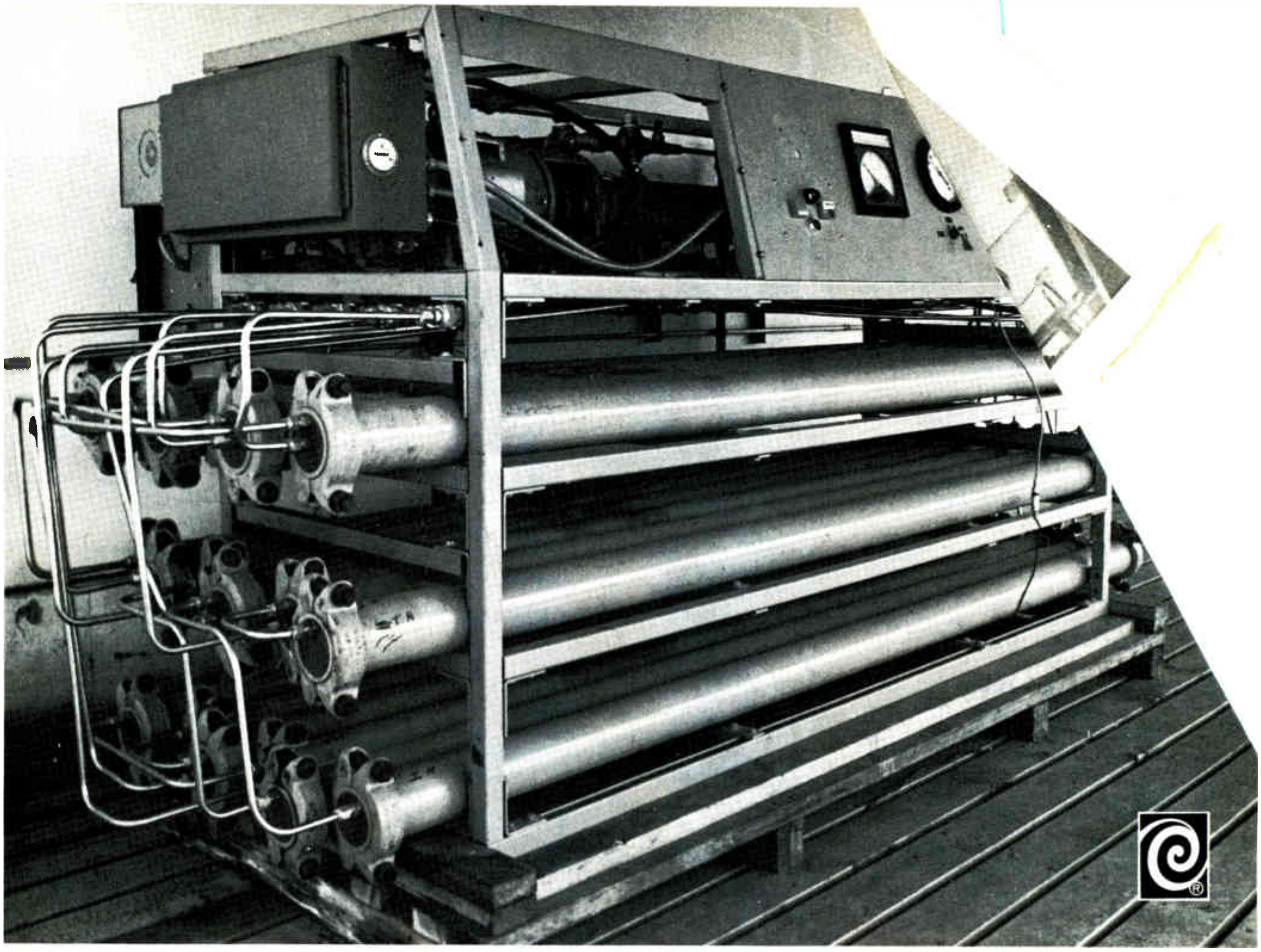
IC tester. Emcee Electronics Inc., 173 Old Churchman Rd., New Castle, Del. 19720. Technical data bulletin 100 describes a self-powered IC tester with flexible cable design. [452]

Fuse selection. Carbone-Ferraz Inc., P.C. Box 324, Rockaway, N.J. 07866. Twelve-page bulletin T2 contains technical aspects of fuse selection for semiconductor protection. Request a copy on company letterhead.

Signal processing. Federal Scientific Corp., 615 W. 131st St., New York 10027. Monograph No. 3 covers general and specific signal processing techniques and theoretical constraints. [453]

Recording systems. Brush Division, Gould Inc., 3631 Perkins Ave., Cleveland, Ohio 44114, has available bulletin 1250G, a six-page illustrated brochure on analog and digital recording systems for industrial, medical, military and scientific applications. [454]

Silicon controlled rectifiers. Westinghouse Electric Corp., Pittsburgh, Pa. 15222. Eight-page brochure TD 54-564 deals with the features, applications and performance characteristics of the T400 and T408 series silicon controlled rectifiers. [455]



How Culligan Reverse Osmosis/Deionization System gives Teledyne quality water at less cost

In the competitive electronics business, transistor yield rate can mean the difference between profit and loss. And the biggest cause of low yields is impurities in manufacturing.

That's why Teledyne Semiconductor, Los Angeles, uses a Culligan Reverse Osmosis/Deionization System plus ozonation to insure that all water used in the manufacture of its transistors is of extremely high purity. The system provides Teledyne with water of 18 megohms resistivity and virtually zero bacteria count. This water is used to rinse transistor wafers after each photo resist and etching process.

"Yield is strongly dependent on the quality of the rinse water," says Group Executive Dr. D. M. Van Winkle. "The plant would have to shut down without quality water. That's how important it is to us."

Compare this to the situation before our system was installed. The plant bought distilled water at 2.7¢ per gallon; Culligan water costs 0.8¢ per gallon. Best quality of the distilled water was 2 megohms, compared to the present 18 megohms.

The Culligan system meets all the plant's volume demands, too. It is supplying Teledyne 20,000 gallons per day, which means savings of $380 per day!

Supplying very high quality water at any volume is a Culligan specialty, and our RO/DI systems are available in a wide range of capacities: from 500 gallons per day with packaged systems, to 60,000 gallons per day with customized installations built with modular components.

In addition to conditioning process and production water, Culligan capability includes equipment for softening, filtration, boiler water, cooling towers, and waste water treatment.

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International Newsletter

January 18, 1971

Marines' Harrier buys give U.K. avionics firms foothold in U.S.

With the Marine Corps starting the ball rolling on a purchase of 30 more Hawker Siddeley Harrier VTOL fighters, **British avionics makers could achieve a sizable penetration of the U.S. military market.** With spares, each aircraft costs about $2 million, of which around 20% is avionics. The Marine Corps, which already has 30 Harriers on order, has indicated it would like to have 114 of the aircraft. The initial 30 planes—the first was handed over Jan. 6—will be British-built and virtually identical to RAF Harriers, including British avionics, apart from a Tacan by Hoffman Electronics Corp.

Subsequent aircraft may be built by McDonnell Douglas under license, in which case some of the British avionics makers also would license U.S. manufacturers. **In fact, Ferranti Ltd. already has licensed Northrop Corp. to make the combined inertial navigation and weapon-aiming system.** Other equipment includes a head-up display and air data computer by Smiths Industries Ltd.; three-axis stabilizer by Elliott Flight Automation Ltd.; IFF by Cossor Electronics Ltd.; vhf and uhf radio equipment by Plessey Co. Ltd., Ultra Electronics Ltd., and Marconi Co. Ltd.; navigation data converter by EMI Electronics Ltd.; and an engine life recorder by Kollsman Instruments Ltd.

Component makers in Germany order layoffs

For West Germany's electronics industry, the new year started out on a discordant note: **curtailments in production have resulted in reduced working hours and nonrenewal of labor contracts with foreign personnel.** For many sectors it's business as usual, but for components makers the immediate outlook is bleak. For example, at Valvo GmbH, a Philips subsidiary and Germany's largest components producer, some employees on the Hamburg IC lines are on a reduced workday basis, while others are being asked to take extended vacations. Intermetall, an ITT subsidiary, has considerably reduced the workday for about 12% of the labor force involved in making discrete components. AEG-Telefunken has done the same for more than one-third of its 2,600 employees at the Heilbronn semiconductor plant.

At the German facility of SGS, the Italian components maker, work contracts for many Yugoslav and Turkish girls—roughly 10% of the labor force—haven't been renewed, while Siemens AG has cut out all overtime at its components plants. **Reason for the industry's current doldrums is overproduction last year coupled with the increased selling efforts of U.S. semiconductor firms in European markets.** However, most industry people believe production will pick up again within the next six months.

Mullard working on rf applications for PDM amplifier

Mullard Ltd. is extending its pulse duration modulation technique for amplification at audio frequencies [*Electronics,* May 12, 1969, p. 240] **to radio frequencies as well.** So far, experimental equipment has yielded 4 to 5 watts output at 1- to 2-megahertz radiated carrier frequency, with 90% efficiency.

Mullard's goal is 20 W at 4 to 5 MHz with no sacrifice in efficiency. This should make possible 50% reductions in the size and weight of batteries for military radio manpacks and similar equipment. The PDM amplifiers would replace the class A or AB amplifiers now in use; these have efficiencies of up to only 50%, and hence use more power. **Standard** two-tone tests on the experimental PDM amplifier circuits have demonstrated intermodulation product levels as low as −36 dB. The main immediate problem is development of output power transistors that will switch at 20 MHz, the pulse frequency necessary for a 4-MHz carrier.

Now an even smaller calculator from Japan

Business machine people in Japan expect Sharp Corp. to put a hand-size calculator on the market soon—perhaps immediately. The new calculator, industry sources say, will be about half the size of Sharp's current Microcompet, but will have the same calculating capabilities. For the new machine's circuits, Sharp has stuck with the North American Rockwell LSI arrays used in the Microcompet. The new unit runs three hours on a built-in, rechargeable nickel cadmium battery. It can also be run off a line-operated power pack that recharges the cells.

Germans develop quartz watch

Fretting over increasing competition from foreign quartz watches, West Germany's watch industry is getting set to fight back. Being readied for introduction, possibly at this spring's Hanover fair, is a German quartz model that's likely to sell for as little as $220. Swiss and American quartz types announced in Europe last year are priced at between $450 and $1,900, depending on exterior design. Thus far, only the Japanese have come close to the German price, with a quartz watch that's retailing for around $275, according to industry spokesmen.

The German timepiece will be marketed jointly by four firms—Junghans GmbH, Wehner KG, Paul Raff GmbH, and Bidlingmaier GmbH, but Junghans will be the only one producing it. The German watch will be smaller than most others, but it will feature the same level of accuracy—deviation of less than 0.1 second per day.

French electric car gains momentum

France's electronic car is picking up speed: the government is buying a share of La Voiture Electronique S.A., the firm that unveiled an electronically controlled, electric utility vehicle at the Paris auto show two years ago and marketed it this fall. The state-backed industrial development institute and the nationalized utility, Electricite de France, each will own 9% of the company. Cic. Generale d'Electricite and other firms also will buy small shares. La Voiture Electronique now will have about $800,000 in new working capital to transform its present model—a $900 vehicle designed for enclosed industrial complexes and airports—into a minicar for city streets. The company aims to complete a prototype by 1973 and market it by 1975.

Japanese EIA racing to meet deadline on color VTR standard

The video tape recorder technical committee of the Electronic Industries Association of Japan is pushing hard to achieve its end-of-March goal for selection of a color standard based on Japan's half-inch video tape format [*Electronics*, Sept. 29, 1970, p. 197]. The new standard probably will have a stereo audio track, with the 1-mm audio track used in the black-and-white version split into two 0.35-mm tracks separated by a 0.3-mm space. Several Japanese companies already are marketing half-inch color video tape recorders with their own unofficial modification of the B&W standard. In addition, Matsushita, Sony, and Victor of Japan have proposed a three-quarter-inch cassette tape.

How electronics is gradually invading Europe's classrooms

Manufacturers are still more interested than teachers in computerized education; but video cassettes show promise

Computer-aided education may be one of the in-words of electronics, but the big market for instructional gear in Europe is the factory and the office, not the classroom. And the big emphasis is still on traditional audio-visual tools—projectors, recording machines, and the like.

Yet the advances in electronics hardware are having their impact on both teaching and training. Computer-based systems, once rejected as too expensive or too impersonal, are at least getting a hearing. What's more, the arrival of video tape cassettes promises to open plant gates and school doors to electronics companies.

That's the view from Paris as the second annual Audio-Visual Show, being held from January 14 to 20, fills the Porte de Versailles exposition hall. With education representing only 10% of the French market for audio-visual equipment, industry offers the most potential, says Yves Serant, manager of the trade association that sponsors the show. "The term 'audio-visual' is starting to bother me—'communications' is a better word," he says, referring to the growing role of electronics in instruction.

Serant believes that the video cassette, for example, is likely to revolutionize personnel communications and training programs in industry. Philips, the Dutch electronics giant, will have its cassette system on the market in about a year and is aiming at educational and industrial users first. But the problem of conflicting systems and standards may put buyers off.

Furthermore, it's not at all certain that educators will be ready for video cassettes. For example, the use of all electronic audio-visual equipment in public education is lagging in France. Although the showcase university at Vincennes, outside Paris, has a costly new closed-circuit TV system, it is little used—and there are no signs other French universities are any more convinced of TV's value.

Yet, this year's Paris show—which includes 160 hardware and software exhibitors, 45 of them non-French—reflects a growing audio-visual market. Though the show has dropped strictly acoustic equipment, which will be shown instead at the Paris Hi-Fi Show in March, exhibition space has grown to almost 200,000 square feet from last year's 160,000 square feet.

The accent this year is on software. "A problem for the moment is how to use existing equipment," says Serant. France's SEMA, for example, is launching a new program to teach data processing using various teaching machines. Cie. Internationale pour l'Informatique, France's major native computer maker, is introducing software permitting its computers to be used as teaching machines. Cegos and Data Communications, both French firms, are showing new teaching programs for video tape recorders.

Not all of this year's new developments are on display at the show, however. In Germany, which has its own biennial "Didacta" audio-visual show, the chronic shortage of qualified teachers is spurring the demand for electronic audio-visual equipment. A number of big companies, like Siemens and BASF, are trying to meet the demand with new products.

The total German market for electronic audio-visual systems is difficult to pin down, but if just the basic individualized systems—the kind which use electronics for sound and picture presentation to a single student—are considered, this year's market should hover around $25 million, states one industry source. As for computer-aided instruction, there's big disagreement among the experts. Some don't see a sizeable market shaping up before 1980. Others see a demand for a $250 million worth of computers for teaching purposes by 1977.

BASF, one of Germany's three big chemical producers, has entered the field through its expertise in magnetic tapes. The BASF systems 2800, 3400 and 5600, to hit the market this year, are designed for both linear programs, where the student advances in step-by-step fashion, and branched ones, where he can backtrack to any previous step if he encounters difficulties. These systems all use special endless Super-8 film cassettes and compact audio cassettes. Philips and others have similar cassette-based systems.

The 3400, however, can be hooked

to a computer, which stores student responses and records them in tabular form. The computer types out the program and lecture number, the number of right and wrong answers, and program throughput rate in minutes and seconds, as well as the class average based on performance of individual students. The computer also furnishes the basis for grading students and for producing certificates.

Siemens also has a computer-based system, which works on a free-choice response basis. It recognizes a correct or incorrect solution to problems no matter how the student phrases his answer. For the system to be practical, Siemens envisions a large setup, with displays units in many classes, even many schools, time-sharing a central computer.

These systems are ambitious, but their makers hope they will escape the fate of the equally ambitious Tutorivac, a feedback classroom marketed by Brussels-based International Visual Aid Center (IVAC), part of the ITT group. The Tutorivac uses a tape recorder and slide projector to impart information and ask questions. Students answer by pressing one of four buttons on a hand-held keyboard. Up to 40 keyboards feed into an electronic analyzer on the teacher's desk, where details on how many students answered correctly, which answer any student gives, and each student's cumulative score are displayed.

The Tutorivac proved too expensive for Britain's school officials and most Continential buyers as well. This spring, IVAC will introduce a lower priced Mini-Tutorivac, which can handle 36 students and has no electronic analyzer—the instructor has to keep count.

Swedes lead in audio-visual

Sweden is probably the best audio-visual market in Europe, when it comes to school and university use. A law passed 10 years ago required that all newly built schools and remodelled schools have at least $400 worth of audio-visual equipment in each classroom. The equipment includes a tape recorder, projector, loudspeaker system, and room darkening equipment.

In addition, the Swedes are teaching English in all schools, new and old, starting at the third grade, using a system known as "English without books"—which means using a tape recorder. What's more, French and German are taught the same way in the junior high classes. Multiply all that by 5,000 schools to get the educational tape recorder market.

The Royal School Board's expert on audio-visual equipment, Aake Anderson, admits the market figure is extremely hard to pin down, but estimates it at $100 million a year. That's for both hardware and software, with software the major part. He said a report from dealers recently showed that Sweden has in operation today 1,100 out of the total 1,400 video tape recorders used in all four Scandinavian countries. TV receivers are not too common in classes—only about one to every five classrooms or so—due to difficulty fitting the school programs that are broadcast into teaching schedules. But video recorders should change that as they enter more schools.

Sweden's schools have four different types of language lab. The most complicated—with a teacher console and individual booths for the students—are found in 250 schools up to the ninth grade. In addition, there are about 50 such labs in the high school level "Gymnasium". Then there are about 400 other such labs for teaching various subjects, so "language labs" is something of a misnomer in Sweden.

Anderson says the school system is just starting to test and follow developments for using computers. Only about 10 schools have minicomputers with student terminals—mainly to teach students how computers operate. Anderson is somewhat skeptical about any big immediate breakthroughs for computer-aided instruction: "It will probably come in about 10 years."

In Britain, where the electronic content of the educational audio-visual market is about $8 million, the emphasis is still on traditional equipment. Michael Grant, an official of Rank Audio Visual Ltd., believes sales will remain concentrated in audio and TV systems. "Sophisticated electronic aids, such as feedback classrooms and computer-aided instruction, are not really suitable for school instruction at the present time." Grant should know: before joining Rank he was manager of the now-defunct British ITT-IVAC Tutorivac operation.

Among the less sophisticated aids, the most interesting developments are the CCTV links being established by the larger local education authorities. The biggest, opened in 1969 in London, takes in 1,000 schools and 130 higher education establishments. Programs are transmitted by cable from central studios to all schools in the area that want them. Similar systems are or will be operating in Glasgow, Cambridge, Hull and Plymouth.

The Italian audio-visual market is also slowed by a "traditional" approach to education. There's even a law that obliges a teacher to pay for any damage he may cause to school apparatus, putting a real damper on buying and using sophisticated equipment. One manufacturer says that at the present rate of growth it would be another 10 years before a sufficient accumulation of hardware in the schools really begins to affect the way teaching is carried out. Then, too, the government has no plan to set up special audio-visual centers or expand audio-visual training. And, point out industry observers, very little software is perfectly suited to Italy; most is American, and not well translated or adapted to the Italian market.

Besides the expected language labs and tape recorders, there is one fairly good seller in Italy—an electronics trainer made by Philips. It resembles a blackboard but has eight removable panels into which designs for different electronic circuits can be set. The student inserts a component into the correct place in the panel, constructing a range of electronic circuits from logical circuits to oscillators and radios. Already 150 have been sold in Italy—even though a trainer with a full set of panels costs $9,600.

West Germany

Laser speeds automatic testing of IC masks

Checking IC masks for accuracy of geometry is a time-consuming procedure even when it's automated. Up to 30 seconds may be required to define the coordinate points of a particular edge on the mask.

Mask inspection at such slow rates, however, is a thing of the past for International Business Machines Corp. Researchers at IBM's German facilities have developed a new photoelectric microscope which, with table movements at rates of up to 100 millimeters per second, gives a speed improvement of 1,000. Even at that high table speed, IBM's new instrument yields an edge detection repeatability of ±0.03 micron, comparable with that of the slower techniques.

Essentially, the new photoelectric microscope uses a helium-neon laser to generate an intense light spot on the mask surface. This spot alternates between two adjacent positions, producing an ac output at a photodetector when an edge passes under the microscope.

Developed by Franz Schedewie of IBM's Manufacturing Research Laboratories in Sindelfingen, near Stuttgart, the new microscope is being used at the measuring and test facilities of the firm's parent company in the U.S. Schedewie says the microscope will be used for wafer inspection as well.

The new instrument is similar to conventional photoelectric microscopes in that it's based on modulated carrier frequency techniques. The big difference, however, is that this carrier is produced by electro-optics. The much higher carrier frequencies thus produced give higher table speeds. The IBM instrument uses a 1.6-megahertz signal with an amplitude of ±900 volts.

The instrument essentially consists of the helium-neon laser, an electro-optical polarization modulator, a set of prisms and lenses, and the photodetector. The laser beam passes through the polarization modulator and then is focused by an eyepiece lens. Depending on how the light is polarized, a subsequent Wollaston prism deflects the laser beam in two different directions. A beam splitter and a microscope objective focus the light on the mask. The IBM instrument produces spots with a diameter of about 2 microns. Separation between spots is 1 micron. The smallest line width that can be detected is roughly 2.5 microns.

Great Britain

Small computer outlook: bleak future for U.K. makers

Remembering the disarray in its large computer industry before International Computers Ltd. was established, the British government is anxious to avoid a repeat performance in the fast-growing small computer field. And the results of a recent government-ordered survey show there are good reasons to be anxious.

Britain's Department of Trade and Industry—the new name for the Ministry of Technology—last year commissioned Urwick Dynamics Ltd., industrial consultants, to look into the small computer market and predict the growth trends over the next decade. The information would serve as a guide should the department decide to pump public money in to support the small computer industry. Urwick completed its field work last summer and the department is now lifting the lid on the generally pessimistic finding.

Urwick defines a small computer system as an installation costing up to about $120,000 in Britain. That definition covers a very wide range, from Ferranti's small Argus 600 process controller costing $4,100 in its simplest form up to NCR's Century 100 punched-card commercial machine at nearly $120,000 in its basic form. On the way, it takes in many terminals, minicomputers, small conventional computers, accounting machines, and visible record systems. Urwick estimates that about 1,250 such systems, worth about $30 million, were delivered in Britain in 1969. In 1975, Urwick believes, the figures will climb to 3,750 units with a value of nearly $90 million, for a growth rate of 20% a year.

Confronted with Urwick's estimates, officials all across the field called the 20% growth rate estimate too low. "If that's all it is, a lot of companies will go out of business," notes a Digital Equipment Co. Ltd. man. "Very conservative," says Clifford Cundall, Ferranti's automation systems sales manager; "I'd say around 30%." "Extremely pessimistic," comments Carl Noble, vice chairman of Computer Technology Ltd.; "I think it will be nearer 40%."

Within the general expansion, Urwick picks out process control and education as likely to show the greatest proportional growth. Education might take 100 installations in 1975 against 10 in 1969, and process control 370 against 50 in 1969. Communications network control, traffic control, machine and instrumentation control, and medical and commercial usage might multiply three or four times. Of these, only commercial applications get out of small figures, to 2,500 installations in 1975.

Yet the Urwick researchers are pessimistic about what the future holds for small British computer makers. Remarking on the heavy development and production costs involved, they say "the depth of advanced and proven American minicomputer equipment could prove too great a force with which to compete."

The report rams home another point: "Although the level of competence of British engineers is not considered to be significantly lower than in the U.S., the way in which it is exploited is reportedly far less effective. Opinion was expressed that most projects devised and put into production within three months in the U.S. would take perhaps one to two years in the U.K. Turnover per head in an American company is also of the order of twice that of a European manufacturer."

However, Urwick is even tougher on computer users. "There is gross ignorance of the potential of small computers, and the costs involved, at all levels of management. In particular, computers are more usually thought of as an entitity separate from the business and which must fit in with old, established methods and precedures. Also, in many cases, there is a vast gap in comprehension of what a computer can do between the higher-educated employees and those of lesser academic attainment who are responsible for providing data input from all levels of the business."

As a result, according to Urwick, computer installations are often not achieving the expected level of performance, and even large organizations are unable to discuss their computer requirements clearly. To overcome this, there must be a great increase in training programs for computer personnel, and on the manufacturer's side there must be development of a "satisfactory man/machine interface to cater for low-skilled operators."

Korea

Electronics helps boost Korea's economic growth

The new skyline of Seoul, punctuated by 30-story buildings and elevated expressways, would surprise many Korean War veterans. Even more impressive, perhaps, is the soaring economic growth curve that backs up the outward symbols of South Korean prosperity. The products exported by foreign investors from the U.S., Japan, and other nations, including electronics companies, are one of the main reasons for the growth spurt.

Korean government offices abound with blackboards and charts showing a gross national product increasing by 15% a year, bolstered by exports growing by 40% annually. In 1970, the country's exports hit the $1-billion mark, an increase of $300 million over 1969 shipments. In 1976, when Korea completes her third five-year economic plan, exports are estimated at $3.5 billion, one-third of the gross national product.

To maintain such heady growth, the government is engaged in a vigorous campaign to attract even more foreign investors—especially in high-productivity fields. Electronics makers stand tall on the most-wanted list.

In the electronics field, a number of U.S. and Japanese firms have already put in about $20 million to establish Korean ventures, and other makers are expected to follow. Exports of electronics equipment have been rising 120% a year for the past five years, although electronics still represents only about 6% of Korea's total export volume. Some 71% of the electronics goods go to the U.S.

Korea's attractions for U.S. companies are manifold. For one, the government's foreign investment inducements offer foreign ventures a five-year tax holiday and a 50% tax reduction for an additional three years. Further, remittance of profits is guaranteed. Then, too, Korea has set up or is establishing for export industries a number of industrial parks where low-cost facilities or land may either be purchased outright or leased on long-term contracts. So far, 14 industrial areas have been set aside, and seven are operational. In addition, the government is constructing a free export zone at Masan, where it hopes 100 light industrial plants will be operational by 1975.

Yoon Sae Yang, director of the government's Office of Investment Promotion, says that it is the Korean government's attitude toward foreign investors, rather than the formal inducements they are offered, which prove most attractive to overseas businessmen.

"Korea's future is as a trading nation," says Yang, "but we have limited capital. Thus, to get the funds we need, we must rely largely on foreign investment."

The government has established a special organization, The Korea Electronics Industry Information Office, to assist foreign electronics firms, as it has formed similar units for other sectors of industry. The office has branches in New York and Tokyo, and offers a wide number of investor advisory services.

Yang says that the government engages in little advertising to attract foreigners, however. "We've found that the businessmen who have to be told about Korea before they are interested are not generally the best businessmen."

Currently, some 215 foreign firms, including 18 electronics manufacturers, have been granted permission to operate in Korea. The largest electronics company is Motorola, which operates a wholly owned venture, Motorola Korea Co. Formed in 1967, the firm manufactures integrated circuits and transistors. Sales in 1969 totaled $12.4 million, making the firm Korea's ninth-largest exporter. Other electronics firms that have located in Korea include Signetics Corp., Applied Magnetics Corp., and American Micro-Systems Inc., all of the U.S., and Japan's Toshiba, Sanyo Electric, and Nippon Electric.

For the most part, the foreign companies are barred from selling their products in Korea. What's more, sky-high tariffs are placed on imported goods, unless they are imported solely for inclusion in export products. In that case they can be imported duty-free. This closing of the domestic market to foreign companies is a sore point with many. Although they won't talk about it openly, company officials privately say that the domestic market is an attractive one, and that by allowing sales by overseas investors the Koreans would pay less for consumer electronic products.

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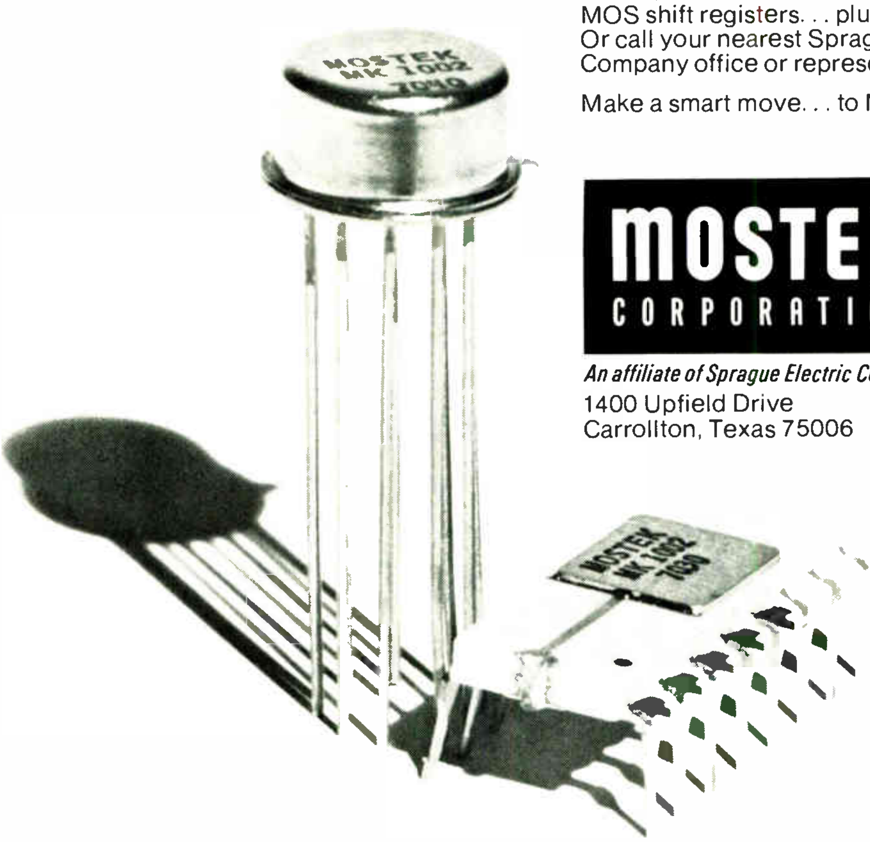

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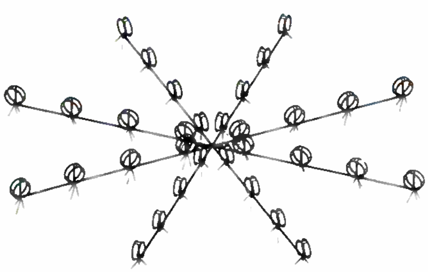

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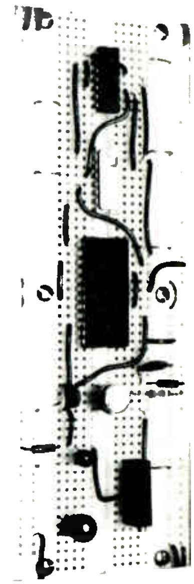

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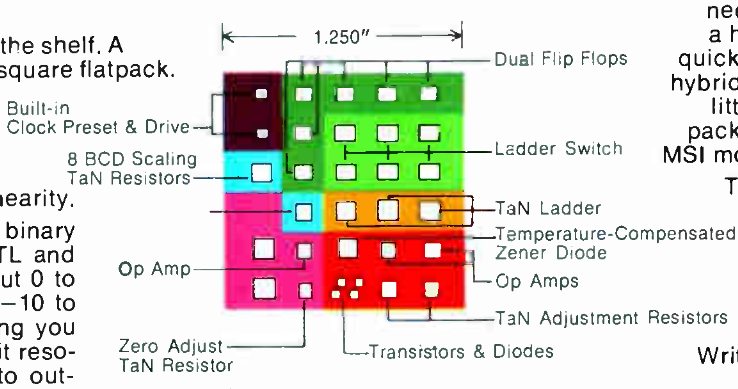

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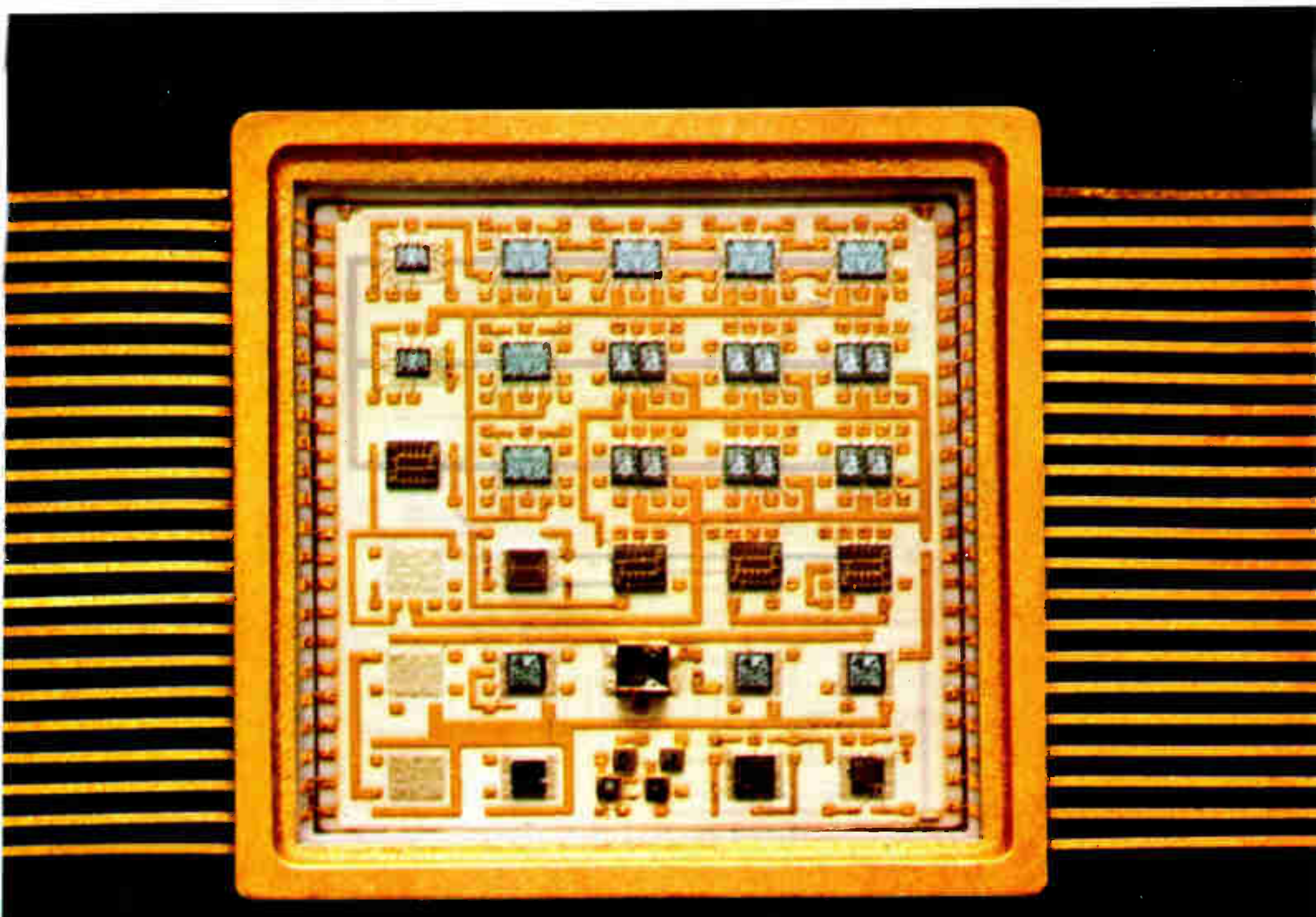

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