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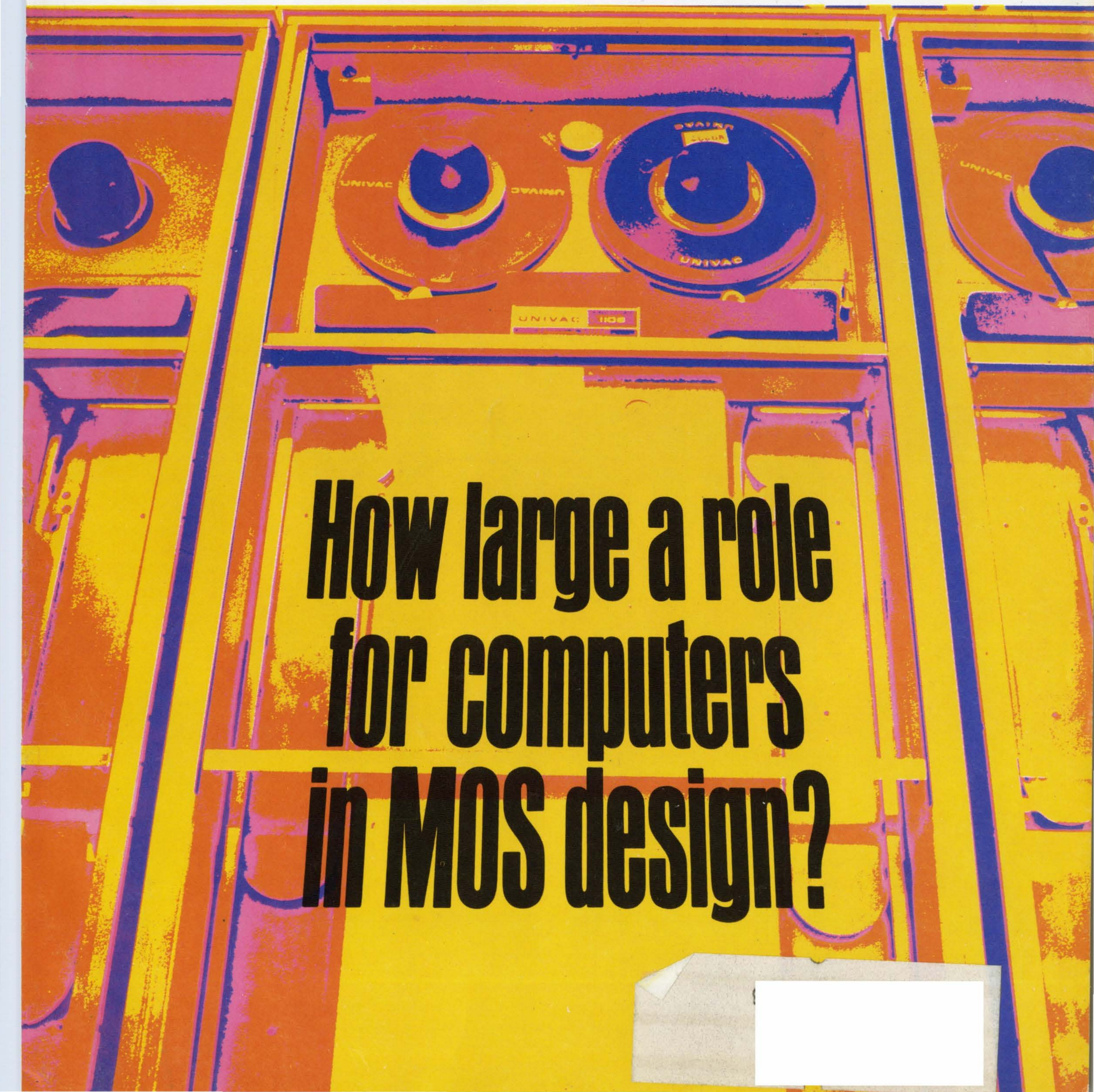
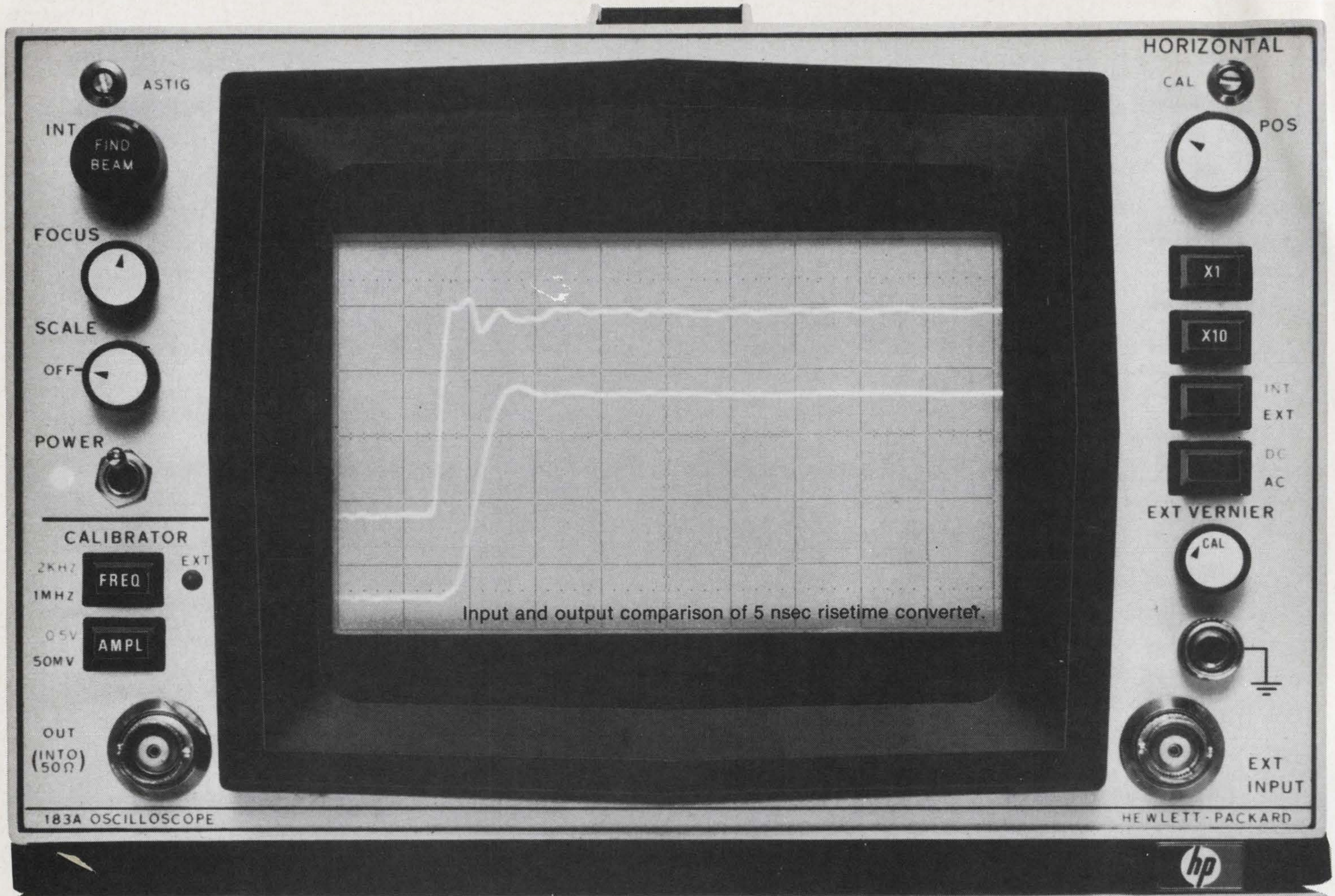


How large a role for computers in MOS design?



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Volume No. 42 Number 21 October 13, 1969

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Readers Comment

Radiation and tv . . .

To the Editor:

In regard to your editorial [Sept. 1, p. 31] you may be interested to know that to date, over 6,000 color-tv sets have been inspected in Suffolk County, N.Y. Approximately 17% of those tv sets checked emitted X rays at or above the recommended levels established by the National Council for Radiation Protection.

Seymour Becker
Department of Health,
Suffolk County
Riverhead, N.Y.

. . . and solid state

To the Editor:

Your editorial [Sept. 1, p. 31] calling for replacement of radiation-emitting vacuum tubes in television receivers with solid state devices seems to presuppose that this hasn't occurred yet. As manufacturers of high-voltage silicon rectifiers and packaged configurations, we can report that:

- Nearly every major color tv producer is redesigning one or more models to incorporate solid state power circuitry to replace the high-voltage shunt regulator tube and/or the high-voltage regulator tube.
- They are evaluating single stacks, doublers, triplers, and quadruplers developed by semiconductor manufacturers.
- We expect that by 1972, the changeover to solid state power supply circuitry will be more than 75% complete, rendering academic the furor over emission of harmful X-radiation.

While the color-tv industry is concerned about the radiation controversy, evidence of the emission of harmful X-radiation is still far from conclusive. The main reason the industry is undertaking the expense of redesigning and testing to accommodate solid state high-voltage circuitry is the very recent development of silicon rectifiers at competitive prices for the applications required. The industry has been moving steadily to replace

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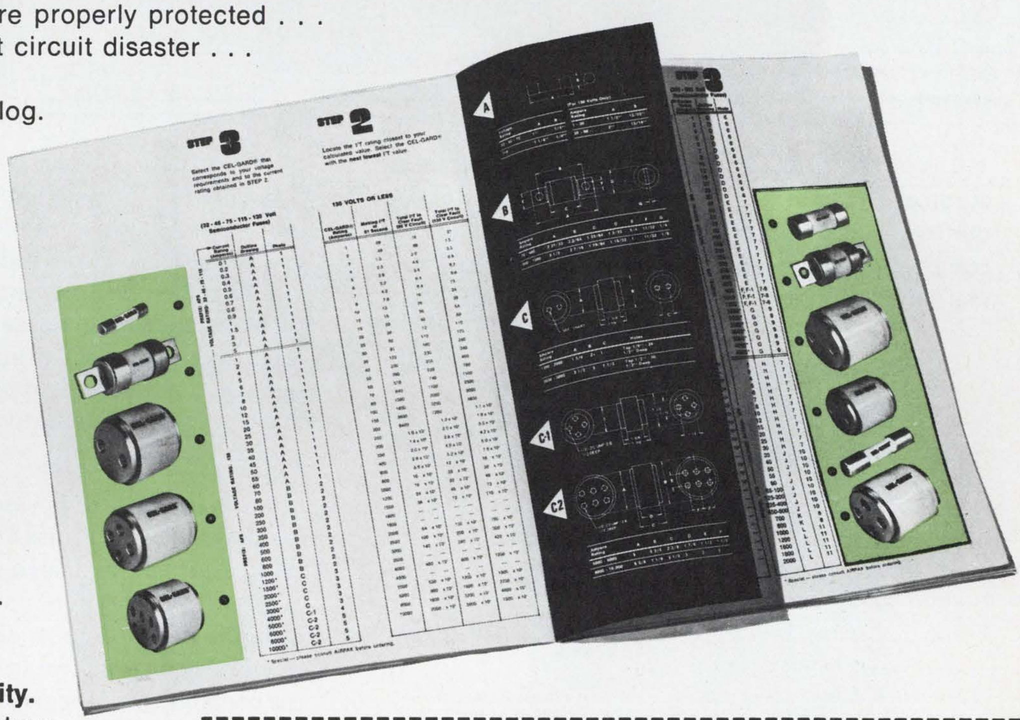

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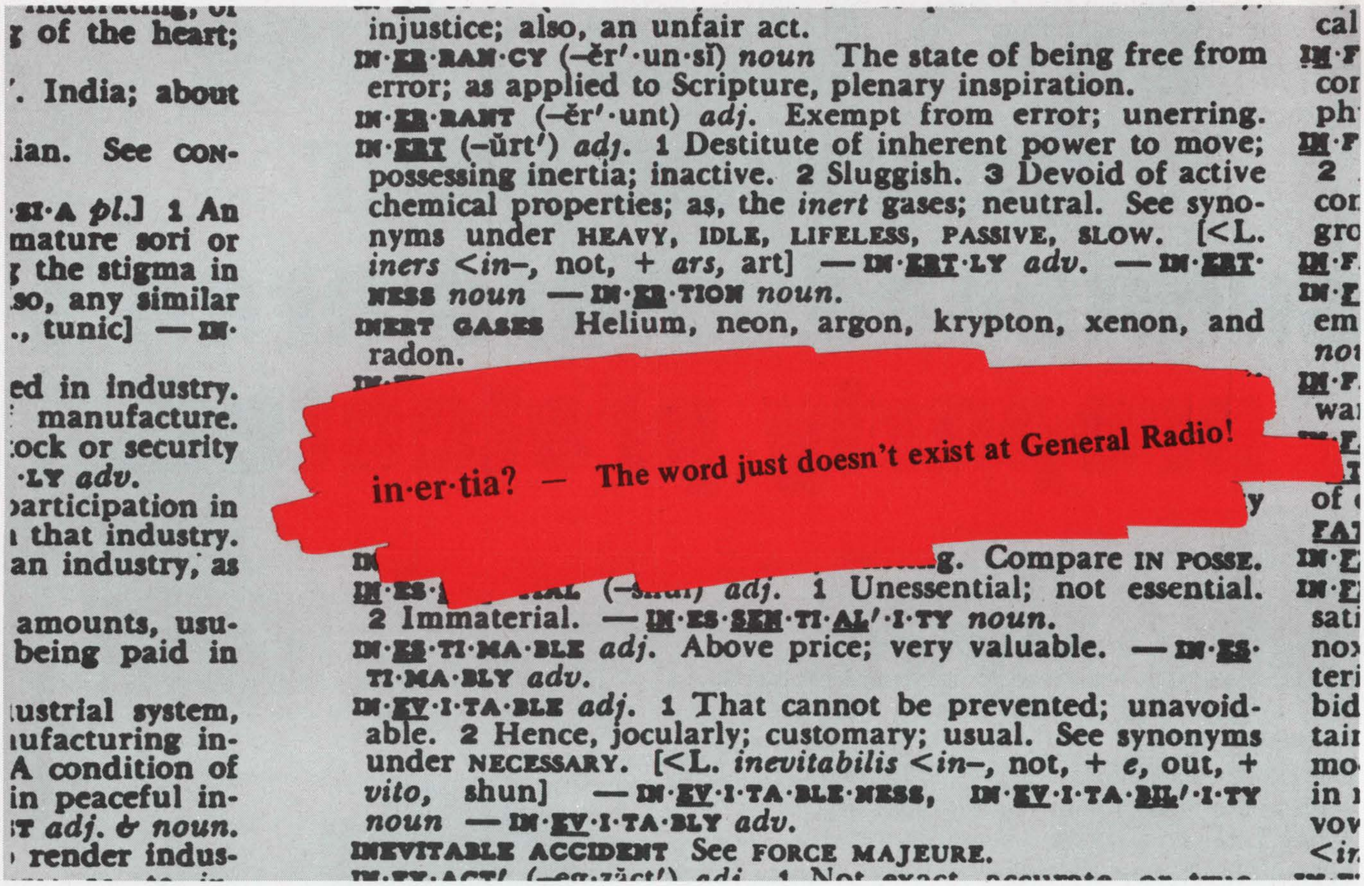

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GENERAL RADIO

Readers Comment

vacuum tubes and, in my opinion, the changeover would have taken place anyway as soon as economic and performance criteria had been adequately fulfilled.

Edmond H. Borneman
President
Scientific Components Inc.
Linden, N.J.

End product

To the Editor:

Your newsletter item [Sept. 15, p. 221] incorrectly states that the Sanyo Electric Co., under a license from the General Instrument Corp., will be allowed to sell large-scale integration circuits separately. Sanyo is licensed for the use of General Instrument LSI circuits for internal consumption only. It is allowed to sell the end product, such as calculators or computers, anywhere in the world, but not the individual circuits.

Lewis Solomon
Vice president,
marketing and sales
General Instrument Corp.
Hicksville, N.Y.

Not new to him

To the Editor:

The concept of multistable logic [Aug. 18, p. 105] is not new to me. Approximately 20 years ago—in the vacuum-tube era and inspired by loran-type stair-step counters—I built a two-counter "phase-shift register," using the grid of a vacuum-tube one-shot as reference and discharge for the capacitor rather than the then traditional blocking oscillator. However, I did not put the circuit to any practical use at the time.

Some eight to 10 years ago, I designed a phase-shift (or multistable) register using three conventional transistor flip-flop counters as two storage counters and one reference counter. This type of circuit (identical in principle to that described in the article) easily produces an analog or a digital readout. The output was to a computer, and the customer was Wright Field in Dayton, Ohio.

Since then, I have built up a file of breadboard and paper designs including logic concepts for a small calculator. My work has not been as extensive as that of the Russians, but I would hate to think that I would have to obtain a license to use a technique I have now used for about 20 years. My approach has been to use transistor one-shot staircase counters, and this Russian circuit is the simplest for the purpose that I have ever encountered in my experience.

W.A. Spoor
Gulf Aerospace Corp.
Houston, Texas

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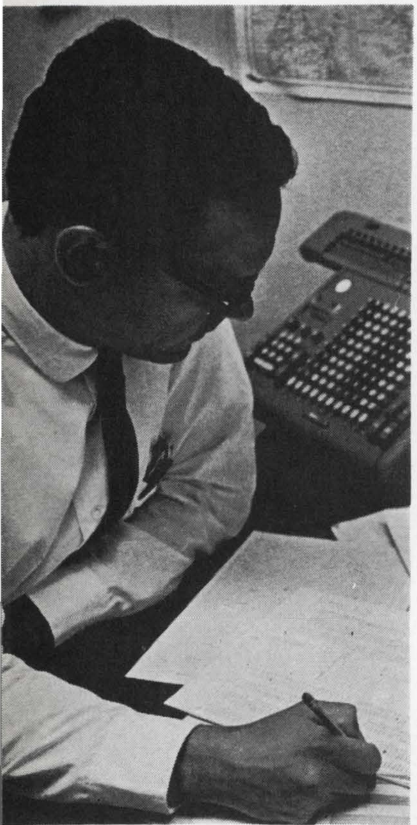
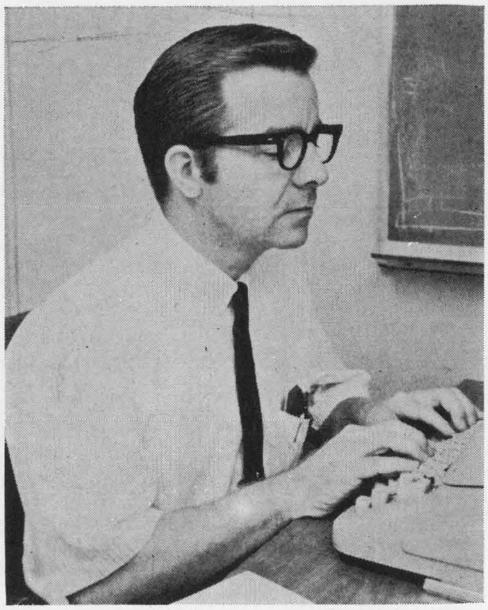
Who's Who in this issue



Gibson

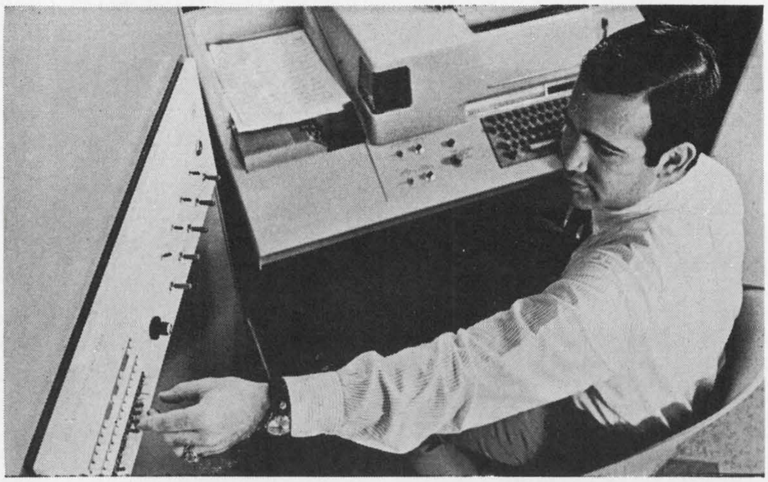
Shevel

Teamwork is as important in developing an engineering concept as it is in scoring a touchdown on the football field. Proof of this is the article starting on page 105, authored by IBM's Donald H. Gibson and W. Lee Shevel. Gibson's work on the buffer design for the 360/85 earned for him the company's outstanding contribution award. He is with the Systems Development division, while Shevel is with the Components division.



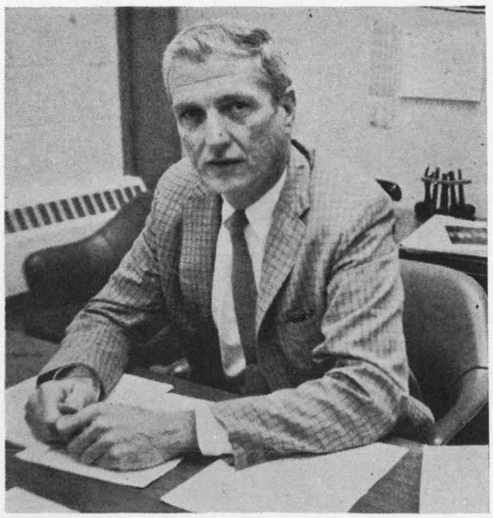
Curran

No stranger to *Electronics*' readers, associate editor Lawrence Curran's byline has appeared frequently since 1967, when he took over the magazine's Los Angeles bureau. Curran has been keeping tabs on the impact of computers in designing custom MOS circuitry and has filed several reports on the subject. His latest is the article starting on page 82.



Harmon

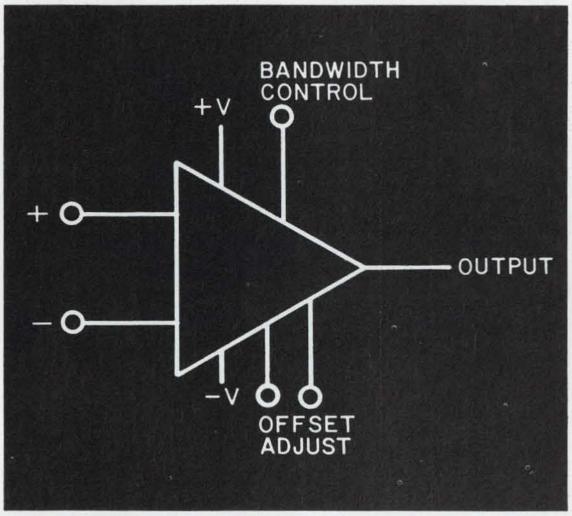
Necessity may be the mother of invention, but there must always be a father—the role played by the Leeds & Northrup Co.'s Ronald S. Harmon, author of the article starting on page 96. A 1965 graduate of the University of Pennsylvania, Harmon is the man behind a thermocouple open-circuit detection system that can be used in multiplexed, digital data-acquisition systems. He is a development engineer at the company's Digital Equipment division, where he has designed, among other things, logic and peripheral equipment for interfacing with computers. In the company's LN-5000 digital computer control system, Harmon was primarily responsible for the analog input subsystem.



Whalen

Robert M. Whalen, author of the article starting on page 108, is an 18-year IBM veteran. A graduate of Cornell University, he helped develop the memories for the company's 7000 series and System/360 series of computers. Whalen designed central-processing hardware before he began his present specialization.

OP AMP FAMILY



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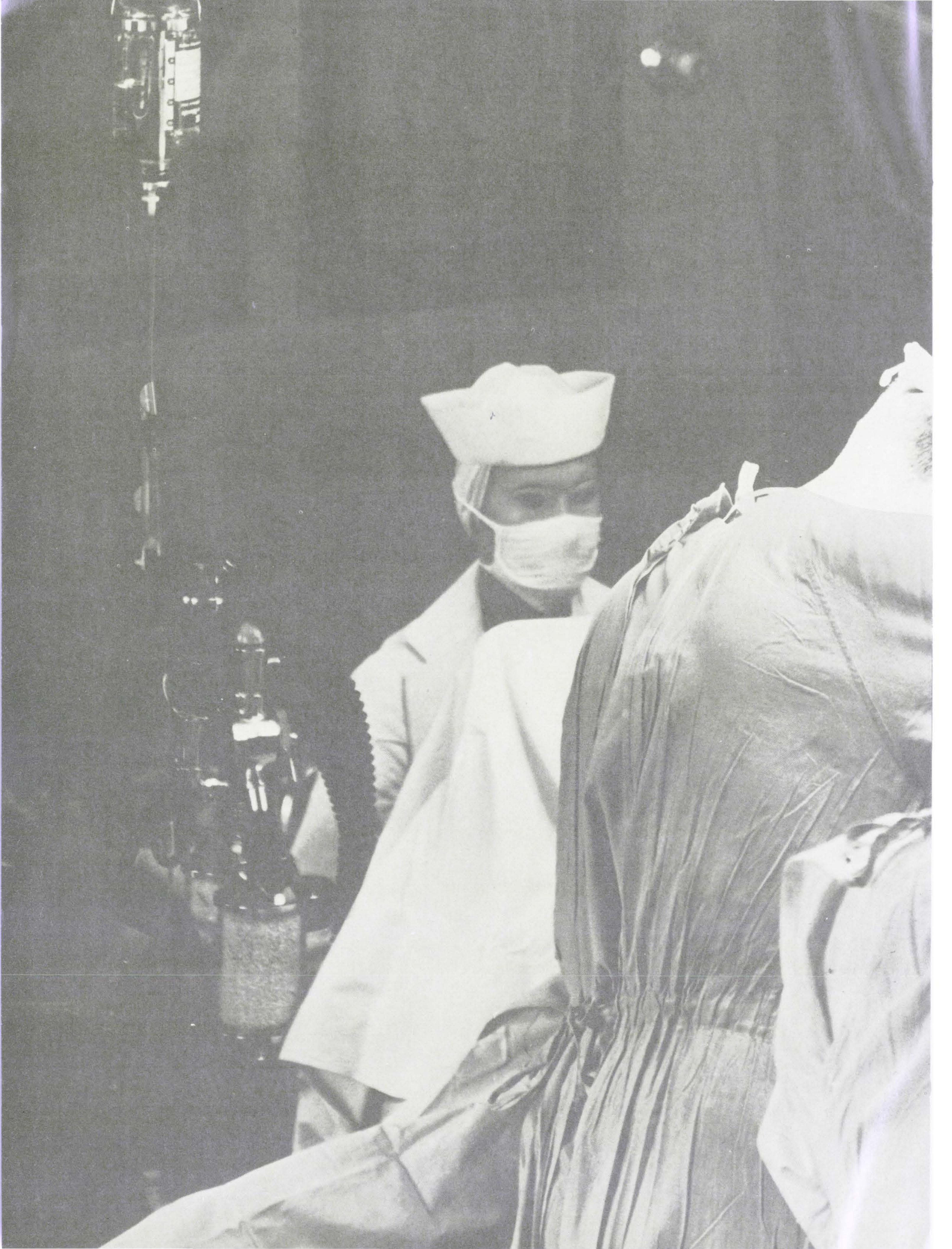


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Who's Who in electronics

API's Reekie

Can a vice president for technology in a giant scientifically oriented company grossing $280 million a year quit and find happiness in a similar job with a $10 million instrument firm?

For James Reekie, who just joined API Instruments of Chesterland, Ohio, as vice president for technology after seven years with Bell & Howell, the answer is yes. There were two major reasons for his move: a reorganization, plus the opportunity to share in the excitement of a fast-growing firm. Reekie, who was vice president and director of technical operations at Bell & Howell's photo products group in Chicago, puts it this way:

"A policy change at Bell & Howell had decreed that the central research staff of 300 people be divided among the five divisions in the group. After company divisions grow to a certain point, they can exert quite a bit of leverage in getting autonomous R&D. That shift, in effect, eliminated my job in Chicago. Also, I have always liked to be associated with ventures which have steep growth curves in developing new technology, or in increasing sales, or whatever. It seems to me API is facing that kind of growth."

Taking both forks. Reekie reasons that API has had steady but relatively modest growth up to now because it had confined itself to instruments. But by expanding its reach both ways, toward the sensing end and toward the information display, API is poised to become a systems supplier rather than simply a component manufacturer, and to turn its projected growth curve sharply upward.

While long-term growth potential is about equal on both ends of this systems spectrum, Reekie says the first effort will be in displays.

"The information explosion is going on in many directions, including industrial processes where a human being must observe, quickly assimilate, analyze, and act upon an increasing amount of data," Reekie points out. "There is tremendous potential for improving the compactness and ease of comprehension of such information, and it doesn't require any new technology, either.

"The instruments and controls in a modern aircraft are a good example of what I mean," Reekie continues. "The display gives the pilot a picture of the plane and what it's doing without his having to think much about it or to interpret it. That's the kind of aspect I believe can be designed into industrial control information.

"Two benefits derive from this approach. One is that great gains can be obtained from technology that already exists. What is required is to think in terms of the human being and his wants and requirements first, instead of emphasizing the machine as in the past. This also avoids the pitfall of going into too much basic research; that can be unwise for a small firm."

Here they come. API will introduce a new product in information display within the next six months or so and, according to Reekie, there are four more new product candidates which will take a little longer to evaluate, select, and develop.

Reekie is reluctant to reveal the precise nature of these new prod-

Who's Who in electronics

ucts. But he does point out that a digital display doesn't give any rate-of-change information, and "from the human viewpoint, rate of change is often critical in determining proper functioning of a system. So, we need to add rate-of-change data to the display."

He envisions a central monitoring and alarm system for the home which would tell the householder through a central panel that all of his pilot lights were on and systems functioning properly.

"I can see such systems being built fairly economically," Reekie says, "and that is what I call large-volume business."

Another possible market? "Automotive," suggests Reekie, "though we may be too late for that one already. But I can see a system which monitors various critical functions and displays the data on the dashboard."

Cleaning up. Still another? "Pollution, and by that I don't mean necessarily air or water," says Reekie. "I'm thinking of noise pollution. Here is an area where no one is quite certain yet what ought to be measured in order to ascertain the levels of pollution. I am recommending that API investigate the measurement of noise in a novel fashion and display the information in novel fashion."

To assist Reekie in his new product efforts, present manning charts call for a development group of about six people. Reekie already has hired two new men for this group, who, he says, have demonstrated their innovative capabilities. One came from General Instrument and the other from General Electric.

What happens when these men and other creative types like them feel constricted by an enlarged API and begin to want to move on?

"I'm not so sure we will want to try to keep them from leaving," Reekie says. "They may already have made their most creative contribution to this company and ought to use their particular expertise elsewhere; and I believe a company needs a more or less constant flow of new people and new ideas to regenerate itself."


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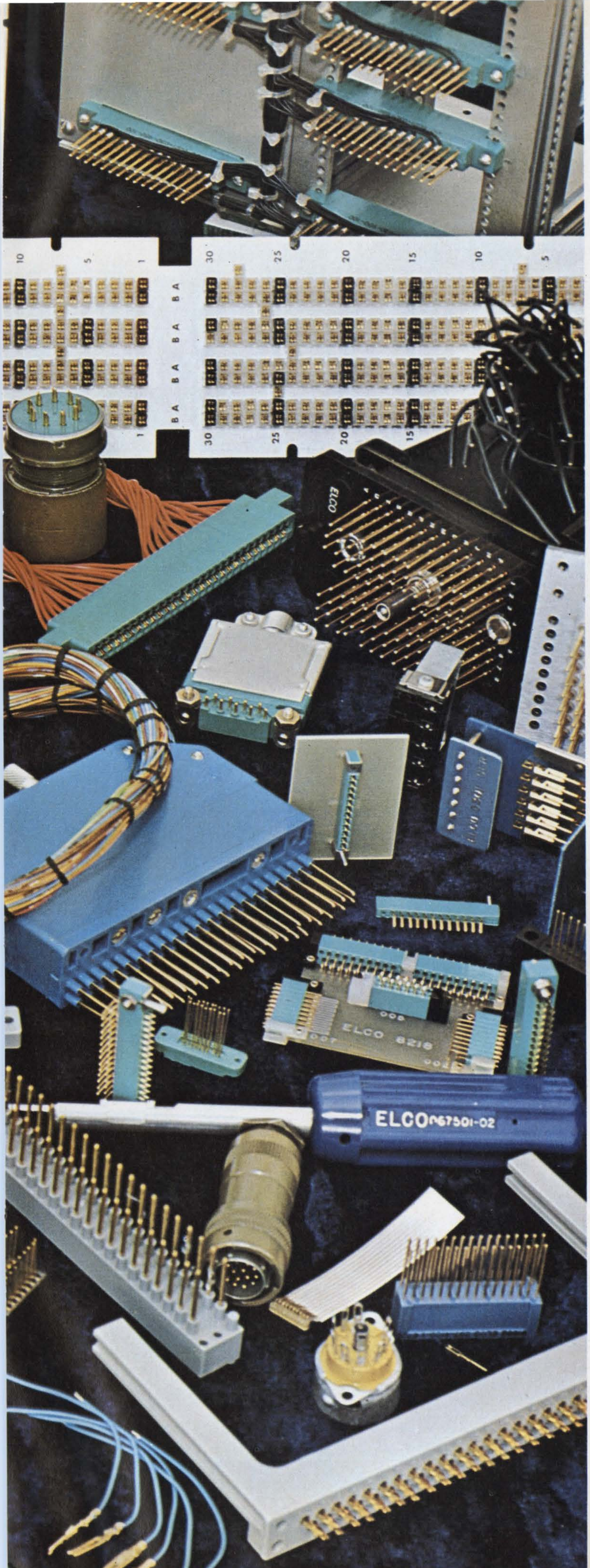

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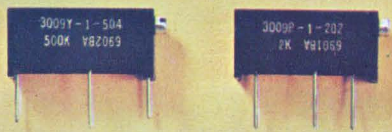


3009Y(RJ11) **3009P**

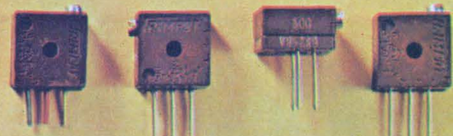
- Low Cost Industrial (RJ11 Pin Configuration)
- Power 0.75 watt at 25°C
- Resistance: 10Ω to 1 Meg.

Model 3069

3069P

- Low Cost Industrial
- Mil-Spec Immersion
- Power 0.75 watt at 25°C
- Resistance: 10Ω to 1 Meg.

Model 3282



3282L **3282H** **3282P** **3282W**

- Meets requirements of MIL-R-22097
- Power 0.5 watt at 85°C
- Resistance: 10Ω to 1 Meg.

Model 3012

3012L **3012P**

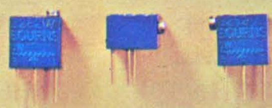
- Meets or exceeds MIL-R-22097, Style RJ11
- Power 1.0 watt at 70°C
- Resistance: 10Ω to 1 Meg.

Model 3052

3052L **3052P** **3052S**

- Meets or exceeds MIL-R-22097, Style RJ12
- Power 1.0 watt at 70°C
- Resistance: 10Ω to 1 Meg.

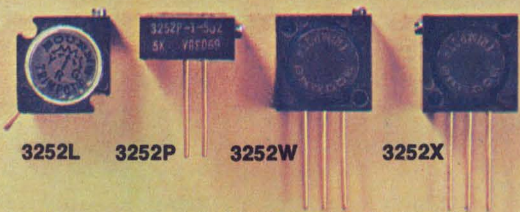
Model 3262



3262W **3262P** **3262X**

- Meets or exceeds MIL-R-22097
- Power 0.25 watt at 85°C
- Resistance: 10Ω to 1 Meg.

Model 3252



3252L **3252P** **3252W** **3252X**

- Meets or exceeds MIL-R-22097, Style RJ22
- CRV 1.6% over entire resistance range
- Power 1.0 watt 70°C
- Resistance: 10Ω to 2 Megs.

Model 3099

3099

- First Dual In Line Cermet Available
- Std DIP size (TO-116)
- Sealed to meet MIL-R-22097 Immersion
- Power 0.75 watt at 25°C
- Resistance: 10Ω to 1 Meg.

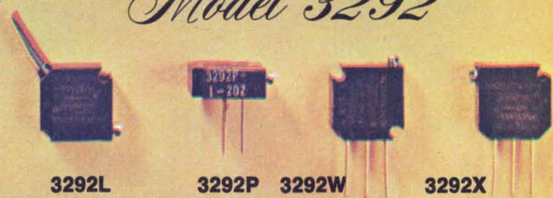
Model 3059

3059L **3059Y** **3059P**

3059J

- Meets or Exceeds MIL-R-22097, Style RJ12
- Power 1.0 watt at 70°C
- Resistance: 10Ω to 1 Meg.

Model 3292



3292L **3292P** **3292W** **3292X**

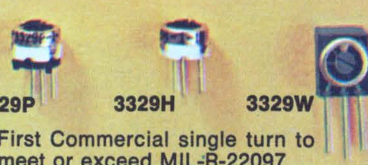
- Meets or exceeds MIL-R-22097, Style RJ24
- Power 0.5 watt at 85°C
- Resistance: 10Ω to 1 Meg.

Model 3082

3082P

- Only .10″ x .15″ x .50″
- Power 0.3 watt at 85°C
- Resistance: 10Ω to 1 Meg.

Model 3329



3329P **3329H** **3329W**

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- Power 0.5 watt at 70°C
- Resistance: 10Ω to 1 Meg.

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BOURNS

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Meetings

Nerem: bring your track shoes

Don't categorize Nerem—it's one of the rare conferences at which it's hard to select one session over another, so attendees should plan to review the proceedings and prepare to rush from one session to another.

To be held Nov. 5 through 7 at the Sheraton-Boston Hotel and War Memorial Auditorium, Nerem—the Northeast Electronics Research and Engineering Meeting—comprises 24 technical sessions, five tutorial seminars, industry exhibits, and a special how-to-do-it presentation on new enterprise for the budding entrepreneur.

The meeting's $4 registration fee looks like a bargain; the Nerem program committee appears to have succeeded in second-guessing this autumn's hot topics and to have obtained good papers to cover them. Air traffic control, electronic navigation, automated test systems, monolithic memory systems, automated IC and LSI artwork generation, electronics in medicine, and other topics are represented.

The hot ones. Lead zirconate and lead titanate may become the 1970's substitute for cathode-ray tubes in some data display applications. C. E. Land of the Sandia Corp., Albuquerque, N.M., summarizes his work, which already has included construction of light gates and modulators, in Session 1, Optoelectronics.

Computer analysis of heartbeat is closer with development of a so-called ectopic beat detector by the American Optical Corp. of Framingham, Mass. The machine, discussed by G. J. Harris in Session 2, Bioelectronics, already has proven its effectiveness at spotting heartbeat irregularities.

Circal-2, a new program for network computer-aided analysis, bows in Session 3, CAD, in a paper by G. P. Jessel and J. R. Stinger of MIT. Circal-2 is modular in form, and offers easy interchange of analysis routines, dynamic core memory allocation, and multimode operation.

The realization that testing soon could become a limiting factor in sale and production of large-scale integrated circuits is demonstrated in Session 4, Computer Instrument Systems. E-H Research Labs' R. S. Broughton discusses a test system for LSI which uses an IBM 1130 computer. Matthew L. Fichthenbaum of General Radio talks about his firm's new model 1970 complex logic tester, a system capable of checking entire instruments.

Artful. Although some companies continue to cut rubylith artwork for LSI designs, it seems that the razor-blade days are numbered. Commercial artwork generators have been around for almost two years, and in Session 7, Artwork Generation, spokesmen from Lincoln Lab, IBM, Bell Telephone Labs, and Systematic Design Inc. present the details of their in-house-developed systems.

Session 21—Monolithic Memories—covers developments in both magnetic and pure electronic devices. The two key papers appear to be R. J. Spain's study of cost and performance of sequential magnetic memories under examination at Sylvania Semiconductor, and a paper by W. R. McKinley and others on development of a read-only memory with a user-programable decoder at Fairchild.

Session 20, Air Traffic Control, reviews the control problem today and from the perspective of the 1980's. General conclusions of the four speakers seem to indicate that more on-board avionics will be needed, as will use of radio-navigation systems like Omega, and perhaps digital data links.

Session 24, Electronic Navigation Systems, complements Session 20 and again looks ahead at doppler navigation as it will evolve, at NASA's work on satellite location systems, the present and future status of Omega, and at a proposed system for civil aircraft based on the Apollo midcourse navigation system.

Session 25, Computerized Test

Meetings

(Continued from p. 22)

Techniques, again explores LSI testing, but also touches on program language requirements and finishes with a discussion of a proposed on-board checkout system for the NASA Air Force space shuttle. J. F. Hughes and L. H. Browning of the Manned Spacecraft Center, Houston, discuss the system aimed at speeding prelaunch turnaround time.

For further information contact Boston Section, IEEE, 81 Channing St., Newton, Mass. 02158

Calendar

Thermionic Energy Conversion Specialist Conference, IEEE; Carmel, Calif.; **Oct. 21-23.**

Joint Materials Handling Engineering Conference, IEEE, American Society of Mechanical Engineers; Sheraton Motor Inn, Portland, Ore.; **Oct. 27-29.**

Joint Conference on Mathematical and Computer Aids to Design, Society for Industrial and Applied Mathematics, Association for Computing Machinery, IEEE; Disneyland Hotel, Anaheim, Calif., **Oct. 27-30.**

Nuclear Science Symposium, IEEE; Sheraton Palace Hotel, San Francisco; **Oct. 29-31.**

International Electron Devices Meeting, IEEE; Sheraton Park Hotel, Washington; **Oct. 29-31.**

Northeast Electronics Research & Engineering Meeting (NEREM), IEEE; Sheraton Boston Hotel, War Memorial Auditorium, Boston; **Nov. 5-7.**

University Conference on Ceramic Science, Dept. of Metallurgical and Materials Engineering, University of Florida; **Nov. 10-14.**

Symposium on Adaptive Processes, IEEE; Pennsylvania State University, State College; **Nov. 17-19.**

Conference on Applications of Simulation, Association for Computing Machinery, IEEE; International Hotel, Los Angeles, **Dec. 8-10.**

International IEEE G-AP Symposium, The University of Texas at Austin, **Dec. 9-11.**

Asilomar Conference on Circuits and

(Continued on p. 26)

Allen-Bradley Type G variable resistors help seal Sylvania's rescue transceivers against

ocean dunkings

Built primarily for aiding in the location and recovery of downed airmen, Sylvania's emergency rescue transceiver must be reliable under extremely adverse conditions. It is lightweight and compact enough to be carried in the pocket of a flight jacket. It must withstand impact and immersion in salt water without damage.

Essential to meeting these requirements is Allen-Bradley's Type G variable resistor. It's rugged. It's compact. And it provides the necessary seal against water. This particular Type G has two "O" rings—one between the bushing and shaft, and one between the bushing and mounting panel. This dual seal prevents water entering the enclosure, as well as the control.

The Type G variable resistor features the Allen-Bradley solid, hot-molded resistance track. It gives long life—less than 10% resistance change after 50,000 complete cycles. The noise level is extremely low, and the smooth adjustment provides virtually infinite resolution. Low inductance permits operation across a broad frequency spectrum.

For complete details and immediate delivery on this ½-inch-diameter Type G ½-watt variable resistor, call your authorized A-B industrial electronics distributor. Or write: Marketing Dept., Electronics Div., Allen-Bradley Co., 1201 South Second Street, Milwaukee, Wis. 53204. Export Office: 1293 Broad St., Bloomfield, N. J., U.S.A. 07003. In Canada: Allen-Bradley Canada Limited.

Type G variable resistor shown actual size

Sylvania AN/PRC-90 dual channel rescue transceiver permits two-way voice communication, the transmission of Morse code or the sending of a homing beacon.

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Circle 25 on reader service card

Meetings

(Continued from p. 24)

Systems, Naval Postgraduate School, The University of Santa Clara, Stanford University, and IEEE; Asilomar Hotel and Conference Grounds, Pacific Grove, Calif., **Dec. 10-12.**

Winter Power Meeting, IEEE; Statler Hilton Hotel, New York; **Jan. 25-30, 1970.**

Annual Symposium on Reliability, Group on Reliability of the IEEE, American Society for Quality Control, American Society for Nondestructive Testing, and the Institute of Environmental Sciences; Ambassador Hotel, Los Angeles; **Jan. 27-29, 1970.**

International Solid State Circuit Conference, IEEE, University of Pennsylvania; Sheraton Hotel and University of Pennsylvania, Philadelphia, **Feb. 18-20, 1970.**

Short courses

Reliability Engineering and Management Institute, General Electric Co., University of Arizona, Tucson, **Nov. 3-12.** $275 fee.

Hybrid Computing Techniques, Programming, and Applications, Purdue University, Lafayette, Ind., **Nov. 10-21.** $300 fee.

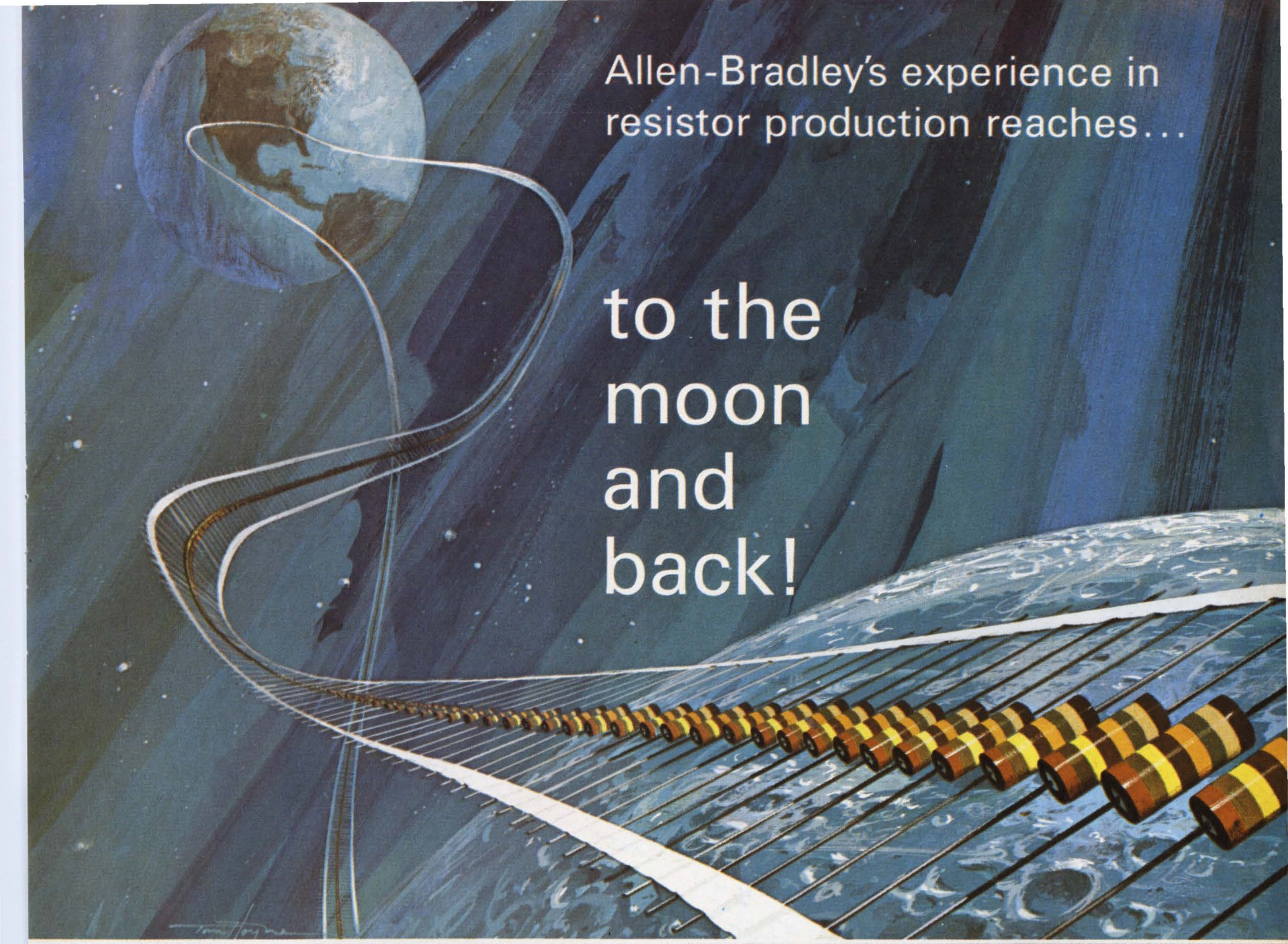
MSI/LSI Circuit Seminar, Airport Marina Hotel, Los Angeles, **Dec. 1-3.** $385 fee.

Call for papers

Electronic Components Conference, Electronic Industries Association and IEEE; Statler-Hilton Hotel, Washington, May 13-15, 1970. **Nov. 15** is deadline for submission of abstracts to Darnell P. Burks Sprague Electric Co., Marshall St., North Adams, Mass. 01247.

National Aerospace Electronics Conference (NAECON) IEEE and American Institute of Aeronautics and Astronautics; Sheraton-Dayton Hotel, Dayton, Ohio, May 18-20, 1970. **Dec. 1** is deadline for submission of abstracts to Mrs. Rita Gustin, 5455 Flotron Ave., Dayton, Ohio 45424.

Southwestern IEEE Conference, Memorial Auditorium, Dallas, April 22-24, 1970. **Dec. 1** is deadline for submission of abstracts and summaries to Prof. Andrew P. Sage, Information and Control Sciences Center, SMU Institute of Technology, Dallas, Texas 75222.



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TYPE EB 1/2 WATT

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TYPE CB 1/4 WATT

TYPE GB 1 WATT

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The reputation for quality and performance established by Allen-Bradley hot-molded resistors is reflected in the fact that they have been an integral part of virtually every U.S. space probe. And they are "on" the moon. No other resistor applications demand a higher measure of reliability.

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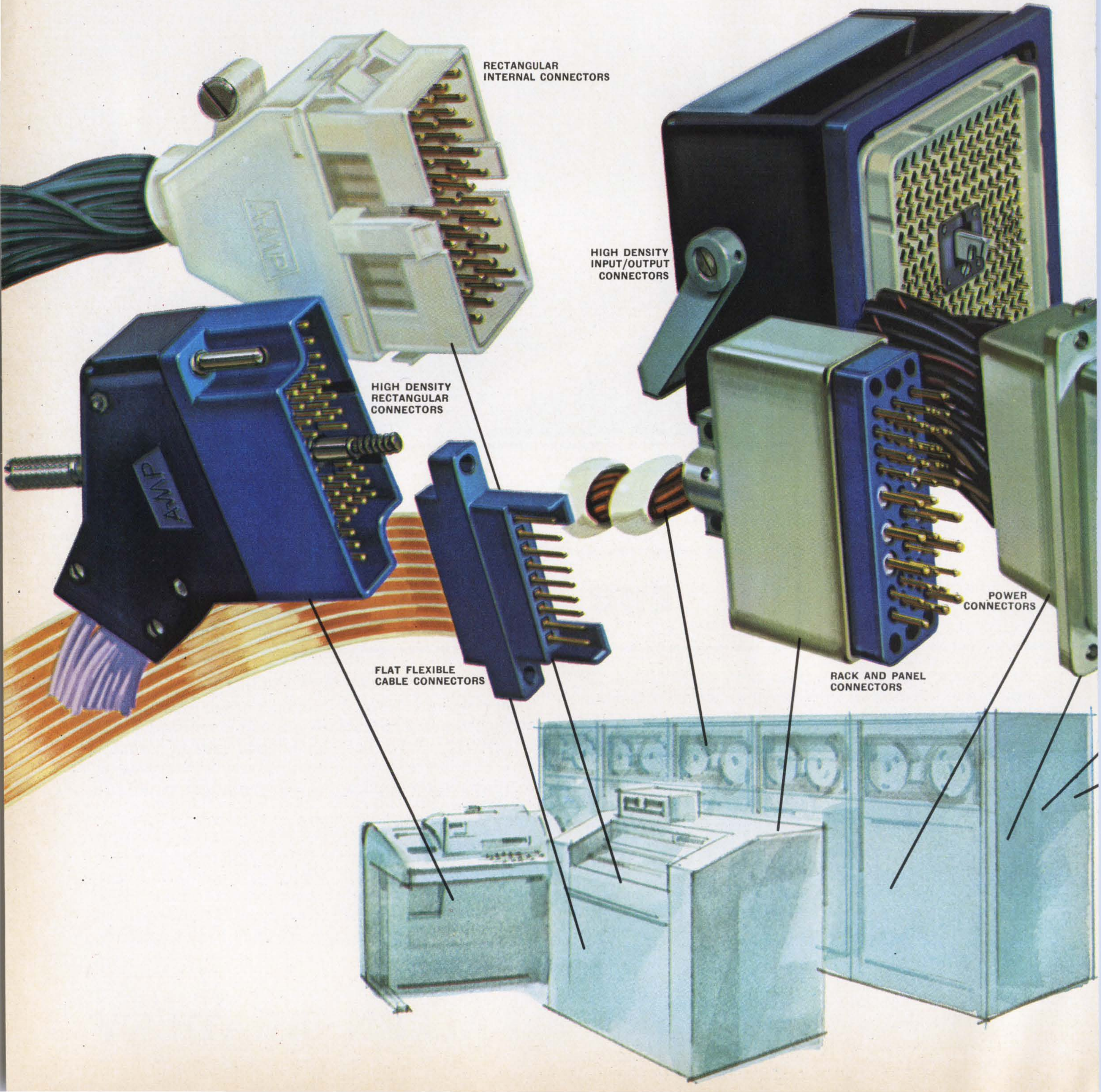


Editorial Comment

A matter of poor communications . . .

More sleepless nights seem the lot of technical executives at the country's telephone companies. Angry subscribers in metropolitan centers are demanding a cure for inadequate and unreliable service. The phrase, "out of order," has become almost synonymous with the public telephone. Furthermore, lines are overloaded and new installations are far behind schedule. But of all the complaints, the loudest and most persuasive are those from businessmen who report loss of revenue. Customers can't get through to them because of overloaded circuits. Data-communications firms, for example, want assurances that their increasing business can be handled by the telephone companies. And now the Federal Communications Commission has asked the telephone companies to account for their increasing troubles.

Ironically, the Bell System, long considered a leading practitioner of systems engineering and management skills, is being questioned on its ability to manage and maintain the U.S. communications network in satisfactory working order. Beyond that, the inquiry delves into Bell's slowness in improving the system—as in the case of its conversion from electromechanical to electronic switching.

Thus far, hearings and criticisms have revealed that the telephone companies' troubles stem from a combination of inadequate forecasting of user requirements, unpredictable overloads, and shortages of trained installers and maintenance personnel. In one Denver area, for example, telephone users attempted to make 40,000 calls at once in an exchange designed to handle 30,000. In their own defense the phone companies say it's difficult to accurately forecast the amount of traffic. The soaring demands of Wall Street and of Florida's east coast are examples. Phone installations in Florida were backlogged for up to five months. Furthermore, the needs of businesses that supply data-communications service are particularly hard to predict. Such firms can emerge virtually overnight and are loath to reveal needs far in advance in an effort to protect potential business.

However, one must be sympathetic to the pressures being brought to bear upon the telephone utilities. Their sheer size and complexity provide a tremendous inertia. Their management systems are unwieldly and improvements in such systems can be traumatic. Even the smallest technological improvement of telephone systems requires weighty deliberation. Nevertheless, predicting future needs is at the heart of the matter, and better forecasting methods are clearly needed.

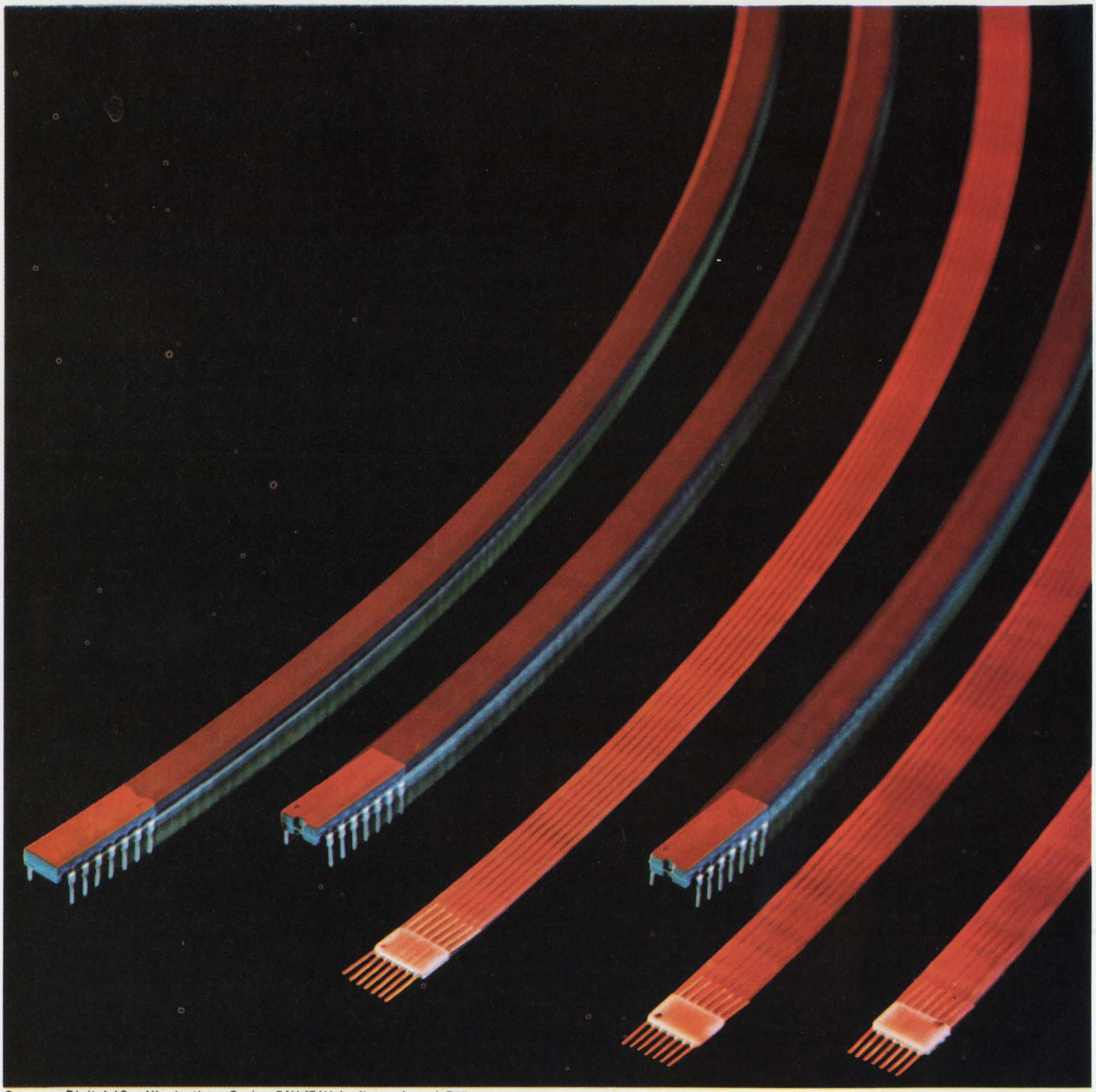
. . . that could get better

Data communications, while not yet a serious contributor to the present phone system logjam, will pose an additional burden in the near future (computer utilities and time-sharing service companies are doubling in volume of business annually). In anticipation of the "data jam," independent firms are seeking Federal permission to establish microwave links that could handle not only data, facsimile, and teletypewriter, but radio and voice transmissions as well. FCC permission to go ahead with one such line in direct competition with AT&T has already been granted [*Electronics*, Sept. 29, p. 133].

In many ways the move to open the private-line market to competition makes a great deal of sense. The telephone companies themselves are the first to admit that the existing system is best suited for voice communications. The flexibility promised by the new independents is indeed appealing. In one case, 72 basic microwave channels will be offered in 10,000 combinations in bandwidths ranging from 200 hertz up to a high of 1 megahertz.

In that system, subscribers can have part-time or one-way use, and as many as five subscribers may share one channel. A communications system designed specifically for data transmission can offer accuracies in the order of one error in 10^7 bits. Also, separate microwave channels avoid potential errors in data transmission caused by noise from telephone-switching circuits. Conversely, the avoidance of heavy data-transmission loads on the telephone utilities eliminates a potential source of noise injection into that system.

Not incidentally, new microwave systems will need terminal equipment designed to transmit a variety of data. Undoubtedly, electronics entrepreneurs are standing in the wings waiting for just such an equipment market to open up, and engineers are already at work analyzing the technical problems such gear will have to solve. Finally, permitting independents to tackle the private-line, data-transmission market could buy time for the telephone utilities, enabling them to catch up with backlogs and iron out management difficulties. ■



Sprague Digital ICs. Illustration: Series 54H/74H in flatpack and DIP

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Electronics Newsletter

October 13, 1969

Search under way for laser scribers . . .

Semiconductor makers, hunting for yield-increasing wafer scribing methods, are taking a hard look at lasers. While such firms as Fairchild and Signetics—both of which say they lose 8% of dice with present diamond scribers—admit only that they're after something better, other companies have taken concrete steps.

Autonetics, for example, says it's interested in lasers; **Motorola has given a study contract to a laser manufacturer.** And the Integrated Circuit Engineering Corp., working for "a major semiconductor manufacturer," is developing a prototype laser scriber. **A major part of ICE's effort will be to find out which type of laser can cut silicon without splattering it on the wafer.**

An ICE source points out that not only could a laser boost yield in the scribe-and-break step, but the resulting clean edges also facilitate automatic handling. **However, he's "not sure it would be economically feasible for normal production,"** indicating the firm's work may involve special requirements, possibly for large chips.

. . . as firms seek better dicers

But there are those who are sticking with, and improving on, diamond scribers. Tempress is known to be working to modify its diamond dicers, but isn't talking about what changes are being made. **Tempress president Fred Christensen points to the silicon redeposition problem as a fault in laser scribing,** and adds that even without that drawback, lasers don't solve the problem of how to break the wafer cleanly into dice.

At NASA's Electronics Research Center, which has a contract from Spacerays Inc. to investigate laser scribing, senior scientist Samuel Polcari doesn't like silicon redeposition either, **and has developed advanced diamond-cutting methods said to produce exceptionally clean edges, leading to nearly 100% separation yields.**

Another firm sticking with diamond tools is National Semiconductor, which has modified some Tempress scribers itself to yield dice edges so smooth they look like they've been lapped, one observer reports. National isn't saying what's involved in the modification.

New firm plans 2-inch-thick, 18-bit computer

Would you believe an 18-bit computer less than 2 inches thick? Computer Logic Systems Inc. hopes to build the rack-mounted machine as one of its long-term goals—**though it might not arrive until late 1970, it still could be among the first to use monolithic MSI circuits interconnected on hybrid substrates to cut size and manufacturing costs.**

For the present, the Billerica, Mass., firm is content to prepare an 18-bit machine as small as an 8-bit computer, and with a price tag well below that of some 16-bit processors. **This one should be ready in January.**

NASA mixing best of antenna worlds

While studies show phased-array antennas will be best for most future communication satellite uses, NASA's Electronics Research Center is trying to develop an interim system combining part of the beam control of an array with some of the simplicity and low cost of reflector antennas. **The goal is a single parabolic antenna, about 15 feet in diameter, with perhaps three 3° controllable beams.** Multiple feeds would steer the beam with individual power amplifiers, and diode-switching would key the proper feeds. Gain would be about 34 db.

NASA spokesmen say there's room in the fiscal 1970 budget request for pertinent study contracts and add that while the system would be an inexpensive phased-array simulator for future communications satellite programs, **the three-feed dish could be cost-effective in commercial applications.**

Response heavy to ATC satellite study request

Plenty of industry interest is being stirred up in air traffic control satellites. **The latest evidence: NASA's Electronics Research Center got more than 40 letters of interest in response to word of a "very modestly funded" study on satellite techniques for air traffic control.** And 38 requests for proposals have been sent out, with responses due Oct. 25. Contracts are to be awarded late next month.

The single six-month study is slated to investigate the concept and implementation of satellite-controlled traffic. "There's still a question about satellite ATC in domestic environments, and we want this study to provide a rationale for either pushing or dropping the effort," says a NASA spokesman. **Another spokesman says industry may envision a significant commitment to satellite ATC in the 1975-1985 period** and wants an early position in the planning stage. Unfortunately, he adds, there's no such commitment yet.

Hall keyboards having problems

Honeywell-Micro Switch's Hall-effect keyboards [*Electronics*, Sept. 16, 1968, p. 169] are disappointing some users. "We got our first six, and all failed," says one customer. The failures seem to center on the temperature sensitivity of Hall-effect devices, he says, and other circuits like the IC strobe control—sometimes strobing stops without warning. **Also, simple workmanship errors and intermittent open or short circuits appear, only to defy troubleshooting.**

Some trouble seems associated with flexible flat cables connecting the keyboards circuit boards; other users say the circuit boards themselves don't hold up—an allegation Honeywell denies, saying the p-c boards are of mil-spec quality fiberglass. **Honeywell lays other errors, such as improper coding, to improper customer specification**—but customers say the keyboards encode properly on delivery and fail soon afterward.

Meanwhile, perhaps to solve some of these problems, **Honeywell is changing to redesigned MOS IC's,** and also expects to save users an estimated $20-per-keyboard worth of coding electronics by packing more circuit functions on the MOS Hall-effect chip.

Comsat gripe cuts off cable talks

The Communications Satellite Corp. has won a battle from AT&T in the satellite vs. cable war. **The victory: an FCC order to AT&T to stop negotiating for new undersea cables.**

A strong, though diplomatic, letter from Comsat chairman James McCormack triggered the order. **McCormack pointed out that the FCC's cable-satellite inquiry was being prejudiced by AT&T talks with French and Hawaiian phone companies for 720-circuit cables, and with the British for an 1,800-circuit link.** Furthermore, wrote the Comsat chairman, new international cable negotiations are a form of leverage for AT&T, and they could embarrass the U.S. if terminated.

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Symbolic electronic signal undistorted by EMI — photographed by Howard Sochurek

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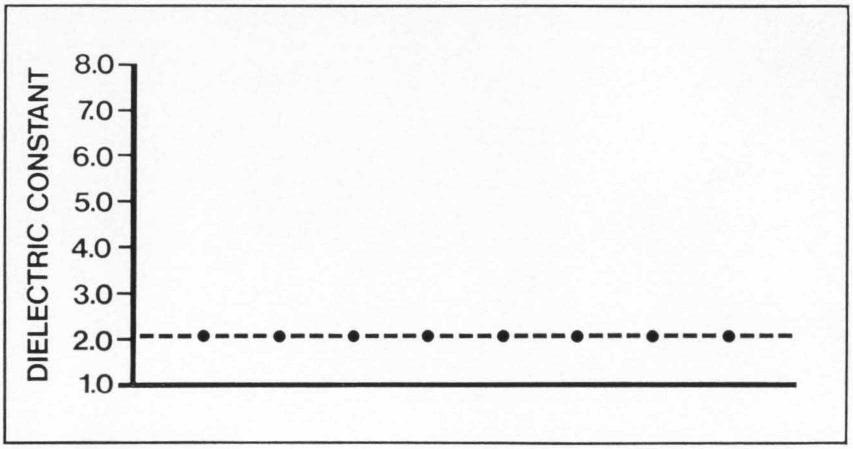
Plotting the dielectric constant of a TEFLON resin against frequency, or temperature, or what-not makes a pretty dull-looking graph.



But useful to an electronic designer.

A straight line parallel to the X axis is about all you get when you plot the dielectric constant of a Du Pont TEFLON fluorocarbon resin—over a wide frequency range—and over a wide temperature range. The same stubborn constancy applies also to the other excellent electrical characteristics of TEFLON: a dissipation factor of only 0.0002 and a high dielectric strength (500 volts/mil).

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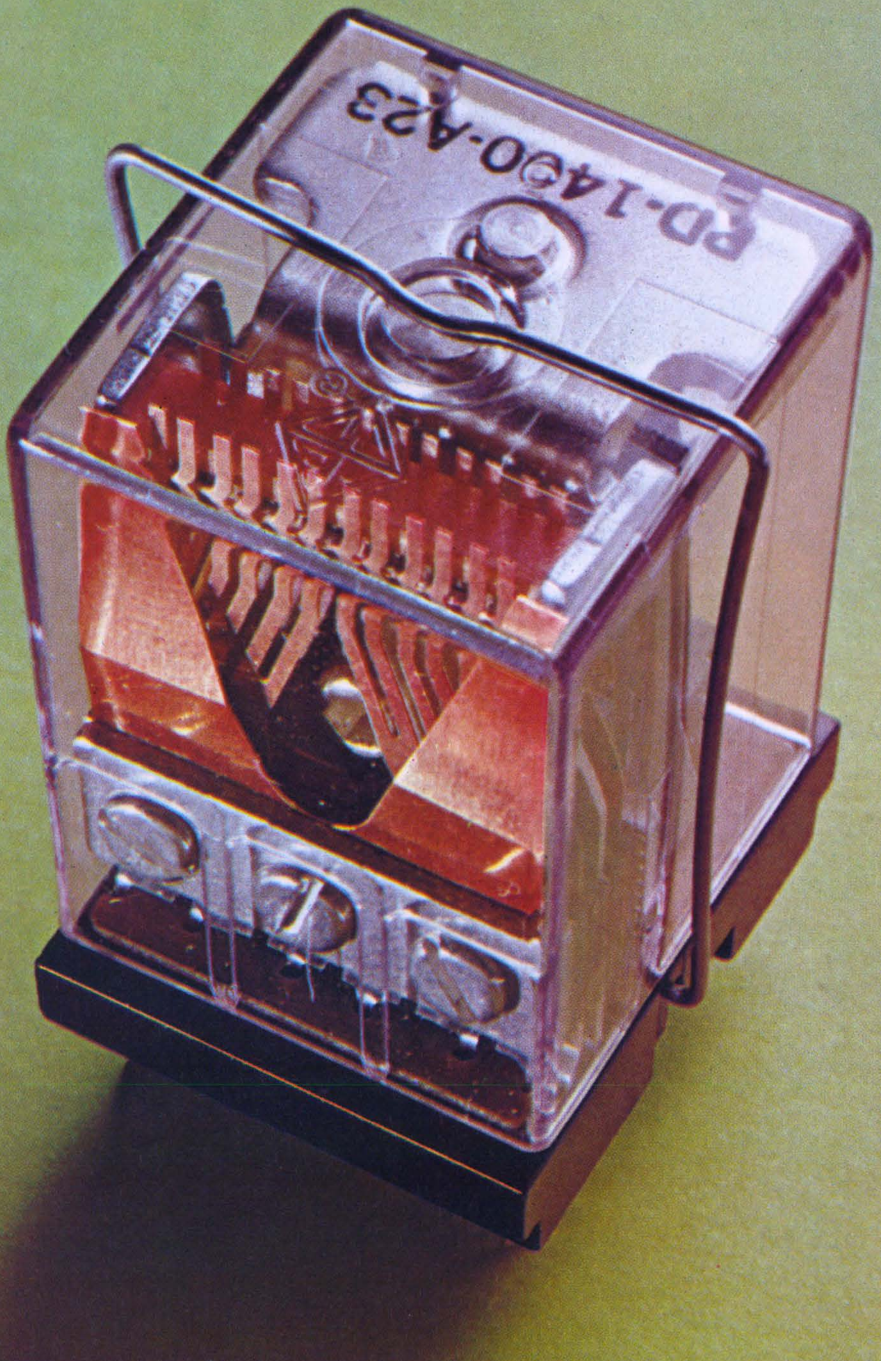
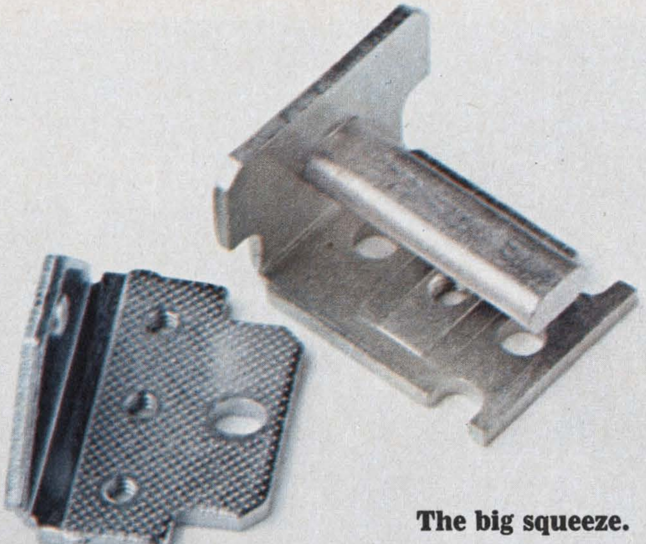




The big squeeze.

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.

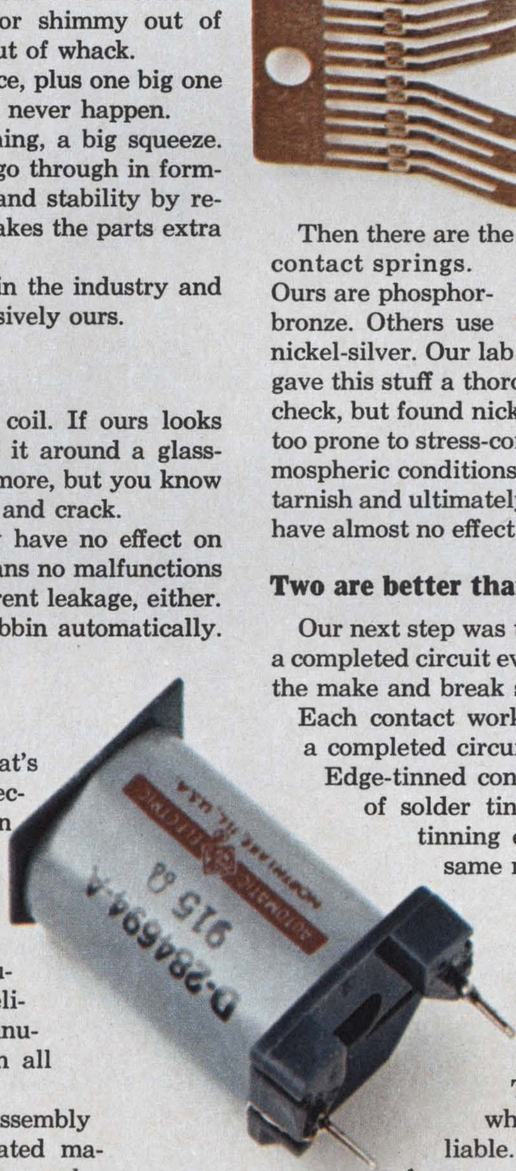
The coil is wound on the bobbin automatically. No chance of human error here.

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.

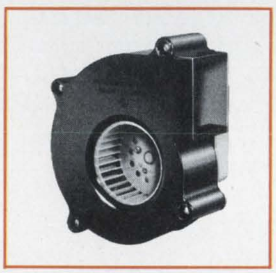
There's a lot more to tell about what makes our Class H relay reliable. Now we're waiting to hear from you. Automatic Electric Company, Northlake, Ill. 60164.

AUTOMATIC ELECTRIC

SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS

Circle 39 on reader service card

we goofed.



This Howard Cyclohm Fan was engineered to run 10 years. So far it's been running 12 years, 6 months, 21 days.

Our modest 5-year guarantee on Cyclohm Fans and Blowers is based on an engineered lifespan of 10 years. So, what do we tell our customers when they report the fans are still blowing strong 12 or even 14 years after installation? We tell them we goofed—and they benefit.

There's more to the Howard Cyclohm Fans and Blowers success story than just long life. There's the high reliability of Howard's unit bearing motor that never needs maintenance or re-lubrication. And all metal construction. Indestructible nylon blades. Standard mounting on 4-1/8″ centers. UL yellow card listing. All units are off-the-shelf . . . available for immediate delivery from Standard Motor Product Sales. All the facts are in the newly-published, 14-page Cyclohm Fans and Blowers Catalog **EL109** From Howard.

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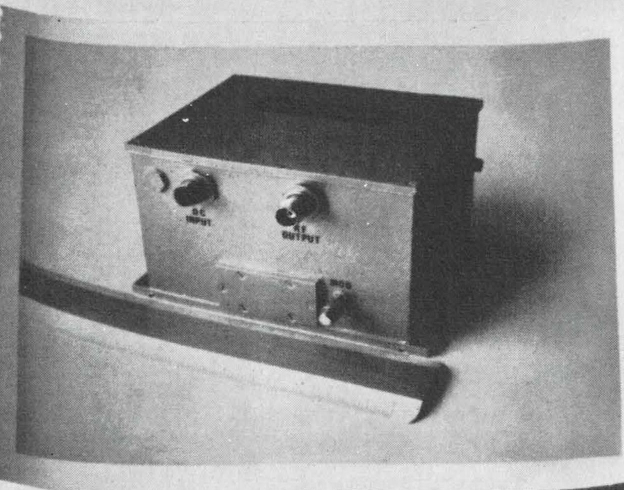
FAIRCHILD'S AIRBORNE QUALIFIED SIGNAL SOURCES (MIL-E-5400)

Meets MIL-E-5400, class II:

SHOCK	15 G's
VIBRATION	10 G's
TEMPERATURE	-54°C to +71°C
HUMIDITY	100%
ALTITUDE	70,000 ft.

Cover entire frequency spectrum from .685 MHz to 14.23 GHz

Standard package for phase-locked sources. Packages for free-running and waveguide sources have same form factor.



NOTE:
Optional crystal and internal oven for ±0.0005% stability (phase-locked).

Now all of Fairchild's signal sources, from L-band through K-band, are available qualified to MIL-E-5400, Class II. They're ready now to make your systems perform better, longer and for less money.

To give you the performance you need in your communication, radar or other microwave systems, we manufacture our sources with our own microwave transistors. And, for critical systems, with our own unique phase-lock technique. To give you performance you just can't get with multiplier chains or klystrons. Like stabilities of ±0.005%, ± 0.002% or ±0.0005%. Like spurious signals 75dB down in band. Like extremely low residual FM noise. And they're all smaller, lighter and less expensive than other designs.

To meet MIL-E-5400, we use three different packages, one each for our free running, phase-locked and waveguide sources. No more expensive "specials," no more "delayed" deliveries. Now just add "−30" to the part number of the Fairchild source you need and call your Fairchild sales representative. We've made it that easy.

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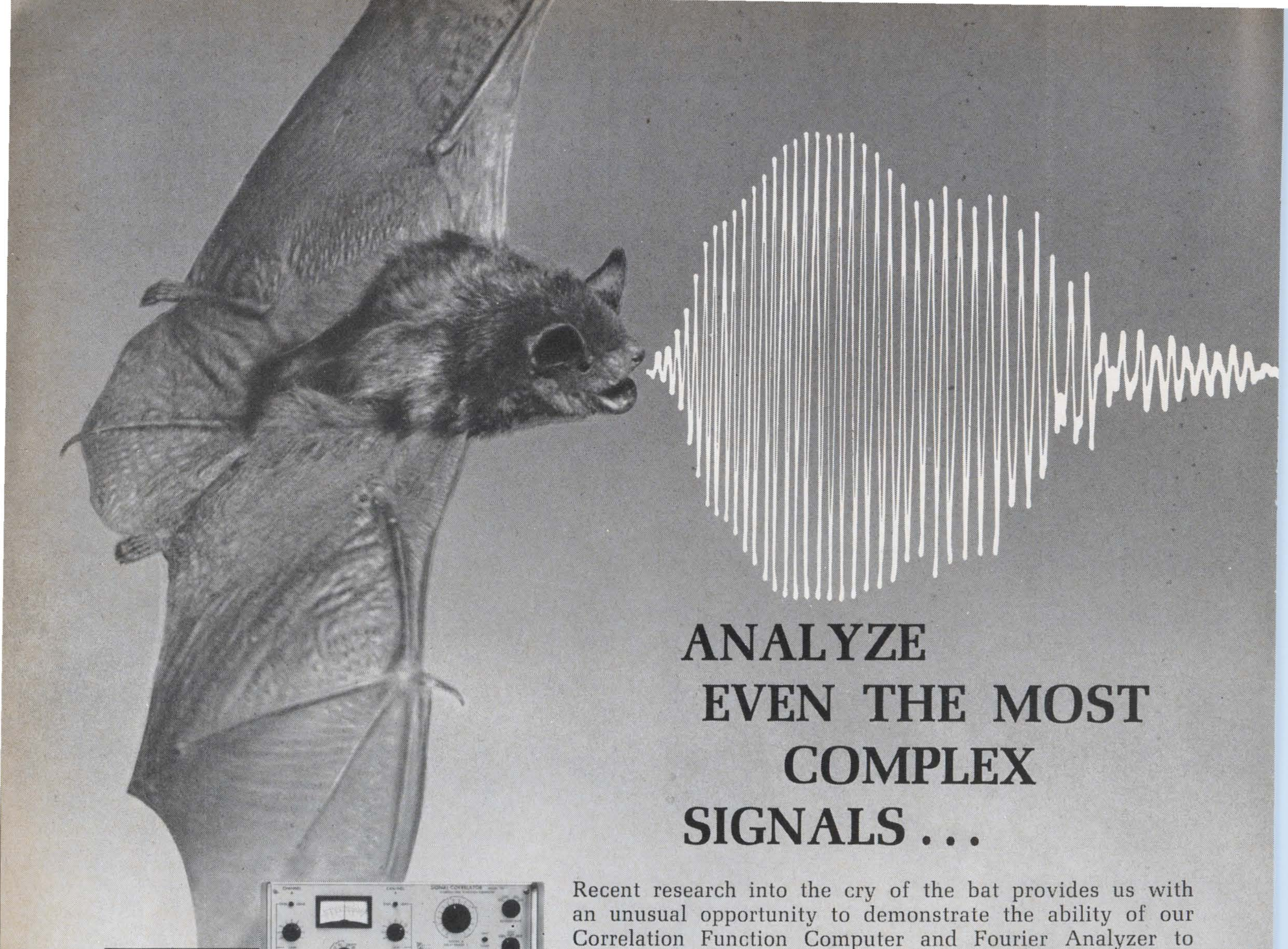
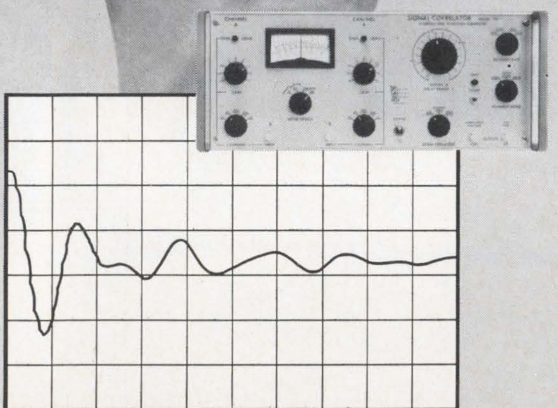
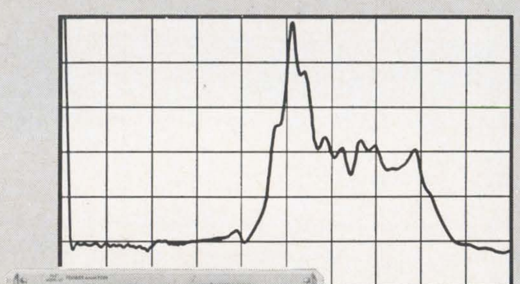


ANALYZE EVEN THE MOST COMPLEX SIGNALS . . .



Autocorrelation of bat cry defined by Model 100 Correlation Function Computer (Price: $8,500.)



Power spectral density of bat cry transformed from autocorrelation function by Model 102 Fourier Analyzer (Price: $2,950.)

Recent research into the cry of the bat provides us with an unusual opportunity to demonstrate the ability of our Correlation Function Computer and Fourier Analyzer to analyze and sometimes derive unsuspected information from a complex signal.

The experimenter's objective was to characterize the bat's acoustic transmission to shed light on its sonic signal processing mechanisms. Through the use of the Correlation Function Computer, he derived the autocorrelation function of the cry and found that the bat's range discrimination success curve mirrored the envelope of the autocorrelation of its cry. This supports the hypothesis that the bat ranges by crosscorrelating its transmission with the returned echo.

The experimenter next processed the autocorrelation function through a PAR™ Fourier Analyzer to obtain the power spectrum of the cry. This spectrum is being studied to gain additional insight into the acoustic physics of the bat's vocal apparatus.

Whether you are working with bat cries or other phenomenon such as velocities in flowing turbulent fluids, potentials in an active plasma, pressure density in a boiling fluid or current flow across a reverse biased p-n junction, let us familiarize you with this powerful signal processing system. Write Princeton Applied Research Corporation, P.O. Box 565, Princeton, New Jersey 08540, or call (609) 924-6835.

PAR PRINCETON APPLIED RESEARCH CORPORATION

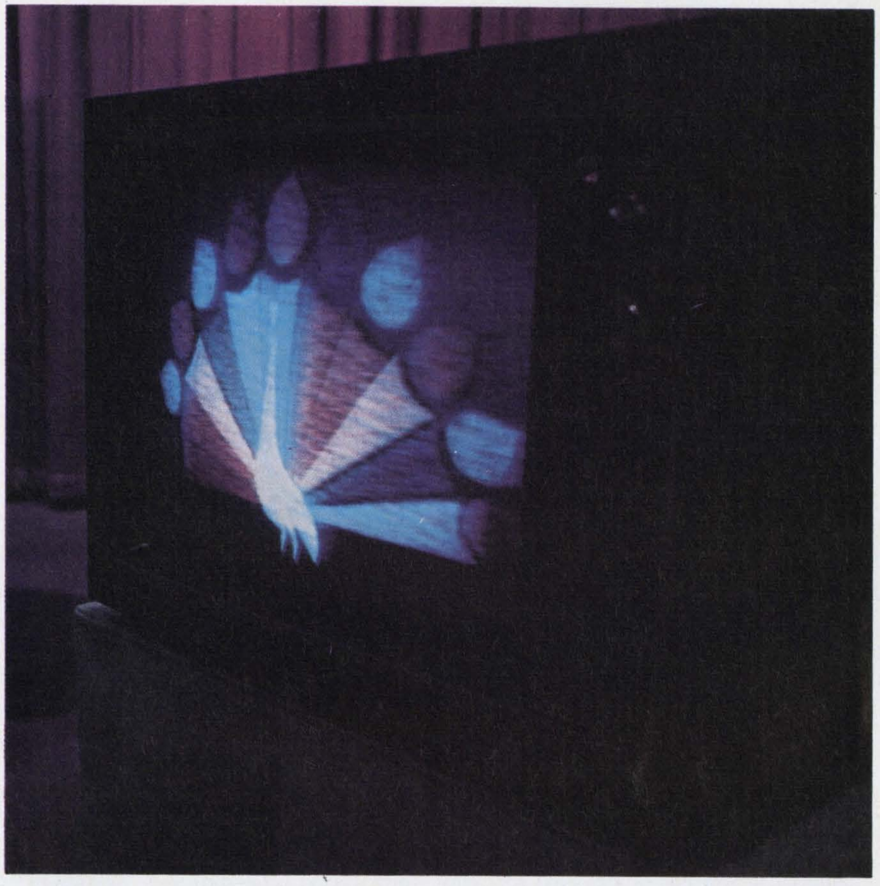
Circle 36 on reader service card

SelectaVision: willing, able, not yet ready

It was like introducing a new prototype sports car with no high gear. RCA, with as much fanfare as ever has been drummed up for a development—that won't be ready until 1972 at the earliest—was showing off its SelectaVision. The home television entertainment system will employ holographs on vinyl film reconstructed by a laser to play prerecorded programs through a color receiver. Exciting because of its design innovations for consumer electronics, SelectaVision's demonstration picture was far from broadcast quality and didn't have a sound track.

But there's a good reason for what some viewed as a premature announcement: RCA simply didn't want any similar system, such as CBS Laboratories' Electronic Video Recording (EVR), to be the only one to be considered now. An old hand at such marketing maneuvers, RCA knows it can't do it alone—that an industry effort will be needed to get SelectaVision going. The company has already put aside a multimillion-dollar kitty for programing—the real key to big sales of the system. So, realizing that it wouldn't get enough of the right kind of programing available from other major suppliers if it kept its system a secret, RCA made the announcement.

While other companies chose between magnetic tape or photographic film for home tv playback systems, RCA picked clear vinyl—the kind commonly used to wrap meat. While the others experimented with photographic images or magnetic recording (neither of which lends itself to high-speed copying), RCA turned to mechanical printing of holographic images, a technique limited only by the speed at which the vinyl rips. And while others tried to keep the playback unit uncluttered, RCA crammed a vidicon and a laser into the SelectaVision unit, hoping the system would tolerate noncritical assembly and less-than-ideal tape handling—yet produce clear images.



Purple pinfeathers. RCA's demonstration of its SelectaVision home tv entertainment system featured the NBC peacock in living lavender—among other shades and tints of purple.

The master is made from a photographic film or magnetic videotape. The program is lasered frame by frame on a plastic tape coated with clear photoresist in the form of a phase hologram. After development, the exposed photoresist is washed away, leaving hills and valleys on the tape, which then is nickel plated. The tape, with its 1-micron irregularities, is sandwiched between two rollers with the clear vinyl film that is to be the copy. Roller pressure embosses the bump pattern into the vinyl. Color is electronically encoded on bands in the hologram's upper-frequency spectrum.

Although RCA has not yet added a sound track, company scientists say it could be effected with similar encoding techniques, or the film could be shot with an optical soundtrack whose image would be recreated along with those of the video frames.

To play back, the clear tape, packed in a cartridge for easy handling, is run smoothly through the light from a 2-milliwatt helium-neon laser. The images produced are recovered by an inexpensive vidicon camera. The adapter includes laser, vidicon, and circuitry to decode color bands and soundtrack. The adapter feeds the signal directly to the tv set.

Plainly much work is required. While the black-and-white image at the demonstration was good considering that the recording technique is new and the film itself requires less processing than ordinary clear plastic adhesive tape, there was slight speckling and a moire effect. The color, which is coded in two upper bands (centering on 3 megahertz and 5 Mhz) in the hologram, flickered a bit, faded out every few seconds, and did not look very natural.

But RCA executive vice president Chase Morsey Jr. promised that "video quality will be equal to the best of broadcast television—no ghosts or interference, and bright, sharp colors."

Opposites. Comparison of SelectaVision and CBS's EVR is inevitable. Actually, though, the two systems have only one thing in common: they play prerecorded programs through a conventional tv set. The CBS version uses film, has not yet demonstrated color, doesn't use holographic images—and now is aimed at a different market.

RCA's Morsey, comparing the two on a cost basis, said SelectaVision's adapter would sell for under $400 while EVR's will cost about $800. He contrasted SelectaVision's intended custom-copying price—$2 to $3 for a half-hour color cartridge—to EVR's $14.40 for a half-hour of monochrome as published in a CBS price list for the educational market. In addition, he said that the RCA system is aimed at the consumer market, while the CBS unit, "as we understand it, is aimed at the higher-priced industrial, educational, and commercial markets."

Equal time. Robert Brockway, head of CBS's Electronic Video Recording division, insists that the RCA comparison with EVR is unfair. "They took figures from our present price list," he says. "and compared it with what they plan to offer in over two years. Our units will be out on the market in less than nine months."

Brockway adds that CBS is readying an announcement about the fate of EVR in the consumer market, "and we haven't said we would necessarily be using a silver emulsion on the film we plan to use in the consumer market."

He also maintains that comparisons between the two systems should be drawn on the basis of image quality and state of development, rather than on cost of unit or tapes. "We have a higher resolution," says Brockway, "and our color is much better than RCA's."

Manufacturing

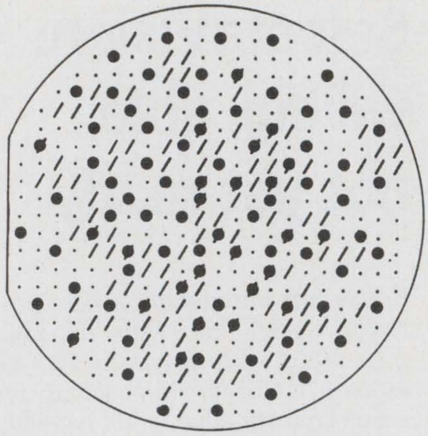
Good, bad, and pad

Until manufacturers of multilayer metallization MSI or LSI circuits achieve consistent 100% good circuits through wafer probing they will be stuck with interconnection methods for good units that ignore bad ones. Since no one is likely to wager that Nirvana is coming, two principal methods of performing multilayer MSI/LSI interconnects probably will continue to be used:

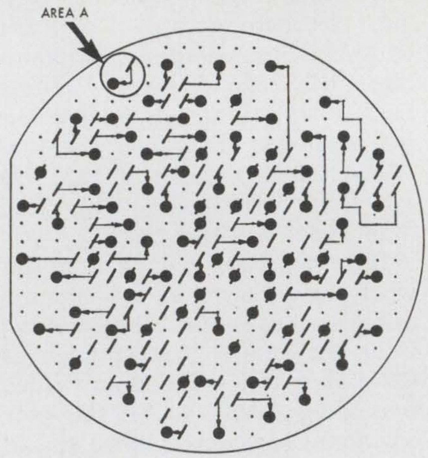
- Employment of a standard interconnect mask assuming 100% good circuits, which limits array complexity because defective circuits inevitably crop up, especially as complex functions dictate large chips.
- For larger arrays, use of some form of discretionary wiring to hook up good dice on the wafer, dictating unique signal interconnect masks for each wafer based on its probe yield.

Yet a third. But engineers in the advanced technology department of Hughes Aircraft's Data Systems division have an alternative for using the good portions of uncut wafers. It's called "pad relocation." Navy and Air Force officials are being converted to the technique, and are backing further study. Hughes has one Air Force contract to further its effort, and is about to get at least two from the Navy and one from the Air Force. The latter will expedite development of a digital data transmission and multiplexing system with pad-relocation.

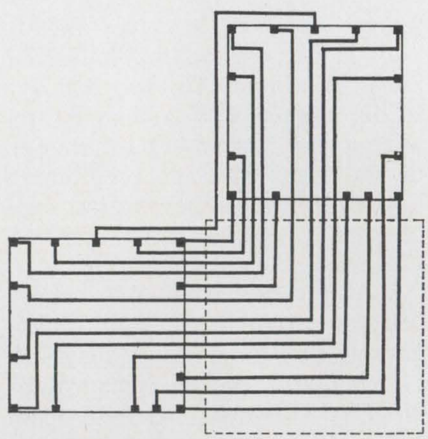
In pad relocation, say the wafer has only one "cell" or circuit type on it—a quad two-input nand gate, for example. (Don Calhoun, project engineer for LSI designs in the advanced technology department, says the firm has worked with much more complex circuit types. Calhoun conceived the technique and will detail it in a paper at the Fall Joint Computer Conference.)



The pad and how to move it. Dots show interconnect pattern . . .



. . . slashes, the good circuits. Area A, when blown up . . .



. . . shows pad relocation pattern needed to replace quad two-input gate.

Before Hughes has any idea what the probe yield of this kind of wafer is, engineers prepare a standard master pattern for the array function, based on typical probe yield distributions. Calhoun says the master pattern assumes more good circuits toward the wafer center than on the periphery. Also, the master pattern of good circuits never places two adjacent to each other, allowing flexibility to relocate in any direction from the assumed good point—up, down, left, or right—to the nearest known good circuit once probed wafers are in hand.

All for one. All wafers of a given circuit function will be matched to this master pattern by pad relocation. The master pattern is superimposed on the d-c probed wafers (top drawing) allowing an engineer to see how far he has to go to relocate the pads of a circuit function from the master pattern to the nearest good circuit on the wafer. Where the dots on the master pattern match underlying slashes indicating a good circuit on the actual wafer, no relocation is needed. The pad positions above a bad or an unused circuit are isolated from that circuit by a dielectric layer.

Calhoun says only two man-minutes were required to manually specify the pad relocations for a wafer with five circuit types: 642 nand gates of four different types, and 128 j-k flip flops. To do the pad relocation from the master location to the nearest good circuit in Area A of the center illustration, the interconnect pattern shown in the third sketch is used. It's one of eight stored in a disk file that can accomplish any pad relocation required for the single-gate function on this wafer.

After manually rerouting the interconnects in the third drawing (automation of this step is being developed), the engineer prepares a coding sheet on a standard form describing the relocation pattern for each point using a four-digit mnemonic. His instructions are keypunched and are entered into a PDP-9 computer, which assembles instructions to withdraw the probe pad-relocation interconnect patterns from disk storage, draws the second-layer metal pad-relocation mask, and then drives a Gerber plotter to cut rubies for that mask.

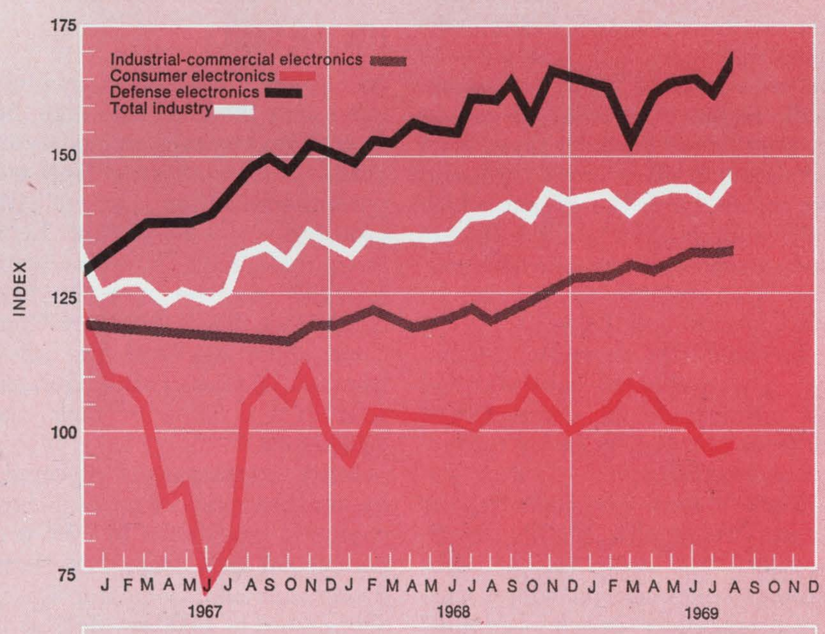
Thus the only unique mask for a given wafer is the pad-relocation mask. If the wafer incorporates three-layer metallization, the first layer interconnect is standard, linking individual devices to form an integrated circuit. The second layer incorporates the unique pad relocations plus cross-under areas from the third or top layer of metal—the signal interconnect layer. The cross-under areas are so specified that they don't interfere with pad-relocation interconnect lines.

Yield doesn't count. The third-level metal for signal interconnection is standard for every wafer of a given type because it's made to agree with the master pattern Hughes prepared before seeing any actual wafers. It is not dependent on wafer yield, as other approaches to full-wafer LSI discretionary wiring are. In traditional discretionary wiring, two unique masks per wafer are required because signal interconnection is done on both of the two upper levels, with one level used for horizontal signal interconnect lines and the other for vertical signal interconnections.

Compared with conventional dis-

Electronics Index of Activity

October 13, 1969



Segment of industry	August 1969	July 1969*	August 1968
Consumer electronics	97.7	96.4	103.8
Defense electronics	170.0	162.3	172.7
Industrial-commercial electronics	134.2	133.9	122.9
Total industry	147.1	142.7	146.4

Total electronics production in August hit 147.1, a 4.4-point advance over the revised July figure, and the second consecutive record month-to-month gain. But the advance was a mere 0.7 point over the August 1968 index.

The defense sector led the August spurt with a 7.7-point jump, which was still 2.7 points behind the 1968 month's total. Consumer electronics production rose 1.3 points, but, like defense, was still off its 1968 pace—by 6.1 points. But the industrial-commercial electronics area, which moved up only 0.5 point from July to August 1969, showed a whopping 11.3-increase over the same month a year ago.

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

cretionary wiring, Hughes says pad relocation involves lower nonrecurring engineering costs, making it ecomomical for both high-volume and prototype quantities. And because the signal interconnection layer is standard for each wafer of a given type, Hughes officials assert testing is simpler than it is for conventional discretionary wiring of full-wafer LSI. They know they can handle wafer complexities of at least 780 gates with pad relocation, and most of the digital military systems they're designing have been partitioned into 250-to-500-gate "chunks," they report.

Pad relocation is the "advanced wafer technology" Hughes has suggested to the Naval Air Systems Command for the Advanced Avionic Digital Computer [*Electronics*, Sept. 29, p. 72] for which proposal requests are expected soon. To date, the technique has been applied only to bipolar MSI and LSI, but when multilayer MOS comes along, Hughes will be ready for it.

Making a deposit

As microwave technology gallops on, the need for better methods to deposit ferrite films on microwave integrated circuit substrates becomes more pressing. The most common techniques—such as chemical vapor deposition, r-f sputtering, and vacuum evaporation—are costly while being tedious and time-consuming. What's more, they leave something to be desired in terms of stoichiometry (proper chemical composition to attain particular characteristics), consistency, density, and adaptability to batch processing.

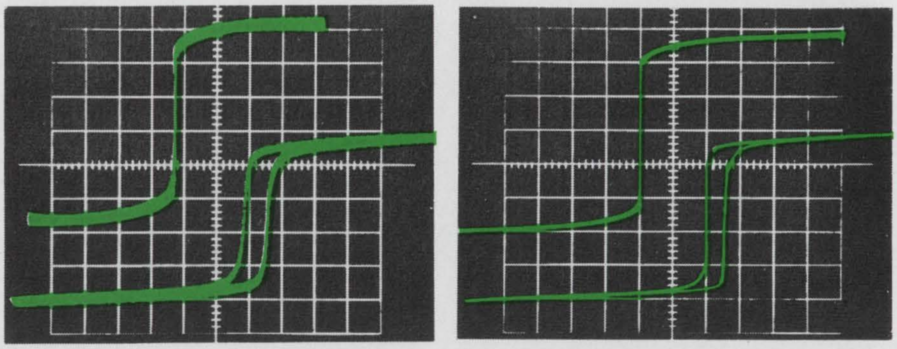
The Monsanto Research Corp. of Dayton, Ohio, a division of the Monsanto Co., thinks it has the answer. Under the direction of D.H. Harris, it has evolved a simple technique that it calls arc-plasma spray that is unique in the control it affords over the stoichiometry of the deposited film.

Spritz. Monsanto has modified a spray gun used to coat turbine blades and rocket linings. It can lay down magnesium-manganese ferrites and other C- and X-band materials on a wide variety of substrates at a rate of 4 microns to 2 mils per minute per square inch. This, says the company, is a rate other methods can't match. The result is a thick, dense film that is chemically and electromagnetically almost identical to the bulk starting material. Additionally, the nonvacuum process is ideal for batch or continuous-run manufacturing because it does away with the confining containers required in vacuum techniques.

The sprayer is a series of gas arc-plasma torches with stabilized vortexes. Inert gases, such as argon or helium, generate a plasma stream. Bulk ferrite is pulverized into a powder whose particles range from 1 micron to 40 microns thick and are injected into the stream, which carries the powder to the substrate surface via any noncombustible carrier. Here, multiple feeders may be used for alternate filming.

Mechanically, deposition is simple. The preheated substrate and the sprayer are fix mounted, and either is rastered by an x-y traversing mechanism.

Good grades. Monsanto reports impressive results. Mg-Mn ferrite powder was deposited on substrates of platinum, palladium, various magnesium titanates, alumina, and beryllia at temperatures of 100°C to 1,300°C, depending on the degree of adherence required. With one ferrite powder used, for instance, film thicknesses from 1 micron up to 130 mils were achieved, indicating the process can be used for thick-film devices.



Intrinsic agreement. Weiss hysteresigraph traces of the Monsanto film at left, and bulk material of the same thickness at right, show close agreement at 400 oersteds. Differences in remanence ratio results from reduced grain size (5 microns) of deposited materials.

Electron microprobes indicate a better than 10% tolerance over the entire surface; densities, measured on free-standing films, average 99% of theoretical. Also, key electromagnetic properties—hysteresis, remanence ratio, dielectric constant, and dielectric loss tangent—all show close agreement with bulk starting material.

Components

It's the heat

As power - switching amplifiers move into the kilowatt range, heat dissipation becomes an increasingly vexing problem. Several large computer manufacturers are evaluating prototypes of a 1.5-kilowatt hybrid integrated-circuit power-switching (class D) amplifier from TRW Semiconductors that is 90% to 95% efficient, about one-tenth the size of comparable Class B amplifiers, and sells at a fraction of their usual $3,000 cost.

Initial application is expected to be in capstan drives for high-speed computer tape decks. In a 200-inch-per-second tape deck, a one-horsepower capstan drive motor must be accelerated to 2,000 revolutions per minute in 10° of shaft rotation, or in about 1.8 milliseconds. Heat dissipation in a Class B linear amplifier reduces efficiency to about 65% because as many as 32 transistors in parallel are being used essentially as variable resistors. Furthermore, high-speed fans are required

to get rid of the heat.

In contrast, the TRW Class D amplifier dissipates only 100 watts at 1.5 kw, and is packed in a 4-by-7-by-3-inch heat sink.

Three cans. Dick E. Noble, power controls project manager for the microelectronics unit, says the size of the amplifier package is dictated by the need for 50 square inches of heat-sink surface at 1.5 kw. In production models, the transistors probably will come in two TO-3 equivalent packages with a monolithic Schmitt trigger in a third, although an alternate configuration with the entire circuit on a single 1-by-1.5-inch substrate also is under consideration.

Hybrid thick-film resistors and interconnects are used on a beryllium-oxide substrate, with two high-speed, 30-amp silicon planar switching transistors. Voltage is placed across the indicator, and the transistors are pulsed to maintain a uniform voltage level. Pulse width modulation is employed: the time constant of the load controls the pulse width, and variations in the pulse width control the motor speed. An external current-sensing resistor in series with the load supplies feedback to the amplifier input. At the maximum switching frequency of 75 kilohertz, 30 amps of current are switched in 500 nanoseconds. The two switching transistors alternately act as a drive to bring the motor to full speed, and as a brake.

The amplifier operates from a dual unregulated ±50-volt maximum power supply, and delivers 30 amps continuous d-c output current into an inductive load. Peak output current is 50 amps with a 25% duty cycle. For a-c operation, the switching frequency is set at 10 times the a-c carrier frequency, and the amplifier is driven with an a-c error signal. In voltage-drive applications, voltage feedback is from a resistor-capacitor network in parallel with the load.

No shorts. A monolithic high-speed differential comparator circuit is used as a Schmitt trigger at the input stage. Input hysteresis is 200 millivolts typical, and input offset voltage 100 mv. Short-circuits between the power supplies are prevented by a filter network that keeps both of the switching transformers from turning on at the same time.

Because the amplifier operation is pulse-width modulated, a 150-milliamp peak-to-peak holding or ripple current must be delivered to the load even when no output current is required. The ripple current is equal to the current through the load required to switch the Schmitt trigger, which has a 150-mv window.

Noble says the 1.5-kw amplifier will be followed by 5-kw-to-10-kw versions over the next five years. "I don't see anything standing between us and the ability to handle 10 kw," he asserts. Power switching applications are expected to include programing machine tool operations, disk files, tape transports, and computer peripherals, he adds.

Industrial electronics

The buck stops here

One of life's little frustrations fades away next year if a new, small integrated circuit currency-note acceptor is built into vending machines. Right now, a consumer needs coins to do business with the machine, and too bad if he only has a bill. While there may be an automatic bill changer on the premises, the odds are against it: only about 40,000 such changers are in operation around the world, usually in attended locations for security reasons.

The new Mark 7 note acceptor, developed by Ardac/USA of Chesterland, Ohio, measures only 3.5 by 6.5 by 4.5 inches and weighs 3 pounds. It's small enough to fit the tight space requirements of most automatic merchandisers. And Ardac president Jack Bayha says its electronic scanning and logic—that analyze details of the engraving – make it foolproof against counterfeit money. It also bars retraction of a bill once the acceptor acknowledges the bill's validity.

Bayha expects his note acceptor will greatly increase the versatility

IF YOU'VE GOT THE TIME...

WE CAN DELAY IT  REPEAT IT  VARY IT  RESET IT  ADJUST IT  RE-CYCLE IT  CALIBRATE IT  SWITCH IT  PROGRAM IT  AND STOP IT.

And if that's not enough, we'll custom build
almost any combination of the above capabilities
to do exactly what you need.
We're timing experts. Call us when you have time.

MIDTEX
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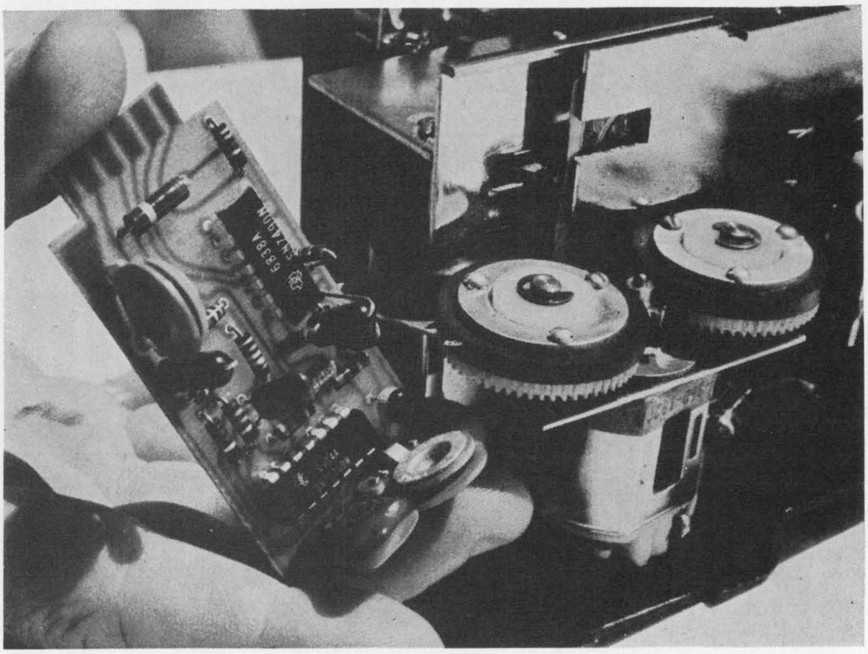
PROGRAMMERS/TIME DELAY RELAYS/MINIATURE COAXIAL RELAYS/INDUSTRIAL RELAYS/MERCURY-WETTED CONTACT RELAYS

Circle 49 on reader service card



For the money. The Mark 7 bill changer uses TI's new gallium arsenide infrared source. The rubber wheels, driven by a d-c motor, pull the bill into the path of the i-r light.

of unattended automatic merchandisers. For example, even if a gas station is closed for the night, a driver can buy gasoline by inserting one or more dollar bills into an acceptor connected to the gas pump. Each device will cost $200 to $300.

Up to date. The Mark 7 incorporates some of the latest electronics technology. In 0.1 second, it scrutinizes and scoops in the bill. Bayha says, for example, that his device represents the first industrial application of Texas Instruments' gallium arsenide infrared source and will use the companion gallium arsenide infrared detector that Texas Instruments has under development.

Infrared energy is absorbed by the bill's engraving pattern and ink thickness in a more specific and efficient manner than the broad-spectrum light from an incandescent lamp used in previous note acceptors. In the Mark 7, the i-r beam shines upward through the bill onto the detector. In front of the detector is a grid, or mask, that is the reverse, or negative, of the pattern surrounding the portrait of the bill.

When a bill is inserted, rubber wheels driven by a d-c motor retract the bill until the portrait background is in the i-r light path. After a delay, a scanning operation moves the bill's pattern past the mask pattern. In effect, the mask interrupts the i-r beam every time there's a match between the two patterns. The detector thus delivers a sequence of pulses; a genuine dollar bill will produce eight.

A 709 operational amplifier increases the pulse signals to drive a TI SN490N IC decade counter. Only when the unit reaches a count of eight will it deliver a signal that pulls in the bill and then, for example, latch a relay in the automatic merchandiser to drop the product and return the appropriate change.

Hold it. If the user tries to prevent the bill from completely entering the acceptor, the motor stops and the latching won't occur even though the bill has been validated. Conduction of the SCR that drives the motor depends on a unique turn-on signal at the SCR's gate. This is derived from the electrical noise generated by the motor's brushes; if the user tries to withdraw the bill, the tight grasp of the rubber wheels will stall the motor. Without the brush-noise

signal, the SCR stops conducting and the motor stops.

Threshold levels in the Mark 7 are set to the specific characteristics of the bill's pattern, ink, and paper. Thus, a unit can be set up at the Ardac factory to accept any denomination bill or any foreign note.

Integrated electronics

Getting the MOSt

Although silicon gates have become the latest hot item in MOS [*Electronics,* Sept. 29, p. 88], another skeptic has joined the ranks that include General Instrument and Texas Instruments. Officials at the Hughes Aircraft Co. feel they have a better idea—ion implantation—to lower capacitance and thereby obtain better MOS device speeds. And Hughes also is shooting for low thresholds with its "IMOS" treatment, although the first test device offered by the Newport Beach, Calif., division doesn't feature low threshold.

This single 64-bit dynamic shift register is the fruit of more than three years' work in ion implantation by Robert Bower, manager of the applied solid-state research department in the Hughes research laboratories, and Hans Dill, the labs' section head for field effect devices. The unit is designated the LISR 0064, and it's available in small quantities at $200 each. The idea is to get samples out to prove that it really works at more than 20 megahertz, against about 10 Mhz for the fastest shift registers available today.

Masks. Fundamental to the Hughes project is the fact that both the gate metal and thick oxide are used as implantation masks, automatically aligning the gate region between the source and drain, and insuring virtually no lateral spread of the boron ions that form the p-n junction about 0.4 micron deep into the channel region [*Electronics,* Nov. 11, 1968, p. 55]. Because the gate doesn't overlap the source and drain, parasitic overlap capacitance is greatly reduced, thus boosting speed. Bower points out that besides yielding automatic gate registration, as does silicon-gate technology, ion implantation is completely compatible with p-channel MOS processing; the silicon-gate method isn't.

"The p-channel technique is the best process for MOS so far," Bower asserts. "Silicon gates or refractory metal gates (molybdenum, for instance) used for auto-registration dictate process changes to make them manufacturable." Dill also maintains that the additional processing required with other methods of automatic gate alignment actually can increase threshold voltages and introduce noise, "in effect, worsening the surface state density compared with that of normal p-channel processing."

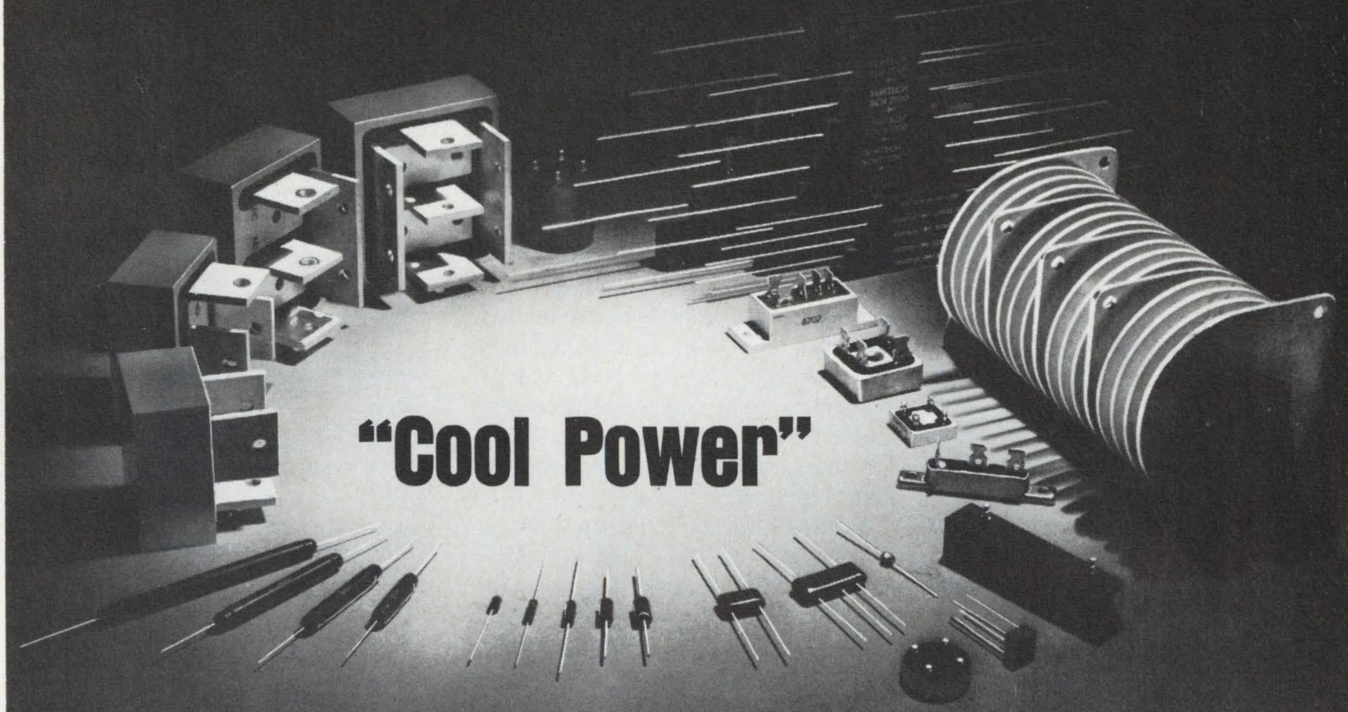
Hughes employs normal diffusion procedures: the gate oxide is grown conventionally. Ion implantation is the last step in the process, done at room temperature after the aluminum gate metal has been deposited. Actual bombardment requires only one or two minutes, although loading and unloading can boost the total time to 20 minutes.

Narrowing price gap. The implantation machine accommodates only one wafer at a time, but an indexing fixture that will hold 20 wafers will be added within a month. A production version of the unit has been designed and capital has been committed for its purchase. This increased production capability is one reason Hughes marketing officials predict the price of IMOS devices will approach that of conventional p-channel parts during the next year.

Dill describes the LISR 0064 as a two-phase device using a ratioless cell design and housed in an eight-lead, solid-base TO-5 package. It operates from 100 kilohertz to more than 20 Mhz (Hughes has specs on it at 30 Mhz). Clock levels are —12 volts at 10 Mhz and —15 volts at 20 Mhz; the drain level is —12 volts at both those frequencies and the input drives are —7 volts for both.

Hughes officials are painfully aware that its semiconductor division has a reputation for not effectively transferring technological strengths into production power,

Semtech Silicon Rectifiers & Assemblies



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so they're hesitant to talk in detail about other IMOS devices. They do, however, have a dual 64-bit dynamic shift register that's been clocked at 30 Mhz, and a 10-channel multiplexer that's about five times faster than today's best. Both parts will be available in sample quantities "in the very near future," they claim.

Companies

Autonetics, Act 2

Undoubtedly jolted when they fell behind schedule in delivering MOS large-scale integrated circuits to Hayakawa Electric Co. for the Japanese firm's desk calculator [*Electronics,* Sept. 15, p. 47], officials at the Autonetics division of North American Rockwell maintain they're back on the track with Hayakawa, and have moved in other ways to strengthen their commitment as a supplier of commercial MOS LSI devices.

Most significant is their preparation of the Microelectronics Products division (MPD) to be spun off as a separate company when the parent firm decides the time is right. North American Rockwell management recently broke out the Autonetics Information Systems division as Narisco (North American Rockwell Information Systems Co.) and indications are that MPD could become a separate entity by Jan. 1.

Making books. The division is realigning its accounting procedures in anticipation of becoming a separate NR company, but MPD general manager Robert Carlson says it isn't clear exactly what organizational reporting lines will be established if the go-ahead is granted. "We'd like to have our cake and eat it, too," says Carlson, an Autonetics vice president. "We want to be able to work in the commercial market but we also want to maintain a relationship that will give Autonetics the benefit of an MOS LSI supplier for its military applications." Carlson has hired Harold Edge as MPD's controller to handle financial and administrative operations. The position is new, and is part of the buildup for a separate company. Edge was controller at Philco-Ford's Houston operations.

In addition, these other developments have strengthened MPD's capacity or added to its backlog:

- A 20,000-square-foot assembly site has been leased in Mexicali, Mexico; it will begin delivering assembled devices back to Anaheim for testing this month. This augments a similar facility in Princeton, W. Va., that has been working on parts since June.
- The division has been delivering small quantities of nine circuit types to Viatron for the memory subsystem of its System 21. These comprise two keyboard circuits, four tape-control circuits, two memory control logic circuits, and a shift register.
- Work already is under way on a follow-on to the contract with Instrument Systems Corp. to supply four circuit types for the multiplexed passenger services and communications systems ISC is building for the Boeing 747. This job, worth about $4 million, brings the total business with ISC to about $5 million.
- The division has added 12 diffusion furnaces at the 40,000-square-foot Anaheim site, giving it a total of 24.

Eye on Viatron. Says Carlson, "We're in a position now to take on more business without further facilities or equipment expansion, but we're readying plans for expansion." This would involve equipment purchases, not new facilities, to the tune of about $2 million in assembly and test gear. The outlay could be triggered if Viatron comes through with a big order. The current contract with Viatron is about $450,000; Carlson says follow-on potential "runs to levels of a million circuits a year or more, but they have backup suppliers and we don't know which circuits we might put into quantity production."

The division has delivered 1,000 of a slightly redesigned version of its 1,024-bit shift register to California Computer Products. Calcomp has an option to buy 9,000 more, but Autonetics isn't disclos-

ing the size of the contract.

Alvin Phillips, MPD director of operations, maintains the diffusion problem encountered in changing from 1½-inch to 2-inch wafers for the Hayakawa circuits has been solved and the diffusion backlog is down to normal levels. "We were getting erratic sheet-resistance," Phillips reports. "We had the diffusion process going beautifully with 1½-inch wafers, but 2-inch wafers meant larger tubes, more silicon material in the tubes, and bigger boats to hold the wafers; this resulted in a difference in gas flows. It was a balancing and tweaking process that took some time." Phillips expects the output for Hayakawa to grow from a reported level of about 88,000 arrays per month to the peak of 160,000 a month by the second quarter of next year.

Computers

Off we go—into LSI

Raytheon's RAC-251 computer may represent the military's first sizable commitment to large-scale integration. But the possibilities for keeping down the machine's size and price are such that it could show promise for commercial applications.

The RAC-251, to be built for radar data processing in the Air Force's TPN-19 program, would use eight large-scale bipolar circuits to form the core (about 3,100 gates) of a 32-bit arithmetic unit and control section.

Private-sector users would be attracted by the combination of a 32-bit processor no larger than most 8-bit machines at a price possibly as low as that of today's 18-bit computers.

Walter F. Dawson, manager of the system design section at Raytheon's Equipment division, Sudbury, Mass., says the 251 makes more use of bipolar LSI than any other computer he's aware of—the only technical competition being an experimental processor built by Texas Instruments for the Air Force's avionics lab at Wright Patterson Air Force Base.

Raytheon uses Texas Instruments' discretionary wired arrays of TTL logic. Eight arrays—each larger than a silver dollar and in a 100-pin package—contain about 385 equivalent gates, including 28 j-k flip flops, 70 three-input nand gates, 22 seven-input nand gates, 21 and-or-invert circuits, several registers, adders, bussing circuits. A total of 35 read-only memories are included in the eight Texas Instruments arrays.

Economy. Dawson feels that the RAC-251 may have been one of the first computers designed with the economics of bipolar MOS strongly in mind. "With LSI development costing $10,000 to $20,000 per circuit, we tried to develop as few circuits as necessary," he says. "We worked out a design that required only a single LSI format, which we'll be able to procure for $500 to $800 per unit."

One goal was to keep non-repeating logic functions to a minimum; otherwise it would have made for costly LSI's with poor gate-to-pin ratios and more basic circuits. One result was a microprogramed controller. "To have built a control unit out of combinatorial logic," says Dawson, "would have required about 500 circuits in flatpack formats. By substituting read-only memories and LSI, we've cut that number by 40% and parceled the remaining logic among the eight LSI's."

Smaller IC's still are necessary, he adds, because some functions just don't repeat often enough to make LSI economical. Thus there are 17 printed-circuit cards, each measuring five by seven inches, containing ordinary integrated circuits.

Much of the development of the RAC-251 came from the RAC-250, an in-house development program, during 1968 and 1969. The TI arrays used in the 250 had only about 300 equivalent gates, "but TI's yields kept going up, and their process began to look much more repeatable as time passed," says Dawson. "So we changed the metallization to add bussing and some other features to the LSI's

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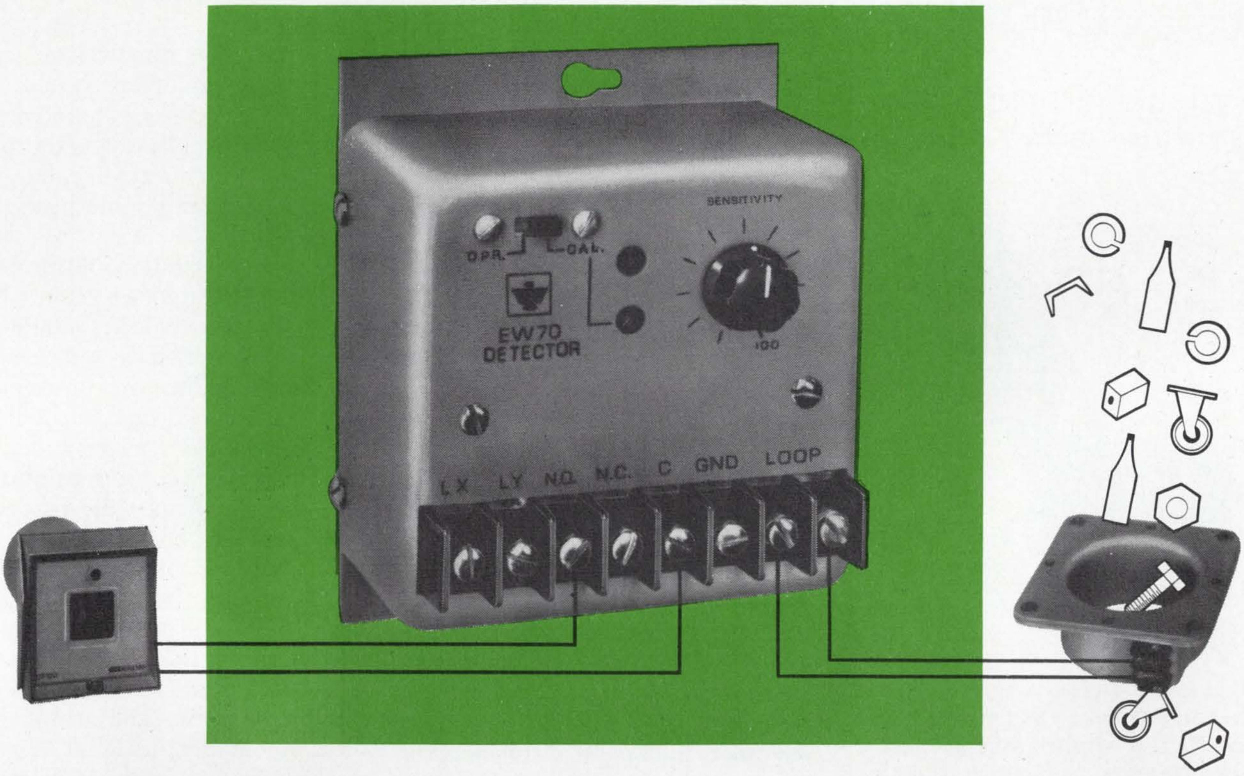

Solid-State Area Metal Detection for Accurate Count or Control

Eagle works with the state of the art to bring you the best automation controls that can be made commercially, using proven components, materials and methods. For example, the new Eagle EW70 carries the art of metal detection beyond mere proximity sensing into clearly defined *area* detection. That is, any *ferrous or non-ferrous* metal object, regardless of size, weight, shape or motion, passing singly through the sensor area is detected as a discrete object. Smoke, oil, dust, water...even vibration...have little or no effect on sensitivity.

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and improve our economics." TI, he says, has never had LSI delivery problems.

Two preproduction models of the RAC-251 are assembled now. They should go into checkout very soon, and should be operating by years' end. By the final quarter of 1970, Raytheon should begin producing the 251 in enough quantity to soak up 1,000 arrays or more by 1972.

Dawson already has done some thinking about the 251's commercial possibilities. "The 251 could cost only about $20,000 if produced at 100 to 200 units a year," he says.

Avionics

Now for a U.S. SST

While the British-French jet transport, the Concorde, was breaking the sound barrier for the first time during a nine-minute flight, the Boeing Co. was acting on President Nixon's SST go-ahead and setting avionics specifications for the U.S. supersonic plane.

The latest word from sources at the Seattle-based firm say that the specs are completed for three major items—the air-data computer system, the inertial navigation system, and flight instrumentation. Boeing will soon release them to industry for proposal preparation. Requirements for the rest of the avionics, including cockpit displays, the airborne integrated data system, weather radar, and attitude direction indicators, are now in various stages of undress, but should be ready by the end of this year.

A multiplexing system for transmission of a variety of signals from the rear of the airplane to the front over common wiring—at one time thought to be a definite SST weight- and space-saving requirement—is now questionable. Boeing sources say multiplexing will definitely not fly on prototype versions of the craft, due in 1972, and may not make it aboard the production models either, which are scheduled to fly in 1978. The reason: multiplexing seemed essential when the SST was still a swing-wing design, but with fixed wings cable runs are much shorter because electronic racks have been relocated nearer the pilot.

Communications and inertial navigation systems on the supersonic craft are not expected to be radically different from those on the Boeing 747 jumbo jet. However, according to one source, Boeing is thinking about moving the inertial navigation system computer off the inertial platform and adding tasks such as data generation for, say, a map display.

The displays themselves, along with a map-projection system, will include a computer generated multifunctional unit that would provide the pilot with weather radar, fuel management, and sonic boom profile data.

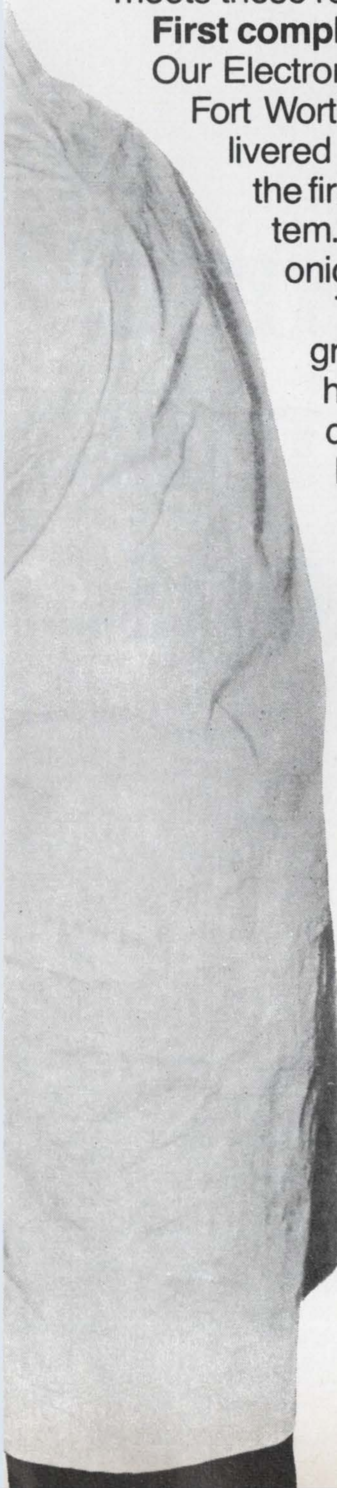
The weather radar will probably be a multifrequency system working in the Ka and Ku bands that locates the top of a weather disturbance, not just its presence as with existing equipment; when a pilot knows where a storm tops out, he can determine the feasibility of slicing through part of it to reach clear weather above.

Currently Boeing is evaluating two attitude-direction indicators developed by Norden. Boeing will also be looking at other systems from both Sperry Gyroscope and General Electric. The attitude and direction indicators will have to work under category III-A landing conditions—runway visibility range of about 700 feet—and will include a landing monitor that will provide the pilot with a picture of the runway from high-resolution Ku-band radar.

For the record

STV on the air. Subscription television (STV) may finally become a reality in December, one year after the Federal Communications Commission adopted rules to set up a nationwide, over-the-air STV service. A U.S. Court of Appeals decision against the National Association of Theater Owners and Joint Committee Against Toll Tv upholds FCC authority to set technical standards and regulations for operation of STV stations.

THIS AGE CAN TEST THE AVIONICS OF ALL NEW AIRCRAFT OF THE 1970'S.



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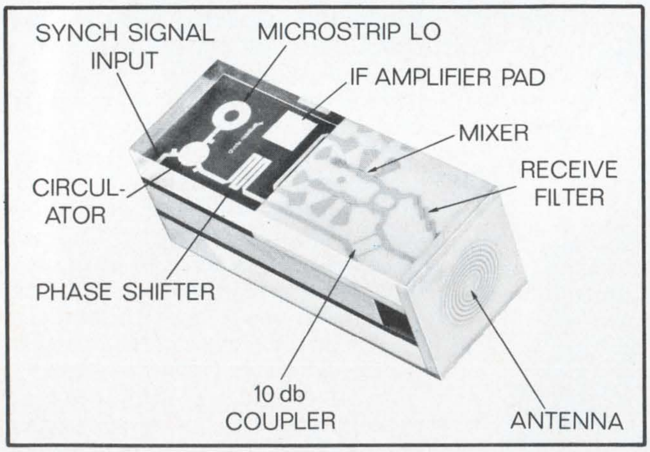
MICROWAVE IC PROGRESS REPORT #7: COMMUNICATION MODULES

Sperry's PACT (Progress in Advanced Component Technology) Program is developing a fully-integrated transmitter/receiver/duplexer module for an airborne communications array at X-band. The program has contractual support from the Air Force Avionics Laboratory, USAF, Dayton, Ohio.

The function of the phased array system is to establish communications between aircraft and synchronous satellite repeater stations, which in turn are linked to a ground station network and to other aircraft. This makes it possible for the crew of an airplane to be in constant contact with anybody, worldwide. Handy for all sorts of missions and indispensable in the event of conflict.



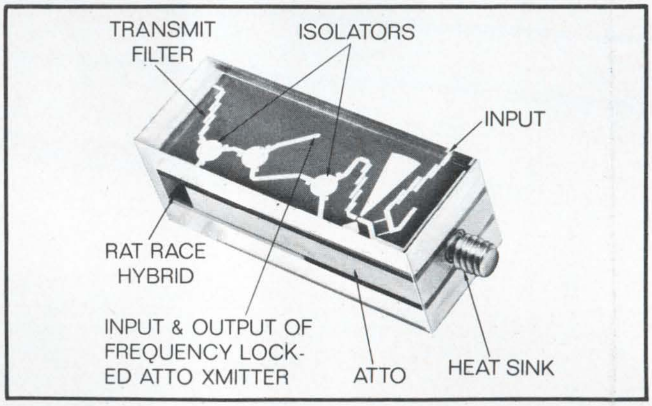
RECEIVER CIRCUIT FOR COMMUNICATIONS MODULE

Within the confines of each phased array element, which is less than an inch square and three inches long, is a complete transmitter/receiver/duplexer. Essentially composed of a signal source, a receiver, a mixer and an antenna, the module utilizes Sperry's advanced thinking throughout.

The rf circuitry is photo etched on metallized ceramic substrates 0.055 inches thick. Conductors are vacuum deposited gold on top of chromium. Follow-up plating produces half-mil thick strips. Transmission efficiency can be gauged by measuring rf energy loss, which, in this case, is no more than 0.15 db per inch.

Transmitter signals are generated by a Sperry Avalanche Transit Time Oscillator (ATTO), discussed in Progress Report #1. Energized by a DC voltage, the ATTO yields a 1-watt CW, X-band signal at an efficiency of 5%.

Sperry's gallium-arsenide Schottky-barrier diodes do the active conversion work in the receiver and the "rat-race" hybrid handles the signal with a single sideband noise figure of better than 6.5 db over a 12% bandwidth. (Sperry hybrid work was discussed in Progress Report #5.) Signal processing and control circuitry design has been materially aided by a Sperry-developed computer program.



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Washington Newsletter

October 13, 1969

House vs. Senate on defense bill . . .

Some maneuvering by hawkish Congressmen like L. Mendel Rivers (D., S.C.) is likely to result in **much of the $1.29 billion cut by the Senate being restored** to the authorization bill for Defense procurement, and research and development. Rivers, chairman of the House Armed Services Committee, "threw in a lot of money at the last minute that the Pentagon never asked for, **and that smells like fat for bargaining,**" says one Senate staffer.

Nearly all of the money cut earlier by the Senate was restored by the House in its $21.35-billion authorization bill. The bill now goes to the Senate-House conference committee, which will hammer out a compromise. **The House seems certain to get at least half of the money it restored—perhaps even more—when the conferees meet.**

This larger spending level is now expected to hold up for fiscal 1970. The appropriation bill follows the final authorization, but it must originate in the House, and any efforts by opponents of rising defense costs to trim appropriations are given little chance for success. **"They've already shot their bolt on the authorization, and they lost,"** summarized one House official.

. . . with Senate yielding on cuts

Although Senate members of the conference committee meeting to thrash out the compromise Defense authorization bill will be **fighting to** wipe out some of the funding gambits added by the House, **most of the House restorations are likely to stand,** according to dispirited Senate sources.

These include just about all of the $75-million House-restored R&D money for Raytheon's Sam-D ground-to-air missile successor to the Hawk; $66.1 million for the A- and the C-versions of Grumman's E-2 aircraft; and $165.4 million for the Lockheed ASW carried-based S-3A. **Apparently safe is $40 million for the long-delayed airborne warning and control system (Awacs),** which gives the Air Force two-thirds of what it wanted.

Other restored money that is expected to remain in the compromise bill includes: $18.5 million for the F-106X Awacs interceptor R&D, $15 million for the RF-111 reconnaissance fighter, and $1 million for the light intratheater transport.

Aircraft money also expected to resist any major cutting is the $104 million for the LTV A-7E, and $38.5 million for the Air Force's A-37B.

One likely subject of negotiation in the conference is Rep. Rivers' controversial insertion of $100 million to acquire long lead-time items for a fourth nuclear attack carrier. A hawkishly-oriented conference, however, is expected to leave in at least some money for the carrier, which was not sought by the Pentagon.

Navy resolicits Tacan proposals

ITT's Federal Labs won its protest over the award of the AN/ARN-84 Tacan navigation contract. **Proposals are now being resolicited by the Naval Air Systems Command.** Originally, Hoffman Electronics was believed to have been selected to build the 526 microminiaturized digital units [*Electronics,* July 21, p. 34]. But ITT, one of three bidders, protested in June that specs were too ambiguous and the open-ended contract would not be "in the best interest" of the Government. **The contract**

is expected to be worth between $12.5 million and $15 million.

ITT received $6.27 million through fiscal 1967 for production of the older AN/ARN-52 analog sets, which the AN/ARN-84 will replace.

Undersea 'R&D' covers up for Caesar's ghost

A $17.8-million cost-plus Navy award to Western Electric for "oceanographic R&D" proves to be one more cover-up for underwater intelligence-gathering systems. Naval Electronic Systems Command won't reveal a thing, but non-government sources say the one-year effort, to be performed for Western Electric at Bell Telephone Labs, Whippany, N.J., is aimed at **developing a Pacific Ocean counterpart to the Atlantic's "Caesar" program**—the submarine detection and tracking network.

But the Pacific system will require hardware capable of operating at much greater depths—the Pacific continental shelf is but 20 miles wide, against the 75-mile width of the Atlantic shelf on which Caesar operates.

Navy confirms Northrop winner of Jifdats award . . .

Hughes and Motorola aren't expected to protest the award of the Jifdats program to Northrop's Electronics division. Northrop's digital proposal to develop the triservice, joint in-flight data acquisition and transmission system won out over partially-analog systems proposed by Hughes and Motorola [*Electronics*, Aug. 18, p. 71]. Indications had been that the losers might protest because the oft-delayed and reoriented program had changed even after the last proposals had been received.

Northrop, which has received its first $25-million increment from the Naval Air Systems Command, has been working with Cubic Corp. for the basic transmission link, with Bourns (Canada) for the airborne film processor, with Philco-Ford for the digital modems, and with Magnavox for beacon transmitters. **The system could be worth $300 million over the next four to five years.**

. . . as Cubic's work on data link seen playing key role

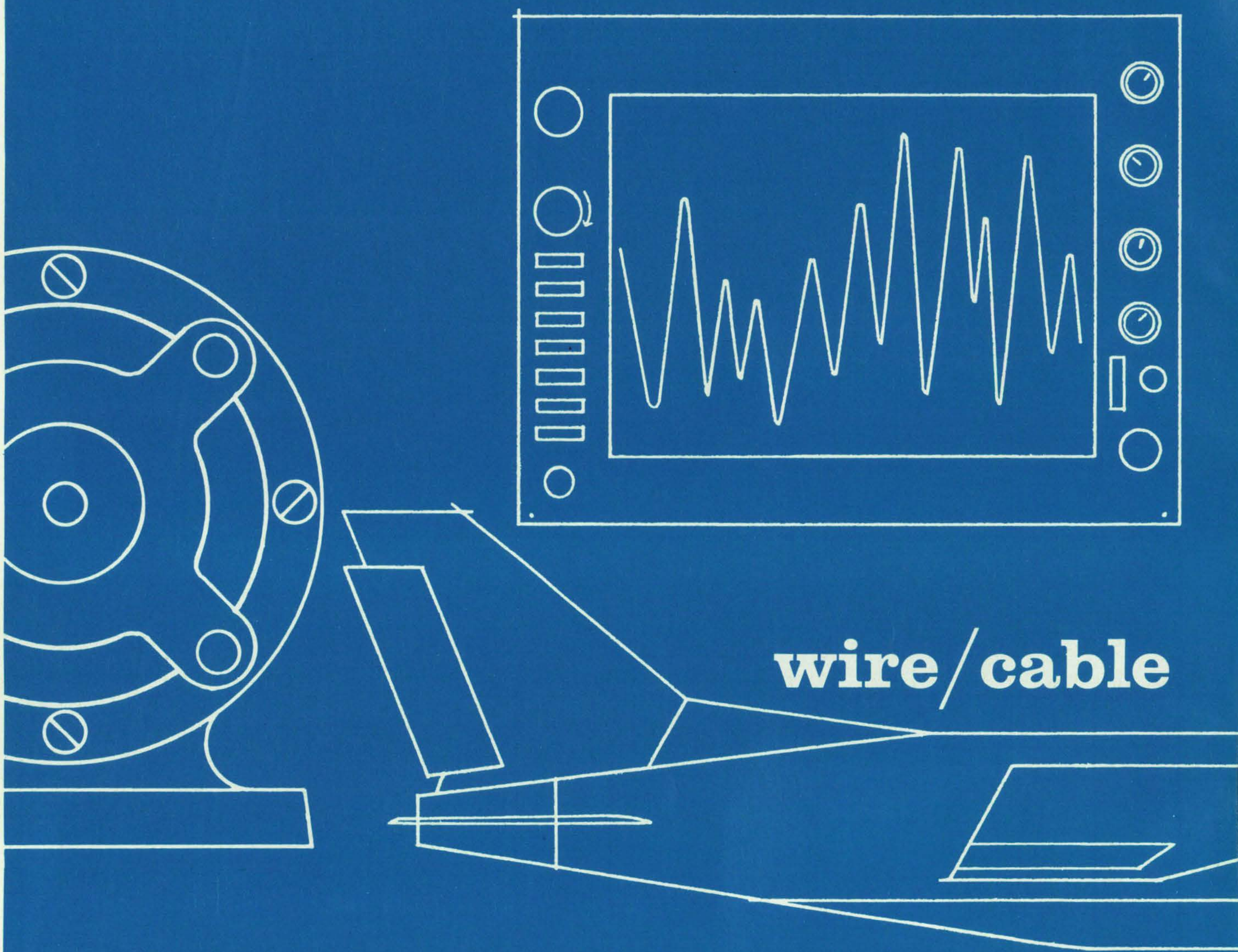
Navy officials who selected Northrop no doubt **had one eye on the Air Force's successful flight tests with a near real-time data link built by Cubic** to meet a Southeast Asia operational requirement (Seaor 45). With the joint Cubic-Air Force tests now completed, the service will conduct further tests on its own before final acceptance and deployment of the data link in the field.

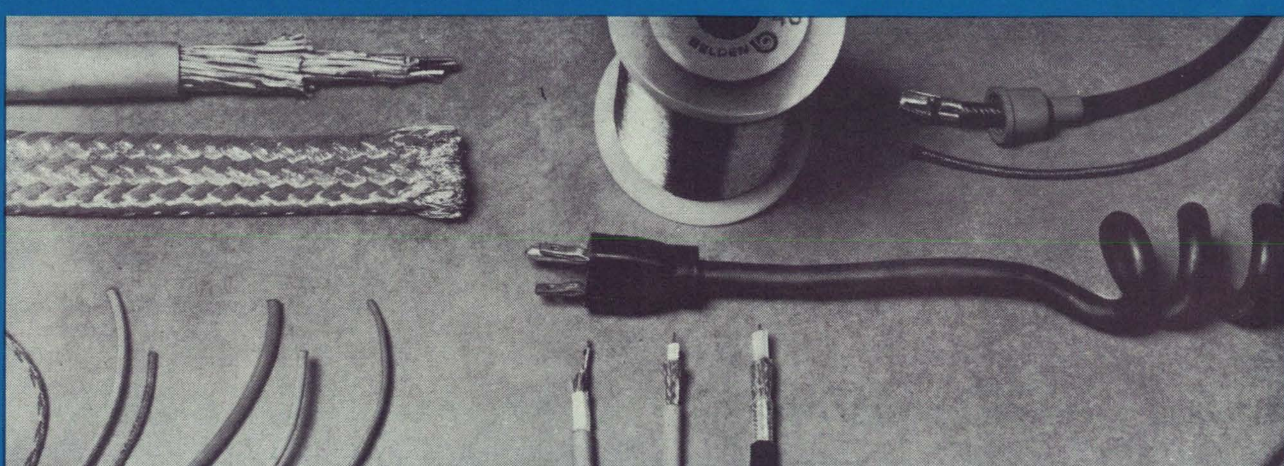
It's believed that Cubic's data link, developed initially to handle infrared-sensor inputs only, can be expanded readily to handle other types of sensors. The firm's original $5.1-million Air Force contract has been expanded, and one source says the new money is not to buy additional systems, but to add additional sensor capability. Cubic competed against Hughes and Motorola's Government Electronics division, among others, to win the Air Force data link award.

Addendum

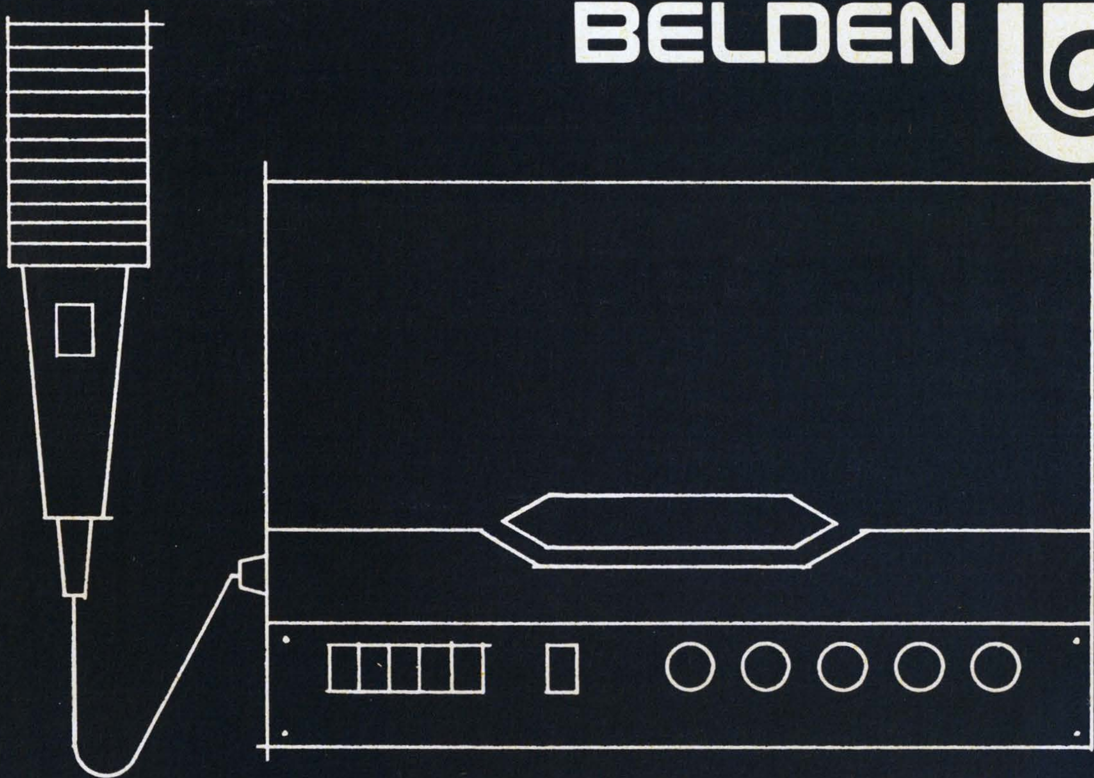
Just because President Nixon gave his blessing to the supersonic transport doesn't mean the program is out of the woods yet. **SST avionics competitors still see political problems before final approval of fiscal 1970 Federal funding for the Boeing program.** So does Sen. Henry Jackson (D., Wash.), who anticipates that the Congressional floor fight will rival that of the Safeguard ABM earlier this year. White House approval of the program still needs a fiscal 1970 appropriation of $96 million over the $90 million the Department of Transportation will carry over.

BELDEN...new ideas for moving electrical energy





BELDEN



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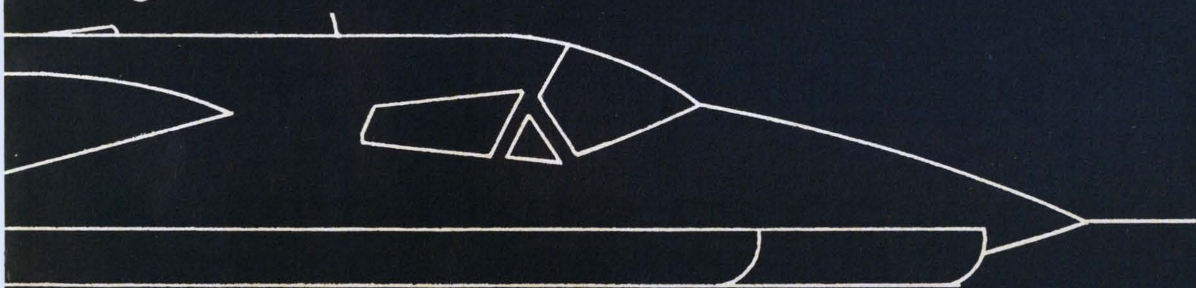

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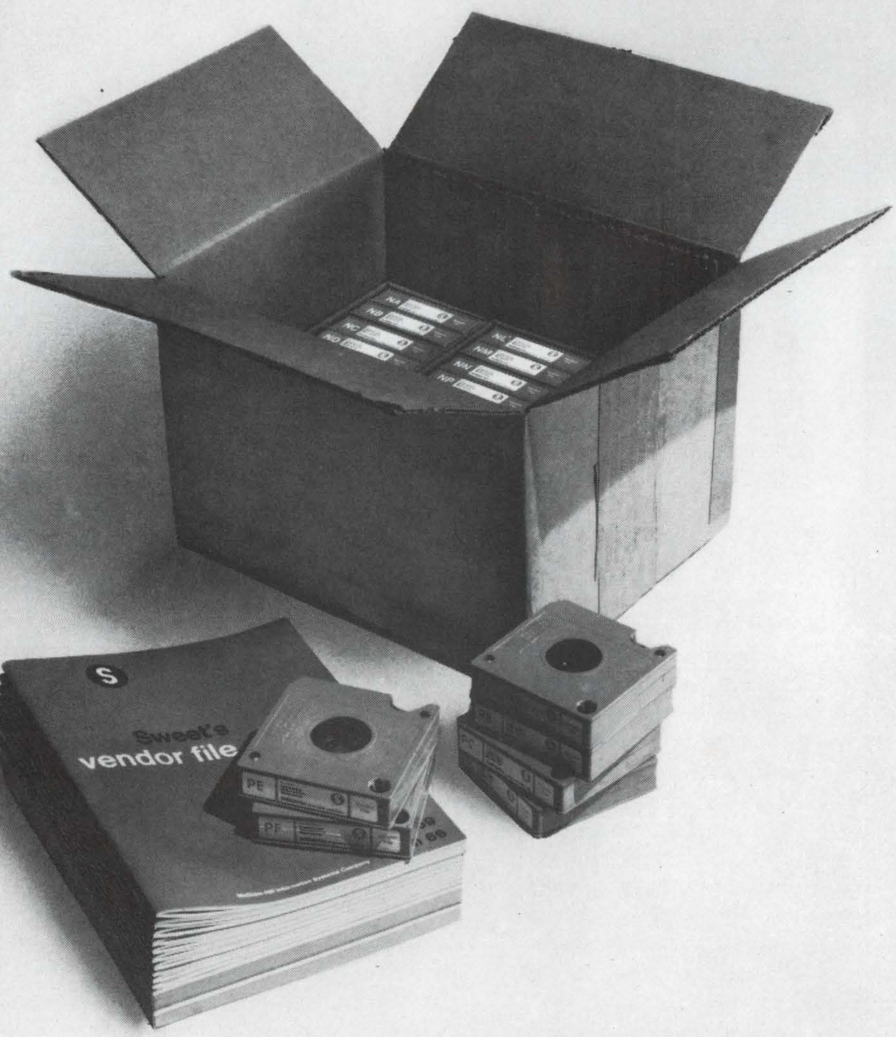
Circle 69 on reader service card

The April update: 95,100 pages of product data

The June update: 90,400 pages of product data

The August update: 129,600 pages of product data.



Every other month, Sweet's Microfilm System packages the data explosion

In 5 minutes, you can collect, index and file the data explosion. That's the amount of time you'll spend every other month putting the latest Sweet's Microfilm System update into the cartridge carousel. Essentially zero-maintenance; Sweet's has done all the work.

We mail about 30 cartridges in each bimonthly update of our product/vendor file. The *total* of current information is already more than three-quarters of a million pages. *More current information than contained in any other system... updated more often, more thoroughly, than any other system.*

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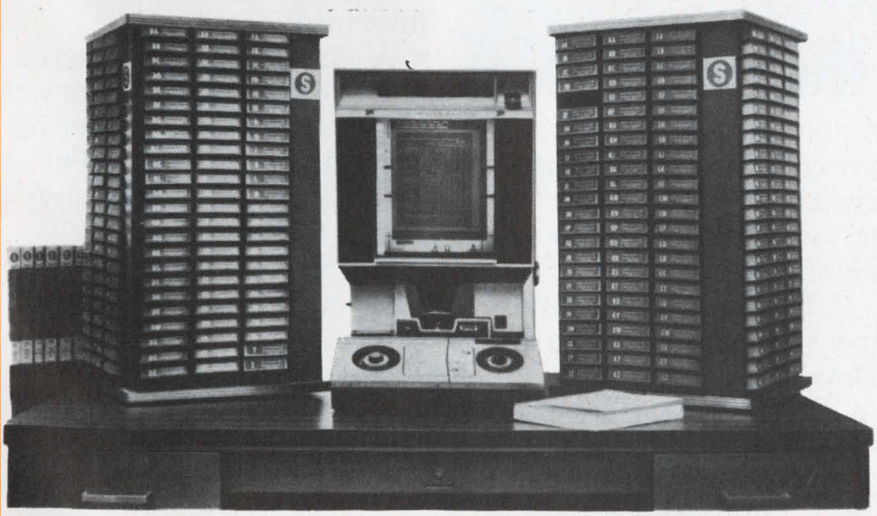

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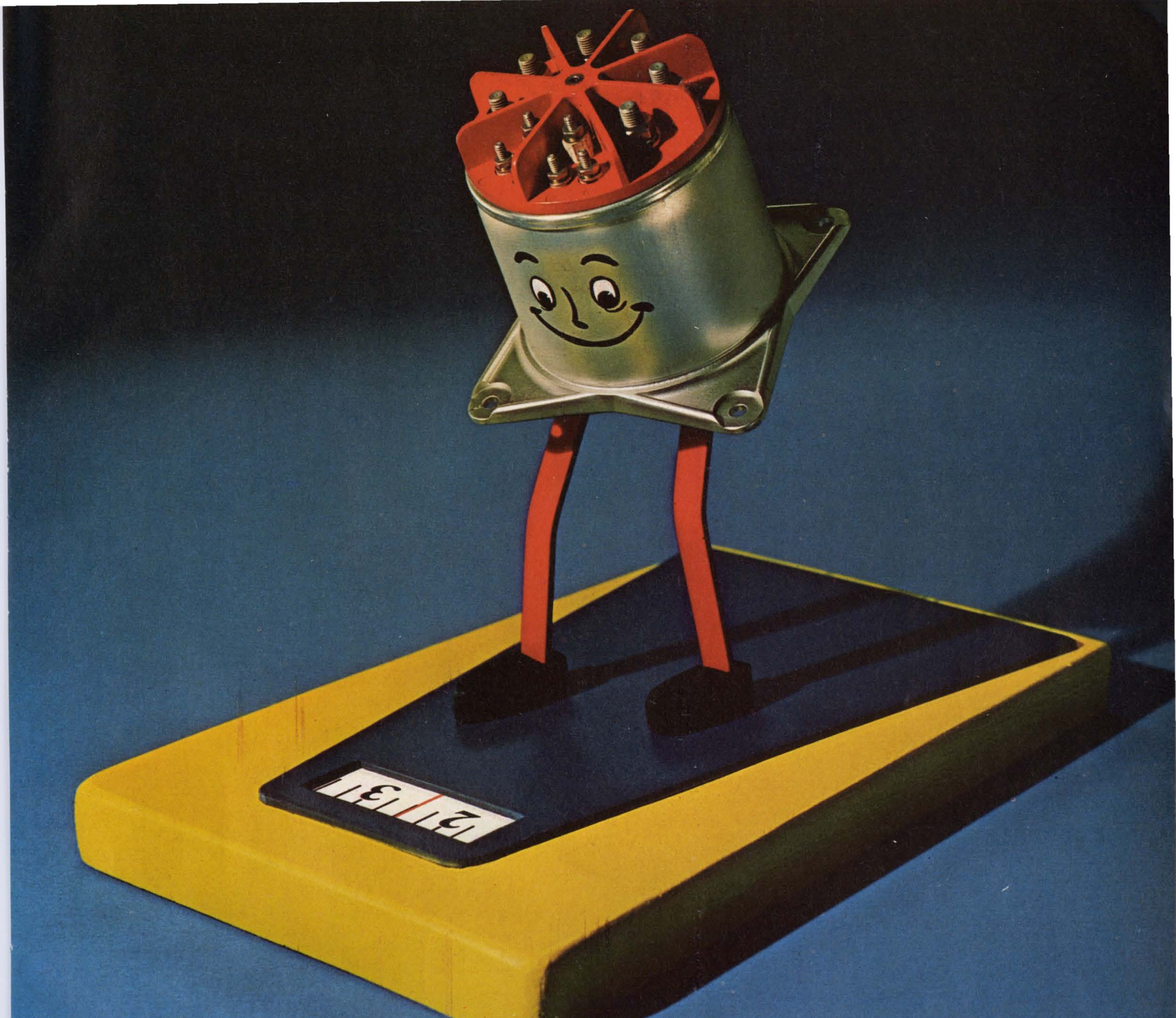

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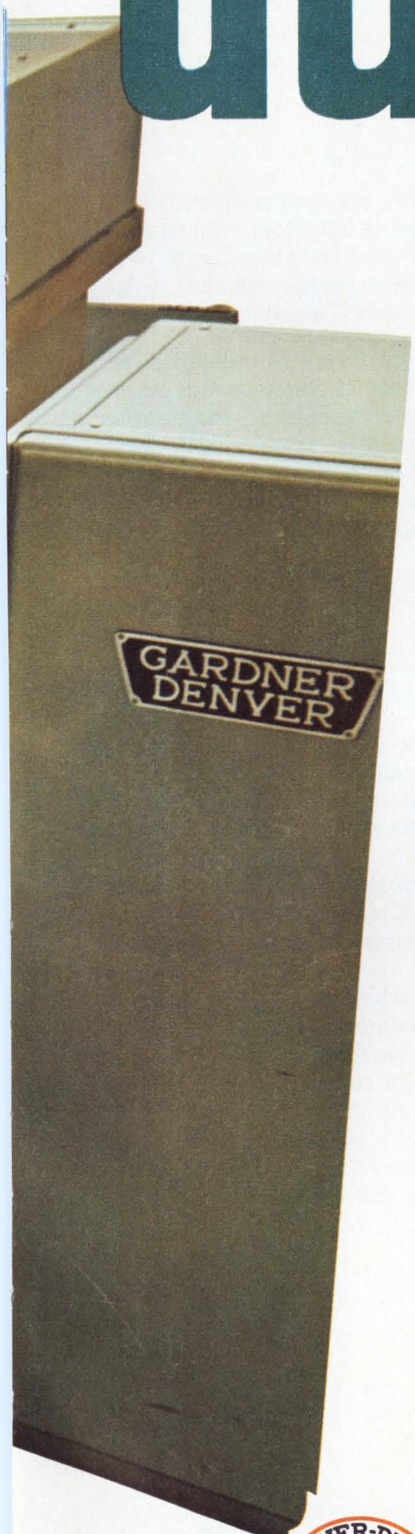
Circle 75 on reader service card


GARDNER-DENVER Wire-Wrap

automate



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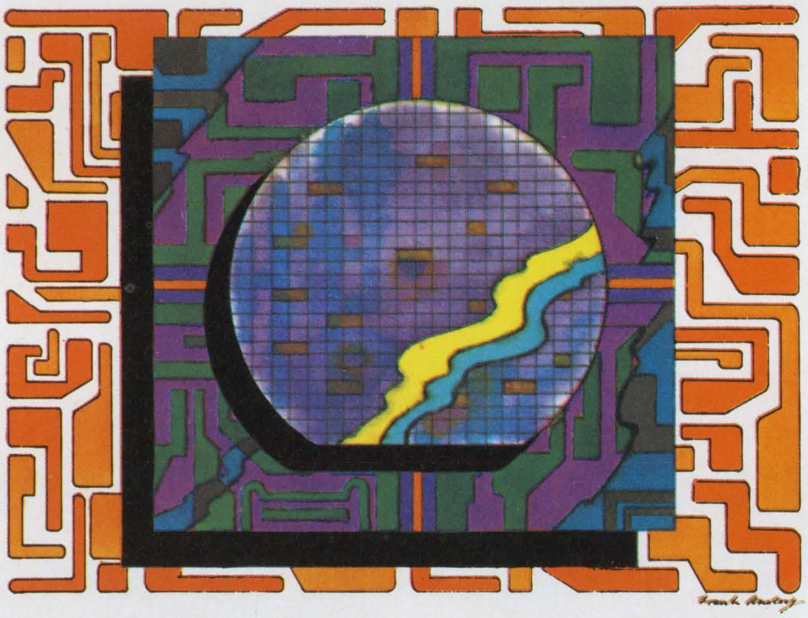
Circle 77 on reader service card



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the most significant development in electronic display

Burroughs, the originator of NIXIE® tubes, now revolutionizes display technology with the first commercially practical dot matrix display sytem. It took SELF-SCAN panel display, the remarkable Burroughs invention that takes the electronics out of the present electronic display ... reducing costly drive circuitry up to 90%.

With a minimum number of leads and drivers, Burroughs' system automatically scans data input into in-plane readout characters formed by glowing dots ... making possible a totally new combination of readability, minimal packaging and cost advantages.

The new flat-panel display is basically a matrix of small gas discharge cells hermetically sealed between heavy glass plates in a sandwich configuration. The matrix itself, formed of insulating material, has small grooves on its top surface to allow positioning of information anode wires which intersect each hole. Cathode conductors behind the center sheet intersect at each cavity with a second set of anode wires.

By utilizing the phenomena of preferential glow transfer and glow shifting, the initial glow caused by cathode ionization in the dot matrix may be moved through selected holes to a visible position on the top surface. A sequential flow of light is thus achieved without separate drivers for individual columns and rows.

Burroughs' alphanumeric SELF-SCAN panel displays are available with or without memory for any application requiring 16 or 18 digit readout.

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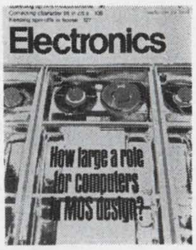
Technical Articles

Computers make big difference in MOS designs
page 82



How large a role does the computer have in designing MOS circuits? Apparently, when it comes to custom circuits, the machine has a dominant role. Not only does it lay out and partition the circuit, but it builds the circuit with standard cells where it can and designs new cells where it can't. After both device maker and customers' check the layout, the computer prepares the instructions for fabrication, controls the cutting of the masks, and even produces the testing procedures. The result: vendors can deliver custom MOS circuits within a few months after a user sends in his first logic diagram.

Taking the heat off thermocouple failures
page 96

In industrial applications, where thermocouples are used to control processes and to safeguard the plant, there's too much at stake to let open thermocouples go undetected. Testing just a few of these sensors is one thing, but testing hundreds of thermocouples is something else altogether. And in high-speed scanning systems, conventional methods of testing these sensors are anything but satisfactory. Engineers at the Leeds & Northrup Co., however, have come up with a solution—an open-circuit detector capable of testing 250 thermocouple circuits a second. Designed specifically for digital data-acquistion and computer-control systems, the detector signals the outcome of each test to the system's computer.

Memories: Boosting performance and speed
page 105

Either you make a memory operate faster or you make it appear that way, with the latter route becoming increasingly popular. Used successfully in IBM 360/85's and 360/195's—not to mention other machines for which it is being investigated by other manufacturers—this approach is based on a secondary memory, a smaller but faster unit that serves as a cache and stores data needed by the computer. The main memory transfers the data to the cache at relatively slow speeds. Of course, you can always make a faster memory. With ferrite cores, this means making the cores smaller—the smaller the core, the faster it switches.

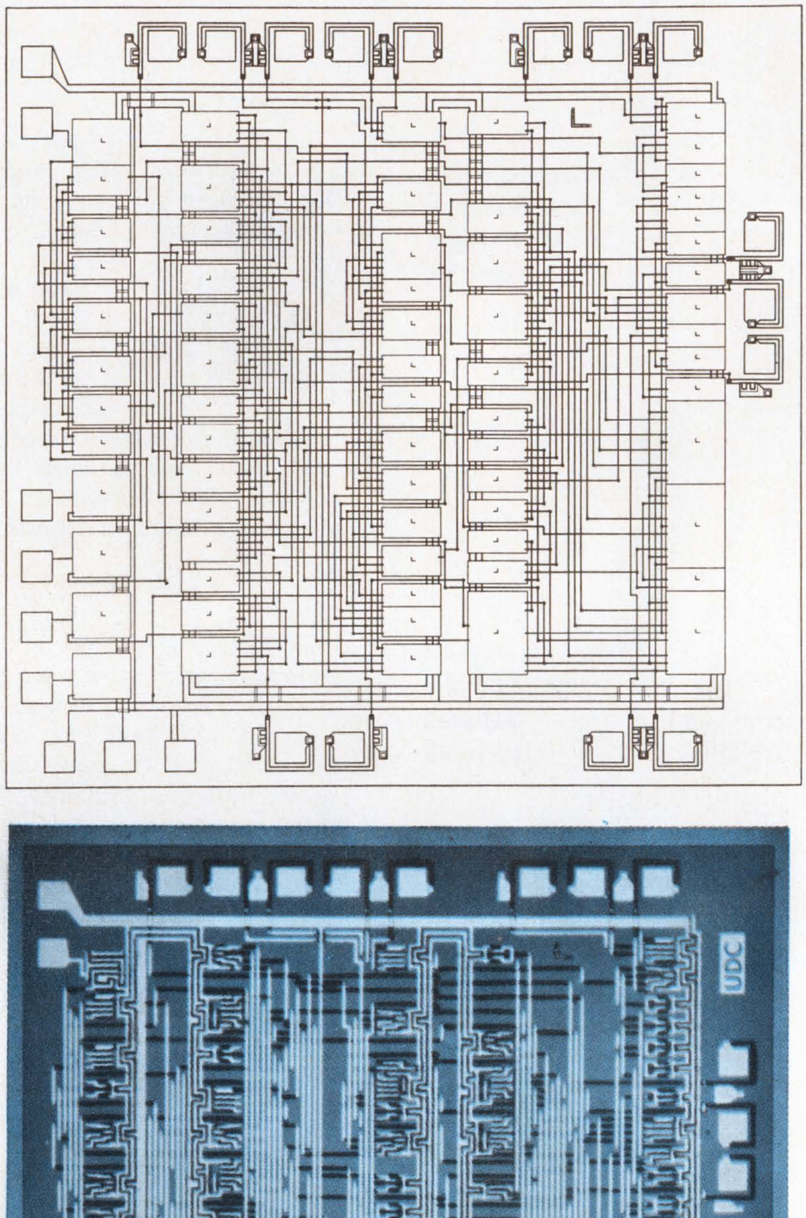
Coming

Air traffic control: Girding for the 1980's

The FAA, criticized for its failure to come up with an adequate air traffic control systems plan as well as its inability to incorporate the latest technology, has developed a blueprint for a system capable of handling the heavy air traffic anticipated for 1980 to 1995. The technology required for this new generation system will be spelled out in a staff-written report.

Computers make a big difference in MOS designs

From just a minimum of design input, machines not only lay out customized circuits, but they provide fabrication instructions as well; in fact, says associate editor *Lawrence Curran*, computers do just about everything.



Before and after. In block-composite form from a computer is a circuit developed at Fairchild Semiconductor. The circuit is a four-bit up-down counter.

• Largely as a result of a growing demand for custom-designed MOS IC's, circuit makers are beginning to rely more and more heavily on automation. Computers can do everything from turning a set of logic equations into a circuit to printing out instructions for fabricating the integrated circuits. They're storing cells (the standard subcircuits put together to make the IC's), partitioning logic, and controlling the generation of artwork.

Speed is the computer's main contribution to the metal oxide semiconductor industry. Starting with just logic equations, the Collins Radio Co. can turn out circuits within 60 days. And the industry average is around 14 weeks. When done by hand, custom designing an MOS IC is sometimes a six-month task.

However, to ensure that this fast turnaround time doesn't become excessively expensive, the buyer should understand the design and manufacturing process. For example, the buyer who hands the circuit maker a set of equations and says "build it" is going to pay a lot more for his circuits than the man who gives the maker already-partitioned logic diagrams.

The buyer can learn quite a bit about the various custom MOS houses before selecting one. Probably the best single document source of information that the vendor can provide in the early discussions is his complete cell library. Cells vary in complexity from maker to maker, which partially explains why some have a few hundred cells in their libraries while other makers have as few as 50 cells in theirs. After perusing the library, the buyer can quickly see if the subcircuits he needs—be they output buffers, binary adders, flip-flops or gating arrays—either are in library themselves or can be made from already-designed cells. If they aren't or if they can't, he'll have to pay time and money for the design of new cells. His alternative is to redesign his logic, making sure that his functions can be synthesized with standard cells.

At the Collins Newport Beach, Calif. facility the library has about 175 cells. Collins also offers the potential buyer a set of computer programs with which the customer can design his own logic. Thus, Collins engineers are less involved in the actual designing and partitioning than they would be if the programs weren't around. Collins officials, noting that they usually charge from $8,000 to $12,000 per circuit for design, estimate that the buyer's design participation saves him $3,000.

The first buyer that Collins signed for its custom-MOS service was the Viatron Computer Systems Corp., the Burlington, Mass., firm that's offering a computer with peripherals that rents for $39 a month [*Electronics*, Oct. 14, 1968, p. 193]. Viatron agreed with Collins to develop nine chips just a few days after Collins announced the beginning of its customer-controlled MOS design automation system at Wescon this year. George Grondin, assistant director of Collins' Equipment division and the man most familiar with the software aspects of the system, reports that of the 1,000 cells included in those first nine Viatron chips, only eight cells were not in the Collins library and had to be designed.

At American Micro-Systems Inc., in Cupertino, Calif., the library has some 70 to 80 cells. One difference between Collins and AMI is that if an AMI customer has to have cells designed and then returns a year or two later wanting the same cells, he may have to pay development costs all over again. Andy Prophet, AMI's supervisor of digital products, says that if there has been a process change, the standard-cell library will be updated while the customer's special cells won't be. Collins' Grondin stresses, on the other hand, that the customer's special cells can be stored.

James Downey, Fairchild Semiconductor's section head for MOS array engineering, says that his division's cell library has about 55 cells. A good many of them are listed in the 24-page "primer" Fairchild gives to potential customers. Called "Micromosaic arrays . . . an MOS approach to customer LSI," the pamphlet contains Fairchild's process specifications; an explanation of the symbols used in logic diagrams (per Mil-Std-806B); and information on packaging and testing options. It also shows the organization of a representative custom array, with cell dimensions, standard cell interconnection alleys, customized interconnection patterns, and bussed voltage and distribution lines. In addition, it has an introduction to the division's Fairsim, the format with which customers can encode array designs on punched cards.

The document's last page is a custom-array technical specification sheet, which the customer can submit to get a quote on his job. The sheet has space for detailed electrical specs and package preference in addition to a place where the customer indicates how much help he wants.

The customer may choose the performance specification as the initial interface point. This choice means more work for Fairchild engineers than would be required if the customer were to supply a cell logic diagram and functional test specifications. If the logic diagram, technical and test specs are firm, Downey says, it takes Fairchild engineers at Mountain View, Calif. just 30 minutes to come up with a firm price quote and delivery data.

Besides the Micromosaic array primer, Fairchild also has a 35-page Fairsim user's manual that acquaints customers with control language and computer simulation of digital systems. However, Fairchild engineers are quick to emphasize that a customer doesn't have to know computer programing before he can use the Fairsim approach. But, Downey says, "The more detailed information the customer gives, generally, the lower the price he'll get." This is not to say that Fairchild won't take on the whole systems design job for the customer who doesn't want to tackle it. They will as will AMI. But Collins' emphasis is on having the customer do the lion's share of the design.

Collins has a four-volume MOS design automation manual which outlines design rules, lists the standard cells, and gives general instructions for specifying circuits. But the firm has decided to boil the huge set down into one volume that will take the customer up to the point of automatic generation of artwork and just short of mask making, where the customer drops out of the loop. The new manual will be available this month.

Collins also relies on face-to-face exchanges with potential customers and an eight-page spec sheet that calls out performance characteristics for its four different manufacturing processes to acquaint customers with its custom-design automation facility.

Although systems engineers are available for consultation on logic partitioning, Grondin expects that once the one-volume user's manual is distributed, little "handholding" with the customer will be required once the logic equations reach Newport Beach. Collins assumes that potential customers are aware of the advantages and limitations of MOS when they prepare their logic design. "For example," observes Grondin, "a customer should know that he can't get speeds of 20 megahertz with MOS logic today."

AMI counts heavily on its cell list to impress its customers, but beyond that, the firm has a team of systems designers available to design and partition the logic. These specialists also are available for any other assistance the customer may need. AMI's Prophet says that his firm has 12 engineers in applications engineering, the first group the customer deals with. "These people represent a merger of two disciplines—systems engineering and MOS design—and they are critical people to find."

AMI offers a virtually fully automated design process when the majority of the cells called for are in the library. Another opinion entails manually drawn cell and circuit-block composites and automatically generated artwork; a third option involves a complete manual design from laying out the cells through drawing the circuit block composite to making the artwork.

At Fairchild, Downey's Micromosaic design group is backed by five men in array systems engineering whose initial job is to draw the logic circuit if a customer doesn't choose to submit one.

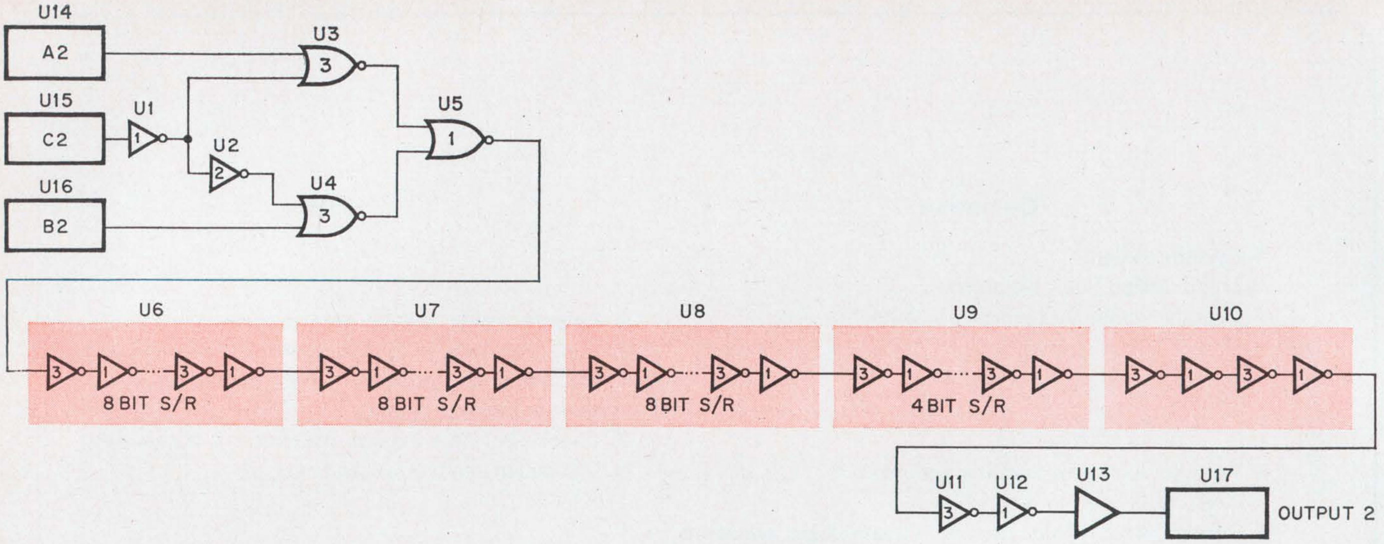
Texas Instruments begins working with its customers at any point in the MOS design sequence, depending on the customer's wishes and experience. As a starting point, TI accepts any input from design concept, logic equations, or logic diagram, through logic circuit designs or partitioned designs, up to numerical-control tapes for making artworks, finished artwork or glass masks. The company draws the line only at processing partly finished silicon wafers. These present too many difficulties because of differences in processing techniques, says Dave Roop, TI's MOS marketing manager.

From logic equations up, TI's design procedure is

Who does what. A great deal of information flows between Collins and the customer in an automated procedure for designing custom MOS circuits.

Automated MOS Design Procedures

Level	Customer		Collins
System level	1. System design.		
	2. Logic design (logic equations).		
	3. Specify simulation (generators, output modes).	→	4. Prepare inputs to Logicomp program (equation cards).
			5. Run Logicomp to generate simulator program inputs (net list cards, generator cards, format cards).
			6. Run simulator program.
			7. Check simulator outputs (Return to 4 if incorrect).
	9. Analyze simulator outputs (proceed to 11 if all logic verified and correct.)	←	8. Deliver simulator outputs to customer.
	10. Correct logic design errors (update logic equations, return to 3).		
Chip level	11. Partition logic into chips.		
	12. Modify logic equations to describe each chip.		
	13. Select MOS process and family of cells.		
	14. Select package.	→	15. Prepare inputs to Logicomp (equation cards, parameter cards).
			16. Run Logicomp; list cells not in file.
			17. Design new cells as required, release to ECS.
			18. Run Logicomp to generate inputs to PRP program.
			19. Run PRP program.
			20. Check PRP outputs (return to 18 if incorrect).
	22. Analyze placement-route-and-patch (PRP) outputs — check overall layout.	←	21. Deliver PRP outputs to customer.
	23. Change equations; modify placement.	→	24. Run Logicomp to generate inputs to PRP program.
			25. Run PRP program.
			26. Check PRP outputs (return to 24 if incorrect).
	28. Analyze PRP outputs—check all loading rules, reroute connections, place pads, place logo, etc.	←	27. Deliver PRP outputs to customer.
	29. Specify PRP patch inputs.	→	30. Run Logicomp to reformat patch data, generate row-column information, generate feature group list.
			31. Run PRP program.
			32. Check PRP outputs (return to 30 if incorrect).
			33. Run plot program.
	35. Analyze outputs (return to 28 if necessary).	←	34. Deliver PRP outputs and block composite drawing to customer.
	36. Order release of cell and interconnect data to ECS.	→	37. Prepare release to ECS.
Automated MOS process			↓ Equipment compiler system (ECS). ↓
			38. Extract cell and interconnect data from ECS.
			39. Convert to areas for each of four masks.
			40. Run Opto conversion program; produce numerical control tasks.
			41. Operate Opto artwork generator to produce four 10X master reticles.
			42. Operate Opto artwork generator to produce four 1X step and repeat masters.
			43. Produce working prints.
			44. Release to MOS fabrication.
			45. Automatically test chip package using characterization data tapes prepared by simulation programs.
			46. Deliver prototype units to customer.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A2
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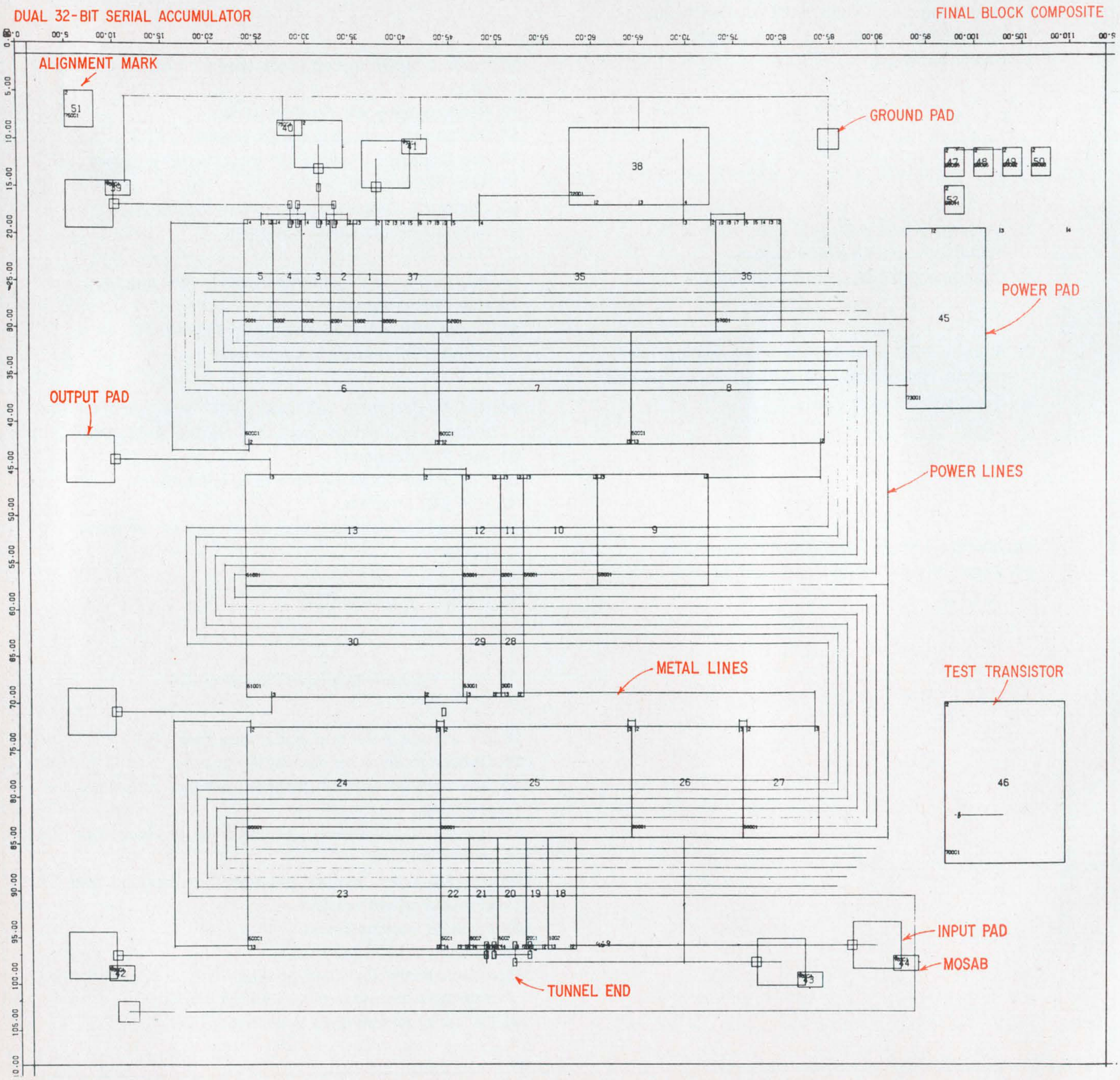

DUAL 32-BIT SERIAL ACCUMULATOR
FINAL BLOCK COMPOSITE
ALIGNMENT MARK
GROUND PAD
POWER PAD
OUTPUT PAD
POWER LINES
METAL LINES
TEST TRANSISTOR
INPUT PAD
MOSAB
TUNNEL END

Half-chip. The dual 32-bit serial accumulator chip developed at Collins has two circuits of the type shown at left. The numbers coded "U" refer to cell numbers, called out in the final block-composite plot, below.

"automated all the way," Roop says. No masks are cut by hand, and even the test patterns and logic checks are computer-generated. "We just can't do these things by hand," Roop says, "there aren't enough draftsmen." He cites as an example of the large-volume turnover the fact that a present customer is calling for the design processing of 30 separate circuits, all of which have to be done simultaneously so that all the circuits will be completed at the same time. Thanks to TI's automated facilities, this program is being handled by only six engineers.

TI is "probably less formal than other manufacturers" in the information it supplies customers, Roop says. For example, the company doesn't furnish a brochure with design rules to prospective customers. However, TI does supply a design manual "once a customer is engaged," Roop says. There are two main reasons for this informal relationship: TI regards many of its design rules as confidential, and also it's constantly updating them.

Once engaged TI's customer gets one of two kinds of information, depending on what he needs and how much he's willing to invest in the designs: a basic cell library of standard sub-circuits or a set of basic design rules without the cell library.

TI also has "a cadre of experienced personnel" to train the customer's engineers, Roop says. "We can educate them in a week or two (in the bare essentials) and then send them home to work. Or we can provide closer liaison and have them work with our engineers."

Final Block. The accumulator, in final block-composite form, shows the computer-designed chip layout with the test transistor added to the chip.

If the customer does the entire design work and supplies error-free masks, turnaround time is six weeks, Roop says. He points out that the IC's can be made in a shorter time, but six weeks is a "realistic" figure that takes into account the intricacies of production scheduling. The lead time grows when the customer calls on TI to take on more of the design and layout work. TI engineers need one to two months to design subcircuits from a logic diagram, two to four weeks to partition, one week to prepare numerical-control tapes, one week to prepare artwork, and two to three weeks to make masks.

Roop reports that most customers want to design tests and supply test patterns to TI. However, "testing is probably one of the most hazy areas in MOS," he says. TI has found it's best to use its own computer systems to check out the customer's testing requirements.

The process flow from receipt of the logic design to delivery of parts differs from company to company mainly in the degree of automation at each step. At some stages in all the automatic processes a design engineer looks at the chip layouts developed by the computer, and makes any needed improvements.

At Collins the customer first sends in his logic equations, along with an indication of the kind of simulation he wants performed.

Grondin says: "We don't force the customer to specify the simulation, but we have SIMOS, TESSI, plus simpler ones that allow him to define the driving inputs and tell how long he wants the simulation to run." Regarding simulator outputs, Grondin explains that the customer can call out every node in his system to find out what its logic state is under any drive condition for whatever number of clock pulses.

Collins engineers then translate the equations and the simulation into punched-card inputs for the Collins' Logicomp program, which converts the equations into the format required for the simulation program. Then Logicomp is run again to generate the simulator program input, such as net list cards and generator cards.

After the generated program checks the simulator outputs, the simulator's printout is sent to the customer, who analyzes the logic simulation and corrects any design errors by altering the appropriate equations. The new equations go back to Collins where a second simulation is generated. This exchange of simulations and equations continues until the customer is satisfied.

Once satisfied, the customer partitions his logic onto individual chips and then does some redesigning to accommodate the logic requirements of each chip, such as providing higher drives at a chip's input. Then he picks an MOS process (static or dynamic, two- or four-phase, high- or low-threshold) and along with it the proper cell family, and selects a package. All of this information goes to Newport Beach where Collins engineers prepare the equation and device-parameter punch cards that serve as inputs for the Logicomp program. The program is then run, calling out cells from the library to be used, and listing those cells not in the Collins file. After the new cells are designed, they're released to the equipment compiler system (ECS). The ECS program puts the new cells into the library, digitizing all the information needed to make masks.

Next the Logicomp program runs again, this time to generate information for a placement, route, and patch (PRP) program. Patching is the technique the customer uses to change the computer-generated designs. The PRP program is then run, and Collins engineers check its outputs, which include the identity of the cell library used; the assignment of gates to patterns; a net list and net capacitance; and the coordinates of each cell, interconnect line, and unwired test device on the chip. The important program outputs go to the customer, giving him a complete digital description of his layout. Collins puts any further modifications from the customer into the Logicomp program which generates new inputs for the PRP program. After the PRP program runs again, its outputs are sent back to the customer for further scrutiny.

Using the PRP outputs, the customer next checks all node loading rules, reroutes connection if necessary, positions the contact pads, and puts his logo on the part. All this is done by making manual patches to the line printer plot. When the customer specifies these new patch inputs—eliminating an interconnect, for example, by calling out its coordinates on the line printer plot—Collins again runs the Logicomp program to reformat patch data, to generate row-column information and any mask alignment marks, and to test transistors and bonding-pad data peculiar to the chip. The results are new inputs for the PRP program. Collins runs the PRP program again, checks the outputs, and delivers a revised line printer plot to the customer, along with a block composite drawing.

The customer is now in the final design stages, and will probably be checking the PRP outputs and block composite for such details as good ground connections to the substrate, pad locations far enough from the chip perimeter, and correct bussing. If he's satisfied, the customer orders his cell and interconnect data released to the equipment compiler system, which generates artwork and instructions for wafer fabrication.

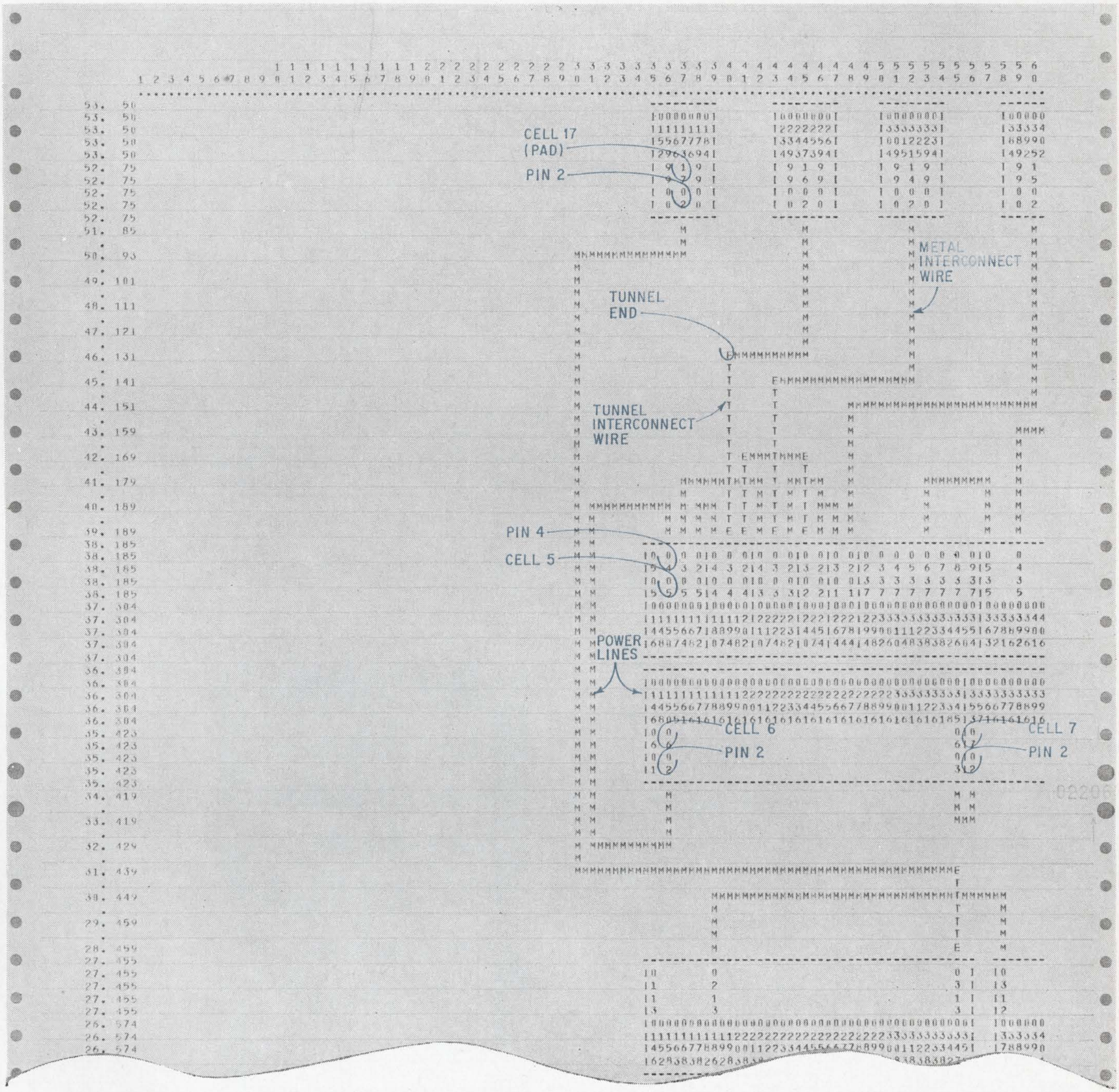
The fast turnaround once the job reaches the ECS is what Collins believes makes its system unique. Three principal programs are called into play. The first extracts all the digital information for each of a circuit's four masks and stores it. The second handles what Collins calls "smashing"—breaking the composite's outline polygons into a group of rectangles compatible with the variable-aperture camera that makes 10X masks in the first of two steps that leads to a 1:1 step-and-repeat master for the fabrication masks.

The third translates the "smashed" information into paper-tape commands that control the aperture, the table on which the master reticle is mounted, and the camera's flash mechanism.

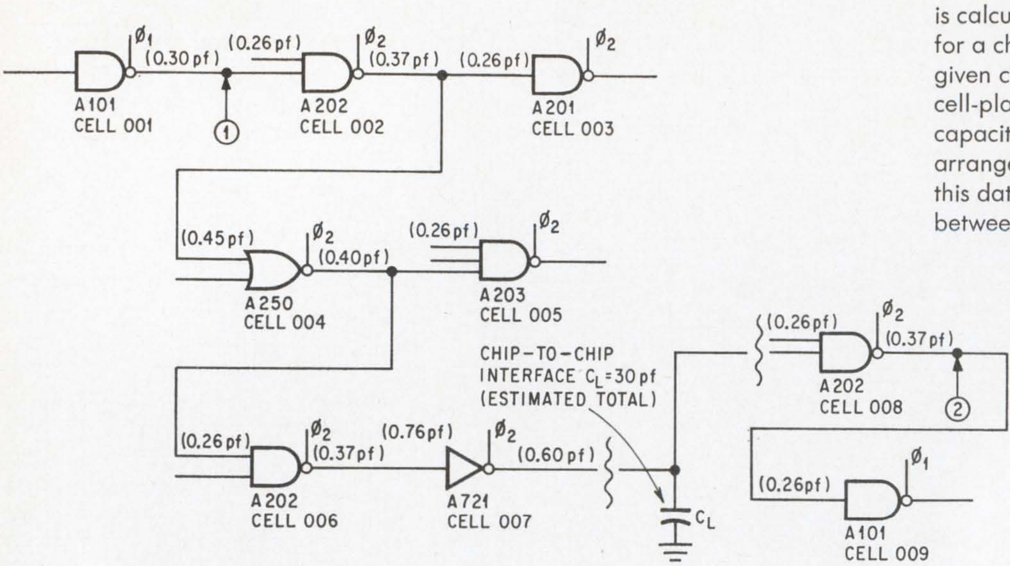
Commands on a second paper tape convert the camera into a step-and-repeat camera, after a second lens reduces the master reticle by a factor of 10.

With this optical system, Collins needn't make rubylith masters and turns out a mask an hour. The company wants to cut that time to 20 minutes by next year.

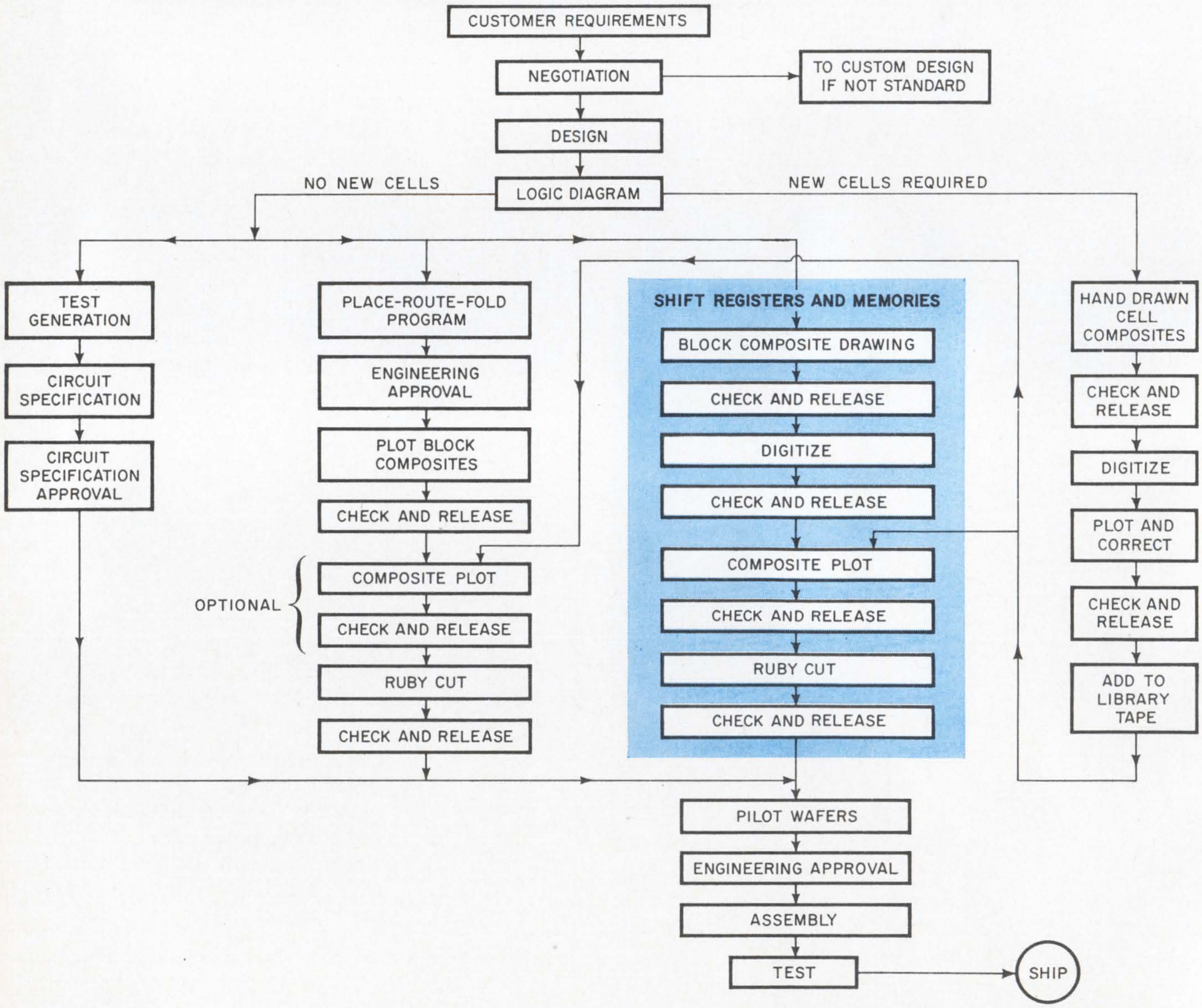
After the circuits are made, Collins uses one of two methods to test them. The firm's digital pseudorandom inspection machine runs both of them. In the first approach, inputs for a chip simulator are derived from the customer's logic equations, but the initial logic state must be specified by Collins. The tester's logic is also simulated to produce a routine that sets the simulated chip to a known reference state. The tape containing the routine is loaded into the tester, and production devices are checked against the simulated reference chip. The clock may be run for, say, 512 pulses, at which time the logic levels of all the output leads are stored in a register. While the test continues, a comparison of the stored logic levels against the simulated reference is made. Another "snapshot" may be made 512 clock pulses later, and the same kind of comparison made. This test is run at from 1 to 2 megahertz, and is run longer than more



Coded layout. A line printer delivers a plot of the chip layout, with metalization coding paths, device cells, and bonding pads coded alphanumerically. This is one portion of the dual 32-bit serial accumulator developed by Collins.



Computation. A typical design problem is calculation of propagation delay for a chain of logic gates driven by a given clock. American Micro-Systems' cell-placement program provides capacitance values after the cells are arranged in an optimum layout. From this data, the worst-case propagation between point 1 and 2 is then calculated.



Simpler path. The design and reduction process at American Micro-Systems shows that shift registers and memories follow a simpler path than less repetitive circuits. In either case, test generation is performed in parallel with design process.

rigid test sequences because of its pseudorandom nature.

In the second test technique, Collins assumes that a device is a good one after getting the customer's routine that sets all clocks to a known initial state. Collins runs a program to generate the reference tape for that good device; then the snapshot procedure is followed to check the outputs of the device under test against the known good device.

Although Collins' 60-day turnaround is the fastest in the MOS industry, Grondin isn't satisfied. "Within one year," he says, "I feel we'll be able to go from logic equations to the finished article in 14 days."

AMI's Prophet feels that supplying a logic diagram is the ideal way for a customer to ensure the fastest turnaround. The AMI manual asks the customer to prepare the logic diagram and calculate propagation delays on the nodes. Says Prophet: "We can handle 300 to 400 devices on a chip, and the optimum chip size is about 120 mils square."

If the logic diagram satisfies AMI's systems engineer, it's coded onto punched cards that identify cells by function. Interconnect paths are coded at the same time. AMI uses a Control Data Corp. 6600 computer in its system and a CDC line printer to make the wire list. Prophet says the 6600 was chosen because AMI wanted a fast computer with a large core memory. Chip-size limitations are tied not only to yield, but also to memory size, he says and adds that the 6600 "is the best we've found" for speed and memory capacity.

Once the punched cards are prepared, any new cells required are hand drawn, their parameters being digitized by a Calma Co. digitizer; then a Calcomp 718 plotter checks the circuit for continuity and design errors. The new design is added to the tape library. Once all the cells are in hand, a special program positions the cells and draws the interconnect pattern dictating the chip layout while minimizing interconnections and optimizing cell density. The Calcomp plot of the chip layout is then checked by a circuit engineer for excessive fanout, capacitance, and chip size. The engineer may have cells and wiring rearranged if his experience suggests a better layout. Once he's satisfied with the design, a magnetic tape is generated that contains the layout.

AMI calls this layout a block composite; on it are the cell outlines (but not precise geometries), interconnect lines and tunnel ends (tunnels are interconnections below the surface of a chip), and rectangles that represent the contact pads. The composite, which has different names at different firms, is becoming important as the document on which the logic designer can sign off, confident that the computer will accurately place the right cells in the right positions.

AMI and Fairchild still make fully plotted composites of all masks needed for cutting the rubylith artwork, which is also checked for continuity and adherence to design rules. And some customers insist on seeing these fully plotted composites. Normally, however, says Prophet, the last thing the customer sees is his logic diagram. Because of growing confidence in computer programs, both AMI and Fairchild are planning to dispense with the fully plotted multilayer composites of the chip.

After the composite tape is generated, AMI technicians replace the pens in the plotter with knives; now when the tape drives it, the plotter cuts the mask pattern in the rubylith. Cutting this way takes 12 hours; by hand it's a three-week job. After cutting, the rubyliths are manually stripped and checked. Then come the conventional steps—photoreduction, the step-and-repeat process, wafer fabrication, and finally testing of the completed chip.

Prophet says that the customer who has his own logic diagram is also likely to have his own test pattern. Using these patterns, AMI engineers work out an internal specification. The logic is thus coded for use in a simulation-verifier program, and test patterns that detect and verify failures are generated. The punched cards used as inputs to the simulation-verifier program are then converted to paper tape to program an AMI-built semiautomatic functional tester. Prophet says, "Pilot wafers are probed by the tester, with approval required from both the systems engineer and the circuit engineer at the wafer probe stage. The systems engineer is the last one to sign off before assembly and final testing."

Five engineers work for Prophet in the digital products group, and, each oversees a custom-design program involving up to 16 chips. He says that AMI can handle about 12 new designs a month in its custom design automation program, and is gearing up to handle more by the end of the year. Daniel Yoder, manager of central marketing, says that circuit development costs for chips done with the design automation program can range from as little as $1,000 to $1,500 for a read-only memory metal mask to a maximum of $15,000 to $20,000 for logic circuits.

Regarding turnaround time, AMI marketing director Glenn Dumas stresses that the firm quotes "realworld times because we're committed to on-time delivery. If everything went exactly right," he adds, "the turnaround time might be 12 weeks, but this isn't the way it happens in 90% of the cases. We'll contract for 14 weeks."

Besides the design automation program, AMI has a second approach which involves a half and half mixture of hand tooling and design automation; the block composite is laid out by hand, but is digitized so that artwork generation can be done automatically. Yoder points out that circuit development costs using this approach range from $7,000 to $25,000. AMI also will manually draw block composites and manually cut the rubylith if the circuits are highly complex. This approach costs between $15,000 to $30,000 per circuit design, and possibly as much as $45,000 for circuits that either push the state of the art in speed, power dissipation, and chip size, or require a large number of new cells to be designed. But this approach leads to better packing density on the chip, and often lower costs to the customer in volume production.

Prophet says that the automation program can handle logic speeds of 1 Mhz using standard cells.

AMI started its design automation program last November, and has designed more than 40 circuits for various customers since then.

Fairchild got going with its Micromosaic program a month after AMI started its program, and has custom designed about 45 circuits since then. And Fairchild is working with customers on 200 new designs, Downey reports.

The process flow at Fairchild is quite similar to that at AMI. Once the logic diagram is in hand, Downey's Micromosaic group codes the network of cells onto punched cards and stores them in an IBM 360/44 computer. A simulation control language is also generated, and it yields the timing diagram to be associated with the logic.

The simulation printout is used to convey to the customer Fairchild's understanding of his requirements. If the customer approves the printout, the network description is translated into a logic diagram. Next the layout program places the cells and routes the interconnect paths.

"At this point," Downey notes, "the designer enters the loop to manually optimize real estate usage, to place cells to special pin-rotation requirements, to make sure that critical high-speed nodes are topologically small, and to shorten the interconnect paths between these nodes. There could be as many as 20 interactions at this point, ranging in complexity from moving one cell over one grid point to moving entire rows of cells." Downey points out that a circuit laid out automatically is usually about 20% larger than it would be if it were laid out manually.

After the manual manipulation is finished, two layout documents are produced. One shows the cells and interconnect paths in printout form, and is done by a high-speed IBM 360/44 printer; the other, called a stick drawing by Fairchild, shows cell locations and interconnect lines, and is similar to AMI's block composite.

Contact pad descriptions are coded in a computer program, but they have to be located manually. Downey says this manual effort represents about 20% of the work involved in manually optimizing the cell layout. Next the Calcomp plotter is used for automatic cutting of the mask artwork. A design review involving the project engineer, project designer, and supervising engineer follows manual rubylith peeling, in preparation for final mask making.

Parallel with laying out the cells, an engineer is working out a test sequence for the circuit. He first proposes a test sequence, and then a test verification program, and then checks it for such errors as stuck inputs or outputs on the cells. Says Downey: "This is usually enough to catch lesser errors, such as shorts or gate inputs taken three or four at a time stuck at various states." He says that the goal of the test-verification program is to identify any test defects that could occur but which the test designer hasn't proposed. These show up on a statistical summary of detected and undetected defects. If the design engineer is satisfied with the statistical summary, a test tape for Fairchild's 8000A array test system is generated. The designer may want to synthesize new test patterns to pin down the undetected errors before the array test tape is made.

Total turnaround time at Fairchild is 10 to 14 weeks. It takes three to four weeks after the receipt of the customer's final logic description before the artwork is finished, and usually six to eight weeks for fabrication, assembly, and testing. Jack Balletto, Micromosaic marketing engineer, is aiming for a total turnaround time of eight weeks by next spring, and says he'll do it by cutting manual cell layout optimization time. Fairchild's development charge for a custom MOS design runs from $12,000 to $25,000.

Most of the static random-control logic chips Fairchild has designed using the program have between 140 and 180 gates, which means the chips are between 105 and 125 mils on a side. "We like to keep the designs under 200 gates," Downey says. "We're able to go larger, but the price per unit starts to go up above 200 gates because the chips have to be larger."

Fairchild doesn't have shift registers in its cell list. But says Downey: "We've seen enough shift register requirements to add this to the family. They're not yet characterized, but they should be in our stable soon." ●

Circuit design

Designer's casebook

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

Load current monitor doesn't break circuit

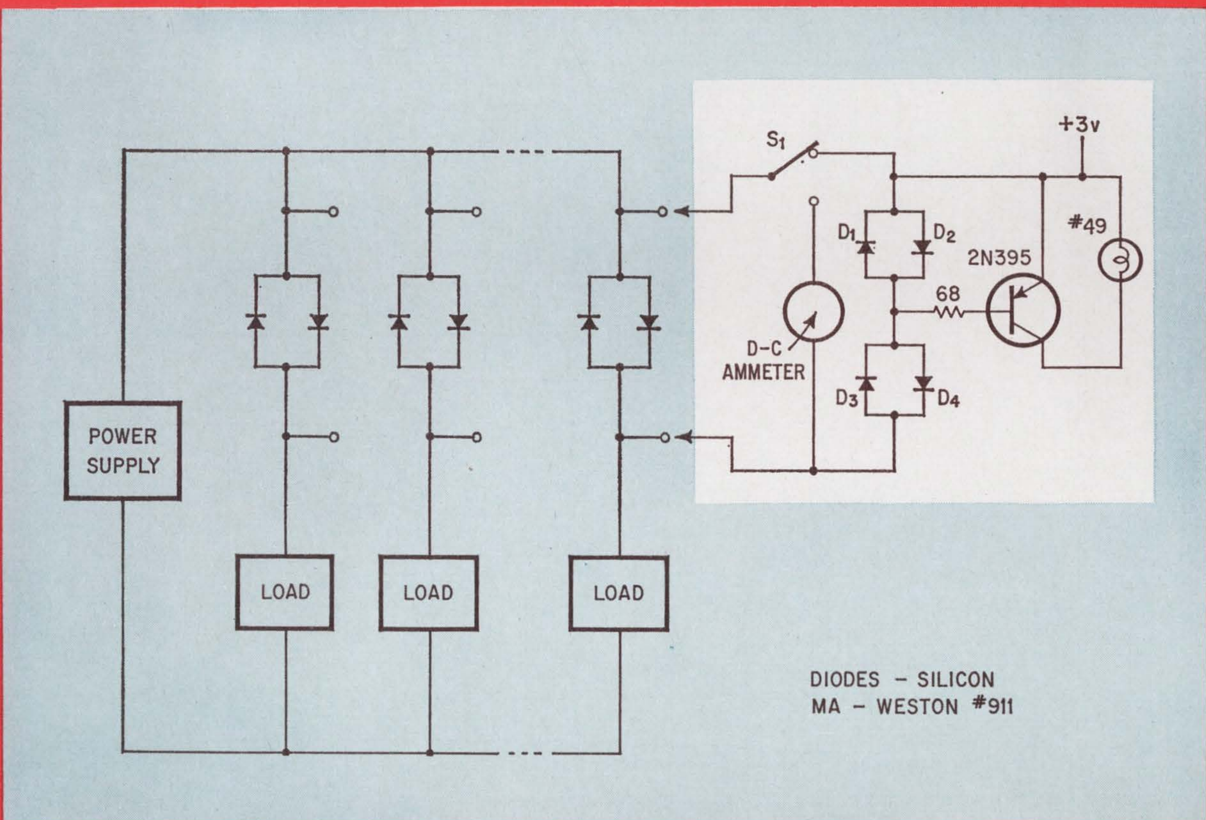
By Fred H. Horan

HO-CO-LO Laboratory, Waltham, Mass.

The common method of locating overloads in complex electronic equipment—measuring current in the load—can create transients as circuits are opened and closed. To eliminate such transients, a pair of diodes, connected in a parallel front-to-back configuration, is inserted in series with each load. This allows the load current of either a positive or negative power supply to be read directly by a d-c ammeter placed across the diode pair.

The ammeter used must have a very low internal resistance and, for this reason, a Weston Model 911, which has a voltage drop of only 100 millivolts at a full scale reading of 10 amperes, was chosen. When the meter is connected across the diodes, the voltage is low enough so that the diodes have a high forward resistance allowing only a negligible amount of the current to flow through them. Thus, almost all of the current in the circuit flows through the ammeter. In this manner, the meter can be switched across any of the diode pairs to measure the current in the load without opening the circuits and causing transients.

To warn against faulty diodes, a lamp lights if any diode is open. If the lamp is off, indicating the diodes are operative, the momentary contact switch, S_1, is then depressed and the load current measured in any of the circuits.



Fault finding. Parallel diodes connected in a front-to-back arrangement along with the current measuring circuit at the right, provide a means of reading load current without breaking the circuit. In addition, if the conducting diodes in series with the load circuit are faulty, a warning lamp lights.

Transistors improve high-frequency limiter

By Roland J. Turner
General Atronics Corp., Philadelphia, Pa.

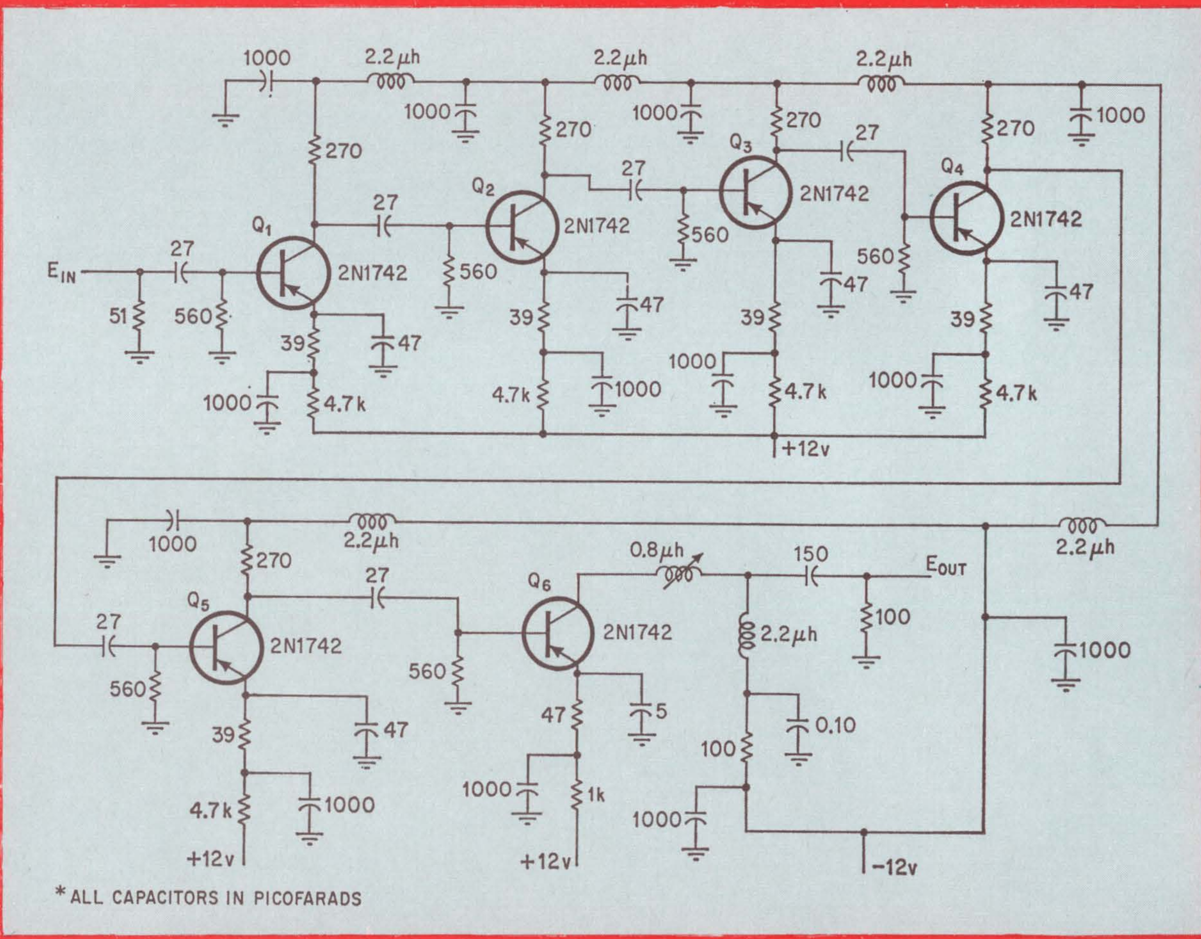
Limiters must provide an output that is essentially independent of input-amplitude changes—and do so without introducing a phase shift between the input and output signals. These conditions are difficult to meet with conventional diode limiters much above 10 megahertz. The reasons: phase shifts that depend on the limiting level are produced, and effective limiting is achieved only at high input signal levels (6 volts peak-to-peak). But, when high-frequency transistors are driven into cutoff to achieve limiting, the circuit's phase response is then insensitive to the limiting level. And several transistor stages can be used to achieve harder limiting over a greater range of input signal levels.

The circuit shown, starts to limit at an input level of 9 millivolts, and maintains the output level constant to within 0.06 db even though the input level is increased by 50 db. Each stage consists of two transistors and functions in the same manner. One transistor is driven into cutoff by positive input voltage swings whereas the following transistor is cut off for negative swings.

The maximum voltage swing at each transistor's collector depends only on the amount of current flowing through the transistor's collector load. The maximum input signal swing before limiting can be found by dividing the transistor's collector voltage swing by its gain. For the values shown, the circuit limits input signals greater than 9mv root mean square.

An output driver stage, which consists of Q_6 and a resonant circuit tuned to 80 megahertz, drives a 50- or 100-ohm cable.

Although the upper cutoff frequency is about 100 Mhz, the upper frequency of operation depends only on the transistor's cutoff frequency, f_T.



Better than diodes. With high frequency transistors, limiting occurs at signal levels greater than 9 millivolts for frequencies up to 100 megahertz. And for a 50-db increase in the input signal level, the output remains constant to within 0.06 db.

Diode generator yields complex functions

By William E. Peterson

ITL Research Corp., Northridge, Calif.

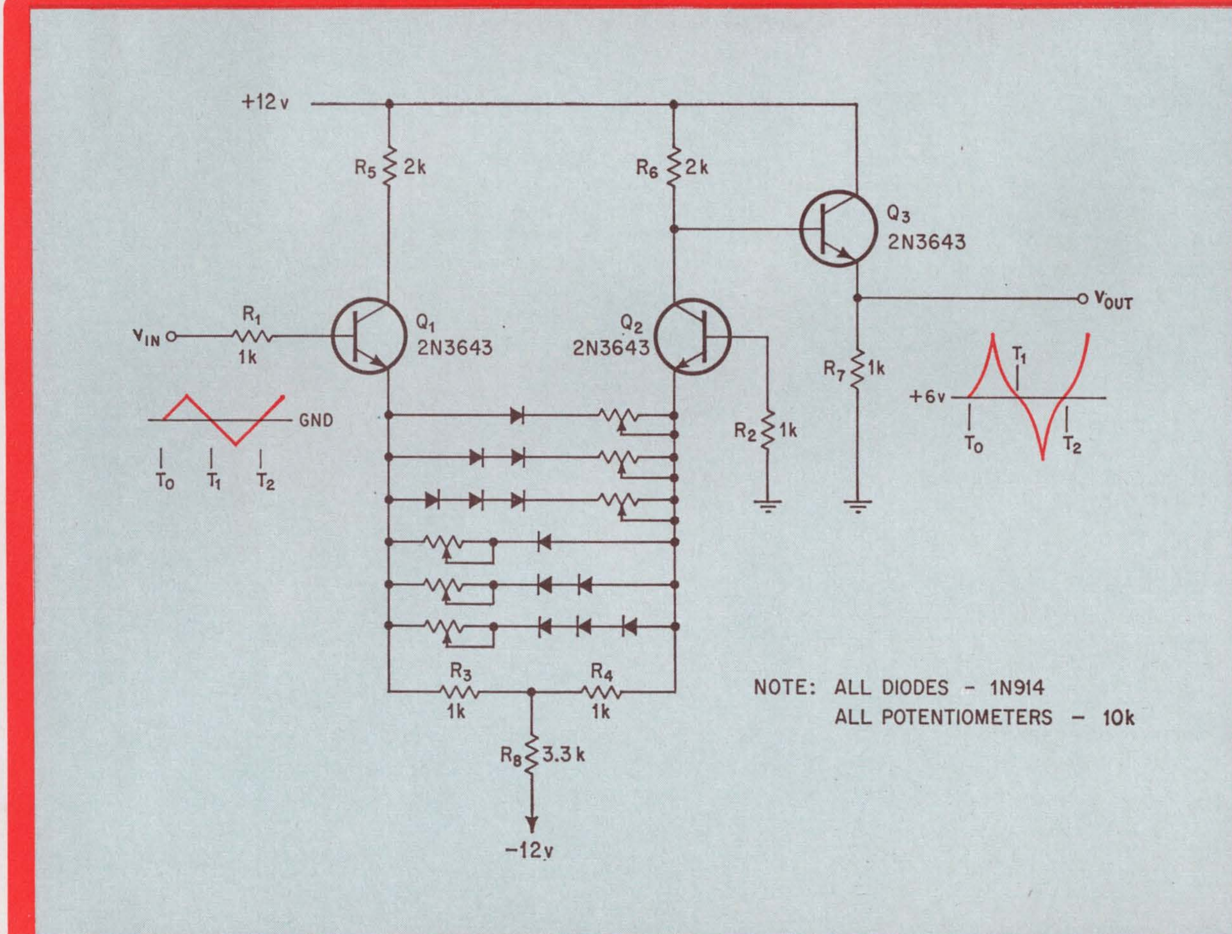
Commonly used function generators fail to perform adequately when required to generate complex voltage waveforms, such as tangent functions or similar functions that become unbounded in magnitude at key points. These function generators, using diode shunts, are suitable for producing an output waveform with a slope that is less than the input, but inadequate for producing functions whose output slopes must be greater than the input slopes. However, these functions can be produced by combining a diode generator with a differential amplifier in such a manner as to sequentially raise the amplifier gain as the input signal increases.

Transistors Q_1 and Q_2 form the differential amplifier. For low input signals none of the diodes conduct, and the gain of the amplifier, determined by collector resistors R_5 and R_6 and emitter resistors R_3 and R_4, is unity. However, when the input signal level is high enough to cause the diodes in the emitter of the amplifier to conduct, the total emitter resistance decreases. This, in turn, increases the gain of the amplifier, which can be controlled by the potentiometer.

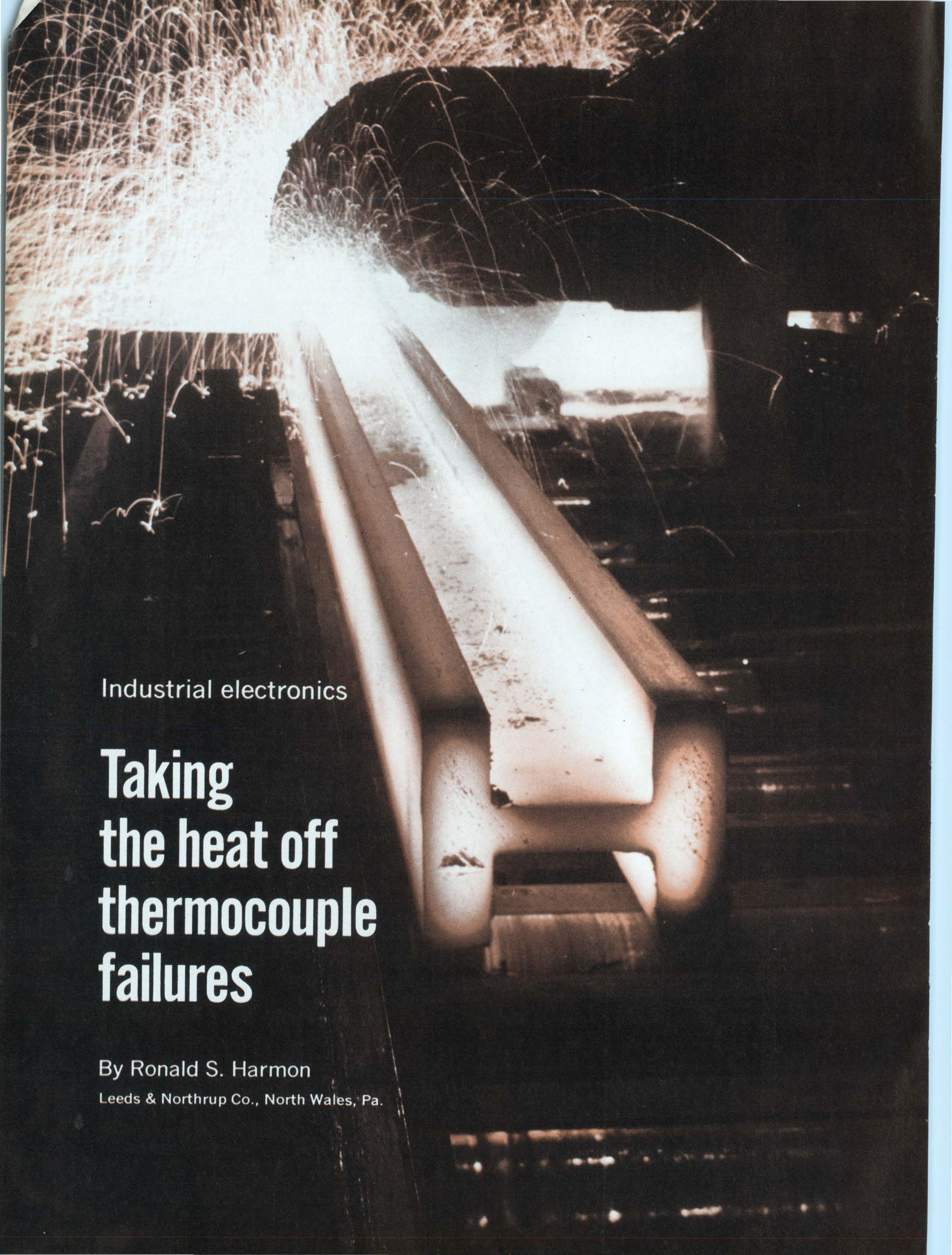
Three break points are used to shape the positive section of the wave and another three for the negative section. Each diode-potentiometer path represents a different break point. The exact shape of the output can be selected by making the appropriate adjustments with the potentiometers.

Q_3 is an emitter-follower that's used to isolate the output collector from loading effects.

The input signal used was a constant amplitude, symmetrical triangle.



Function generator. The diode-potentiometer branches in the emitter section of the differential amplifier lower the emitter resistance as the voltage increases thus increasing the amplifier gain. Q_3, an emitter follower, matches the high impedance circuit to a low impedance load.

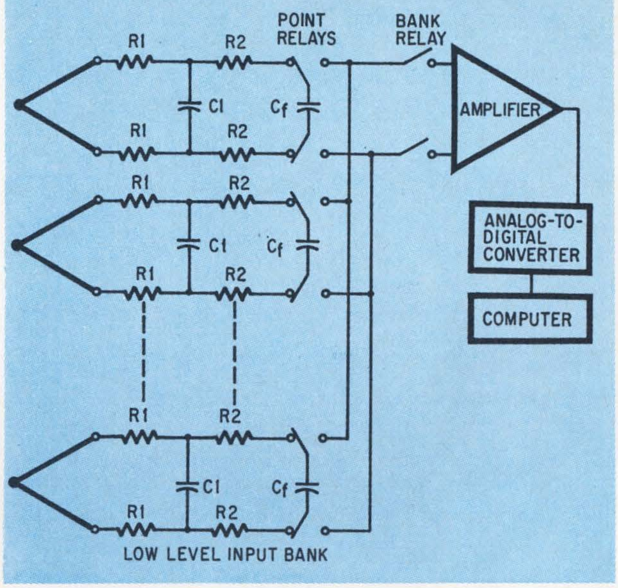


Industrial electronics

Taking the heat off thermocouple failures

By Ronald S. Harmon

Leeds & Northrup Co., North Wales, Pa.



Bitter experience teaches that the thermocouple, on which industry depends so much to control its processes and safeguard its plants, can open circuit and invalidate the very reason for which it was installed. Thus for critical processes, it's mandatory that each thermocouple be tested every time it's read to see whether it's operating properly or has failed.

When a plant has hundreds of temperatures that must be sensed by thermocouples, perhaps 200 to 800 of them, a digital data-acquisition system is used because it reduces instrumentation costs, centralizes information for the operator, and helps run the plant better. In a few seconds, the data system must test, read, and convert to digital format all TC outputs.

Unfortunately, the seeming simplicity in checking for an open thermocouple circuit is complicated by the intricacies of a multiplexed digital data acquisition system. A new electronic method for thermocouple open-circuit detection—tailored specifically for digital data-acquisition and computer-control systems and developed by the Leeds & Northrup Co., of North Wales, Pa.—tests 250 thermocouples a second and signals the outcome of each test to the system's computer for appropriate action. If the test indicates an open thermocouple circuit, the action might be to sound an alarm for the plant operator's attention and disregard the measurement. However, if the test indicates a valid measurement, the data system continues normally.

It's not unusual for thermocouple circuits to open because of the harsh industrial environment in which TC's operate. Vibration leads to fatigue, and exposure to extremely high temperatures leads to melting. Then, of course, there are open connections, broken transmission lines, and mechanical damage.

How dangerous is an open thermocouple circuit? Consider a simple case. A thermocouple is inserted in a bearing of a 100 horsepower motor, and should lubrication fail, it will set off an alarm before the expanding bearing suddenly locks the motor's shaft. However, if the thermocouple open circuits, the system wouldn't know it—without an open circuit check. The reason: after the TC opens, a signal still may remain stored on on the capacitors in the input filter, and this can be mistakenly interpreted as a valid signal by a data acquisition system's data amplifier.

Because the new method of thermocouple open-circuit detection (TCOCD) was designed for multiplexed systems, such a system is reviewed first—at the right. This is followed by a discussion of why the shunt-battery (page 98) and bridge (page 99) methods have practical shortcomings. The main focus is on the TCOCD, which is described on pages 99 and 100. A significant factor is that one TCOCD is shared by all thermocouple channels. Further, TCOCD requires neither periodic recalibration nor battery replacement.

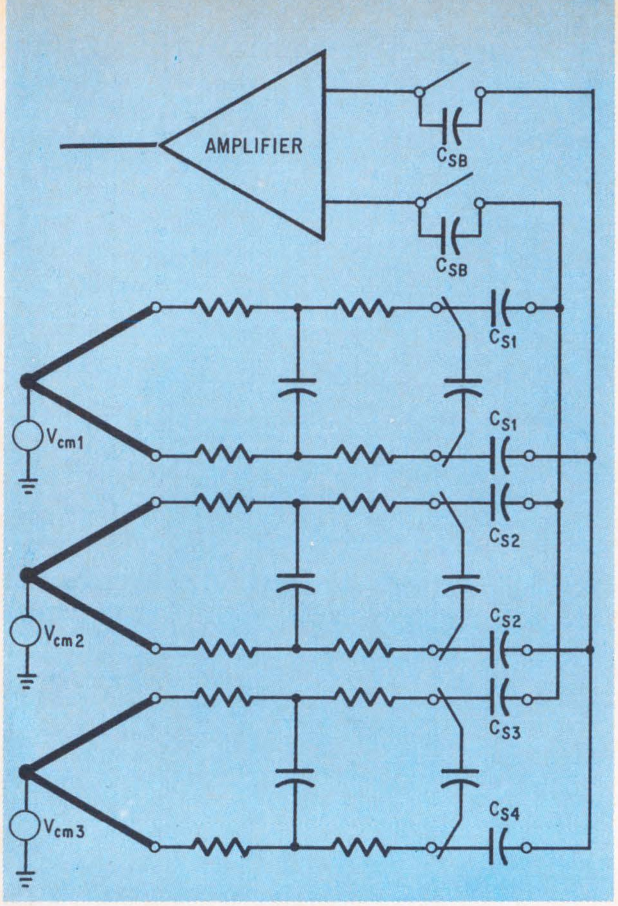
In digital data acquisition and computer-control systems, such analog inputs as thermocouples are multiplexed—switched in and read one at a time—into a single data amplifier and a single analog-to-digital converter.

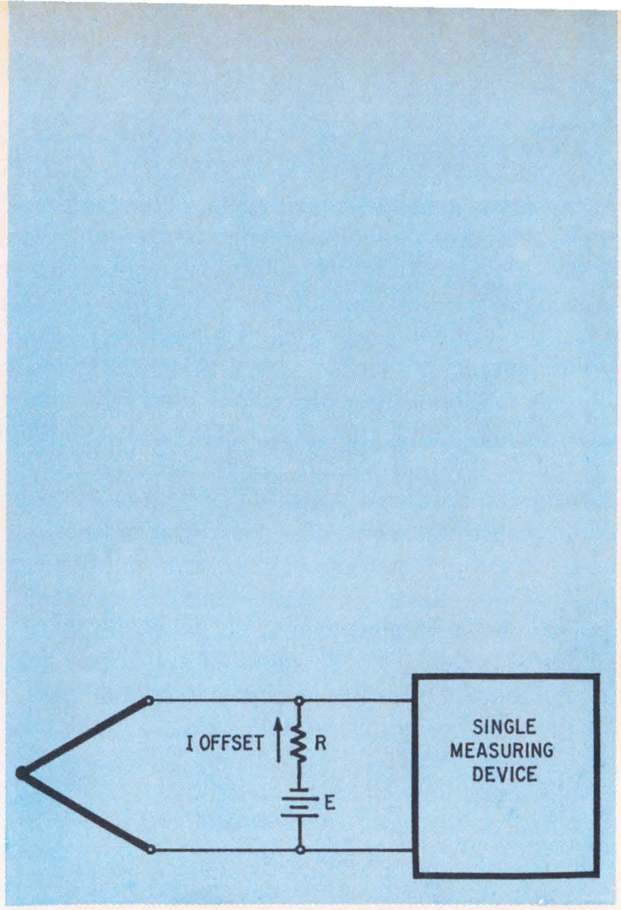
The actual measurement site may be thousands of feet away from the system, and the long signal-transmission lines more than likely pick up electrical noise from nearby equipment and power lines. Thus, for high-accuracy, high-speed data systems, each input channel includes a low-pass RC filter. Further, all of the many hundreds of thermocouple channels must be thoroughly isolated from the data amplifier because the TC's are usually ungrounded, so while each line in the pair may float at the same voltage, these common mode voltages can be quite large and quite different from each other.

A typical low-level analog-input multiplexing scheme is shown above. The input differential filter, comprised of R_1, C_1, R_2, and C_f, usually gives about 60 decibels of rejection at 60 hertz.

Capacitor C_f, called the flying capacitor, charges to the thermocouple-signal voltage. When a channel, or point, is addressed by the computer for read out, the associated point relay transfers C_f to the amplifier's input. After a few milliseconds' delay for amplifier and relay settling, an analog-to-digital conversion occurs, and then the computer instructs that the digital information be read into the computer as the measured value of the addressed point.

But the flying capacitor isn't ideal . . .





Ideally, the flying capacitor should isolate the data amplifier from the input lines. In fact, however, each unaddressed point relay contributes a contact capacitance, C_s, between the point inputs and the amplifier input, as shown above. The large number of point-relay-contact capacitances in parallel reduces isolation and increases the amount of common mode voltage converted to normal (or signal) voltage.

However, isolation can be improved by connecting a group, or bank, of point relays to the data amplifier through the contacts of a bank relay. Now, bank contact capacitance, C_{sB}, is in series with the parallel capacitances of the point relay contacts. The net capacitance is reduced between input-signal-lines and the amplifier and thus creates a much higher impedance, hence greater isolation, between all the inputs not being addressed and the amplifier.

What complicates the detection of an open thermocouple circuit by any simple method, such as the shunt-battery technique that works well for single thermocouples, is that the many hundreds of thermocouple circuits will probably have different TC internal resistances and use different lengths of transmission lines. The single amplifier can't compensate for so many variations. The next panel, on the shunt-battery method, explains the problem in more detail.

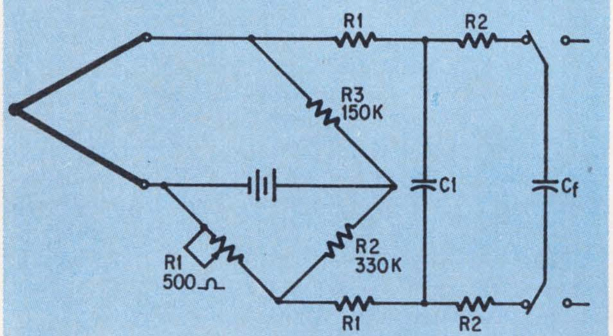
In the shunt-battery method of thermocouple open-circuit detection, above, a single thermocouple feeds into a single measuring device such as a d-c moving-coil meter. Then a high-value current-limiting resistor in series with a battery, E, is shunted across the thermocouple.

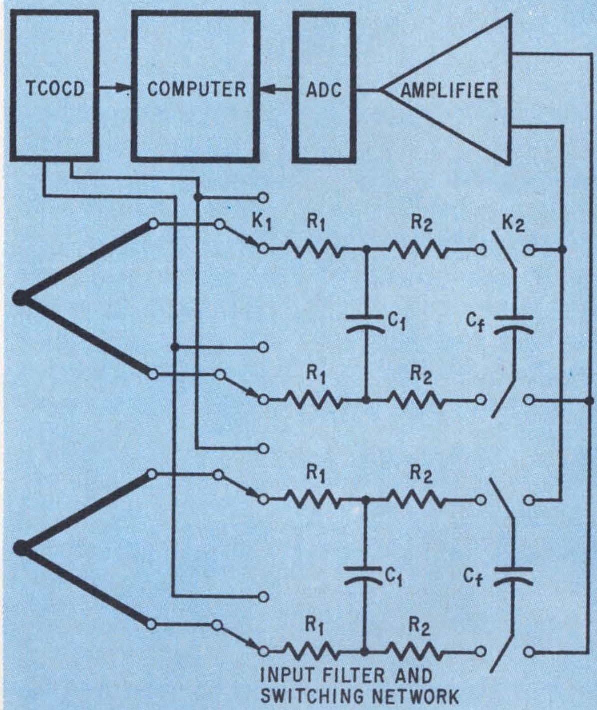
Because of different line lengths, the resistance of the thermocouple and its lead wires ranges from 25 to 500 ohms; this is much less than the current-limiting resistance, R, which is about 100 kilohms. The current through the resistor develops a millivoltage that offsets the thermocouple's true reading. This offset voltage can be zeroed or calibrated out easily over the temperature range of interest.

If the thermocouple opens, though, the full value of E would then drive the meter's pointer off scale.

This method of open-circuit detection is more than satisfactory for single-channel temperature measurement in which the compensation for that one TC can be made permanently in the meter. But when it comes to complex digital data-acquisition and computer control systems, in which such highly accurate equipment as a data amplifier and an analog-to-digital converter are shared in succeeding time intervals by many hundreds of input measurements, the shunt-battery method is anything but satisfactory.

For a geographically widespread industrial plant, with varying lengths of transmission lines, each thermocouple channel would be likely to have an offset different from all the others. The single data amplifier could not, within the scope of engineering reasonability, be designed to change to a different zero to compensate for the unique offset of each thermocouple.





To avoid the offset problem, a common approach to TC open-circuit detection is to have the thermocouple serve as one of four arms of a bridge circuit, shown above. Since a variable resistor, R_1, balances the bridge in each of the channels, there is no offset in any channel and thus hundreds of channels can be multiplexed to the single amplifier.

Should a thermocouple open, its bridge becomes severely unbalanced, and the amplifier input signal —approximately equal to the battery voltage—can be easily interpreted by the computer as an open-thermocouple situation.

While the TC bridge circuit eliminates the offset situation, it creates design and installation problems when used in multiplexed systems.

- Each ungrounded thermocouple may be operating at a different common mode voltage.
- To avoid circulating currents, hence erroneous voltage drops, each bridge must have its own isolated excitation—usually a battery.
- Each of perhaps 200 to 800 bridges must be balanced when the system is installed and rebalanced periodically thereafter.

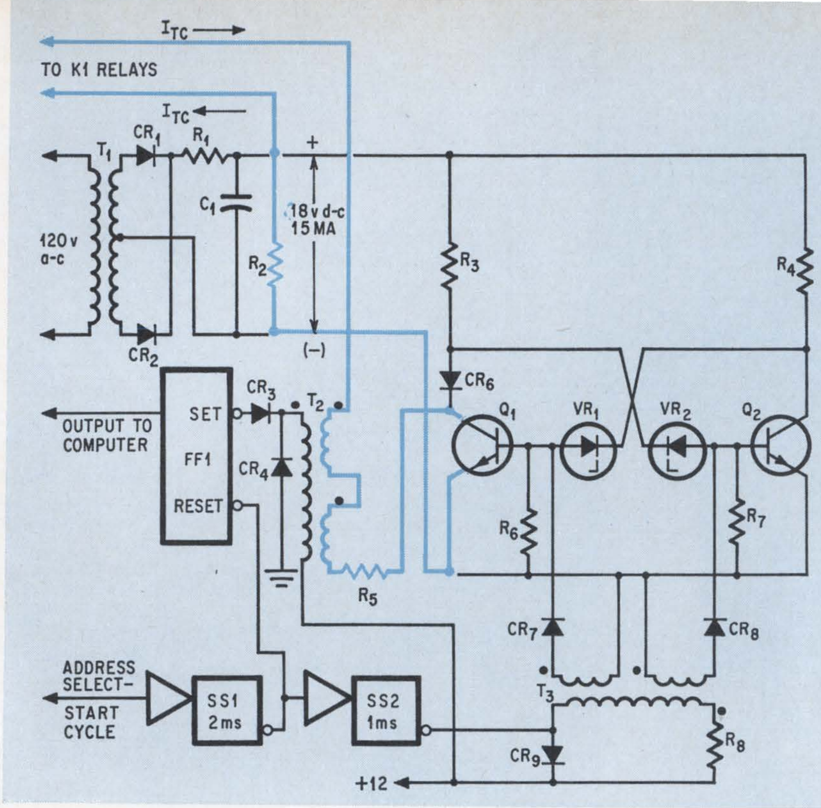
Using the bridge to detect TC open circuits poses a serious tradeoff problem. On the one hand, to reduce battery drain, R_3 in the bridge must be made relatively large. (Even so, batteries must be replaced about once a year.) On the other hand, this same resistance forms part of the channel's noise filter. Thus, a large R_3 increases the filter's time constant if the TC opens and slows the channel's response.

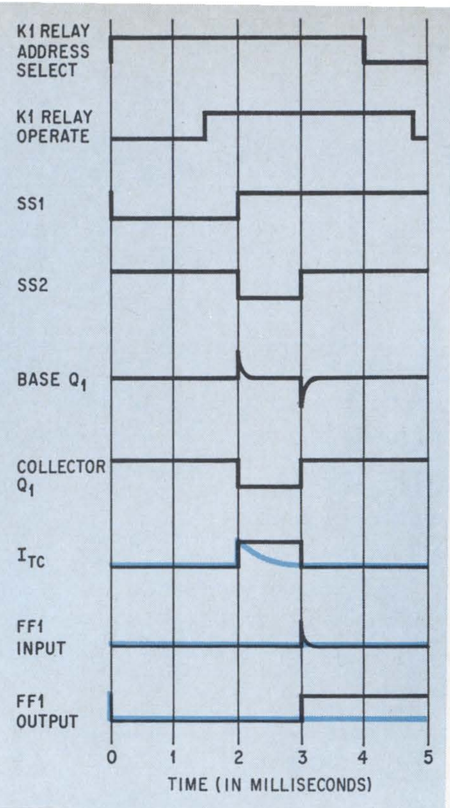
Thus in multiplexed systems, neither the shunt-battery nor bridge methods are entirely adequate for detecting open thermocouple circuits.

Specially designed to operate in multiplexed systems and to avoid shortcomings of both the shunt-battery and bridge methods of TC open-circuit detection, a newer scheme (patent applied for) employs a pulse of current to sense whether the circuit is complete or open. Since the thermocouple open-circuit detector, shown above, tests 250 points a second, it can determine whether an open circuit exists in less than four milliseconds. In doing so, it must differentiate between a true open circuit and a high-resistance circuit that can be caused by 1,000 or more feet of thermocouple connecting wire; and it must distinguish between a complete circuit and an open circuit that—because of the large capacitance of long connecting wires—may appear as a complete circuit to the pulse.

One TCOCD is shared by all thermocouple inputs. Each input point requires a relay, K1, that connects the thermocouple to the TCOCD. The TCOCD relay, K1, operates at the same time that the point relay, K2, is addressed by the computer, and transfers C_f to the amplifier input. Thus, both the open-circuit check and the data conversion take place in the same four-millisecond time interval allotted to a channel.

Pulse occurs only when circuit is complete . . .





In the thermocouple open-circuit detector circuit, shown above left, transistors Q_1 and Q_2 form the main flip-flop which permits a detectable pulse to develop only when the TC circuit is closed. In the timing diagram shown above, right, black pulse shapes denote conditions for a complete TC circuit, and the colored pulses denote an open TC.

At the instant of point selection the address-select start-cycle signal fires the one-shot multivibrator SS1, which resets a flip-flop, FF1, and also provides a two millisecond delay for the K1 relay to operate and settle. At the end of this delay, SS2 initiates a one-millisecond pulse whose leading edge turns on Q_1 and sets the main flip-flop.

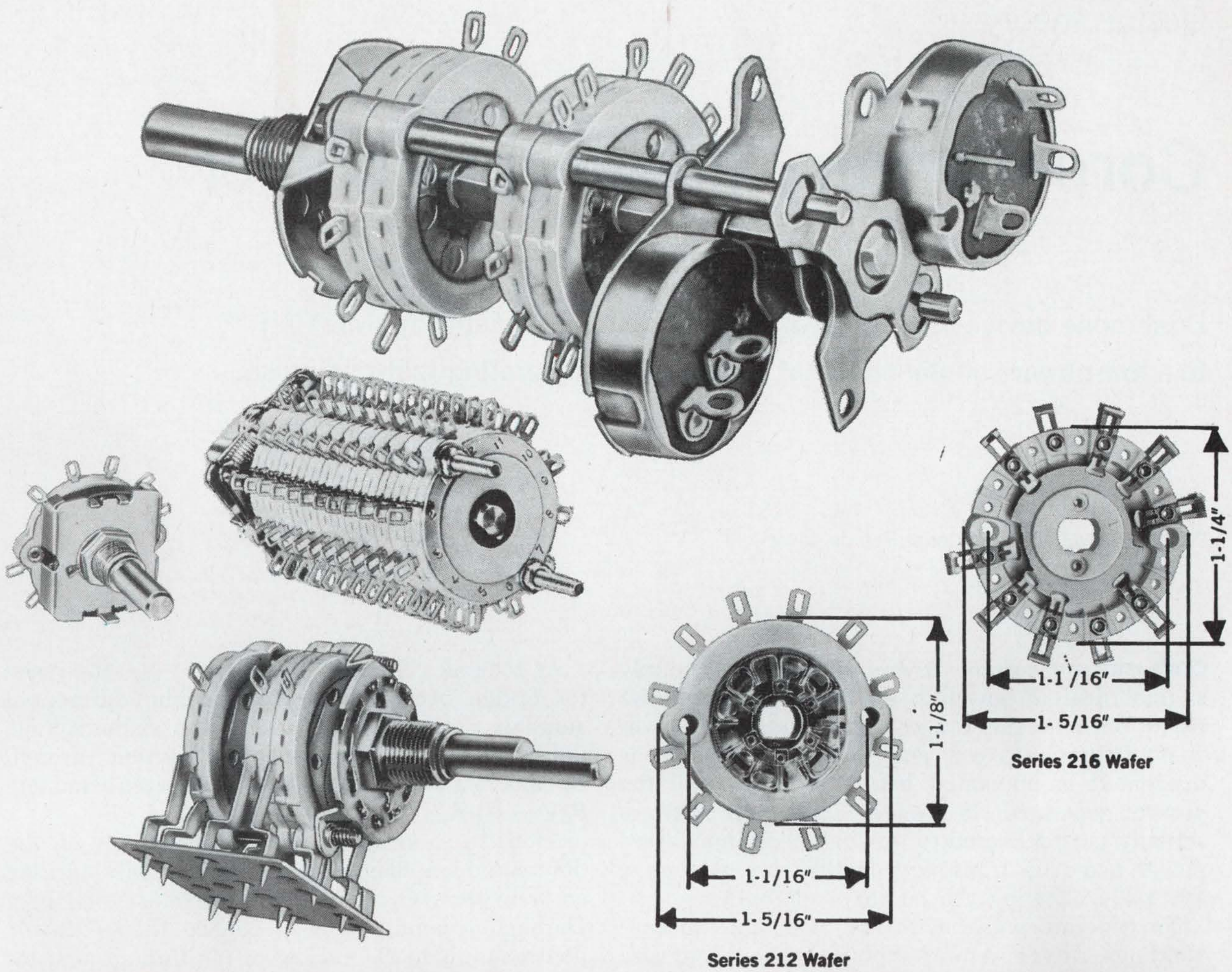
As the heavy lines in the schematic show, with Q_1 conducting (low resistance) and if the thermocouple circuit is closed, a current, I_{TC}, flows from the positive side of the 18-volt supply, through the thermocouple via the K1 contacts, through the primary of pulse transformer T_2, through R_5, through Q_1 and back to the negative of the supply.

At the end of the one millisecond interval the trailing edge of the SS2 pulse turns off Q_1 thus resetting the main flip-flop. If the thermocouple circuit is complete when Q_1 turns off, the current in the primary of pulse transformer, T_2, collapses and generates a pulse in the transformer's secondary. The secondary's pulse sets FF1, and this state tells the computer that the thermocouple circuit is complete. If the TC is open, then there's no current in the primary, hence no pulse is created in the secondary—and FF1 remains in its reset state.

The one-millisecond interval provided by one-shot SS2 allows the stray capacitance of the line to charge to a steady state so that current flow due to line charging is not confused with current flowing due to a complete circuit. In a typical case, the TC circuit might be 500 ohms and the stray capacitance 0.5 microfarads. There's an additional 1,000 ohms in the path due to R_5. Thus, the charging time constant would be the product of 1,500 ohms and 0.5 microfarads, or 0.75 milliseconds.

Note that the test circuit is completely isolated from ground by pulse transformers and a floating power supply. Thus the TCOCD can handle thermocouples which, while they develop millivolt-level signals, may actually operate in an environment that produces much higher and different common mode voltages.

The TCOCD is compatible with computer requirements. In a computer system using a 16-bit word, the analog-to-digital converter produces a 15-bit word, 14 bits of which are for the digitally converted analog measurement and 1 bit is for the word's sign. The 16th bit comes from the TCOCD's FF1 output. This flip-flop's state (SET for open, and RESET for closed thermocouple) is checked by the computer program at the same time the 15-bit digitized measured value is read into the computer. Thus it takes only one READ instruction for the computer to store a measurement and ascertain that the thermocouple hasn't failed and the reading is valid. ■



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Core-memory driver runs cooler

Dual-mode device reduces heat dissipation by automatically switching to a low-power constant current source after generating fast-rise pulse

By Charles J. Ulrick
Collins Radio Company, Cedar Rapids, Iowa

Core-memory current drivers initially must supply a great deal of power to generate fast pulse rise times. But once this is accomplished, all that power is no longer required, and the excess amount is dissipated in unwanted heat. Less than half the power generated in conventional core drivers actually gets delivered to the load. And the wasted power heats up transistors in the current source, adversely affecting the circuit's reliability.

To generate pulses with fast rise times in core windings, drivers require voltage sources four and five times larger than those used to power ordinary integrated circuits. But once the pulse's rise time has been effected, the energy requirement to maintain a constant current through the winding drops sharply. A current-monitoring circuit operating as a voltage generator and as a current generator dissipates much less power than ordinary drivers, has a cooler ambient temperature, and can be packaged in integrated circuit form.

When the circuit is triggered, a large voltage is delivered to the selected core, generating a fast-rising pulse across its inductive load. Current through the core winding increases and is sensed by a comparator which, at a selected current amplitude, switches off the large voltage supply and automatically substitutes a constant current source with a low supply voltage.

The circuit consists of a differential amplifier, Q_3-Q_4, that activates either of two voltage supplies, +5 volts and +12 volts. A resistor bridge, R_1, R_2, R_3, R_4, and R_s, feeds the input terminals of the differential amplifier.

A push-pull circuit, Q_1 and Q_2, supplies a reference voltage, V_{REF}, of —5 volts or +12 volts to the differential amplifier's input depending on the input logic swing.

The core driver is inactive when the reference voltage is at —5v and triggers when the push-pull circuit applies +12v to the amplifier's input.

As soon as +12 volts appears at V_{REF}, the resistor bridge becomes unbalanced. The differential amplifier, acting as a comparator, senses the voltage difference across R_s. The output current through R_s rises to a steady state value, I_o, of approximately R_2V_{REF}/R_1R_s.

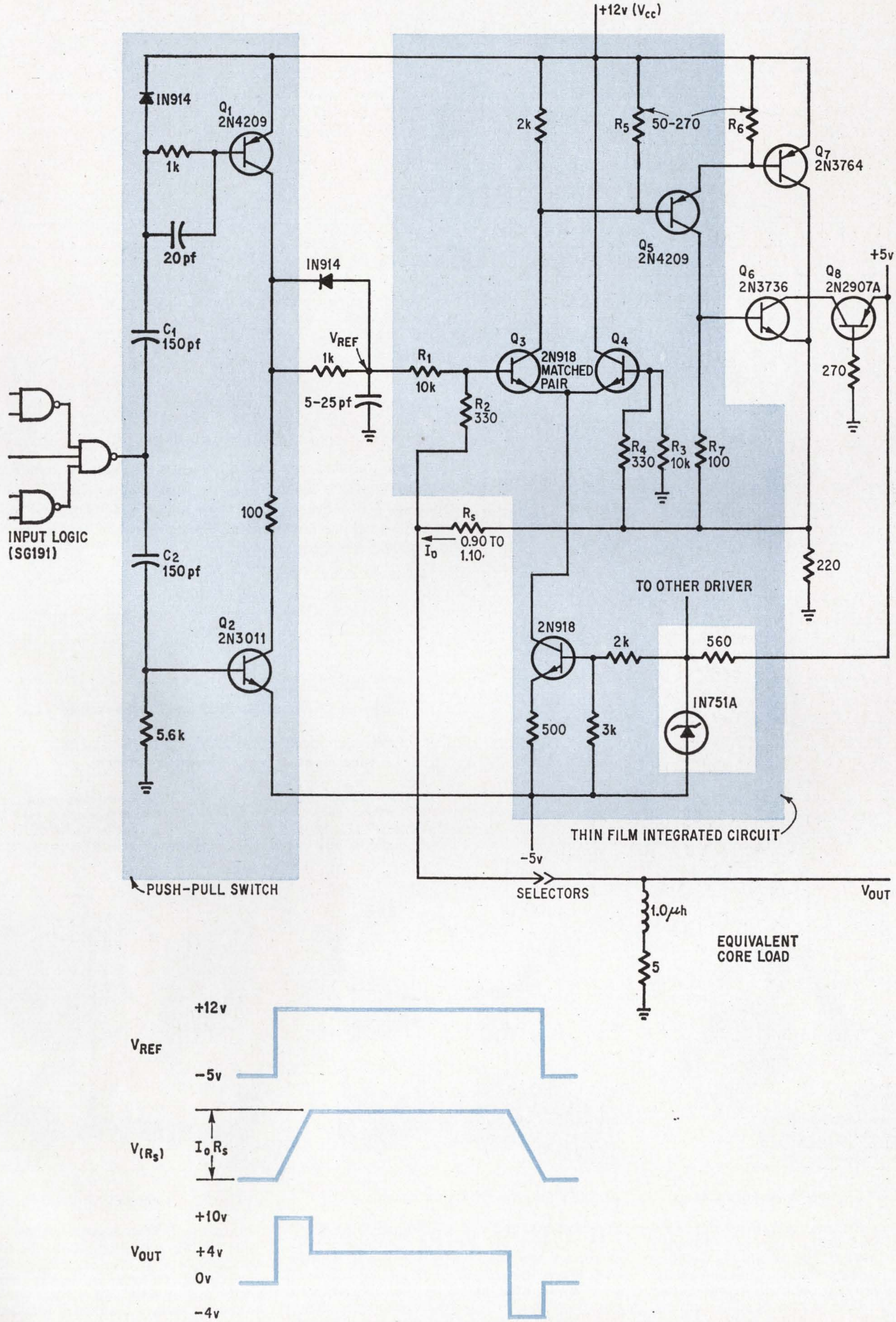
After V_{REF} switches to +12 volts, Q_3 of the differential amplifier conducts very heavily, turning on transistors Q_5 and Q_7. These transistors, in a Darlington configuration, connect the +12-volt power supply to the inductive load through resistor R_s. The pulse's leading edge continues as long as the +12-volt supply is applied.

While the +12-volt supply generates the pulse's leading edge, the +5-volt source remains cut off because Q_6's base-emitter junction is reverse-biased.

As the current through the inductor approaches the steady state value I_o, Q_3 of the differential amplifier conducts less and less. Current through the Darlington pair decreases and the voltage delivered to the load begins to drop. Q_5 and Q_7 cut off when the load voltage of +5 volts is reached.

But the voltage never drops below 5 volts, because at this level transistors Q_6 and Q_8 are conducting, applying the current source to the load. Little or no current flows through the Darlington pair as long as R_5, R_6, and R_7 are selected properly.

Quick switch. This core driver operates in two modes to reduce power losses. When activated by the input control logic, the 12-volt supply kicks in to deliver the power necessary to generate a 50-nanosecond rise time. Once the desired current level is reached, the 5-volt supply takes over and delivers a constant current with much lower power dissipation. The reduced power requirement makes this circuit suitable to be packaged as a thin-film IC.


+12v (Vcc)
IN914
Q1
2N4209
1k
20pf
C1
150pf
C2
150pf
5.6k
INPUT LOGIC
(SG191)
100
Q2
2N3011
PUSH-PULL SWITCH
IN914
VREF
1k
5-25pf
R1
10k
R2
330
Q3
Q4
2N918
MATCHED
PAIR
2k
R5
50-270
R6
Q7
2N3764
Q5
2N4209
Q6
2N3736
Q8
2N2907A
+5v
270
R4
330
R3
10k
R7
100
RS
0.90 TO
1.10
I0
220
TO OTHER DRIVER
2N918
2k
560
IN751A
500
3k
THIN FILM INTEGRATED CIRCUIT
-5v
SELECTORS
VOUT
1.0μh
5
EQUIVALENT
CORE LOAD
+12v
VREF
-5v
V(RS)
I0RS
+10v
VOUT
+4v
0v
-4v

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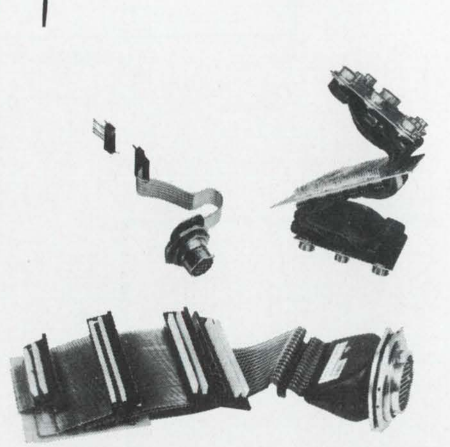

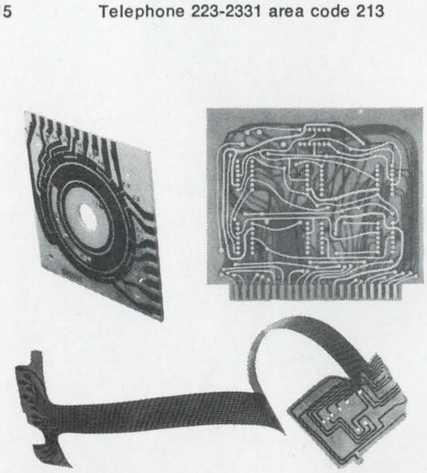

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'Cache' turns up a treasure

By Donald H. Gibson
Systems Development Division, International Business Machines Corp., Poughkeepsie, N.Y.

and W. Lee Shevel
Component Division, International Business Machines Corp., East Fishkill, N.Y.

Caught between the devil and the deep blue sea is the designer who wants to build a computer that incorporates both high speed and large main-memory capacity—say 10 million bits or more. His quandary: such a memory is large physically, and the rate at which data can move is limited by the speed of light.

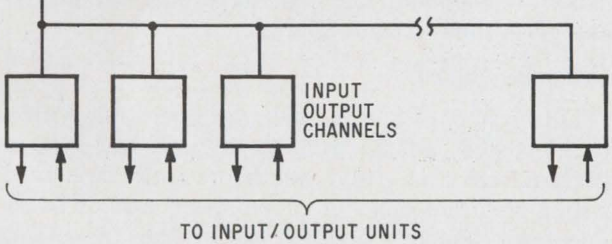
In practice, the data may take more than 100 nanoseconds to traverse the distance between a storage location in the memory and a register or other location in the processor, while the processor's cycle is likely to be less than 100 nsec. Speeding up the memory wouldn't minimize this mismatch, and it might even boost the memory's cost to an unacceptable level.

The trick is to use two memories. Such a hierarchy, properly organized, can resolve the clash between design objectives and the laws of the physical universe.

One is a buffer, small and fast to match the speed of the processor, and close in for quick accessibility; the other is large and relatively slow, but able to transfer large batches of data into the small memory in a single cycle.[1] Thus the two memories have approximately equal bandwidths, but their cycle times differ by a factor of, say, 10 to 16.

For example, the IBM System 360 model 95 had a multiunit processor whose basic machine cycle was 60 nsec and had a main memory of of approximately 10 million bits. When the main memory, standing alone, was exercised under the control of its own circuits, a pulse could travel from the main panel into the memory array itself in 60 nsec, to begin the actual reading out of data. Yet the functionally identical signal, originating at the adder in the processor when the memory operated as part of the system, took 180 nsec—three times as long—to travel into the array and initiate the same process. A larger memory would have required an even greater time spread.

But in the 360/85, the buffer memory, or "cache," is used for the first time in a production-line computer. The cache is a monolithic semiconductor memory packaged inside the processor and it is 12 times as fast as the main memory, or "backing store." The latter is in a separate frame several feet away along a direct line and further away along the connecting cables. The cache contains instructions and data immediately required for processing, and exchanges these directly with the processor, as shown at left, which thus needs only occassional reference to the backing store.

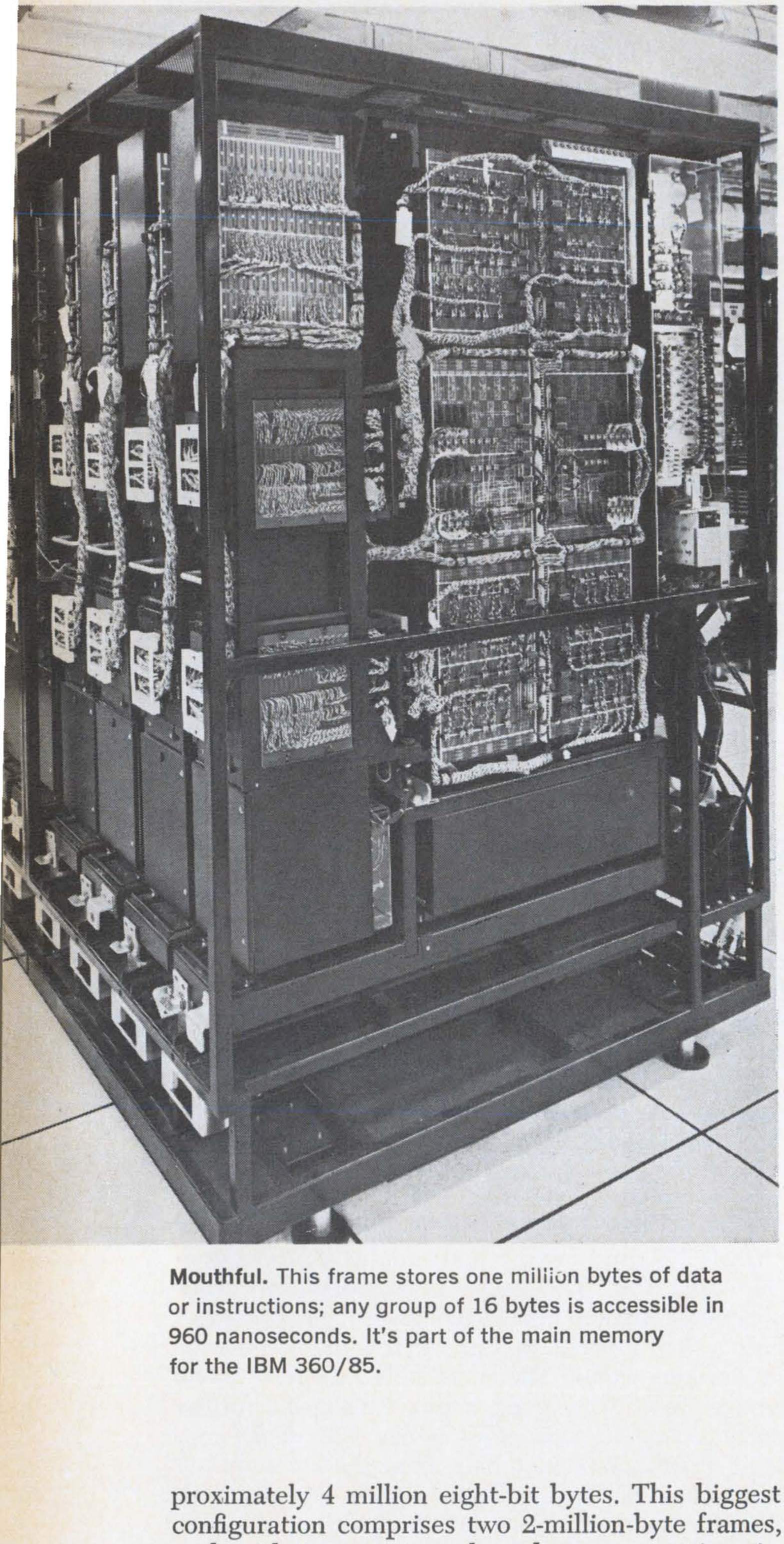


Cache. Like a squirrel's store for the winter, the processor keeps a supply of instructions and data readily available in the high-speed buffer.

Big one

The backing store in the 360/85 is available in several capacities; the largest contains ap-

This is the 13th installment in *Electronics*' continuing series on memory technology, which began in the Oct. 28, 1968, issue.



Mouthful. This frame stores one million bytes of data or instructions; any group of 16 bytes is accessible in 960 nanoseconds. It's part of the main memory for the IBM 360/85.

proximately 4 million eight-bit bytes. This biggest configuration comprises two 2-million-byte frames, each with its own controls and error-correction circuits; within each frame are two 1-million-byte modules, one of which is shown above, each made of eight subunits containing 16,384 words of 72 bits per word. These eight subunits are electrically organized as four 16K-by-144-bit memories, reading out two 72-bit words in parallel in each cycle. The 72 bits include eight 8-bit bytes and eight redundant bits that work with error detection and correction circuits. The backing store is made with conventional toroidal ferrite cores 21 mils in diameter, which switch in less than 200 nsec. They are wired into a stack of 36 planes, each plane a square array 128 cores on a side.

The cycle time of the modules in the larger-capacity backing store is 960 nsec. Access time of each 16K-by-144-bit element is 415 nsec. When placed in the physical configuration of the 360/85, the memory's access time as seen from the processor is 960 nanoseconds—the same as the module's cycle time. The difference between 415 nsec at the memory frame and 960 at the processor is accounted for by transmission delays in the cable and propagation lags in the priority and error-correction circuits.

In the 4-megabyte backing store, the four 1-megabyte modules are interleaved four ways, permitting new cycles to be initiated in each module at 80-nsec intervals. Thus, with interleaving, the main memory's time slot temporarily matches that of the buffer—a request for data from the main memory produces two 72-bit words or 16 eight-bit bytes from the first module, 960 nsec after the request is issued; but it also automatically triggers interleaved requests for data in the other modules, and this other data arrives in 16-byte groups at 80-nsec intervals. But no single module can be accessed a second time before the end of its 960-nsec cycle.

Little one

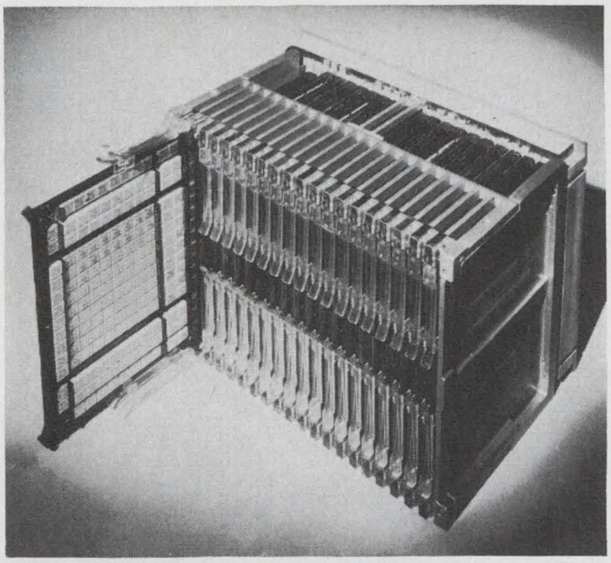
The second key element of the hierarchy is the buffer memory. This unit, or cache, on the IBM 360/85 is available in sizes of 16K, 24K, and 32K bytes (K = 1,024). The 16K-byte unit contains 16 cards, identical in function and in components, each with a 1K byte capacity.

The storage cells on each card are contained in an 8-by-9 array of modules in the center section of the card; these are surrounded by circuits for addressing, writing, and sensing. The modules are based on IBM's half-inch-square solid logic technology (SLT) substrates. Each holds two silicon chips, and each chip contains an 8-by-8 matrix of storage cells. Thus each module holds 128 binary storage cells.

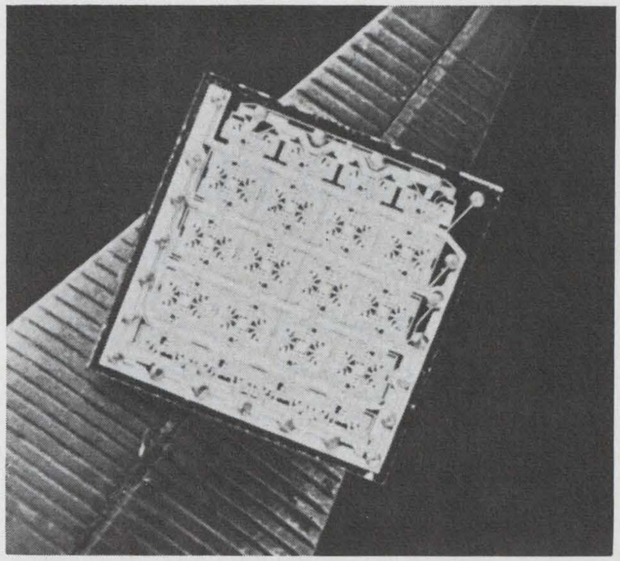
Other memories could be structured using the same set—for example the cache in the 360/195. In fact, this system utilizes the buffer even more efficiently than the 85.[2] The 85 also has smaller memory registers of 64 to 256 bytes that are composed of these same modules mounted on smaller cards. The smaller registers have a faster access and cycle time of 25 to 30 nsec.

Ultimate—almost

This system of a cache memory operating with a backing store attains 64% to 96% of the system performance that could be theoretically achieved with a single memory of cache speed and of backing-store capacity, housed within the processor. If the actual cache always contained the data required by the processor, the performance would be 100%; and even when the program was care-



Buffer. These 16 cards can hold 16,000 bytes for quick access by the 360/85 processor. The data arrives in groups of 64 bytes from the memory.



Small but fast. This silicon chip, shown on the nib of a pen, contains 64 memory cells that deliver data in as little as 54 nsec, in the 360/195.

fully constructed to have the required data in the cache as seldom as possible, performance was 64% of the theoretical maximum. To date, no actual customer's program has been worse than the most severe worst-case programs. If these percentages hold for a 16K cache, they would be somewhat higher for larger caches, because, obviously, the proportion of data found in the larger cache is higher.

These results were obtained by a simulation process, and verified in an exhaustive study that employed cycle-by-cycle timing modules for a number of cache system designs, and actual programs of IBM 360/65 and IBM 360/75 users.[3] From the results of simulation runs on these designs and programs, detailed timing charts were prepared of program performance on a machine with a cache.

Questions and answers

These charts provided answers for the major questions that arise in evaluating the cache concept: How large should the cache be? What optimum block size should be transferred between backing store and cache? How does performance vary with backing-store access time?

The study produced highly favorable results. It disclosed that cache capacity of 16K to 32K bytes is sufficient for holding, on the average, 95% of all storage requests made by the central processing unit. When extended to the model 195, the study showed that the proportion of storage requests satisfied in the cache averages 99%. A block of 64 bytes represents the proper amount of information to bring into the cache when a backing store access is required. System performance varied no more than 10%-15% as backing store access time ranged from zero to two microseconds, corresponding to a wide range of cycle times for the main memory, and of cable lengths between it and the processor.

These results correspond reasonably well to the findings for an IBM 7000 series machine.[4]

The cache concept has proven feasible largely because the set of programs to be run on a cache system have addressing patterns readily adaptable to the concepts. This is true because programs usually comprise lists of instructions in successive locations to be executed in sequence, and because blocks of data also are usually in successive locations. They don't have to be, but it would be more effort for programers to scatter them around and it wouldn't have any advantage.

The cache concept, as implemented in the System 360/85, has proven to be as good as expected. But one interesting point has been established by the hardware that was not established by the simulation, because the hardware includes a switch on the console to disable the cache. With this switch set in the disable mode, all programs require three to four times as long to complete as when the cache is working. It's one of several controls that disable certain parts of the machine; they keep the system running at reduced speed in the presence of a component failure that otherwise would stop the machine completely. ■

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Speeding up ferrite-core memories

By Robert M. Whalen

International Business Machines Corp., Poughkeepsie, N.Y.

For nearly 20 years, the introduction of new fast computers has been confronted by the discovery of a class of problems that require even faster processors—and faster memories. However, the drive for faster ferrite-core memories has temporarily slowed, due to developments in computer architecture that make them seem to run faster than they actually do [see "Prodding memories," p. 109]. But these architectural developments themselves require fast memories that presage the even higher speeds required of future main memories.

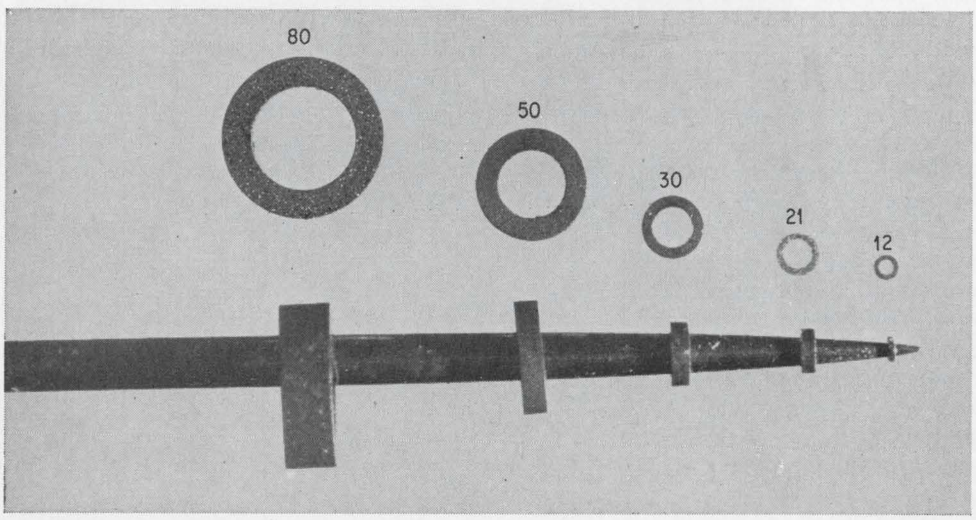
Conceptually, the method of making today's memories faster is to make the cores smaller. Smaller cores can be made to switch faster without increasing drive current, because they have shorter magnetic path lengths which result in higher switching fields. They also have smaller cross-sectional areas, which reduces inductance, and can be placed closer together, which reduces drive line length. The result is lower transmission delay, back voltage, and power dissipation. The latter two make the storage array, as a load, easier to drive with high-density integrated circuits. The shorter line lengths even compensate for the higher resistance per unit length of the smaller wires that are required.

Signal-to-noise ratios do not deteriorate when core size is reduced, as shown on page 110, because delta noise, which is produced by half-selected cores, can be cut in proportion to signal output, and lower drive voltages and line delays reduce spurious couplings, thus generating less noise. The surface-to-volume ratio also increases as cores get smaller, increasing their efficiency in dissipating heat generated during switching.

Mechanical problems

The principal problems in smaller cores are more mechanical than electrical.[5] Making, testing, and wiring cores becomes more difficult as core size is reduced. The problems in making cores range from obtaining finer ferrite powder, to building presses with close tolerances, to controlling time and temperature in sintering. In testing, the cores must move continuously along controlled paths despite air currents and magnetized mechanism parts. And in wiring, the cores usually are vibrated into positions in a type of jig that is quite difficult to make for the smallest core sizes.

Wiring the cores—a task that up to now has been largely manual—inevitably will become completely automated. Limitations of human dexterity and, coordinately, the inability of manual threading to stay abreast of an ever-increasing bit market, will



Sized for speed. Five common ferrite core sizes have been in use in computers. Each was smaller than the one before, and made it obsolete, because the new size could switch faster. Numbers show the outside diameter of the cores are in mils; the lower line-up shows them mounted on the tip of a sewing needle.

Prodding memories

Ferrite-core memories with cycle times faster than 500 nanoseconds are not generally available commercially, even though designers long have been tinkering with the idea of building them,[1, 3] and even though a relatively large memory with a 100-nsec cycle was demonstrated as long ago as 1966.[2]

But faster memories have not appeared for three primary reasons: the development of architectural techniques that match relatively slow memories to faster processing units; difficulties in handling and wiring the small cores that would be required, and the expense of achieving speed by switching only part of the ferrite core's toroidal volume instead of all of it.

There are two basic types of architectural techniques. The simpler of these divides the large memory into relatively small modules that can operate at the necessary speed, and are connected via a single common bus to the central processor. But even this approach is limited by transmission and switching delays, which erect a performance barrier between the processor and its large and remote memory frame.

To compensate, the architectural alternative is to add a relatively small, high-speed buffer directly in the processor to exchange data with the remote memory [see p. 105]. The processor could randomly access individual words in the internal buffer without delay while the buffer obtains new data from the external main memory in larger blocks. Although this requires more control hardware in the processor, the cost/performance tradeoffs have made it worthwhile.[4]

A high-speed buffer still requires the external main memory to transfer data at a rate commensurate with the internal buffer's cycle time, and there are techniques to accomplish this that do not impose severe requirements on the latter. For example, the accesses to separate modules can be interleaved—new cycles can be started in one or more modules before a previous cycle in a different module is complete—or long words can be transferred by accessing several modules in parallel. Thus the main memory cycle can be considerably longer than the buffer cycle.

Module capacities for these systems usually are limited to a half-million bits or less, which is desirable because, by distributing successive memory addresses, it permits an apparently very fast cycle but doesn't require individual modules to be unusually speedy. In an interleaved operational mode it reduces the statistical probability of a double access to a single module during its cycle time—this would interrupt the data flow.

But there's a tradeoff for permitting the modules to be slow: they also must be inexpensive. For this reason 3-D and 2½-D organizations are most frequently used.

make automation an economic must. But it will be necessary to further extend the capability of the wire insertion tools presently available, or to develop an entirely different approach to plane design—for example, a way of fabricating ferrite arrays in batches.

These mechanical problems have been solved, at least on an experimental basis, with cores that have an inside diameter of 7½ mils, an outside diameter of 12 mils, and a thickness of 2½ mils—compared with today's standard size of 20 mils o.d. A 12-mil core can switch in about 70 nsec when excited by a full-select current of 900 milliamperes. In a 3-D memory the core must switch both ways, first to read out the data and then to store it again for reuse later. This two-way switching time typically represents about 50% of the cycle of a 3-D memory in the quarter- to half-million-bit range; the other 50% permits transients to die away. These figures thus project a 280 nsec cycle. A slightly faster cycle time of about 230 nsec can be projected for a three-wire 2½-D organization, primarily because of the elimination of one of the dimensional controls.

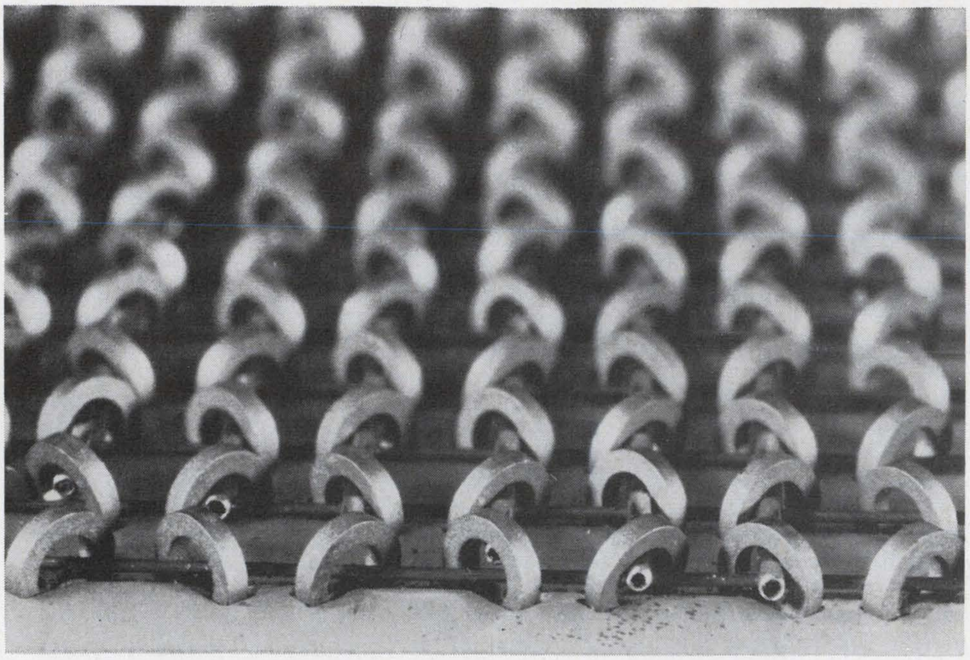
But these projected times don't really indicate how much swifter main memories will actually become. There are too many factors that will influence future demand—for example, how much a customer is willing to pay for speed, or how quickly competing technologies develop and how rapidly they're adopted.

Buffer memories

Fast operation becomes the key requirement—if necessary, at the expense of bit capacity—when cores are used in buffer memories. Their clock cycles must match those of modern high-performance processors—usually faster than 200 nsec, and in some cases even 100 nsec. Buffer memories also must be compact enough to house the required bit capacity within or very near the processing unit. These two requirements—speed and compactness—when coupled with cost and limitations of today's memory technologies, have restricted buffer capacity to a quarter of a million bits or less.

Ferrite cores can meet the speed and compactness requirements for most buffer applications, but they lose much of the cost advantage in main memories. Although the necessary compactness can be achieved in 3-D or 2½-D organization with still smaller cores, a significant improvement in performance is possible, with present standard core sizes through partial switching. Because it switches less flux—in effect, less of the core's toroidal volume—switch time is cut.

Switching duration could be made almost arbitrarily small, except for some practical limitations such as the 1-to-0 signal ratio; it becomes pro-



Wired up. These cores are being wired in an automatic machine. One coordinate already has been threaded and the second is being inserted through hollow needles. Use of the needles indicates that the cores are 30 mils or more in diameter; in smaller cores, a similar machine simply pushes the wires through a row of cores without the use of needles.

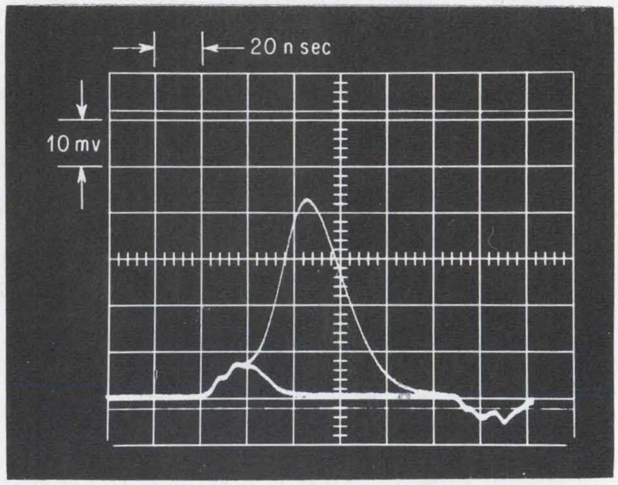
gressively smaller as less flux is switched. To maintain the ratio at a practical level, a second core is introduced at each bit position. The second core is used to store a reference flux; a differential flux-sensing system detects the presence of a 1 by measuring the difference between the flux stored in the data core and the flux stored in the second core.

2-D is a necessity

But the chief disadvantage of partial switching is that it requires a 2-D or word-organized system. A 3-D or 2½-D organization cannot be used because both depend on half-select current pulses that affect many cores besides the full-select core; a partially-switched core produces large spurious signals when exposed to these half-select pulses, and these can even change its flux state. In a 2-D organization a single word line is selected; it carries the full drive current, but it requires more drive and sense circuitry, which, together with the use of two cores per bit, makes an inherently more expensive system than one using full switching.

On the other hand, partially switched cores dissipate less power and use lower drive currents, which are more easily obtained with state-of-the-art semiconductor circuits. Furthermore, because even in the fastest systems only two wires thread each core, the array is easier to assemble, and therefore less expensive.

Whether 2-D ferrite core systems continue to be cost-competitive with other technologies remains to be seen, though the availability of low-cost monolithic drive and sense circuits will enhance their chances. From a performance standpoint, quarter-million-bit memories with 100 nsec cycle times can be produced with the 7-by-12 core. To attain even higher speeds, a number of design choices are available, but the most challenging and most promising in many respects is to continue to make cores smaller. This will increase core fabrication and winding problems, but will considerably ease the semiconductor and cooling requirements and permit a denser package. ■



Silence, please. These 1 and 0 signals from a 12-mil core under worst-case coincident-current test conditions still show an excellent signal-to-noise ratio.

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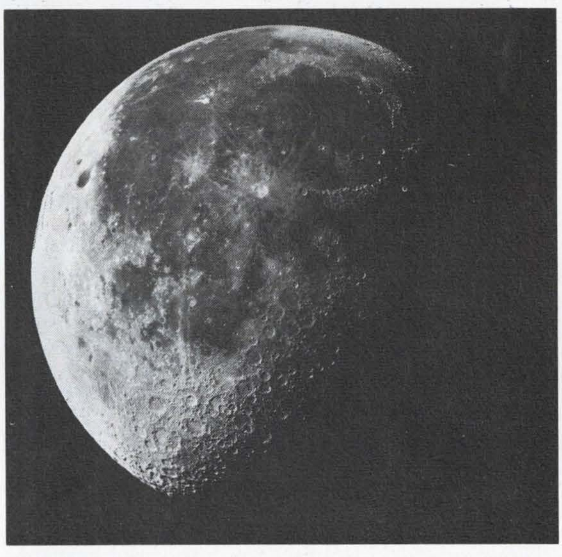
1. J.A. Rajchman, "Computer Memories—Possible Future Developments," RCA Review, June, 1962.
2. G.E. Werner and R.M. Whalen, "A 110-Nanosecond Ferrite Core Memory," IEEE Transactions on Magnetics, September 1966.
3. T.J. Gilligan, "2½-D High-Speed Memory Systems—Past, Present and Future," IEEE Transactions on Electronic Computers, August 1966, p. 475.
4. C.J. Conti, D.H. Gibson, and S.H. Pitkowsky, "Structural Aspects of the System 260 Model 85," IBM Systems Journal, Vol. 7, No. 1, 1968, p. 2.
5. John L. Turnbull and John J. Kureck, "Smaller cores, bigger challenge," Electronics, Oct. 28, 1968, p. 112.

Signetics was on the ball.



We've also been to Mars.

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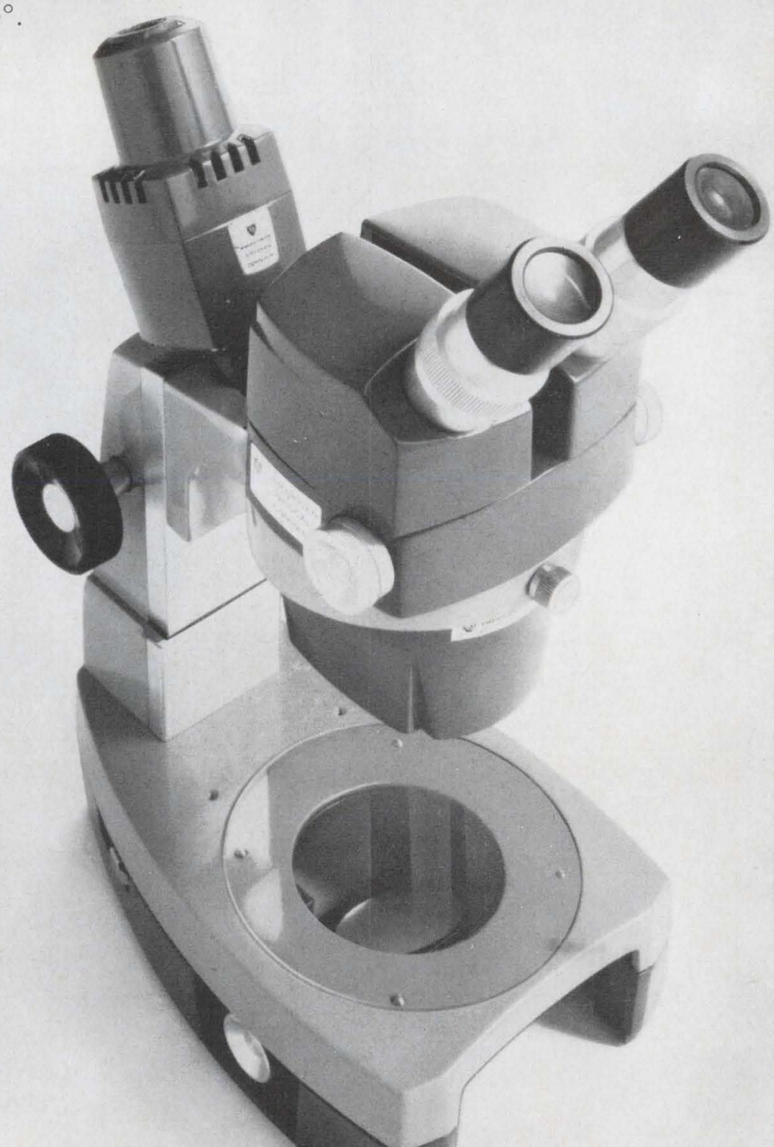

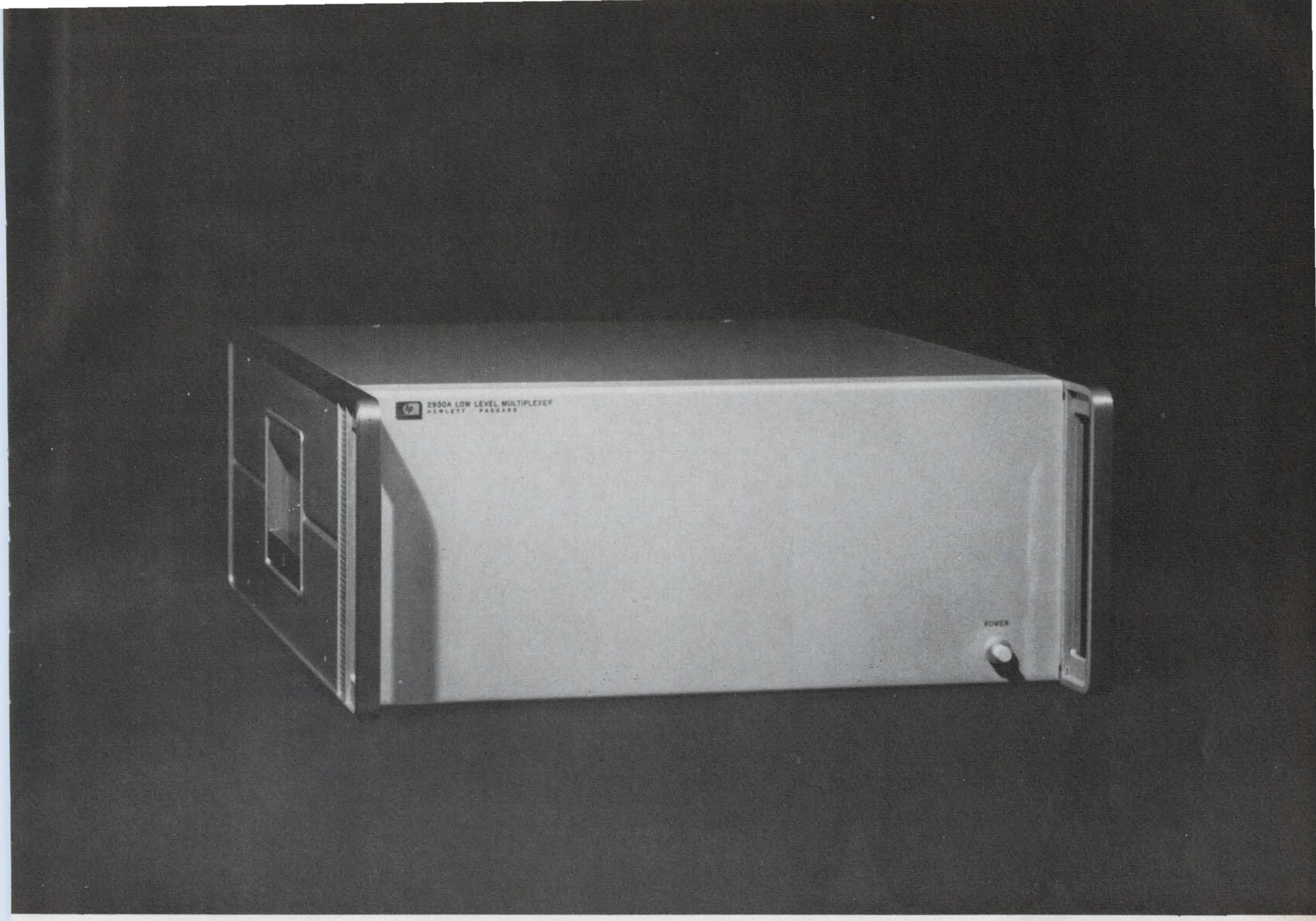

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There's only one multiplexer that can boost millivolt-level signals to 10-volt levels at switching rates to 20 kHz—with 120 dB common mode rejection and cross-talk below 100 dB.

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And interfacing with any A-to-D converter and 16-bit or 12-bit computer is straightforward through one of five plug-in interface cards.

Channel capacity is plug-in expandable from 8 to 64 channels in the mainframe; several multiplexers can be controlled through one computer I/O channel. Ask your HP field engineer about other advantages of the HP 2930A Low-Level Multiplexer. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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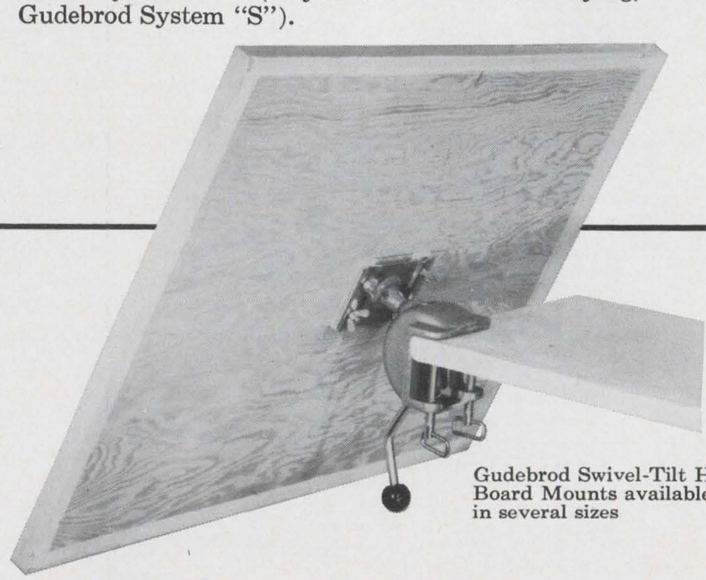

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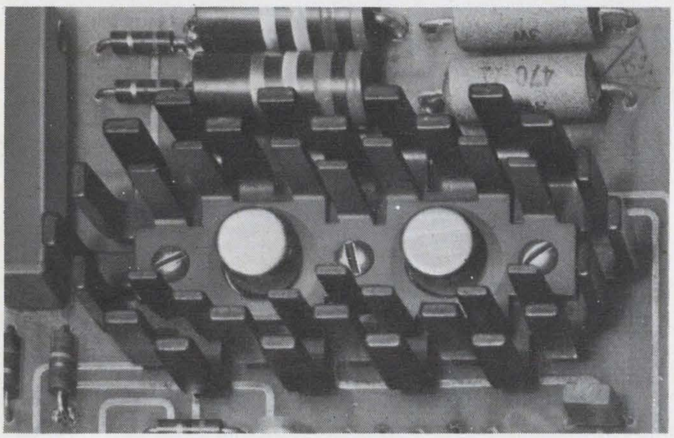
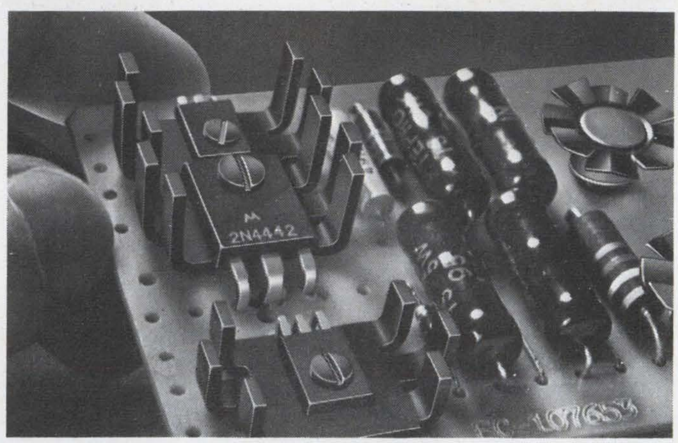
Tips on cooling off hot semiconductors

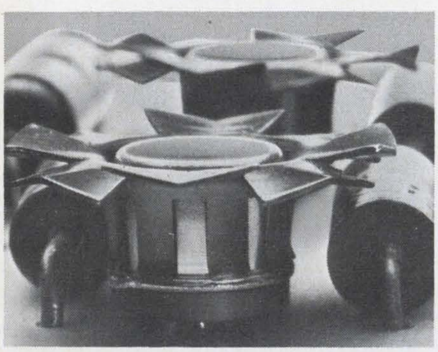
As power levels go up and up and package size shrinks, circuit designers are keeping semiconductors cool with IERC Heat Sinks/Dissipators. Reducing junction temperature gives many benefits: faster rise and fall times, faster switching speed and beta, fewer circuit loading effects and longer transistor life and circuit reliability.



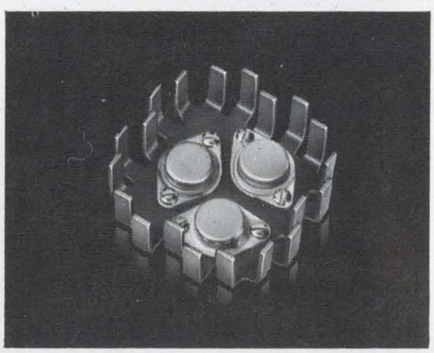
Thermal mating of matched transistors, such as these TO5's shown on a dual LP, maintains matched operating characteristics. The LP's unique multiple staggered-finger design (both single and dual models) maximizes radiation and convection cooling, results in a high efficiency-to-weight and -volume ratio.



Power levels of plastic power devices such as X58's, MS9's, and M386's can be increased up to 80% in natural convection and 500% in forced air when used with PA and PB Dissipators. PA's need only .65 sq. in. to mount; PB's 1.17 sq. in. Staggered finger design gives these light-weight dissipators their high efficiency.



TO5's and TO18's in high density packages can be cooled off with efficient push-on Fan Tops that cost only pennies. T-shaped, need no board room, let other components snuggle close. Spring fingers accommodate wide case diameter variations. Models for RO97's, RO97A and D-style plastic devices also.



High power TO3's, TO66's, TO6's, TO15's, etc. can be operated with much more power when used with HP's. These compact, lightweight staggered finger devices accommodate from one to four TO3's. Provide the same heat dissipation as an extrusion that's three times heavier and one-third larger.

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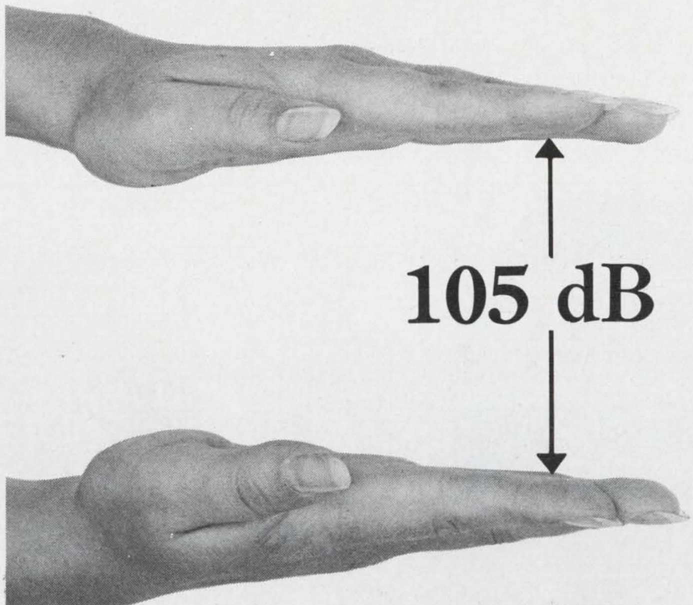
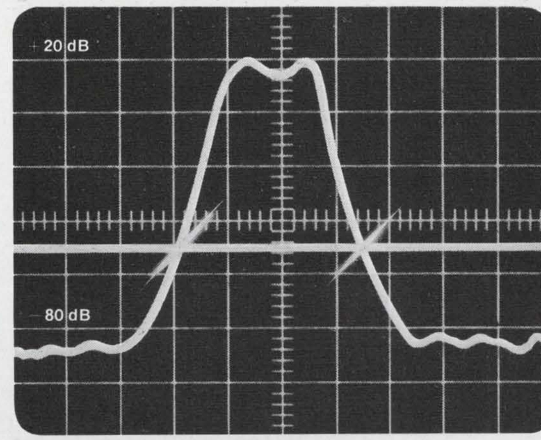


OF SIGNAL LEVELS

Telonic's new Log Amp Detector operates over a dynamic range of 105 dB *without switching scales*. That's a 178,000 to 1 voltage swing which can be displayed on a scope or XY plotter in sweep operation, or read on the instrument's meter for fixed frequency measurements.

And if that doesn't make it the most versatile detector ever built, consider a few more



features: a tangential sensitivity of −85 dBm, frequency range of 400 kHz to 130 MHz, direct readout in dBm, and a calibrated reference line for swept operation.

Capable of accepting any RF input within its frequency range and as low as −85 dBm, the 6001 Log Amp Detector converts the signal to a log DC output for display or readout. Its *calibrated* dynamic range is −70 dBm to +20 dBm and convenient Expansion and Offset controls permit even closer looks at low level signals.

(Note: For users of Telonic's 2003 Sweep/Signal Generator, the Log Amp Detector is available as a plug-in unit, Model 3353).

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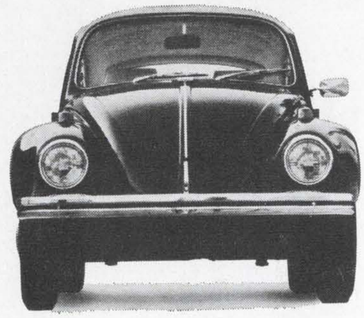

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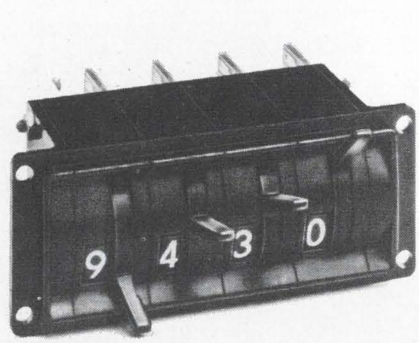

90-degree arc as the wheel rotates displaying 0.200 inch high characters. And a sweep of the hand re-sets everything —up to 12 positions—back to zero.

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Higher sensitivities are achieved at greater bandwidths than ever before. 5 mV/div at 150 MHz, 1 mV/div at 100 MHz and 10 μV/div at 1 MHz. With . . .

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Each mainframe accepts up to four plug-in units. Thirteen plug-ins are currently available to cover virtually all multi-trace, differential, sampling, and X-Y applications. Plus . . .

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Greater convenience in all areas of instrument operation. Features such as Auto Scale Factor Readout, lighted pushbutton switching, and true automatic triggering assure faster, more accurate, less complicated measurements.

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7504

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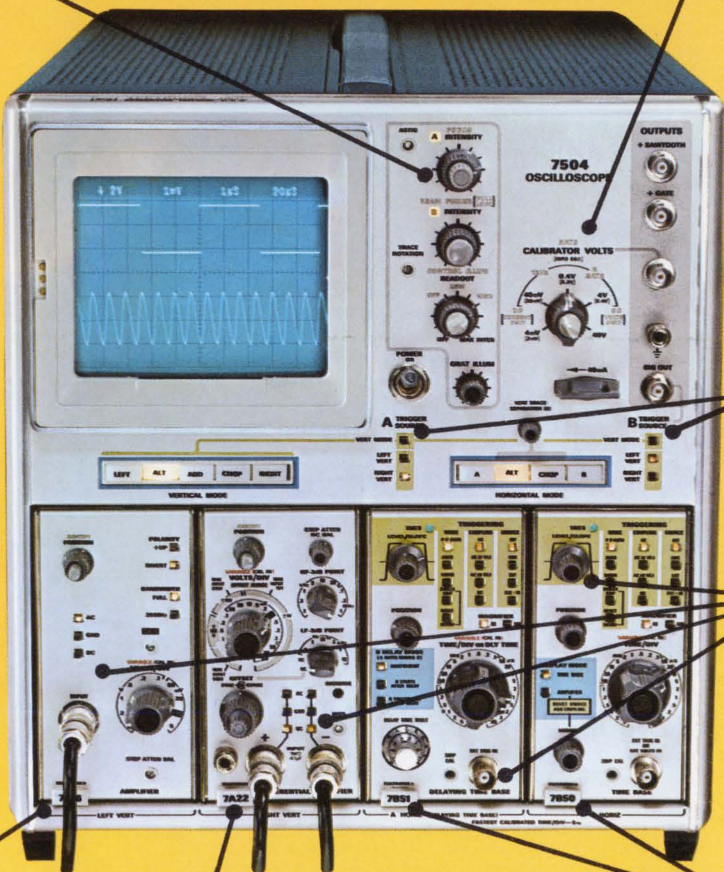
CALIBRATOR

A multi-function generator usable as a "standard" for calibration of voltage and current GAIN, time/div, and probe compensation. The output is DC or AC (1 kHz or variable) voltage or current (fixed at 40 mA). The amplitude accuracy is within 1% and the time accuracy is within 0.5% at 1 kHz.



TRIGGERING

The signals from both vertical plug-ins are coupled through a mainframe logic circuit and made available to each horizontal plug-in, selectable from LEFT channel, RIGHT channel, or slaved to VERTICAL MODE. The latter frees the operator from manual source changes during single-trace operation and, in conjunction with the P-P AUTO TRIGGER MODE in the time-base units, provides true hands-off triggering during routine measurements.

FOUR PLUG-IN CHANNELS

The modular approach is the answer to instrument flexibility. With dual-trace switching in the mainframe amplifiers, each plug-in can be "specialized" in function and operate in combination with other units. Thirteen plug-ins are currently available for the 7000-Series. Together, they represent the widest range of performance options for multi-trace, differential and sampling applications available today.

nd Amplifier

IHz (2.4 ns tr) in the ns tr) in the 7504. mV/div at full band-

7A22 High-Gain Differential Amplifier

Bandwidth—DC to 1 MHz with selectable upper and lower —3 dB points.

Min deflection factor—10 μV/div at full bandwidth.

7B51/7B50 Time-Base Units for the 7504

5 ns/div maximum sweep speed. Operable singly or in combination for delaying sweep capability.

7M11 Delay Line Unit

Two 75 ns, 50-Ω delay lines. Trigger selection from either line.

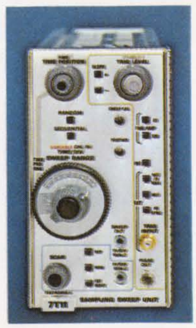
7S11 Sampling Amplifier

Accepts the plug-in sampling heads for bandwidths to 14 GHz (25 ps tr).

7T11 Random Sampling Time Base

10 ps/div to 5 ms/div sweep range, accomplished with equivalent-time and real-time techniques.

Triggering to 12 GHz.



7704

AUTO SCALE FACTOR READOUT

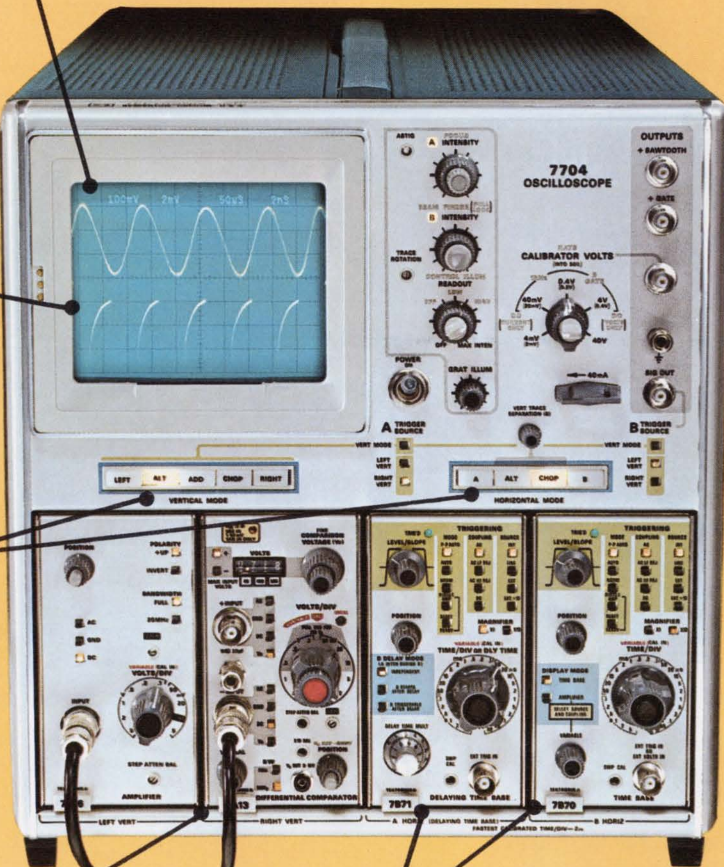
A character generator senses the position of volts/div, amps/div, time/div, polarity, and uncalibrated variable controls, then accounts for probe attenuation and displays the correct scale factors for all channels directly on the CRT.

DISPLAY (

Three intensity controls adj
and READOUT brightness
focus control, a screwdriv
and a two-position beam
group.

BRIGHT TRACE

The acceleration potentials are 24 kV for the 7704 and 18 kV for the 7504 for improved trace visibility. Single-shot photographic writing speed is 3300 cm/μs (7704) measured with the standard P31 phosphor, the new C-51 camera and 10,000 ASA film. The display area is 8 cm x 10 cm with a parallax-free illuminated graticule.



DUAL-TRACE SWITCHING

Both the vertical and horizontal *mainframe* amplifiers are "dual trace" providing a unique level of flexibility with plug-in combinations. A relatively small number of plug-ins can then meet a wide range of application requirements. The CHOP and ALT modes permit simultaneous displays of delaying and delayed sweep, and, through switching logic, may be "slaved" to provide a functional dual-beam type of display.

7A13 Differential Comparator Amplifier
Bandwidth—DC to 100 MHz (3.5 ns tr) in the 7704; DC to 75 MHz (4.7 ns tr) in the 7504. Min deflection factor—1 mV/div at full bandwidth.

7B71/7B70 Time-Base Units for the 7704
2 ns/div maximum sweep speed. Operable singly or in combination for delaying-sweep capability.

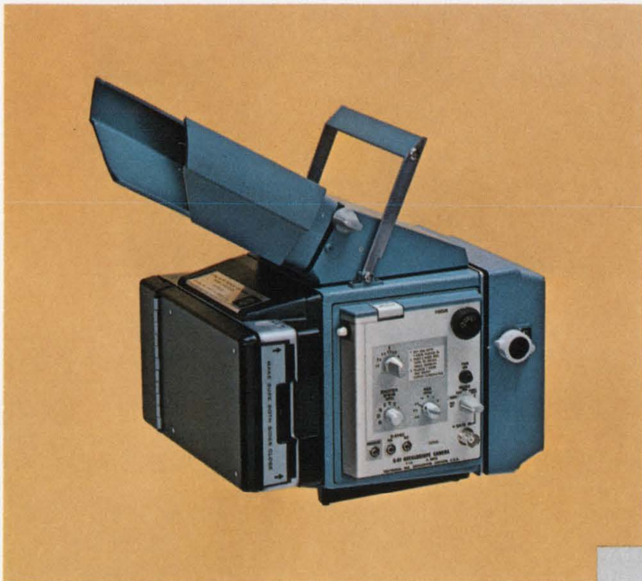
7A16 Wide-B
Bandwidth—DC to 150
7704; DC to 90 MHz (3.
Min deflection factor—
width.

7A11 Captive FET Probe Amplifier
Bandwidth—DC to 150 MHz (2.4 ns tr) in the 7704; DC to 90 MHz (3.9 ns tr) in the 7504. Min deflection factor—5 mV/div at full bandwidth.

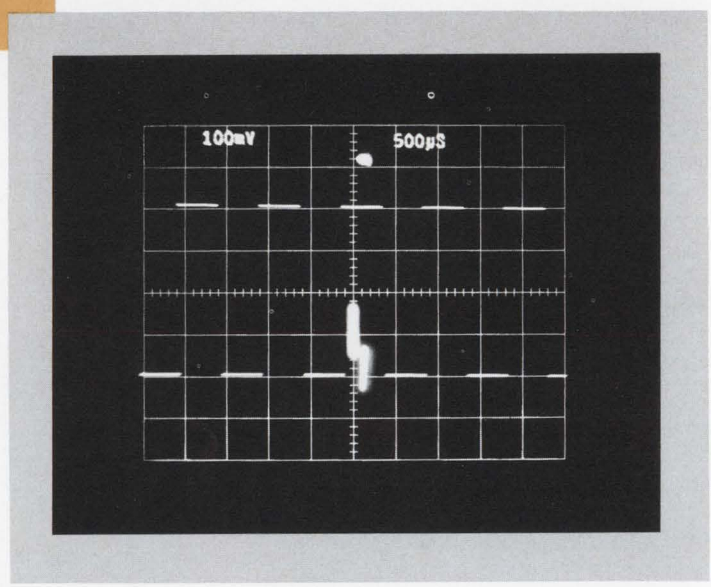
7A12 Dual-Channel Amplifier
Bandwidth—DC to 105 MHz (3.4 ns tr) in the 7704; DC to 75 MHz (4.7 ns tr) in the 7504. Min deflection factor—5 mV/div at full bandwidth.

7A14 AC Current Probe Amplifier
Bandwidth—25 Hz to 105 MHz depending on mainframe and current probe; two probes available. Min deflection factor—1 mA/div at full bandwidth.

C-51/C-50 Trace-Recording Cameras



Two new compact trace-recording cameras have been designed for direct compatibility with the 7000-Series Oscilloscopes. The C-51 and C-50 cameras are basically identical units, differing only in the lens system. The C-51 has an f/1.2, 1:0.5 lens; the C-50 uses an f/1.9, 1:0.7 lens. The C-51 is recommended for single-shot photography at the fastest sweep rates, the C-50 for more general purpose applications. Photographic writing speed of the two 7000-Series mainframes with the C-51 and 10,000 ASA film (without prefogging) is 3300 cm/μs (7704) and 2500 cm/μs (7504).



The cameras offer a new level of operational convenience for mistake-proof trace photography. The guess work normally associated with selection of f stop and shutter speed to match the ASA index and trace brightness is eliminated. After setting the ASA index, the built-in photometer allows a *visual* correlation of trace intensity to the correct f stop setting and shutter speed. After initial adjustment, a change of f stop or shutter speed will still maintain the same exposure. Focusing is accomplished by two beams of light projected on the CRT which, when superimposed, indicates optimum focus. The insert shows the photometer spot and the rangefinder focusing images.

SCOPE-MOBILE® CARTS

The 204-2 Scope-Mobile® Cart is specifically designed for the 7000-Series instruments. It provides a securing mechanism for the oscilloscope, nine positions of selectable tray tilt, a large storage drawer, storage for five 7000-Series plug-ins, and large locking-type wheels.

PROBES

The P6053 is a miniature fast-rise 10X probe designed for full compatibility with the 7000-Series instruments. Input R and C is 10 MΩ, 10.3 pF. Probe risetime is 1.2 ns or less.

The P6052 is a passive dual-attenuation probe designed for measurements below 30 MHz. A sliding collar selects 1X or 10X attenuation. Input R and C is 1 MΩ or 10 MΩ, 100 pF or 13 pF. Risetimes are 60 ns (1X) and 7 ns (10X).

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7704 Oscilloscope	$2500
7504 Oscilloscope	$2000
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7A12 Amplifier Plug-In	$700
7A13 Amplifier Plug-In	$1100
7A14 Amplifier Plug-In	$575
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U.S. lights fire under microwave ovens

HEW seeks to reduce the allowable level of emitted radiation to 1 mw/cm^2, but industry sees no clear evidence of health hazards under its own standard

By Robert Westgate
Associate editor

Too much radiation from high-power microwave sources isn't good for you—that's a fact. But just where to draw the line between what poses a health hazard and what doesn't isn't quite that clear cut—at least not to the Government or, for that matter, to the manufacturers of microwave ovens.

At issue is a decision pending before the U.S. Bureau of Radiological Health on setting the maximum safe emission level from the ovens to one-tenth the value previously considered safe by both the military and industry. One milliwatt per square centimeter, measured 5 centimeters from any of the oven's outer surfaces, is the new level proposed by the bureau, an agency of the Department of Health, Education and Welfare. As the manufacturers see it, the proposal could spell disaster.

"The proposed standard would restrict and inhibit the development of the . . . American market and restrict technological progress in microwave ovens and in other fields," says Gunther Baumgart, president of the Association of Home Appliance Manufacturers. "It would also increase oven design and manufacturer's costs," he adds.

The problem is an old one in industry-Government relations. The oven manufacturers, like the automobile and color-television makers before them, fear Government standards will raise cost and purchase price, eliminating potential customers. But, buttressing the association's position that the present industry-regulated standard of 10 mw/cm^2 is "wholly adequate" is the absence of any general scientific agreement as to levels at which microwave radiation becomes a health hazard. The 10 mw/cm^2 standard also is considered adequate by the Electronics Industries Association, whose members supply the magnetrons for the ovens, and the American National Standards Institute, which sets standards for a wide range of industries.

Having their day

They will have the chance to air their views on Oct. 31, when the 14-member Technical Electronics Products Radiation Safety Standards Committee meets in Washington to hear arguments from the microwave-oven manufacturers. Established by the Radiation Control for Safety and Health Act of 1968, the committee advises HEW on radiation standards for all products. It reportedly favors the lower minimum level.

The committee has asked the manufacturers of the ovens, which operate at either 915 or 2,450 megahertz, to supply answers to several key questions:

- How does the age of an oven affect microwave radiation leakage?
- What is the industry's record in product improvement?
- What design changes would be necessary, and how long would

For consumer protection

One of the biggest problems facing the microwave oven industry is how it will be able to assure HEW—and the general public—that its products will remain safe as they grow older. What happens, for instance, if it is dropped, or dirt accumulates around the dirt seal, and the door leaks excessive radiation? And how can anyone detect it?

The industry feels dealer installation and periodic checks of the ovens might scare the public and would be too expensive. Federal Trade Commission regulations might be violated if the installation and checks were restricted to the dealer's factory-trained repairmen, they contend.

However, at least one company is trying to develop a reasonably priced (less than $10) sensing device which would indicate excessive leakage. A company spokesman says the device might flash a light for several seconds and then turn off the oven.

But making measurements is even a problem in a laboratory. Researchers do not use standard instruments or methods to determine radiation levels. And up to now, a safe, accurate instrument that would not disturb the measured field does not exist.

However, Ronald R. Bowman of the National Bureau of Standards, Boulder, Colo., has drawn up a list of characteristics for an electromagnetic probe which the bureau feels would be ideal for testing radiation levels. And Paul W. Crapuchettes, a vice president and technical director of Litton Industries' Electron Tube division, has completed an instrument study as a consultant to the Association of Home Appliance Manufacturers. The study describes several new instruments that he rates as effective for measuring the radiation.

they take to implement if the 1 milliwatt standard should become law?

▪ What "normal service adjustments" performed by a repairman would not cause an oven to leak excessive radiation?

▪ How could companies assure that the standard would remain in force for the life of the oven?

HEW's proposed standards also would require that ovens be equipped with two independent interlocks—one mechanical, the other electrical—in addition to the on-off switch. The interlocks would shut off primary power between the power source and the magnetron when the oven door is opened. They could be located on either side of the power transformer, but one would have to be hidden and "defeatable" only if the oven were dismantled to the point where it can no longer operate. The interlocks would not cut off power to the oven light, blower, or tube filament.

Underscoring the needs

HEW says it is trying to push the industry to the limits of its technical ability. Many of the engineering problem areas already are known. Better-fitting doors are needed, as are higher quality and more effective r-f seals; a good repair schedule; a corps of trained servicemen; an efficient way to measure microwave radiation leakage from the ovens, and possibly a latch that would cut off the radiated power before the door is opened, HEW says. HEW claims tests have shown that leakage may balloon to as high as 100 mw/cm^2 after the door is opened and before present interlocks switch off the power.

It's also been found that the metal-to-metal seals deteriorate with age. Newer ovens that use a choke seal with energy-absorbing material may leak more than the metal-sealed ovens at first, and may be harder to clean, but thus far they appear to maintain their leakage level better with age. The latter seal also may be troublesome when used in a self-cleaning oven which subjects even the seal to temperatures above 800° F.

More pollution. Why are microwave radiation standards necessary? According to one expert, William T. Ham, chairman of the Biophysics department at Virginia Commonwealth University, microwaves are a definite air pollutant. "The atmosphere is permeated from one area to another with microwave radiation," he says. "The pollution problems aren't that great now, but we must be ready for the future."

HEW points out that "microwave systems have become a part of our way of life." Exposure is not just limited, for instance, to military personnel operating radar equipment or to those involved in a radar manufacture and installation. Microwaves are used in laboratories, in commercial drying and heating processes involving such diverse products as photographic film, potato chips, and glue binders, and in communications and navigation. Use of microwave ovens is increasing rapidly in restaurants, hospitals, and self-service vending and fast-food operations, and—most important in terms of potential hazards—in homes. Therein lies the urgency of immediate, adequate safety standards, HEW asserts.

The market for microwave ovens already is substantial—roughly $15 million annually. Predictions are that by 1976 a quarter of the ovens sold in the U.S. will be microwave. And HEW fears most of the oven owners will be unaware of the potential hazards to their health.

U.S. appliance manufacturers now making microwave ovens, which range in price from about $500 to $1,200, include the General Electric Co., Louisville, Ky.; Microwave Oven division, the Tappan Co., Mansfield, Ohio; Microwave and Power Tube division, the Raytheon Co., Waltham, Mass., and a Raytheon subsidiary, the Amana Refrigeration Co. in Amana, Iowa; Microwave Oven division, the Roper Co., Kankakee, Ill.; and Atherton division, Litton Industries, Minneapolis.

Imported, and perhaps lower-priced, units from Japan, Britain, Holland, Sweden, and Germany haven't hit the U.S. market yet, chiefly because models haven't been submitted to the Federal Communications Commission for frequency checks or to HEW for safety examinations. Foreign ovens will be subject to the same emission regulations, but the law will be even tougher on them than on domestic products: if foreign ovens

Coordinating research

Look for at least two groups to coordinate future research on the effects of microwave radiation: HEW's Consumer Protection and Environmental Health Service and an ad hoc committee headed by Dr. John M. Heller of the New England Institute for Medical Research, Ridgefield, Conn.

Assistant Surgeon General John J. Hanlon says HEW hopes to coordinate all Government research in this area. Dr. Heller says his committee will act as a clearing house for research papers, so that scientists can share the results of their experiments and avoid duplication.

A number of veteran researchers in the field were dissatisfied with the quality of research papers presented at last month's symposium on the health implications of microwave radiation held in Richmond, Va. They suggested that some of the less experienced scientists didn't understand good research practices, that time and money were being wasted on performing experiments on organisms or animals when the conclusions could not be applied to humans, and by duplicating experiments which had first been done in the 1940's and 1950's.

are found defective, they can be destroyed; U.S.-made ovens either must be repaired or replaced, or their cost refunded. One British company complained to HEW that this provision amounts to "another Boston Tea Party."

How safe is safe?

Until now, 10 mw/cm^2 has been considered a safe emission level by military and industrial organizations, and oven manufacturers say they've accepted this standard for their designs. But HEW doesn't think this level is safe enough for commercial and household installations.

Military personnel, scientists and industrial users have plenty of microwave experience, are aware of the hazards, and know how to handle problems should they arise, HEW points out. The ordinary user, HEW feels, must have extra protection.

"The 10 milliwatt level is close enough to levels that have created injuries in animals and we just can't take the chance that it won't have a bad effect on humans," says an HEW spokesman.

Most ovens right off the production line could readily meet the 1 mw/cm^2 standard, HEW believes. Far more serious is the problem of maintaining this level for the life of the oven. It will be hard to do even if checks and adjustments are made by dealer- or factory-approved repairmen. And according to recent Federal Trade Commission rulings, appliance guarantees must hold regardless of who makes the repairs.

Unlike gas or electric ovens, microwave units operating at 915 Mhz do not produce a heat sensation to warn a user he is being burned. Microwave ovens heat up too quickly—in seconds. Usually, the burn occurs in a subsurface skin layer where the effect is not immediately evident [*Electronics*, Sept. 30, 1968, p. 43]. And although the higher oven frequency—2,450 Mhz—does produce a heat sensation, it poses another danger. It can cause cataracts in the eyes. Most microwave ovens now on the market are designed for the higher frequency.

Affects sex life. Even more bizarre human health and biological effects of low-level microwave radiation have been claimed by Russian observers. These effects include everything from headaches and irritability to lessened sexual activity, fear, asthma, hypochondria, and fatigue.

The full clinical significance of Russian and other East European studies into the cumulative effects of low-level radiation is not fully understood by Western scientists, perhaps because they are skeptical about the validity of the findings. Westerners claim the Russians do not supply enough data to support their findings, and do not—or are ordered not to—answer questions.

However, U.S. scientists not only disagree with the Russians—they disagree among themselves. At last month's Symposium on the Biological Effects and Health Implications of Microwave Radiation in Richmond, Va., the lack of agreement was highlighted by Assistant

Surgeon General John J. Hanlon, deputy administrator of HEW's Consumer Protection and Environmental Health Service. Reading from testimony about microwave radiation during Congressional hearings, Hanlon said he was impressed by the "frequent use of such phrases as 'no systematic work has been done' . . . 'no one knows if' . . . 'we do not know if there are other harmful effects' . . . 'our present knowledge is limited'." There is a great need for additional, well-controlled microwave research to provide a sound basis for regulating microwave-radiation-producing devices, he said.

But after three days, the nearly 400 delegates were still divided on the conclusions to be drawn from the research papers presented. Some said there wasn't enough valid information on incapacitating injuries resulting from the radiation, and at what field strengths, frequencies, and exposure times they occur. Others felt that even the sketchy existing data was enough to warrant the low standard. The split perhaps was epitomized by a seven-man, blue-ribbon panel convened to discuss future research needs. To the question of whether it was premature to toughen the existing standard, three panel members replied it was not premature, three said it was, and one had no firm opinion.

Nebulous. One of those opting for the stricter standard, Allen Frey of Randomline Inc., asserted that "it is not a matter of inadequate information. We must make the best decision on standards with the information we have. And we can't wait to see if the same effects that have appeared at low-level microwave radiation in animals—such as a change in brain activity—also will appear in humans."

On the other side of the issue were Dr. John H. Heller of the New England Institute for Medical Research, and Sol Michaelson of the University of Rochester. Heller wanted still more research. "Until we have explored different frequency ranges and different human systems," he said, "we must be careful before setting standards people consider safe." And Michaelson, who helped write the 1965 Air Force report recommending a 10 mw/cm^2 level, said he had learned nothing new from the symposium. It was premature, added Russell Carpenter of Tufts University, "to take a stab in the dark. Let's stay with the 10-mw standard and experiment to see if it should be lowered."

To complete the fragmentation of opinion, others at the symposium said it would be better to ease a tight standard, rather than tighten an easy one. With 1 mw/cm^2 established as a level of acceptable risk, said symposium chairman Stephen V. Cleary of Virginia Commonwealth's biophysics department, research should then begin to determine how high radiation levels could rise and still be safe for humans.

Because of all this uncertainty the appliance manufacturers' association charges that 1 mw/cm^2 maximum leakage level may become law on the basis of unsupported health hazard claims. The design of microwave ovens was based on the opinion of leading microwave scientists that the safe radiation exposure level was 10 mw/cm^2, the association points out; changing the design is unwarranted without conclusive evidence.

Only one microwave oven manufacturer, the Commercial division of Magic Chef, Cleveland, Tenn., says it has accepted the tougher standard. The company is making its initial entry into the restaurant and vending market.

Almost all the other companies in the field, though reticent to discuss the hazard factor, were seriously concerned about the "bad press" the industry was receiving. They referred to "scare headlines" and "inaccurate" stories about alleged effects on animals—effects which they felt could not apply to humans.

One company official concluded that "the growth of an industry depends on the industry itself. If stricter standards are set, I am sure we have the technical competence to meet them . . . if we are given time to do so." HEW has proposed an 18-to-24-month delay in adopting the 1 mw/cm^2 standard to give the manufacturers time to meet the requirements. The new standard, which will be set initially at 10 mw/cm^2, could go into effect as early as next summer, according to one HEW estimate.

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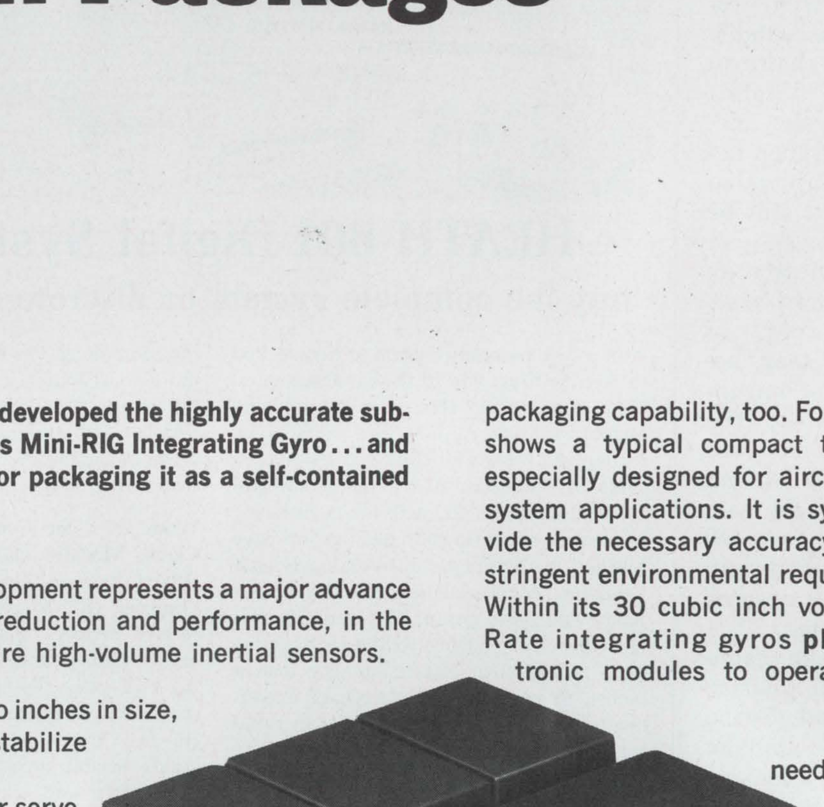

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Charting a course to high profits

With Sporck at the helm, National Semiconductor moves from red ink to black by narrowing the scope of its research and focusing on high-volume devices

By Stephen Wm. Fields Associate editor

Turning a money-losing company into a highly profitable one isn't as easy as ABC, particularly in the hotly competitive semiconductor industry. But, from Charles Sporck's point of view, the ABC's —or basics—point the way to black, rather than red, ink. For that's exactly what has happened at the National Semiconductor Corp. since Sporck took over as president in 1967, a year in which the company reported an operating loss of $724,000 on sales of $7.2 million. (In the same fiscal year, ending on May 31, National Semiconductor also reported an extraordinary loss of almost $1.5 million as a result of inventory writeoffs.)

What were Sporck's ABC's for success? In straightforward terms, they were (and still are):

- Concentrate on products that fill special needs so as not to spread resources too thin while, at the same time, enhancing the company's reputation.
- Accept no orders for small runs of custom products, but produce in large volume only.
- Keep a reasonable emphasis on research and be reasonably sure marketable products are in sight.

Financial statements for 1968 and 1969 provide ample testimony as to how well Sporck's approach works. In 1968, National Semiconductor earned $900,000 on sales of $11 million; a year later the figures were $1.5 million and $23 million, respectively. But what about the current fiscal year, which will end next May 31? The company is publicly projecting sales in the neighborhood of $48 million—and is privately expecting $75 million, according to insiders. And that's a long, long way from sales totaling $28,530 in 1959—the year the company was founded.

At the outset, Sporck had to cope with the purchasing-agent psyche. "We couldn't be a 'me too' type of company," says Sporck, "because then we would have nothing special to offer. And why should a guy start buying semiconductors from an unkown company when he could just as easily get them from one of the big boys?" National decided to market a special product to fill a specific need.

The philosophy behind this, according to Sporck, was "to get a foot in the door and get the name National known." Thus LM 100 and LM 101 were born. The LM 100 was the first monolithic voltage regulator. The LM 101 is an operational amplifier that's essentially a better version of the Fairchild 709, and that, by comparison, offers reduced input offset current and voltage, eliminates latch-up, is short-circuit proof, and requires fewer external components for compensation. The 101 was designed by Bob Widlar, National's director of advanced circuit development, who had designed the 709 while at Fairchild Semiconductor. What's more, both linear circuits—the 100 and the 101—fell in with Sporck's strategy.

National became known as the "linear house." Sporck saw this as only a stepping stone to "maximum sales, maximum profit, and minimum dilution of corporate funds." Sporck's three points could be any company's goals but for one thing. "At National, we live by, and for them," says Sporck. "Other companies might think that they do but they don't." For example, some try to be innovators, which, says Sporck, is all right as a name builder but can be disastrous as a way of life. Free-wheeling research

Strategist. Charles Sporck is the chief architect of National Semiconductor's growth. His strategy consists of product selectivity, applied research, and large volume production.

and development carries a stiff price tag and produces only a few items with a large market. And a large market is necessary for high profits.

National keeps up with the latest technical developments by drawing on the same people who work on production-line items, rather than by going to a group hidden away in some corner. "This way," says Sporck, "we can get something from the lab into production with less effort. We haven't got the left hand developing prototype 50-lead large-scale integration packages when the right hand can't produce the LSI chips." Pursuing directed research exclusively isn't unusual for a small company, but it is for a company with such large sales.

Second source houses also espouse the three points. They spend almost nothing on R&D. Instead, after signing licensing agreements, a company will produce a complete line of someone else's products. According to Sporck, this is a wasteful tactic; rarely are all the products in a given line profitable.

The third type is the custom house where everything is made to order. Profit can be made here, according to Sporck, only when very high volume orders are involved, and this is not the case with the majority of custom orders. "And besides," adds Sporck, "with the custom business, you spread your designers too thin. Too much time and money is spent in designing circuits while the profit is in producing them."

Stepping out. Having made a name for itself with monolithic linear integrated circuits, National went looking for a high-volume line of digital circuits. And it didn't have to look too far. Texas Instruments was having trouble with its complex transistor-transistor logic devices, and in stepped National with two of its "people."

Jeff Kalb and Tom Thorkelson had been with TI during the design stages of the 54/74 series of TTL devices. Kalb, who is 28 years old, had been working for TI in its co-op plan since he was 17 and was the chief architect of National's TTL line. Kalb designed a complete line of medium-scale integration TTL devices for National, while Thorkelson, who is digital product marketing manager at National, provided the software backup.

And once National's MSI TTL devices started moving off the line in high volume, it was only natural for Kalb to design a series of TTL gates for National. Exercising discretion, National only second-sourced those TI devices that it thought could be sold in high volume. According to Sporck, this is not the typical "me too" approach. Although National's TTL devices are pin-for-pin replacements for TI's, the design has been improved and the manufacturing process is different.

National's next step was to avoid the computer main-frame market, which Sporck says is too specialized to the point of being custom, and concentrate on the small business machine, the computer peripheral, and the industrial markets which have settled on certain types of TTL circuits, and are considered standard markets.

As to why National's TTL line would be bought over TI's, Floyd Kvamme, National's microcircuit product manager, says, "National can deliver in quantity and at a lower price. We showed our customers that we could deliver complex TTL when they needed it, and we could do the same thing with TTL gates."

At the same time the TTL line was introduced, National also brought out a line of metal oxide semiconductor shift registers and analog gates. Again, this was to be high-volume only and no custom orders would be taken. National's MOS technology was brought over from the Hewlett-Packard Co. in the person of Ken Moyle, leader of an IC development group at H-P working on 1-0-0 silicon. From the outset, National built its MOS devices with 1-0-0 silicon—a factor, which, while not greatly emphasized at the time, made these devices low-level and thus TTL compatible. Later, when the other MOS manufacturers started touting their low-level circuits, National already had them in production.

National has organized engineers into workteams according to device technology. For example, Ken Moyle is the MOS process engineer, and he works with Dan Izumi who is an MOS circuit designer. Together, they are responsible for a product from its initial design stages through final production and for any problems that may crop up as long as the product is being made.

According to Floyd Kvamme: "When Sporck and the rest of us came to National in 1967, we knew what didn't work from what happened at Fairchild, so we tried something else. In effect, we have a design engineering group that reports to the plant management and the process people, and they are backed up by a systems group that provides applications support." Moyle was working on MOS processing techniques at Hewlett-Packard before he came to National, and Izumi was with Philco-Ford (formerly General Micro-Electronics) as an MOS designer.

Jeff Kalb, Bob Schwartz and Tom Thorkelson make up Na-

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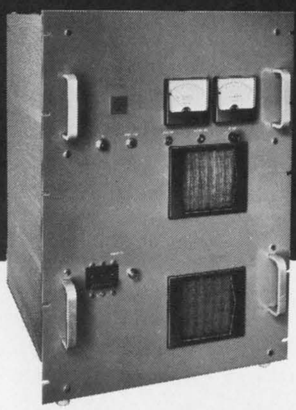


Rally 'round the flag

Founded by Bernard Rothlein in 1959, National Semiconductor was building momentum when in 1965 it was hit with a patent-infringement lawsuit by Sperry Rand—Rothlein's former employer. The reaction on Wall Street was a plunge of National Semiconductor stock. No sooner did this happen than Peter Sprague, nephew of the Sprague Electric Co.'s Robert Sprague, entered the picture.

First on a speculative basis and then later with the intent of gaining control of the company, Sprague bought up shares of the then-sagging National Semiconductor stock. Within a year, Peter Sprague was in a position to oust Rothlein as board chairman, and take his place. He then proceeded to woo Bob Widlar and Dave Talbert from Fairchild Semiconductor. But Sprague's crowning achievement was getting Charles E. Sporck to join him as president in February 1967. This ushered in a new era at National Semiconductor.

For with Sporck came Pierre Lamond as general manager, Roger Smullen, as production manager for standard linear circuits, Floyd Kvamme as microcircuits product manager, Fred Bialek as international operations manager, and Bill Routh as director of engineering—all from Fairchild. That June, Don Valentine left Fairchild to become National's director of marketing. Other acquisitions included from Hewlett-Packard—Ken Moyle as MOS process manager; from Texas Instruments—Jeff Kalb for digital design, and Bob Schwartz for digital process; and from Philco—Dan Izumi for MOS design; Dave Campbell, another Fairchild alumnus, took over National's linear design. Bob Christiansen, who is responsible for FET process, is from Union Carbide, while Don Wollesen charged with FET design stems from Philco-Ford. John Finch, plant manager for transistors in Danbury, Conn., came from Motorola.

tional's digital team. Schwartz is also an ex-TI man. As a team they have designed, developed, and produced National's complete TTL line as well as its new diode-transistor logic line.

The advanced linear design team is Bob Widlar and Dave Talbert. All of National's operational amplifiers and voltage regulators were developed under their guidance. They worked as a team at Fairchild before coming to National and are responsible for the LM 100 and LM 101, the two linears that got National on its feet. Their latest design is the LM 109 voltage regulator [*Electronics*, Sept. 29, p. 141]. Talbert is the process man who, in effect, makes Widlar's circuits work.

Passed along. Once the Widlar-Talbert circuits are past the development stage, they are passed along to Roger Smullen and Dave Campbell—both ex-Fairchild people—who are in charge of linear circuit production. Campbell is also the designer of what National calls standard linear circuits which include communications devices such as the LM 371 integrated r-f or i-f amplifier.

National also has an extensive line of field effect transistors produced by the Don Wollesen-Bob Christiansen team. Christiansen came from Union Carbide where he was a FET designer, and Wollesen came from Philco-Ford where he was in FET design applications.

Bill Routh, National's director of engineering, says that National's staff is about one-third of "what you would normally expect from an operation as large as ours. We don't waste people because they're our most important asset. Ken Moyle, for example, may be solving some production problem, but at the same time, he's the one who keeps abreast of new techniques such as the silicon gate process.

"Other companies have a solid division between design and manufacturing," says Routh. "But we have chosen to tear down these artificial barriers." And this goes for the hardware as well. Pilot production is done on the regular manufacturing line.

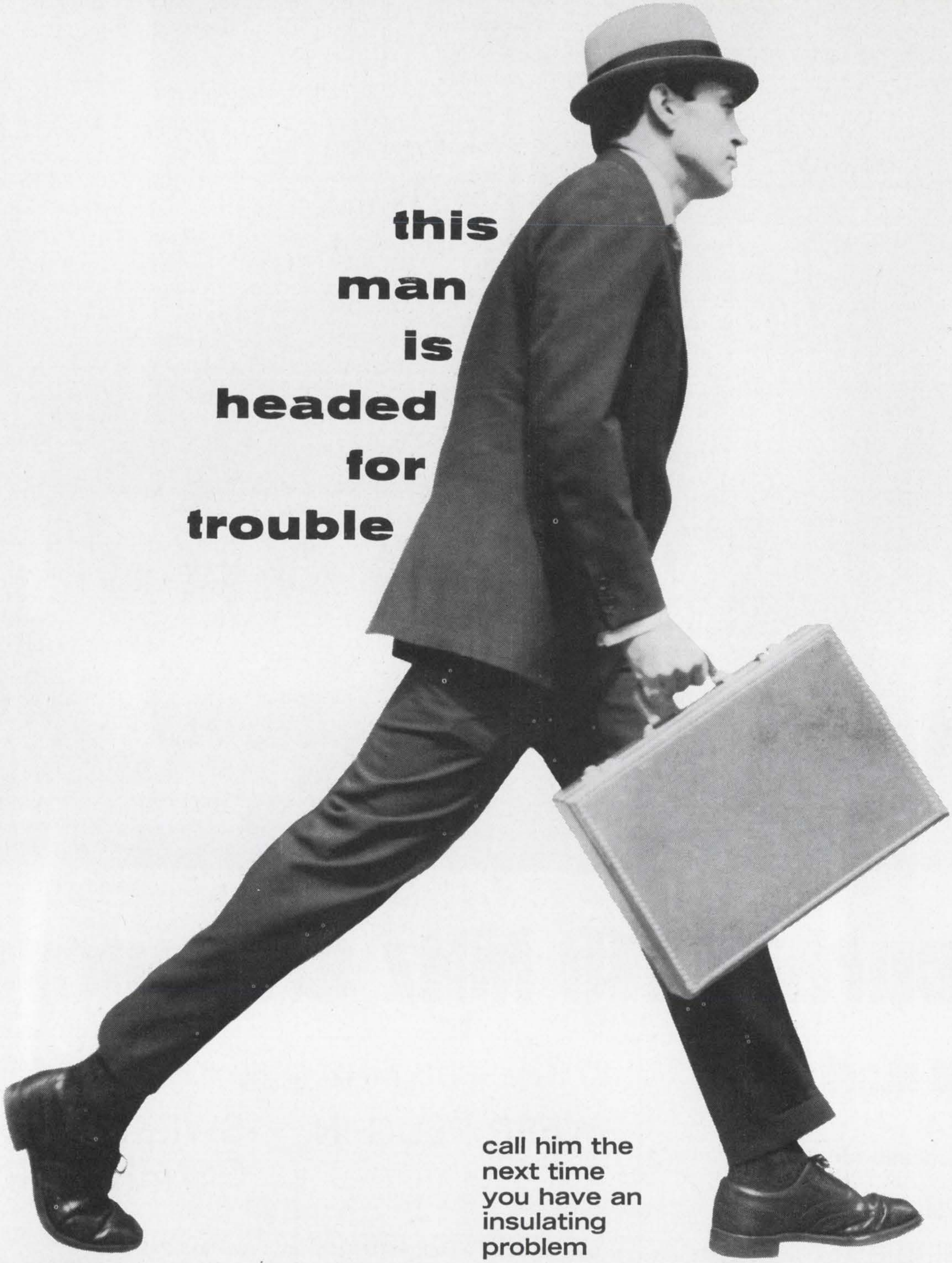
Farms out. To keep the engineering staff small and creative, the company emphasizes the design and production of silicon wafers. Sporck says, "When we came to National, our initial strength had to be people and not equipment. We knew who the technically competent people were, and we knew

how to apply this competence. The problem was to obtain and hold them. We did this by letting them work in the field of their choice, by promising that they would not be doing something unrelated to the tasks of making semiconductor devices, and by offering them an extensive stock-option plan."

Sporck's list of unrelated tasks includes such things as the construction of mechanical fixtures, transistor and integrated circuit assembly, and the printing of applications notes. These jobs were done under a subcontract basis. One of National's competitors says that this arrangement may be one of the reasons for National's success—initially, the company didn't have to invest in assembly equipment. Instead the subcontractor would have to update and maintain the equipment. Problems with any particular assembly operation were solved by changing subcontractors. However, National now has a considerable amount of assembly equipment in its overseas locations.

Not the surroundings. But Sporck says the main reason he went outside was to avoid bogging down his people. Sporck's theories must work because it certainly isn't the surroundings that keep the employees content. Although a new main building is under construction, National's present Santa Clara headquarters is spread out over five small buildings, and the surrounding streets are congested with engineers in smocks carrying semiconductor chips from building to building. The offices are just about adequate, and the halls are cluttered with test equipment and office machines. But this doesn't seem to bother anyone—the place is just as busy at 7 a.m. or 7 p.m. as it is at 10 a.m. and the quality of the product apparently hasn't suffered any. In fact, a price-cut on Mil-Spec MOS circuits was announced last month indicating that National is having no trouble at all in producing high reliability products.

All wafer fabrication, except for transistors, is done in Santa Clara. Assembled in Singapore, the completed devices are shipped back to Santa Clara where they are packed for delivery. Plants in Germany and Scotland are planned and these also will handle assembly and final test-



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ing. However, Sporck intends to keep the wafer fabrication close at hand.

Tailored equipment

The job of keeping the production lines rolling and profitable rests with Pierre Lamond and Fred Bialek. Lamond is the general manager of the Santa Clara facility and is responsible for wafer fabrication. It's Bialek's job to see that the devices are assembled and tested—he's National's international operations manager. Bialek has a team of specialists that modify production and test equipment "to make them more efficient and turn out more good devices." In fact, National tailors most of its equipment for a specific need.

The success of these modifications combined with National's overall marketing approach is confirmed by the company's sales projection for 1970 of $48 million. However, even this figure may be modest as last month, the company had memo pads (for internal use only) printed with the number 75 at the top. This, together with the opening of the plants in Germany and Scotland, and production figures that are projected for 1970, could indicate that National expects to triple sales in 1970 to $75 million.

Present production is about 1.6 million IC's and 700,000 transistors. By June 1970 it will be 7.5 million IC's and 3 million transistors. The IC increase is expected to come largely from digital circuits.

Move to DTL. National will add a line of DTL circuits. Accounting for this move, Kvamme says: "We have a tremendous amount of assembly equipment, especially for dual-in-line plastic packages. We wanted to find an area where we could take up excess production capabilities." There are about 7 million plastic DTL devices made a year. According to Kvamme, they now sell for about the same as ceramic devices, "and we can sell them for less." Putting it another way, he says, "We make complex TTL circuits which are used with DTL circuits, so why not make the DTL circuits."

But most important, it's a volume market, and that's National's overall target. ■

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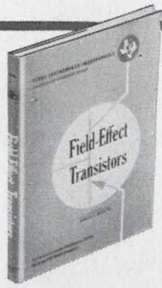

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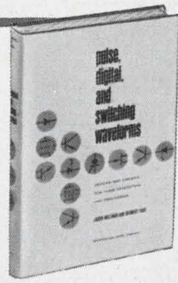

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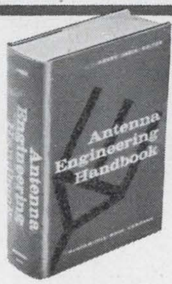

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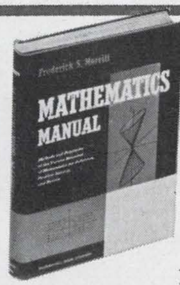

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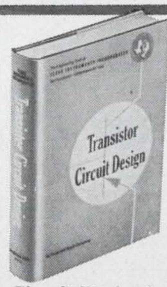

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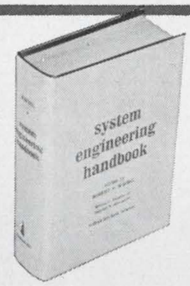

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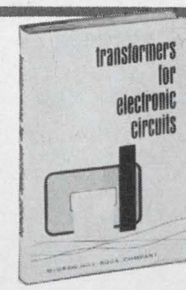

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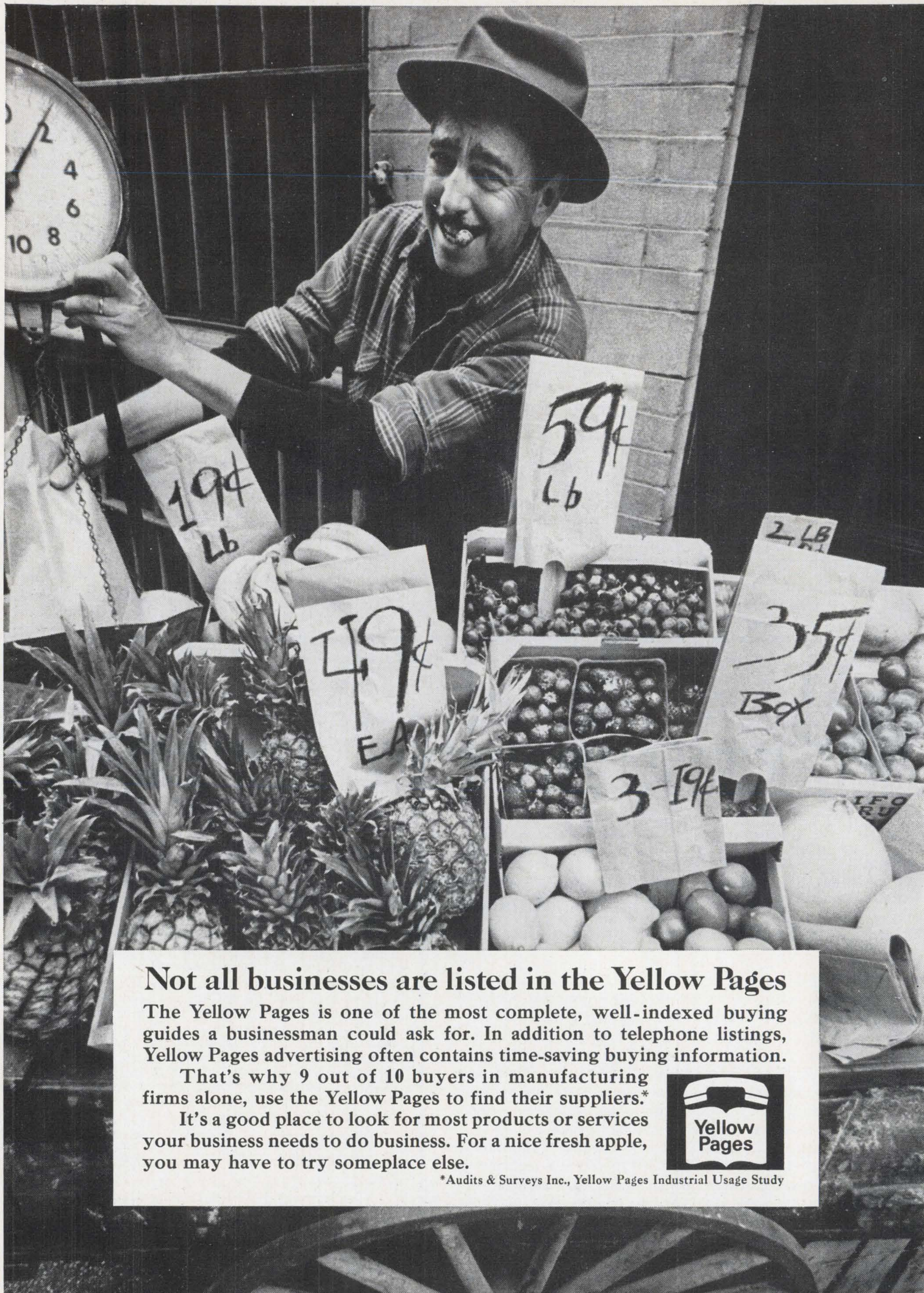

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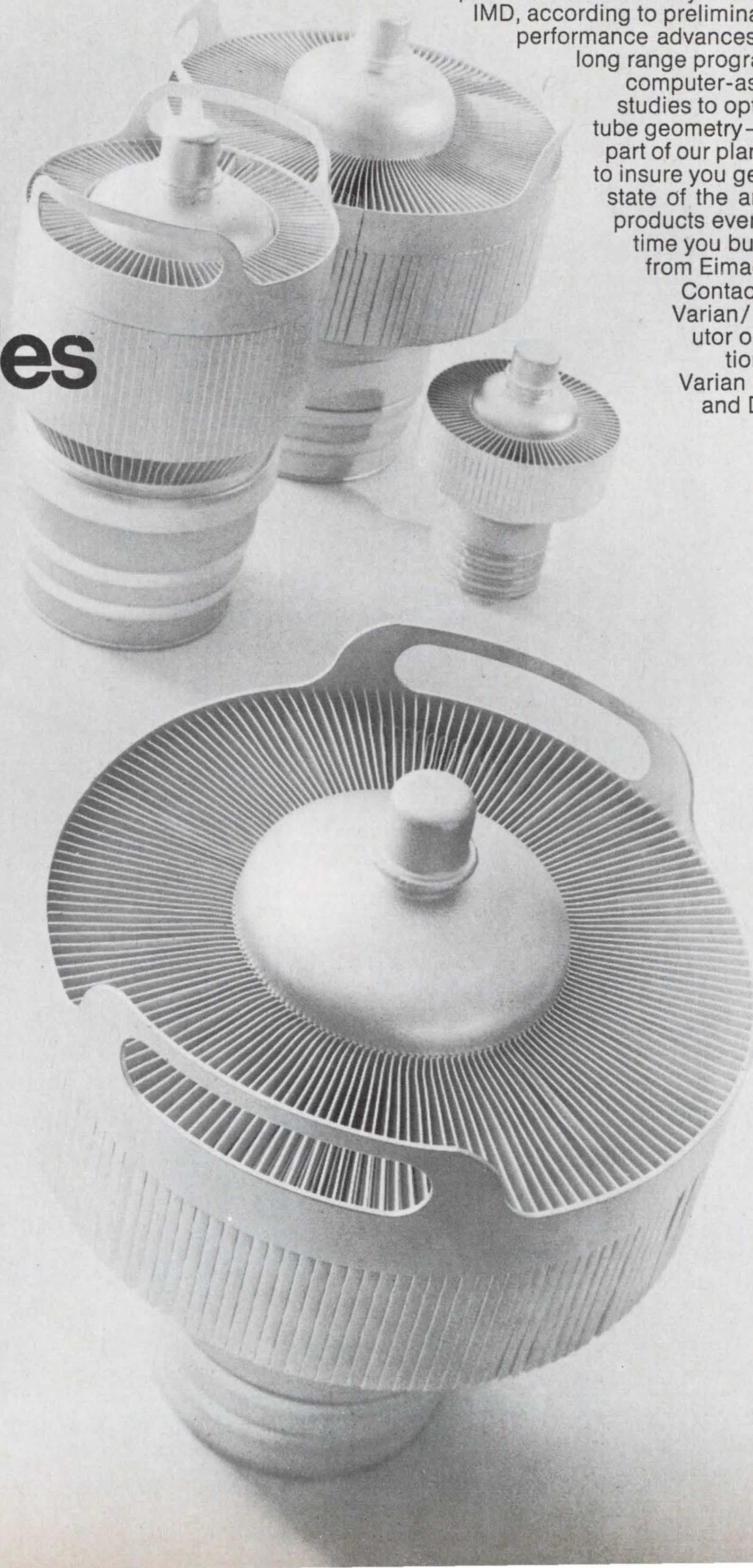

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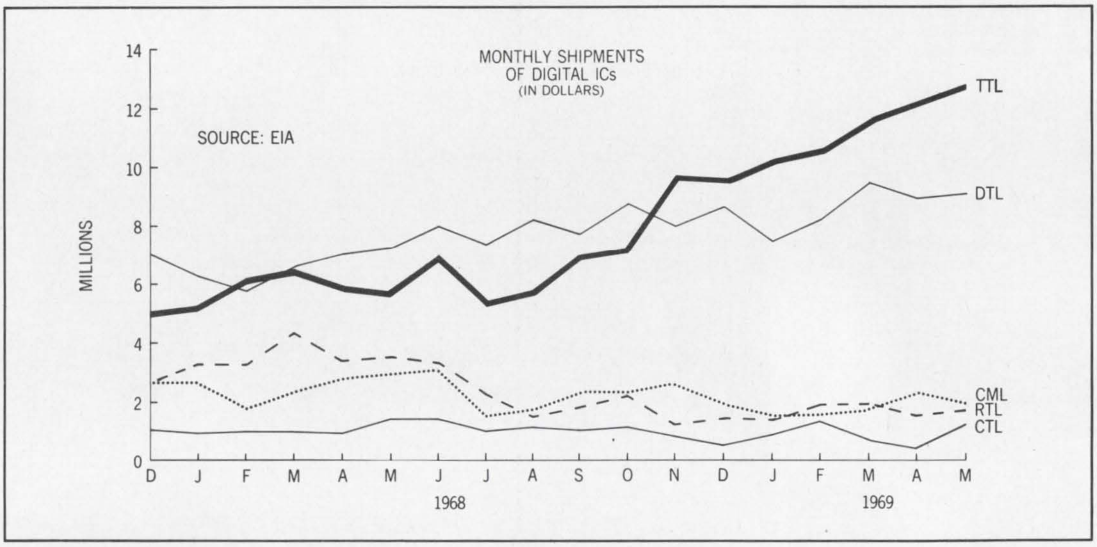

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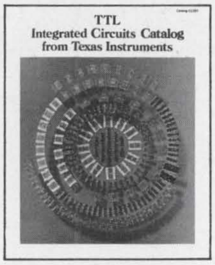

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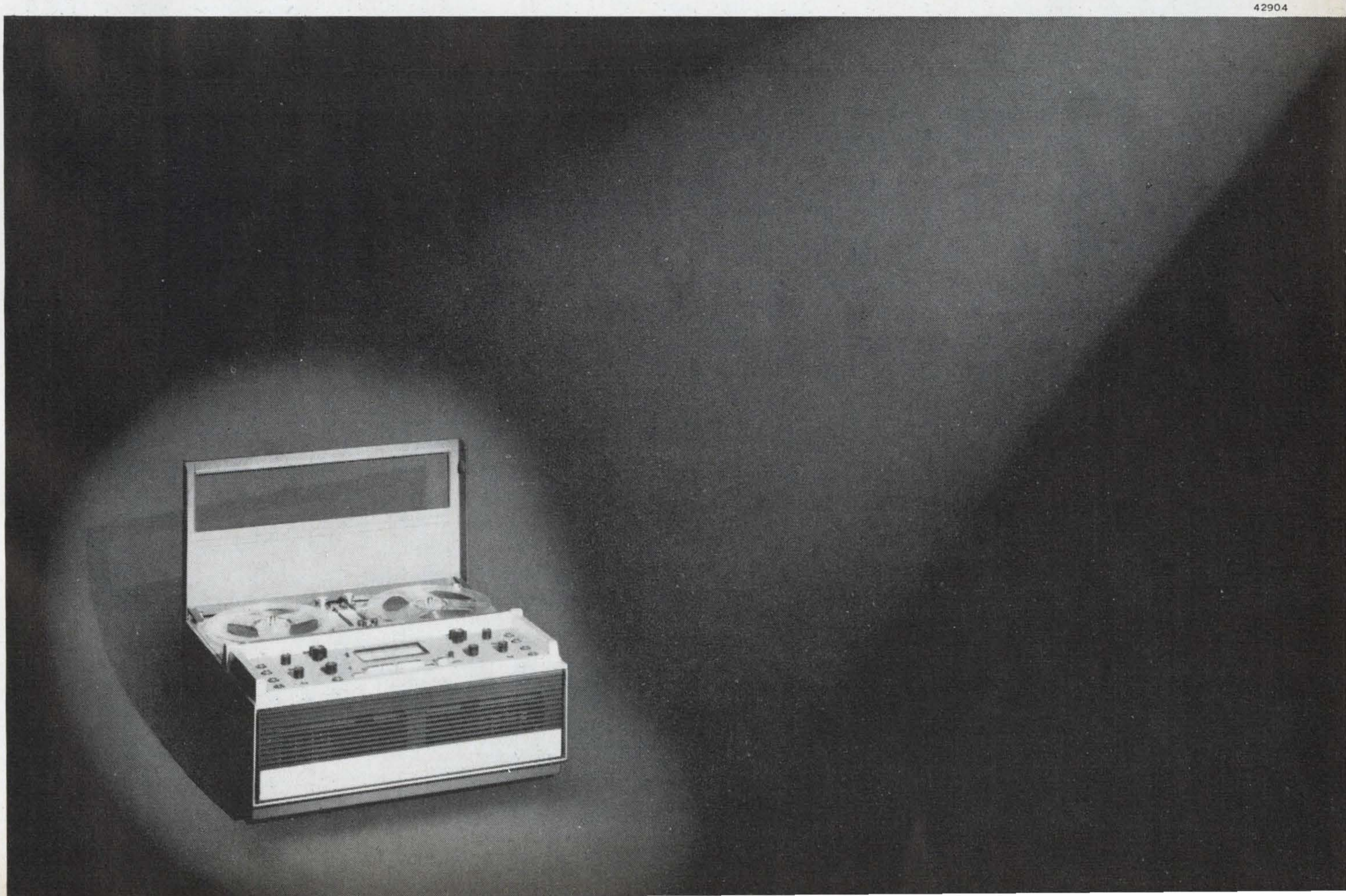

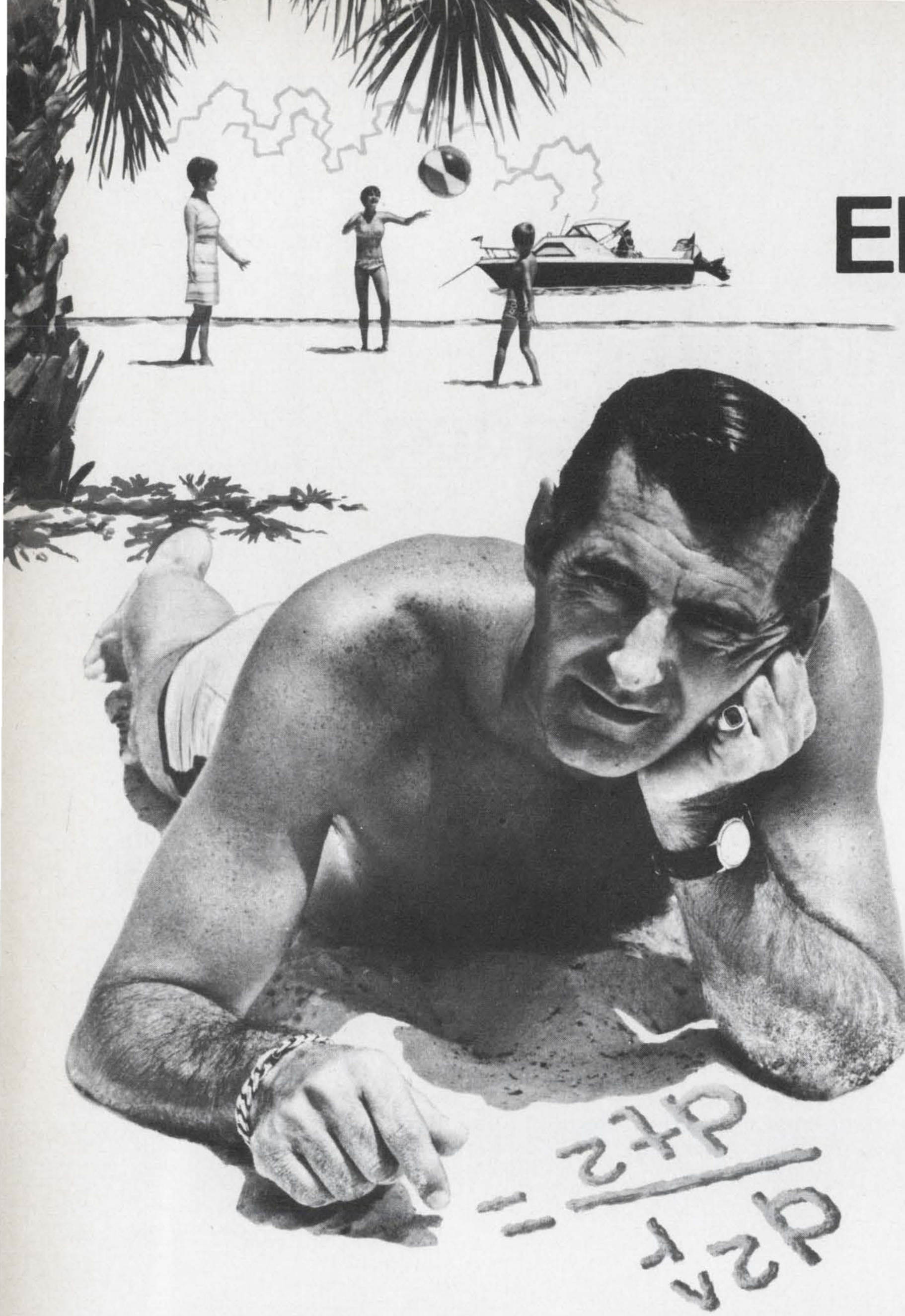

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Disk memory runs on air

New mechanical design includes air bearings and fluidic control; 'clean room' protects replaceable disk; fixed heads shorten access time

Team member. Disk memory, center, has an input-output section that makes it compatible with most computers.

Brilliant electronics engineers don't necessarily design good disk memory systems. And, according to officers of the Digital Information Storage Corp., the usual design team is composed of five logic designers to each mechanical engineer. As a result, says DISC president Roland Boisvert, the less costly disk memories now available have flying heads that crash or that sink onto the disk when rotation stops and abrade it, they have electrical interference that causes errors, and they are generally troublesome units.

Boisvert and his partner, Steven A. Lambert, vice president, are veterans of design work at the Digital Equipment Corp., and have specific ideas about the right way to make memories. As defined by their new DDR-1 disk memory, the right way includes interchangeable disks and fixed heads, air bearings, fluidic control of disk position, a "clean room" compartment to minimize contamination of the disk during operation, skew-free timing, and what they call anticipation logic to ease computer software problems. The DDR-1 will be shown for the first time at the Fall Joint Computer Conference in Las Vegas, Nov. 18-20.

One of the first areas attacked by the company was the problem of supporting the memory disk. The decision to use 16 fixed head pads for short access times had already been made, as had the commitment to removable and replaceable disks for convenience. Ball bearings had been a thorn in the side of both of Boisvert and Lambert while at DEC; according to Boisvert, "It's just about impossible to buy ball bearings which not only have good runout and vibration specs at first, but retain them. Also, the same model ball bearing is going to show unit-to-unit performance variations that are troublesome."

So Lambert suggested the air bearing, whose characteristics read like the reverse of those for ball bearings. Friction (and thus wear), is very small because there's no metal-to-metal contact. At high temperatures, an air bearing's load-carrying ability increases, making a room-temperature design a worst-case design. Low friction translates into high speed, and it's attained without lubrication (removing a possible contaminant from the area of the disk). Finally, the air bearing is self-centering and mechanically stiff, free from vibration and mechanical noise.

Shiftless. Having removed one cause of unreliability and timing skew by moving to a vibration-free air bearing, DISC's designers then added a special timing system. Rather than using a separate timing track, DISC's approach inserts a separate timing mark between each recorded word, thus timing is resynchronized at each word. And with timing and data signals read

Air tight. Sealed cartridge containing disk is received or ejected at push of button on front panel.

from the same head, timing offset is impossible.

As added insurance, DISC has designed its own magnetic recording disk an eighth of an inch thick —more than two times the 0.050-inch thickness of usual disks. This offsets the umbrella effect in which a disk sags around its edge. Also, rather than a number of small holes near its center, the new disk has a single large-diameter hole which fits on the spindle. Boisvert hints at ultra-high-speed disk recording in the future, perhaps with modified DDR-1's, when he notes that the several smaller holes used in most disks can cause stress patterns, then microscopic cracks, and perhaps shattering of disks driven at very high rates.

To keep the disks free from abrading dust, they are packaged in an air-sealed case, called a DISClosure. To load a disk onto the drive, the case is pushed into a slot on the front of the DDR-1, opening a seal on the case and a second seal in the machine itself. A fork-like handler driven by a pneumatic cylinder pulls the disk out of the case, into the DDR-1, and places it on the spindle. Filtered air discharges into the "clean-room" compartment now enclosing the disk and maintains positive pressure to keep out dust. Thus the recording disks are never handled or exposed directly to the air, and so it is hoped their surfaces will hold up longer than those of more easily contaminated disk-packs.

Breadth of air. "With pressurized air already in the machine, we began thinking about fluidic logic control. It seemed natural," says Lambert. They soon realized that fluidics could eliminate electrical noise of relay-controlled systems which can distort readouts and cause error. Such electromagnetic noise also could trigger optoelectronic sensing schemes. Thus, the job of sensing disk position and assuring the proper 100-microinch distance below the heads also is done with fluidics. "Interference and false alarms are cut, and there are no electromechanical failure mechanisms to fret about," says Lambert.

The fluidic logic system, supplied by Pitney-Bowes, comprises 80 NOR gates in a laminated block about the size of a small brick. An antipollution pump from a Ford car supplies pressurized air which feeds both the air bearing system and fluidic logic; a 1-microinch fine air filter strains out dust and contaminants.

Thus fluidic sensors, switches, and logic help position the disk on its spindle, control the position of the spindle itself, and operate the electric motor drive. Furthermore, through diaphragm or strain gage transistor switches, the fluidic system controls the status displays on the front panel. The system also monitors the spinning disk's position relative to the heads, preventing scraping, and warns of electronic and mechanical malfunctions.

Heads up. Each of the 16 head pads contains eight heads, making a total of 128 read-write heads. The system records five megabits on one surface of a disk. If more on-line storage is needed, up to three slave disk drives can be controlled from the basic DDR-1, to bring total accessible data up to 20 megabits.

Data transfer rate is 16 microseconds per 16-bit word plus parity and timing; average access time is 16.67 milliseconds with the maximum reaching 33.3 msec.

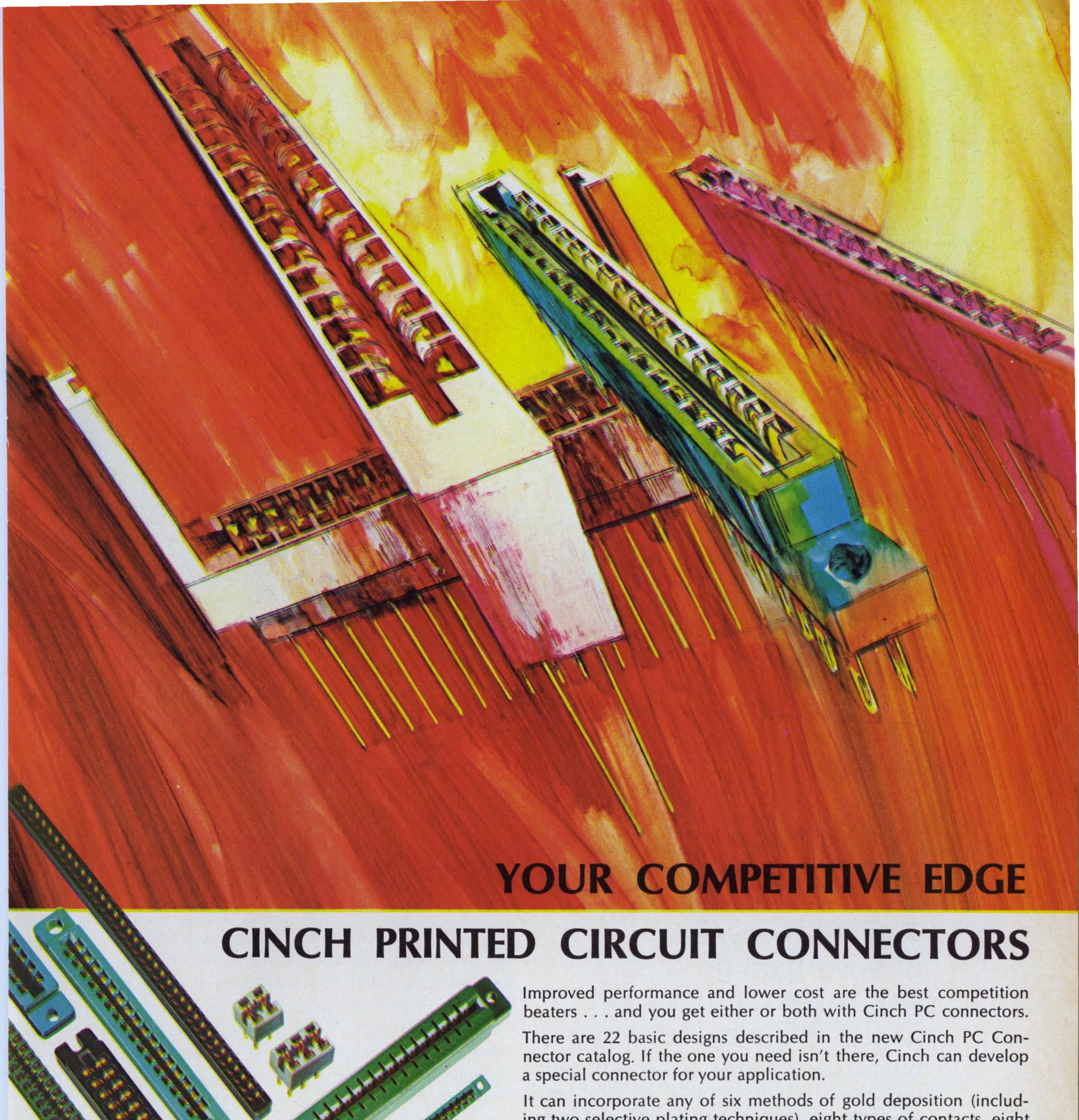
For reliability, each of the 16 head pads has its own read-write circuitry. Thus, if one read-write block fails, 15/16ths of the data is still available.

DISC's anticipation logic is aimed at easing the load of time sharing or multiprograming operations. Large machines usually have hand-wired interrupt features that allow programs, data, and interim results to be stored quickly and easily. By contrast, smaller slower machines generally do fewer tasks in parallel, and an interrupt may force them to dump work already done.

With the DDR-1, when a computer requests data in a given position, the DDR-1 notes this. At a certain number of microseconds before readout, it warns the computer that the data will soon arrive. Thus the computer's software can be written to allow the processor enough time to efficiently prepare for the data.

The DDR-1 is priced at about $14,500 minus OEM discounts. Delivery time is 90 days.

Digital Information Storage Corp., 100 Carter St., Berlin, Mass. 01503 **[338]**



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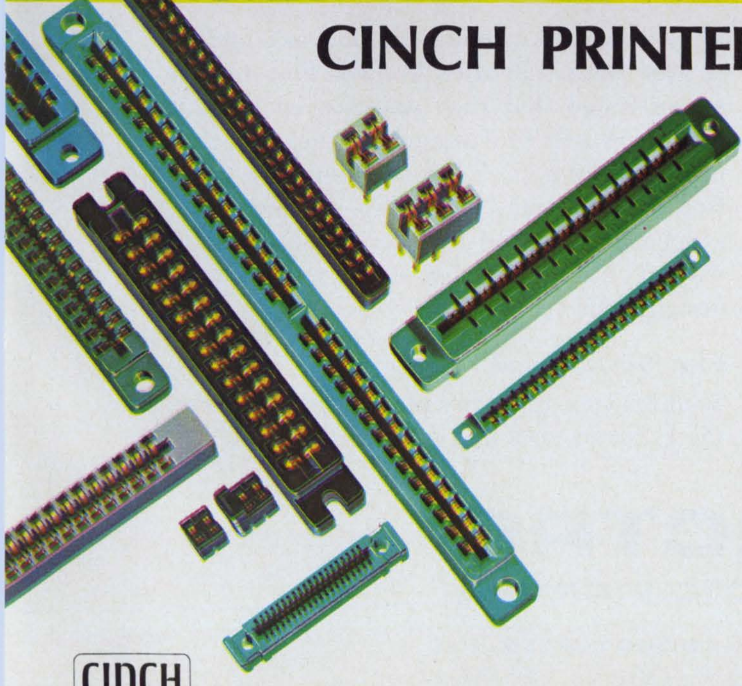

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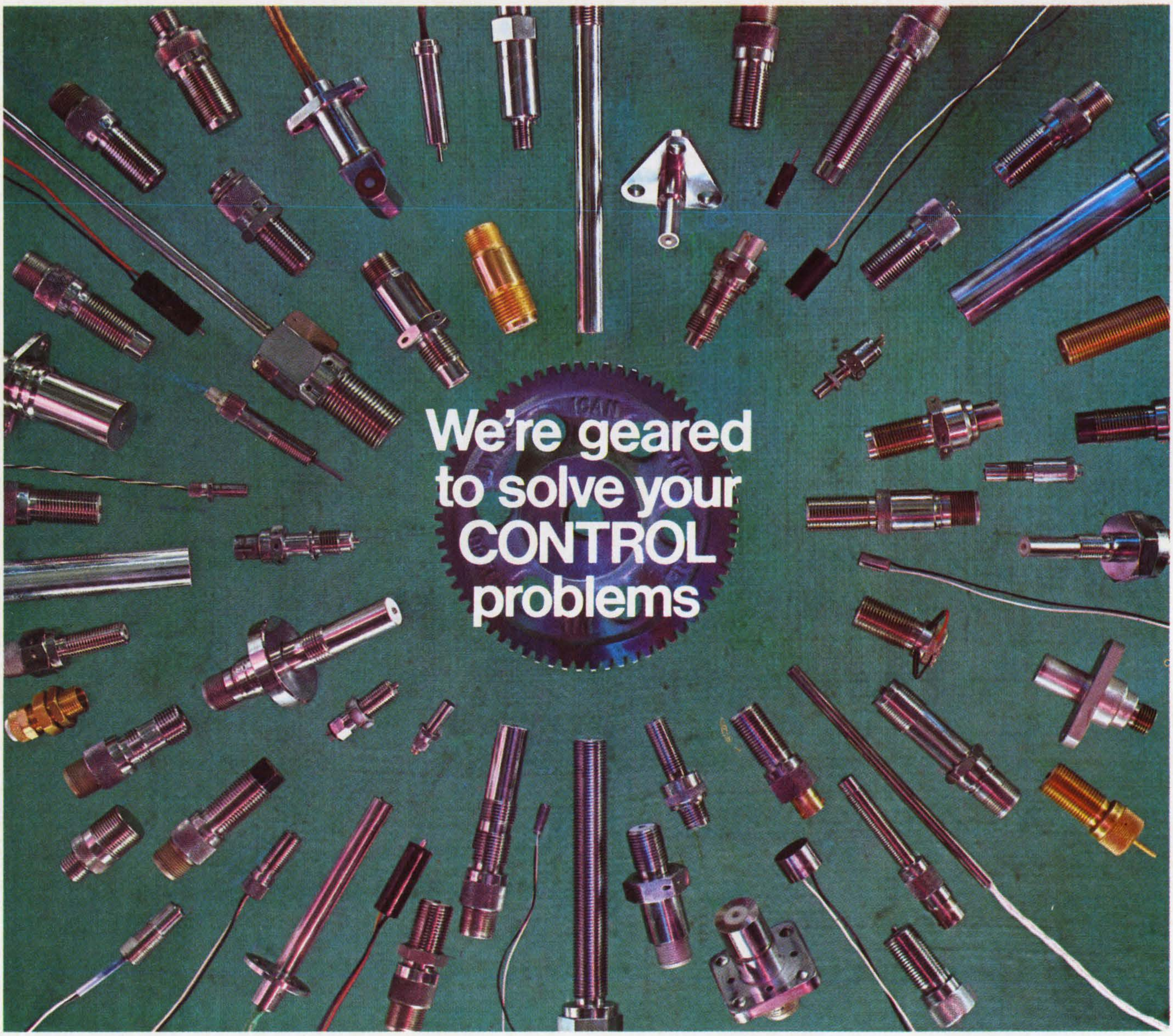

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A miniprinter for minicomputers

200-lines-per-minute unit will sell to equipment manufacturers for $6,000; IC controls made possible by lightweight, spring-loaded hammer mechanism

By James Brinton
Associate editor

Small, low-cost computers generate a demand for inexpensive peripheral equipment; users don't like to spend more for an accessory than for their processor. This explains some of the drive for inexpensive crt terminals, memories, modems, and other peripherals. But line printers have lagged behind, with many "lower"-priced printers costing as much as $10,000 more than OEM price for a minicomputer, and with those in the $7,000 to $10,000 bracket offering restricted specs.

A printer with 200-line-per-minute speed, and with most of the features found on larger machines, at a price of about $6,000 in OEM lots and $10,000 in unit orders, is the first product of Nortec Computer Devices Inc., Ashland, Mass. Nortec vice president Richard Holtzman hopes the model 200 is the "Volkswagen-type printer" that makers and users of minicomputers may have been waiting for. It will be introduced at the Fall Joint Computer Conference in Las Vegas, Nov. 18-20.

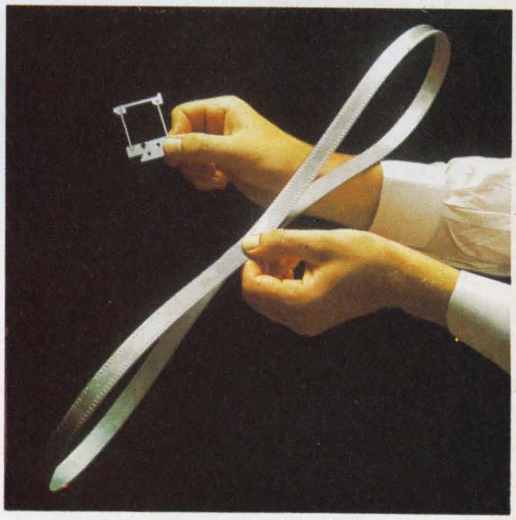
Nortec cut costs by using more electronics and less electrical and mechanical gear. It came up with a printer little larger than an electric typewriter. "Instead of being as big as a desk, the model 200 fits on top of one," says Holtzman, "and its other parameters are in proportion." The machine weighs less than 100 pounds, and needs only about 300 watts of power.

"It's necessary to know what the model 200 isn't to understand what it is," says Holtzman. It isn't a drum- or chain-type printer. In those devices, a heavy metal cylinder with raised letters spins in front of an array of solenoid-controlled hammers, and as the proper letter appears along the line being printed, banks of relays fire the appropriate hammers, which squeeze the paper and ink ribbon between themselves and the drum. Chain printers are similar, but substitute a sidewise moving link belt for the horizontally spinning drum. Both systems require high current for banks of hammer solenoids. This usually means heavy equipment for relay switching and bulky power supplies. Holtzman says that some of the power supplies now in use weigh more than the whole Nortec 200. By contrast, the 200's supply fits on a single circuit board.

The chain and drum in printers also are heavy, and expensive to manufacture. For them Nortec substitutes a thin alloy belt, said to be lighter and both easier and less costly to produce. For solenoid hammers, Nortec has substituted smaller, lighter spring-loaded hammers, cocked by the paper advance system, and fired by energizing a small coil to neutralize the holding force of a magnet latch.

These coils in turn are controlled by an integrated-circuit hammer selection and switching matrix.

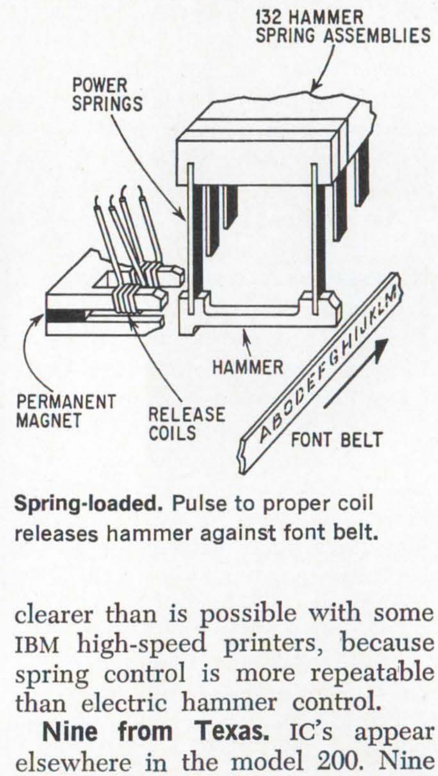
The hammer design is basic to many of Nortec's economies. Since the designers of the 200 didn't have



Small and light. Desktop-size printer swings open in front for loading convenience. Font belt, shown above with one of the print hammers, takes the place of chains and drums used in many printers.

to worry about the rise time of solenoid hammer actuators—the lag time between application of a pulse and the point at which the hammer begins to move—they didn't have to begin one set of pulses before terminating others. Thus the current needed at any given time is lessened. Also, the mechanical energy needed to thrust the hammer against the paper and font belt is supplied by springs, not by a solenoid, and so current requirements are cut further.

These two factors reduce current enough so that the control of the hammers can be performed using a small power supply and integrated circuits rather than relays, or even discrete transistors. Also, says Holtzman, print quality, even down to the sixth carbon copy, is



Spring-loaded. Pulse to proper coil releases hammer against font belt.

clearer than is possible with some IBM high-speed printers, because spring control is more repeatable than electric hammer control.

Nine from Texas. IC's appear elsewhere in the model 200. Nine dual 50-bit MOS/LSI static shift registers from Texas Instruments form the heart of the model 200's buffer system. The buffer accepts parallel 6-bit character identification data from most small computers without modification. Input data rate is as high as 500 kilohertz, and the buffer holds a full-line width of 132 characters.

Most printers use a system of gears, chains, or encoders to synchronize arrival of a hammer blow with the appearance of a letter on a chain or drum. Nortec instead

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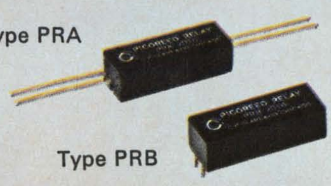
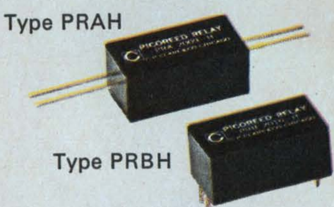


Type PRB

High Sensitivity

Type PRAH



Type PRBH

Electrical and Dimensional Characteristics	Types PRA/PRB—Low Profile		Types PRAH/PRBH—High Sensitivity	
	Form 1A	Form 5A	Form 1A	Form 5A
Operate time, including bounce	500 µs	600 µs	600 µs	900 µs
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Pcb mounting centers	.375"	.375"	.500"	.500"
Length	.781	.800	.800	.800
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*Widths vary according to number of switches. One through 5 available.

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places a magnetic code on the font belt beneath each letter, and adds an additional code location to tell when the belt has made a full revolution. The code is read with a reluctance-sensitive pickup and the results sent in turn to a code character generator and a digital comparator. The former tells the comparator what letters are where at any given time, and the comparator checks this information against data in the MOS buffer. And if the information matches, the comparator circuit triggers the hammer-release electronics to print the desired character.

Nortec's electronic timing is said to eliminate print position errors that otherwise would creep in, caused by gear backlash, slipping pulleys, or other mechanical factors.

The character generator, comparator, and hammer control electronics are all IC, with the hammer release circuits being custom-made, multistage pulse power amplifiers capable of 2-amp, 0.5-millisecond pulses.

Each pulse is shared among five hammers, with only one of the five printing when a transistor switch closes the circuit.

Because IC's are smaller and less costly than gears, relays and the like, Nortec has been able to design into its machine several control and mechanical features much like those found on printers selling for $15,000 or more, according to Holtzman.

Among them are tape-controlled vertical formatting, variable width (any width up to 132 columns), lateral positioning (with a vernier for adjustments as small as ± 0.05 inch), and adjustable hammer impact.

The company plans delivery of the first printers within three months after introduction of the machine at the FJCC.

Specifications

Character set	64 alphanumeric characters (cols 2 through 5 on ASCII chart)
Paper advance	10 inches per second slew, one line in 25 milliseconds
Size	22.5 x 9.5 x 20 inches

Nortec Computer Devices Inc., 95 Nickerson St., Ashland, Mass. 01721 [339]

Light-emitting diode seeks mass market

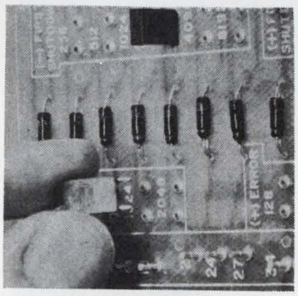
Long-lived unit challenges subminiature incandescent lamps for use in printed-circuit boards, panels, optical logic cards

Though available for about five years, light-emitting diodes have been largely confined to high-price, low-volume applications. Now Monsanto is marketing its gallium arsenide phosphide units for high-volume jobs at a reduced price of $1.50 each in quantities of 1,000. One of the principal reasons for lower manufacturing costs, Monsanto says, is batch fabrication using the lead-frame technique, a production-line method first developed for transistors.

Monsanto claims the visible solid state light source, designated the MV 50, already has proven its superior reliability—the device has a calculated lifetime of nearly 1 million hours, against the 5,000-hour lifespan of incandescent lamps.

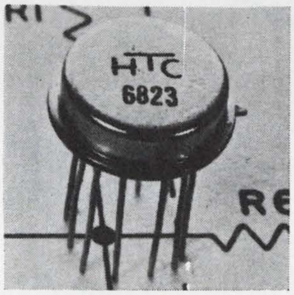
The biggest disadvantage of filament lamps is their large inrush or initial current, which can be 12 times as great as normal operating current. And their weak filaments reduce reliability under rugged conditions.

The MV 50 however, has no problem with either the filament or the inrush current. The light source is a diffused, planar, gallium arsenide

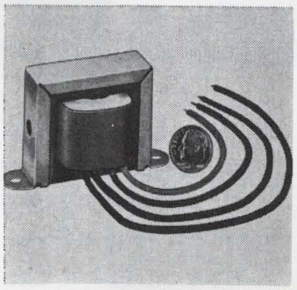


Sized-to-order Cirkut Socket allows direct plug-in to circuit boards of component and connector leads of varying diameter. Sockets are installed in circuit boards by a simple swaging operation with a die set and standard arbor-press. Installed profile of the socket projects 0.040 in. above the p-c board surface. SAE Advanced Packaging, E. Edinger Ave., Santa Ana, Calif. [341]

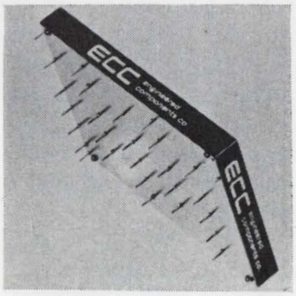
Wirewound power resistors in the WP line have a standard total resistance tolerance of only 1%. They are stocked in a variety of 9 sizes and styles ranging from 0.078 x 0.250 in. to 0.375 x 1.780 in. in ratings from 0.4 to 11 watts. Maximum resistance ratings are available from 3.5 kilohms to 200 kilohms. Nytronics Inc., 550 Springfield Ave., Berkeley Heights, N.J. 07922 [342]



Timing module in a TO-8 case measures 0.5 in. in diameter by 0.170 in. in height. It provides time delays of from 1/10 to 100 sec with an accuracy of ±3% and a repeatability of ±2%. Type 333-35001 features an scr output rated at ½ amp at 28 to 32 v d-c. It is suited for airborne and industrial use. Price is $25. Hi-Tek Corp., 2220 So. Anne St., Santa Ana, Calif. [343]

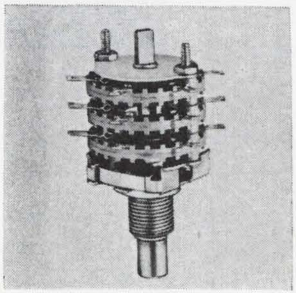


Silicon and selenium rectifier power transformers series RT feature multiple primary taps to provide a large range of secondary a-c output voltages under load. Voltages vary from 11 to 29 volts or 25 to 53 volts, depending upon which transformer is in use. Prices (1-9) range from $7 to $77 each; availabilty, from stock. Essex International Inc., 3501 W. Addison St., Chicago [344]

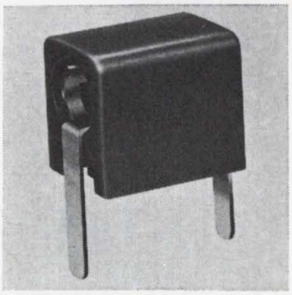


Delay line series 25 is a lumped-constant unit that can be tapped at any or all single nsec increments between 1 and 25. Attenuation is less than 0.06 db and rise time is 4 nsec in both the 50 and 90 ohm versions. Unit is encapsulated with epoxy in a diallyl phthalate case 1.40 x 2 x 0.225 in. Engineered Components Co., 2134 West Rosecrans Ave., Gardena, Calif. [345]

Relay series 600 (4pdt) is for aircraft, missile and ground support equipment power switching. It is rated at 10 amps for 100,000 cycles minimum at 28 v d-c. Its contact mechanism delivers a positive wedge-wiping action which cuts through surface films to create a continual self-cleaning of the contacts during make and break movements. Electro-Tec Corp., Ormond Beach, Fla. [346]

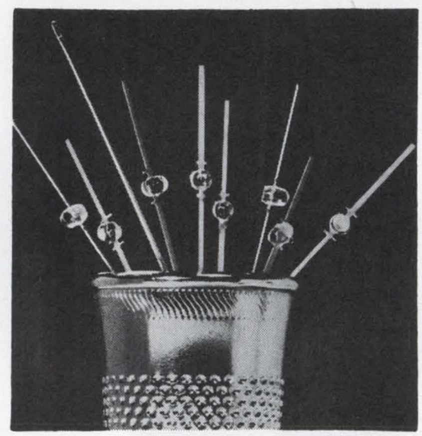


Selector switch series 223 for instrumentation and industrial controls is 1 in. in diameter and provides 0.812-in. strut screw spacing. It has a double-ball detent with 30° indexing from 2 to 12 positions. Detent rotational life is rated at 100,000 cycles through 12 positions and return at 10 cycles per minute. CTS Electronics Inc., 1010 Sycamore Ave., S. Pasadena, Calif. [347]



Horizontal p-c jack measures 0.203 in. high (mounted), 0.208 in. long and 0.150 in. wide. It accepts an 0.080 in. diameter tip plug at either end. It has maximum current capacity of 5 amps and an operating voltage of 1,500 v rms at sea level. Contact resistance is less than 2 milliohms. Unit is available in 10 colors. E.F. Johnson Co., Waseca, Minn. 56093 [348] phosphide diode that needs only 0.03 watt driving power to generate 750 foot-lamberts of brightness. And because of its low power requirements, the device is compatible with integrated circuits, where it is expected to find its widest applications. It requires 1.6 to 2.0 volts input, and can be switched at speeds as fast as 1 nanosecond, according to Monsanto engineers.

Its 0.08-inch-diameter lens makes the MV 50 suitable as an indicator for use in computer systems and electronic data processing equipment, as an on-off indicator for instruments, or as an element in large visual arrays and optical logic systems. And Monsanto is aiming at such high-volume applications as diagnostic lights on printed-circuit boards and panels.



Point sources. Light diodes with leads are batch-processed.

The MV 50 can be used to replace miniature and subminiature lamps as small as the T3/4 size.

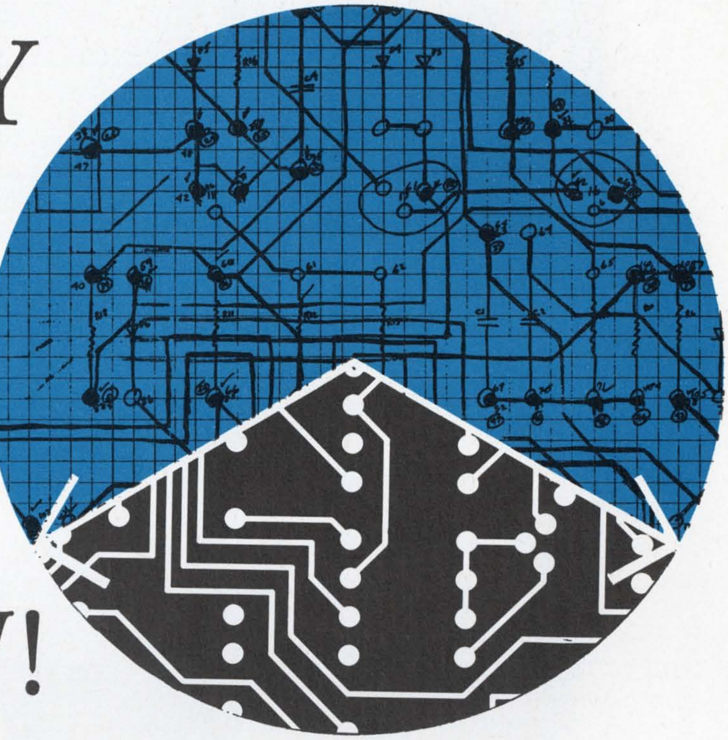
Simultaneously, Monsanto will market another light-emitting diode that the company calls the highest-power unit of its type on the market. Designated the MV4, it emits 5,000 foot/lamberts and requires a 2-watt, 1-amp input.

Specifications (maximum)

Power dissipation at 25°C ambient	70 mw
Derate linearly from 25°C	1.6 mw/°C
Storage temperature	—55°C to 100°C
Operating temperature	70°C
Continuous forward current	40 ma
Reverse voltage	3 v

Monsanto Electronic Special Products, 10131 Bubb Road, Cupertino, Calif. 95014 **[350]**

TODAY YOUR CLOCK IS 32 HOURS SLOW!



And, you can lose a valuable 32 hours on every circuit board film master you produce . . . unless, of course, you have a SLO-SYN® N/C Photo Artwork Generator to shave those 32 hours from the time it normally takes from printed circuit board sketch to finished size film master.

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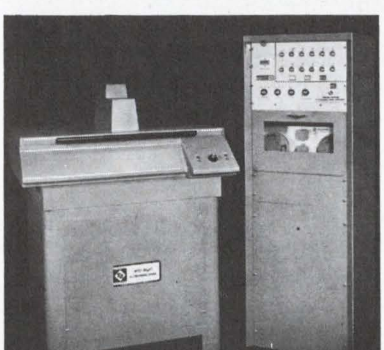

Other systems include conventional and cantilever style positioning tables and complete machines for PC board drilling, wire terminating and eyelet insertion. Request complete literature file.

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New components

Hybrid op amps offer low drift

Converter units are temperature-compensated and miniaturized

Low amplifier drift under wide ambient temperature changes is essential to stable analog-digital and digital-analog converter performance. To meet this requirement, the Quantum Devices Corp. has developed four hybrid, temperature-compensated miniature operational amplifiers featuring offset voltage drift as low as ±0.5 microvolt per °C, while maximum internal temperature change can be held to 10°C/100°C ambient temperature swing.

The amplifiers, designated as models 08304, 08305, 08301A, and 08302, offer maximum drifts of ±0.5, ±1, ±1.5, and ±3 μv/°C, respectively. The dual in-line devices measure 0.78-inch long, 0.28-inch wide, and 0.15-inch high, and can be mounted on a printed-circuit card or inserted into a standard 14-pin dual in-line connector. The operating ambient temperature range of the amplifiers is from −25°C to +75°C. The model 08304, the most sensitive unit, has only a ±5°C change in the temperature of the hybrid substrate and is priced at $85 singly or $72 in quantities of 100.

Each of the units is capable of accepting both inverted and noninverted inputs. Open-loop gain is 150,000. Unity gain is achieved by adding an external resistor; voltage offset can be trimmed to zero through a potentiometer. The amplifiers are internally frequency-compensated and have circuit protection on both the input and output stages. The temperature-compensation circuit requires external bias voltages of +15 volts and −15 volts; each bias supply provides 20 milliamps.

Delivery is from stock.

Quantum Devices Corp., 15 West Main St., Bergenfield, N.J. 07621 **[350]**

When accuracy is important – and noise, harmonic distortion, or nonsinusoidal wave shapes are a problem – a true rms responding voltmeter is the only answer.

With the HP 3450A digital multifunction meter you get **true** rms readings! The AC Voltage and AC Ratio (Option 001) makes the 3450A the only five-digit DVM available today with this capability. And you not only get **true** rms readings, but you get them from 45 Hz to 1 MHz on any of four ranges (1 V to 1000 V). When you add the midband accuracy of ±0.05% you know that what you are reading or recording is the true value of the ac voltage you are measuring.

The same ac converter (Option 001) also provides true four-terminal ac ratio capability. Gives you the complete isolation you need between X and Y inputs to make accurate ratio measurements between two ac voltages. Four ranges (1:1 to 1000:1) of true four-terminal ac ratio are provided. Option 001 gives the 3450A the capability to make fast, accurate ac readings for **all** the ac information you need.

And, true rms ac voltage measurement is only one face of the incredible dodecameter! The 3450A can also be used for dc and ohms – with ratio, limit tests and ratio limit tests. You get autoranging on all functions and there are options to provide remote control and rear input terminals.

The basic dc unit is integrating and fully guarded for excellent noise immunity. You can make 15 readings per second with a sensitivity of 1 μV. You start with this basic meter and add the capability that best fits your requirements. If your requirements change, any of the options (except the rear input terminals) can be easily installed in the field.

To get more information on how rms readings will improve the quality of your ac measurements or on any of the other options for the 3450 – just call your local HP Field Engineer. Or, write Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

Price: Basic 3450A, $3150; AC Option 001, $1250; Ohms Option 002, $400; Limit Test Option 003, $350; Digital Output Option 004, $175; Remote Control Option 005, $225; Rear Input Terminal Option 006, $50.

099/21

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- DM15, DM16, DM19, DM20 . . . perfect for miniaturization and for new designs using printed wiring circuits. Also available in DM30, DM42 and DM43.
- New "hairpin" parallel leads insure easy application.
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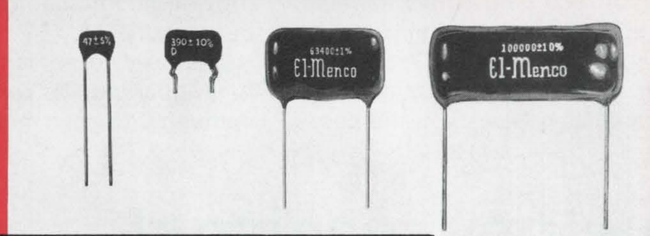

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Design Versatility!

- Available in 350 VDC and 500 VDC as well as other test voltages.
- All bases are of low-loss steatite.
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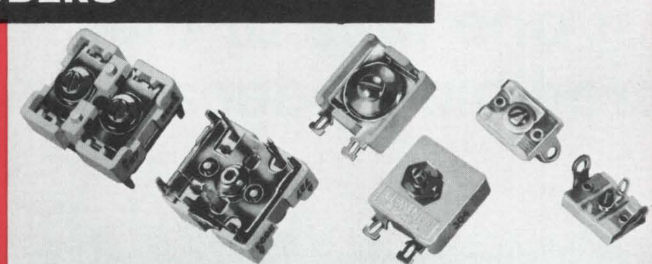
- Miniature units are available.
- Solder Lugs can be bent in any position without affecting the capacity setting due to the rigid construction.
- Various types of mounting brackets are available for all trimmers.
- Units can be constructed for special applications.

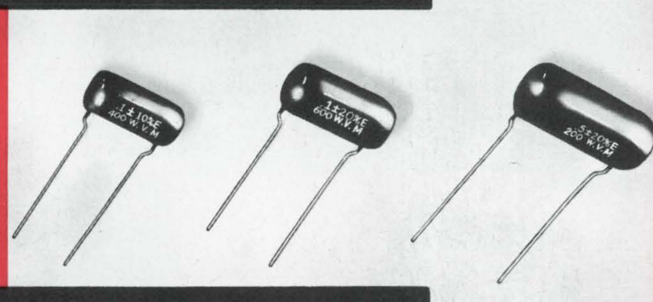


EL-MENCO *MYLAR-PAPER DIPPED CAPACITORS

Only 1 Failure in 7,168,000 Unit-Hours!

- Life tests at 100°C with rated voltage applied have yielding only 1 FAILURE PER 716,800 UNIT-HOURS for 1 MFD. Since the number of unit-hours of these capacitors is inversely proportional to the capacitance, 0.1 MFD Mylar-Paper Dipped capacitors will yield only 1 FAILURE PER 7,168,000 UNIT-HOURS!
- Working volts DC: 200, 400, 600, 1000 and 1600.
- Durez phenolic resin impregnated.
- Tolerances: ± 10% and ±20% (closer tolerances available).
- Dielectric strength: 2 or 2½ times rated voltage, depending upon working voltage.
- Exceed all electrical requirements of E.I.A. specification RS-164 and military specifications MIL-C-91A and MIL-C-25A.

*Registered Trademark of DuPont Co.



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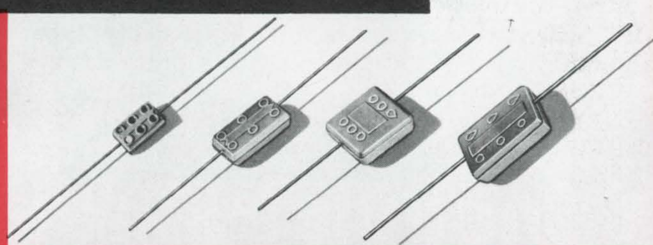

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Monolithic memories carry five-year warranty

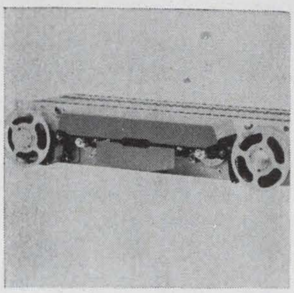
Quartz-sealing of chips and solder-reflow bonding are used in manufacture; complete system including logic is contained on a single card

Although the technology is less than five years old, monolithic semiconductor memories have advanced to the stage where high-reliability claims will be backed by a five-year warranty.

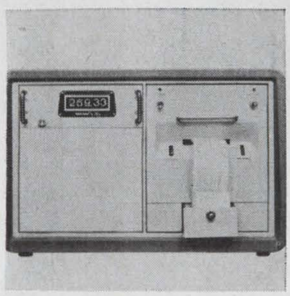
The warranty is offered by the Cogar Corp., a company formed in 1968 by a group of former employees of the Mohawk Data Sciences Corp. and IBM. The memory systems, to be available early next year, will be guaranteed for five years against all defects and failures, a precedent-making move by Cogar. Most manufacturers guarantee their memories for 90 days.

Cogar's first series of products will provide in the semiconductor memory market what Sanders Associates' Memcards offer in the ferrite-core segment of the business—a complete storage and logic system on a single card [*Electronics*, Dec. 9, 1968, p. 144]. The Cogar systems will be offered in bit capacities of from 10,000 to 5 million and in cycle times of from 80 to 300 nanoseconds.

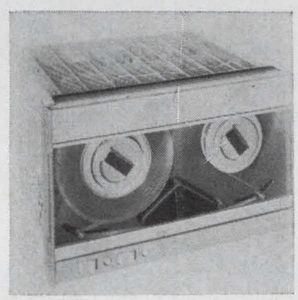
The company's initial product line includes three general classes of memory: high-performance, where maximum speed is manda-



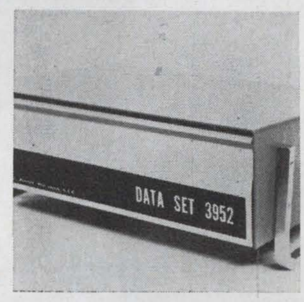
Photoelectric punched tape readers series 5000 are capable of two years of continuous operation with simple operator maintenance. Readers and handlers operate to 625 characters per sec synchronous and 300 cps asynchronous. Tape capacity may be specified from 100 ft of fan-fold to 1,000 ft of tape on the TH500 handler. Chalco Engineering Corp., S. Broadway, Gardena, Calif. [401]



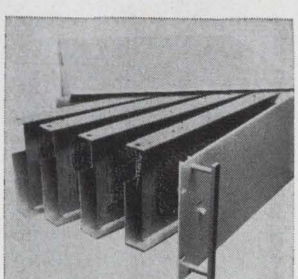
Data monitor DM-1 provides continuous digital readout as well as a printed record of remotely-located analog variables. The parameter being monitored may be an angular rotation, a synchro or resolver output, or the voltage output from a pot or load cell. Range is 0 to 9999; accuracy, 1 part in 10,000; printing rate, 3 lines per sec. Theta Instrument Corp., Fairfield, N.J. [402]



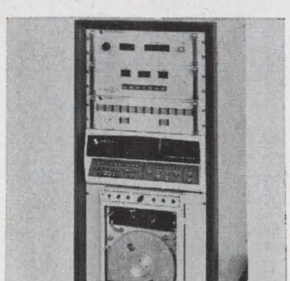
Magnetic tape handler model 3600 is for the small digital computer data acquisition, and data communication fields. It is IBM 360-compatible, sells at under $3,000, operates at 24 ips, handles 8½-in. reels and includes all read/write, servo and motion control elctronics. It handles 800, 556, or 200 bpi, ½-in. wide tape. Digitronics Corp., Albertson, N.Y. [403]



High speed modem model 3952 is for digital data communications. It transmits and receives serial binary data over a voice bandwidth at a synchronous rate of 2,400 bits per second. It is designed for use with all present-day transmission equipment including conventional and dedicated telephone lines, power lines, microwave and radio. RFL Industries Inc., Boonton, N.J. 07005 [404]



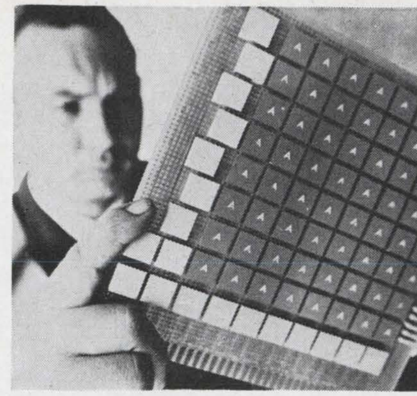
Controller series 1200 models are available for interfacing the 7200 series disk memories with most small computer systems. The 1200 operates up to four 7200 series memories. Each memory has a capacity of 6.4 million bits, and an average access time of 17 msec. Typical controller cost is less than $8,000. Data Disc Inc., 1275 California Ave., Palo Alto, Calif. 94304 [405]



Computerized data logger model 100C makes it possible to monitor up to 100 analog points, translate into binary data and instantaneously produce finished computations in engineering units. The computer has a 4,096 word core memory, expandable up to 16,381 words. All software is provided from the factory. A. D. Data Systems Inc., Linden Ave., Rochester, N.Y. [406]

Eleven-high disk storage drive designated ISS714 has an access time ranging from 10 to 60 msec. It maintains complete disk pack and data compatibility with the IBM2314. The unit provides storage of 29 million bytes at a data transfer rate of 312,000 bytes per sec, and utilizes the 20 recording surface. Information Storage Systems Inc., N. Tantau Ave., Cupertino, Calif. [407]

High speed communications computer model 15 will interface directly with the IBM360, Burroughs 5500 and Univac 1108 computers. Two or more semi-autonomous processors operate in a foreground/background relationship to balance the teleprocessing load on the system. Price is between $40,000 and $70,000, depending upon options. Interdata, Oceanport, N.J. 07757 [408]



Complete. Array modules, drivers, other functions are on single card.

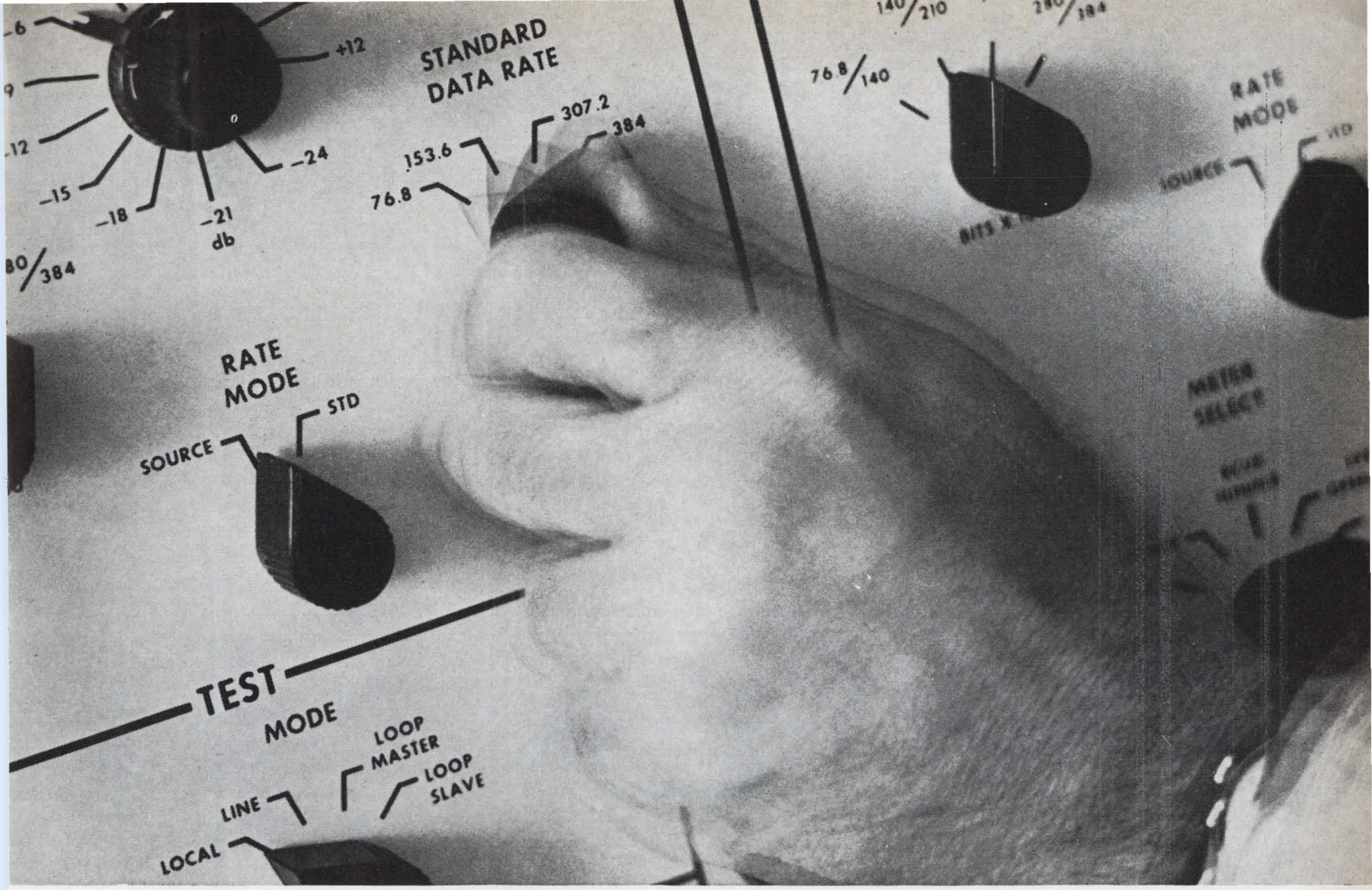
tory; medium-performance, where speed is still important but less so; and cost-performance, where capacity is more important than speed. All three classes are available as either read-write or read-only memories, and all three kinds of cards can be paralleled to create large-capacity memories.

Circuits in the high-performance line are compatible with emitter-coupled logic, although they are not themselves ECL circuits. They are a modified multiemitter circuit similar in appearance to transistor-transistor logic, but capable of higher speeds. The medium-performance units are made of TTL and diode-transistor circuits, while metal oxide semiconductors are used in the cost-performance models of the memory.

The guarantee is made possible by advanced manufacturing techniques such as sealing the silicon chips onto the substrate with a thin film of quartz, applied by sputtering. This is the same process IBM uses in its solid-logic-technology hybrid microcircuits; Cogar has obtained a license from IBM to use the process. But unlike IBM, Cogar encloses the circuits in a metal container that is just clipped on; anybody can, with a little effort, pry the container off and look at the circuit underneath without damaging it. IBM's circuits are encapsulated in plastic.

Also expected to add to reliability are the use of computer-generated masks, a solder-reflow bonding process, and extensive quality control and computer-controlled testing procedures.

Cogar Corp., All Angels Road, Wappinger, N.Y. **[409]**



Our new modem just set a speed record: 384,000 bits per second.

Finally somebody has developed high speed modems that can grow as your communications system grows.

With two new IBM modems, all you do to upgrade is flip a selector switch. Custom-built for government applications, the speed can be varied from 9600 all the way to 384,000 bits per second.

One mil spec modem (AN/USC-25) operates on a wideband 240 khz channel without expensive automatic equalization. It can be equalized quickly with built-in fixed and manual controls.

Another model, AN/USC-24, operates from 9600 to 76.8 bits per second on 48 khz channels.

It has an average error rate of only one in a million bits. Other features: independent full duplex capability, and built-in self test.

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Circle 167 on reader service card

Memory cycles in 200 nsec

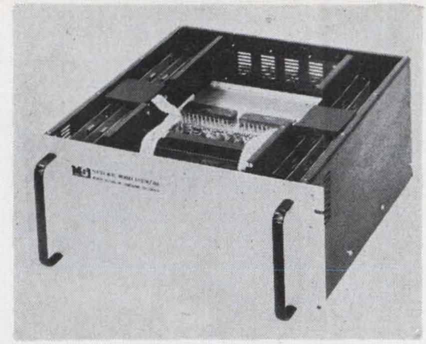
Plated-wire system designed for control, buffering, special jobs

Nature abhors a vacuum—and so do creative computer systems developers. Bruce Kaufman, president of Memory Systems Inc., found that the direction of wire-plated memories, aimed largely at military applications, main-frame computer memories, and in-house corporate needs, was leaving an important gap—the special-purpose memory sector. So his new company stepped in to fill the vacuum with its System/200, a 36,000-bit memory system with a 200-nanosecond cycle time and nondestructive readout. The plated wires are horseshoe-shaped, so that the word wire crosses each bit twice.

The system's capacity is 1,024 36-bit words, with options of 4,096 9-bit words or 2,048 18-bit words. Read access time is 120 nsec maximum, with a random access mode in which the selected address is generated by a 10-bit binary number. Word current is 700 milliamps, read or write, with one-turn word strap. In addition to permitting NDRO, the equal read-write word-drive currents simplify circuitry because the word-drivers need drive only one current level, Kaufman says. Bit currents are ±45 ma; the Texas Instruments 74-H family of high-speed transistor-transistor-logic gates are used as digit drivers.

The system package is mounted in a standard 19-inch rack, and uses a 115-volt power supply. Environmental operating limits are +15°C to +45°C.

The word-select matrix uses an ITT 2N3725 transistor per word line instead of a diode per line because diodes tend to develop capacitance at speeds faster than one-half microsecond, says Kaufman. The transistors are used in a floating switch configuration so that the current flows in a loop and



Storage module. Memory is designed for special tasks in systems.

doesn't leak into the circuit. To assure a clean wave form, all the word lines are shunt-terminated with 0.25-watt shunt resistors, and transmission line problems are minimized through impedance matching.

The system organization is 2-D multiplex, utilizing a large memory word in which either the upper or lower half are selected from 72 readout signals for a 36-bit output. Each of 36 RCA 3000 series integrated-circuit sense amplifiers is switched between two channels; the sense amplifiers are driven and selected by 72 gated preamplifiers. High-speed TTL is used in the system both internally and at the interface port. Interconnection within the system is through a printed-circuit mother board. Several interface options are available, including a sequential access buffer with a counter, and a 100-nsec read cycle achieved at the expense of slower write time.

Kaufman says the System/200's cycle time compares favorably with other plated-wire memories, including Univac's 600-nsec memory built for the 9000 computer, and Toko's 500-nsec memory without nondestructive readout.

He predicts the system will find wide use as a cache store in systems with memory hierarchies, as a control memory, and as a mainframe storage memory for small, fast central processing units. It also may be used in high-speed pattern generators for LSI testing, and fast Fourier transform processors, according to Kaufman. The price is about 10 cents per bit in quantities of 50 memories or more. Delivery time is 60 days.

Memory Systems Inc., Hawthorne, Calif. [410]

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Controller features a stored program

Modular unit is adaptable for monitoring data, tests, lighting, and communications

When is a computer not a computer? When it's a low-cost digital controller such as the H-112, developed by Honeywell's Computer Control division. The $5,000 unit, which has almost everything that a computer has except an extensive arithmetic unit, can be used either independently or as part of a computer system to control or monitor data flow.

The H-112, latest entry into the control segment of the data-processing industry, is a stored-program machine. Honeywell says this flexibility makes it suitable for use in data acquisition, where it may act as a remote terminal, a buffer unit, or as an electronic data assembler and message switcher. It also may be employed to control test equipment, conveyor systems, numerical-control machines, graphic displays, lighting systems, or communications networks.

Modular in design, the H-112 contains a plug-in control panel, a 4,096-word, 12-bit memory, a logic section, and power supply. The unit can be tailored to a variety of control applications by the use of standard digital and analog modules and subsystems.

Honeywell integrated-circuit logic modules are used throughout; they are similar to the modules in the company's series of 16-bit computers for control applications.

Memory is organized into 128-word sectors, 32 in the basic controller, and 64 with the optional 8-kilobit expanded memory. Cycle time is 1.69 microseconds.

The rack-mountable H-112 measures 19 inches wide, 7 inches high, and 26 inches deep. Power consumption is 200 watts.

Honeywell Computer Control Division, Old Connecticut Path, Framingham, Mass. 01701 [411]

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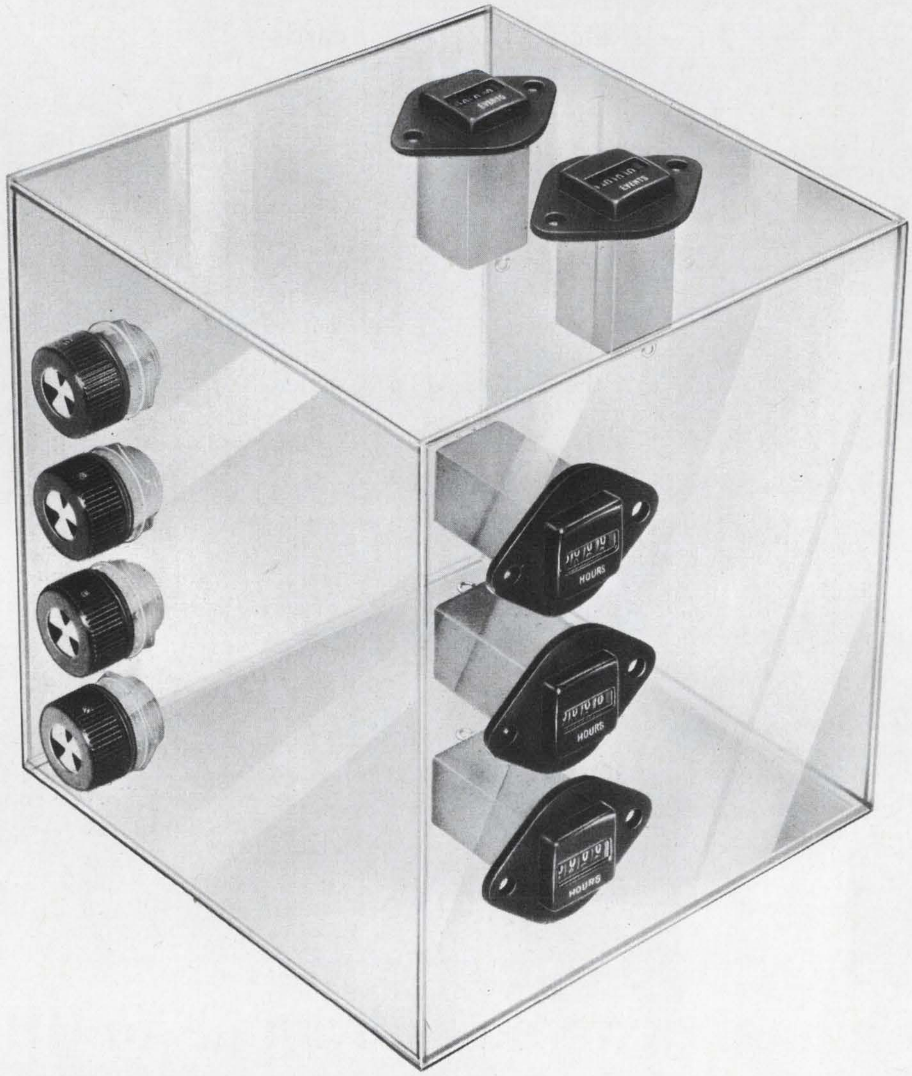
For additional technical information, or for Singer's new Application/Data Bulletin SG-10, contact your nearest Singer Field Representative or write directly to The Singer Company, Instrumentation Division, 915 Pembroke Street, Bridgeport, Conn. 06608. (203) 366-3201. *In Europe contact:* The Singer Company, Instrumentation Division, P.O. Box 301, 8034 Zurich, Switzerland, Telephone: (051) 47 25 10

SINGER
INSTRUMENTATION

**Hewlett-Packard Models 608F, 606A and 5245L/5253B./ Marconi Model 1066B/6, Pin Diode Modulator, Coaxial Switch*

 Circle 173 on reader service card

Maintainability³



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BITE INDICATORS • ELAPSED TIME INDICATORS • EVENTS COUNTERS • ROTARY SWITCHES • TRIMMER POTENTIOMETERS

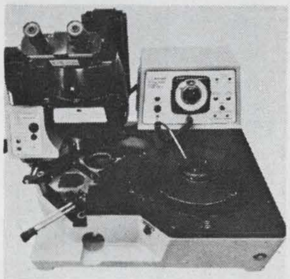
P-c artwork generated automatically

Price—and precision—of system geared to circuit board needs; special software package converts sketch data for input cards

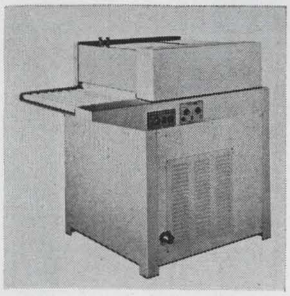
Generating masks for printed-circuit board fabrication can be an involved procedure, requiring drawing, cutting, and peeling a rubylith master, and then photographing and reducing it. However, a "turnkey" system manufactured by the Gerber Scientific Instrument Co. can considerably lighten the burden by automatically preparing p-c artwork from design sketches or engineering drawings.

Other automatic artwork generators are geared largely to integrated-circuit mask-making. With the very high accuracy required in this application, prices shoot up into the several-hundred-thousand-dollar range. The Gerber unit, called the System 40, is designed expressly for printed circuits, and extremely high accuracy isn't needed. The price is $55,000.

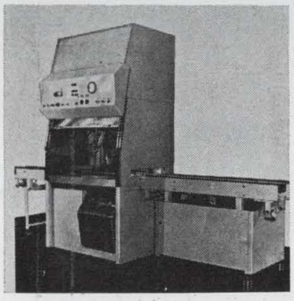
Dimensional data from the sketch is fed into the System 40 by punched cards prepared on an IBM 024 or 026 keypunch, or optionally, on an ASR-33 teletypewriter. A program, called Gerber Graphics Generator, or 3G, was developed by Applied Programming Technology, a Gerber subsidiary, to convert sketch data for the system's



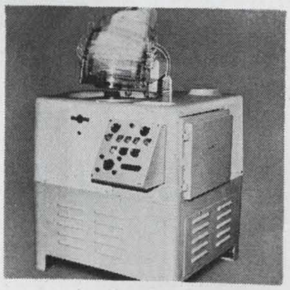
Optical mask alignment and exposure system model 500D offers operational flexibility and initial exposure rates as high as 430 wafers per hour. Wafer-to-mask alignment is accomplished by an X-Y joystick control. The system's vacuum chuck will accommodate wafers from 0.750 to 2.125 inches in diameter. Electroglas Inc., 150 Constitution Drive, Menlo Park, Calif. 94025 [421]



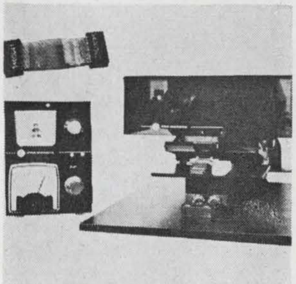
P-c board drier D-4 24-HPVC is a high pressure water rinse unit that cleans the boards after sanding or removes any other foreign matter that fills and clogs the holes. The high production unit takes up less than 12 sq ft of floor space, dries boards up to 24 inches wide and any length, and has a built-in sink and drain. Marco Engineering Co., Box 5247, Buena Park, Calif. [422]



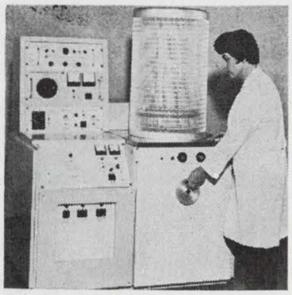
Conveyorized automatic precision coating system series 11000 provides uniform coatings as low as 5,000 angstroms at feed rates up to 10 ft per minute. Applications include photoresist on p-c boards and thin-film substrates, adhesives on frets for magnetic heads and laminates, and silicone for packaging and circuit protection. Zicon Corp., E. First St., Mt. Vernon, N.Y. [423]



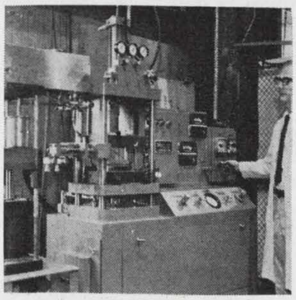
Automated wafer finishing machine simultaneously flat finishes both sides of silicon wafers, ceramic substrates and many other materials with surface finishes to one micron precision. One worker operating several machines can easily achieve production rates exceeding 1,000 high-precision 1-in. wafers or substrates an hour. P.R. Hoffman Co., 359 Cherry St., Carlisle, Pa. [424]



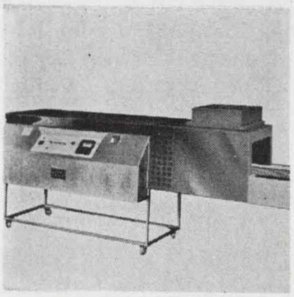
Flat flexible cable soldering systems series FS joins soldered connections rapidly and reliably using focused infrared heating techniques. Entire rows or groups of joints are soldered simultaneously and the heater never touches the workpiece. A complete row of terminations, as many as 200 joints, require less than 5 sec to complete. Argus Engineering Co., Hopewell, N.J. [425]



High-vacuum console model 625 features a design oriented toward continuous operation for high-level production of semiconductor devices or other high-vacuum processed products. Units are available manually controlled, with presettable sequencing timers, and with interlocking pushbutton controls. Davis & Wilder Inc., 1115 E. Arques Ave., Sunnyvale, Calif. 94086 [426]



Liquid transfer molding system can be used for encapsulation of a new range of electronic components as well as components presently encapsulated by transfer molding. A wide range of two-component-resin systems can be used, some with properties unobtainable by transfer molding. Extremely fragile devices can be encapsulated. Hull Corp., 9030-N Davisville Rd., Hatboro, Pa. [427]



Infrared oven F037-A is for fast drying and curing of silk screening, epoxies, and inks on p-c boards and other small parts. Parts are carried through the oven on a flat, continuous mesh conveyor belt. Conveyor speed can be varied from zero to 8 ft per minute. The oven has a built-in cooling section. Glo-Quartz Electric Heater Co., 188 N. Berkeley Ave., Pasadena, Calif. [428]

input cards.

Lights on. System 40 reads the cards and automatically plots the p-c-board interconnection pattern by exposing photographic film or glass plates. Because the plotting table has its own light-proof cabinet, the system can operate in a normally lighted room, which must be darkened only when the film is loaded and unloaded.

Plotting is both sufficiently accurate and fast for p-c work. Maximum error is ±0.0015 inch, and repeatability is ±0.0005 inch. Plotting can proceed at a maximum speed of 100 inches per minute over the 14-by-20-inch plotting area. The photohead, mounted on a beam over the plotting table, has 24 apertures which can be selected by the computer for flashing images

Artwork station. Photohead is mounted over plotting table. Light-proof cabinet forms a darkroom.

or tracing lines from 0.0005-inch to 0.250-inch wide. Because of its smallness, the System 40's table, instead of the photohead, is movable, whereas in other plotting modes the table is stationary.

After the whole pattern has been exposed on the film, it's removed from the cabinet and developed. There's no need for photographic reduction—a major source of error—since the film is plotted on a 1:1 relationship with the final p-c board.

The System 40's price includes plotting table, plotting control, photohead, and keypunch, as well as a complete software package.

The Gerber Scientific Instrument Co., 83 Gerber Road, South Windsor, Conn. 06087 **[429]**

Test drive the new Honeywell 2206 Visicorder

That's right. Go ahead and test drive it . . . mounted, for example, in an automobile. Or a tractor. Or on a piece of heavy machinery. Or even in a pleasure boat. This is the oscillograph that's built so rugged and so light-tight (with integral take-up), it goes where other recorders fear to tread. And that consumes only 150 watts . . . from a standard vehicle electrical system or from separate batteries . . . for complete portability.

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To arrange a test drive of our new Honeywell 2206 Visicorder or to just get more information, call your nearest regional sales manager (listed below), or write: Honeywell Test Instruments Division, P.O. Box 5227, Denver, Colo. 80217.

Regional sales offices: Albuquerque, NM (505) 345-1656, Dave Dimick; Chicago, IL (312) 674-9770, Frank Doherty; Long Island City, NY (212) 392-4300, John Paull; Los Angeles, CA (213) 724-3500, Durke Johnson; McLean, VA (703) 893-4660, Milt Womack.

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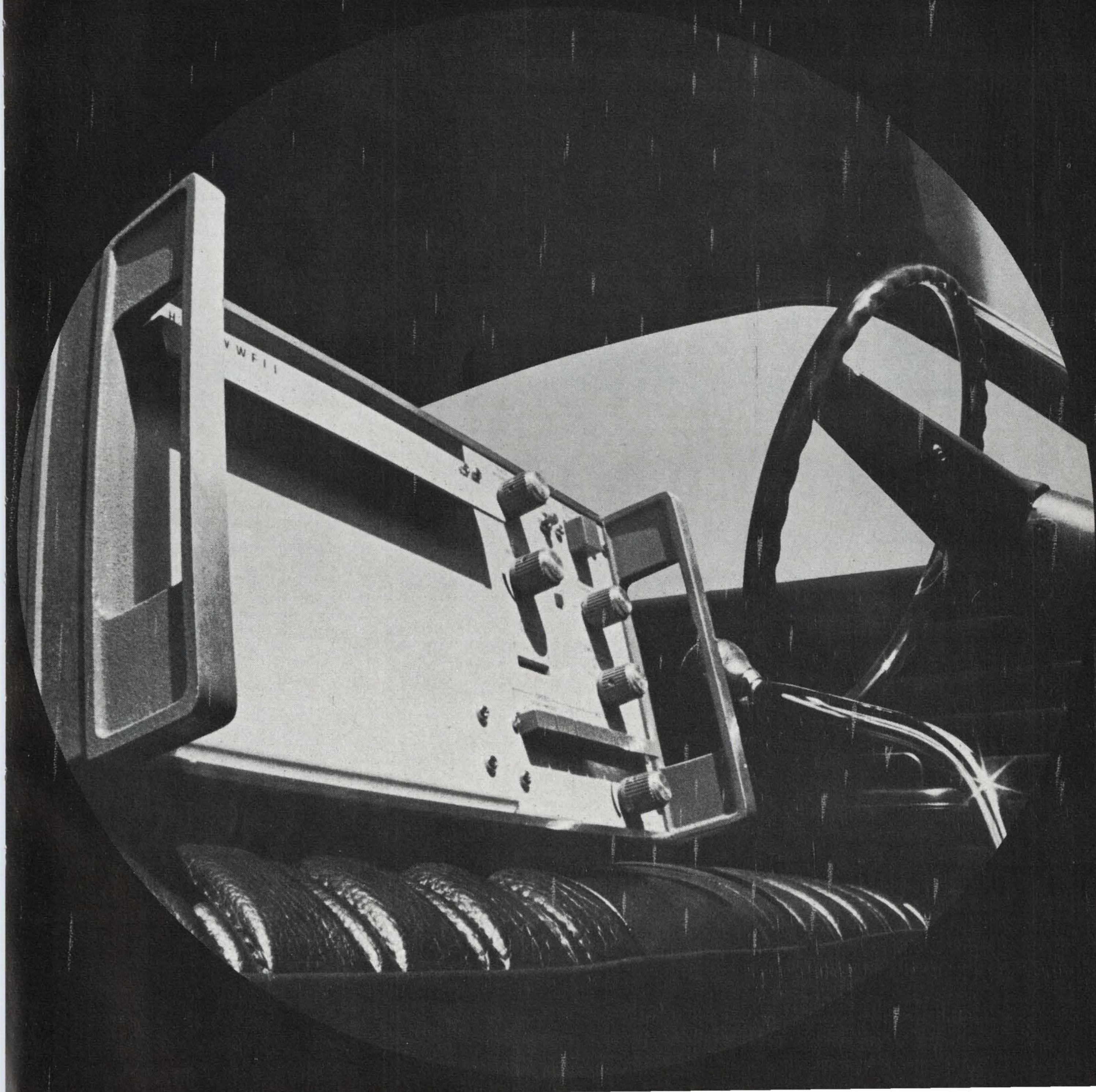

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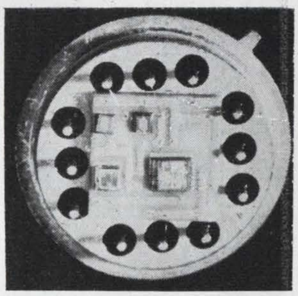
IC light-sensitive switch can handle 5 ma

British company developing integrated optoelectronic devices also markets strip-array detector for linear measurements

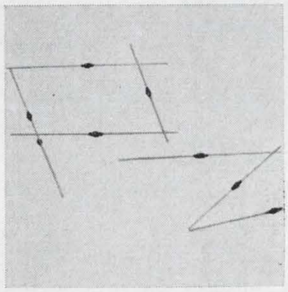
After a heavy investment of its own and British government money to develop integrated optoelectronic devices, the Plessey Co. found demand was not great enough to merit production. But one of the British company's chief research engineers decided that there was enough for a small company to handle. So Peter Noble founded Integrated Photomatrix Ltd. to design and manufacture light-activated semiconductor devices and systems, using integrated-circuit techniques.

Among his firm's first products are an IC light-sensitive switch and a strip-array detector of 50 chips, each containing a silicon planar photodiode, MOS output amplifiers, and associated circuitry. They will be available off-the-shelf this month, and will be marketed in the U.S. through Teknis Inc.

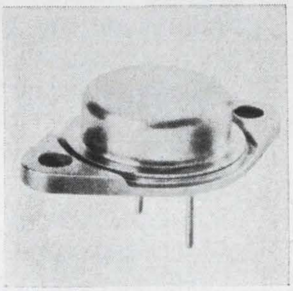
Noble says different design and processing criteria must be emphasized in integrated optoelectronics technology, vis-a-vis conventional digital or linear IC's. The spectral response of the material is important, and so are structural and geometric uniformity—to insure that the response from all diodes on the



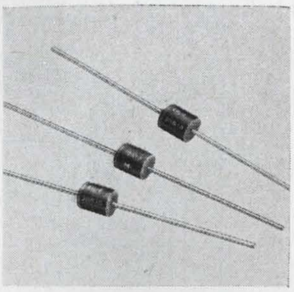
Operational amplifier model 2741 is for military and industrial use in sample and hold applications, as integrators, and as high impedance filters. It provides low input bias current of 40 pa, low input offset current of 15 pa, and low power dissipation. It is available in flatpack or TO-8. Amelco Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94042 [436]



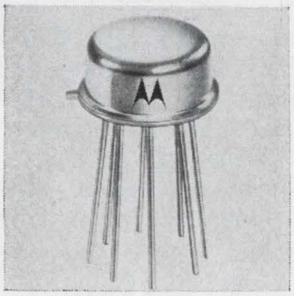
Fused-in-glass, zener diodes designated PZ Zener are subminiature devices. The series is rated at 1 watt continuous and 30 watts surge with reverse leakage as low as 500 na. They are designed to replace conventional zeners from 400 mw to 1 w. Price (in lots of 1,000 pieces) is from 69 cents each. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172 [437]



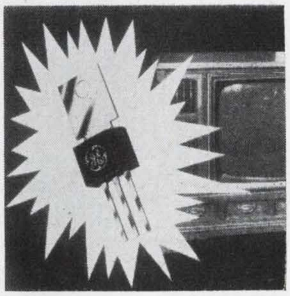
High-voltage epitaxial transistor type 1843 has a typical speed of 30 Mhz at voltages up to 375 v and a peak current of 30 amps. It is for use in power supplies, voltage regulators, d-c to d-c inverters, linear amplifiers, d-c to a-c converters, and control circuitry. Price in 100 lots rated at 300 v is $45.75 each. Westinghouse Electric Corp., Box 868, Pittsburgh, Pa. [438]



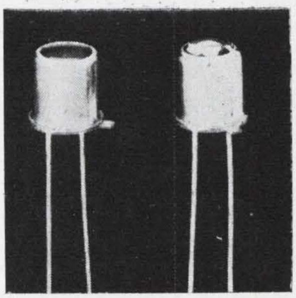
Silicon rectifier series 30R is a 3-amp unit featuring prv ratings from 50 v to 1,200 v, and designed for industrial and commercial service. Use of high density molding compounds and silicon polymer junction coatings insure long life stability in adverse environments. Prices are from 40 cents to $1 in small lots. Erie Technological Products Inc., 644 W. 12th St., Erie, Pa. [439]



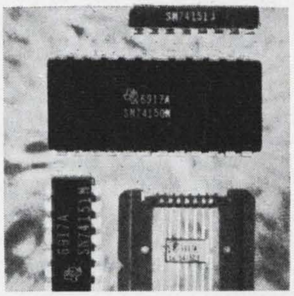
Monolithic r-f/i-f amplifier type MC1590 is for the commercial and military communications equipment markets. It features an agc range over 60 db, power gain of 40 db minimum at 60 Mhz, and can operate as a general-purpose amplifier at frequencies as high as 200 Mhz. Price (100-up) is $3.75 each. Motorola Semiconductor Products Inc., Box 20924, Phoenix [440]



Power transistor for application in tv circuits is a 300-v video output device. The D40N is packaged in silicone and features an excellent free-air rating of 1.33 w at 50° C ambient, and a 6.25 w rating at 25° C tab temperature, a 3 pf maximum collector capacitance at 20 v, and an f_T of 75 Mhz minimum at 20 v. General Electric Co., 1 River Road, Schenectady, N.Y. 13025 [441]



Photodiode detectors MD1 and MD2 are designed to complement the company's light-emitting semiconductors. Responses range from 0.4 to 1.1 microns. At 0.9 micron the MD1, which has built-in optics, has a minimum sensitivity of 1.5 μa/mw/cm^2; and the MD2, with its flat lens, a minimum sensitivity of 3 μa/mw/cm^2. Monsanto Co., 10131 Bubb Rd., Cupertino, Calif. [442]



Three series 54/74 MSI data selectors are announced. The SN54150/SN74150 are 16-bit units in 24-pin plastic packages (with 600 mil row spacing). SN54151/SN74151 are 8-bit devices in either the 16-pin plastic or ceramic dual-inline package. SN54152 is an 8-bit circuit in a 14-pin ¼ x ⅛ in. flatpack. Texas Instrument Inc., N. Central Expressway, Dallas [443]

Light switch. TO-18 can with transparent top houses device.

same array is identical. On the other hand, says Noble, ultraminiaturization is not important. "We're not concerned to get the ultimate in minute definition," he asserts, "and that will help us keep our costs down. But we do have to bother about high uniformity on more than normally complex chips." He uses MOS transistors because of their low leakage current and high input impedance.

In addition to current applications, Noble sees jobs for light-sensitive semiconductor triggers in biomedical research—particularly cellular studies—in crystallography, position-sensing in industrial processes, and fingerprint recognition.

The first of the company's products, the light-sensitive switch designated the IPL 11, is described as the first fully integrated light switch on the market. It will switch a current of up to five milliamps when incident light falls above and below a preset level. Light reaches the diode through the glass top of the can. The switching level is adjustable over a range of 1,000 times the minimum sensitivity level, and two alternative minimum sensitivities are offered: light levels corresponding to 10^{-7} and 10^{-5} watts per square centimeter. Switching speed varies from about 100 microseconds at maximum light levels to 100 milliseconds at the minimum. Nominal operating voltage is —27 volts, which Noble says is sufficient to interface directly with small relays, but it would

more often drive a medium-power transistor to switch larger loads.

The chip, which measures 20 mils by 40 mils, combines a boron-diffused silicon planar photodiode with MOS control circuitry. The adjustable switching level is set by an external resistor-capacitor circuit, the only external components required.

Refil. Noble calls the circuit Refil, for recharge from inversion layer, and it essentially consists of measuring the photodiode current by comparing its leakage rate with a fixed current input to the diode, instead of the conventional method of measuring the charge level of the diode after a fixed time period. The chip thus requires neither sample-and-hold circuitry, nor timing and threshold networks.

The IPL 11, housed in a TO-18 can will sell in the U.S. for $5.50 each in quantities of 1,000.

The second item offered off-the-shelf is a 50-by-1 strip array of silicon planar photodiodes and MOS output amplifiers integrated on a single chip with scanning circuitry, consisting of a 51-bit MOS shift register and 100 MOS gates. This device is controlled by an external clock and gives an output with amplitude proportional to the scanning rate and the light intensity at the sampled diode. It is intended to be used with optical input systems for character recognition, position-sensing, density-profiling and other linear measurements.

The chip measures 228 mils by 40 mils and is packaged as a half-inch-diameter, glass-fronted, circular flat-pack with 40 circumferential leads, of which 15 are used. The U.S. price will be between $200 and $300.

The device works by repetitively recharging the photodiodes in sequence and measuring the charge decay of each diode after a fixed time interval set by the clock. The 51-bit shift register is in parallel with the diode array, and as the data pulse traverses the register, it operates two gates connected to each diode. The first gate allows the charge level remaining in the diode to be sampled; the second gate recharges the diode to the fixed datum level.

Teknis Inc., Plainville P.O., No. Attleboro, Mass. 02762 **[444]**

New semiconductors

IC device reads wire memories

4-channel sense amplifier converts 3-mv signals to TTL logic levels

Performance requirements until now have held back use of integrated circuits for reading signals from plated-wire memories. The major problem is that signal levels in a plated-wire memory are so low—typically ±3 to ±10 millivolts, uncomfortably close to the offset voltage of most IC's. For reliable detection of a 1 or a 0 from a plated-wire memory, the sensing IC should have an offset at least an order of magnitude lower. The low signal level also means that the IC must provide uncommonly high gain.

Now Motorola Semiconductor Products Inc. is challenging the primacy of discrete devices with a monolithic four-channel sense amplifier that meets the needs of plated-wire memories. The input offset voltage for any channel of the device is 0.5 mv and typical voltage gain is 600. The unit, designated the MC1546L, overcomes the substantial common-mode noise usually present at the sense amplifier's input terminals during the write cycle. It has a ±5-volt tolerance of those signals and a common-mode recovery time of 60 nanoseconds, which is vital to preserve the less than 400 nsec cycle time of the plated-wire memory.

A binary code with two bits is used to select one of the four channels, and the common-output stage has strobe capabilities. The output is compatible with TTL/DTL signal levels, and operating temperature is —55°C to +125°C.

The unit is packaged in a 16-pin, dual in-line ceramic case, and is priced at $38 in 100-unit quantities. A modified version, the MC1446L, with 0° to 75°C operating range, costs $28. Both devices are available off the shelf.

Motorola Semiconductor Products Inc., Phoenix, Ariz. **[445]**

Circle 183 on reader service card →

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Circuit Design of Digital Computers
Joseph K. Hawkins
John Wiley & Sons, 515 pp., $17.50

It is the author's thesis that up to now no comprehensive treatment of digital circuit behavior has been available—that all studies of the circuits have been fragmented or limited to specific types of behavior, such as static stability equations or approximate switching time calculations.

To correct this omission he has put together a comprehensive and well-written description of just what a digital circuit is and what is expected of it—including magnetic as well as semiconductor elements. He describes both combinational and sequential functions—which he terms "decision" and "memory" functions—in the most basic terms, and he includes some forms that couldn't possibly be of any use, such as circuits that are always 0, always 1, or always one or the other unalterably.

The book's high level of sophistication and low level of basic fundamentals is perhaps best illustrated by its inclusion of an entire chapter on mapping functions (it had never occured to this reviewer that enough could be said about mapping to fill a whole chapter, but there it is). Mapping is the first of two operations in a decision function—it transforms the input variables into a single intermediate variable, on which is based the decision functions' output. In a diode-transistor logic circuit, for example, the diodes do the mapping and the transistor makes the decision. This chapter, of course, is mated with one on transistor decision elements—the longest in the book.

Equally informative are the chapters on equivalent circuits for transistors and for magnetic elements. The author derives a universal equivalent circuit for a transistor, showing how to simplify it for specific purposes. This is chapter 2—out of sequence in this review, but not in the book. The magnetic-core equivalent circuits are in chapter 3.

New Books

There also is a chapter on transistor memory elements—not quite as long as the one on transistor decision elements, but equally exhaustive. Its treatment is limited to the four basic kinds of flip-flops: the set-reset, the trigger, the J-K, and the combination set-reset-trigger.

The book concludes with chapters on magnetic decisions and memory elements, magnetic-core storage, and magnetic surface recording, all as basic, thorough, and sophisticated as their predecessors.

Bits of conversation

Telecommunications and the Computer
James Martin
Prentice-Hall Inc., 470 pp., $14

Most promotional phrases on book jackets seem to come from a standard bag: "most exciting development," "explains in very clear language," "contains a detailed survey," and "discusses new developments." This book is no different; all these phrases are found on its jacket. Here, though, these hard-sell lines are true, at least for the moment. The terminal equipment field evolves so rapidly that any discussion of it has a limited shelf life.

The marriage of the telecommunications and computer technologies is an exciting development. This book clearly explains to data processing personnel what they need to know about telecommunications. A detailed survey charts the sorts of errors that can be expected to crop up when communications lines are used for data. And it does discuss new developments, such as satellites, lasers, waveguides, pulse-code modulation and broadband switching.

Estimates for the 1970's list machine to machine communications as a greater source of communications revenue than man to machine or man to man, says the author. His discussions of the telecommunications networks centers, for the most part, on the Bell System, but coverage is also given to Western Union, General Tele-

New Books

phone & Electronics, and the major international satellite communication systems, such as Comsat and Intelsat.

After starting from basics—telegraph circuits and baseband signaling—the author soon moves to such topics as transmission media, attenuation and repeaters, channel capacities, noise and distortion, modulation and demodulation, and multiplexing. In each discussion, however, the author keeps his eye on the requirements of data handling.

The chapter on data errors, summarizes the results of error-rate studies for transmissions over telegraph and telex circuits, 200-band circuits, and voice grade lines. Primary sources are the Bell System studies and a study made by the International Telecommunication Union on the German telephone network in 1964. While both sources report similar results, the author says he has encountered errors greater than the numbers he reports. However, such errors as these only serve to point up the need for correct adjustment of terminal equipment.

Recently Published

Stimulation with GASP II; A Fortran-Based Simulation Language, A. Alan, B. Pritsker, and Philip J. Kiviat, Prentice Hall, 332 pp., $10.50

Thoroughly explains GASP II, a new Fortran-based simulation language, and its use as a basic for understanding the concepts of simulation. Contains numerous examples and solved illustrative problems, along with 11 complete simulation studies involving queueing situations, network analysis, design, and inventory systems. Includes flow charts and final output reports.

Computerized Approximation and Synthesis of Linear Networks, Jiri Vlach, John Wiley & Sons, 477 pp., $14.95

A practical guide for designers of linear networks, this book covers the two basic areas of approximation and synthesis. Emphasis is placed on computer approximation, and computer programs are included, in addition to explanations of techniques. Intended for readers with a background in engineering and some knowledge of Fortran.

Technical Abstracts

Show off

Displaying engineering data on a color crt
Walter H. Tew Jr.
General Electric Co.
Daytona Beach, Fla.

Consolidating computer-processed information—that is, displaying large quantities of monitored data of different characteristics—is a logical application for the color cathode ray tube. Not only is there a human-engineering advantage in making it easier for the user to select specific data from a myriad of similar data, but it's often cheaper to use the color crt.

In a large operating system, such as at a rocket launch site, it's been customary to display thousands of measurements on meters, strip chart recorders, event lamps, and hard copy printers. Together, such equipment yields analog values, events and event sequences, time histories, and alphanumeric messages. One installation takes over 700 square feet of panel to mount all the devices.

Each of these devices permits information to be rapidly absorbed and understood by the user and gives him a physical feel for the meaning of the measurement. An event lamp is a good case in point. When an event lamp changes from green to red, there's no doubt that the meaning is "trouble".

To demonstrate a standard color crt's effective use as a replacement for individual devices and its capacity to edit information for the user, a project was set up with the following goals:

- To display 30 analog measurands (quantities to be measured) on a "page" complete with their values in engineering units and in color to indicate each measurand's status within predetermined limits.
- To produce 90 discrete measurands on a page to indicate go, no-go, or caution.
- To generate one or more history plots of analog measurands.
- To handle alphanumerics.
- To incorporate combinations of these four formats.

A raster-scan crt with a 525-line raster pattern is the display. The crt face can be considered as having 455 × 525 unique cells determined by the horizontal sweep frequency and the vertical frame rate. However, the vertical retrace time between sweeps—540 microseconds during which data is fetched from the computer—reduces the usable matrix to 384 × 496. Cells can be addressed in an ordered sequence. Synchronization and logic circuits decode a cell's x-y address, decide whether the data word energizes a cell, and—if so—in which color.

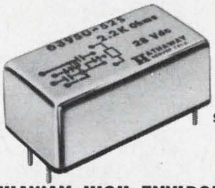
The display subsystem ties in with the computer, so display operation intimately depends on computer software. All desired information formats—metering, events, histories, and the like—can be obtained through programing.

In analog meter representation, for example, counts (cell locations) 128 to 255 along the raster line are allocated to the meter display itself, counts 0 to 127 for alphanumeric legends to identify the meter reading (CBN Temp, for cabin temperature), and counts 256 to 383 for the alphanumeric value of the measurand in engineering units (68.0 DEGF, for degrees Fahrenheit).

The height of the meter bar is 10 raster lines, allowing a total of 30 meters to be displayed vertically and leaving room at the top for meter-group titling (for example, Life Support). A separate processor converts the measurand's data value to a proportional length across the meter bar, and the bar's color depends on the measurand's state—that is, green for in-tolerance, red for out-of-tolerance, and yellow for marginal.

To plot trends, previously stored data is called from the memory, ordered in time sequence, and returned to memory. Through decoding, a dot is written at its appropriate x-y cell location on the crt to display the value and time of each data point. Because of fast dot-writing speed, screen persistence yields a time record of the measurand. Color selection information, to indicate tolerance value or to distinguish two or more measurands plotted relative to each other, can be carried along with

Relay Race!



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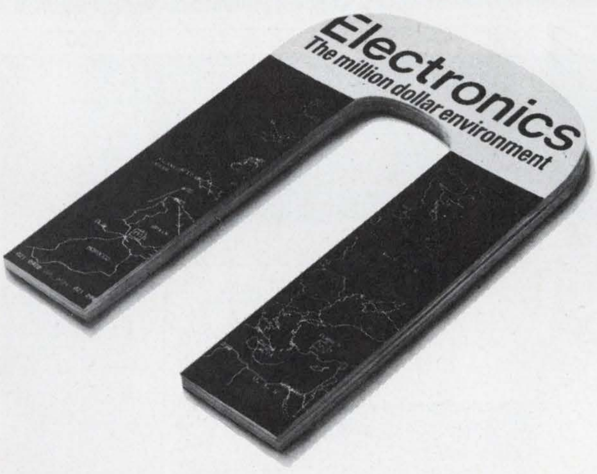

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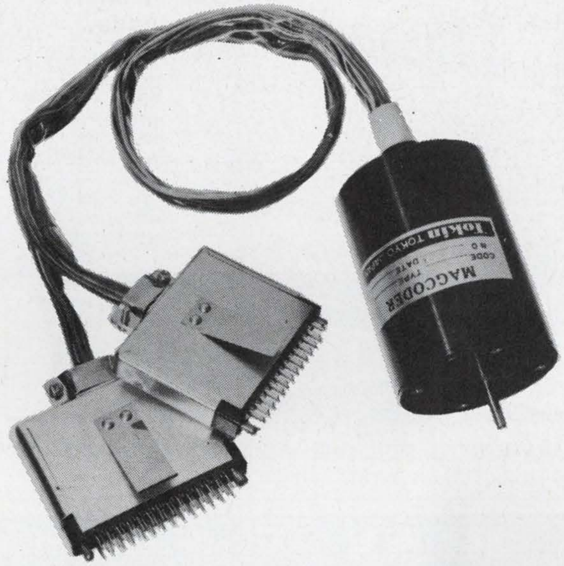

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the other information about a dot. Or, color bands denoting tolerance regions can be drawn across the crt's face.

Presented at Wescon, San Francisco, Aug. 19-22.

Use a library

Computer-aided LSI design
Robert W. Ulrickson
Fairchild Semiconductor
Mountainview, Calif.

Future economic feasibility for large scale integration requires a drastic cut in design costs and turnaround time. In general, the high cost of LSI devices derives from their complex custom design and low manufacturing volume.

Only computer-aided design and the concept of the cellular array can bring about the necessary cost reduction. For the cellular array technique, standard cells—composed of a variety of logic circuit building blocks—are designed, characterized, and their descriptions stored in a computer library. Once specified, these cells can be used again and again as components in larger, more complex circuits. Previous tests and use in other circuits guarantee a completely debugged cell and fewer design errors. Ordinarily, only the actual production reveals an error in design.

Computer programs for circuit analysis, logic simulation, and test generation along with programs for cell placement, wire routing, and artwork generation are used to reduce to a few weeks the time required to go from the logic diagram to masks. This, in turn, permits technicians and draftsmen to do work that once required engineers.

In a typical LSI design system, the process starts by partitioning the logic to fit on a particular size chip. The predesigned cells—logic blocks—are then chosen from the computer library and placed in an array. The computer then simulates the logic function to verify that the design is correct and performs as the customer intended. To aid in checking, the simulation includes a list of input and output signals as a function of time, and additional information such as the fan-in and fan-out of each signal. At this point, the customer is asked to approve the design.

Once the design is approved, a mask is made. Topological data on all cells used in the array is taken from the computer's memory and used with a placement algorithm. The algorithm arranges the cells in a pattern of rows to minimize length and difficulty of interconnections. The designer then reviews the design, makes any modifications that may be necessary, and calls for the artwork generation programs that draw the mask on the plotter. With the artwork completed, a prototype can now be produced. At the same time, the designer goes back to the computer where he gets a list of all possible faults and a sequence of tests. The units are then tested, assembled in a package and tested again.

Presented at Wescon, San Francisco, Aug. 19-22.

Powder's Pluses

Powder interconnections
L.F. Miller
IBM Components division
Hopewell Junction, N.Y.

Reliable interconnections between layers in multilevel ceramic modules can be effected by using a conductive powder. This method results in much higher yields than the paste method, requires no registration and no change in tooling, except for land pattern masks and new holes as circuit formats are changed. Moreover, it requires but one operation.

In the powder process, interconnections are formed by filling holes with a flowable metallic powder which electrically connects internal conductive layers to other parts. The assembly then is fired to sinter the powder and metallurgically bonded to the other parts. If the powder does not enter a particular hole, that part can be reprocessed without any detrimental effects. Even in the case of an electrical open, the powder can be pressed into that hole and reprocessed to salvage the part.

Although the conductive powder method features many pluses, there are a few noteworthy minuses. Holes must be open at the top surface—no blind holes should be made; for adequate filling, the holes are limited to a minimum diameter of about 0.010 inch and should be closed at the bottom to prevent the powder from falling out. And connections could be more susceptible to thermal shock.

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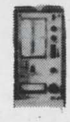

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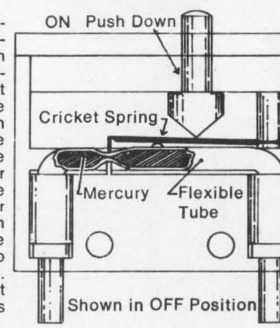

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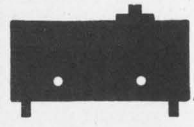

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New Literature

Computerized induction motor. McLean Engineering Laboratories, Princeton N.J. 08550. A high-speed digital computer in conjunction with internal program analysis was used to achieve optimum predictable performance in PSC induction motors described in a new catalog.
Circle **446** on reader service card.

Test sockets/carriers. Textool Products Inc., 1410 Pioneer Drive, Irving, Tex. 75060. A six-page short-form catalog describes a line of versatile test sockets and carriers for integrated and hybrid circuits, MSI and LSI, rectifiers, and other semiconductors. **[447]**

Charge amplifiers. Kistler Instrument Corp., 8989 Sheridan Drive, Clarence, N.Y. 14031, has released bulletins on two new charge amplifier models. **[448]**

Drivers and pulse-shapers. Adar Associates Inc., 85 Bolton St., Cambridge, Mass. 02140. Bulletin 350-1 describes the D-50 series of drivers and pulse-shapers designed to handle the high voltage and capacitive load requirements of MOS drivers. **[449]**

Variable electronic filters. Rockland Laboratories Inc., 13 Erie St., East, Blauvelt, N.Y. 10913, offers a four-page catalog describing an extensive line of precision variable electronic filters, including the new programable series. **[450]**

High-purity nickel. Magnetics Inc., Metals Division, Butler, Pa. 16001, has issued a data sheet describing Blendalloy 22-1000 high-purity nickel rod, wire, and strip products. **[451]**

Automated test systems. American Computer Technology Inc., 8740 Shirley Ave., Northridge, Calif. 91324, has published a facilities brochure detailing its capabilities in the design and production of complex computer, digital test and control systems; subsystems and components, and the use of counter-programed design for electronic manufacturers. **[452]**

Test instrumentation. Siemens America Inc., 350 Fifth Ave., New York 10001, has available a four-page bulletin describing the R127 capacitance bridge and K946 generator and detector. **[453]**

Binary ladder network. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634. A two-page catalog sheet describes the model 815 binary ladder network. **[454]**

Trimming potentiometers. Techno-Components, 7803 Lemona Ave., Van Nuys, Calif. 91405, has released a catalog covering its line of miniature wire-

New Literature

wound trimming potentiometers. **[455]**

Crystal can relays. Welch Relay Co., 11161 W. Pico Blvd., Los Angeles 90064. A 12-page brochure describes a complete microminiature, crystal can relay line. **[456]**

Analog multiplier/dividers. Intronics Inc., 57 Chapel St., Newton, Mass. 02158, announces a six-page catalog featuring four new analog multiplier/dividers. **[457]**

R-f crystal oscillator. Reeves-Hoffman division, Dynamics Corp. of America, 300 W. North St., Carlisle, Pa. 17013. A two-color specification sheet gives technical data for a fast-warmup r-f crystal oscillator. **[458]**

Mounting sockets. Barnes Corp., 24 N. Lansdowne, Pa. 19050. Product bulletin PB-1005 describes 041-007 and 041-008 sockets for high density mounting of TO can-style transistors in production applications that require a provision for easy replacement of individual transistors. **[459]**

Temperature controller. Gulton Industries Inc., 3860 North River Rd., Schiller Park, Ill. 60176. Bulletin 300 describes a series of solid state temperature controllers designed to use a minimum amount of panel space. **[460]**

Life test/burn-in systems. Wakefield Engineering Inc., Wakefield, Mass. 01880. Catalog 61 covers several new additions to the company's line of temperature-controlled semiconductor life test/burn-in systems. **[461]**

Automated artwork. Optical Gaging Products, a division of Ex-Cell-O Corp., 26 Forbes St., Rochester, N.Y. 14611, has published a four-page color brochure on its Optimat system for automated artwork generation. **[462]**

Ground plane tape. Tapecon Inc., 475 River St., Rochester, N.Y. 14612, has available a data sheet discussing the use of pressure sensitive ground plane tape as an aid to production of delay lines. **[463]**

Data modems. RFL Industries Inc., Boonton, N.J. 07005. An informative booklet discusses transmitting and receiving data for computer, data terminal, time sharing, and other digital devices over standard telephone lines. **[464]**

Ultrasonic level monitor. Industrial Nucleonics Corp., 650 Ackerman Rd., Columbus, Ohio 43202. The AccuRay ultrasonic level monitor, for continuous level measurement to 60 feet, is described in a four-page folder. **[465]**

P-i-n diodes. Hewlett-Packard Co., 1501

New Literature

Page Mill Rd., Palo Alto, Calif. 94304, has published 20-page application note 922 covering the uses of p-i-n diodes. **[466]**

Timing cells. Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247. Complete technical information on miniature, current-integrating timing cells is given in engineering bulletin 11001. **[467]**

Alternate action switch. Grayhill Inc., 523 Hillgrove Ave., La Grange, Ill. 60525. A four-page, illustrated technical bulletin describes a line of alternate action push-button switches designed for on-off switching, or maintained circuit condition. **[468]**

Capacitors and resistors. Corning Glass Works, Corning, N.Y. 14830, has released short form catalog EPD DSF-1 on a line of capacitors and resistors. **[469]**

Recorder/reproducer. Magnasync/Moviola Corp., 5539 Riverton Ave., N. Hollywood, Calif. 91601. A 16-page catalog contains a general description, applications, features, specifications and typical systems installation diagrams of the series TR-1700 10- and 20-channel audio logging recorder/reproducer. **[470]**

Tunnel diodes. Aertech Industries, 825 Stewart Dr., Sunnyvale, Calif. 94086. Publication 105 is a four-page bulletin on an extremely reliable line of alloy junction tunnel diodes. **[471]**

Silicon chips and wafers. Union Carbide Corp., 8888 Balboa Ave., San Diego, Calif. 92123, has released a semiconductor and IC chip catalog describing silicon chips and wafers, and listing 13 separate categories of transistors and IC's with their type numbers and important parameters. **[472]**

Arc suppressors. Genisco Technology Corp., 18435 Susana Rd., Compton, Calif. 90221. Specifications of a new series of rfi miniature arc suppressors —each smaller than an ordinary thimble—are provided in a data sheet. **[473]**

H-v power supplies. Spellman High Voltage Electronics Corp., 1930 Adee Ave., Bronx, N.Y. 10469. Six-page condensed catalog 6900 describes a line of high-voltage power supplies. **[474]**

Resonant reeds. Motorola Communications and Electronics Inc., 4501 W. Augusta Blvd., Chicago 60651, has released brochure TIC3521 describing its Vibrasponder contactless resonant reeds. **[475]**

Snap switches. Sigma Instruments Inc., 170 Pearl St., Braintree, Mass. 02185,

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556

Circle 199 on reader service card

New Literature

offers a catalog providing technical data on an expanded line of Omron precision snap switches. **[476]**

Straight cable plug. Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543. Product bulletin CX-99A deals with a clamp-type straight cable plug developed for the SRM series of miniature r-f connectors. **[477]**

Shielding foil. Magnetics Inc., Butler, Pa. 16001, has issued a data sheet on an 80% nickel-iron shielding foil, called MuGuard 80, designed to provide optimum initial and maximum permeabilities for electromagnetic shielding applications. **[478]**

Spectrum analysis. Federal Scientific Corp., 615 W. 131st St., New York 10027. A technical paper describes a method for using the Ubiquitous real-time spectrum analyzer to test and service high-quality tape recorders. **[479]**

Data generator. Adar Associates Inc., 85 Bolton St., Cambridge, Mass. 02140. Bulletin 200-1 describes the Sq 260/280 generator, which offers versatile and high-speed data generation for stimulating digital devices and packages with preprogramed forcing functions. **[480]**

Readout indicators. Alco Electronic Products Inc., P.O. Box 1348, Lawrence, Mass. 01842. An eight-page catalog lists and illustrates the company's line of miniature readout indicators and the decoder-drivers required for particular models. **[481]**

Electronic kits. Heath Co., Benton Harbor, Mich. 49022. The 1970 edition of the Heathkit catalog illustrates over 300 electronic kits for every budget and interest. **[482]**

Programable data amplifier. Dana Laboratories Inc., 2401 Campus Dr., Irvine, Calif. 92664. Two-page data sheet 972 describes the capabilities of the model 2865 programable data amplifier. **[483]**

Coils and chokes. J.W. Miller Co., 19070 Reyes Ave., Compton, Calif. 90221. An 80-page catalog describes the standard line of industrial r-f coils, r-f chokes and related components. **[484]**

Power equipment. Lambda Electronics Corp., 515 Broad Hollow Road, Melville, N.Y. 11746, has available four new lines of power components, power instruments and power systems. **[485]**

Electronic switches. Lorch Electronics Corp., 105 Cedar Lane, Englewood, N.J. 07631. Catalog ES-697 illustrates and describes the company's line of electronic switches and represents a useful tool for the design engineer. **[486]**

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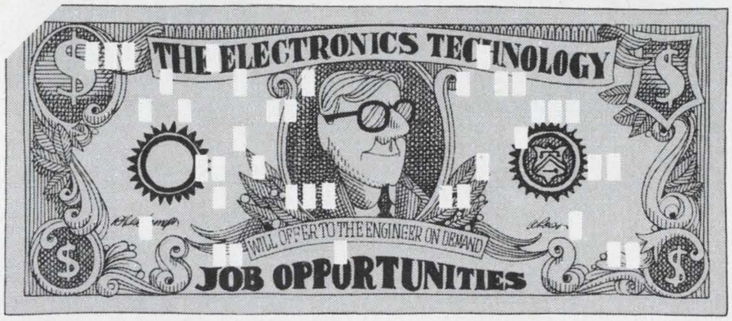

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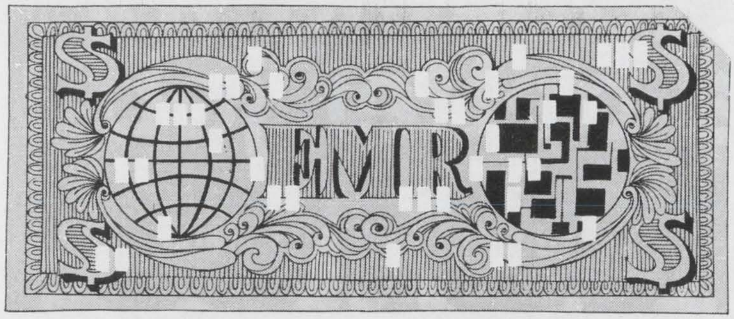

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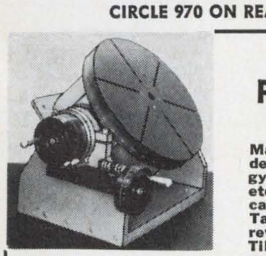

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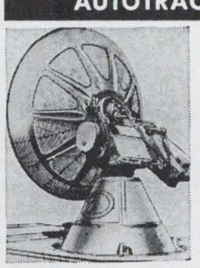

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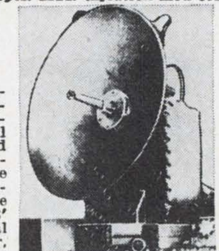

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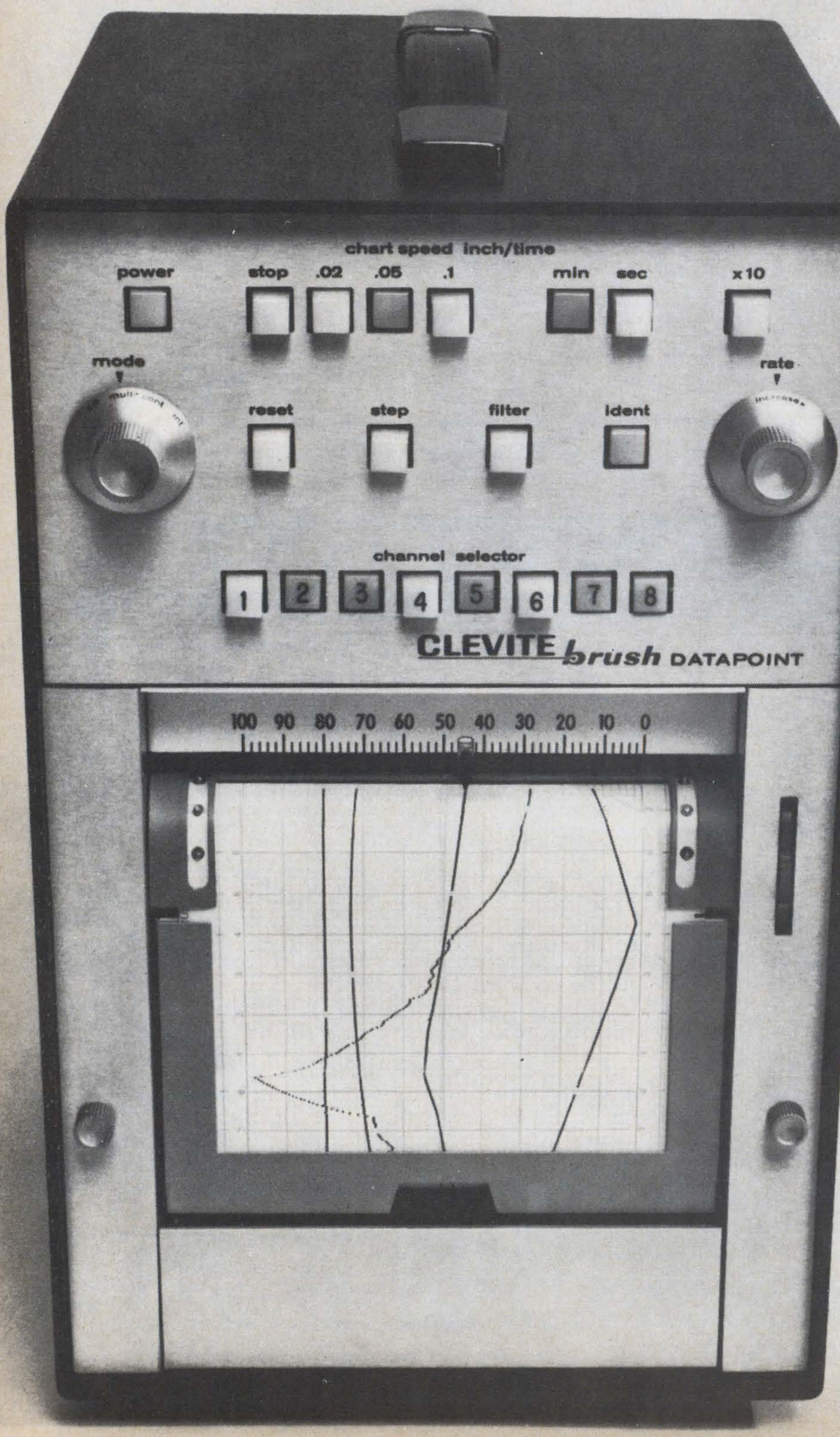

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CLEVITE BRUSH

International Newsletter

October 13, 1969

British mini-computer makers gear up . . .

U.S.-owned companies that dominate the under-$12,000 computer market in Britain—Honeywell, Hewlett-Packard and Digital Equipment Corp.—will face some unexpected competition from the natives next year. **Although the big British computer manufacturers have shown no interest in this sector of the market, at least three new, small British companies plan to deliver during the first half of 1970 the initial models of machines costing less than $12,000.**

One firm, Arcturus Electronics Ltd., has government financial backing for a machine with four or eight accumulator processors and an 18-bit word store. It will sell in a four accumulator, 4-K store configuration for less than $10,000; smaller versions will cost less than $5,000.

Essex University engineers are producing an eight-bit machine selling for $12,000 with 100-K disk store, and $5,000 with 1-K of internal store. It uses single-byte instructions operating on multi-byte data, and incorporates microprogramming from a read-only store. The first production model will go to the Department of Health in January for on-line patient monitoring.

The third company, Micro-Consultants Ltd., analog-to-digital conversion specialists, will sell, for about $7,000, a 16-bit 1-K machine aimed at process control.

. . . to reach market ahead of Viatron

The market for small British machines as well as the reigning U.S. units may well be upset if Viatron Computer Systems Corp. succeeds in getting its planned 16-bit 4-K machine off the ground in the U.S. and then onto British market as projected in the fall of 1970 at $5,800—half the price of the Honeywell 316 in Britain. **Viatron is drawing crowds at the London Business Efficiency Exhibition with its prototype microprocessor with crt display which is priced at $2,100 in 1,000-word memory form**—less than one-third the price of the only directly comparable unit, the Italian Olivetti 521.

Sescosem gets leg up in French IC market —with U.S. help

The secret's out: the French government's attempt to break the U.S. stranglehold on semiconductor sales may owe its success to American know-how. **The only French-owned semiconductor maker, Sescosem—recipient of $18 million in government aid—has quietly teamed up with America's National Semiconductor Corp.** Under an agreement signed 18 months ago but never made public, Sescosem is importing complex integrated circuit chips diffused by National, and is assembling them in France. These American chips account for about 10% of Sescosem's IC production, due to reach 200,000 circuits a month by year-end, according to Sescosem president Olivier Garreta.

National also is helping the French firm project IC sales patterns in Europe one to two years from now, based on National's U.S. experience. **In return, Sescosem expects to help National break into Europe, although details are still to be worked out. And Sescosem ultimately hopes to sell its components through National in the U.S.**

Sescosem, a Thomson-Brandt subsidiary, began making IC's in January 1968; they already account for 40% of the firm's expected 1969 sales of $35 million. One study gives Sescosem 18% of the French IC market, compared to 24% for the leader, Texas Instruments.

← Circle 204 on reader service card

International Newsletter

New postal service in West Germany: time sharing

Postal officials have begun plumping for a massive program to make time-share computer services available to West Germany's small- and medium-sized companies. **The plan calls for about half-a-dozen central computer installations to which firms would be linked by regular Post Office teleprinter or phone lines.** Officials are confident that trials will start during the second half of 1970.

As a first step the Post Office, together with Siemens AG and AEG-Telefunken, has set up a new company to help push this scheme. Called Deutsche Datel GmbH (DDG), the firm will sell computer time on a rental basis. DDG also will offer firms programming and software packages for specific computer operations, advise them on terminal equipment and help support development of new terminal devices.

Philips bid for Sema-Metra threat to Plan Software

Philips Gloeilampenfabrieken is negotiating for a 35% interest in France's largest software and management consulting firm, the Sema-Metra group. Leasco Data Processing Equipment Corp. tried to buy 20% of Sema last spring, but was blocked by the French government [*Electronics,* April 28, p. 155]. **This time Sema officials say the government is giving the green light, so long as the partner is European.**

Government support comes as a surprise, since this goes counter to talk of a French Plan Software to include Sema [*Electronics,* July 7, p. 182] But, Sema, needs capital and is anxious to become more international. The firm is studying the feasibility of a European computer time-sharing system and now is negotiating with hardware makers. The network could be set up early next year, Sema officials say, and would compete directly with the General Electric Co.'s time-sharing operation in Europe.

British-made IC's bound for Japan

The Plessey Co., which has found a regular market in the U.S. for its specialized communications linear integrated circuits, is probing the Japanese market. **Plessey will appoint the Nichimen Co. of Osaka provisional agent for its IC's on a mutual trial basis until end of the year;** a permanent arrangement is possible.

According to Plessey, Nichimen will push hardest on consumer IC's particularly color-tv devices. However, prices may not be competitive; hence the best sellers may turn out to be, as in the U.S., its logarithmic i-f amplifier and high-frequency communications amplifiers, for which Plessey claims a world lead in performance.

AGFA-Gevaert enters IC photoresist field

Semiconductor producers soon will have a second major source for photoresist materials they need to turn out integrated circuits.

AGFA-Gevaert, the German-Belgian photochemicals combine, is field testing a negative-working resist for microcircuits: its resolution is unusually high and its pinhole density is very low. Unless the tests uncover a flaw, AGFA-Gevaert will start marketing the resist early next year. **So far, Kodak has had this market—between $2 million and $4 million yearly—practically to itself.**

AGFA already has on the European market similar, but lower resolution, resists for printed circuit production. And last spring, the company started selling in Europe and the U.S. photographic plates for IC fabrication. The plates have a resolution of better than 50,000 lines per inch, currently the upper limit for commercially available photo plates.

Circle 241 on reader service card→

Japanese take two steps forward in MOS-bipolar compatibility

One team at the government's Electrotechnical Laboratory use double-diffusion to make MOS FET's. The other, at Hitachi, uses alumina

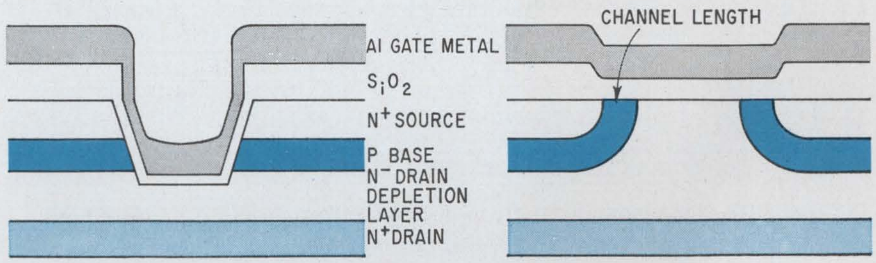
Using double-diffused bipolar-transistor fabrication techniques, researchers at Japan's Electrotechnical Laboratory have succeeded in making microwave MOS FET's. What's more the technique is inherently self-aligning.

The team of Yasuo Tarui, Yutaka Hayashi, and Toshihiro Sekigawa are responsible for the advance. They previously collaborated on such significant developments as Schottky diodes in IC's [*Electronics*, Feb. 5, 1968, p. 209].

Two factors combine to limit the frequency capabilities of MOS transistors fabricated by present photolithographic techniques. First, the margin of accuracy inherent in the process makes it impossible to achieve channel lengths—distance between source and drain—of less than about 1 micron. Second, the depletion layer extends almost completely through the channel, shorting the source and drain for channel lengths below about 0.7 microns.

Tarui has long felt that MOS transistors have the potential for better high-frequency operation than bipolar units, because theory predicts that for same base width or channel length the cut off frequency of the MOS transistor is proportional to minority carrier diffusion velocity. This velocity is one or two orders of magnitude higher for an MOS transistor because of the drift-field provided by the source-to-drain voltage across the channel.

The process for making the new device, called DSA for diffusion self-aligning, yields MOS transistors with channel lengths equivalent to those of conventional high-frequency bipolar transistors. The



One mask, two structures. Japanese team have made both planar and nonplanar MOS transistors using double-diffusion fabrication techniques, instead of photolithography. Same masking system can be used as pattern for etching moats in nonplanar structure (left) or for under-mask diffusion in planar version of the device (right).

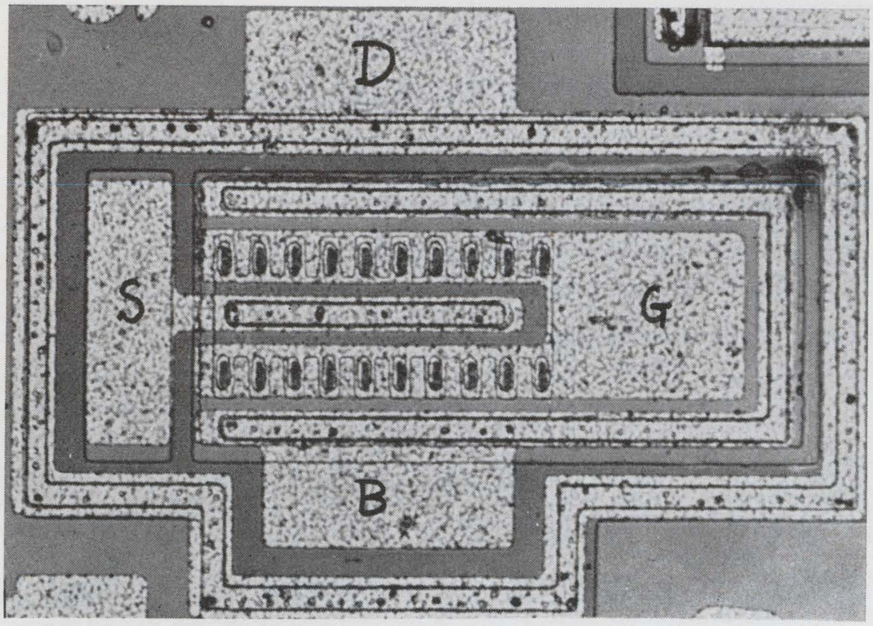
usual photolithographic procedure is replaced by a double diffusion process. The channel length is determined by the difference in depth of two diffusions, just as is base width in bipolar transistors. The difference can be controlled very precisely to obtain short channel lengths. If the wafer is an n^+ substrate with a thin n^- epitaxial layer, the depletion layer will extend into the n^- drain rather than into the channel, and a decrease in output resistance or punch-through will not occur even for submicron channel lengths.

Planar or nonplanar. Two types of geometry are possible. In the nonplanar version the device's geometry is oriented perpendicularly to the chip surface. The starting wafer is n^+ with an n^- epitaxial layer about 2 microns thick. Lattice orientation is 1-0-0 to allow clearly defined moats to be etched.

Diffusion steps are similar to the base and emitter diffusions of a bipolar transistor, with separate masks for each. In experimental units, n^+ diffusion extends about 0.5 micron below the surface, while the diffusion extends about 0.6 micron further into the chip. Separate leads can be brought out from the two regions. The n^+ lead is the source lead. The region lead, while functionally equivalent to the substrate lead in a standard MOS transistor, is similar geometrically to the base lead of a bipolar transistor.

Gate fabrication is started by etching a number of moats about 5 microns wide and 15 microns long into the region where it overlies the region. The moat's depth is sufficient to extend through the region but not through the n^- region. Silicon dioxide of appropriate thickness is regrown over the sides and bottom of the moat, and metal is applied to form the gate electrode.

Since the n^- drain is a depletion region the capacitance of the gate to the drain is small. And since the silicon dioxide coating over the source from previous diffusions is thick the capacitance of the gate to the source is small. Also, the short distance through the n^- layer from the channel edge of the low-resistivity substrate source connec-



Diffused MOS. Non-planar geometry of microwave-frequency FET is one of two used by Japanese team to make transistor by bipolar-type diffusion. The rows of vertical slots are gate moats etched through the source, base and drain depletion layers, then covered with oxide and metal.

tion keeps the added parasitic resistance low. This structure is somewhat more difficult to fabricate than the planar structure also developed, but it promises to give the best characteristics when optimum performance is required.

Planar. The other geometry is planar, and is fabricated on an epitaxial substrate with a single mask. With the mask, which is a single rectangle of silicon dioxide at the center of the chip, impurities diffused vertically also diffuse laterally the same distance under the silicon dioxide. The transistor is completed by stripping off the oxide mask, regrowing a thin oxide layer over the surface, and then applying gate metalization.

The silicon dioxide naturally grows thicker over the high-impurity-density source region, cutting down on gate-to-source capacitance. Gate-to-drain capacitance is low because the region is a depletion region with all carriers swept out. The big disadvantage of this structure however, is that carriers must travel further through the n^- layer to reach the n^+ substrate, which somewhat degrades high-frequency performance.

The group has not yet operated the DSA devices at gigahertz frequencies, because they have not yet been able to obtain appropriate headers. Indeed, the first units were only fabricated within the past month. But, a cutoff frequency of about 6.8 Ghz is predicted from measurements of d-c forward transfer admittance and high-frequency measurements of capacitances.

. . . Alumina enhancement

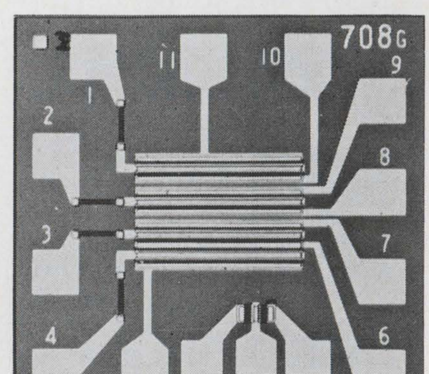
Many's the time circuit designers would like to couple MOS and bipolar transistors in the same circuit, but trying to match threshold voltage and circuit polarity often makes this marriage incompatible. Bringing alumina to the rescue, researchers at Hitachi's Central Research Laboratory have come up with an IC fabrication technique that promises greater MOS-bipolar compatibility.

Shigeru Nishimatsu and Takashi Tokuyama use the alumina to fabricate n-channel transistors that operate in the enhancement mode. These devices differ from conventional MOS transistors in having a thinner layer of silicon dioxide over the channel, and in adding a layer of alumina between the silicon dioxide over the gate and the aluminum gate metal.

Enhancement transistors have n-type source and drain, and the channel region under the gate normally is p-type with low impurity concentration. Enhancement-biasing the gate causes inversion of the channel to n-type silicon, which greatly reduces channel resistance and causes an increase in source-to-drain current of the field effect transistor.

In theory, n-channel transistors are preferable to the p-channel units commonly used because the carrier mobility in n-type silicon is about three times better—as are transistor frequency response, transconductance, and current. Thus, if a given requirement calls for p-channel units with channel lengths so short that yield is too small, more than sufficient speed and good yield could be obtained with n-channel units and slightly larger channel length. Or channel width could be decreased to obtain smaller units with the same current rating but higher frequency operation than p-channel units.

But in actual practice, the charge contained in the silicon-dioxide insulating layer between the gate and the channel causes inversion of the channel with no bias applied. Depletion bias on the gate will cause the inverted layer to become p-type, and thus n-channel transistors usually can be operated only in the depletion mode. This same inversion does not occur in p-channel transistors, and so, normally,



Two oxides. MOS approach uses alumina as well as silicon dioxide. Numbers ease microscope work.

enhancement transistors are p-channel type.

But when alumina is added over the silicon dioxide layer in the gate insulation, negative charges at the interface between the alumina and silicon dioxide cancel the effects that tend to invert p-silicon, opening the door to n-channel enhancement devices.

Convenience. Enhancement transistors are convenient to use in digital circuits. The zero input condition provides stable operation with no power supply drain, and the threshold voltage offers a noise margin against unwanted inputs. And in linear circuits biasing is easier for enhancement-type units.

Hitachi calls its new structure MAOS for metal/alumina oxide/silicon. Fabrication of the integrated circuit transistors using this process starts off in the same manner as for conventional MOS devices. Dopants are diffused through windows etched into the silicon dioxide layer to form source and drain regions in a 5 ohm-centimeter substrate. Then in regions overlying the channels the silicon dioxide is etched until the thickness is only about 800 angstroms, thinner than in conventional devices.

Next come two cycles of alumina deposition and etching. Deposition is done by pyrolytic decomposition of organo-oxyaluminum compounds on wafers heated to about 450°C. The first deposition forms a 0.6-micron layer of alumina. Alumina is etched away over gate regions and where windows for making contact to sources and drains are required. This thick insulating layer greatly reduces capacitance of interconnection metal to substrate and also decreases parasitic effects where metal overlies other portions of the substrate.

The second alumina layer, 1500 angstroms thick, is deposited and etched away where contacts are required. This layer and the oxide form the gate insulation. Finally aluminum is deposited on the wafer and etched to the pattern required.

Gateway. Since the dielectric constant of the alumina is about six, the equivalent thickness of the insulating layer in terms of silicon dioxide is about 1800 angstrom units. Experimental transistors have gate lengths of 10 microns, and gate widths of 450 microns. Threshold voltage is on the order of 1 volt.

Further improvements and life testing are under study. There are organic contaminants in the deposited alumina layer, but they evaporate during annealing. The alumina does provide protection from contamination by sodium ions.

West Germany

Breaking a log jam

Wind-tunnel tests help predict aircraft and missile performance, but nothing beats in-flight test to show how they actually do perform. But the instrumentation required often is too bulky to be carried aloft in anything but the larger test vehicles, making multiple flights necessary. And there are some cases—sounding rockets, for example—where it is impossible to get all the flight data needed because the vehicle is small and the exact flight pattern cannot be repeated.

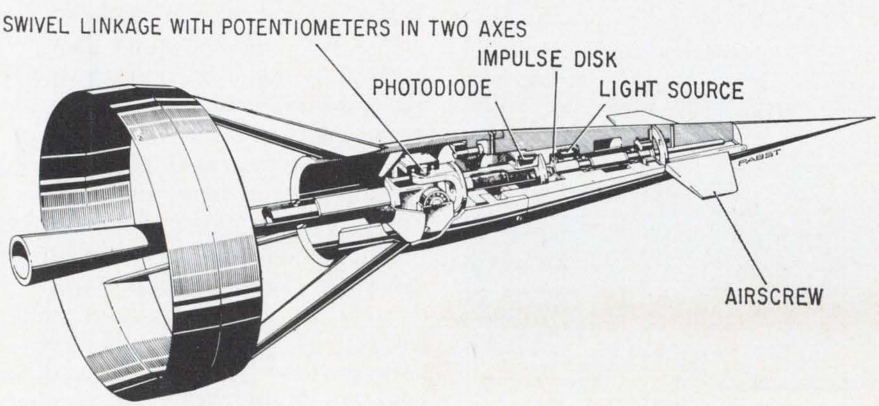
What's more, to get data on air speed at specific air densities, acceleration, angle of attack, sideslip, spin rate and other variables, a number of individual sensors are used—pitot tubes, temperature probes, and other transducers—boosting test costs.

Faced with just those obstacles, engineers at Dornier GmbH, a large West German aircraft-maker with substantial avionics interests, have developed a small airborne device that can monitor the physical quantities aerodynamicists need for determining flight behavior. Dornier's all-purpose instrument, called the Airlog, packs potentiometers, a photodiode and other electronic components into a missile-shaped assembly only 20 inches long and weighing less than 2 pounds.

An even smaller version, which Dornier calls its miniature Airlog, was developed specifically for testing small sounding rockets and military missiles. It is about 5 inches long and weighs only 50 grams. Since the device is aerodynamically styled and symmetrically mounted on the nose of the aircraft or missile, it has a negligible effect on the airflow around the vehicle. Although developed mainly for in-flight testing of aircraft and missiles, Airlogs can be used in wind-tunnel tests and for meteorological investigations for determining the magnitude and direction of airstreams. They are designed for speed ranges between 7 miles per hour and Mach 2.5.

Jointed. The Airlog, a cone-shaped body with a two-axis swivel joint at its center of gravity, aligns itself with the airstream for sensing true air vectors. A stabilizer ring at the tail end of the device keeps it aimed into the airstream. Attached to the airlog's nose is a small impeller, or airscrew, of known pitch, driven like a propeller as it passes through the air.

Mounted out in front of an airplane, the Airlog can measure with



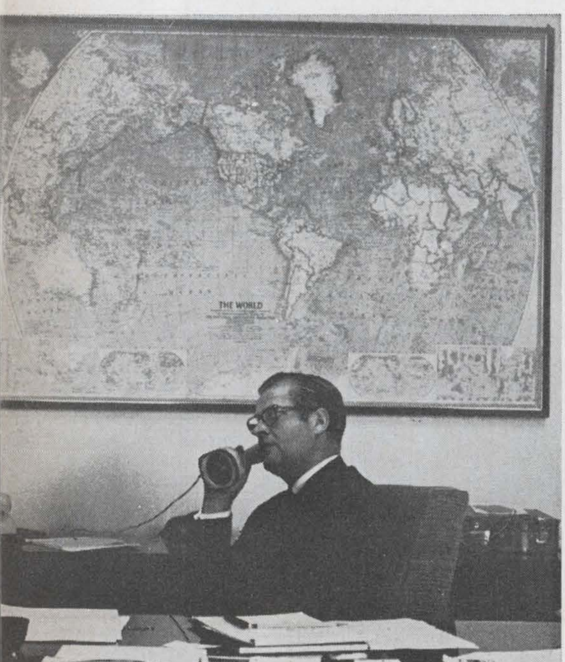
Out in front. Mounted on a boom extended ahead of an airplane, the Airlog is free to swivel. Potentiometers and airscrews deliver in-flight data.

accuracies that are far better than those obtained by ordinary means. The airspeed measurement, for example, is accurate to better than 0.4%. Conventional methods of determining airspeed use dynamic pressure sensors, which can be thrown off by changes in temperature and atmospheric pressure, and so results can be accurate only to roughly plus or minus 3%.

The Dornier Airlog has no such troubles—it derives airspeed from the number of revolutions of the impeller. A counting unit inside the aircraft simultaneously records both the number of revolutions and time, permitting digital or analog indication of true airspeed. The number of impeller revolutions is sensed by a torqueless pulse generator—a light source, a slotted disk and a photodiode. The slotted disk, spun by the impeller, rotates between the lamp and the photodiode, producing a train of up to 1,000 rectangular pulses per impeller revolution. Each pulse has an amplitude of 4 volts peak-to-peak. True airspeed is then determined inside the flight vehicle by counting these pulses against a fixed time interval. Acceleration in the direction of flight is obtained by time differential analysis of the number of pulses.

Pitch and yaw. The flight vehicle's angle of attack and amount of sideslip are detected by the Airlog's precision potentiometers which sense the direction the Airlog is pointing, compared with its longitudinal axis. Pitch and yaw data are similarly sensed. The potentiometers are wound at five turns per degree, yielding angular information to accuracies of 0.2°. The number of spin rotations and the rate of spin are also obtained from these potentiometers. They sense the relative movement between the Airlog and the vehicle itself.

An independent d-c power supply unit with a pulse amplifier, which can be mounted in the beam extending from the aircraft's nose, stabilizes outputs, despite fluctuations of the plane's regular airborne d-c supply system. During test operations the data from the Airlog generally is stored on magnetic tape, but it can be registered on plotters or cockpit displays inside the vehicle. Magnetic storage takes up the least bulk and allows the data to be digitally evaluated later.



Far-flung. Alvar Ohlsson leads push to put U.S. on AGA's manufacturing map.

Sweden

Vikings, modern style

The old-time Vikings came to the Western Hemisphere and all they found were grapes. Now some Swedish descendents of the Vikings are coming back looking for a more substantial harvest—a slice of the U.S. electronics market.

AGA AB, well-known in Europe but not in the U.S., plans to grab more of the business by starting to manufacture in the U.S. rather than just selling imported gear. It already makes, in many parts of the world, a broad range of electronic products, including medical instrumentation, laser ranging systems, thermal imaging equipment, and navigational and radio communications devices. Until last year, AGA maintained only sales and service operations in the U.S.

Under the leadership of Alvar Ohlsson, president of AGA, USA, the company has chosen to go the acquisition route instead of building facilities for manufacturing and research - and - development work from the ground up. Already it has bought a controlling interest in two U.S. firms, with others soon to follow, according to Ohlsson.

Its first acquisition—Boxton-Beel Inc., a Brooklyn, N.Y. maker of precision optics—could well be the model for AGA's overall approach to the tricky business of building itself up in the U.S.

Grubstake. Until it was purchased last fall, Boxton-Beel had been a small—about 100 employees —manufacturer of prisms and beam splitters. Almost all of its work was with glass. Under a five-year development plan AGA is increasing Boxton-Beel's staff to around 600 and taking over an adjacent building for more room, as well as pushing the company into the electro-optics area. Now under development, for example, is a low-light-level television system, a logical step from the kind of work the company had done with gun sights and scopes, comments Ohlsson.

Boxton-Beel is no stranger to military work. In fact, during the last three months it has won contracts to supply periscopes and daylight scopes for Army tanks.

Further, according to Ohlsson, besides looking forward to manufacturing AGA's existing product line in the U.S., Boxton-Beel also will become a center for extensive R&D. "Not only does the U.S. represent half of the total market for so-called sophisticated electronic products, but it also has the most access to technological knowhow as well as a much larger work force," he says.

Last month AGA took another step toward establishing itself in the U.S. by acquiring control of Consolidated Airborne Systems Inc., an avionics firm in Carle Place, N.Y. Although Ohlsson hesitates to comment on Consolidated Airborne's eventual role in AGA's American plans, he indicates that the company's products are a natural tie-in with AGA's own line of radio communications and navigation products.

Circle 245 on reader service card→

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Bounce Time	**2 ms., max.**
Shock	**50 g's (11 ms.)**
Vibration	**30 g's, 38-2000 Hz**
Operating Temp.	**−65 °C to +125 °C**
Life	**100,000 operations, min.**

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6					MT 2500	
5				MT 2500		
4			MT 2500			
3	MT 1061A	MT 2500				
2	MT 2115					
1.5	MT 2116					

OSCILLATOR PERFORMANCE

Frequency (GHz)	Output Power					
	1W	.5W	250mW	100mW	50mW	25mW
.5	MT 1039	MT 1039	MT 1060A			
1.0	MT 1038A	MT 1039	MT 1060A			
1.5		MT 1038A	MT 1039	MT 1060A		
2.0			MT 1050	MT 3833	MT 3834	MT 3834
2.5				MT 1050	MT 1070	MT 1070
3.0				MT 1116	MT 1115	MT 1070
3.5				MT 4014	MT 1116	MT 1115
4.0				MT 4015	MT 4014	MT 1116
5.0						MT 4015

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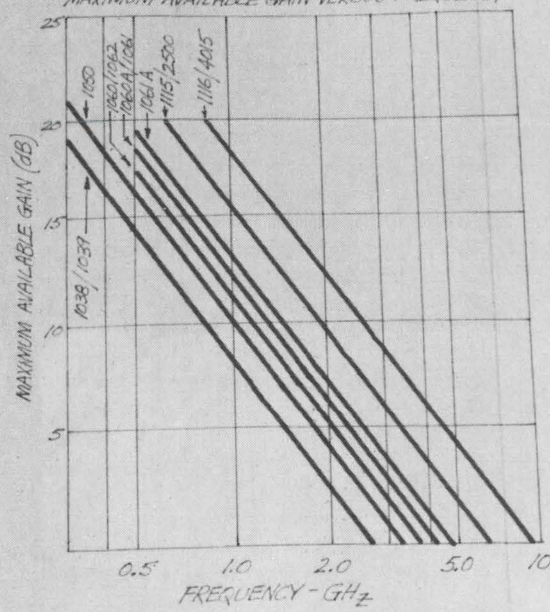

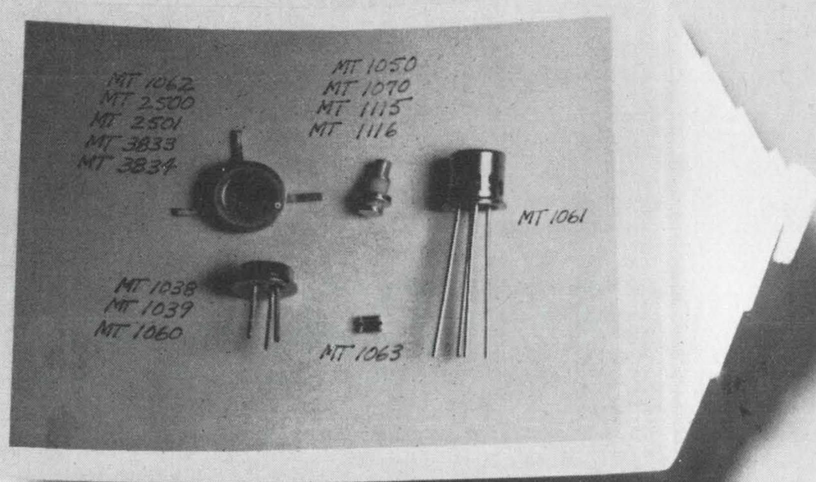

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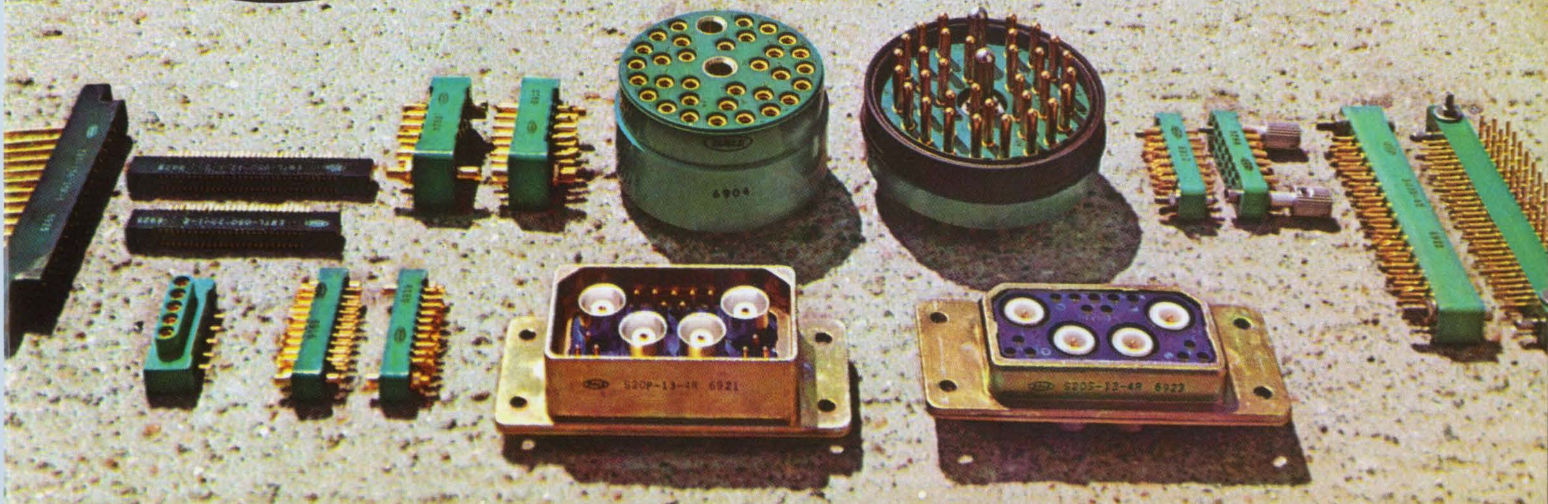

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DIP (14-lead)	CA3029 $ .98	CA3029A $1.90	CA3030 $1.58	CA3030A $2.90	CA3047 $1.58	CA3047A $2.90
Open Loop Voltage Gain	60 dB typ.	60 dB typ.	70 dB typ.	70 dB typ.	90 dB (Diff) typ.	96 dB (Diff) typ.
CMR	94 dB typ.	94 dB typ.	103 dB typ.	103 dB typ.	100 dB typ.	108 dB typ.
Input Bias Current	12 μA max.	4 μA max.	24 μA max.	6 μA max.	350 nA max.	200 nA max.
Input Impedance	10 kΩ min.	15 kΩ min.	5 kΩ min.	7.5 kΩ min.	1.5 MΩ typ.	1 MΩ typ.
Noise Figure @ 1kHz	------	12 dB max.	------	16 dB max.	------	------

(all prices shown at 1000-unit level)

Circle 902 on reader service card