April 26, 1973

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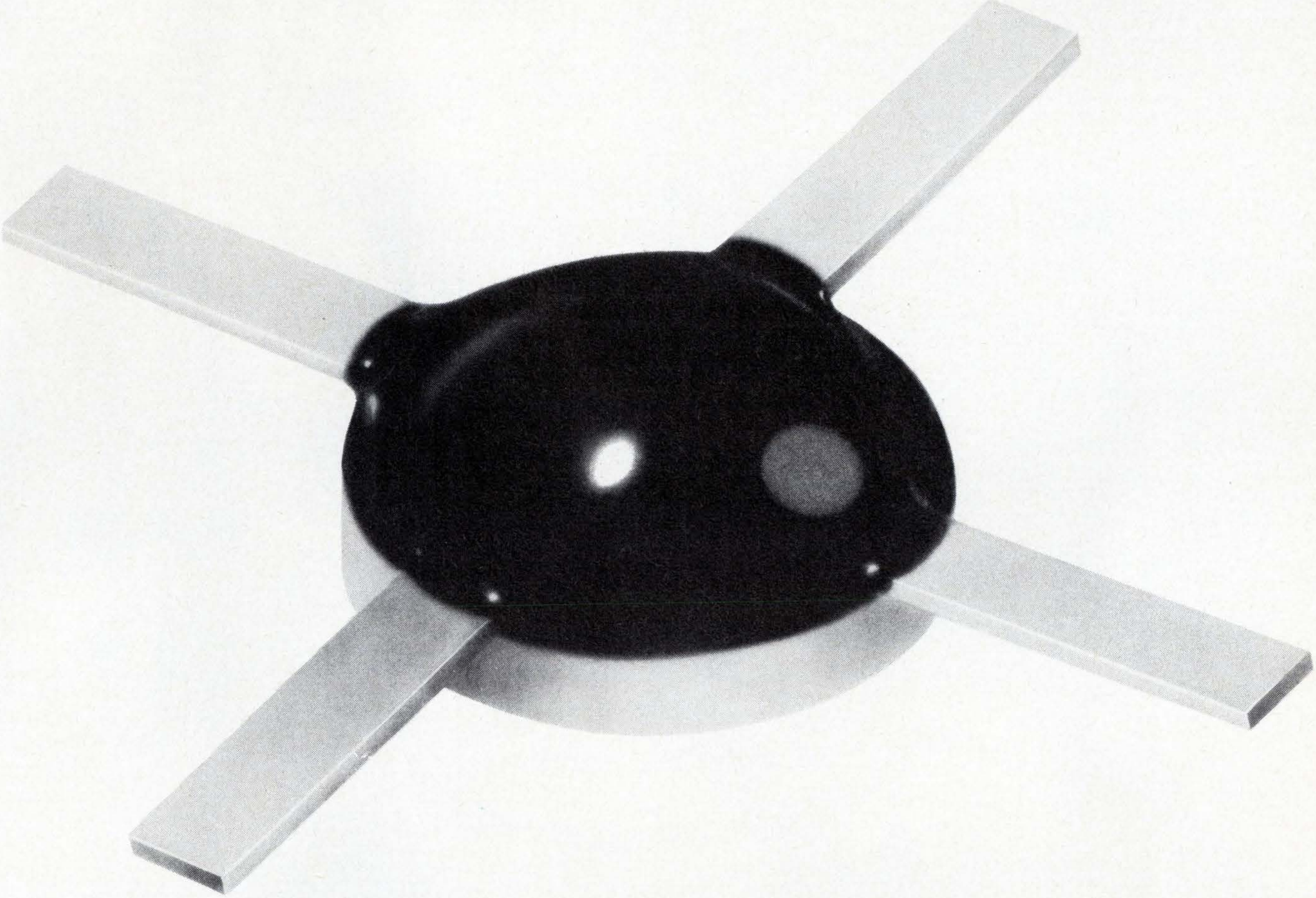

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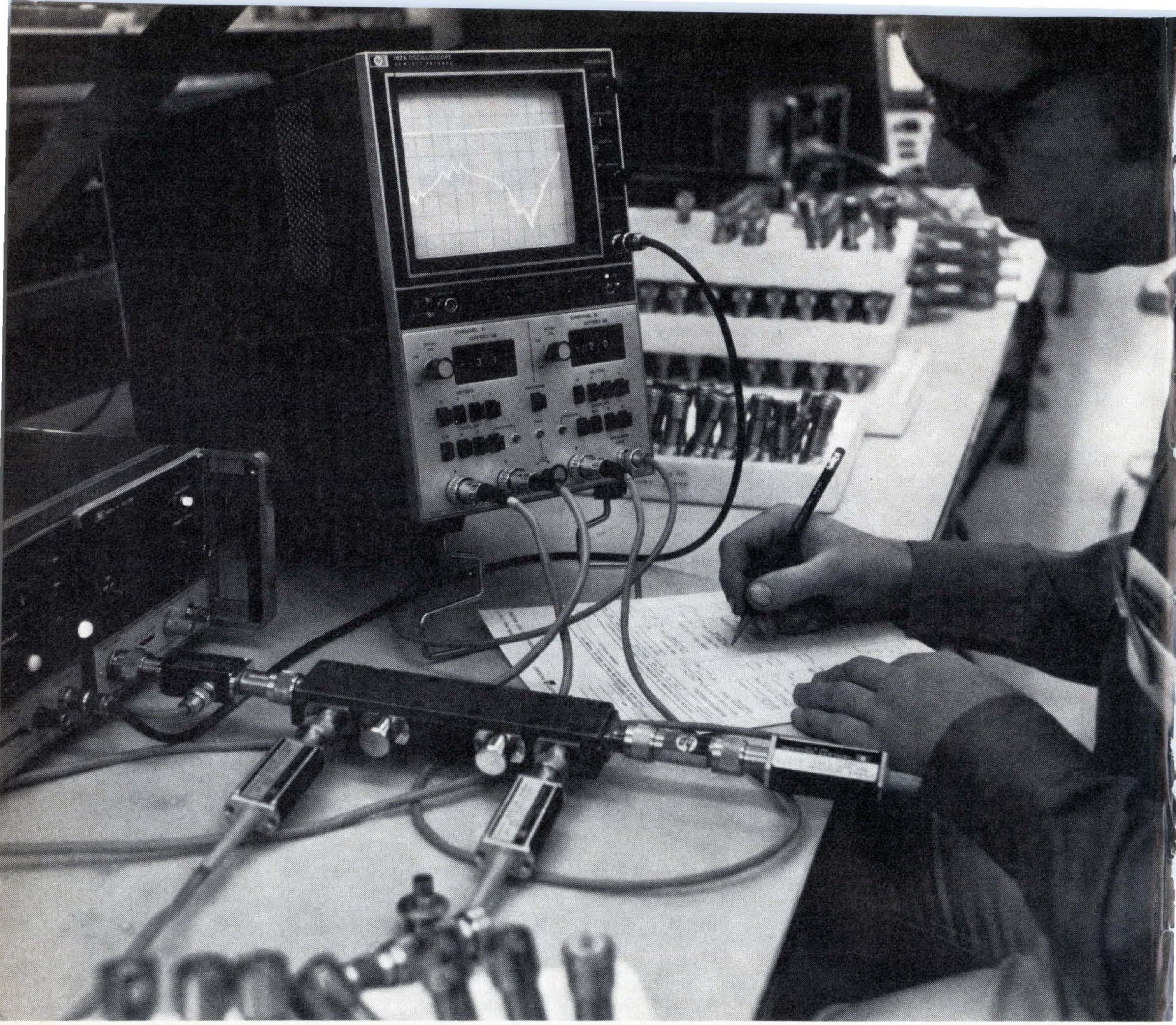

How to squeeze 60 dB of swept frequency response from 10 mW of RF drive.

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Electronics

The International Magazine of Electronics Technology

Vol. 46, No. 9 • April 26, 1973

Departments

Highlights

The cover: Discrete semiconductors flourish, 85
New markets among automobile and TV manufacturers plus a reputation for reliability are helping discrete devices to achieve prosperity. Field-effect transistors and power devices are especially strong. Cover photo by Associate Art Director Charles Ciatto says it fittingly with flowers.

A house in space, 67
For four weeks in May and June, three astronauts will make their home in Skylab, an earth-orbiting laboratory in which they'll carry out experiments in astronomy, earth observation, and biology.

Better driver circuitry for displays, 95
Besides making tradeoffs between the different types of multidigit display, it's a good idea to optimize the circuitry that drives the output elements.

The MOS memory that scored over cores, 108
The inside story of the Intel 1103—the first dynamic MOS random-access memory to break into the computer mainframe market in a big way—is the second of *Electronics'* profiles of unusually successful products.

And in the next issue . . .
Special report: is electronics making it in the home? . . . 25 years after: a retrospective on information theory . . . simulating sonar displays with minicomputers.

Electronics

Publisher's letter

Discrete semiconductors, as you can see by our cover, are blooming. Actually, says Larry Altman, our Solid State Editor, who wrote the 10-page special report that starts on page 85, the strong growth in discretes is a bit of a surprise, considering the attention grabbed by the more glamorous areas of integrated-circuit technology.

"When we started," says Altman, "we planned something along the lines of a state-of-the-market piece. That's because during research for our annual market survey, published in the first issue in January, we were impressed by the great market boost shown by discretes.

"Once we got behind the numbers, however, we saw all the great technological innovations that have helped discretes. Of course, these innovations are not being applied across the board. Manufacturers are applying them in growth areas—such as power devices, field-effect transistors, and radio-frequency and microwave devices."

And, speaking of rf and microwave, we had to leave those areas out of the report because of space limitations. But you can expect a second installment, covering those devices, in an upcoming issue.

The cover, which carries through the "blossoming" theme, is the handiwork of Charles Ciatto, our Associate Art Director. While his photographic work has appeared in *Electronics* before, this marks his first photo cover. He is also, as he says, "a bug on plants." So the combination of horticulture and photography was a natural.

After touring the flower district for the right blossoms, he brought them home and sweated under photoflood lights for hours. To keep the plants from wilting, too, he sprayed them occasionally with water. And, serendipitously, when the slides came back, the ones with the water droplets were far and away more striking. He notes that he used a Nikormat, close-up lenses, and high-speed Type B Ektachrome.

Dan McMillan

April 27, 1973 Volume 46, Number 9
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Readers comment

Calculator puzzles

To the Editor: The pocket calculator short cuts in the Engineering Notebook section of the magazine are excellent, and I certainly enjoy reading them. I would like to suggest that you include some things on the lighter side that can be done with a pocket calculator.

Here is a mathematical weirdo you may find amusing: Take 15873 times any number one through nine, multiply the result by seven, your answer is the same as your multiplier. For example, if you use the multiplier five, the answer would be 555555.

There must be many mathematical puzzles that can be worked out on the pocket calculator, and I am sure your readers would appreciate knowing what they are.

Philip H. Alspach
Lafayette Hill, Pa.

Active filter correction

To the Editor: Vittorio Pomo of Olivetti Labs, Ivrea, Italy, brought to my attention an error which appeared in my article in the October 23, 1972, *Electronics*. Here is a listing of the correct capacitors values for section 1 of the odd-order filters in Table 8.

M = 0.2

Order	C(1)	C(2)	C(3)
3	2.47691	2.33579	0.345685
5	3.22787	1.49698	0.427236
7	3.5182	1.35747	0.437102
9	3.70761	1.30237	0.434685

M = 0.4

Order	C(1)	C(2)	C(3)
3	2.58726	2.13013	0.362895
5	3.32331	1.48091	0.432982
7	3.62987	1.36148	0.440894
9	3.77101	1.31802	0.443208

M = 0.6

Order	C(1)	C(2)	C(3)
3	2.70422	1.96242	0.376872
5	3.4203	1.46691	0.438404
7	3.71401	1.36895	0.447313
9	3.85115	1.33283	0.450391

M = 0.8

Order	C(1)	C(2)	C(3)
3	2.82576	1.82427	0.387978
5	3.51655	1.45504	0.44373
7	3.7984	1.37715	0.453805
9	3.93223	1.34813	0.457678

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40 years ago

From the pages of Electronics, April 1933

President Roosevelt, in the midst of the banking emergency, changes the whole public psychology by a 13-minute talk over the nationwide radio networks.

A great Atlantic liner talks with a ship below the horizon, by means of a modulated light-beam playing on a distant cloud-bank.

New realism in sound reproduction—three-dimensional "talkies" or telephony—is made possible by a binaural or stereoscopic pickup.

An infrared "fog-eye" locates hot ships' funnels through a naval smokescreen—in preparation for iceberg detection through fog later this Spring.

To eliminate troublesome fading, KDKA engineers obtain baby blimp to hold antenna aloft to a vertical height of 1500 ft.

Professor Theremin, musical-instrument inventor, now applies "space control" principle to industrial uses, machinery operation, police alarms.

Sodium-vapor lamp installations, with luminous efficiency sixfold that of tungsten, are put in operation in England, Holland, Belgium, and Denmark.

Engineers experiment with 8- and 9-prong tubes; on combined detector-output tubes; on two-tube superheterodynes.

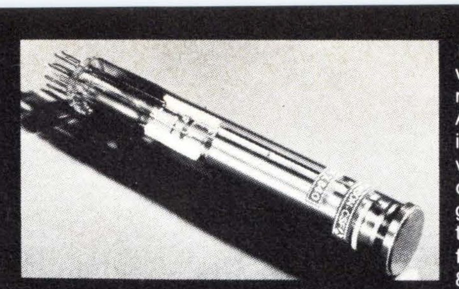
A plane takes off in fog in Washington, never sees ground until it is guided back to earth by short-wave landing beam installed at Newark Airport.

Bergen County Police, Hackensack, N.J., install police radio system on 2480 kc., get reports on reception from all over the state and New York.

Leading radio manufacturer produces a four-tube radio receiver, to retail complete with tubes and dynamic speaker, at $12.95. Factory price, $6.40.

We pick the above at random from the crowded record of electronic happenings in a span of thirty days. These examples show how varied, how potent, and how far-reaching are the changes which the electronic tube is injecting into the world around us.

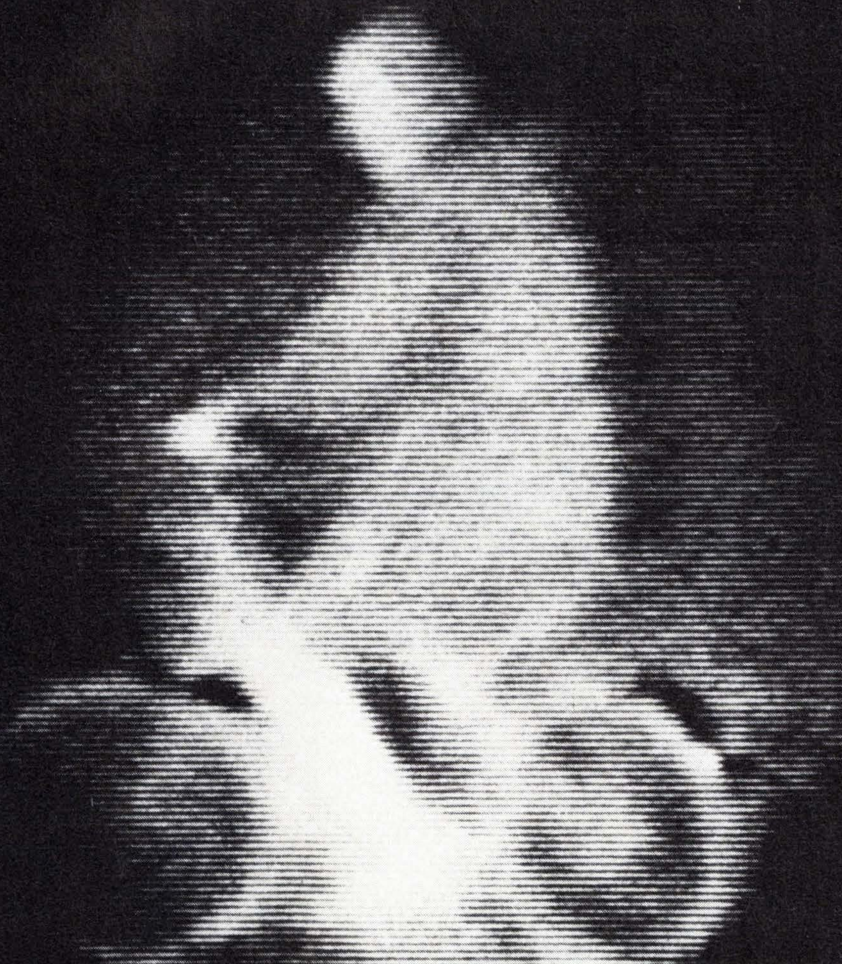
This revealing TV picture was taken with our Pyricon*, THOMSON-CSF new pyroelectric camera tube. The THX 840 Pyricon* was realized by incorporating the electronic scanning structure of a vidicon with the infra-red sensitive capability of a pyroelectric retina,an original THOMSON-CSF idea.



A unique pyroelectric material in the retina picks up thermal images from camera scanned scenes and transforms the infrared radiation detected from thermally emitting bodies into a clear video image that can be read on an electron beam.
Pyricon* operates at room ambient temperatures without need for ancillary cooling equipment. Its sensitivity and resolution capabilities are compatible with normal industrial surveillance requirements for low light level environments. An additional feature of the Pyricon* is its inherent capability to distinguish moving targets from stationary objects by cancellation of fixed temperature background scenes when desired. The spectral response of a Pyricon* is optimized for operation in the wavelength range of 8 to 13 microns or on special request can be optimized for the 3 to 5 microns range. Pyricon* cameras utilize standard vidicon accessories with optical components chosen to suit the application. And it's definitely on target...

* THOMSON-CSF trademark

We shot this man on a dark and drizzly night, from a distance of 600 feet.



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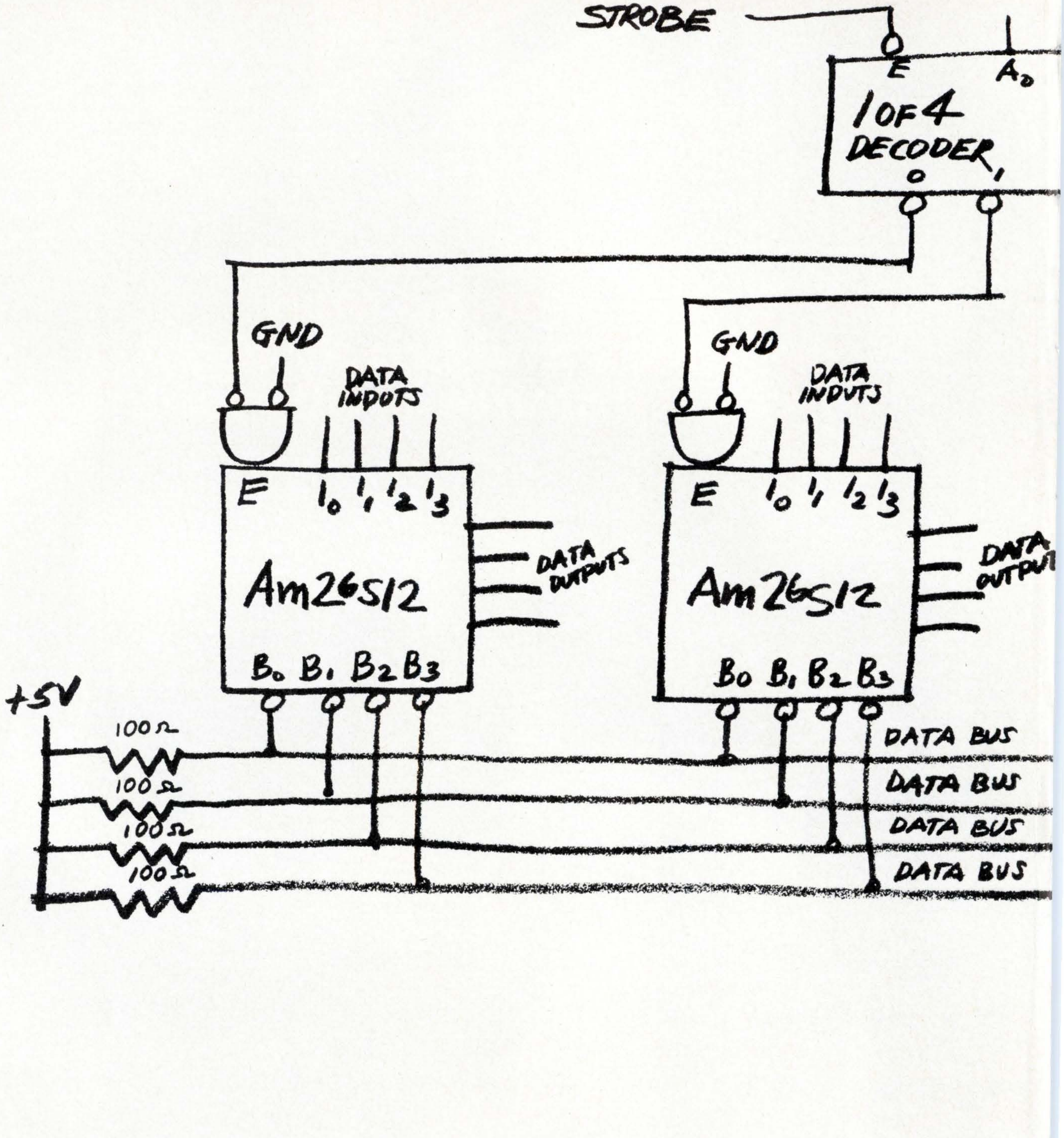

STROBE
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1 OF 4 DECODER
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1
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Am26S12
DATA OUTPUTS
B_0 B_1 B_2 B_3
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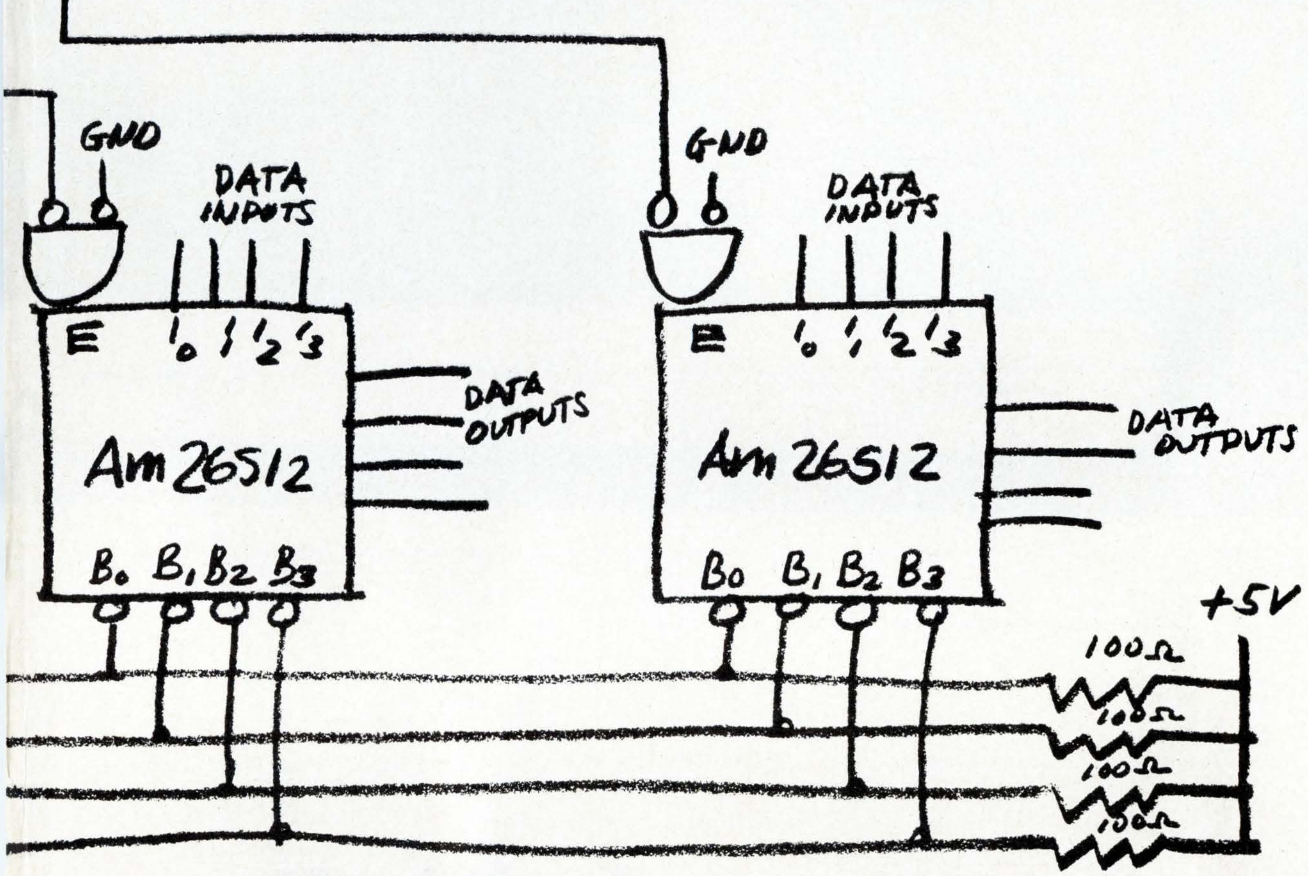
Am26S12
B_0 B_1 B_2 B_3
+5V
100Ω
100Ω
100Ω
100Ω
DATA BUS
DATA BUS
DATA BUS
DATA BUS

Am26S12 Quad Bus Transceiver.

Designed using Schottky clamped transistors, the Am26S12 has a bus driver current sink capability of 100mA at 0.8V (maximum) which enables it to drive as many as 200 devices. Receiver hysteresis provides high noise immunity with noise margins of greater than 1.0V. The unique terminating scheme of the Am26S12 allows each end of the bus to be terminated with a resistor as low as 100 ohms. Threshhold limits are 1.4 to 2.0V ± 0.2V. Also available: The Am26S12A. Pin-compatible with DM8838. Threshhold limits, 1.2 to 2.25V ± 0.2V.



It's a bus driver with the world's highest drive capability and a bus receiver with unbelievably high noise immunity together in a single package.

It's the speedy new Am26S12 Quad Bus Transceiver. Yet another step forward in our relentless effort to become the sixth largest maker of integrated circuits in the country by 1975.

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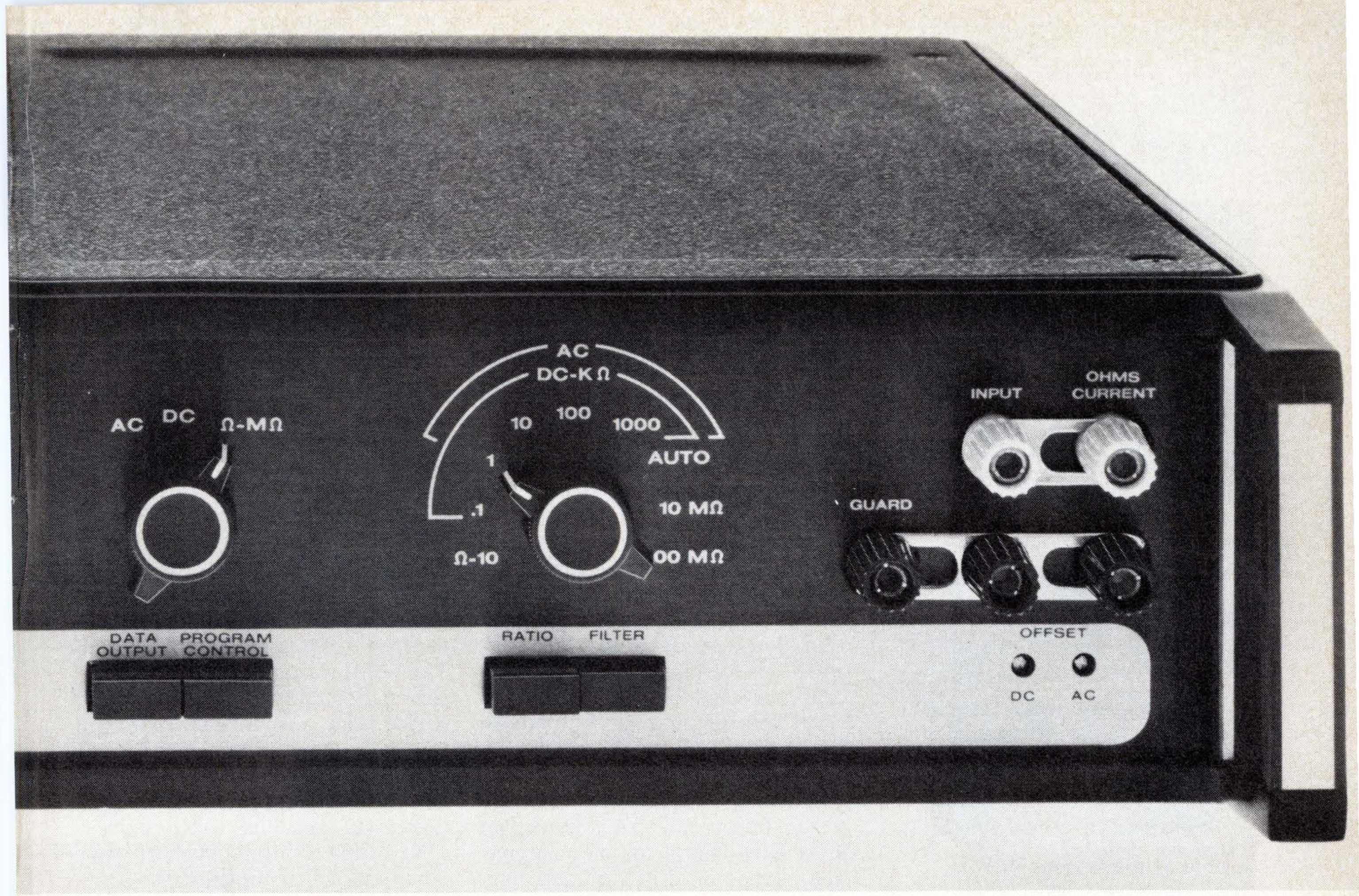

The challenge infuriates an engineer. Excellence cannot traditionally be compromised by economics. But if you can't afford it, you won't buy it. So sometimes we have to do both.

Above you see one of the "plus" machines from Dana. "Plus" because it is truly a better machine. And "plus" because it is priced to give you a new level of quality for the money.

The 5900+. A new standard.

This new unit may well be the world's most accurate and stable 5-digit multimeter.

It delivers 0.001% total accuracy.

It has 350 volts RMS protection on all ohms measurements.

It provides true systems capability. It has 5 DC ranges, 60% overrange, and full ratio capability. Its basic price is $1795. Nothing at that price is comparable in accuracy and quality.

The 5000+ DVM. The price is lower. The standards aren't.

This new DVM is the lowest priced 5-digit multimeter we've ever produced. Yet because it was engineered and built by men who have been dealing with units costing ten times as much, the 5000+ reflects their standards.

It is absolutely reliable. (Silicon solid state circuitry plus LED display.)

It has 5 DC ranges capable of measuring from 1 μV through 1000V.

It offers autoranging in all functions and 100% overranging on all ranges.

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People

Ken Dixon's winning mix: electronics and horses

Making it. Ken Dixon owns champion horses, but still designs equipment.

If your dream is to start your own company, sell out handsomely in a few years, then retire to a gentleman's life in the country and raise champion horses, you should talk to Ken Dixon. He did just that, but then discovered his interest in robot production equipment was so strong that he founded another company, Dixon Automation, to pursue this business.

Dixon, who was with Hewlett-Packard's Mosely division and with rocket maker United Technology, formed the K Dixon Company in 1968. There he developed and marketed a silvering machine for chip capacitors and a chip sorter. Two years ago, he sold the business to Deval Corp. The machine is still in production and widely used.

With his responsibilities there ended, Dixon moved to a ranch that must have one of the most impressive views in all California, and, with apologies to those living elsewhere, that's saying something. It's on a top of a hill in Camarillo, 50 miles west of Los Angeles where Dixon looks down through a gap in the coastal mountain range near Point Magu. From his living room, he can see the channel islands of Anacapa, Santa Cruz and Santa Rosa, that start 11 miles off the coast and extend 60 miles westward.

In addition, Dixon raises champion Morgan horses, the small but highly regarded breed developed in America and formerly used by the cavalry. Last year, Dixon's Morgan stallion won the Western regional grand championship. And as it turns out, he says, horses are a good business to be in.

But Dixon, with an EE from UCLA and a master's in mechanical engineering from Stanford, couldn't keep occupied with horses alone. Remembering his long-time interest in robots, he felt he could do things with electronics technology that no one else seemed to be working on. The result was a sophisticated robot chip handler [*Electronics,* April 12, p. 15] with a small but powerful controller that learns its job as it is moved through the motions. Dixon has found a lot of interest in the two-board controller, which replaces a full-blown minicomputer plus other equipment for this type of application in other automated machines, and he obviously has plans to apply similar techniques to other problems.

Ken Dixon, at 35, has made good use of the free time he sought and earned: "You can't do this in a big company. If you think it can be done, you've got to go off and do it yourself."

Armstrong calls shots for Motorola's color TV

In 1950, shortly after Motorola entered the TV business with the first black-and-white set priced under $200, Merle Armstrong approached

Knows how it is. Merle Armstrong started off on Motorola's assembly line. Now, 23 years later, he's in charge of all the Consumer Products division's television receivers and stereo and four-channel components.

GREAT MOMENTS IN MOS

TTL/DTL COMPATIBLE RAM

The announcement that a 1024-Bit MOS Random Access Memory was available was quite an event. Indeed, it contained a promise to revolutionize data processing . . . but there was one serious drawback. The design engineer was faced with a complex problem of developing costly and intricate interface circuitry if he was to utilize the RAM's unique characteristics. MOSTEK approached the problem with its ion-implantation method, fabricating depletion loads to replace the conventional MOS load resistors, and doing the whole job on a single chip! As a result, TTL/DTL compatibility was achieved at all inputs of Mostek's MK 4006 RAM thereby allowing economical use by eliminating the need for special interface circuitry.

Large-system users could benefit from this MOSTEK innovation, but small-system users could benefit even more. These users, like the manufacturers of display terminal or data terminals, found the MK 4006 and MK 4008 the only 1K RAMs economically suitable for their systems because of reduced interface costs.

Again, our ion-implantation technique demonstrated its ability to meet the needs of the market; and yet, ion-implantation has just begun to yield its potential. At this moment, we are at work on some MOS devices that we feel will prove to be just as exciting as our MK 4006 RAM family. At MOSTEK, we try to recognize the needs of an expanding technology and develop meaningful contributions. As a result, Great Moments in MOS just seem to follow.

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the firm with newly-won BSEE in hand. After lining up at the personnel entrance of the plant, he landed a job on the production line—adjusting coils. Still, Chicago looked better than his hometown in Nebraska, and he figured the surplus of engineers was bound to dry up.

Now, 23 years later, Armstrong is the newly appointed manager of product development engineering, with responsibility for all the Consumer Products division's output, including color and black-and-white portable and console TVs, and stereo and four-channel components. Today, color TV provides the bulk of the division's sales. And as the former manager of color-receiver design engineering, Armstrong knows that his group's charter requires substantial innovative inputs—such as Motorola's high-frequency-switching type of low-voltage power supply, and its circuitry for stabilizing color saturation in the company's "instamatic" one-button tuning feature.

"Integrated circuits can do almost anything you want them to," says Armstrong, but the competitiveness of the TV industry forces him back down to earth. "When we put an IC in, it must be equal to or less than its discrete equivalent in cost." Also dictating Motorola's reluctance to leap blindly into the widespread use of ICs in TV products is the firm's emphasis on modular construction and servicing, Armstrong explains.

"But for future chassis, we're designing them in at break-even cost." Top-of-the-line receivers now use ICs for the audio i-f, color processor, and demodulator-ICs largely conceived and designed by the consumer Products division. "Phoenix [the Semiconductor Products division] has a first and second video i-f IC," he adds, "but we're not moving that way today because there's not enough cost reason to."

The next functions to be integrated most likely will be part of the video i-f, automatic gain control, video detector, and automatic frequency control, and Armstrong expects that those can be done on two chips.

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SIGNETICS ROM SELECTION GUIDE

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8,192	2,048 x 4	+5, −12V	700	0.20¢	2580N
5,184	64 x 9 x 9	+5, −12V	750	0.31¢	2526N
4,096	512 x 8	+5, −12V	750	0.39¢	2530N
3,072	64 x 5 x 7	+5, −5, −12V	600	0.29¢	2516N
2,560	64 x 7 x 5	+5, −5, −12V	600	0.35¢	2513N
2,048	256 x 8 512 x 4	+5, −12V	950	0.47¢	2461Y
2,048	256 x 8 512 x 4	+12, −12V	750	0.47¢	2430Y
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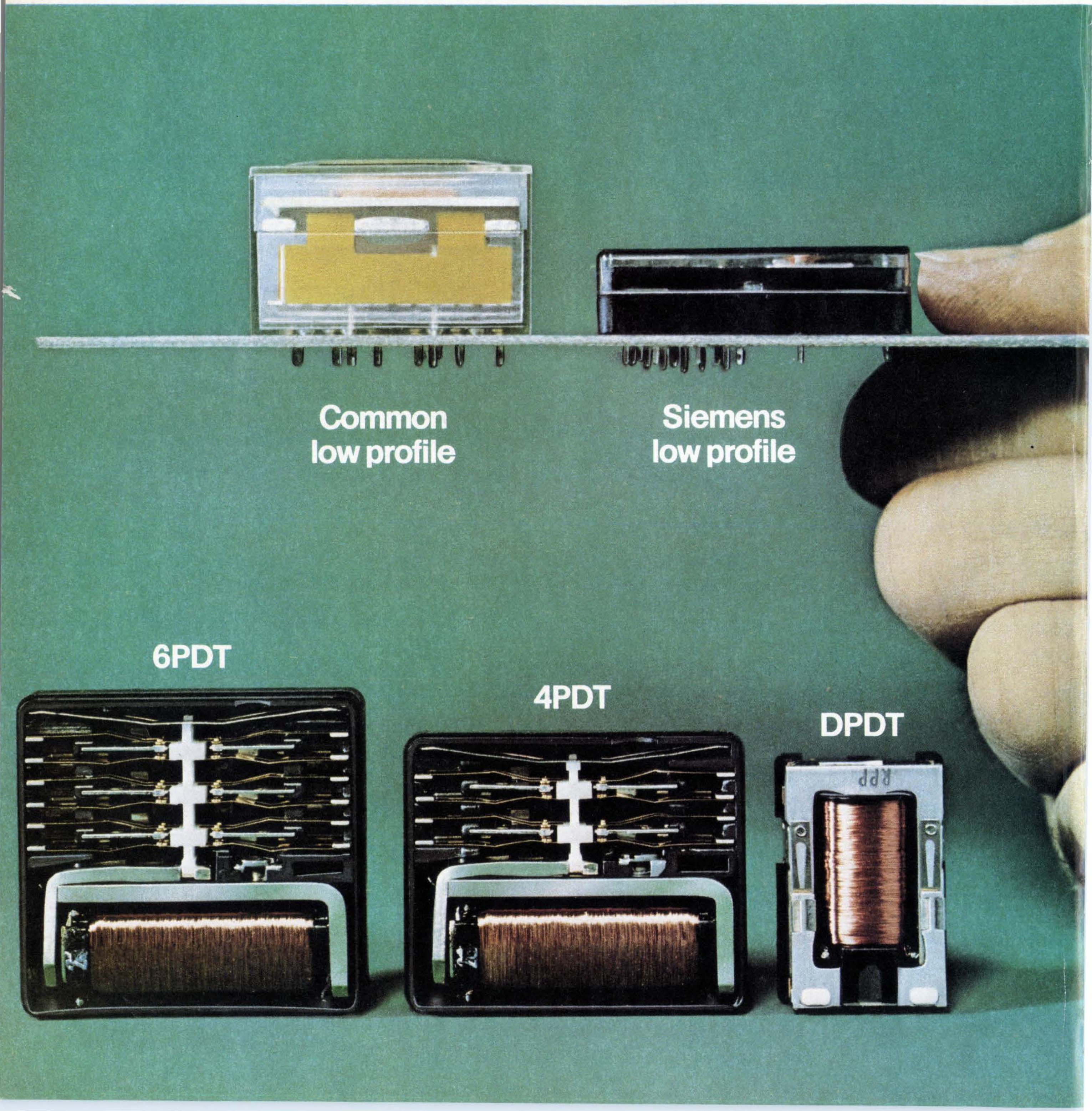

Meetings

Electronic Components Conference: IEEE, EIA, Statler-Hilton, Washington, D.C., May 14–16.

Naecon: IEEE, Sheraton, Dayton, Ohio, May 14–16.

International Symposium: SID, Statler-Hilton, New York, May 15–17.

Electron, Ion, and Laser Beam Technology: MIT and IEEE, MIT, Cambridge, Mass., May 21–23.

Aerospace Instrumentation Symposium: ISA, Frontier, Las Vegas, Nev., May 21–23.

National Aviation System Planning Review Conference: FAA, Washington Hilton, Washington, D.C., May 21–23.

Electronic Component Show: RECMA, Olympia, London, England, May 22–25.

Conference on Laser Engineering and Applications: IEEE, OSA, Hilton, Washington, D.C., May 30–June 1.

International Microwave Symposium: IEEE, U. of Colorado, Boulder, June 4–6.

National Computer Conference and Exposition: AFIPS, New York Coliseum, June 4–8.

Frequency Control Symposium: ECOM, Howard Johnson's Motor Lodge, Atlantic City, N.J., June 12–14.

International Symposium on Electromagnetic Compatibility: IEEE, New York Hilton, June 20–22.

International Symposium on Fault-Tolerant Computing: IEEE, Palo Alto, Calif., June 20–22.

Design Automation Workshop: ACM, IEEE, Sheraton, Portland, Ore., June 25–27.

International IEEE G/AP Symposium and USNC/URSI Meeting: IEEE, U. of Colorado, Boulder, Aug. 21–24.

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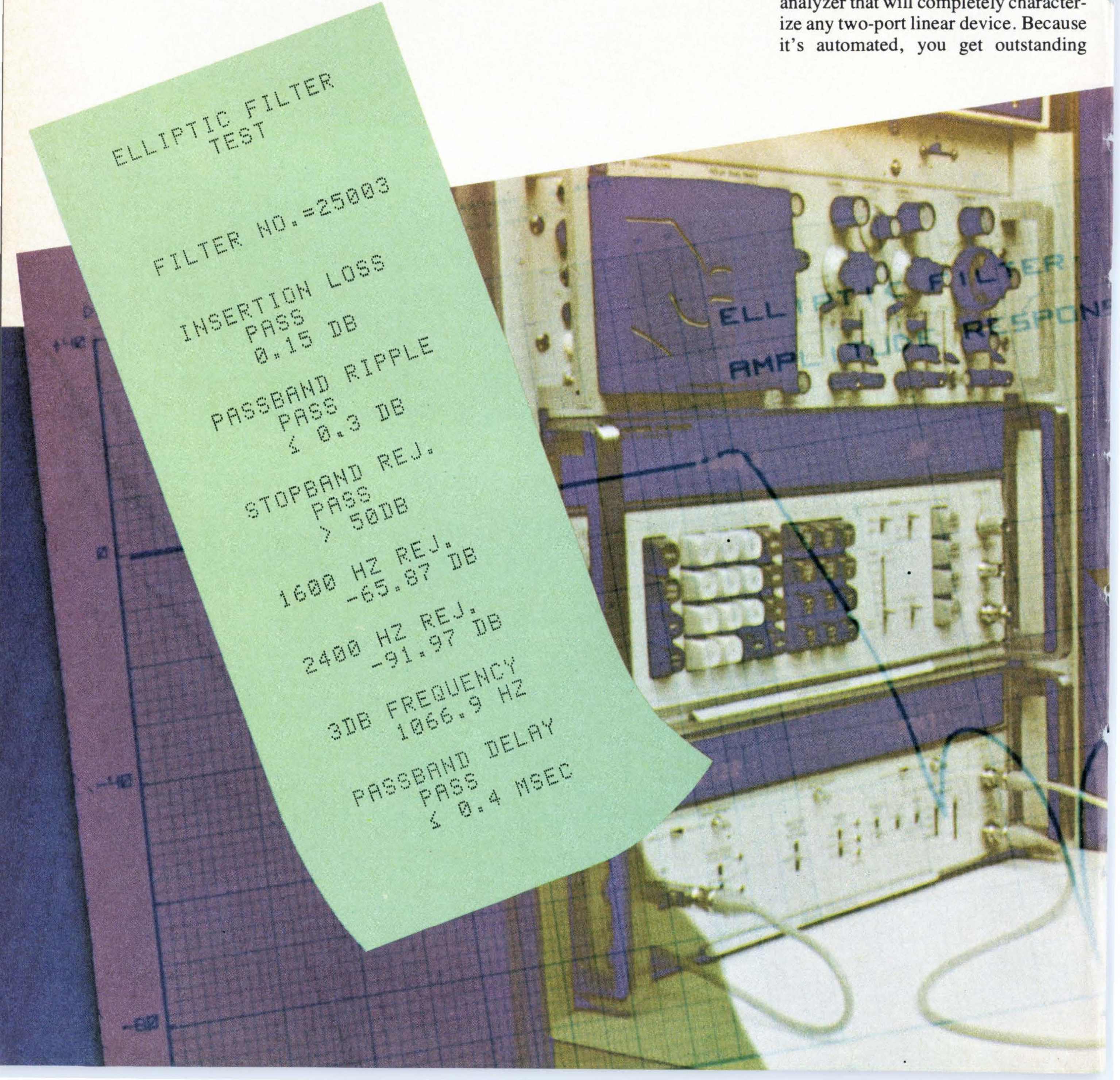

data repeatability along with the dramatic speedup in testing rate. Use it to fully test such time-takers as active filters, crystals or op amps. You can do them in seconds or minutes instead of the usual hours or days.

The system is comprised of three standard HP products—a synthesizer source, a tracking detector, and a calculator. This powerful combination applies equally to one-of-a-kind lab tests, or to repetitive production line testing. And, in addition to being able to make such tests as group delay, limit testing and offset measurements automatically, you also gain the capabilities of data reduction and decision making. You can have this fast, capable 3042A System for $22,300—ready to operate.

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All three of the Network Analyzer systems help you do more work in less time and with less labor. With them you can telescope what formerly took hours, or even days, into only minutes or seconds. Optional accessories let you select and pay for only the exact capability you need. For full details on these network analyzer systems call your local HP field engineer. Or, write Hewlett-Packard, Palo Alto, California 94304. In Europe: HPSA, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.

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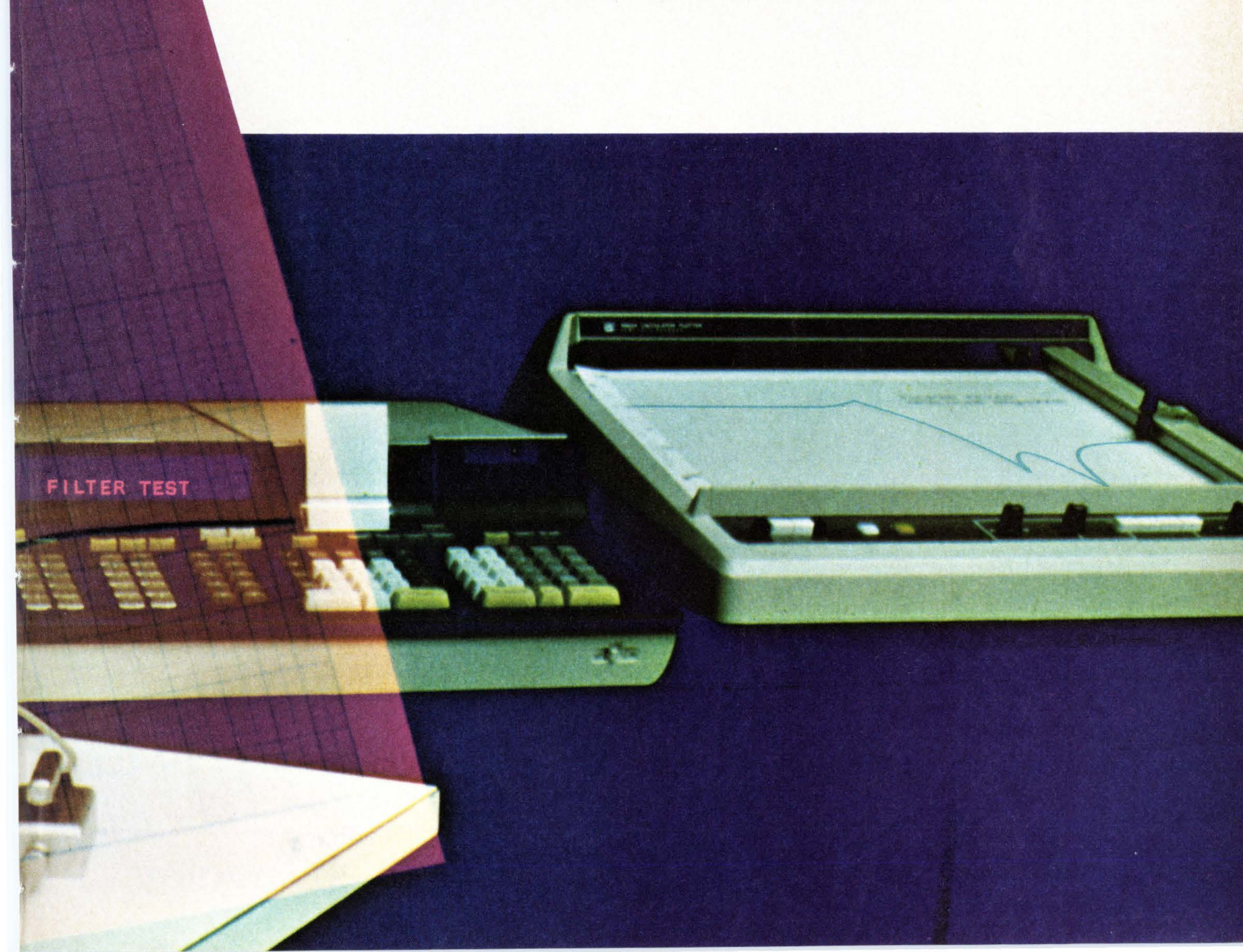
Circle 23 on reader service card



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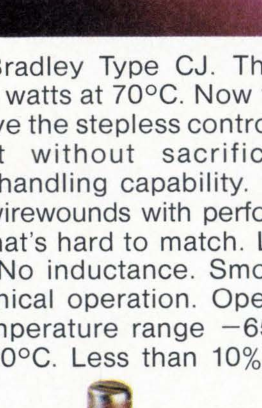

A-B QUALITY

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Circle 24 on reader service card

Electronics newsletter

Magnetic-bubble memory takes megabit shape

Using the "highest-density shift-register chip ever built" in any technology, Bell Laboratories, Murray Hill, N.J., is putting together a 1.1-megabit bubble memory that "could do all the functions of a fixed-head disk memory," declares J.E. Geusic, magnetics department head. Made of epitaxial garnet film with a permalloy overlay for propagation and conductors for control, the chip is only 200 mils square yet contains 20,000 bits. And only two photo-lithographic steps, versus as many as eight for semiconductor memories, are needed in its fabrication, Geusic points out. **A complete memory, which comes with 56 chips as well as a magnet and rotating field coils, would occupy 1.3 by 3¼ by ½ inches.**

Japan space agency to buy U.S. system

In one of the largest electronic programs let to a foreign country, and the first ever directly to a foreign company, Japan's National Aeronautic and Space Development Agency is buying **over $3 million in communications equipment for its N-launch vehicle program** from Motorola's Government Equipment division. The equipment will be delivered starting late this year for a late 1975 launch. **The N launch vehicle will use C-band radar-tracking transponders for command data** instead of depending on the usual separate S-band command system.

National builds monolithic pentode replacement

A monolithic replacement for vacuum tubes is being made in prototype quantities by National Semiconductor Corp. of Santa Clara, Calif. Teledyne Semiconductor, Mountain View, Calif., which initially developed hybrid ICs (Fetrons) built around high-voltage junction field-effect transistors (Electronics, April 10, 1972, p. 85), has **estimated the potential market as $500 million a year.**

The prototype circuits meet the performance specifications for 6AK5 vacuum tubes, but chip yields are still too low for mass production, says Paul Pagnini, product manager at National. He doesn't expect the devices to go into commercial production until late this year.

Tests show epoxy IC packages have reliability edge

Epoxy-packaged ICs are bettering their phenolic and silicone brethren by more than one order of magnitude. That's the news from the site in Panama where the U.S. Army Electronics Command, which is headquartered at Fort Monmouth, N.J., has been conducting environmental tests. **The epoxy-A packages are exhibiting a failure rate of 0.14% per 1,000 hours compared with 5.5% for phenolic and 13.5% for silicone.** The 80 epoxy packages had accumulated 1.4 million hours at the time of the test report, and there had been one failure. Temperatures at the Panama test site range from 80° to 90° F at relative humidities from 85% to 95%.

Wafer shortage sends U.S. firm to Japan for chips

While many of the MOS calculator chip sets made in the U.S. are assembled by Japanese firms, Electronic Arrays Inc., may go all the way and have the chips made in Japan, too. Earl Gregory, EA vice president, says the company is considering **a production arrangement with**

Mitsubishi Electric Corp. whereby the Japanese firm would process p-channel chips with masks supplied by Electronic Arrays. Mitsubishi Electric, according to reports, has already made sample quantities of wafers for evaluation.

The move was prompted, says Gregory, by the shortage of wafer-fabrication capacity in the U.S. If the deal goes through, it would affect only p-channel MOS chips.

Fast fax systems show their stuff

Fast facsimile transmission schemes are bidding to take their place in communications of the future. The latest comes from Comfax Communications Industries Inc., a small New York-based development house. Comfax has **a prototype Comfax-15 that transmits at 9,600 bits per second**—that is, it can send an 8½-by-11-inch, double-spaced, typewritten page in something over 15 seconds. It can operate over leased lines, but—for lack of a suitable modem—not over the dial-up telephone network. Essentially, the company has multiplied by four the data transmission rate of its Comfax-60 one-minute machine first shown as a prototype a year ago.

Electronics Associates Inc., West Long Branch, N.J., will manufacture, market and service the units. Production of the Comfax 15 is slated for year's end; Comfax-60 for June. Also showing a system to prospective users is Dacom Inc., Sunnyvale, Calif. Marketed by Savin Business Machines Corp., Valhalla, N.Y.; it transmits a page in something over 35 seconds.

Victor Comptometer enters programable calculator business

Taking advantage of its penetration of the business and commercial calculator markets, Victor Comptometer Corp. will enter the programable electronic calculator business later this year with a series of four low-cost machines. The Chicago-based firm is aiming at the dead center of the "virtually untouched" business and commercial segments, says J. E. Smith, president of Victor's Business Products group, and he hints **the company will tackle H-P and Wang in the more specialized engineering and scientific market segments later on.** The series will start at about $1,800 and will offer up to 102 registers and 1,000 steps, programable with a magnetic program card.

Addenda

The Federal Aviation Administration will conduct tests this fall to see how much better for domestic navigation differential Omega is than Omega alone. Bendix Corp.'s Navigation & Control division, Teterboro, N. J., will supply the equipment. . . . At Texas Instruments' annual meeting in Dallas, Mark Shepherd, president, announced first quarter income of $18.9 million as 75% better than last year's record first quarter. . . . The requirement for automatic fine tuning on uhf detent tuners in black-and-white TV sets will become optional by 1975 under rule changes proposed by the Federal Communications Commission. . . . The Federal Highway Safety Administration has turned down Detroit's request for extending the deadline on seat-belt interlocks. This equipment, which prevents a car from starting if the belts aren't fastened, must be present in 1974 models.

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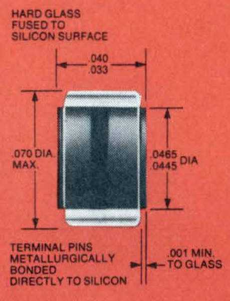

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UM7902A	200		
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See EEM Section 4800 And EBG Semiconductors Section for more complete product listing.

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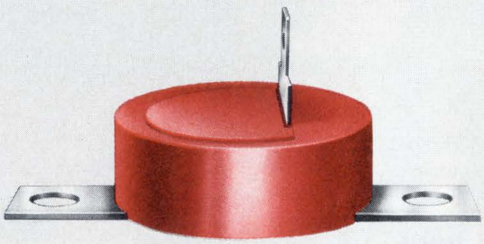

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V510PA80A	10	510	655	12.60	8.51	7.56
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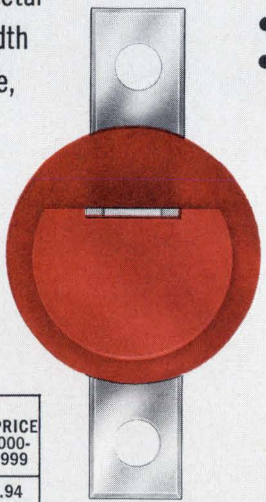

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GENERAL ELECTRIC

Electronic industries worry over the cost of Nixon's trade bill

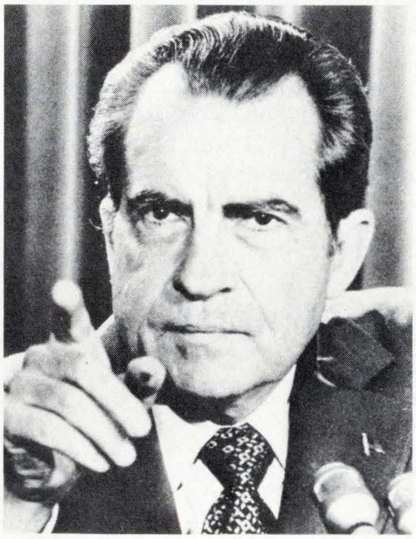
Offshore manufacturers could pay much higher tariffs and taxes if the Trade Reform bill passes

How much will it cost? That is the gut question being asked on all sides about President Nixon's sweeping Trade Reform Act of 1973, and the initial assemblers of semiconductors and consumer products in particular are saying that the price of what they are being asked to give up in tariff and tax advantages may turn out to be more than they will get in return.

Tradeoffs. "There are always tradeoffs in any situation," observes one Washington counsellor to Electronic Industries Association companies, "but the puzzling thing—maybe clever is better—about this bill is that manufacturers can figure what they are being asked to pay with no substantive guarantees about what they will get." The industry is being asked to surrender the advantages of Items 806.30 and 807 of the U.S. Tariff Schedules, under which unfinished parts exported for foreign assembly may be reimported in a finished product—whether it is an integrated circuit or TV receiver—with tariffs paid only on the value added, usually labor.

Less obvious, but perhaps more threatening to electronics manufacturers in terms of lost revenues, are the prospects for higher taxes contained in the Administration's trade bill. Of particular concern is the request that revenues of what Nixon called "the classic runaway" plant—that ships more than 25% of its output—be taxed in the year they are earned, rather than in the year when the corporation decides to repatriate those earnings.

Among semiconductor makers, however, the threat of repeal of Items 806.30 and 807 attracted the greatest initial attention, although that prospect has been anticipated in Washington for some months [*Electronics*, March 1, p. 25]. Earlier this year, the EIA wrote urging their retention, noting that the tariff savings represent "approximately half of the profit margin" of many of the products covered. At Signetics Corp., Sunnyvale, Calif., marketing vice president Jack Halter concurs with the EIA view and contends that because of the lower tariff on value added only, semiconductor makers with offshore operations have been able to sell at high volume overseas and thus sell at lower prices domestically to minicomputer makers.



Tough trader. The President's bill seeks broad powers to control tariffs and taxes.

Halter also points out that, if a tax is placed on the shipment of materials overseas, many U.S. companies who support the semiconductor manufacturers could also be hurt.

On the issue of higher taxes for offshore operations, John Cobb, vice president and controller at Intel Corp., Santa Clara, Calif., believes the trade bill is "misdirected" since it would "obviously make offshore assembly more expensive" and thus inhibit the price advantage that has helped keep U.S. semiconductor makers dominant in world production of complex devices. Cobb sees the Nixon bill as overreacting to the concerns of U.S. organized labor and wants the electronics industries to "mount a strong lobby against it."

Opposition. Assessments of the Nixon bill and early drives to develop a position for the electronics industries have been much on the mind of EIA and the California-based manufacturers group, WEMA, since the package was sent to the Congress in mid-April. EIA was ready early, setting up industry meetings in California and Washington within a week. Although there was some feeling among manufacturers against moving too quickly before settling on a firm position, industry organization officials noted they had to have an outline of their position ready April 27, along with their requests to testify at the first round of hearings set to begin May 7 before the House Ways and Means Committee headed by Rep. Wilbur Mills (D., Ark.).

The Nixon package stands a good chance of passing with only limited changes in many of the President's requests for new and unprecedented authority. The Congress may give the President the power to wheel and deal in international trade negotiations while restricting imports of specific items at home to protect domestic jobs and industry. With the initial reaction of the powerful Chairman Mills recorded as "I think it will go," the Congress appeared overwhelmed by the White House. To most Washington observers, however, that reaction was simply a reflection of how well the Executive branch had done its homework in consulting with key congressional leaders on the content of the bill.

Nevertheless, the puzzling parts of the bill remain to be spelled out in the months of debate to come. The Congress is expected to tighten somewhat the virtually complete freedom the President has requested for negotiating "free but fairer trade" and expanding trade with Communist and less-developed nations on a bilateral basis. There is also much to be determined as to how and when and under what circumstances Nixon would impose quotas and tariff surcharges on heavy imports from countries like Japan in order to lever them into a more equitable trade balance.

Presidential power. But the President wants the power to raise, reduce, or remove tariffs "in the context of negotiated agreement," and he wants them for five years. He also says he is anxious to negotiate removal of the less visible and stickier nontariff trade barriers like those EIA sees rising in the European Economic Community on imports of U.S. components. But he is asking Congress and U.S. industries not only to take his administration of these new powers on trust but to surrender certain concrete advantages they already have.

In the case of Congress, it is the surrender of more of its powers; for industries like electronics it is Items 806.30 and 807, and tax advantages. While neither group is willing to surrender these benefits readily, they see the threat of the protectionist Burke-Hartke bill as a greater evil. And that is exactly the kind of leverage the White House appears to believe will help it acquire its new powers for the President without having to spell out precisely how they will be used. □

Solid state

Microwave bipolar devices combine ion implantation with Isoplanar

The race is one between microwave field-effect transistors and bipolar devices. Last month, microwave FETs were gaining, particularly in the 6 gigahertz range [*Electronics*, March 1, p. 41], but now it is the turn of bipolar devices.

Fairchild has attained noise figures of 2 to 4 decibels at 2 to 8 GHz in bipolar transistors that combine ion implantation with the Isoplanar process.

John Archer, of Fairchild's Microwave and Optoelectronics division, who developed the new transistors, estimates the chips can be produced for a third the cost of gallium-arsenide FETs developed for low-noise small-signal microwave amplifiers [*Electronics*, Nov. 1, 1972, p. 90]. The company plans to produce them commercially, but has not yet set a price.

FETs score. Archer says Isoplanar transistor noise figures are as low as those of GaAs FETs up to about 6 GHz, after which FETs pull ahead. He prefers to compare them with conventional bipolar microwave transistors, such as Fairchild's FMT4000. At 4 GHz, typical noise figures are 3.6 dB for the FMT4000 versus 2.3 for the new ones. The difference increases rapidly with frequency, reaching 6 to 7 dB versus 3.9 dB at 8 GHz. Gain of the transistors is about par for a small-signal amplifier—a maximum of 8 dB at 6 GHz, for example.

Ion implantation is used to overcome the high base resistance that usually degrades the noise performance of bipolar microwave transistors. The Isoplanar technique provides better gain at high frequencies through reduction of junction areas and parasitic capacitances.

Processing steps. Ordinarily, a bipolar transistor is made with two diffusions, base and emitter. Microwave multi-emitter types have two base contacts on either side of each emitter stripe. To get this structure to work at higher and higher frequencies, the base diffusion must be made shallower and shallower.

In turn, that causes the sheet resistance of the inactive base region surrounding the emitter to rise. The effect of the high resistance between the base contacts can be alleviated by narrowing the emitter stripe, to reduce the active base resistance, but the total resistance remains high.

Archer avoids this problem by first masking the base area with silicon nitride. Then the exposed silicon is deeply oxidized—the Isoplanar step—leaving the transistor area walled in by thick oxide. Next, the inactive-base area is exposed and deeply diffused with boron. Then, 1-micrometer-wide emitter stripes are etched in a silicon nitride film, and arsenic is diffused. Finally, a shallow layer of boron ions is driven through the emitter to form the base, and the wafer is annealed.

The oxide wall eliminates the collector-base sidewall junction capacitance found in conventional transistors, Archer says, and allows lead bonds to be made over very thick oxide, reducing pad capacitance. Thus, the Isoplanar method cuts the collector-base feedback capacitance, giving the transistor high gain at high frequency. Besides cutting inactive-base resistance, the heavy diffusion of boron spreads under the nitride, masking the emitter and reducing the effective emitter width to 0.5 micrometer.

Archer is now working on a new version of the transistor. He thinks the performance will be further improved if he substitutes additional implantations for the diffusions. If the technique works, he will update the paper he is to present at the Semicon Conference. □

Avionics

Mini rate sensor works on gas

Prototypes of a radically different kind of angular rate sensor—one with no rotating or sliding parts—are being shipped by Hamilton Standard, a division of United Aircraft Corp. What's more, the division thinks it can turn the new sensor into a production unit featuring "virtually unlimited" life and capable of withstanding several thousand g of shock and vibration.

The device is already being evaluated for two military systems, says Eric J. Herzlich, sales manager of Hamilton Standard's operation in Trumbull, Conn. One system is in an advanced version of the Redeye missile, and the other involves a cannon-launched guided missile.

Called the Superjet, the sensor relies on a continuously circulating flow of helium gas that impinges on two hot-wire tungsten resistors, instead of the high-speed rotating wheel of conventional electromechanical gyros. The wires are connected into a resistance bridge.

Any angular rate impressed on the unit causes the helium jet passing over the wires to deflect laterally so that the wires are cooled at different rates. The equations governing this deflection are similar to the well-known Coriolis equations.

Because one wire is cooled more

Component sales boom in Europe and delivery times stretch out

"We're booked solid." This situation report from Guy Derome, manager of the passive components division of Thomson-CSF, is being heard more and more in Europe these days as the semiconductor business surges.

When asked, "if I ordered today, when could you deliver 200,000 TTL gates?" Jean-Jacques Teillet of LaRadiotechnique-Compelec (RTC) replied, "since you'd be a new customer, at least six months."

This is the rule, not the exception, as European companies face one of the tightest semiconductor supply situations ever. It affects most countries and both active and passive components. Business is so good that vendors have pushed the nagging worry of double ordering to the back of their minds, although marketing experts such as ITT Europe's John Posthuma van der Helm believe that there is some double ordering going on as companies seek to insure sources of supply.

Both Derome and Teillet, who heads the semiconductor and microelectronic division of RTC, point out that their companies are keeping largely on schedule with programed deliveries. However, even to take care of long-term customers, suppliers are juggling schedules, stretching out large orders, and adding production shifts.

Why the boom? Fueling the boom is the color-television market which is expected to hit 5.7 million sets in Western Europe this year, up from 1972 sales of 4.3 million. And according to recent market forecasts made by Philips Gloeilampenfabrieken, business will continue strong through 1975. Philips forecasters predict sales of 7.2 million units in 1975, up 28% from this year's forecast.

Other factors include an increase in demand from the professional-commercial sector of the electronics industries. Orders from this sector have risen sharply since the beginning of this year, says Erich Gelder, marketing manager for integrated circuits at Siemens AG.

The shortage in the U.S. [*Electronics*, April 12, p. 79] also has its impact. Particularly, importer-distributors note a squeeze. Their suppliers in the U.S. and Japan have trouble keeping up with domestic customers' needs and tend to put export business second. Meanwhile, the European customers are clamoring for components. "There's a tremendous shortage of resistors and capacitors," says François Le Cain of Tranchant Electronique's import division. "We're selling high-price film resistors to some set makers who can't get enough consumer-grade ones."

Delivery times are six months for tantalum capacitors, and on some types Plessey Co. Ltd. is quoting 10- to 12-month delivery. Film and electrolytic capacitors may take six months. At Stettner and Co., Emil Fries, manager of technical sales, is quoting delivery times ranging from three to seven months on some types of capacitors.

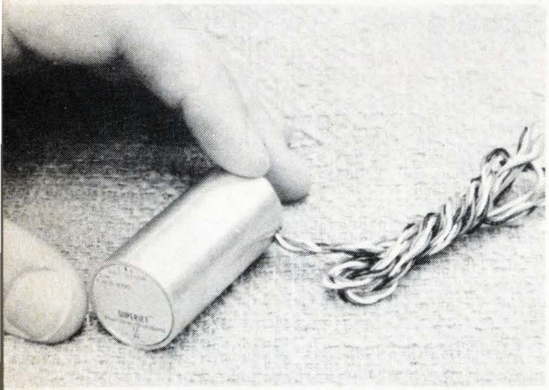
Price hikes. Prices are creeping up. Vendors point out that prices were depressed as the industry came out of the recent recession. And, furthermore, labor and material costs are going up.

Shortages are also hampering efforts to increase production. Roy McLauchlan, general sales manager of AEI Semiconductors Ltd., says the silicon shortage has hit planned production increases in thyristors, 90% of which formerly would be delivered from stock but which now require an average four to six weeks for delivery. At Plessey, John Hayden, commercial manager of the company's integrated-circuit facility, is ordering silicon wafers 12 months ahead, and ceramic packages 16 weeks ahead.

Overall, companies remain reluctant to build additional capacity. The most popular moves are to add shifts, and then add production lines in existing space. Explains Gelder of Siemens, "we're not investing as much as our customers think we ought to invest. We don't want to face the same situation we did during the last semiconductor slump when we found ourselves with too much capacity."

than the other, their resistances vary, unbalancing the bridge and producing a signal proportional to the rate input. The result is an extremely rugged rate sensor, about the same size as the conventional $200 Supergyro unit already in production at Trumbull. It has a full-scale rate range of up to 2,000° per second, a threshold and resolution of 0.05% full scale, and, because no

It's a gas. Three-ounce rate sensor measures to 2,000°/s, withstands 1,000 g.



wheel has to be brought up to rotating speed, almost instantaneous startup time, according to Herzlich.

In addition, the absence of mechanical parts such as a rotating motor, tight tolerances, pickoffs, bearings, or small gaps between moving elements, means the unit is exceptionally rugged. "It's like a block of metal for all practical purposes," Herzlich asserts. He says the new sensor has already withstood shocks of over 1,000 g, versus 50 or 60 g for the $200 unit. "We expect that 10,000 g is well within the Supergyro's capabilities," he continues. And with nothing to break or wear out, life could be extremely long—over 10,000 hours is a "conservative" figure.

Weight: 3 ounces. As now designed, the Superjet is in a 1-inch-diameter aluminum cylinder that could be anywhere from 2 to 3.28 inches long, depending on its rate range. Its only moving part is a piezoelectric diaphragm electrically vibrated, much like the diaphragm in an ultrasonic cleaner, to keep the helium gas circulating. Approximately 2.8 watts of power for the diaphragm and hot wires are supplied from a +28-volt dc source. And the unit weighs about three ounces, with the bridge and current-sensing electronics producing an output signal of up to ±5 V dc.

Hamilton Standard obtained the rights to the fluidic sensor last fall, when it acquired VI Products, a manufacturer of low-cost rate gyros and inertial platforms. Shortly before, VI had acquired a license for the Superjet from Hercules Inc., the chemical company, whose Allegany Ballistics Laboratory, had been developing it for several years. Humphrey Inc., another small gyro manufacturer in San Diego, is also licensed by Hercules.

The acquisition was made to help Hamilton Standard diversify out of its sophisticated space-oriented hardware, and into the low-cost inertial field.

Hamilton Standard is developing the sensor with two basic application areas in mind, according to Herzlich. Its extreme ruggedness and a possible $50 price would make it quite useful in missiles and projectiles, he points out. The other application would be in aircraft. Here a more accurate sensor would be required—the conventional Supergyro unit has a resolution, for example, of 0.002% of full scale—but the target cost of $100 would be twice as expensive. □

Processing

Protons are key to IR detector arrays

Proton bombardment may become just as valuable in processing optoelectronic devices as the more familiar ion implantation is for processing semiconductor devices.

At the Massachusetts Institute of Technology's Lincoln Laboratory, Lexington, Mass., proton bombardment is being used to produce 20-element arrays of infrared photodetector diodes with what laboratory spokesmen call good quantum efficiencies and "unusually high" yields. The arrays, which are being supplied in limited quantities by the laboratory's Solid State Division to the U.S. Army Night Vision Laboratory, Fort Belvoir, Va., range in quantum efficiency from "abnormally low figures" of 17% to 20% to a more typical 30% to 35%. The reasons for this spread are not fully understood, but the technique of proton bombardment is being studied, and the answer may very well lie there.

As for yield, 50 arrays of 20 diodes each are laid down on indium antimonide wafers. Generally, half of these arrays are usuable: 18 have defects due to photolithographic errors or dirt, which Lincoln says greater care would prevent, and only seven have electrically bad diodes, indicating that the process, once it is refined, may produce high yields.

The laboratory's applied physics group plans to take advantage of proton bombardment's yield potential in a program to develop much larger arrays in an expansion of an indium-antimonide-array vidicon program.

How to make them. The diodes are np junction devices. The base material is p-type indium antimonide. A 1,000-angstrom-thick layer of silicon oxynitride is first deposited, followed by a 1,500-angstrom layer of silicon dioxide, 300 angstroms of chromium, 800 angstroms of gold, and 250 angstroms of titanium. The gold doubles as bombardment mask and, later, as the detector's field plate.

This metallic sandwich is etched down to the base to produce windows above those areas that will become diodes; the windows are 4.75 by 2.75 mils and are spaced about 5 micrometers apart. A stream of 100-kiloelectronvolt protons then bombards the wafer so as to convert the exposed areas of indium antimonide to n-type material. The titanium and gold layers are removed where electrical contacts must cross over the active diode area, and the wafer is coated again with silicon dioxide. Afterward, 1-mil-square holes are etched down to the gold, and crossover contacts are laid down to pro-

vide electrical connection with standard-size bonding pads.

Finally, the wafer is scribed and separated, with arrays bonded to a sapphire header either in groups or individually. The pinout is via standard gold wire, and operation is in a liquid nitrogen-filled dewar flask. □

Commercial electronics

Computer verifies ID from photos

A new Swedish identification system may augur the era of "big brother." The system, invented by Eric Rothfjell, the head of Europe's largest identification-card company, makes it possible for computers to identify photographs on identification cards. Until now, attempts at computer-recognition of faces and voices have either required tremendous memory capacity or were not accurate.

Rothfjell's system involves drawing lines on the back of a photograph of the face to outline the main facial characteristics—the curve of the nose, a prominent cheek-bone, cleft chin, deep wrinkle, eye-socket curve, or the shape of the forehead. The individual is photographed in three positions—full-face, profile, and at a 45° angle. So far, all lines have been drawn by hand on test cards, but Rothfjell says this process could be automated.

To verify a person's identity, the facial curves on a passport or ID card are scanned by an optical scanner and fed into a computer memory, along with other data—such as name, address, and account number. The system needs only about 200 to 250 bits of information to ensure positive identification. Rothfjell says that no two faces are alike and that curves drawn for one person will definitely not match those of another person, except for identical twins.

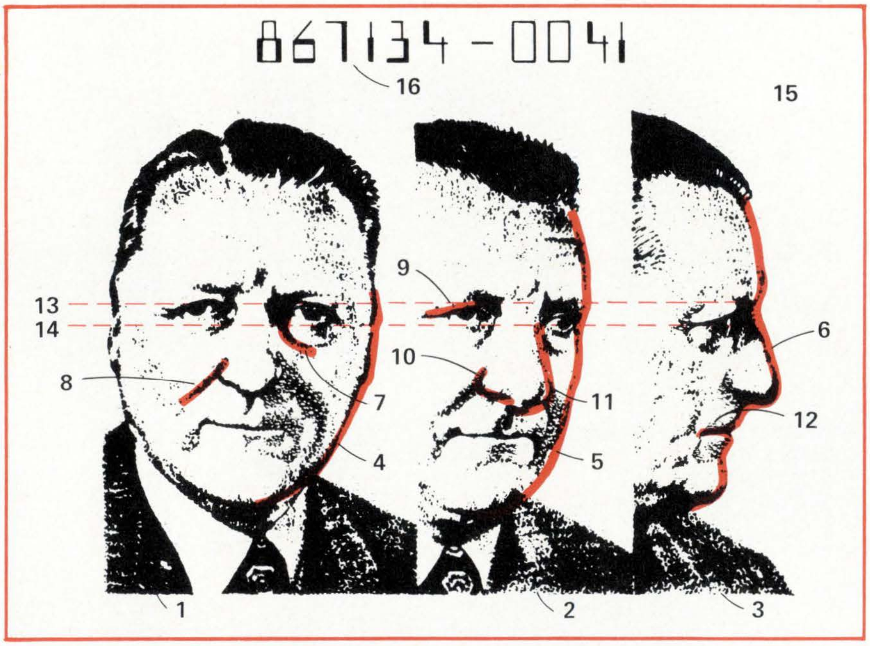
These curved lines drawn on the reverse of the identification card are not visible on the front. To use a credit card, a shop clerk inserts the card into a special viewer, and the card is lit from behind. The clerk checks to see if the lines on the back of the card match the face on the front. The card is then placed into a scanning instrument, which scans the curves and transmits the information to a computer for confirmation of the customer's credit. Rothfjell will not give details of the scanning instruments, but he says that prototypes are being tested by manufacturers.

"Big brother?" Why does one need lines or curves for scanning when the middleman—the clerk or teller—is still needed to recognize the bearer of the card from the photo? Rothfjell says: "The time when you can have direct computer-recognition of an individual—by facial recognition or voice-print—is a long way off. My system can be put into use right now. The difference between my system and direct reading of cards by use of magnetic strips or other devices is that here you have a combination foolproof identification card that can also serve as a credit card or in a passport. When you take the big next step, into direct personal recognition by computers, then you are facing 'big brother.' "

The personal-identification-card market—although downstream in many countries—arrived in Sweden several years ago, and today it is a part of life.

Although the market is already here, Rothfjell realized that the system will need worldwide marketing. He says that a company to market the system is being organized in the U.S. A Swedish subsidiary will handle Scandinavia. □

Computer knows best. The main facial characteristics, shown in color, are scanned and fed into a computer along with personal data to confirm a person's identity.



Navigation

Omega/inertial mix improves nav system

Most ships and aircraft, particularly military ones, have numerous navigation systems for different conditions and for backup. One of the most expensive is inertial guidance, and one of the newest is Omega; officials at Northrop Electronics are betting that a combination of the two may be most popular for military uses, since it would offer significantly lower costs than full inertial, plus better performance than either.

J. Stuart Parsons, director of busi-

ness development at the Hawthorne, Calif., division, estimates that a hybrid system, in which altitude and heading reference inertial platform would be combined with Omega updating, could reduce costs over present full inertial systems from $100,000 to $50,000. Such a hybrid system is being installed on a U.S. Air Force WC-130B by prime systems contractor Kaman Aerospace Corp. for the airborne weather reconnaissance system (AWRS). The division also has contracts for the airborne warning and control system (Awacs), and the P-3.

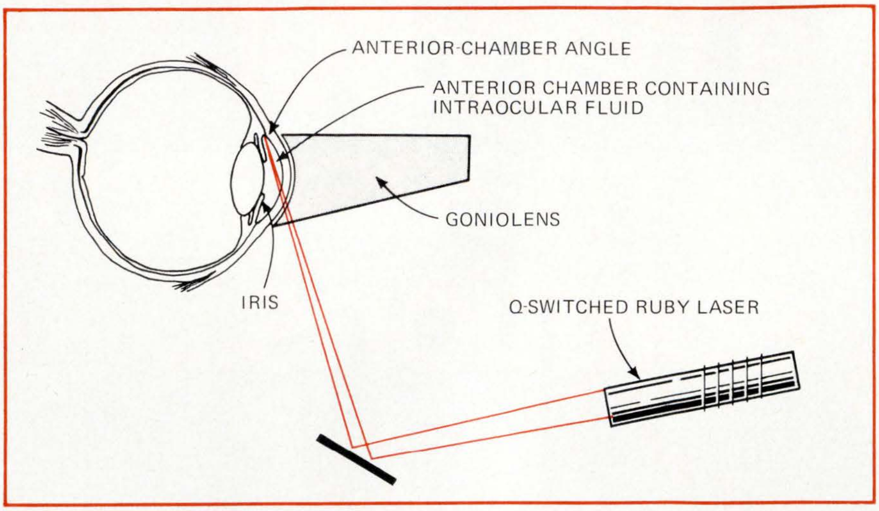
The performance advantages of the Omega/inertial combination according to Parsons include:

- A bounded error with accuracies of 1 to 2 miles.
- Low maintenance and high reliability.
- Reduced reaction time for resetting—from 18 to 25 minutes on the ground to 5 to 8 minutes.

The AWRS system includes a floating-ball platform from the C-5A, a Northrop AN/ARN-99 Omega receiver, plus an IBM 4 PI computer. It is designed for a 1.2-nautical-mile circular error probability in 15 hours flight. The Awacs system will be more complex, using two Delco platforms plus a Ryan doppler radar. □

Medical electronics

Russians use laser to treat glaucoma



Painless. The use of multiple bursts of laser light has been found to be a quick and painless treatment for glaucoma, the second leading cause of blindness.

Soviet doctors have developed a nonsurgical method using Q-switched lasers to treat glaucoma, the second leading cause of blindness. Called laser goniopuncture, the method must be repeated periodically but is quick and painless. It also saves patients from the bad side effects of surgery, such as scarring of eye tissue or a second operation for resulting cataracts, or from bothering with drug treatment.

Glaucoma may start with the blockage of very small passages through which intraocular fluid passes to lubricate the eye. When these passages close up, the buildup of pressure permanently damages the optic nerve. Surgical methods of treatment involve cutting new passages. The Russian method, however, uses the laser to punch through the blockage. This happens so quickly, says its inventor, Dr. Michael M. Krasnov, that the eye nerves cannot detect any pain. Krasnov, who is on the staff of the Second Medical Institute and a member of the Soviet Academy of Medicine, explained the technique at a press conference held in Washington, D.C., this month by Patent Management Inc. Patent Management is making the technique available for license in the U.S. on behalf of the Soviet Union.

Aiming the light. Since in most glaucoma a microscopic filtering "mesh" in the anterior-chamber angle of the eye is affected, Krasnov uses an angle lens, or goniolens, a conventional slit lamp, and a second low-power neon-helium laser to aim the ruby Q-switched laser precisely. The laser beam strikes the eye at an angle to prevent damage to the cornea, he says. The eye lens is transparent so it transmits the laser beam directly where aimed, he adds.

While for some time U.S. doctors have used the precisely focused heat of a laser beam to "spot-weld" detached retinas to the back of the eye, Soviet scientists turned to Q-switched lasers to treat glaucoma so that sensitive tissues would not be damaged by heat buildup. "The starting point was to find a laser which will not cause scar tissue to form," the noted ophthalmologist says in explaining why a Q-switched laser was selected, but "such a laser had never been tried on the eye before." Here he had advice from A.M. Prochorov, who shared a Nobel Prize with Charles Townes for co-inventing the laser. Chosen was a 6,943-angstrom laser firing 0.2 joules, or "several megawatts per burst" in 20-nanosecond pulses.

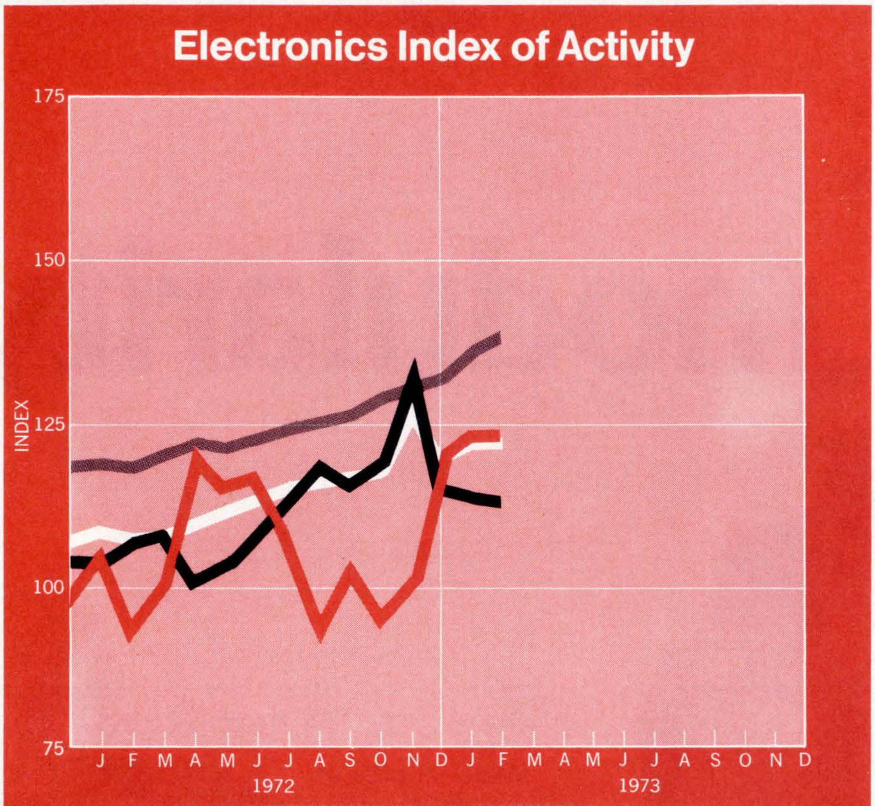
Of the 94 adults treated so far, only a few have failed to respond to the treatment, Krasnov says. Patients must return at two- to eight-month intervals for repeat treatment as the glaucoma reblocks the passages. This takes less than 10 minutes for the 10 to 15 firings. □

Packaging

Electrolysis used to predict failure

Basing their analysis on a common electrochemical mechanism—electrolysis—Bell Laboratories researchers say they can predict the failure caused by humidity on plastic-packaged ICs over 30 to 40 years.

Stewart Peck and Connie Zierdt,



Segment of Industry	Feb. '73	Jan. '73*	Feb. '72
Consumer electronics	124.8	124.2	105.4
Defense electronics	113.6	114.5	104.7
Industrial-commercial electronics	138.3	136.7	119.4
Total industry	122.8	122.8	109.3

The Index was unchanged at 122.8 in February, 12.4% ahead of last year's level. Industrial-commercial-electronics gained 1.2%. This is 15.8% above February 1972's level. Consumer electronics rose 0.5%, 18.4% higher than last year. There was a 0.8% decline in defense electronics in February, leaving this sector 8.5% above 1972's level.

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.

from Bell Laboratories in Allentown, Pa., say their technique is based on establishing failure rates at severe temperature-humidity environments over the short term (tens of hours) and then determining how these conditions accelerate failure. Peck told the Reliability Physics Symposium in Las Vegas in early April that "this predictive technique based on an acceleration rate has not been established before."

For example, if a package might exhibit 0.1% failures at 85°C and 85% relative humidity after 10 hours, its failure acceleration relative to 30°C and 15% humidity might be 20,000. Then one can predict that the device will exhibit a 0.1% failure rate after $10 \times 20{,}000$, hours—more than 20 years.

Electrolysis occurs when two metals are separated by insulation and biased by an electric potential, causing ions to migrate from one metal to the other. What happens is that raising the humidity decreases the surface resistance of the insulator. Therefore, the leakage current across the surface increases, and the plating rate increases, hastening the destruction of the device. Raising the temperature has the same accelerating effect.

The evidence supporting this theory is by no means complete. For although the correlation of theory with experimental data on epoxy, silicone and phenolic packages is good, a limited number of devices were involved in the tests, and more test data will be needed to substantiate the technique.

Humidity is but one cause of failures in plastic packages. Another one in the news is wire-bond failure due to temperature cycling. □

Communications

Cw diode laser emits in visible red

For the first time a semiconductor laser has been made to operate continuously in the visible spectrum at a wavelength as short as 6,500 angstroms. This is the shortest wavelength obtained for continuous operation of a diode laser.

Surrounded by liquid nitrogen, the aluminum-gallium-arsenide injection laser has an output of 50 milliwatts. The work is being done at RCA Laboratories, Princeton, N.J., under partial sponsorship of NASA.

Henry Kressel, who heads the research team at RCA, says that "these compact, efficient, and easily modulated visible laser diodes are of special interest as a replacement for the bulky and power-consuming gas lasers that are now being used in high-speed film-encoding of data." Kressel says that previous laser diodes were not suitable for film recording because they could only operate continuously in the infrared where the spectral response of the film is poor.

Uses heterojunction. The first cw infrared lasers operating at room temperature were announced in 1971, by Bell Laboratories and RCA Laboratories [*Electronics*, Aug. 31, 1970, p. 37]. These devices contained a diode structure called a

heterojunction, which efficiently concentrates the laser light within the cavity. The same heterojunction structure is used with the visible-laser diode, but to make it emit at the shorter wavelength, it must be doped with aluminum alloy. And because of fundamental limitations in the AlGaAs-alloy structure, operation at this wavelength presently

News briefs

No boycott on supermarket electronics

The recent development of a Universal Product Code, standardizing product identification in the grocery industry, has generated more interest in point-of-sale equipment than a steak sale.

NCR, Dayton, O., has recently entered the field with an interactive terminal, model 250, adaptable to reading the selected code, and will show it at the Super Market Institute convention next month. Each unit can be individually programed to handle food stamps, checks, bottle returns, coupons, and merchandise returns.

Also showing at the convention will be the Pitney Bowes-Alpex Sesame system, which uses a code scanner at the end of the counter tied to the register; Sweda's SupeRegister, which incorporates a nonvolatile core memory using an MOS LSI microprocessor; Nuclear Data's ESIS, which is tied to a central disk memory, and Data Terminal Systems DaCap 44, another stand-alone register.

Dumont adds support to Thomson

The need for a U. S. source of manufacture is seen by Ernest L. Stern, president of Thomson-CSF Electron Tubes Inc., New York, as the major reason why his parent company, Thomson-CSF, Paris, has acquired Fairchild Camera & Instruments' Dumont Electron Tube division in New Jersey. Stern, who will double as chairman of the board of the Dumont facility, saw his subsidiary's sales increase from about $1 million in 1969 to $3 million last year.

Another push for high-density tape

Another high-density magnetic-tape system has appeared—this time from Telex Computer Products Inc., Tulsa, Okla. The units store data at 6,250 bytes per linear inch of tape and move the tape at speeds of up to 200 inches per second, giving a data transfer rate of up to 1,250,000 bytes per second. The Telex units are said to be compatible with the IBM high-density units recently announced; Telex thus joins Storage Technology Corp. in the high-density business [*Electronics,* March 29, p. 39].

Sprague switches to profit

After running up a loss of over $8 million in fiscal 1971, Sprague Electric Co. has turned the corner and reported earnings of $215,516 on sales of $146.65 million in fiscal 1972. These earnings exclude Sprague's equity in affiliated companies, chiefly Mostek Corp., in which Sprague holds 48% of the stock. Equity in the unaudited net earnings of affiliates should push final net profit figures up by $1.2 million

CAD program from IBM emphasizes speed

IBM's new circuit analysis software package makes use of the latest numerical analysis techniques to minimize computer time and, therefore, cost. Called ASTAP (Advanced STatistical Analysis Program), the package is intended to compete with current major programs like the powerful Sceptre (System for Circuit Evaluation and Prediction of Transient Radiation Effects) and IBM's own ECAP (Electronic Circuit Analysis Program). ASTAP can perform either time-domain, frequency domain, or statistical analysis; it is said to be up to eight times faster than ECAP II for nonlinear transient analysis.

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requires a refrigerated temperature of 77 to 100 degrees kelvin. But this is not considered a significant drawback since the refrigeration advances in IR systems can be readily adapted for this system. □

Military electronics

Army to pinpoint targets from air

The latest move in military efforts to map enemy artillery emplacements is to go airborne. Conventional surveying is the technique commonly used, and the Army's Engineering Topographic Laboratory at Fort Belvoir, Va., has been considering the position and azimuth determining system, known as PADS [*Electronics*, July 31, 1972, p. 22], which uses an inertial platform mounted on a jeep.

But now Motorola's Government Electronics division, Scottsdale, Ariz., has developed a seemingly faster, safer, and easier technique using an aircraft to make ranging flights over a 60-by-60-kilometer area at altitudes of 10,000 and 20,000 feet within a two-hour period. This position and surveying system (PASS) transmits and receives information from the ground and can locate artillery sites within 2 or 3 meters in azimuth and range and 5 to 10 meters in elevation.

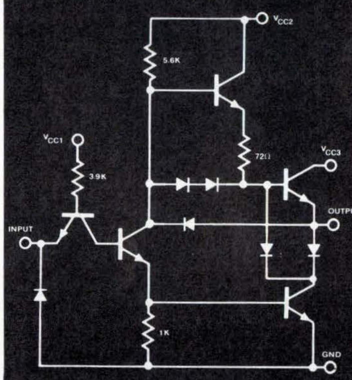
As many as 27 enemy sites can be pinpointed within the two-hour flight. The ground stations, which transmit data independently on command, weigh only 60 lb so they are easily transportable. The system operates on a single spread spectrum frequency with antijamming capability. And the ground stations need only transmit very short bursts to minimize possible detection.

In addition to the ground positioning sets, PASS includes local ground-reference equipment weighing 130 lb, an airborne reference set, and a computing center. Operation is off line, with transfer of data to the center and reduction taking under 30 minutes. □

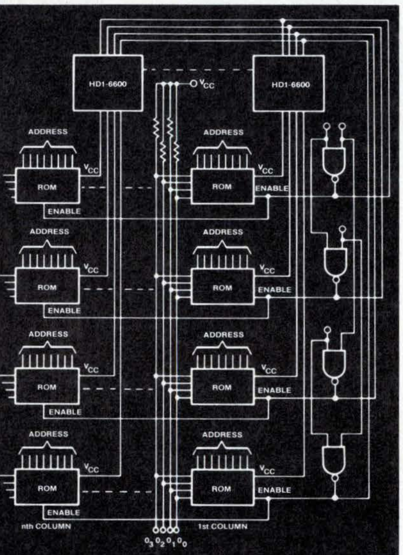
Power down:

Our new Quad Power Strobe selectively activates system components to permit reduction in standby power requirements by as much as an order of magnitude.

The HD-6600 is the industry's first monolithic, dielectrically isolated quad power strobe. Designed primarily for use with ROM and PROM systems, the device offers four power outputs which can be activated selectively, thereby greatly reducing standby power requirements—up to as much as an order of magnitude. Each output can deliver up to 150mA simultaneously with no more than a 250mV drop from the power supply to the strobe output. Access time from the HD-6600 input to a HPROM-1024 memory output is typically 100ns. System access time as low as 50ns can be obtained by powering the memory circuit prior to the read operation. Other applications for the new device include use in telephone relay switching, strobing of general logic circuitry, and multiplexed LED display systems. For more details see your Harris distributor or representative.



Each HD-6600 chip contains four identical strobe circuits, one of which is shown in the diagram above.



The HD-6600 Quad Power Strobe allows the expansion of any ROM system by a factor of four with only nominal increase in system power.

Features:

High drive current	**200mA**
High Speed	**Typically 50ns**
TTL compatible inputs	
Quad monolithic construction	
Inverting logic	
Power supply flexibility	
Low power	
Standby	**30mW/Device**
Active	**95mW/Device**
Supplied 14-pin ceramic DIP	

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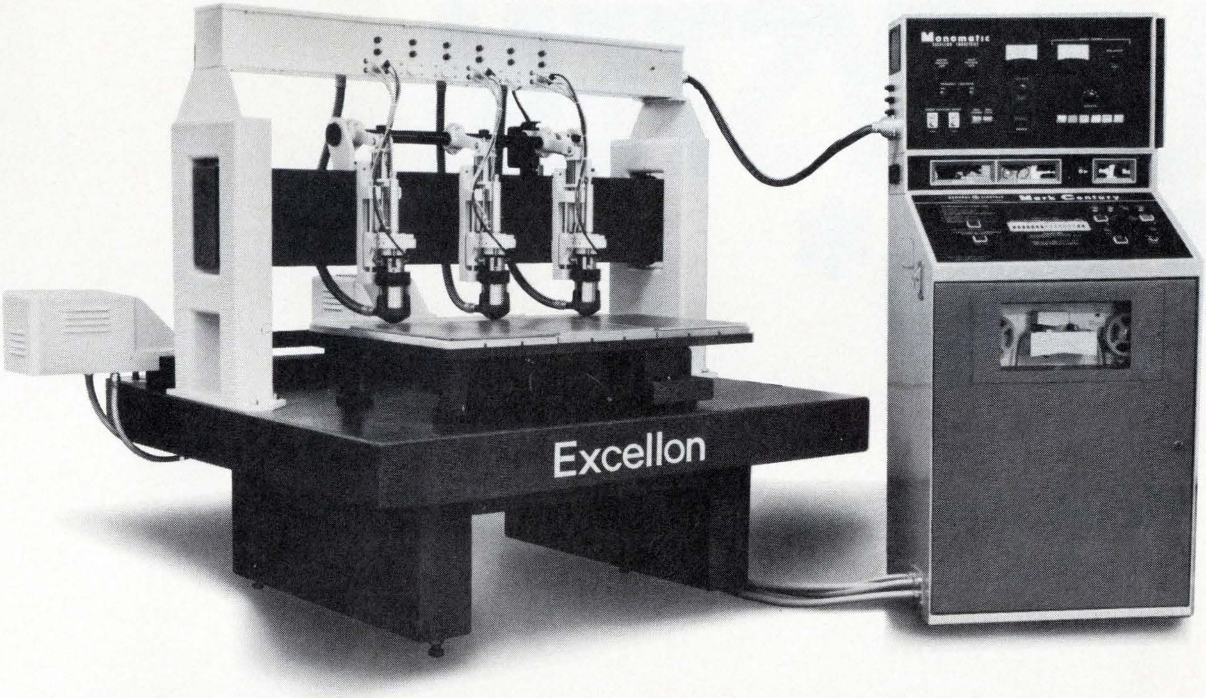

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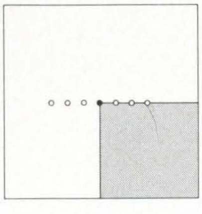
Like the Mark III, the Monomatic/7 can be equipped with optional 80,000 rpm air-bearing spindle motors.

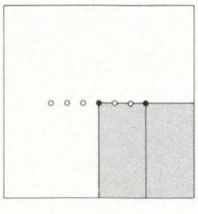
And like the Mark III, it can be fitted with an optional Excellon automatic drill changer that permits you to drill up to 12 different hole sizes with one setup.

Of course, it's a little less sophisticated than the Mark III. But then it's a little less expensive, too.

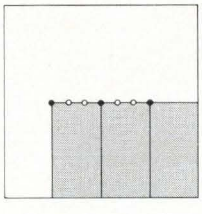
For a competitive costs analysis of the Monomatic/7 and Mark III, and complete specifications, call Dick Hogan, Sales Manager, at (213) 325-8000. Or write him at the address below.



1 Spindle, 1 Stack 25.5" x 25.5"



2 Spindles, 2 Stacks 12.75" x 25.5"



3 Spindles · Extension Table, 3 Stacks 12.75" x 25.5"

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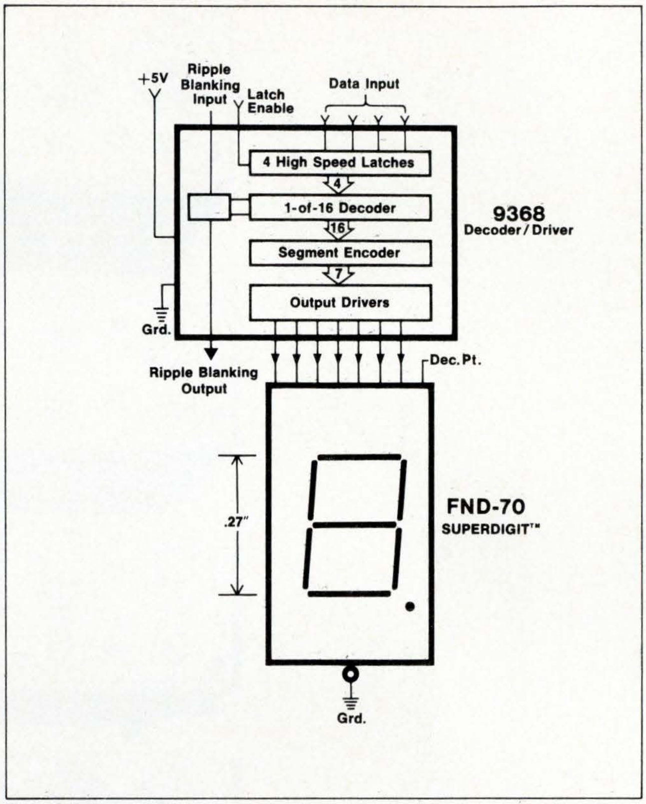

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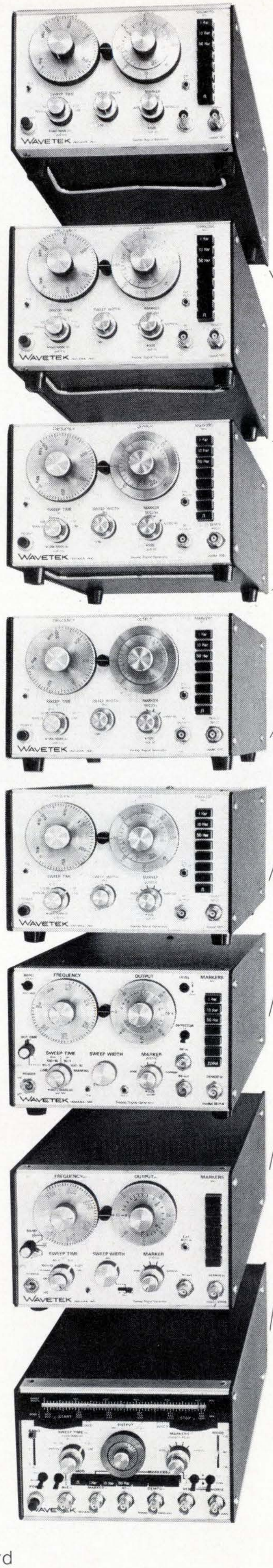

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Washington newsletter

OTP seeks over-all navigation-system plan . . .

The White House Office of Telecommunications Policy is readying **requests for proposals to study Government-supported air, sea, and land navigation systems** as part of a plan to consolidate Federal programs and "cast out obvious redundancies," according to informed Government sources. RFPs are expected to be issued shortly to "four or five" qualified companies selected by OTP but as yet unnamed. Winner of the OTP study contract will be expected to use a fall symposium of the Institute of Navigation to elicit the views of equipment makers and users.

The effort would be a "broad-brush study of requirements and capabilities of various navigation systems" and a first step **in helping the Administration determine the most widely used systems** deserving of continued Federal support. Administration intent is to have users with narrow requirements pay their own way.

. . . in effort to dominate policy

The OTP action comes on the heels of its **move to establish a maritime navigation policy, which is expected to be issued soon** following skirmishes with the Departments of Defense and Transportation, as well as maritime and airline interests [*Electronics*, April 12, p. 59 and March 1, p. 49]. The new drive to set top-to-bottom navigation policy undoubtedly **will embroil OTP with many new Government and industrial interests.**

X-ray lasers forecast by Naval Research Lab

Development of the first X-ray laser is within the realm of the "possible," in the view of the Naval Research Laboratory, now that it has measured the first gain of **a new laser in the vacuum ultraviolet area from triply-ionized carbon ions (C IV).** NRL, which says the measurement is the first in this spectral region and **the first use of ions for lasers below wavelengths of 2,000 angstroms,** is optimistic about the prospects for an X-ray laser using ions. Ions have more highly spaced energy levels than molecules and are therefore capable of generating a shorter laser emission. While the 1,548- and 1,550-angstrom wavelengths emitted by the C IV laser are no shorter than wavelengths observed from other lasers, NRL researchers note that the traveling-wave low-pressure-discharge technique used to produce them seems "extendable as far as the X-ray region."

Air Force to start high-level study of pilotless planes

Remotely piloted vehicles have at last got the high-level military backing they need to qualify them for a larger share of the Defense Department's static R&D budget [*Electronics*, July 31, 1972, p. 51]. Maj. Gen. John J. Burns, chief of operational requirements and development plans, will head **a steering committee of 10 Air Force generals** in a six-month study of the technical capabilities and future missions of RPVs, long advocated as a solution to soaring costs of manned aircraft.

Air Force Under Secretary John L. McLucas, former Mitre Corp. chief and RPV fan himself, formed the 41-man group, which sources say will concentrate a significant portion of its effort on **looking for solutions to the pilotless plane's biggest single weakness: deep-strike missions,** where telemetry and command and control of the aircraft are vulnerable to jamming. First meeting of the committee is set for May 9.

Washington commentary

Medical communications lives on handouts

No one disputes the claim of America's Indians that they have been getting the short end of the stick ever since the founding of the republic. Thus it seemed a refreshing, if relatively small, change was in store when the Secretary of Health, Education, and Welfare Caspar W. Weinberger reported that the Papago Indian Reservation outside Tucson, Ariz., had been selected as the site for the design, installation, and two-year test of a $13 million medical-care system by Lockheed Missiles and Space Co.

Has technology at last come to the Indian? Yes, but only incidentally. The integrated medical and behavioral laboratory measurement system, dubbed IMBLMS by the acronymists, is a complex of advanced medical instrumentation, computers and modern communications that will enable physicians at a central site to receive medical data from a patient at a remote site for diagnosis and to prescribe treatment by trained technicians with the patient.

The principal goal of the program, however, is not for the benefit of the Papago. It is, in HEW's words, "intended to appraise the technical requirements for remote health care in space" under the joint HEW-NASA program. In brief, it seems, the Indians will serve as guinea pigs for the space program. To be sure, the Public Health Service Indian Hospital, which will operate the display and communications consoles on the reservation, will get to keep the system "based on community willingness to support the costs of the system after the initial two-year test period is over."

The rest of us

But that is not the whole story. In the context of the nation's emergency medical services, particularly its application of proven communications technology, the Papago will be a lot better off than most Americans. The status of emergency medical services in the United States was recently described by the National Research Council as "one of the weakest links in the delivery of health care in the nation." And the communications segment of those services is "fragmented" because "individuals and institutions needing help have no central place to call," according to National Academy of Sciences president Philip Handler.

In a society that prides itself on a communications expertise that has put a radio in the hands of most cab drivers, the lack of emergency medical communications can be costed out in a number of ways. In lives, the NAS and others estimate that 90,000 could be saved annually by prompt emergency medical treatment. That is more than 11% of the more than 700,000 who die from heart disease and the 115,000 who die from accidents; it comes to nearly double the number of Americans killed in Southeast Asia during the torturous decade of Vietnam involvement. If you factor in the additional 400,000 who suffer long-term disability each year because of accidents, the dollar cost runs to nearly $3 billion in medical and hospital expenses and more than $7 billion in lost wages, according to NRC figures.

Aid from a foundation

Nevertheless, development of regional emergency medical communications nets is still getting short shrift from the Government. The priority is in fact so low that the NAS attached great significance to its recent announcement that a private philanthropic organization, the Robert Wood Johnson Foundation, was going to fund a two-year $15 million program to provide "basic support" for the establishment of 40 to 50 regional medical communications systems throughout the country. The competitive grants under the program to be administered by NAS will range from $200,000 to $400,000. A condition of the grants to be awarded by year's end is that, after the money runs out,the communities receiving them agree, like the Papago tribe, to continue to fund the communications programs on their own.

"That kind of money won't buy much hardware," observes one communications-equipment supplier tracking the effort, "so it looks like we are still sitting on square one." In truth, that is the case, for much of the NAS-Johnson award monies appears likely to go on coordinating and training efforts for medical communications dispatchers and establishing area-wide telephone links between hospitals and special medical centers.

Part of the NAS-Johnson program also calls for a demonstrated ability to produce "immediate citizen access to the emergency medical system through a centralized communication unit open round the clock, with reserved channels and easy-to-remember, well-publicized call numbers, such as 911." In that context it appears that the Papago Indians will benefit nicely at the hands of NASA and HEW, leaving the rest of us with little else but 911 to dial. That number, you will recall, was first proposed for national use by AT&T in January, 1968, after it had been proved out in 30 years of use in England.

—Ray Connolly

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Low-loss glass fibers step up plans for optical communications

The era of optical communications over glass-fiber cables has been ushered in with the first sales of 100-meter lengths of Selfoc cable by Nippon Electric Co. and Nippon Sheet Glass Co. During the first year, the two companies expect to sell between 500 and 1,000 lengths. Export price will be $2,100 each.

Two developments enabled the companies to open a market for the cable: the ability to fabricate low-loss fibers in long lengths at reasonable prices, and the discovery of a method for coating the individual fibers with plastic, without which they are prone to snap when bent.

Low loss. Typical transmission loss of the cables is about 20 decibels per kilometer, but the companies have allowed themselves a margin for safety and describe it as less than 48 dB/km.

They also allow for a loss of up to 0.5 dB for mismatch when an optical signal enters or leaves a length of cable, so they guarantee a less than 5-dB loss for each 100-meter length. The figure is low because each cable end has been polished and then equipped with a connector that butts mechanically onto the next cable end with precision.

All loss measurements are in the 0.81- to 0.85-micrometer wavelength range of the semiconductor lasers that Nippon Electric assumes will be the standard signal source for future optical communications systems. However, the cables have low loss in the 1.06-μm wavelength of YAG lasers and also work well at the 0.63-μm wavelength of helium-neon lasers.

Different glasses. In the new process, the fibers are drawn from a double crucible with coaxial nozzles so that different types of glass form the center and outside of the fiber. At first glance, this would appear to give a clad fiber with separate indexes of refraction for center and outside. But the glasses are molten, and instantaneous exchange of thallium and sodium ions takes place between the thallium-oxide-doped borosilicate glass in the center and the sodium-oxide-doped borosilicate glass on the outside.

The resultant fiber has a refractive index that is maximum at the center and falls off with an S-shaped curve to a nearly constant value for the outside region. For fibers currently in production, the diameter at half value for the region of decreasing index of refraction is about 30 μm, the total variation in refractive index is about 0.02, and fiber diameter is 200 μm. The protective sheath gives the cable an outside diameter of 1.5 millimeters. The outside diameter of the connecting plug is about 2 mm.

Spurious modes suppressed. The single-fabrication process enables production of almost unlimited lengths of fiber. Fluctuations in the refractive index distribution are very small, keeping the generation of spurious modes to a very low level. Thus the effects of modes with different group velocities are minimized and bandwidth is very large. The large slope of the change in refractive index keeps the light beam continually close to the axis of the fiber, even if the fiber itself bends back and forth. □

Sweden

IR camera system, weighs 18 pounds

Sweden's AGA has come up with an infrared camera that, because of its light weight, is even more significant from a marketing and applications view than the company's original unit, which was the first real-time infrared camera and was put on the market by AGA in 1965.

The new IR system, Thermovision 750, features a hand-held miniature camera—about the size of an amateur movie camera—and a portable thermal-picture display unit. AGA's present Thermovision—as well as competing IR cameras—are large units, requiring a sturdy tripod or support. The display is on a relatively heavy, definitely nonportable oscilloscope or TV monitor.

Hot-spot detection. With the 750 system, users will be able to carry the camera around easily, use it in cramped quarters, and aim it simply and quickly. Readout is either on a display unit carried in a harness by the user, or on a larger remote screen. AGA sold its first system to the Central Electricity Generating Board of Great Britain, after taking engineers on a demonstration flight over power lines in a helicopter.

The camera, which weighs 3.3 pounds, uses prism scanning of an indium antimonide photovoltaic detector and requires liquid nitrogen coolant—the same system as the one used in earlier models. For the normal lens, the focusing range is from 20 inches to infinity, while the scanned area at 20 in. is 6 by 5¼ in.

The camera's spectral range is 2 to 5.6 micrometers, and the minimum detectable temperature difference is 0.2°C. For object temperatures around 30°C, the temperature measurement range is 20° to 900°C, which can be increased to 2,000°C by using a special IR filter.

The display unit, carried on a chest harness, weighs 7.5 pounds and is connected to a separate 12-volt battery pack weighing 7.3 pounds. The camera and display can also be operated from a tripod to pan both units in unison, which allows the display to function as a hot-spot locating device. □

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International newsletter

British missile, based on Sparrow, will have new head

In a three-cornered deal, Hawker Siddeley Dynamics Ltd. will use Raytheon Co. Sparrow technology as the basis of a new air-to-air missile. Marconi Space and Defence Systems Ltd. will supply the homing head for the new missile, being developed for Britain's Ministry of Defence, but Raytheon gets the right to build the head. This head, a semi-active radar type, homes in on reflections from the target of radar waves transmitted from the attacking aircraft or from the ground. **It was originally intended for U.S.-built Sparrows bought for the Royal Air Force. But Hawker Siddeley proposed a similar, but higher-performance, missile to use the head,** and this view has prevailed. Meanwhile, the RAF will use Sparrows with U.S.-built homing heads.

Diodes show promise in analog displays

Now that light-emitting diodes have begun to prevail for alphanumeric readouts, display makers on both sides of the Channel are **turning their talents to LED substitutes for swinging needles and similar analog displays.** At a colloquium on alphanumeric-readout devices held in Paris earlier this month, RTC-La Radiotechnique Compelec, a French unit of Philips Gloeilampenfabrieken, disclosed details of a diode-bar display it has developed. RTC's base element is a row of 16 diodes driven by a bipolar IC chip mounted on the same substrate. **Up to 16 elements can be ganged simply, making the device, in practice, a 256-diode display.**

The driver circuit, compatible with transistor-transistor-logic inputs, gives a choice of three kinds of display. Addressed diodes alone can light up, giving the optical effect of a moving point. Or the addressed diode and all those below it can be powered, for a bar display that resembles a thermometer. The third choice, the addressed diode and all those above it, gives an upside-down thermometer display.

Standard Telecommunication Laboratories in Britain has come up with something quite similar. **STL's version, though, is made up of 100-diode bar elements, each 60 mils long.** The drive dircuits are nine MOS shift-register chips first designed for seven-by-five-matrix displays.

Decca pushes data link for temporary use

A production prototype of a portable solid-state Q-band (36–46-gigahertz) data link has been built by the Instrument division of Decca Radar Ltd. It hopes to sell the unit for establishing **temporary data links over a maximum of about six miles where a land line is not practical.** The company believes that there's a worthwhile market for such a link, particularly for temporarily connecting peripherals to computers.

Identical transmitter-receiver modules at each end use a 25-five milliwatt continuous-wave Gunn diode for transmission. Amplitude modulation is by a p-i-n diode, which produces pulse data rates up to 15 megabits per second. The superhet receiver uses a similar Gunn diode, with a lower output, as the local oscillator.

The company chose Q band partly because it believes that radio authorities will be more likely to grant licenses there than in X band (5.2–10.9 GHz). Also Q-band antennas can be kept small, and the band has sectors where atmospheric absorption is low, an important consideration in low-power equipment. Transmitters and receivers will be standardized, but the antenna will be chosen to suit the intended application. **Decca hasn't decided price, but it is aiming for $3,500.**

Bosch buys half of Teldix, boosting its anti-skid R&D

To broaden its already strong base in the automobile accessory market, West Germany's Robert Bosch GmbH has bought a hefty share of Teldix GmbH, a firm heavily involved in the automotive electronics. **It acquired the 50% interest held by Bendix International Finance Corp. The other 50% is retained by AEG-Telefunken.** Although Teldix is primarily known for its expertise in navigational and control equipment for land, marine, and aerospace vehicles, the 800-man Heidelberg company has become quite active in automotive electronics, **particularly in developing anti-skid systems for passenger cars.** Bosch will combine its anti-skid design efforts and concentrate them at Heidelberg.

Two LED displays have memory properties

Solid-state displays with inherent memory are in the pipeline in Japan and Great Britain. Sharp Corp. has fabricated experimental gallium arsenide light-emitting-diode matrixes in a four-layer construction that has both negative resistance and dynamic memory. **Depending on the rise rate of the scanning pulses, diodes can be turned on, kept turned on, or erased. Writing and erasing can be done by a light pen, too.**

In Britain, Ferranti Ltd. is working on a self-latching gallium phosphide diode it calls a Thyroptor. Here, **the light-emitting junctions are underlaid with a high-resistivity region that acts as an avalanche photoconductor and gives the diodes negative resistance.** Once turned on, the diode has to be pulsed off.

Grundig markets Secam adapter for its PAL sets

To overcome the incompatibility of Europe's two color-TV transmission standards, Grundig AG has come up with a relatively simple and inexpensive adapter, which allows reception of either PAL or Secam programs on Grundig-made Supercolor sets. **The new adapter—designed to handle television programs from East Germany, where Secam is used—will hit the market next month and retail for only $60.** The company will later come out with similar units accommodating programs from France, the homeland of Secam; France has different line- and sound-transmission norms.

Poland now has home-grown TV sets

Poland's fledgling color-TV market is fast gaining its independence from foreign imports—particularly from goods from neighboring East Germany and the Soviet Union—now that domestically designed models are being produced. **For the new all-Polish models, called the Rubin 707 P, rapidly rising production figures are predicted: 10,000 by the end of this year,** climbing to between 30,000 and 40,000 units annually during the years to come.

Addenda

Nippon Electric Co. has notched up another contract for a complete Intelsat ground station, this time in Zambia. The contract, for roughly $5 million, calls for completion of the station within 16 months and technical support during the first year of operation by NEC and Technology Resources, a Paris-based consulting outfit. . . . British minicomputer maker Computer Technology Ltd. has landed a $700,000 order with ESRO, the European space research agency. The company will supply two Modular One systems to process telemetering data from a geostationary scientific satellite that ESRO has in development.

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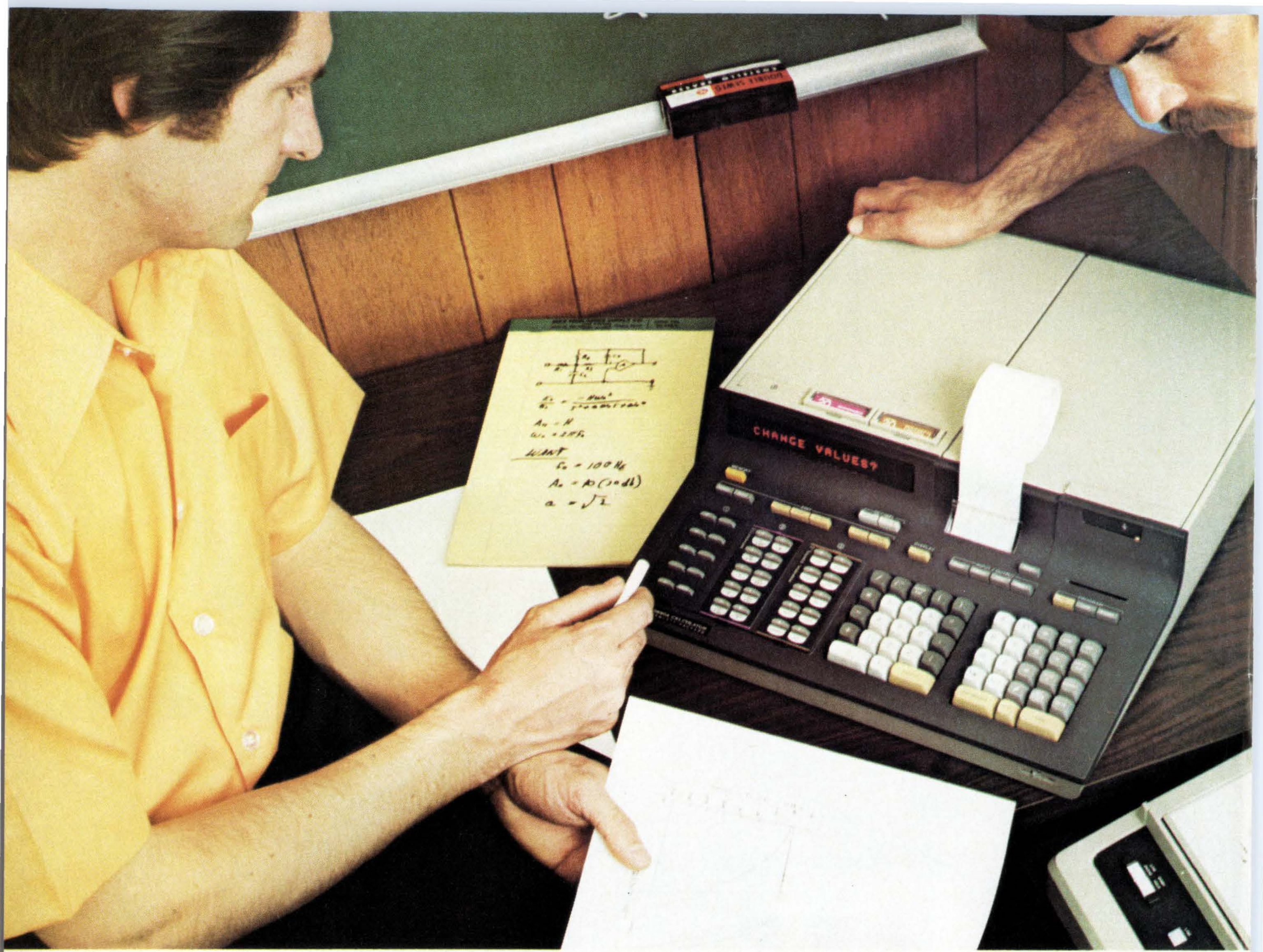

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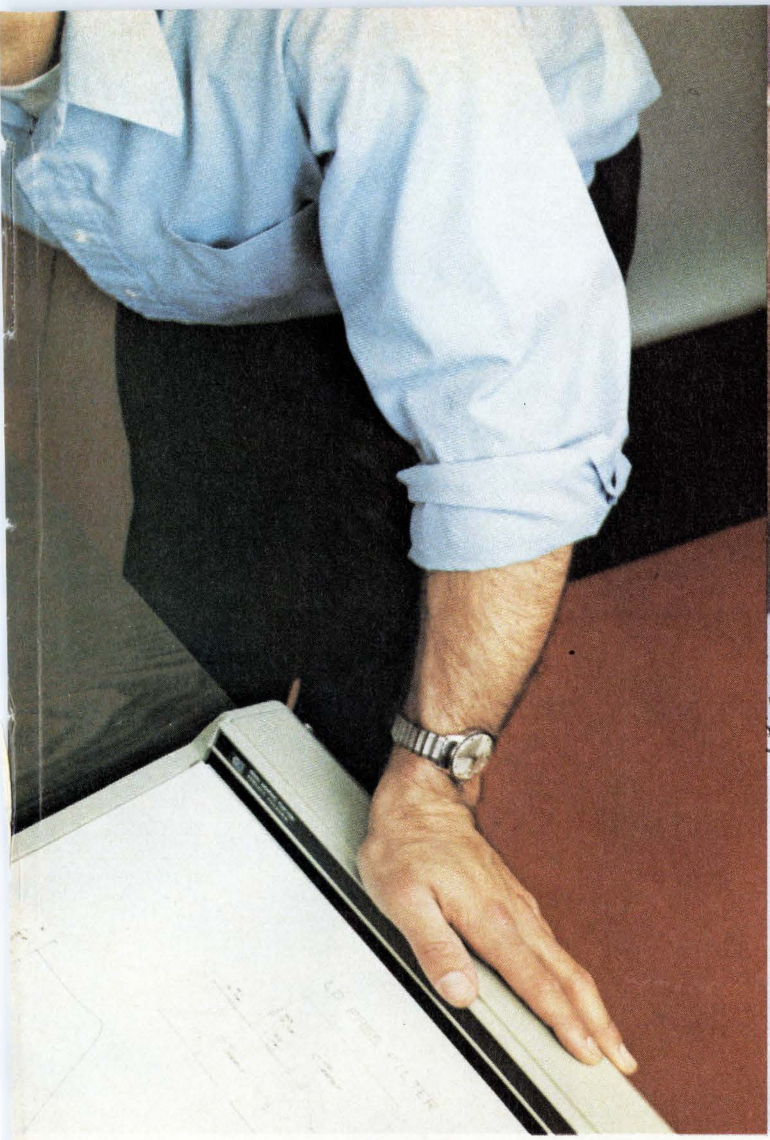

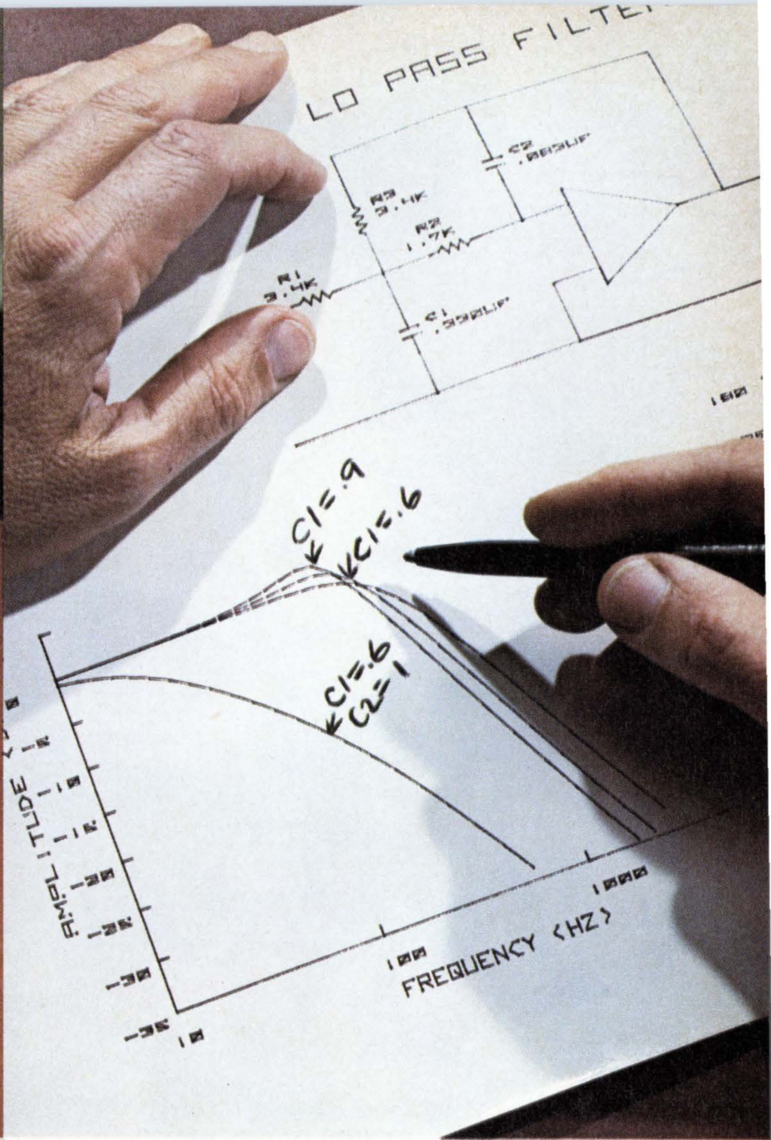

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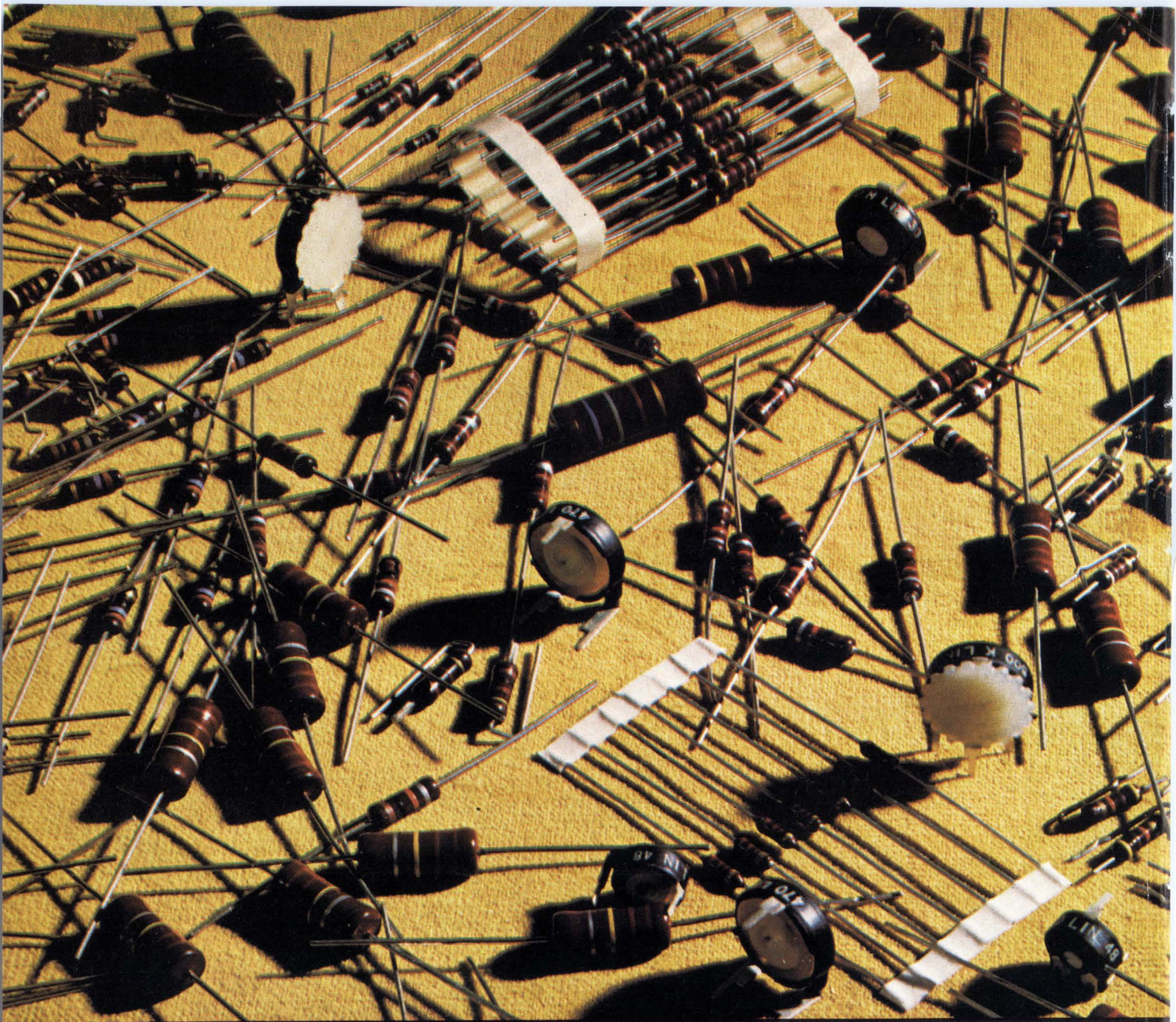

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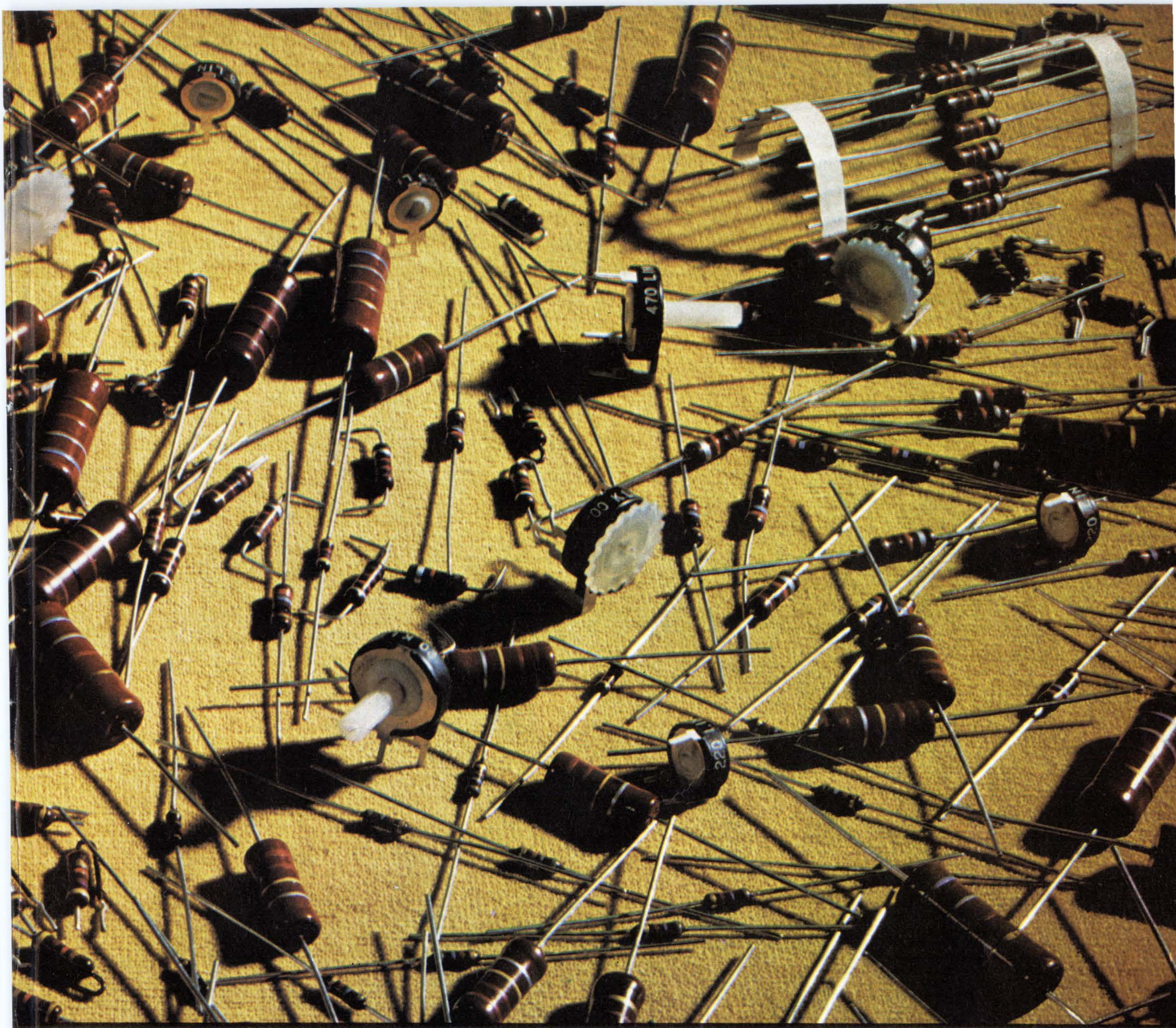

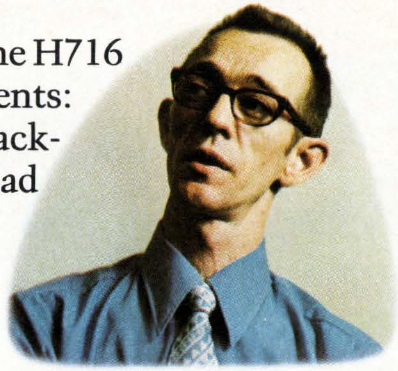

Dave Fillio

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"The most logical approach seemed to be printed wiring boards. But to accommodate all our controllers could have required as many as eight boards. And we couldn't afford the room. Also, when recycling changes are taken into consideration, the design cycle of printed wiring boards becomes too long and, consequently, too costly.

"Multi-layering offered a minimum of flexibility, and it, too, was rejected.

"The only practical solution was the plug-in socket panel. And of all the vendors, Augat was the only manufacturer that could provide a completely uniform, broad range of standardized products, the lowest possible profile and maximum reliability.

"The reliability tests we conducted on the Augat machined sockets included environmental exposures, accelerated-life, vibration, thermal shock, and durability. All tests with the Augat system were positive.

"From a field service standpoint, a key consideration with increasingly complex and flexible systems like the H716 is keeping them on the air at all times. Because of the reliability of the Augat interconnection system, we've had no reports of machine down-time associated with the Augat product since the introduction of the H716 eight months ago."

The H716

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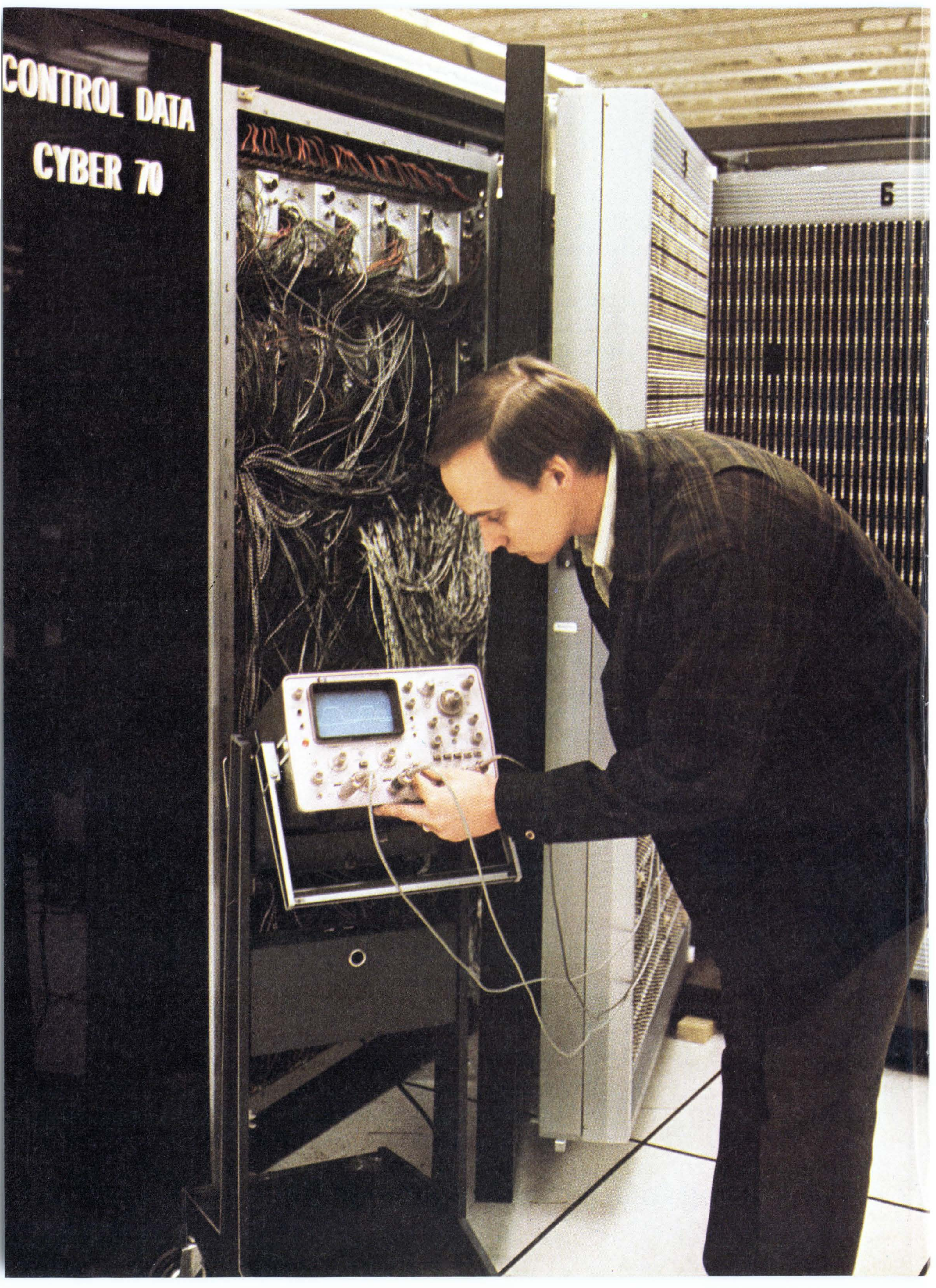
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Scopes Are Changing; Think Twice.

083/2

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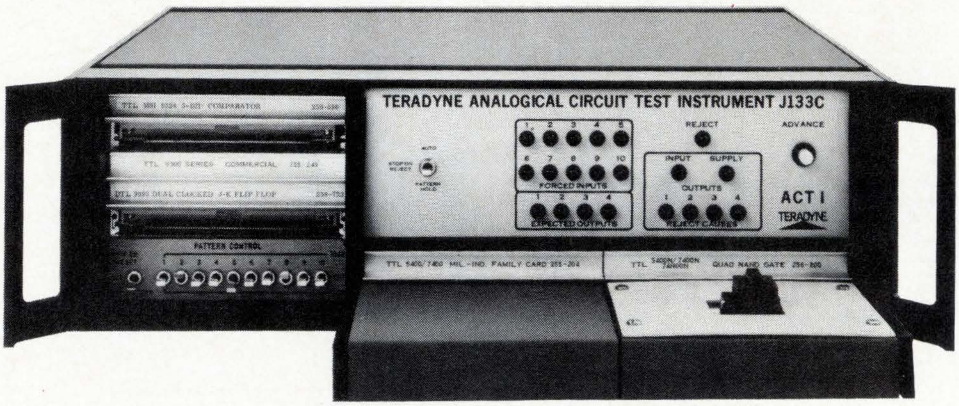

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Skylab: a houseful of electronics

NASA's orbiting space lab to be launched next month will look at sun, space, stars—and man's ability to live among them

by William F. Arnold, Aerospace Editor

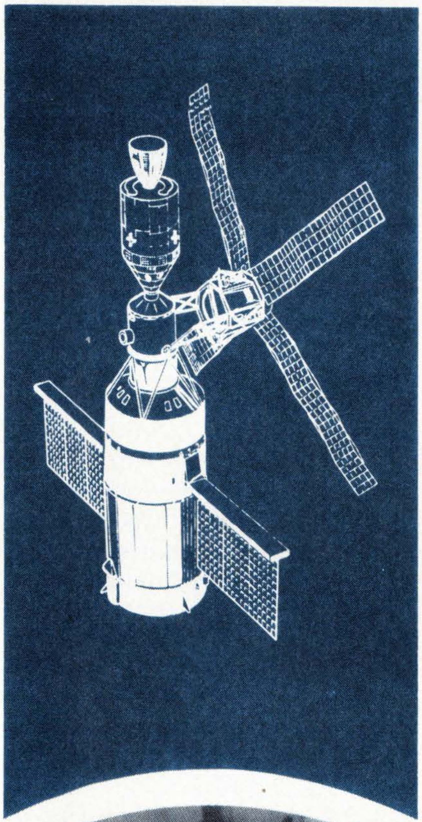
Early in the afternoon of May 14, a Saturn V rocket, made familiar by the Apollo program, is scheduled to blast off from Cape Kennedy. But instead of bearing an Apollo spacecraft toward the moon, the missile will carry NASA's Manned Space Program in a new direction: the launch of Skylab, an earth-orbiting space laboratory the size of a small three-bedroom house. A day later, a smaller Saturn rocket will send the first team of three astronauts to live there for 28 days. In the course of the program, three such teams will take turns at inhabiting the floating laboratory for periods up to 56 days.

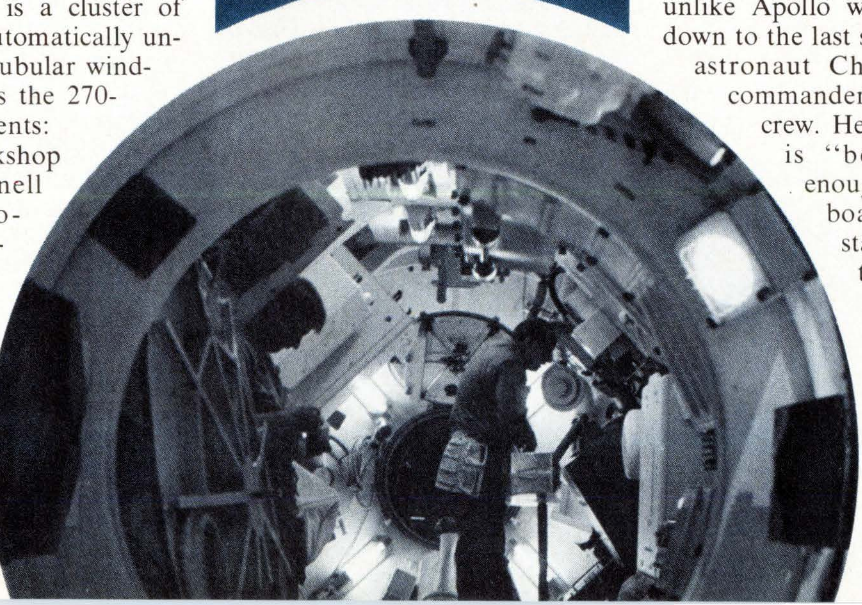
Supported by a load of electronics, Skylab will transport a large mission of solar investigation, earth observation, and medical analysis of the effects of prolonged weightlessness on man. This data will be used to help NASA plan for the permanent space station on the drawing boards for the 1980s. Thus, Skylab carries an impressive array of high-resolution, short-wavelength solar astronomy equipment, earth survey gear, and biomedical monitoring equipment.

Basically, Skylab is a cluster of elements that will automatically unfold to resemble a tubular windmill when it reaches the 270-mile orbit. The elements:

- The orbital workshop (built by McDonnell Douglas Astronautics Co.) containing the crew's quarters, the experiment area, and the structural support for the large solar arrays.

Windmill. Two astronauts, below, work in multiple docking adapter trainer. That's the module to which windmill-like antenna is attached in the drawing above.





- The Apollo telescope mount, including the solar experiments and a solar array providing electric power.
- The airlock module (from McDonnell Douglas) containing an airlock for extravehicular excursions—the NASA term for walking in space—plus the main data and communications links.
- A multiple docking adapter (from Martin Marietta) providing the telescope-mount control panel, a window for earth-resources viewing, and the docking port for the modified Apollo command-service module in which the astronauts will be ferried back and forth.

Overall, the Skylab cluster, an assemblage of modified Apollo and Saturn pieces left over from the truncated Apollo program, will be 118 feet long, 90 feet wide, and weigh 181,300 pounds. Total program costs will be $2.6 billion, about a tenth of the 17-mission Apollo program's cost. Inside the silo-like chambers and tubular passageways of Skylab, the astronauts will have lots of room and plenty to do during their stays in orbit.

"It's not a rigid flight schedule, unlike Apollo which was planned down to the last second," says lunar astronaut Charles P. Conrad, commander of the first Skylab crew. He explains that this is "because we have enough experiments on board that we can stay busy for more than 140 days," adding that a mission-planning computer keeps experiments together.

figure in a good share of the 60 experiments aboard, particularly in the earth-resources experiments package (EREP), and in the equipment for studying solar physics, astrophysics, and the life sciences. Another set of experiments of interest to electronics manufacturers are those concerned with the manufacture in space of such semiconductor materials as gallium arsenide crystals, to determine whether low-cost, high-yield automated production out there is ultimately feasible [*Electronics,* Jan. 18, p. 107].

What next? With the Earth-Resources Experiments Package, "we fly six instruments to find out what we can do and what instruments we should design for future missions," says Arnold Aldrich, deputy manager, Skylab research office at Houston Johnson Space Center. Elaborating, Harold Granger, Earth Resources program officer, says the EREP instruments are in three categories: object detection and pollution monitoring; the surveying of water, mineral, forestry and agricultural objects; and meteorology.

To accomplish those wide objectives, NASA will use complementary infrared and microwave techniques. The infrared gear will "determine and take out atmospheric effects as measured by the sensors to classify and determine things on the ground," explains Granger, while the microwave equipment, not severely attenuated by cloud cover or rain, will provide the only all-weather sensing system. Designed to be complementary with survey data from the Earth Resources Technology Satellite 1 [*Electronics,* July 3, 1972, p. 31], EREP's results will be compared with ground and aircraft sensing "to tell the difference between what we're reading on the ground and what we get from the air," says Granger. A complementary package, the infrared experiments will be loaded, operated, and maintained by the crew.

Sun gazing. But the astronauts will look at the sun and stars, too. Here, they will use the ultraviolet region because the earth's atmosphere attenuates about 80% of ultraviolet radiation and, since Skylab will float above the atmosphere, "we hope to gain information that we're unable to obtain on earth," explains Reg Machell, manager of the orbital assembly office, Skylab program office.

The X-ray/UV solar photography experiment (Naval Research Laboratory with Martin Marietta Corp. as subcontractor) will peer into the 10- to 200-angstrom wavelength, the lower end of ultraviolet and upper end of X ray, to determine the effects of the sun's energy on the earth's environment, ionosphere, and weather, Machell says. A similar UV stellar astronomy experiment (Northwestern University) will use the 14- to 3,000-angstrom wavelength to look at the stars because stars emit "a large amount of energy in the UV but we can't see it from earth," he says.

Horizon photo. The UV experiments also include an airglow horizon photograph (also WRL-Martin) to look at the earth's ozone; a UV panorama, a French experiment to measure the UV brightness of stars; a UV scanning polychrometer spectroheliometer (from Harvard College Observatory with Ball Brothers Research Corp.) which will be used to observe changes in the sun's environment by measuring the extreme UV region of 300- to 1,350-angstrom wavelengths, and a similar experiment by NRL and Ball Brothers for 150 to 650 angstroms.

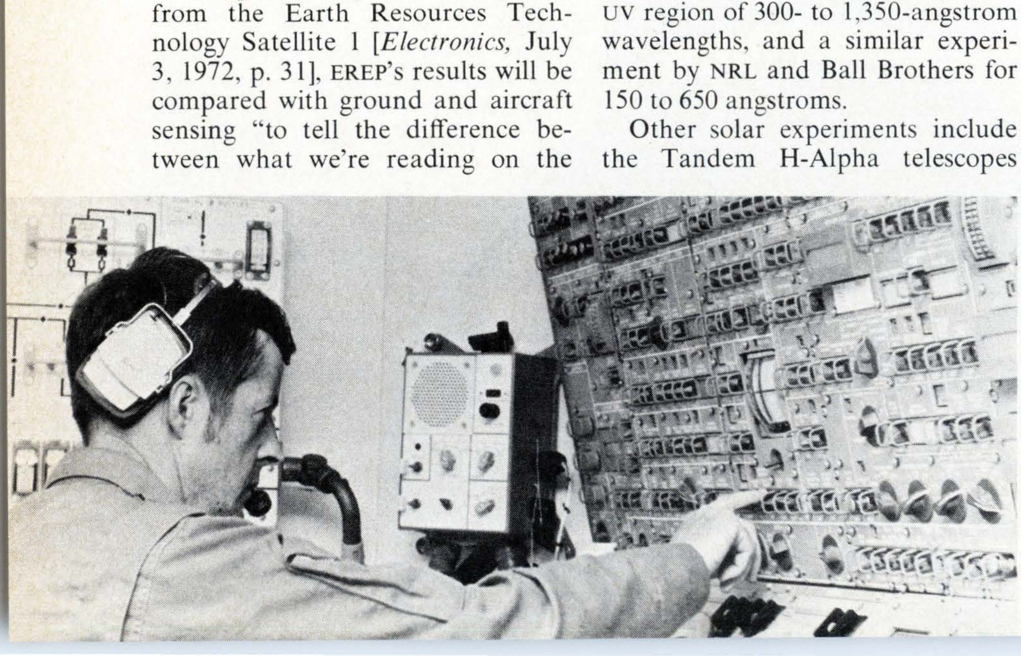
Other solar experiments include the Tandem H-Alpha telescopes (from Perkin-Elmer) which will measure solar UV and X-ray phenomena with vidicon and photographic techniques; a TV-movie camera system (from High Altitude Observatory and Ball Brothers) to view the corona; and two X-ray telescope systems by American Science and Engineering and NASA's Marshall Space Flight Center.

Life in space. Of the 30-odd experiments on crew health and performance in prolonged zero-gravity living and the habitability of the quarters, the most interesting electronically is the one monitoring the crew's sleep. Here, "a small computer sorts out signals into seven categories to monitor sleep patterns," explains Richard S. Johnston, life sciences director.

To do this, the drowsy astronaut will enter a cocoon, don a special cap containing monitoring electrodes, and doze off. A preamplifier will transmit the signals to the panel assembly containing the computer, which will convert the analog signals to 3-bit binary codes for near-real-time telemetry, sampled every 10 seconds, to mission control. There the data will be shown as: the astronaut's current sleep state, cumulative time in each of the seven stages of sleep, and a continuous graphic display of his sleep profile. The analog signals will be recorded for later analysis.

Two channels. Communications among the crew and between them and the ground are handled by a two-channel setup, in which one channel is for internal communications and not recorded and the second is recorded for "experiment debriefing" to the ground, explains Conrad. There's also TV in the command module in which selected segments can be recorded up to 25 minutes.

Early in April, the Russians orbited a Salyut spacecraft, which would become a manned orbital space station when they send a crew up to man it. Two years ago, a record 26-day mission aboard Salyut 1 met diaster when the cosmonaut crew died during re-entry. Another Salyut launching attempt last year was unsuccessful. □



Looking. Astronaut Joseph P. Kerwin at the console of Apollo telescope mount.

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Circle 69 on reader service card

Electronics abroad

The show's the thing . . .

. . . as Europeans in healthy numbers eat and drink at a staggering round of exhibitions; the contacts, not the sales, are the point

by Arthur Erikson, Managing Editor, International

"The show must go on" is a sacred tradition among theatrical troupers. By and large, companies doing business in Western Europe adhere to the same credo, albeit seldom with the same conviction.

For electronics companies, putting on a performance at the plethora of shows, exhibitions, expositions, and salons now crowding the calendar means frustration and often hefty expenses. And when the final curtain comes down on a show, exhibitors are hard put to reply to questions about exactly what they've gained from their efforts. More often than not, the answer is that they've been able to make low-key sales pitches to customers over drinks in the back-of-stand bars that abound at European shows.

The round of major shows in Europe started earlier this month with the Salon International des Composants Electroniques. It started its six-day run in Paris just a few days after the doors closed at the kingpin U.S. show, the IEEE's Intercon. Then, the week after the components show, Paris was the scene of Mesucora, an instruments and controls exposition. Later this month, the action will shift to West Germany for the Hanover fair. In late May there are components shows in London and Milan. Every other year there's the big late-fall Electronica in Munich. And month in and month out there are smaller, specialized shows all over, so much so that for Thomson-CSF, France's largest electronics firm, show time is almost every week throughout the year, whether for the company itself, for a subsidiary, or for a major distributor.

Overkill. Needless to say, most companies feel it's become too much. "It's inflation," says an executive of a major West German components producer. "In West Europe we need only one international show a year," says Tony Fletcher, administration manager of the Electron Tube division of EMI Electronics Ltd.

Even the Paris show's sponsors admit that the current round of components show is too much of what for them, anyway, is a good thing. But serious talks among the organizers of major shows in France, Britain, and Germany have yet to start. "It will be another three years at least before we can have any sort of unified salon," predicts Guy Baumont, executive director of the French components-producers trade associations–Sipare/Sitelesc–that sponsor the Paris show.

There are all sorts of reasons. A major one is that considerable financial interests are at stake. The organizers' budget for this year's Paris show, financed mainly by fees for booths and catalog advertising, was a whopping $1.8 million. Then there's national prestige, and for the French the fact that they were the first to run a truly international components salon. Another hitch in "Europeanization" turns up in the long-term contracts that some companies have with the Hanover fair.

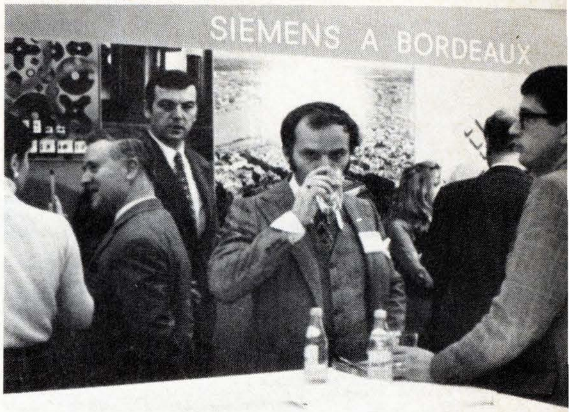
Baumont thinks one possible solution could be a biannual European rotating salon to introduce new products, paired with annual national shows to refresh customer contacts.

Rotation wanted. A rotating European show, something machine-tool makers achieved years ago, would bring applause from nearly every big electronics company. At Siemens AG, West Germany's largest electronics/electrical producer, the preference would be a four-year cycle: Paris, Munich, London, and then Italy. Others would be satisfied, for starters, with better scheduling for the Paris and Munich shows; in alternate years they come only five months apart.

Until the show organizers get together, electronics companies seem condemned to spend a lot of money getting their wares and their sales engineers onto the stands. At the Paris show, most companies figure to spend about $250 in direct costs for each 10 square feet of stand. The

Show time. Thomson-CSF alley at Salon International des Composants Electroniques.

Jungle. RTC stand at Paris components show is a kind of garden spot on the aisle.



Over the border. West Germany's Siemens tells Paris about its new Bordeaux plant.

figure includes mainly stand rental, decoration, equipment costs, and food and drink. Stands range from 100 ft^2 on up to Thomson-CSF's 15,000 ft^2. Thomson-CSF's tab, then, ran over $300,000, not counting the time of salaried salesmen and executives. At Hanover this year Siemens expects to spend $1 million, counting personnel costs.

In a recent survey of French industrial companies by the Association Française de Publicité Industrielle, about 50% of some 200 companies that responded indicated they spend between 10% and 30% of their "advertising" budgets for expositions.

No sale. For their show money, few companies get any immediate return, and practically none expect any. "We don't sell any more during the salon than we do during any comparable period during the year," maintains Jean la Chesnay, a market promotion executive at RTC-La Radiotechnique-Compelec, who is nonetheless a strong backer of the salon.

For Bernard de Charentenay, marketing manager of Thomson-CSF's Sescosem Semiconductor division, the show is mainly a chance for sales engineers to meet customers in a relaxed setting. Seated at a table in the indoor garden that flanked the bar in the back of Sescosem's booth this year, de Charentenay emphasized, "We don't sell here." Smaller firms feel the same way. "We're here for contacts," says François le Cain of Tranchant Electronique, a major importer-distributor. "We rarely get an order, but mainly all we get is more names for our mailing list."

French companies large and small, then, turn up mainly to strengthen their bonds with customers. That's why some stands have more space for entertaining than for showing new products. Motorola Semiconductor carried the concept almost all the way. The company had a striking stand in pop colors and not one single new-product display in plain view.

Foreign companies, unless they're breaking into the European market, show up for much the same reason French companies do. "For a company that supplies to European companies, the show is essential," maintains Andrew Procassini, a product marketing manager for Fairchild Semiconductor. Says W.B. Miller, the marketing manager of Video-Color SpA, an Italian firm that's jointly owned by RCA and Thomson-CSF, "The show allows executives of our company to chat with practically all of our customers in a week's period. I personally have a chance to see people I never get to see in a normal sales situation." Alan Risley, assistant manager for international operations, explains Teledyne-Philbrick's presence: "We rarely get a purchase order, but we get good coverage, which pays off in sales later on."

Technology gauge. East European components outfits participate for somewhat different reasons. East Germany's VEB/RFT components combine comes to Paris to "compare its level of technology with that of the West as well as to make business contacts," says Gerhard Mathea, a VEB/RFT sales manager. Yugoslavia's Iskra mounted its stand to introduce itself to new French customers.

A lot of companies, though, show up only because they're afraid they'd be conspicuous by their absence. Michael Riley, sales promotion manager at RCA's European headquarters in London, wanted to pull out of the Paris show this year, but the company's marketing people insisted on taking a stand. Herbert Jesse, the commercial director at TRW Composants Electroniques SA feels the show is a waste of time. "But," he quickly adds, "you must attend because otherwise people you do business with wonder why you weren't there."

Counting feet. Mullard Ltd., a British unit in the Philips group, participates mainly for the benefit of British customers who come over for the show. "If they didn't put their feet up here," says Mullard stand manager Arthur Cookney, "they might put them up at ITT."

Some of the performers, then, are reluctant, but the Paris show—unlike the New York IEEE exhibition—goes onward and upward. This year, with instrument makers diverted into the Mesucora show, some 865 electronics companies took some 258,000 ft^2 booth space. That's 30 companies and 21,500 ft^2 more than the comparable figures for 1972. And the salon show still draws big crowds. The Société pour la Diffusion des Sciences et des Arts, a nonprofit company set up by the Fédération Nationale des Industries Electroniques to organize industry trade shows, reports it logged nearly 58,000 visitors this year, some 7,000 of them foreigners. The total is roughly a thousand more than it logged last year, not bad considering Mesucora siphoned off visitors this year. □

Consumer electronics

How does an organ maker go LSI?

For Hammond, retreats in Wisconsin led to five-year plan, lessons from a consultant—and eight new models

by Larry Armstrong, Midwest bureau manager

Until the 1960s, Hammond Organ Co. virtually owned the consumer organ market because of its 1935 development of the electromechanical tone-wheel generator. Then, taking a hard look at static and decreasing market shares, the Chicago-based pioneer realized it had to change technologies or lose its leadership position.

It wasn't easy to ditch 35 years of mechanical technology, experience, and patents, and start from scratch, but that's what Hammond did via electronics. Although it still sold as many organs as its two closest competitors combined, increasing cost pressures—labor, materials, service, size, and features—forced the leader to seriously weigh the high initial cost of getting into the electronics business against the high eventual cost of staying in the mechanical business. And Hammond's confidence and competence were showing as it managed to become the first consumer organ manufacturer to switch entirely to custom MOS LSI circuitry.

In 1967, top management and planning people from Hammond retreated to a Wisconsin resort to outline a five-year plan to improve competitiveness, increase market share, and insure long-range growth. Out of that meeting came specific goals. After six weeks of study, the individual task forces met again in Wisconsin, and decided MOS LSI was the only way to go.

Hammond's five-year plan culminated last summer with the introduction of the under-$6,000 Concorde model, quickly followed by seven more LSI organs—a big step for a firm that's been averaging two or three new products annually. "We originally planned to start incorporating electronics at the low end, because the Hammond has never been known as a low-priced organ," says James C. McLin, product and musical development manager. "Instead, we elected to hit the top end head-on to show what we could do." The Concorde, using 47 MOS LSI chips from Mostek and American Micro-systems Inc., flaunts more features than the firm's $10,000 organ introduced in 1965.

Music box. This is what's under the hood of Hammond organ. Harwood B. Moore, engineering vice president, checks it out.

And February's announcement of the under-$700 Dolphin series proves that the electronic technology is as economically feasible at the bottom of the Hammond product line as at the top.

Learning LSI. But first, Hammond faced a massive job of educating its personnel. "Arthur D. Little Inc. was brought in to teach LSI and adapting to LSI," says Harwood B. Moore, Hammond's engineering vice president. "And we realized that there must be a marriage between the manufacturer and the MOS house." Initial exploratory work and some original chip development was done at General Instrument, General Electric, and Philco-Ford, but Hammond decided it had made a false start. It changed its approach in 1969, and from a field that included GE, GI, Motorola, and Texas Instruments, chose AMI and Mostek.

The Hammond MOS LSI circuits "generate from the master oscillator all of the frequencies for each note by division," Moore explains. "They also sense whether the key is up or

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down, do dc control work for turning harmonics on and off, and mix the harmonics and regulate their amplitudes." Those functions require 27 chips on the top-of-the-line Concorde; an additional 20 chips generate complex waveforms for more dramatic percussive sounds, like piano, banjo, and harpsichord.

Never before. "Circuits like the ones Hammond asked for had never been successfully manufactured in MOS," comments Gordon Hoffman, director of marketing at Mostek, "let alone for cost-sensitive consumer electronics." Hammond had studied a digital scan approach similar to that used by Allen Organ Co. for its more expensive institutional organs [*Electronics*, May 24, 1971, p. 79], but decided to translate its musical needs into electrical specifications calling for linear and digital integration.

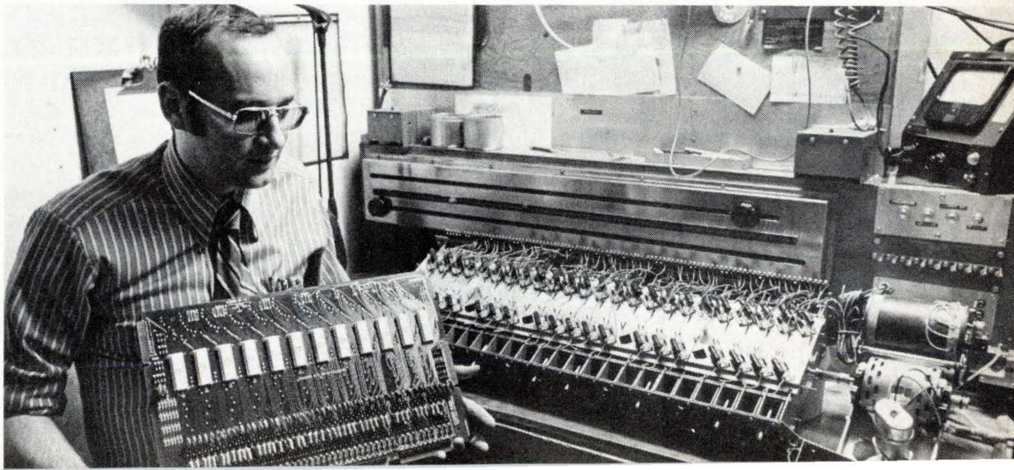
Each chip type uses up to 34 matched resistor networks coupled with a four-bit counter to achieve a 16-step staircase waveform. Restrictions are placed on resistor tolerance so that chip-to-chip variations do not require individual adjustments for each chip in the final organ, and because accuracy of the resultant waveform determines spurious harmonic content.

Hammond's production is currently running about 70% electronic and 30% mechanical—it is still manufacturing every mechanical organ introduced in the past three years. Cost for the LSI organ and its mechanical predecessor are running about the same, estimates John L. Lavey, manufacturing vice president. "But we recognize over the long term what's happened to labor availability and costs," he says. Capital costs, however, are tremendous: "Over five years, we could easily spend $10 million, and that's probably a conservative estimate," he adds.

"The change in technology has not been as important a factor in manufacturing as component availability and quality," Lavey notes. "The inability of components manufacturers to supply parts on time has interrupted our flow," he explains, "and we were getting a quality problem from the diode vendors. For example, the legends were backwards on a whole roll of diodes, and it screwed up every board on the floor for weeks. Now we catch almost every bad diode, and it's improved our yields tremendously," Lavey points out.

Strict inspection. Quality, however, has been within contractual limits, points out Jack Buick, manager of quality assurance, but even a 1% failure rate presents problems in the volumes Hammond uses—a million diodes a month and up to 10 million transistors per year. "At one point, a less than 1% failure rate in transistors was causing 70% organ fallout at final inspection," he explains. So Hammond has set up sophisticated inspection equipment, unusual for a traditionally non-electronic manufacturer. The firm has gone to 100% incoming inspection on diodes, transistors, and resistors, and will add equipment to automatically check capacitors and ICs later this year. Incoming inspection costs a fraction of a cent per transistor, "but it costs about $3.50 to find a bad one at the subassembly level, and about $5 or $6 in the final organ," Buick adds. □

The new and the old. John L. Lavey, manufacturing vice president, holds Hammond's new LSI tone generator. Old electro-mechanical model is atop the desk beside him.

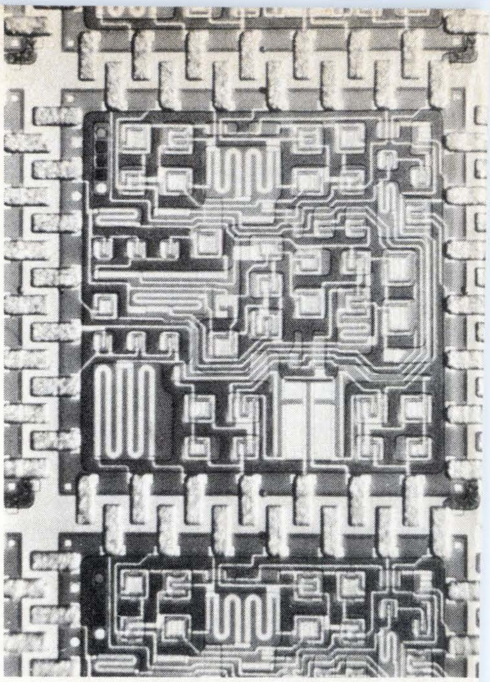


Semiconductors

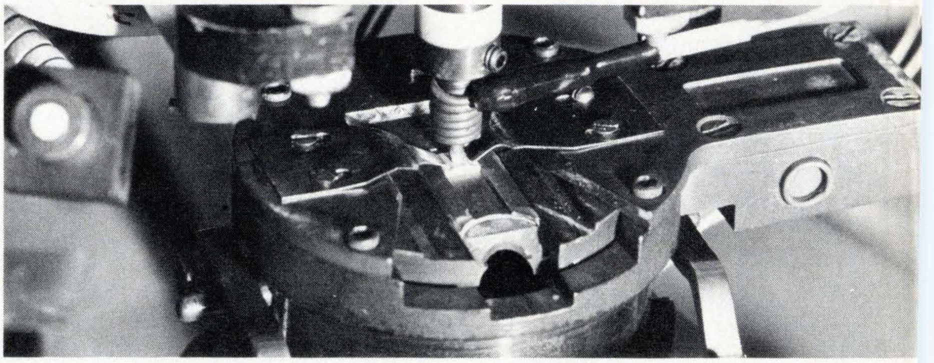
Beam leads gaining

Manufacturers are optimistic about commercial chances as they fill the gaps in their product lines

by Paul Franson, Los Angeles bureau manager



On the beam. Motorola beam-lead IC is shown at right, while wobble-bonding process at Raytheon is shown below. Some 90% of devices are wobble-bonded.



Is the beam-lead semiconductor about to go civilian in a big way? Fallouts from high-reliability military programs, the parts are inching their way into more commercial products. But even though users of hybrids would like to switch to beam leads—costs are lower, they use less space, and they save fabrication time—the devices are unlikely to find immediate broad commercial application.

The obstacle is one that could vanish gradually: not all the common chips are available in the beam-lead catalog. Since this would often force hybrid designers to mix beam-lead and venerable chip-and-wire, an unattractive prospect, the older technology usually wins out. And while makers of beam leads say they're filling in those gaps in the catalog, they've been having a difficult time with the more complex chips containing many inputs and outputs, and beam-lead devices can't be used above 1 watt.

Business growing. Nevertheless, two of the three U.S. producers of beam-lead semiconductors report growing commercial business as they add available parts. At one of them, Raytheon Semiconductor, Mountain View, Calif., marketing director Gene Selven reports that his firm will ship $4 million in beam-lead devices this year, compared to $100,000 last year. He puts the total U.S. market at $8 million this year. Though the Raytheon business will be mostly military, with sister division Raytheon Missiles and Space taking a big chunk for the SAM-D programs, Selven also reports sales to Singer's Kearfott division, Bendix in Kansas City, and Medtronic, maker of heart pacers. And the division recently received a substantial second-source contract from a watch maker.

Expectations are similar in Phoenix, Ariz., where Motorola Semiconductor Products division also reports growing commercial sales. According to Paul V. White, manager of high-reliability market, the telephone industry is especially interested since phone equipment is expected to last at least 20 years. White says sales of Motorola's package beam-lead crosspoint switch are growing rapidly, and he sees other applications in other telecommunications, portable communications equipment, and medical electronics—the same as the markets Raytheon is eyeing. Motorola recently received a 300,000-piece commercial add-on order.

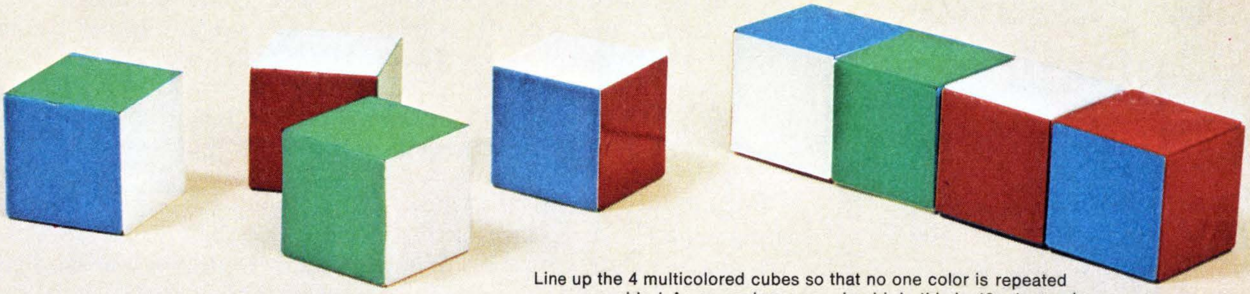
As for the other U.S. supplier, Texas Instruments is sticking to the Government market at present.

Origins. The classic beam-lead process, developed by Bell Labs in 1962 and reaching its highest promise in the Safeguard missile program, involved mounting semiconductor chips face down with small flat beams or tabs that also provided the electrical connections to the chip. Its biggest feature for military applications is its high reliability, a result of a complex metal system and nitride passivation that eliminates the need for hermetic sealing and substitutes thick metal beams for fragile wire bonds. The beams, being attached to the chip, also eliminate half the bonds required.

This last feature also is the main appeal for many commercial hybrid-IC users. Not only does it reduce the number of bonds, the greatest source of failures, but it also permits die- and wire-bonding in one step instead of generally required die-bonding, followed by two wire bonds for each lead.

Motorola's White attributes lack of commercial success to inertia, fixation on materials cost, and, especially, product availability. Motorola offers 12 linear parts and 21 TTL products in the 54/74 series, and is introducing 20 diode and transis-

This problem should take you about 42 minutes to solve.



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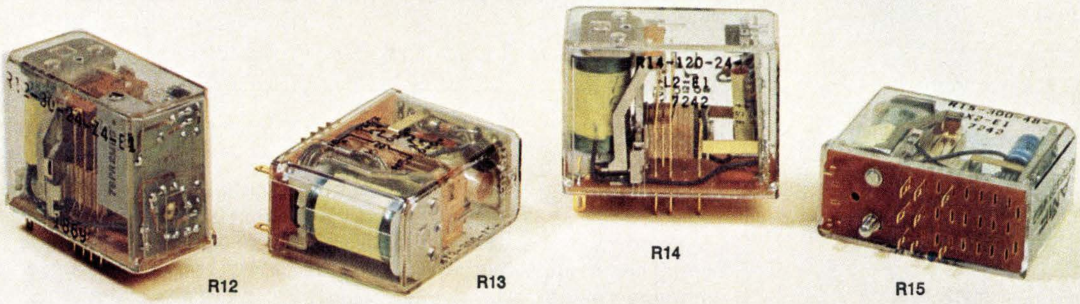

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tor chips. Raytheon, which alone offers commercial devices at about 65% of military prices, has about 70 parts: 15 transistors, three field-effect transistors, eight diodes including zeners, 13 linears, and 28 TTL in SUHL (Ray I and Ray II), not as popular as the 54/74 series. Texas Instruments offers low-power 54L TTL, low-power Schottky 54Ls, some standard 54 TTL, some transistors, and one linear circuit.

In spite of the relatively wide offering, there's not much second-sourcing and standardization. White says that Motorola and TI work closely in exchanging data, and Raytheon also says it is working with an EIA committee. But White admits, "there's no real interchangeability." The EIA specs give standard chip sizes for a number of beams, but not much more yet. And TI and Motorola use the Bell Labs process while Raytheon uses its own technique.

One area of beam leads that has been drawing much interest is the large gate array that permits fast turnaround and relatively economical custom LSI. Raytheon is making a 60-gate "universal slice" for SAM-D, with 120 combinations possible by changing metalization. Robert Goedjen of Raytheon says the part is also being evaluated for other military programs, and possibly for commercial use. He says the array can reduce costs by replacing 10 to 20 individual chips. Motorola also has an 86-gate array for military use."

In addition to the large arrays, Motorola has made sample beam-lead versions of C-MOS parts. The low power consumption of C-MOS is ideal for beam-lead devices which have limited power dissipation—most heat must be conducted through the relatively small beams. At the other extreme, the company is working on power-transistor chips for beam-lead construction. Here, due to the power-handling problem, chips are die-bonded face up, and the beams provide only electrical connections. □

Beams on the substrate, not the chip

In beam leading, the beam is normally attached to the semiconductor chip and bonded to the substrate. But the reverse is also possible—bonding the chips to beams already on the substrate. In that case, they are called inverse beam leads. Motorola Semiconductor attempted to make an 8,192-bit memory module this way a few years ago, and it's not clear whether its failure was due to the interconnection scheme, problems with the MOS memory chips, or, as the firm claimed, lack of a market.

More recently, Northrop Electronics has developed a related technique called BLIP (for beam-lead interconnect packaging) for some military programs such as Task-Oriented Processing Systems [*Electronics,* April 12, p. 44] and for classified equipment. The company is also investigating commercial applications and licensing, particularly for uses where conventional packaging is inadequate, as in watches and cameras.

The biggest appeal to Northrop, however, is that the process gives the advantages of the beam-lead technique without the need for the special beam-lead devices. Virtually any semiconductor chip can be used.

Northrop's BLIP is a laminate containing an alumina substrate, a thin photo-etched plate with holes for chips, and then one or more thin, double-sided "circuit boards," the top one supporting an etched metal pattern incorporating beams that are bonded to the chip. Very-high-density packaging is possible, and the system lends itself to multilayer interconnections, as well as the incorporation of thin- and thick-film resistors and capacitors. Further, the fact that the chips, too, are bonded to the substrate improves heat dissipation over conventional beam leads.

So far, Northrop has used ultrasonic bonding rather than mass bonding such as the wobble bonding used for beam-lead chips, but this still halves the number of wire bonds normally required. The company has been using gold beams—the complex metal system needed for conventional beam-lead semiconductors isn't required—but is also working with other metals, notably aluminum, which is well known for superior performance in radioactive fields.

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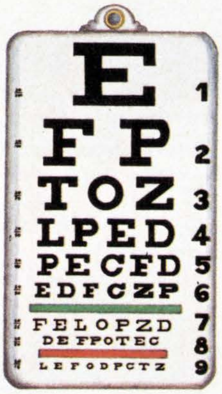

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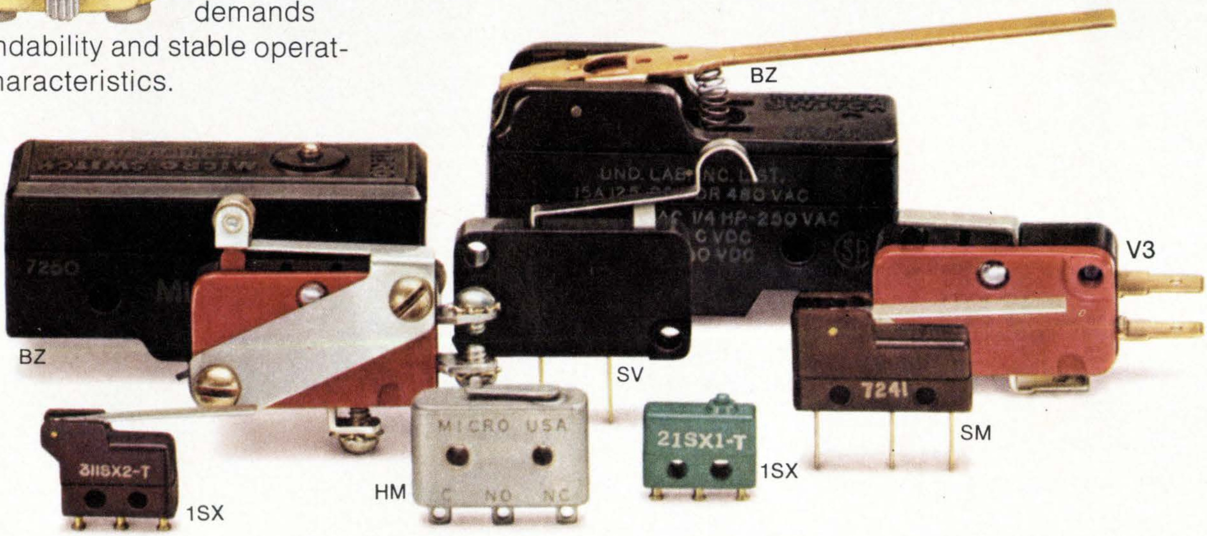

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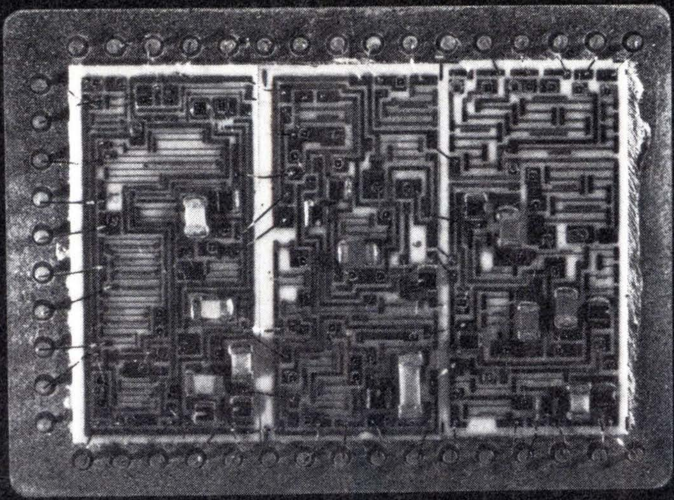
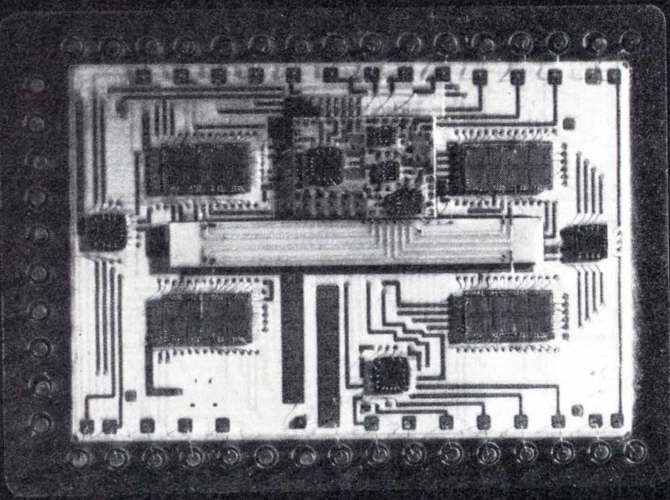
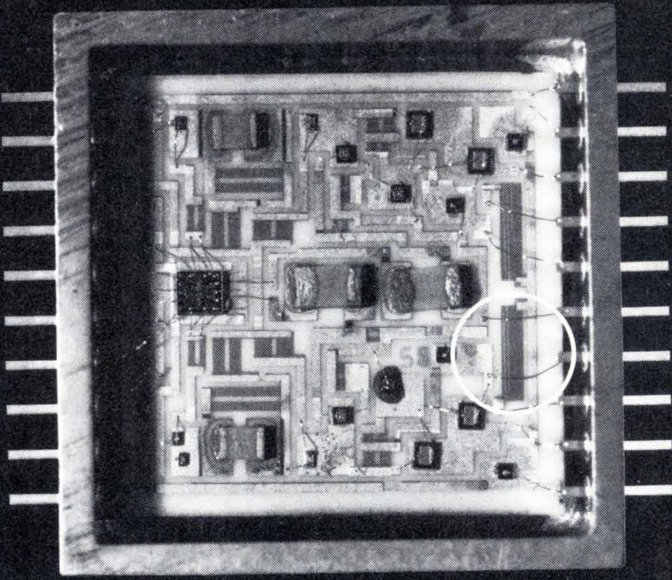


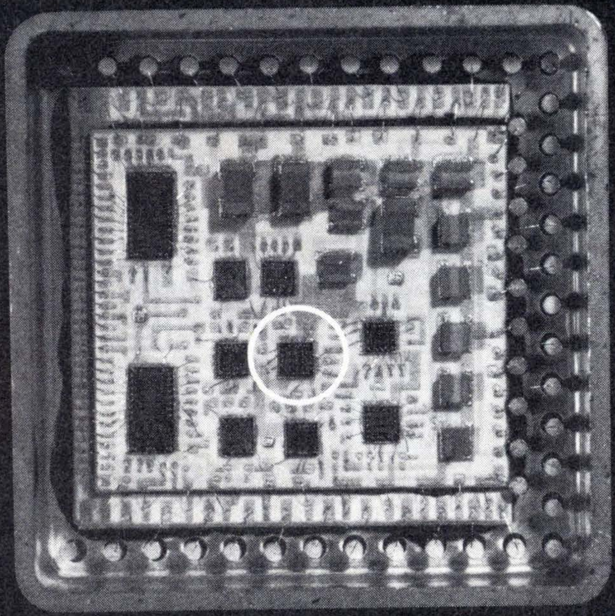
1. Is this circuit a thick film or thin film hybrid?
■ Thick ■ Thin



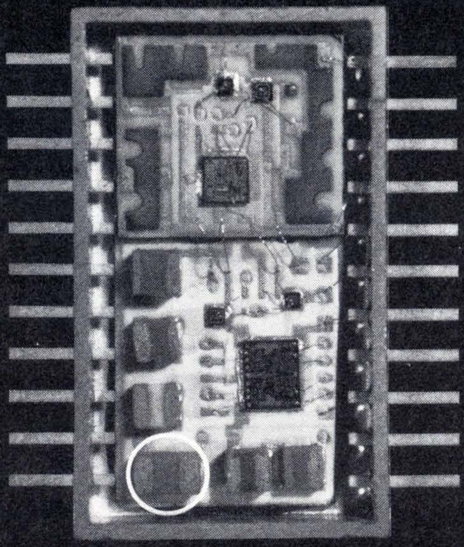
2. Is this hybrid's package designed for a hermetic seal?
■ Yes ■ No



3. Has this resistor been abrasive or laser trimmed?
■ Abrasive ■ Laser



4. Is this semiconductor chip an integrated circuit or transistor chip?
■ IC ■ Transistor



5. Is this passive chip a resistor or capacitor chip?
■ Resistor ■ Capacitor

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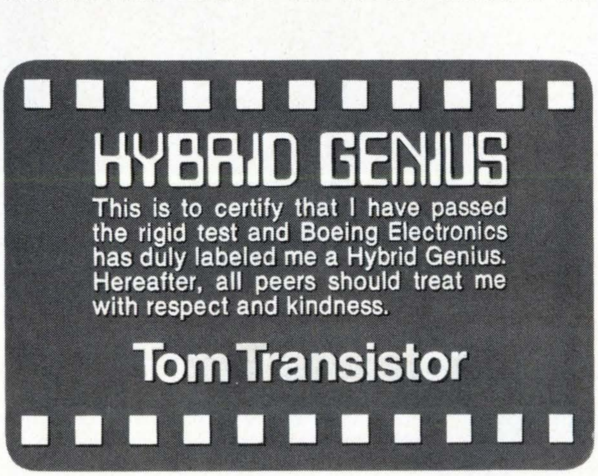

The right answers:

1. Thin Film. This is a digital logic circuit being used in a military guidance and control system.

2. Yes. This is a 4096 bit random access memory circuit for a digital computer.

3. Laser. This hybrid dual current switch circuit handles .4 amps per switch in an airborne computer.

4. IC. This 16-channel multiplexer hybrid is used in an aircraft on-board maintenance and test system.

5. Capacitor. This circuit is an accelerometer restoring amplifier used with a gyro in a guidance and control system.

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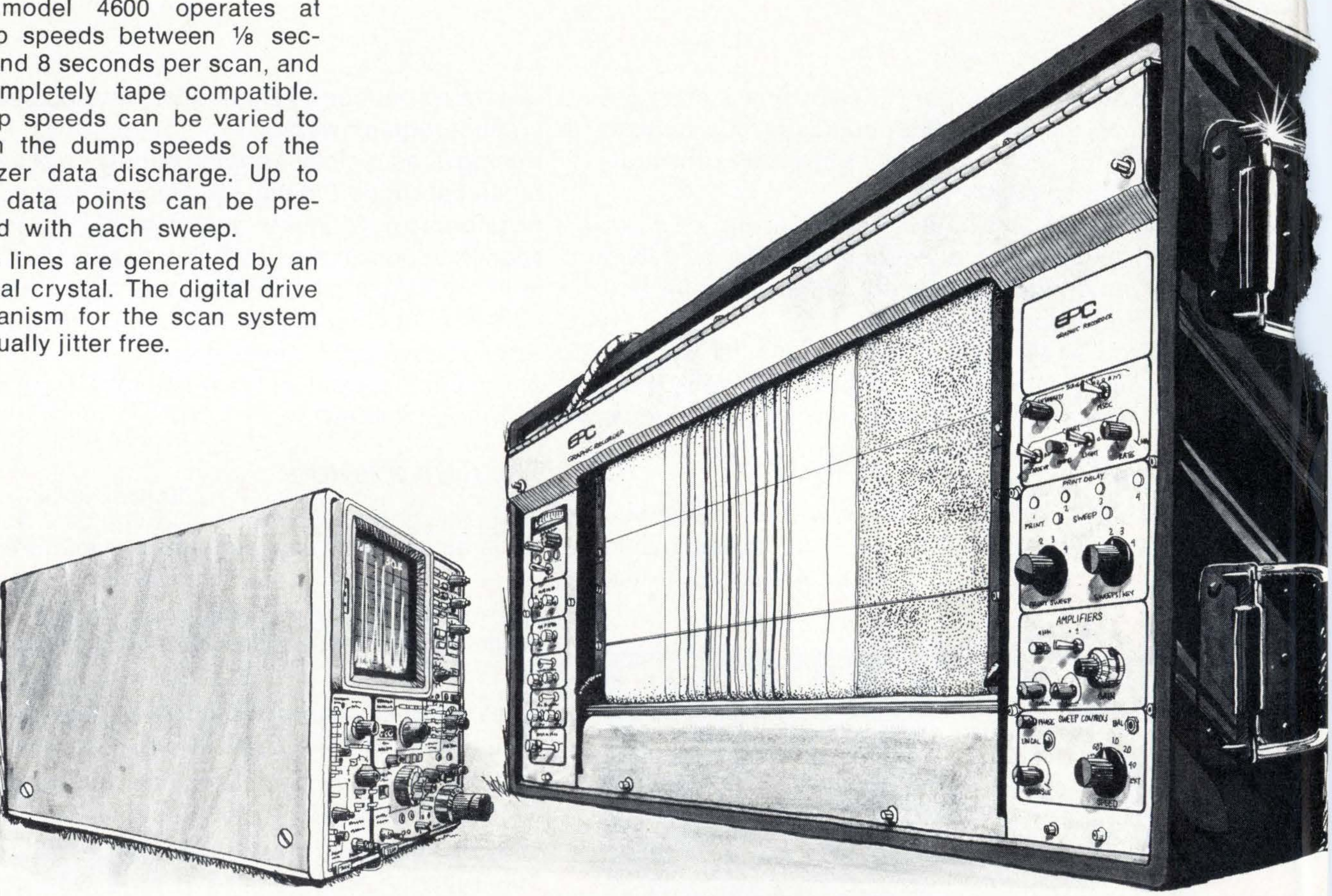

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Discrete semiconductor devices proliferate and prosper

Field-effect transistors are big movers, and so are power devices, which have new markets in automobiles and television; but even old established components are selling well in this unexpected boom year

by Laurence Altman, *Senior Editor*

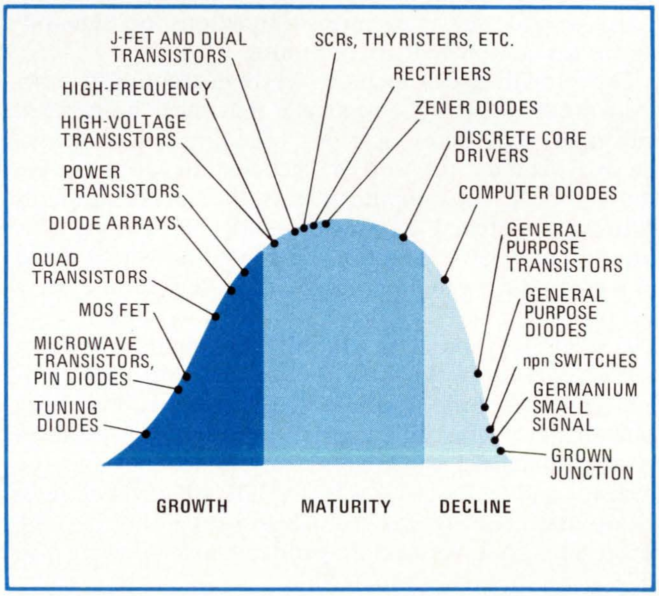
☐ Once again discrete semiconductor devices are blooming, and this season especially they are refusing to yield their place in the sun to integrated circuits. Indeed, whole new areas of application are opening up for power devices, and field-effect transistors face a glorious future. Just now, however, thanks to the boom, just about every variety of transistor or diode is flourishing.

Total U.S. factory sales for discrete semiconductors (excluding optoelectronic devices) reached the $675 million mark in 1972, an 11% increase over 1971's activity and the equal of IC sales. More significantly, over three billion discrete components were consumed in U.S.-manufactured equipment last year, with an estimated increase of 500,000 units to be used in 1973.

Feeding this vigorous growth is a continually expanding technology:

- Discrete field-effect transistors with micrometer dimensions can now operate in amplifier and tuner front ends with ultra-low noise and ultra-high gains, boosting the sensitivity, reducing the size, and lowering the cost of television and radio chassis.
- Microwave FETs made with gallium arsenide are now available with a maximum frequency of oscillation as high as 20 gigahertz for millimeter-wave communications links.
- Junction-FETs can now be built with input-bias current requirements in the picoampere range for high-performance analog-to-digital conversion.
- Double-diffused metal-oxide-semiconductor FETs are being used in the input structures of vertical amplifiers in top-of-the-line oscilloscopes because they keep intermodulation distortion lower than any IC device (new D-MOS products can operate up to 1 GHz with gains of 10 decibels and noise of 5 dB at power levels of 300 milliwatts, and soon D-MOS transistors will operate at the gigahertz level with 1-watt outputs).
- High-voltage silicon transistors capable of supplying 700 to 2,200 volts to the tube of a TV chassis are now routinely available, sounding the death knell to the last vacuum-tube holdout in today's sets.
- Power Darlingtons capable of handling 100 watts are now driving heavy-duty motors in any number of industrial applications.
- Ion-implanted power transistors with improved heat-sinking packages can now routinely supply 600 W of continuous-wave power.
- Ion implantation is revolutionizing the tuning diode as well, allowing a single device to be tuned over the entire TV band with low voltage and high stability, and promises to open up a whole new field of electronic tuning in the United States.
- Multiple discrete transistors and diodes (duals and quads) matched to a particular parameter are taking over many of the computer-switching and memory-driving functions formerly handled by individual discretes, as well as finding their way into industrial process-control systems.

Even the established discrete components are experiencing a renaissance. Equipment makers, at great cost, have found that the IC promise of lowering costs and increasing reliability is not yet a reality, and many have decided to stay with the discrete devices they have learned to trust, at least for the short term.

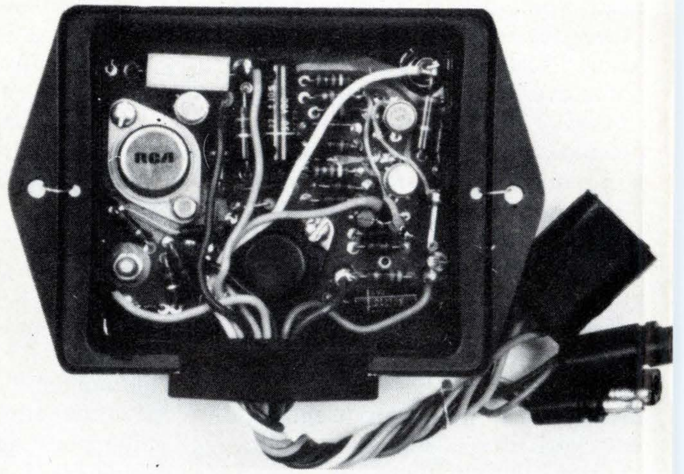


1. Life cycles. Like biological species, electronic products flourish and become extinct. Dying out are small-signal discrete components whose functions have been taken over by ICs. On the increase are high-performance FETs, tuning diodes, power devices, and arrays.

This preference is particularly evident among the high-volume manufacturers of TV sets, calculators, and automobile electronics. TV makers, for instance, have at their disposal as many as six ICs that can do almost the entire job for a TV chassis, yet TV sets are loaded with discrete semiconductors, from input FETs in the tuner and preamp front ends, small-signal and power transistors in the sound channel, high-voltage and medium-power small-signal transistors in the i-f, uhf, and vhf stages, and high-power discrete drivers in the deflection and color circuits.

Other equipment combines ICs with a heavy endowment of discretes. Hand-held calculators often contain as many as eight high-current drivers to power the displays, plus four small-signal sensing transistors, and that's a surprising number of discretes to find alongside a single IC chip containing the calculator's entire memory and logic functions. Similarly, one seat-belt interlock design scheduled for 1974 automobiles has a single complementary-MOS logic and control chip surrounded by 14 individual transistors and diodes to supply the functions of biasing, zener regulation, and current sources.

Power's big and getting bigger. The heaviest new demand for discrete semiconductors is in power. Above, this germanium power transistor from Motorola is capable of 600-V operation. Automobile ignition is big consumer of power devices; the car ignition system built by Ford has an RCA device capable of 6-A, 40-V service.



Tradeoffs

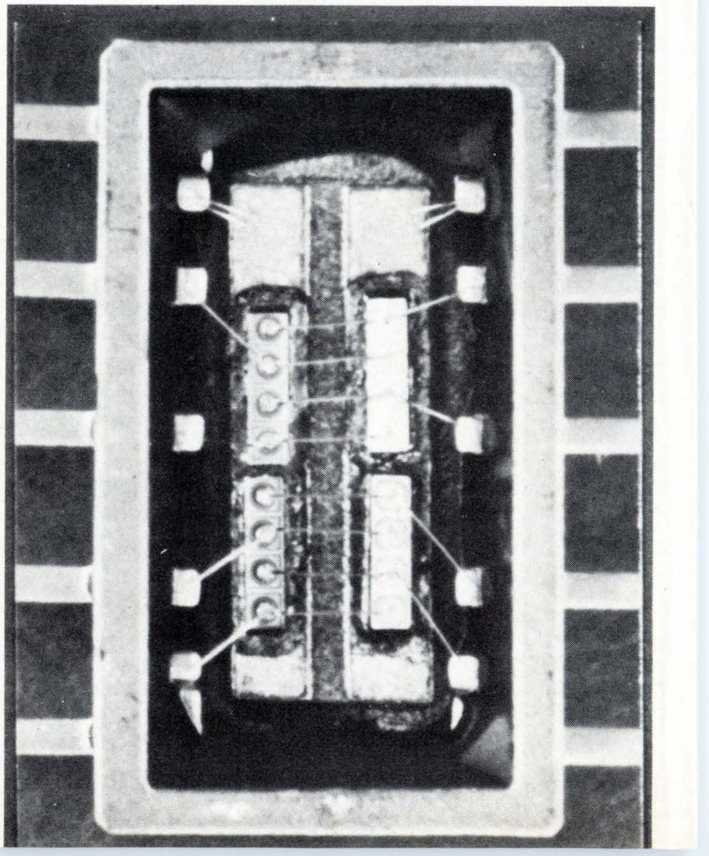
The question is: when should the designer use the discrete component and suffer an increase of package count, wire costs, and space requirements, and when should he go to an IC? Although the ground keeps shifting as ICs improve, the basic rule is: when a demanding parameter must be met, use a discrete (or in some cases a hybrid, but that's another story). Picoampere leakage input currents, low intermodulation distortion, low input noise, high output powers, high oscillation frequency, tight voltage regulation, and high-current switching can generally best be obtained with a discrete device.

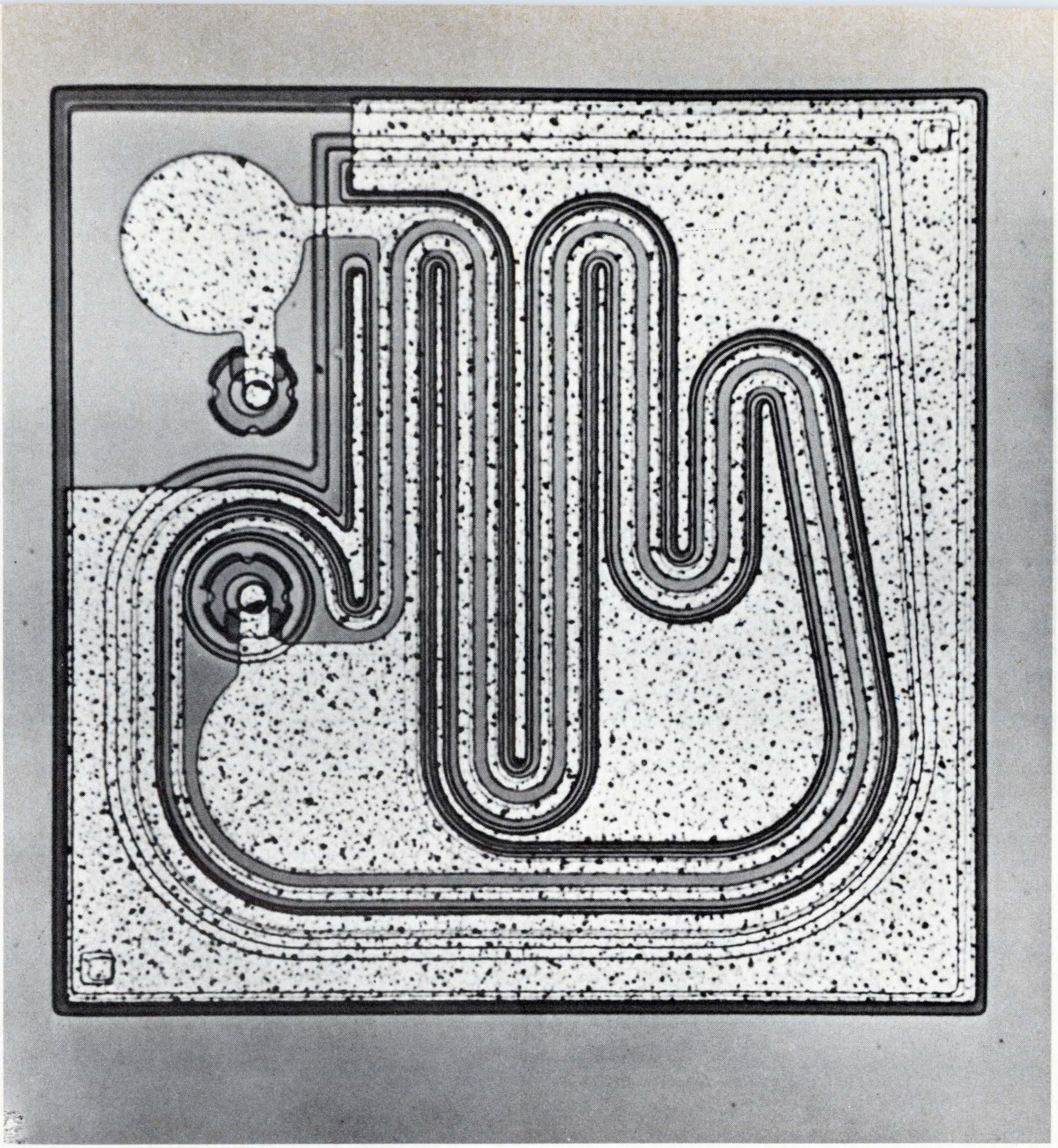
Figure 1, which shows the product life cycle of discrete components, illustrates clearly which are on the increase because they can perform functions too demanding for ICs—and which are declining.

The growth areas include the high-frequency, low-noise MOSFETs, the diode arrays that meet high-speed and high-current core-memory switching requirements, the high-voltage i-f and deflection-tube circuits, the J-FETs and their low input currents, the duals and quads with their matched parameters and space-saving features, all the power functions of 5 W and over, and the high-frequency and microwave functions of the FETs and p-i-n diodes.

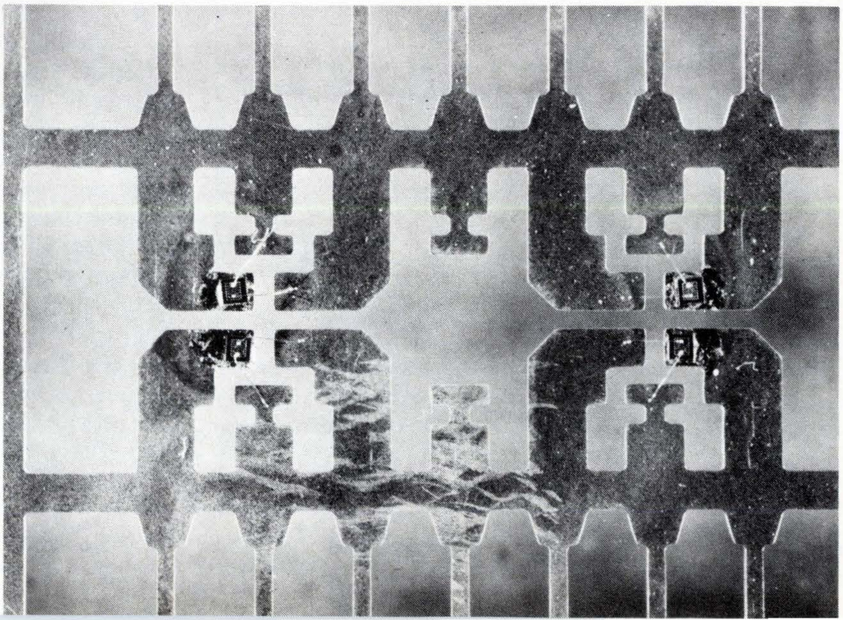
The middle ground, or mature area, includes the rectifiers, zeners, and the 1- to 5-W silicon-controlled rectifiers and thyristors. Many of these intermediate-grade functions are being integrated onto the IC chip—witness the high-powered Darlington pairs (2 to 5 A) and the thyristor and SCR equivalents that lately have been integrated into linear IC designs. Clearly it will not be long before this group of mature products now peaking will slide down the curve into decline.

Actually on the decline, according to the chart, are all the low-current, low-gain, low-power electronic functions—computer diodes, general-purpose transistors and diodes, npn switches, grown junctions—which are out-





Growth. Outside the power area, field-effect transistors and multiple devices are hot items and growing hotter. Above is a dual-gate FET for tuner/mixer applications; left, a diode array in a single package for computer switching; right, four diodes on a single lead-frame for driving core memories. All are from TI.



CHARACTERISTICS	VACUUM TUBE	BIPOLAR	MOSFET	J-FET
Input impedance	High	Low	Very high	High
Noise	Low	Low	Low	Very low
Size	Large	Small	Small	Small
Power consumption	Large	Small	Very small	Very small
Aging	Noticeable	Negligible	Negligible	Negligible
Bias voltage temp coefficient	Low, unstable	Low, consistent	Consistent	Low
Typical gate/grid current	1 nA	–	10 pA	0.1 nA
Reliability	Low	High	High	High

performed by an IC, whether a digital memory or logic array, or a linear device like an op amp or multiplex switch.

But in this boom year for all semiconductor products, the mature devices still have some good times ahead of them. Zeners with precision-controlled voltages now regulate voltages from as low as 2 to 3 V to up to several hundred volts for such diverse applications as analog-to-digital conversion, analog process control, and high-density computing. Silicon-controlled rectifiers and thyristors are at the heart of recent efforts by manufacturers of industrial plant equipment, like printing presses and textile power looms, to modernize plant and process control. Core memories continue to resist the inroads of semiconductor ICs and require high-current (600-milliampere) discrete transistors and arrays to drive the bit lines.

Moreover, even the theoretically declining segment of Fig. 1 is thriving. Even the grown-junction device, long considered an antique by most designers, continues to be the work-horse in many military programs such as gun control mounts, automatic firing systems, both in ground and air installations, and in some of the early computer-controlled firing systems.

The general-purpose diode is doing better yet—it's been pushed up the life cycle curve by the emergence of consumer products that have built-in battery chargers. In calculators, lawn mowers, shavers, hand-held driers and similar equipment, designers have found the general-purpose diode a very cheap way of achieving the rechargeable function, and in fact it is taking the place of the more expensive rectifier in most recharging circuits handling currents of up to 0.5 A.

For the general-purpose transistor, on which the transistor radio industry depends, the change is in the package, with inexpensive plastic found almost everywhere. The small-signal metal-can devices are presently in demand only by the military, and even here, designers of military equipment are expected to convert to plastic as its reliability improves.

The npn switch is another product with a new lease on life, being suddenly in strong demand among computer designers for use in some of the older logic modules. It's liked partly for its very reliable operation and partly because of its availability amid the sudden shortage of transistor-transistor-logic gates and flip-flops. For, although these logic chips have taken over the

D-MOS comes on line

Heralded as a major advance in discrete and integrated-circuit MOSFET technology [*Electronics*, Feb. 15, 1971, p. 99], the double-diffused field-effect transistor pioneered by Signetics Corp. is ready for production. Initially four D-MOS products in metal cans will be available: two tetrodes, plus two double-gate tetrodes for use in circuits with automatic gain control. All four are n-channel-MOS, enhancement-mode devices with a channel length of only 1 micrometer.

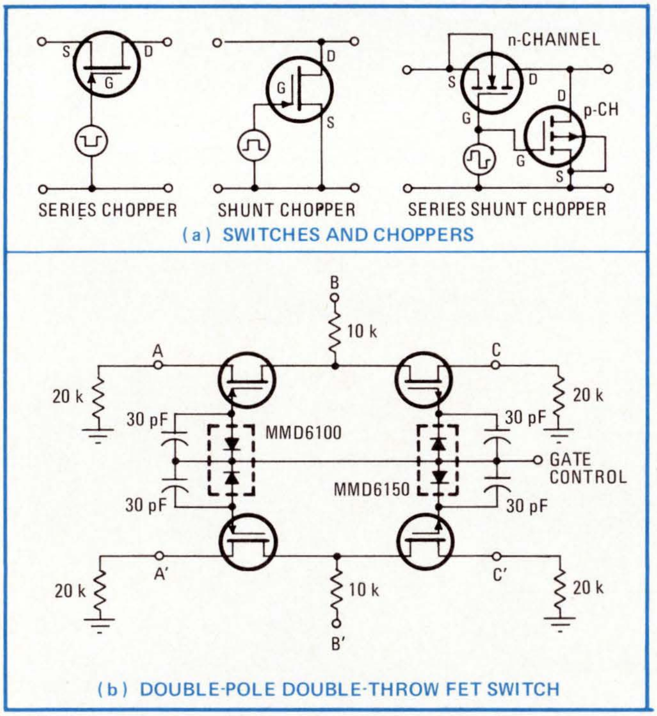
They have impressive specifications. In standard configurations they can operate to 1 gigahertz with a gain of 10 decibels and noise of only 5 dB at power levels of 300 milliwatts. What's more, these new D-MOS devices will operate up to 2 GHz in a microwave strip-line configuration with the same specifications—a feature that makes them not only desirable for the front end of most S-band equipment, but also ideal input structures for many vertical amplifiers used in measuring equipment.

In addition, since they exhibit linear power-frequency characteristics, they may find applications at power levels not normally associated with bipolar FET devices operating at ultrahigh frequencies.

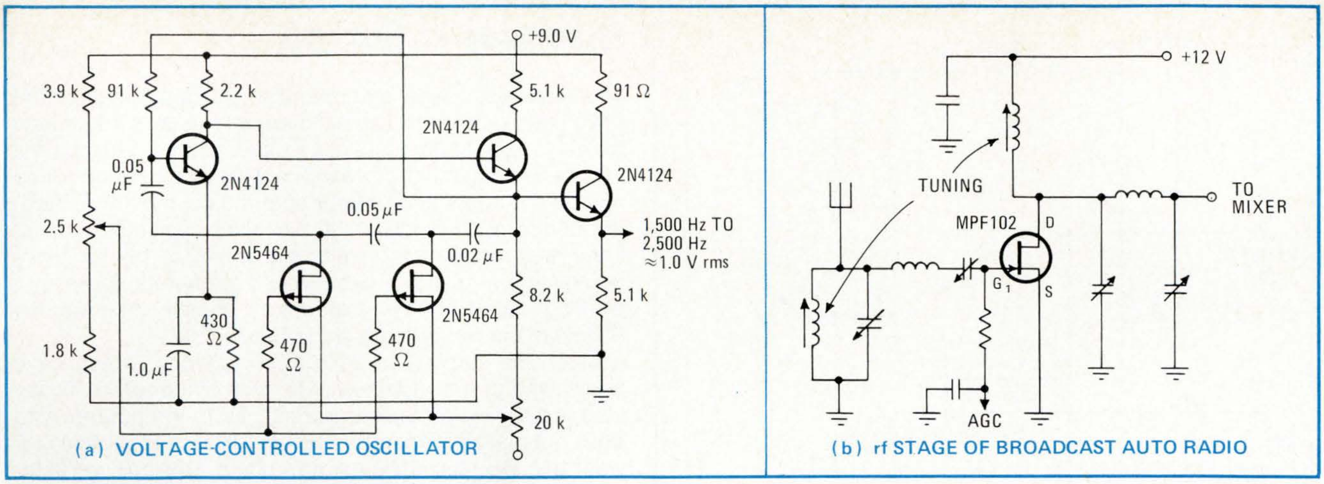
Also useful is the double-diffused FET's low parasitic capacitance at the inputs and outputs, a property that will make the device appropriate as an analog switch because output spikes will be eliminated.

The high performance of double-diffused FETs stems from the designer's ability to make micrometer-long channels without undesirably low breakdown voltages. It's the combination of short channels with high-drain-source voltages that is responsible for the high gains at the high frequencies. Ion implantation is now used in the process to control device doping profiles, thereby adding to the stability of the device.

The first tetrode products will operate at 25 volts. Moreover, experimental D-MOS FETs have been built with 300-V operating voltages and 1-W power ratings. Indeed, it's expected that the D-MOS technology will soon yield 1-W production devices operating at 1 GHz.



2. Switching and chopping. FETs make good switches and choppers. The series chopper (a) performs connect-disconnect functions and acts as a single-pole single-throw switch. Four J-FETs and four dividers (b) make a double-pole double-throw switch



3. FETs in audio. A three-section voltage-controlled oscillator (a) contains two FETs in feedback loop and generates a linear sinewave over 1,500 to 2,500 Hz. Typical FET rf stages in an auto radio (b) replace tubes with only minor circuit changes. Circuits are from Motorola.

switching function of new designs on paper, in practice they are suffering from backlogs of as much as six months, especially the versions that use medium-scale integration. Still, most designers see it eventually dying as TTL becomes more readily available, and the demand is expected to trickle away by 1975.

Somewhat similarly, the computer diode is also gaining from 1973's sudden brisk demand. And the facts here are that many computer manufacturers, because of a huge backlog of equipment orders, are staying with some of the older memory designs that use the readily available diode instead of the equivalent hard-to-get integrated circuit. This demand, however, appears temporary, not so much because of the declining popularity of diode memories as because the discrete computer diode is rapidly being replaced by the diode array. Arrays with as many as 16 diodes in a single package are now available at half the price per diode of the old discrete. Also, such an array occupies only three times the area of a single-packaged device.

Growth beyond the boom

The use of the 16-element diode array points up a general trend in the discrete component industry toward multiple devices—dual and quad transistors, diode arrays, Darlington pairs, complementary npn pnp devices. The advantage a multiple device offers the equipment designer is that it can be matched to a particular parameter, cutting out the costly selection process that is especially troublesome in high-volume equipment. For example, dual J-FET devices are now available with matched impedances, eliminating the need for external balancing resistances in many amplifier designs. Transistors can also be matched for input current, gain, g_m, betas, indeed almost any transistor parameter.

New dual power Darlingtons recently introduced from Unitrode follow this trend to more power in less space. Duals can be obtained with 5-A and 10-A service for use in motor drives, converters, send servos, and lamp and relay drivers.

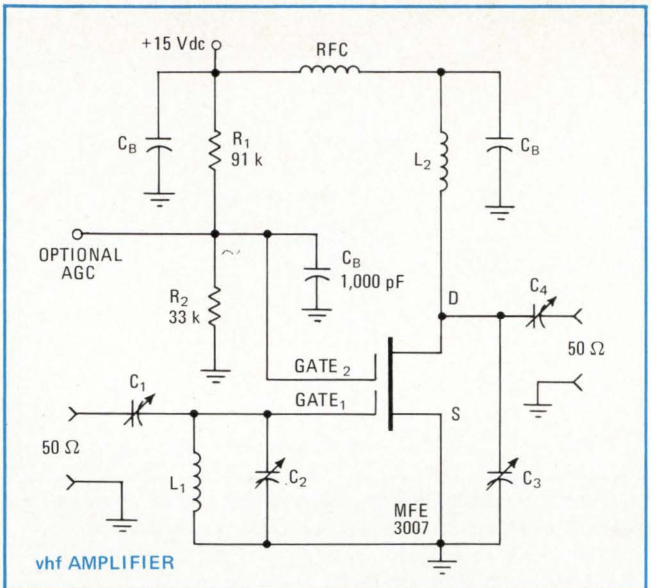
A second area of growing demand is the core driver, both the discrete transistor driver and the multiple quad device. Here, because of the high currents (600 mA) required to drive the bit lines of today's core memories, ICs have been slow to take over the function. It is only recently that an IC core-memory driver has become available, and it is too soon to determine its penetration into this market. In any case, the stubborn resistance of core memories to the onslaughts of the new MOS and bipolar semiconductor memories means that the discrete memory driver will remain strong throughout 1975.

Over the long term, however, they are doomed—on the one side by the IC driver that will eventually be cheaper and smaller than the discrete devices, and on the other side by the ever increasing penetration of semiconductor memories, which have on-chip drive circuits or can be driven by a driver sense amp IC. Indeed, much the same could be said for the general-purpose devices and computer diodes and arrays, all devices whose functions will either be taken over by the IC or eliminated in new designs.

However, the field-effect transistor, like the power device, represents real long-term growth and stability in the discrete-product arsenal. In recent years the FET has become almost as ubiquitous as the bipolar transistor, finding its way into such diverse pieces of equipment as video amplifiers, analog switches, balanced mixers, voltage-controlled resistors, and rf amplifiers, and serving as switches in choppers, as voltage-controlled oscillators, vhf varactor tuners and amplifiers, and as zener source elements in discrete logic circuits such as half adders.

Mainly about FETs

Feeding this application growth are a host of new junction-FET and MOSFET devices. For instance, newly available from several component manufacturers, including Motorola, General Instruments, Siliconix, Intersil, Fairchild, National, TI, Teledyne, RCA, and Analog Devices, are both n- and p-channel dual-gate MOSFETs that offer lower noise and higher power gains than devices of a couple of years ago. A case in point is the dual-gate 3N204 series from TI, which has typical noise figures ranging from 2 dB at 200 MHz to 7 dB at 900 MHz with gains of 24 dB at 200 MHz to 12 dB at 900 MHz. Offered in TO-72 metal cans, FETs of this type are being



4. FETs over tubes. J-FETs substitute for tubes in these kinds of vhf amplifiers. Here, a J-FET has replaced the old 12BL6 pentode.

used extensively in vhf-rf amplifiers in TV and fm tuners and for uhf-rf amplifier applications as well as vhf mixer application. All these devices have low cross-modulation distortion, a trait especially useful in tuned high-frequency amplifiers such as those found in TV i-f strips.

As for J-FETs, a new Analog Devices' n-channel J-FET has very low noise, specified at less than 15 nanovolts at 10 hertz, and low offset voltage (5 mV maximum). It is intended especially for sensing small signals in opto-electronic, biomedical, nuclear, and in low-level transducer applications. Systems designers are finding this type of device more economical and easier to use than hybrid dual-chip equivalents.

The J-FET and MOSFET differ in their construction. The J-FET uses a reverse-biased junction (which produces the depletion region) to control the drain-source current, while in the MOSFET the gate is a metal film deposited on an oxide layer and is insulated from the source and drain. Although both devices use an electric field to control a channel current, the control mechanisms for the two are different, and their characteristics, especially the gate characteristic, consequently differ

Discretes in Europe

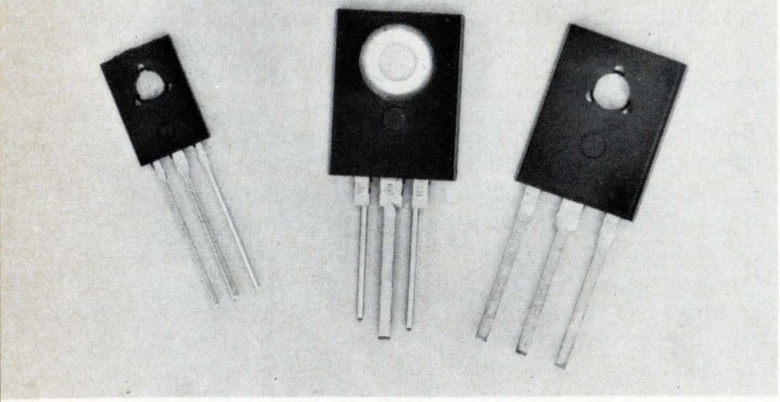
The Europeans who manufacture consumer equipment have been quicker than the Americans to pick up on new trends in solid state. FETs are a case in point. Throughout Europe for a number of years now they have been found in tape recorders and uhf portable radios, mostly as high-frequency input transistors in the mixer-oscillator circuits. They are based on conventional mesa or planar technology and were first put to this use about four years ago, by Grundig AG of West Germany, closely followed by Philips of the Netherlands and others.

Much the same is true for tuning diodes, which have been used in uhf radios and TV sets since 1965. Today it's hard to find a major European TV manufacturer who does not make varactor tuned sets—Philips Electrical Ltd. was the pioneer in England, using Mullard varactor diodes. American manufacturers are expected to follow suit. Recently Intermetall GmbH, a member of the ITT Semiconductor group and the firm that pioneered tuning diodes, began investigating ion implantation methods for diode fabrication—a hot development item also in America—but such diodes are likely to be too expensive to impact consumer applications at all soon.

An innovation in consumer products in Europe is p-i-n diodes in TV sets, an idea taken over from the measuring-equipment industry. Again, Grundig was first, using the diodes in the tuner section where they perform a control function. Supplied by Siemens, the diodes are arranged electrically in π form and feed uniform and steady-state signals to the input transistors of the subsequent vhf and uhf stages. This eliminates the need to adjust these stages and also allows the use of high-current input transistors. The result: interference between signals, such as occurs with closely spaced transmission channels or with maladjusted community-antenna equipment, is no longer a problem.

Similarly, high-voltage transistors and thyristors are finding their way into consumer products, for example, in deflection stages in TV sets. Intermetall has received orders from several European TV set makers for large quantities of thyristors, a figure which the company says

considerably. In short, the input of the J-FET behaves like a reverse-biased diode, while the input of a MOSFET is similar to a small capacitor. It is the reverse-biased property of the J-FET that accounts for its low input current, while it is the capacitor-like action of the MOSFET that accounts for its low noise and high gain.



Plastic on the rise. Plastic-package transistors, like these from Motorola, are penetrating the industrial market.

Design with FETs

Both types of FET have several advantages over the conventional bipolar transistor. They are relatively free of noise, they are more resistant to the degrading effects of nuclear radiation, and they are inherently more resistant to burnout. The parameters, both for the MOSFET and for the J-FET, are compared with those of the vacuum tube and the bipolar transistor in Table 1, supplied by Motorola.

Other attributes of the FETs are advantageous for certain design considerations. The inherently high input impedance—typically many megohms—is useful in impedance transformation, chopper and switching applications. Since it is a voltage-controlled device, the FET can be readily self-biased, which frequently makes for a represents one of the ITT group's biggest sales of discrete semiconductor devices for entertainment electronic applications. Since it currently lacks the capacity to produce the thyristors at its own plant, Intermetall will have them made at ITT's facility in Footscray, England.

The thyristors, types BT 119, BT 120 and BT 121, were designed by Intermetall in cooperation with the Stuttgart-based ITT applications labs and are intended for the horizontal deflection circuitry in color and black-and-white TV receivers. In this transformerless circuit concept, the thyristors, together with fast diodes and rectifiers, replace the tubes formerly used in horizontal deflection stages of PAL and Secam receivers.

British companies are also active in developing devices for horizontal line deflection circuits. As in American sets, using 1,500-V transistors for these circuits is fairly standard, and now 1,700-V devices are coming in, for instance, in sets from British Radio Corp., a division of Thorn Electrical Ltd.

Higher voltage switching with these units means a cheaper regulator handling less current. In this category is Texas Instruments Ltd.'s 2,200-V transistor (see p. 94), now being evaluated by set makers. It has an interdigitated structure made by triple diffusion. The color-set device is rated at 4 A, the mono device at 3 A, and each comes in a TO-3 can bolted to a heat sink.

Like RCA in America, ITT Components Group Ltd.'s Semiconductor division reckons this voltage requirement is pushing the transistor technology to its limit and believes a double thyristor-switch operating at around 700 V is more reliable because it operates well within its capability. The ITT device is used on the continent, and ITT is trying to persuade British set makers to take it up.

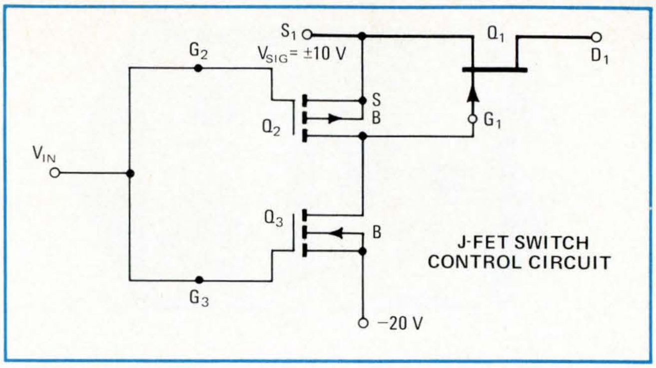
For industrial applications, Intermetall will shortly unveil a family of high-voltage pnp silicon epiplanar transistors capable of handling a collector-emitter voltage of 250 V. Designed to work as a driver in conjunction with linear ICs, the BSS54 high-voltage transistor is intended for use in the push-button type of telephone set, where it replaces conventional mechanical components.

simpler circuit than would be possible with a bipolar transistor. Its ability to operate at a gain-source voltage less than pinch-off can be exploited for automatic gain control. Also, the FET has a very high output resistance, making the device useful as a constant-current source, again when operated at a drain-source voltage greater than pinch-off.

The chief shortcoming of the FET is its relatively small gain/bandwidth product. Although this limits its use in many high-frequency applications, the FET can provide excellent results in vhf circuits, where its linearity overload resistance makes it far superior to bipolar transistors.

Some typical FET applications have been identified by Motorola, a major supplier of FET products, and include switches and choppers, a typical double-pole double-throw FET switch, a voltage-controlled oscillator, the rf stage of an auto radio, the vhf amplifier of a TV set and a zener source element for any number of circuit applications.

The simple series chopper shown in Fig. 2a performs the connect-disconnect function or acts as a single-pole single-throw switch placed in a signal path to the load. The shunt chopper is a straightforward way of providing shunting signals with high impedances. It may also be used in conjunction with the series chopper to remedy the latter's speed limitation. Here, when the series chopper is turned off, the gate-drain capacitance must discharge through the load impedance, which limits the upper frequency of operation; but when the series device is turned off, the shunt device is turned on, discharging the series' gate-drain capacitance, and allowing for higher operating frequencies.



5. Switch to FETs. FETs are increasingly being used as solid-state analog switches. Typical circuit from Siliconix contains J-FET.

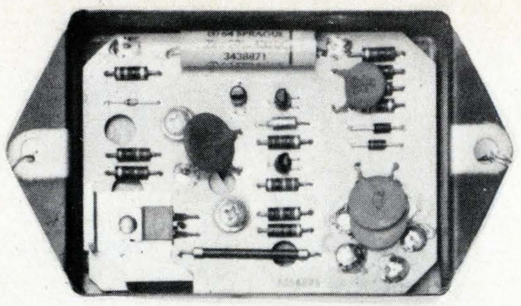
The double-pole, double-throw FET switch (Fig. 2b) is made up of four J-FETs and four dividers controlled by a common gate circuit. When the gate control goes negative, the p-channel J-FETs are turned on, and the n-channel device is off. The opposite happens when the gate goes positive, implementing the dpdt control.

The voltage-controlled oscillator (Fig. 3a) is obtained by including an RC phase-shifting network in a typical amplifier's feedback loop. In this three-section phase-shift oscillator a linear sine wave is generated over the range of frequencies from 1,500 to 2,500 hertz with an output signal amplitude of approximately 1 V. This 1-kHz frequency swing is controlled by an input control voltage that varies from 2 to 5 V dc.

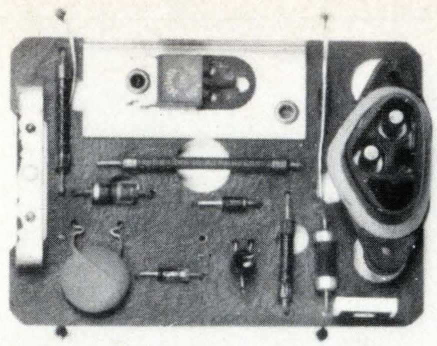
The types of rf amplifier that are based on FETs are practically unlimited. Indeed, many designers are finding that circuits designed around small-signal pentode tubes can use FETs as replacements with only minor modifications.

Figure 3b shows the circuit of a typical rf stage for a broadcast auto radio, in which an n-channel J-FET has replaced the old 12BL6 pentode. FETs have also replaced tubes in the vhf amplifier of Fig. 4, which has been designed to operate at 100 to 400 MHz. To set the proper bias in this circuit, resistors R_1 and R_2 are adjusted for 4V dc at gate 2. They have high values to minimize current drain. Note that gate 2 must be well bypassed at the signal frequency lest the low impedance to ground cause instability or loss of gain. Included are capacitance values for different frequencies.

A FET is also an ideal zener current source, a property that stems from its ability to perform as a constant-current generator. As a zener-diode source element, the constant-current FET has a distinct advantage over the use of a series resistor by itself, because variations in input voltage have virtually no effect on output voltage when the load current is constant.



Power takes a ride. Biggest new power market is in the car. In this Chrysler Corp. ignition system is an RCA 200-V, 5-A transistor.



Under the hood. Chrysler unit contains a 40-V, 3-4-A discrete device from RCA, typifying use for cars' voltage regulators.

Stimulated by the growth of industrial analog-to-digital systems is the increased need for a solid-state analog switch—and that function is performed admirably by both J-FETs and MOSFETs. The operation of the FET as an analog switch springs from the fact that the device is in effect a conductor whose cross-sectional area may be varied by the application of appropriate voltages. When the conducting area or channel is maximum, conductance is also maximum. When the conducting area is minimum, resistance is maximum. Consequently when conductance is maximum, a FET switch is on, and when conductance is minimum, the switch is off.

Two types of FET switches are available: the depletion-mode devices, which have high channel conductance with zero gate-channel voltage and are "normally on" switches, and the enhancement-mode FET, which require that voltage be applied to the control gate to create a conducting channel—the "on" state—and are "normally off" devices.

Figure 5 shows a typical J-FET switch circuit developed by Siliconix, a major supplier of FETs of this kind. Here Q_1 is an n-channel J-FET, Q_2 an enhancement-mode p-channel MOSFET, and Q_5 an enhancement-mode n-channel MOSFET. In this configuration, an input voltage of -20 V will turn Q_2 on and Q_3 off so that the points S_1 and G_1 shown in the figure will be connected ($V_{GS} = 0$ V) and Q_1 is on.

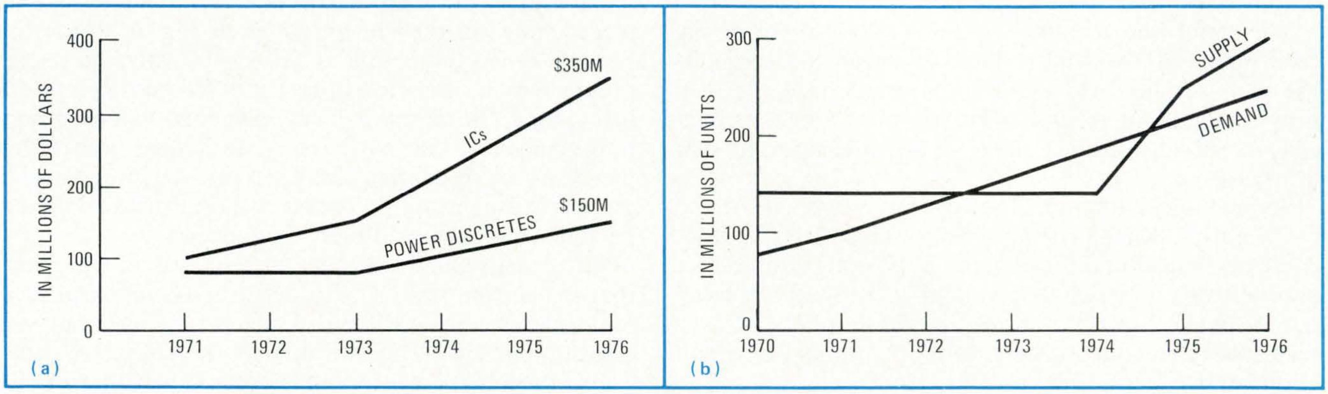
A new market in power

Since IC designers are unlikely to be able to integrate power circuits above 10 W in the audio range and 1 W in the rf range for some time, the discrete power semiconductor device is truly a long-term growth area in such applications as audio and TV equipment, mobile rf radio and communication equipment, automotive equipment, and white goods—in short, wherever high power and high reliability are demanded.

Just how fast the power market is growing can be seen from Fig. 6a, which shows it reaching a total of $150 million in U.S. factory sales in 1975. Indeed, the demand for power products is so great, having increased suddenly in the latter half of 1971 with the upturn in market activity, that throughout 1972 the supply dramatically lagged demand. And the situation is expected to become worse. Figure 6b shows that the suppliers will begin to meet the market's needs in power products only in 1974, when the newly designed power transistors and Darlington products go on stream.

Worldwide demand is even stronger, and the total dollar value of the market is expected to exceed $220 million in 1973. European equipment makers have long been more innovative in the use of solid-state components in consumer products, and this trend will accelerate in 1973 when European automobile manufacturers begin using power devices in their fuel-injection and seat-belt interlock systems. Based on an average unit price of 85 cents per power device, the total number of power devices consumed worldwide in 1973 will exceed 300 million in 1973 and rise to 600 million by 1977.

As with small-signal discretes, the consumer and automotive industries have most need for power components (Fig. 7). Starting in 1971 the market share for automotive power products began to increase at a rate twice that of other major segments, with home enter-



6. Rosy prospect. Texas Instruments sees the U.S.. demand for power paralleling the strong growth of ICs, reaching $150 million in 1975. Trends are for higher power and more plastic packages. Demand will be so high that TI planners see shortages through 1974.

Four paths to power

To provide the wide range of characteristics required in power devices, the major semiconductor component manufacturers have developed four different processes (see figure, courtesy Motorola).

The oldest technique puts a simple epitaxially grown base area on a standard collector substrate. This epi base process is used for general-purpose power devices ranging in output up to 25 watts and intended for a host of amplifier applications, with both npn and pnp polarities available for complementary design. Most audio amplifier circuits are still served by this process.

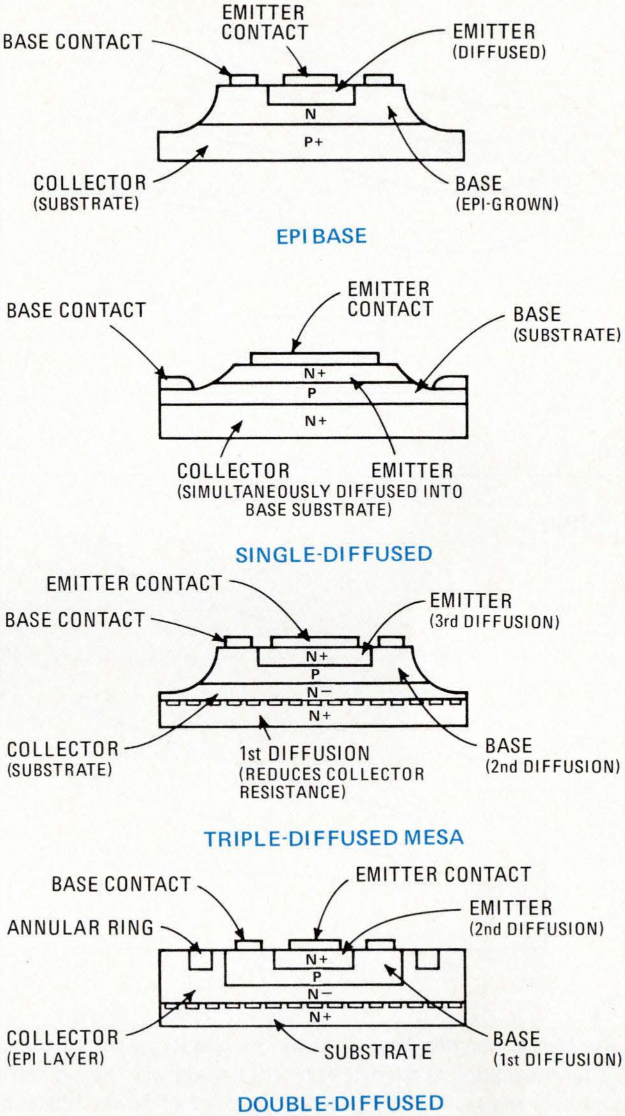
Taking the place of the epi base method for newer high-powered applications are the single- and multi-diffused processes.

The single-diffused process, which is best suited for rugged, low-frequency applications requiring powers up to 50 W, is the mainstay of power designs. Here, collector and emitter areas are diffused simultaneously into the base substrate so that low junction temperatures are maintained at high powers.

For higher-frequency operation at moderate power outputs, a double-diffused device is generally fabricated on the basis of techniques developed for integrated circuits. The base is first diffused on a collector epi layer, and then a second emitter diffusion is made. Because the base and emitter require independent process steps, they can be separately doped to make them yield the high currents at high frequencies necessary in uhf and vhf applications.

The newest power transistor process is a triple-diffused system that was developed principally for high-voltage applications in TV deflection circuits, automobile ignition, and power supply switching. The key here is the ability of the process to reduce collector resistance so as to obtain breakdown voltages of up to 1,600 volts. Here, a first diffusion lowers the collector substrate resistance, after which the conventional base and emitter diffusions are made.

More recently, some suppliers, principally RCA, have been able to modify their double-diffused process so that they can achieve similar high voltages without the need for a third diffusion.

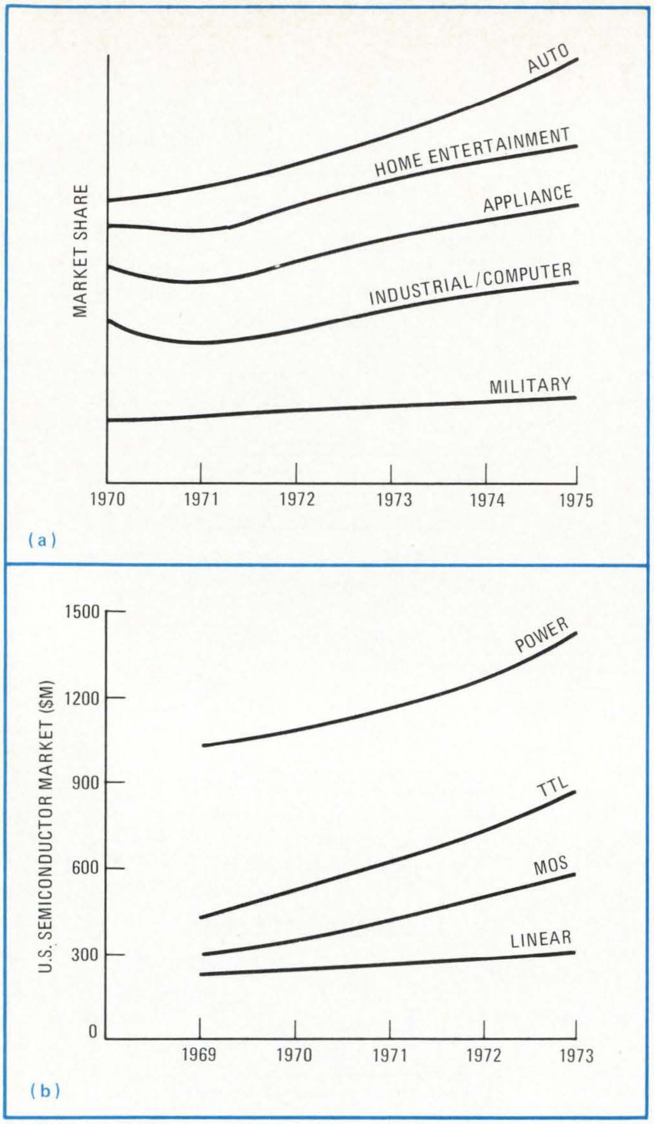


tainment and the appliance industry next in line. Only in the industrial computer market will power needs remain constant through 1975.

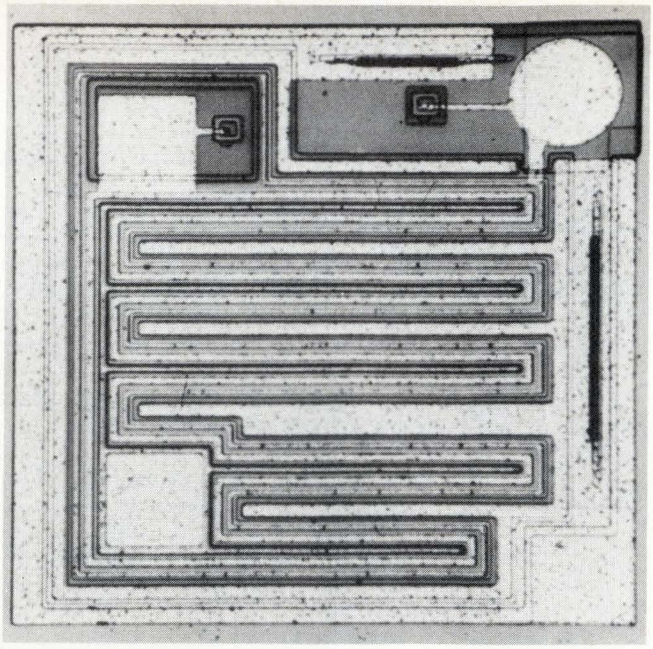
The automobile is a very new consumer of power discretes. For example, the ignition system of all 1973 Chryslers will contain two power transistors, a 2-A, 40-V plastic device, and a 300-V, 5-A output transistor in a metal can. The voltage regulator of many 1973 cars has a 3- to 4-A, 40-V transistor in a plastic package in its circuit. Designers of the seat-belt interlock system presently required in all cars in the 1974 model year will have at least two power devices, a 1- to 2-A plastic transistor to power the buzzer, and a 2-A plastic device to control a blocking solenoid in the ignition system. In all, six or seven power sockets will exist on 1975 model year cars, representing a unit demand of almost 100 million in 1974. This is in addition to any control devices such as windshield motor variable drives and heater control devices and those required for the anti-skid control—all of them 4- to 5-A, 40-V devices.

Satisfying these circuit functions are two types of semiconductor: the standard metal-can or plastic transistor for the high-voltage application and the newer Darlington pair for the high-voltage, high-current applications. Both are now available from all the major semiconductor suppliers. The plastic devices will be generally confined to low-duty applications—as in the seat-belt interlock where the power rating is less than a watt—while the hermetically sealed products will perform the more critical high-powered functions in the ignition and regulator systems.

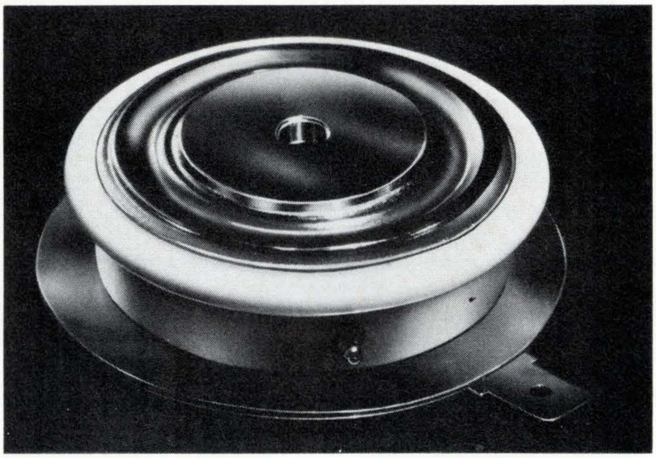
Television is another major consumer of power devices. There is an average of five power sockets in a color set. The horizontal deflection circuit driving the picture tube now requires either a thyristor or a high-voltage power device. The vertical drive requires an 80- to 100-V complementary pair capable of supplying 3 to 4 A at the output. The chroma circuits are driven by two or three power devices in the 300-V, 100-mA range. With TV production forecast at 10 million sets this year,



7. Satisfying the consumer. Industry demand for power products, (a), shows auto and home entertainment leading with the industrial and military market remaining steady. Altogether power products represent a 25% share of the semiconductor market.



FET blanket. TI's new double-gate FET is one of many that have a nitride-passified coating to increase stability.



Established. SCRs represent a mature industrial portion of discrete demand. Motorola device has puck-type package for easy mounting.

this market represents a 50 million unit demand.

To meet the horizontal-deflection requirements, output voltages as high as 1,500 V in unregulated systems and 700 to 800 V in regulated systems are necessary, as well as blocking voltage as high as 2,000 V. One of the newest devices that can do the job is a power transistor from TI rated at 2,200 V and 2 A. With its exceptionally high output voltage, it was developed mainly for use in the European 220-V, line-operated sets. But it is capable of operating directly off an unregulated line, according to TI, and can be cost-effective with lower line voltages because it eliminates the need for regulation.

RCA has been recently innovative in TV deflection devices with a double-diffused 800-V device which it feels will be more useful than the higher-voltage devices, especially for the in-line TV tubes of 1974 set designs. But perhaps more important, the ability of these devices to switch in less than a microsecond will also help to meet the growing demand for faster high-frequency switching applications.

Indeed, RCA, Motorola, Fairchild, TI, and others have developed devices that can switch high power-supply voltages at frequencies above 20 kilohertz. This means that, because of the higher-frequency operation, the manufacturers of power supplies can use smaller transformers and less elaborate heat-sinking methods and greatly reduce the size and cost of their supplies. Motorola's devices, the 2N6306, 07, and 08, have 8-A collector current ratings and voltage breakdowns of 700 V and can switch at speeds less than 0.05 μs. This represents a 2:1 improvement over existing devices in speed/power switching capabilities and should evoke strong interest from power-supply manufacturers, the computer industry, and audio and TV circuit designers. And it must be kept in mind that each power-supply circuit requires three devices, one inverted driver and two output units, representing 4.5 million new sockets that must be filled over the next few years. □

Matching driver circuitry to multidigit numeric displays

It is worthwhile for the designer to choose the optimum combination of parallel and serial circuitry to drive the output elements, rather than simply making tradeoffs between various readout devices

by Alan Sobel, *Zenith Radio Corp., Chicago, Ill.*

☐ All too often, the design of an electronic numeric display system is based primarily on the characteristics of the various display devices available, with only secondary regard for the necessary driver circuitry. However, the display-system designer will find it profitable to consider such important criteria as driver power, element-switching time, and decoding-circuit complexity.

For a particular application, there may be several system organizations that can give low total cost and good performance. To find these, however, the characteristics of the output elements and the drive electronics must be considered together.

Display-system organization

The design of a display system must begin at the source of the information to be displayed. This may be the output of a counter or an analog-to-digital converter, for example, and it may have such outputs as binary or binary-coded-decimal (BCD). The display device, on the other hand, may require a drive system for seven-segment digits, seven-by-five-element dot matrixes, or some other format. All digital readouts considered in this discussion contain more than one digit, and it is therefore often desirable for corresponding segments of several digits to time-share a common driver.

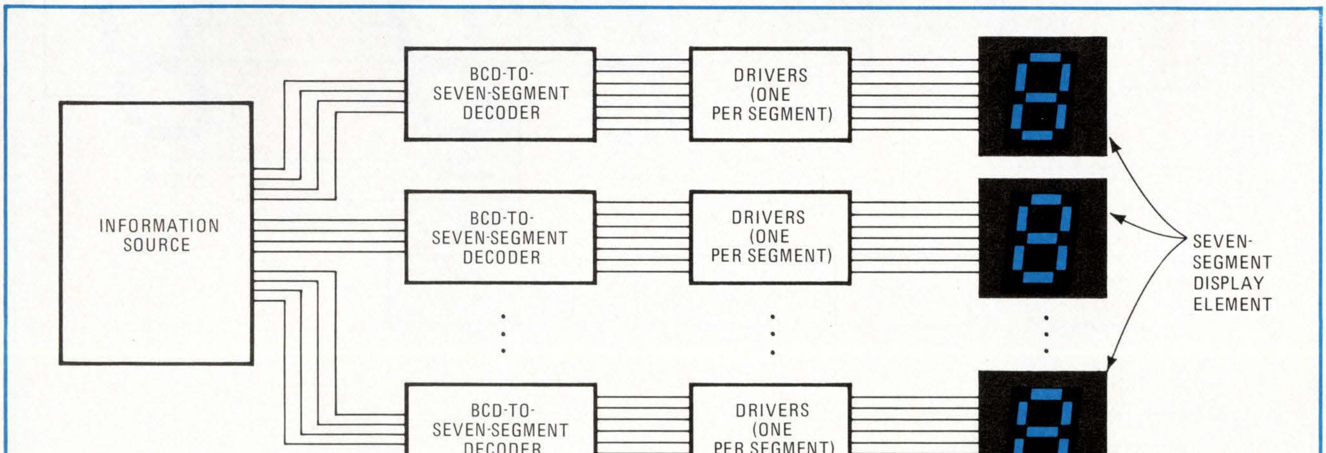
For such multidigit display systems, there are two fundamental drive-system configurations—full-parallel and matrix. Most practical display-system designs are compromises between the two. The "full-parallel" configuration (Fig. 1) is simpler, but usually more expensive. Because separate lines from the information source are routed to each individual digit in the display, each set of lines from the source is translated in the decoder to the format required by the drivers and the display devices. Using the full-parallel configuration, the duty cycle of each of the energized digits is, for all practical purposes, 100%.

Such a full-parallel display, however, requires a maximum amount of circuitry, since a decoder and driver must be supplied for each digit. The "matrix-drive" configuration (Fig. 2), which reduces this hardware requirement, is also called a "full-serial," "strobed," or "multiplexed" display system.

Matrix-driven display

Although it reduces hardware needs, the matrix design is more complex, and it makes tougher demands on the display elements. Thus, a careful analysis of the total system is necessary in order to make a proper choice between the two.

In matrix configurations, data from the source feeds a



1. Full parallel. In the most straightforward approach to display-system design, one decoder and seven drivers are required for each digit. Such designs, however, are generally wasteful of decoding and drive-circuit hardware in displays of more than three or four digits.

single decoder, either over a single set of lines, which is switched in the source from digit to digit, or via a switch that takes the information from the individual digit sources and transmits it sequentially to the decoder. Corresponding segments of each digit are connected together, and the particular digit to be energized is selected by activating another switch.

Besides reducing the number of decoders, the number of drivers required in a multidigit display can also be substantially reduced. In a 10-digit display with seven elements per digit, for example, the matrix configuration would require 17 drivers, in contrast to the 70 that would be required in the full-parallel approach.

Most numeric display and driver configurations today fall somewhere between the full-parallel and the matrix systems. For example, a single decoder can be time-shared among separate sets of drivers for each digit, but the drivers may include storage capability to keep each element energized for a duty factor close to 100%. Such an arrangement, shown in Fig. 3, has 28 drivers (seven segments times four digits). The particular design shown has been used for a digital-voltmeter readout.

Duty factor and repetition rate

In the matrix arrangement, the operating duty factor for each digit cannot be larger than 1/n, where n is the number of digits in the display. The duty factor will usually be less, since time must be allowed for the new information for each digit to be transmitted to the decoder. Some display devices (multiple-digit gas-discharge devices, for example) may require dead times between adjacent digits to avoid inadvertent illumination of elements when they should be off.

Average light output is the peak output times the duty factor. Therefore, to radiate, say, 50 foot-lamberts average luminance from each element in a 10-digit display, each digit must generate at least 500 foot-lamberts while on. Some devices, like gallium-arsenide-phosphide light-emitting diodes, thrive on this pulsed treatment. Other devices, however, simply cannot meet the instantaneous requirements in some applications. Limitations on the peak-output capabilities for some devices, then, limit the number of digits that can be multiplexed. Thus, to maintain adequate luminance for each display element, it may be necessary to divide a display-drive matrix into several smaller matrixes.

The lowest frame-repetition rate is fixed as the lowest rate at which the devices can be operated without noticeable flicker. This is typically 30 frames per second, although in applications where the device is subjected to a great deal of vibration, it may be desirable to use repetition rates as high as several hundred frames per second to avoid annoying breakup of the display. On the other hand, the highest frame rate is sometimes limited by switching times of the display elements used (see table, p. 99).

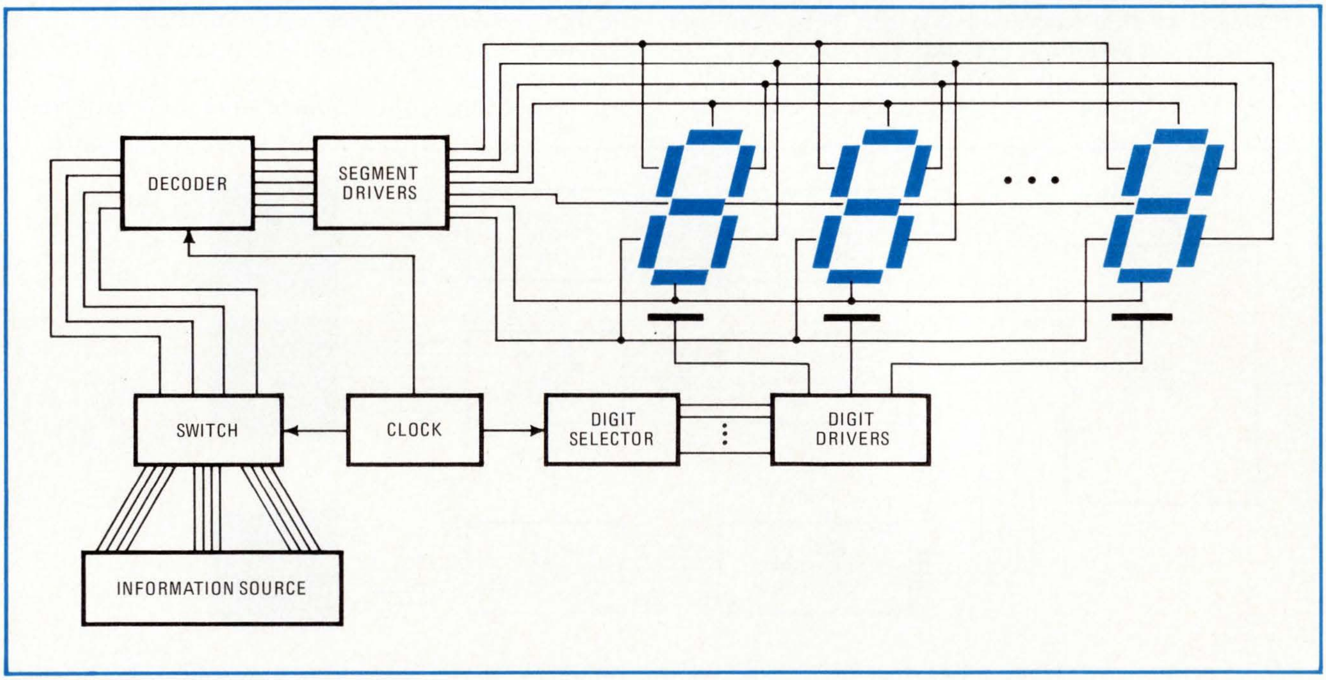
How duty factor affects contrast

Specifications concerning brightness and ease of viewing a display are partly established on the basis of subjective factors, but probably the most important criterion for legibility—and an important factor in designing matrix-drive systems—is contrast. If the duty factor is less than unity, both the output of the display and the contrast, that is, the ratio of output from an on segment to that from an off segment, will be reduced. (The ratio of output from a segment to light scattered from the surroundings will also be reduced.)

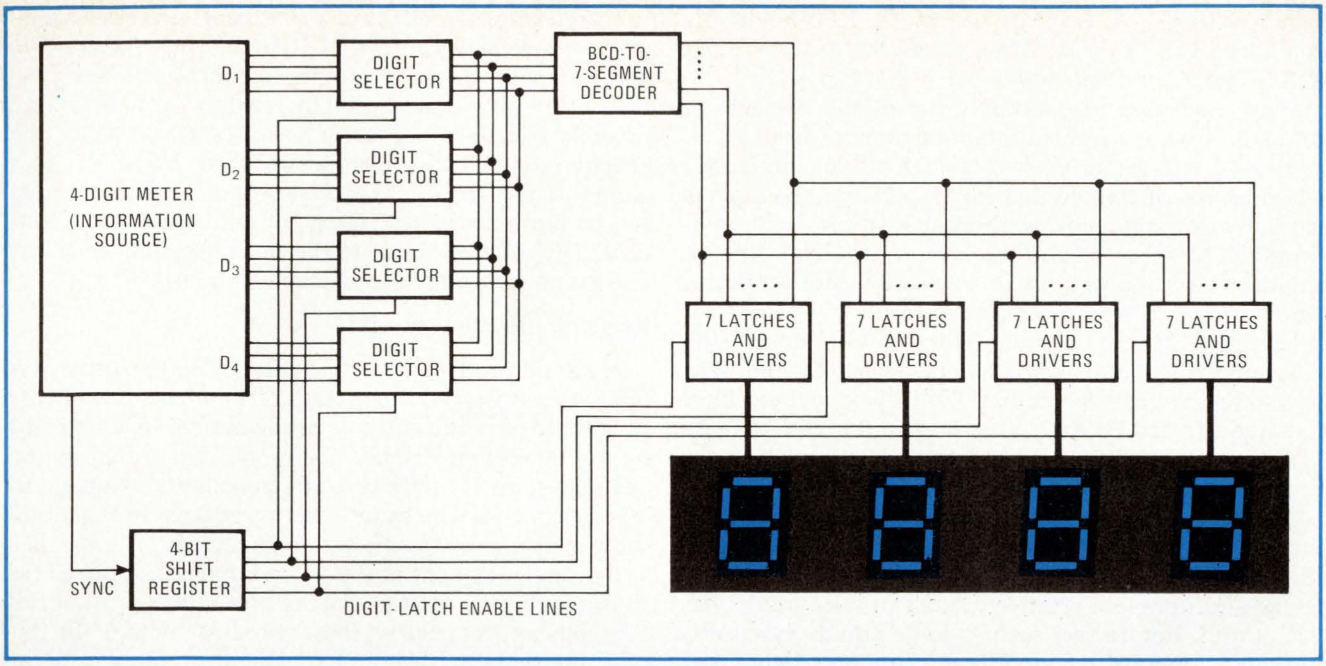
An off segment is not totally blank; it scatters some ambient light, and it may also be energized partially by undesired current paths in the drive matrix. The output of an energized device, then, is:

$$L_{on} = CL_{off} \qquad (1)$$

where C is the contrast ratio and L_{off} is the output of the



2. Matrix magic. When displays are matrixed, fewer decoders and drivers are required than in the full-parallel system in Fig. 1. The relative advantage of the matrix system is increased further as more digits are added to the display.



3. Voltmeter readout. For use as a voltmeter readout, this system trades an increase in decoder circuits for less complex selector switches and latching circuits. Latches are synchronized with the digit selectors. Thus, each element is energized with a duty factor of nearly 100%.

device that is off. Because of the duty factor, F, of matrix displays, the effective contrast ratio is:

$$C_{eff} = [FL_{on} + (1 - F)L_{off}]/L_{off} \quad (2)$$

which combined with Eq. 1, reduces to:

$$C_{eff} = F(C - 1) + 1 \quad (3)$$

The importance of the difference between contrast and effective contrast can be seen by plugging numbers in for typical display situations. In an LED display, for example, if C = 10 and F = ¼, then the effective contrast is only 3¼, while for a display contrast of 50 and F = 1/10, C_{eff} is only 5.9.

Alternatively, if an effective contrast of 10 is needed in a particular application, and the duty factor is 1/10, then a display element must be chosen with contrast of 99. Such a requirement is not impossible for a light-emitting display, particularly if appropriate filters are used over the elements.

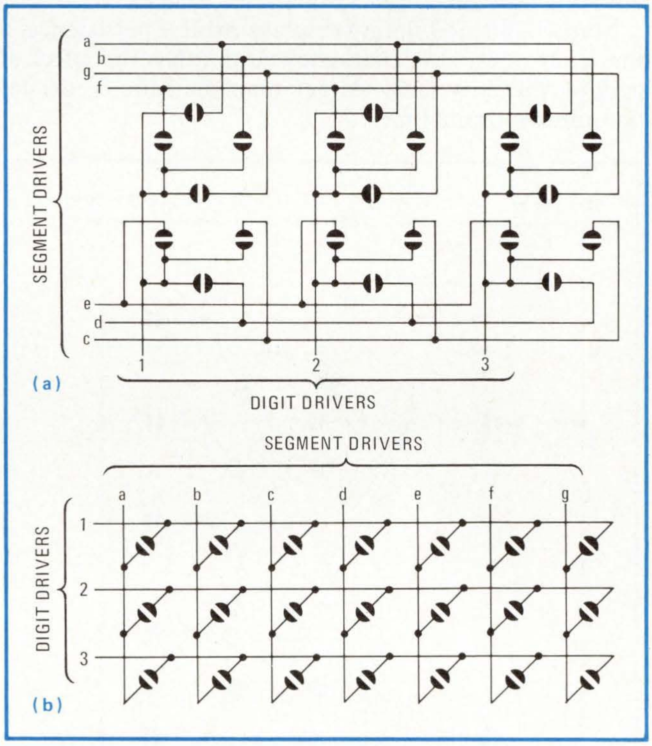
Filter can optimize contrast

If the effective contrast is found to be less than desirable for a given combination of drive technique and display elements, filters can often be used to improve viewing ease. A neutral filter (one with a constant output over a broad range of light wavelengths) attenuates both the ambient light and the output of the device equally.

However, the ambient light is attenuated in two transits of the filter, while the light from the display passes through the filter in only one direction. The result is a net gain in contrast at the expense of luminance. It has been shown[1] that the effective contrast when using such a filter is:

$$C_{eff} = [F(L_{on} - L_n)/L_n + L_aSG] + 1 \quad (4)$$

where L_n is the light output from an unenergized element with no ambient light, L_a is the ambient illuminance, and G is the filter transmission. The quantity L_aS is the output of scattered light from a display element, assumed to be unaffected by whether the element is energized or not.



4. Three-digit multiplex. Three seven-segment numeric elements (a) are multiplexed for better drive-circuit utilization. The same circuit is redrawn in (b) to illustrate the three-row, seven-column matrix configuration, and the matrix is further restructured in Fig. 5 to better explain the effects of parasitic driver currents.

From Eq. 4, it is readily seen that the effective contrast increases substantially as the filter transmission decreases. Again, plugging in numbers for a typical 10-digit LED matrix-driven display illustrates the point. In such a system, F = 1/10, L_{on} = 500 fL, L_n is negligibly small, and L_aS = 30 fL. Then for G = 1, C_{eff} = 2.67; or G = 0.5, C_{eff} = 4.3, and for G = 0.1, C_{eff} = 17.7.

These increases in contrast come at the expense of luminance, which in this example decreases from 50 fL for G = 1 to 5 fL for G = 0.1, since output luminance is $L_{on}FG$. Sacrificing luminance for increased contrast is generally desirable, however, because in low-light environments, display brightness is not needed, while in brighter surroundings, there is usually still sufficient contrast for the display to be read.

The use of a colored filter that matches the wavelength of the display element output can be even more effective than the neutral filter. A typical red filter matched to a red GaAsP LED, for example, can increase contrast by as much as tenfold without attenuating the desired output by more than 30%.

Depending on the application and the environment, circular polarizers and other types of filters may also dramatically attenuate light reflected from the display device and impose a relatively small penalty on the device output. For devices such as some liquid-crystal displays that operate by modulating ambient light, performance cannot be improved by neutral filters, since these will attenuate both useful and undesired light by the same amount.

Many light-modulating displays exhibit persistence, a sometimes desirable characteristic that has the effect of making the duty factor larger than the ratio of excitation time to frame time.

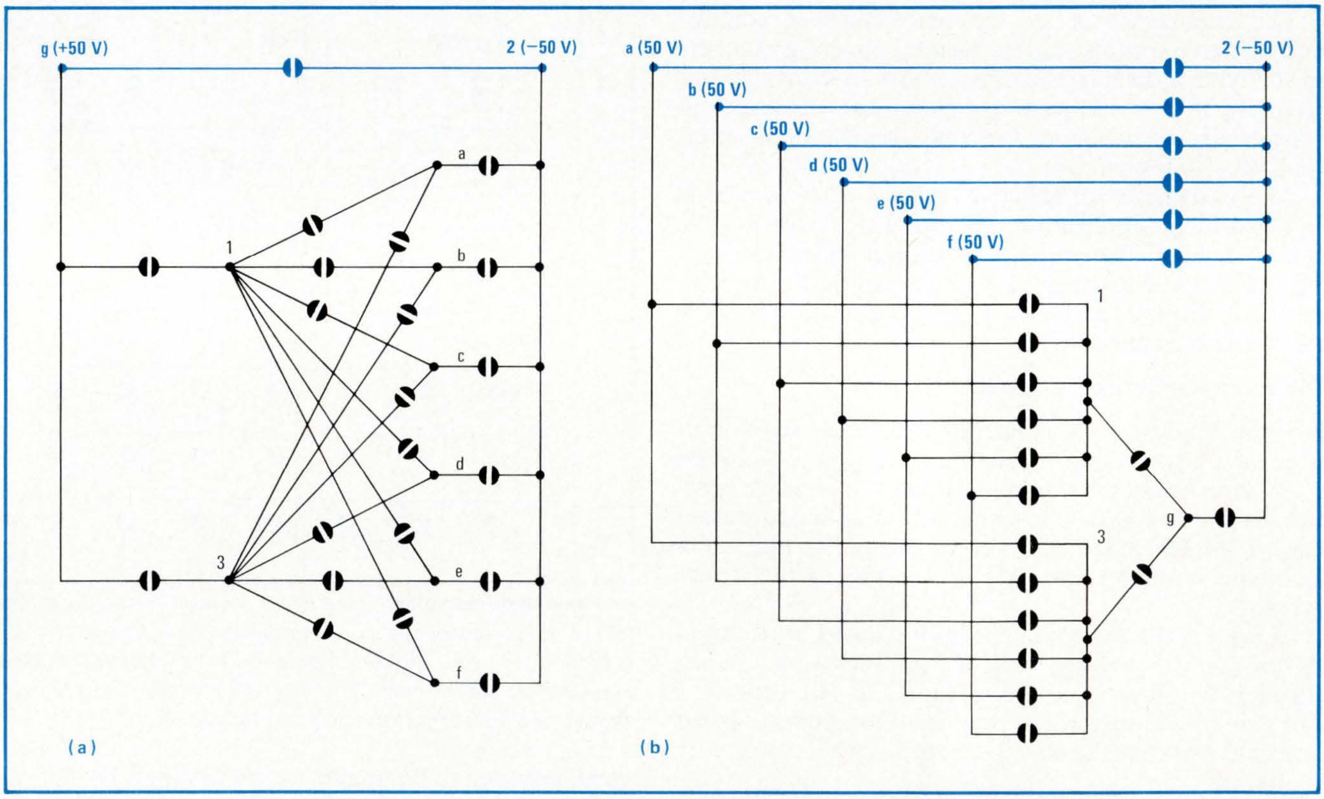
To illustrate the effect of persistence, consider a display with element contrast of 10 and a duty factor of 1/4. If the element turns on rapidly but turns off slowly, so that once energized, it remains on for 3/4 of the frame time, the effective duty factor is 3/4. In such a display, the effective contrast will be improved from 3 1/4 to 7 3/4. This is one of the reasons that some liquid-crystal devices can be multiplexed effectively, despite their lower contrast. The slow response of the liquid crystal, however, may be unacceptable in some applications.

Keeping off-elements off

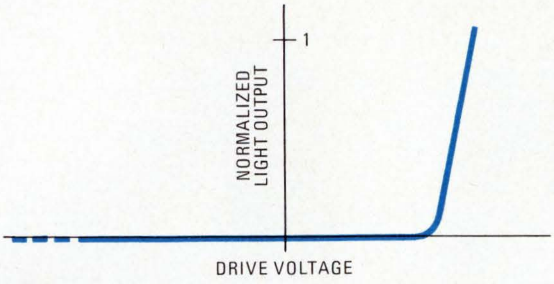
A second fundamental limitation of matrix-drive systems—the unwanted energizing of unselected segments because of parasitic currents in the matrix—is illustrated by the three-digit display in Fig. 4a. Each digit in the example consists of gas-discharge elements, arranged in seven segments. The same array is redrawn in Fig. 4b to show more clearly the matrix arrangement.

If a single segment of the second digit is energized (as shown in Fig. 5a for the display of a minus sign), a full 100 volts appears across the desired segment.[2,3] In this case, the signal path is from segment-driver g to digit-driver 2.

However, a substantial fraction of this voltage can appear across the g segments of digits 1 and 3, as well as across all the other segments of digit 2. Depending on source impedances and current-sinking capabilities of the drive circuits, unselected segments may be lit. The problem of turning on unwanted segments gets worse as



5. Sneaky currents. Parasitic currents within a display matrix must not inadvertently turn on unselected segments. In case (a), where only segment g of digit 2 is biased on, a total of 100 volts is placed between nodes g and 2. All other nodes are driven at 0.0 V. Since most gas-discharge segments start to turn on at about 80 V, no other segment will light up. However, if two segments are driven on (as for displaying the number 1) some of the unselected segment driver outputs may begin to rise above 0 V. This problem becomes most severe when all but one segment is biased on (as for displaying a zero, shown in b).



6. Ideal matrix device. Ideal element for matrix displays is highly nonlinear (there is no light output when biased below a given threshold) when forward-biased, and it emits no light when reverse-biased.

more selected segments are biased on, and it is worst when all but one segment are biased on (as for displaying a 0 in 5b). Here, parasitic currents from six segments converge on nodes 1 and 3. If not adequately clamped to 0 volts, segment g of digit 2 could be turned on. To keep this unselected segment from turning on, it is therefore necessary to provide a low impedance with adequate current-sinking capability at the digit-drivers so that they are clamped to 0 V.

On the other hand, segment-drivers should generally have high output impedances. This makes the drivers look like constant-current sources to the segment elements, and it gives uniform illumination from each diode in the display.

The matrix arrangement will work only if each display element is nonlinear and has a well-defined threshold, as shown in Fig. 6. Even if the digit drivers in Fig. 5b have zero impedance, half the applied voltage will appear across all segments, except g of digits 1 and 3. If half the applied voltage is below the knee of the curve in Fig. 6, there will be no output, but if the knee of the input-output curve is not well-defined, the unselected segments will begin to light up.

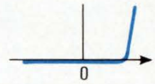
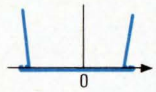
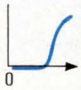
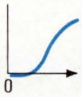
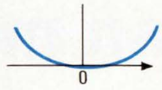
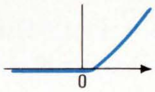
Choosing the best element

For display devices that do not have sharp thresholds, nonlinear elements can be inserted in series (such as diodes in series with incandescent filaments). Or for dynamic-scattering nematic liquid crystals, two-frequency operation can be used.[4,5,6] The amount of softness of the knee that can be tolerated depends on the number of digits in the matrix and the contrast required. Because of the additional display elements needed, the nonlinearity requirement is generally more rigorous for dot-matrix digits than for seven-segment digits.

Typical characteristics of the more common display elements are compared in the table. The quantities provided are intended only to give general comparisons of today's performance. Detailed data must, of course, be obtained from each manufacturer's product specification sheets.

The over-all attractiveness of the LED for matrix displays is readily apparent in the table. In addition to having excellent input-output curves, LEDs can be switched in about 1 microsecond, and they have excellent luminance. Their efficiencies are low, however, and their deep red output is difficult for some people to see.

TABLE: LEADING DISPLAY ELEMENT CANDIDATES WITH TYPICAL CHARACTERISTICS MOST AFFECTING DRIVE-CIRCUIT CONFIGURATION

Device type	Relative brightness/ contrast	Typical switching time On	Off	Input-output curve*
Light-emitting diode	Good to excellent	1 ns	1 ns	
Gas-discharge tube	Excellent	5–10 μs	100 μs	
Thin-film electro-luminescent	Excellent	100 μs	1 μs	Pulsed excutation 
Liquid crystal	Fair to good	5 to 10 ms	10 to 20 ms	Alternating current excitation 
Incandescent	Excellent	15 ms	20 ms	
Vacuum fluorescent	Good	5 μs	50 μs	

*Curves normalized to typical full-scale light output (Y-axis) and to drive excitation magnitude (X-axis)

Gas-discharge devices also lend themselves to matrix displays, while liquid crystals, with their more linear input-output curve and their dependence on ambient light, have thus far been primarily limited to use with parallel-type drive systems.

Incandescent elements have been used in multiplexed displays of two to four digits, but difficulties in obtaining the higher peak power required in displays with more than about four digits have so far tended to inhibit their use in larger displays.

There are also a few less-well-known candidates for use in matrix displays. Fluorescent displays have been used successfully in multidigit matrix-type displays, especially where small size has been a requirement. Also, electroluminescent displays, while requiring a high-voltage ac drive, are capable of excellent contrast. □

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Closing the loop

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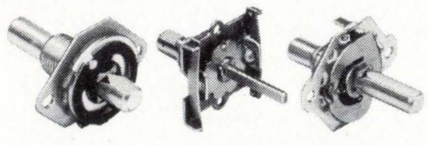

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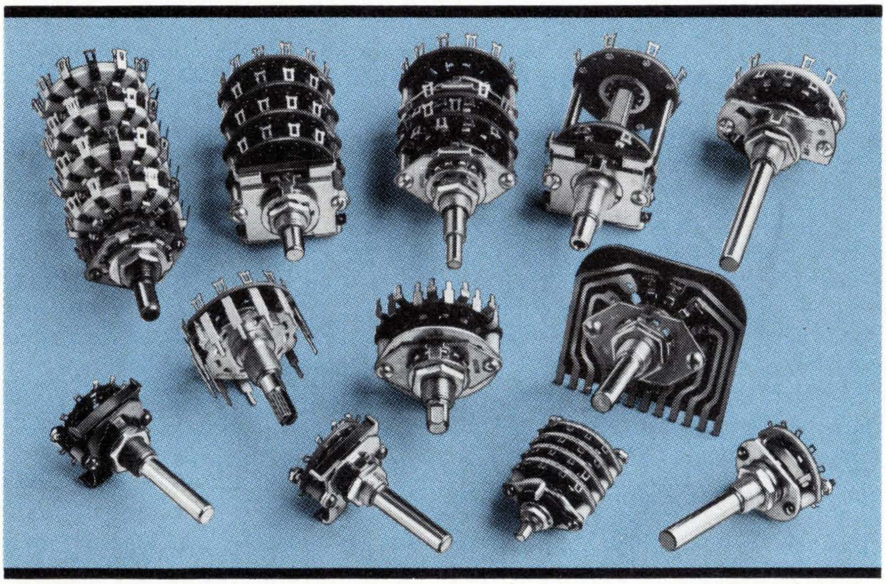

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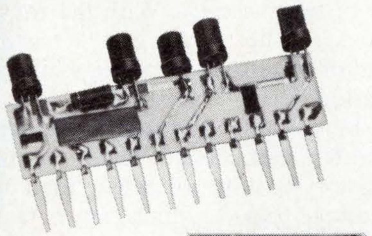

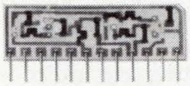

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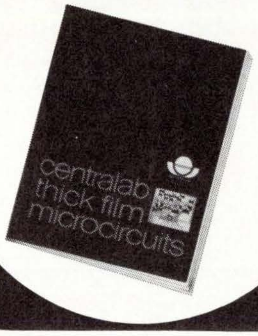

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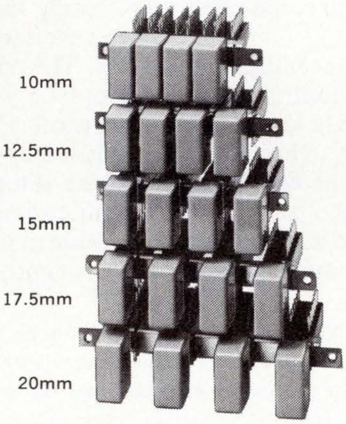

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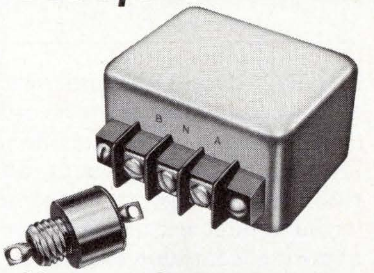

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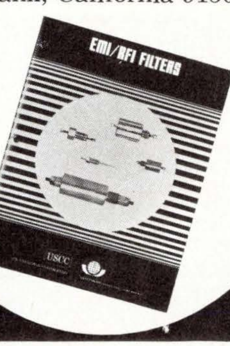

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Voltage-to-current converter for process-control systems

by Harry L. Trietley, Jr.
Taylor Instrument Process Control Div., Sybron Corp., Rochester, N.Y.

To avoid damage to process-control instruments, such as controllers and chart recorders, the maximum value of the signal current that drives these devices must be limited. This signal current, which corresponds to a control signal voltage, can become too large if the control-signal voltage exceeds its normal range or if some other abnormal condition occurs.

Without requiring a series output resistance, the voltage-to-current converter in the diagram limits output current to between 24 and 40 milliamperes, a safe range for much process-control instrumentation. The circuit converts an input signal of 0 to 1 volt to a current of 4 to 20 mA for driving a load of 0 to 1,300 ohms.

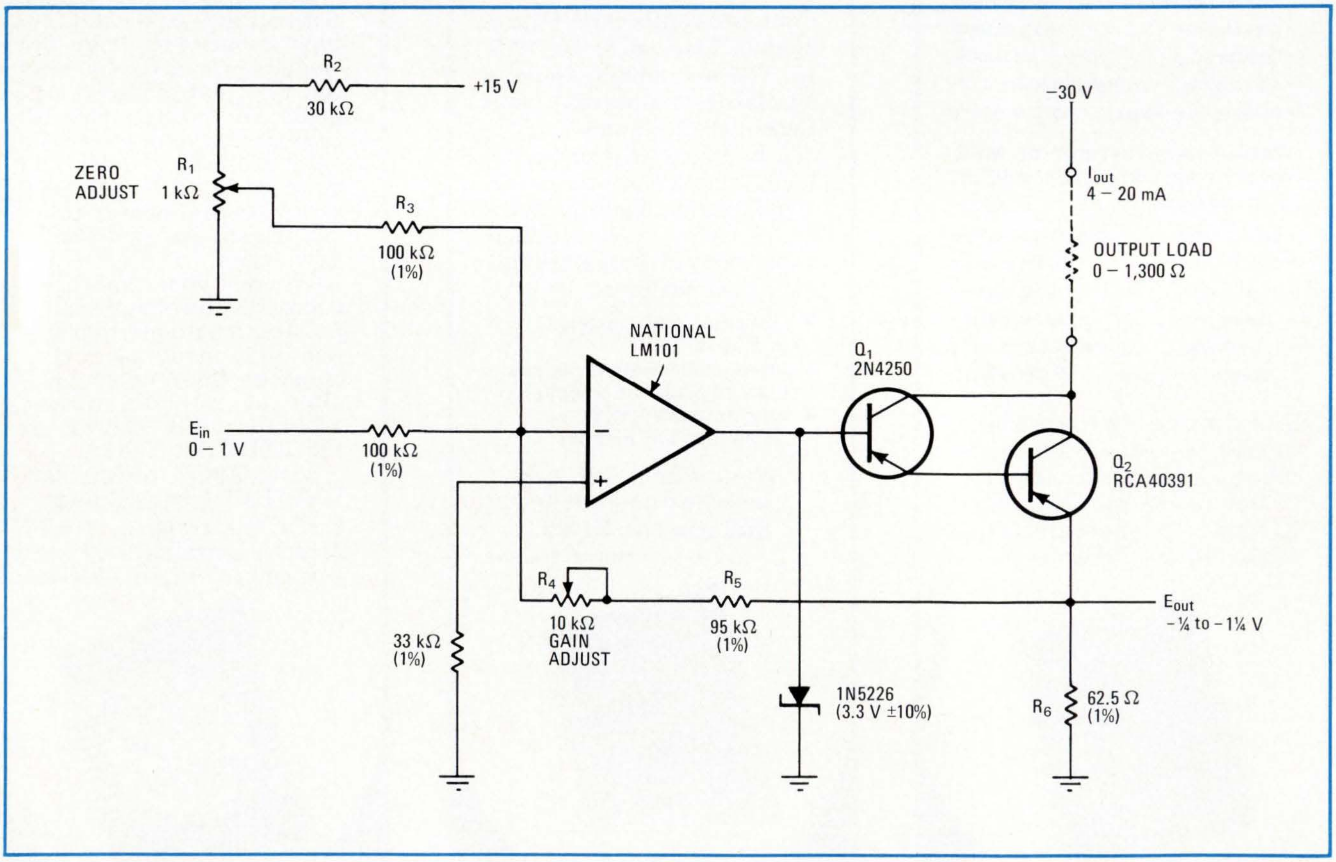
Under normal operating conditions, the zener diode does not conduct. The amplifier and transistors Q_1 and Q_2 perform as an operational amplifier, the output of which is at the emitter of transistor Q_2. With the resistance values shown, the circuit has a gain of 1. Resistors R_1, R_2, and R_3 form an offset zero adjustment, while resistor R_4 provides precision gain adjustment.

The output current, I_{OUT}, equals the sum of the currents in resistors R_5 and R_6, regardless of the size of the output load. Since resistor R_5 is much larger than resistor R_6, the output voltage (E_{OUT}), which ranges from ¼ to 1¼ V, produces a current of 4 to 20 mA.

Integrated op amps, such as the National Semiconductor LM101 used here, are internally limited to output currents of about 25 mA. When the converter's output reaches the zener's voltage, the zener will conduct, grounding the amplifier's output current and clamping the converter's output voltage to a nominal level of 3 V ±10%. The output voltage is actually limited to between 1.5 and 2.5 V because of the base-emitter voltage drops of transistors Q_1 and Q_2. The output current is then limited to a maximum value of between 24 and 40 mA.

If the value of resistor R_6 is lowered to 25 ohms, the output current range becomes 10 to 50 mA, with limiting occurring between 60 and 100 mA. Other outputs, gains, or current limits can also be realized. □

Instrument interface. Circuit converts control signal voltages to signal currents for driving process-control instruments, such as chart recorders. For the components values shown, this converter limits output current to between 24 and 40 milliamperes to protect the instruments from excessive driving currents due to out-of-range control voltages. The zener diode limits output voltage to 1.5–2.5 volts.



Data averager for panel meter operates from meter's clock

by George Mitchell and Richard D. Spencer
University of Illinois, Urbana, Ill.

In many scientific applications, measurements made with a digital voltmeter require time-averaging to reduce the measurement uncertainty of a noisy signal. A simple averaging circuit can be easily added to a digital panel meter for summing independent measurements so that the uncertainty of the data is reduced.

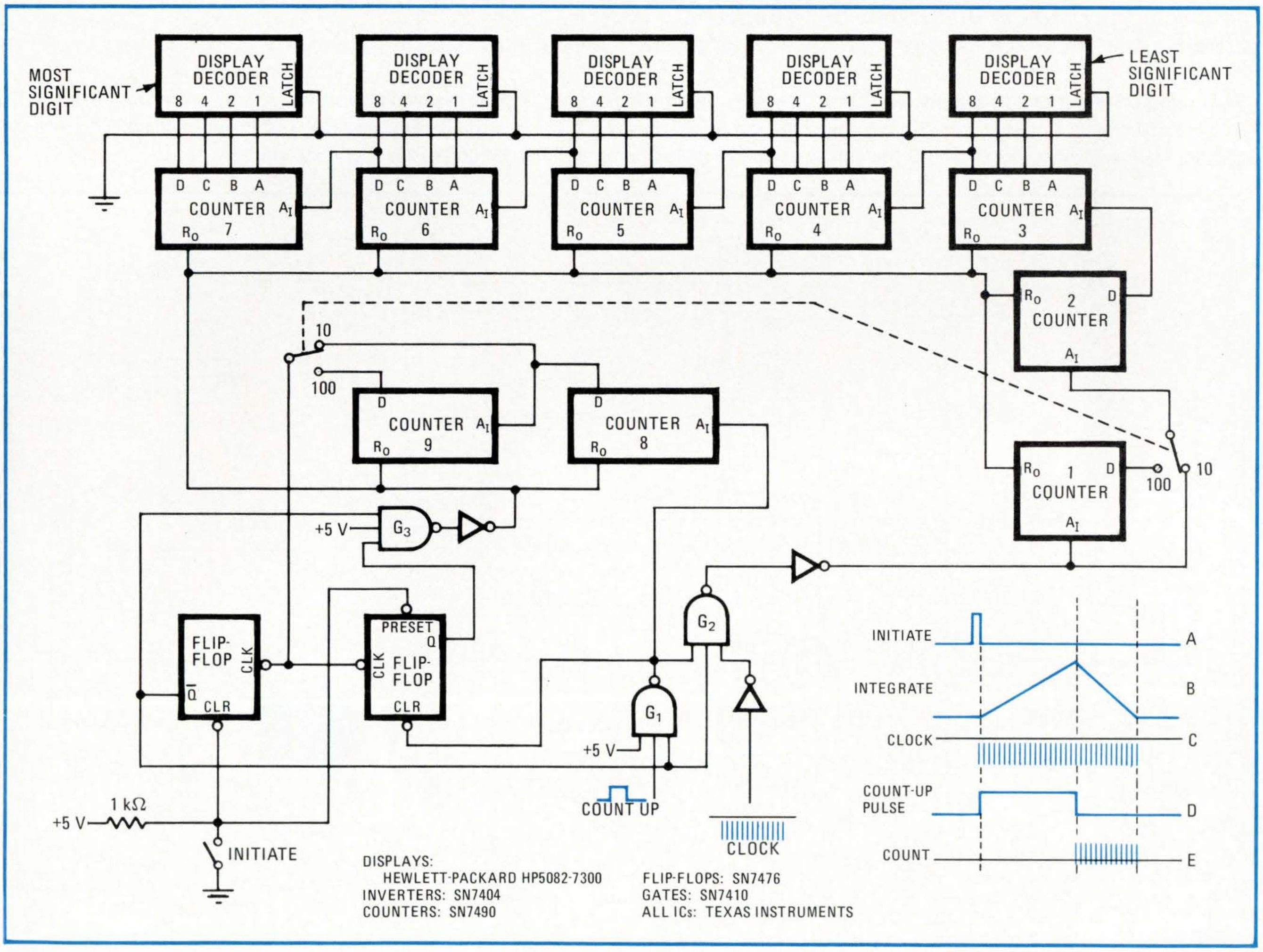
The averaging circuit shown here causes the DPM to sum 10 or 100 measurements (depending on switch position), thereby reducing data uncertainty by a factor of 3.2 or 10, respectively. Although this circuit is intended for an Electro-Numerics' model 305 4½-digit ratio panel meter, it can be readily adapted to any DPM that uses a dual-slope converter.

The circuit, which is activated with an initiate pulse (trace A in the figure), takes advantage of the clock pulse train (trace C) from the DPM's dual-slope converter. The clock train is transmitted during the integration period (trace B) of the analog signal and reference inputs. The count-up pulse (trace D) corresponds to the fixed integration time of the analog signal input.

NAND gates G_1 and G_2 use the count-up pulse to gate the clock output of the DPM's dual-slope converter so that the input to either decade counter 1 or 2 (trace E) is directly proportional to the ratio (in this case) of the analog inputs. As can be seen, counters 1 and 2 are scalers of 10 and 100, respectively, for the gated clock pulse train. Counters 3 through 7 form the decimal accumulator, and counters 8 and 9 are tally registers that inhibit averaging of data past the required number of samples (10 or 100).

The averaging circuitry is synchronized to the DPM's converter cycle by the two flip-flops and three NAND gates. Grounding the initiate line clears the tally registers and scalers, as well as the accumulator, and initiates the accumulation of a new average. The average, or scaled, output is displayed by light-emitting-diode readouts that have their own decoder/drivers. The binary-coded decimal output of the accumulator may also be used to transfer data directly to a printer or computer. □

Averaging out noise. Measurement uncertainty of noisy signals is reduced by time-averaging circuit for digital panel meter. The circuit, which runs from clock of DPM's dual-slope converter, sums 10 to 100 measurements, reducing data uncertainty by 3.2 or 10. Counters 1 and 2 are the scalers, counters 3 through 7 make up the accumulator, and counters 8 and 9 are the tally registers.



Binary rf phase modulator switches in 3 nanoseconds

by Roland J. Turner
AEL Communications Corp., Lansdale, Pa.

By employing a diode-steered current source, binary rf phase modulation is accomplished by translating transistor-transistor-logic levels to a bidirectional current drive in less than 3 nanoseconds. The rf modulator is intended to provide phase coding and correlation in jamming-resistant radar and secure communication links, where transmission and reception are essential in a hostile environment.

The binary (0° and 180°) phase modulation is effected by switching Schottky diodes in a ring modulator at high video/i-f rates. These high data rates require TTL signal levels to be translated to a ±15-milliampere current drive for the ring modulator in extremely short time intervals. The complete binary rf phase modulator consists of the video driver (a), which employs stripline techniques, and the ring modulator (b).

When the input logic level to the video driver is at -5 volts, transistor Q_1 is off, diode D_1 is on, and diode D_2 is off. This forces current source Q_2 to deliver 15 mA to the ring modulator. When the input logic level increases positively from -5 V to 0 V, transistor Q_1 turns on, reverse-biasing diode D_1 so that this device turns off. Diode D_2 now turns on, and current source Q_3 forces 15 mA to be drawn from the video port of the ring modulator. The i-f/rf signal phase is then shifted by 180° as it passes through the ring modulator.

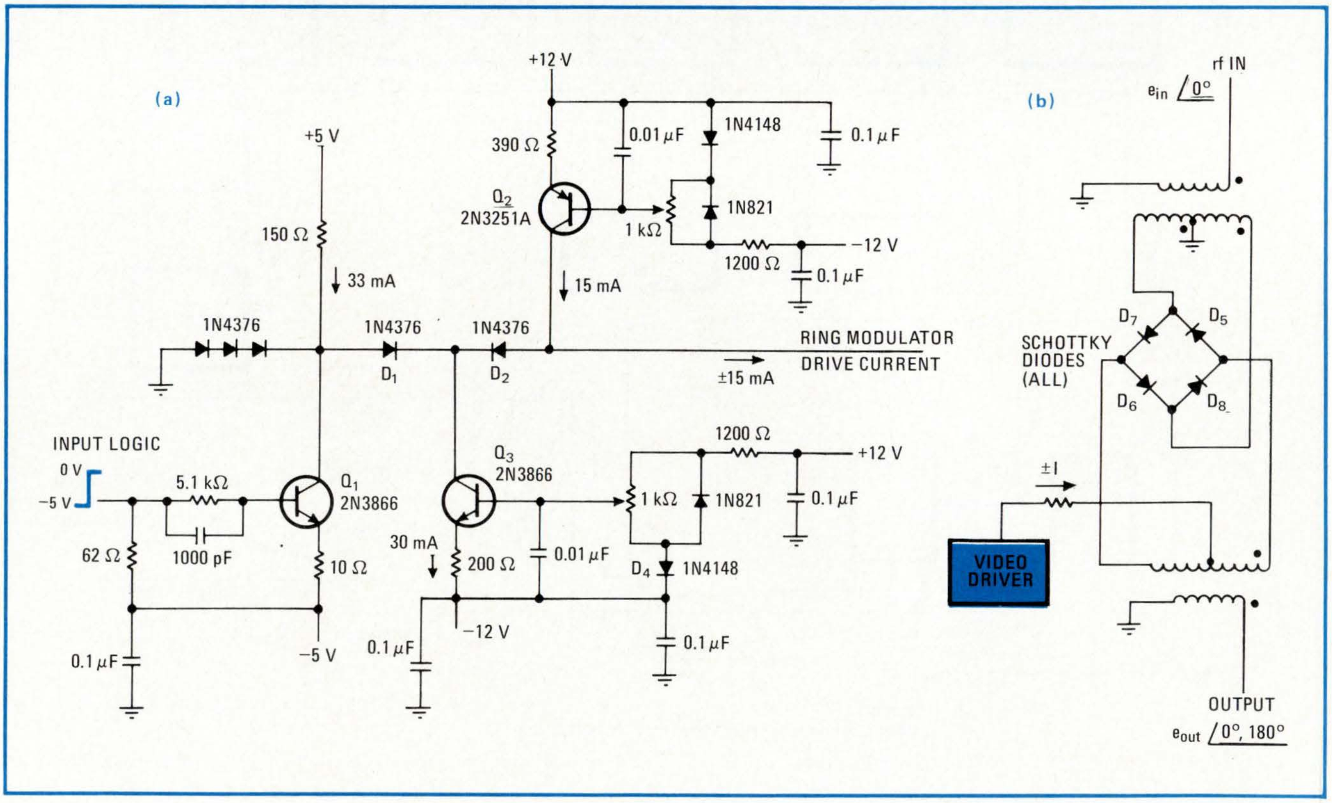
This binary phase modulation is accomplished in only 3 ns because the current sources can force rapid charging of any circuit capacitance. Also, load-circuit switching is forced by impressing a large negative or positive voltage on diode D_1. Since D_1's switching voltage transition is low relative to the drive voltages, switching can be done in a small time interval. (Current sources Q_2 and Q_3 are temperature-stabilized by diodes D_3 and D_4.)

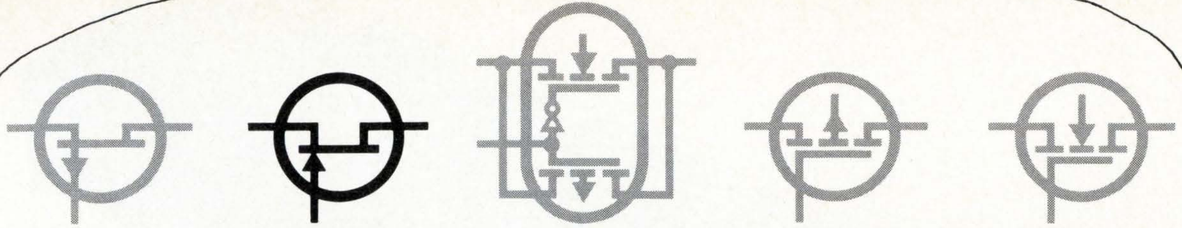
The switching current from the video driver is applied to the video port of the ring modulator. When the driver supplies current (+I) to the video port, Schottky diodes D_5 and D_6 conduct, and the output phase is 180°. When the driver sinks current (-I) from the video port, Schottky diodes D_7 and D_8 are forced to conduct, and the output phase is 0°.

This switching technique is quite useful in applying coded rf phase modulation to an interrogating radar or in applying secure modulation to a secure communication link. The system then becomes very difficult to jam since correlation reception at the receiver enhances detection and suppresses the effects of noise, whether the noise source is Johnson noise or intentional noise jamming. □

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

Reversing phase at radio frequencies. Phase modulator switches phase of rf signals between 0° and 180°. Video driver (a) translates TTL inputs to bidirectional switching current for Schottky-diode ring modulator (b) in under 3 nanoseconds. The driver employs diode-steered current sources (transistors Q_2 and Q_3) to supply or sink 15 milliamperes for the video port of the ring modulator.





P-channel J FET

N-channel J FET

CMOS FETs

P-channel MOS FET

N-channel MOS FET

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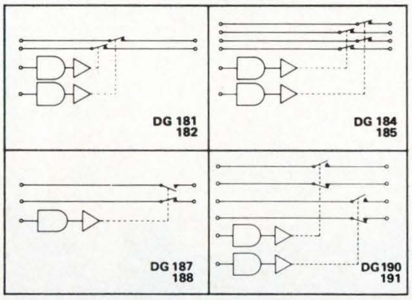
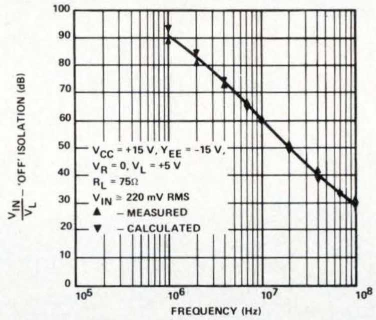


DG181-DG191 Functional Diagrams



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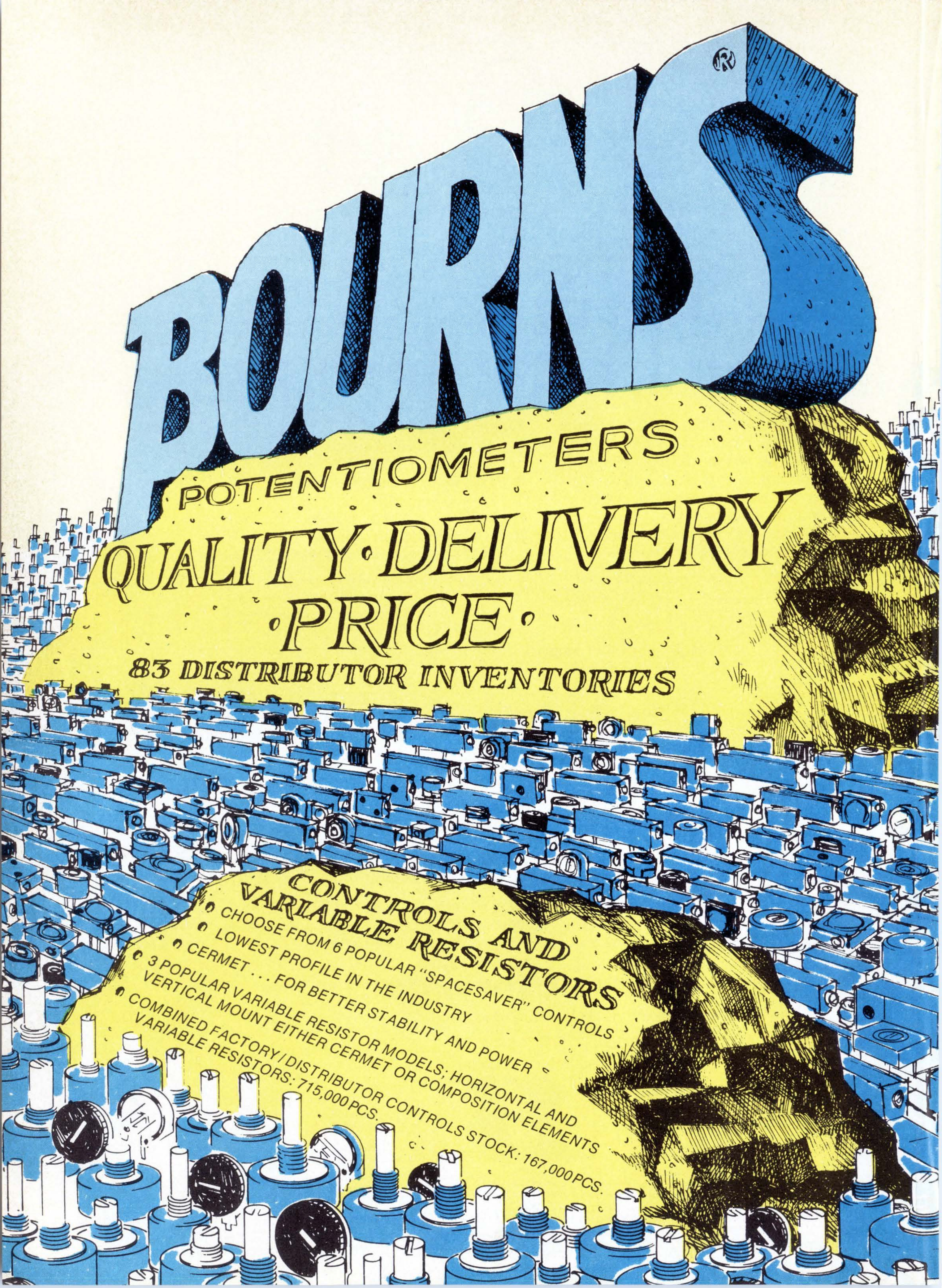
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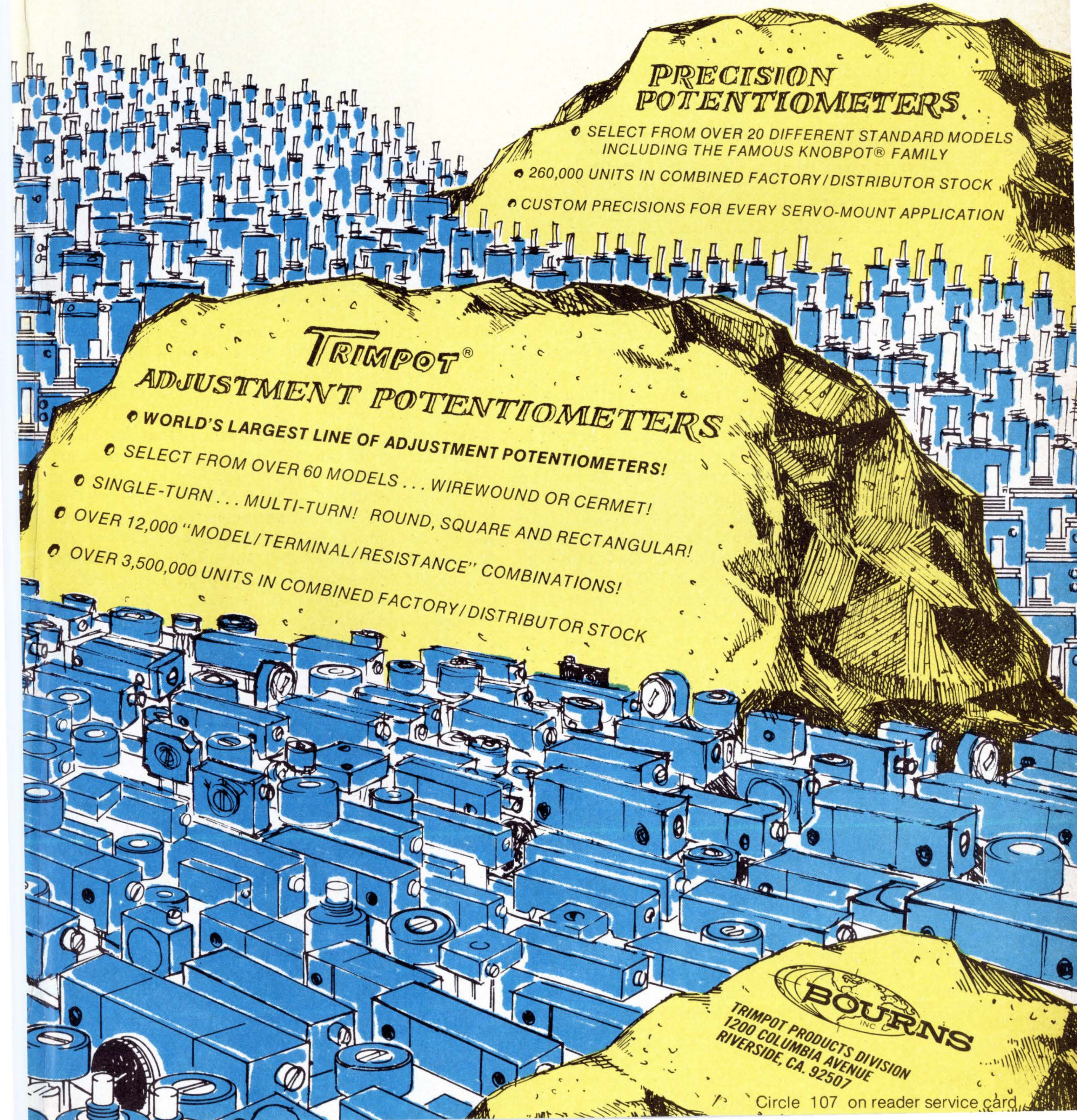
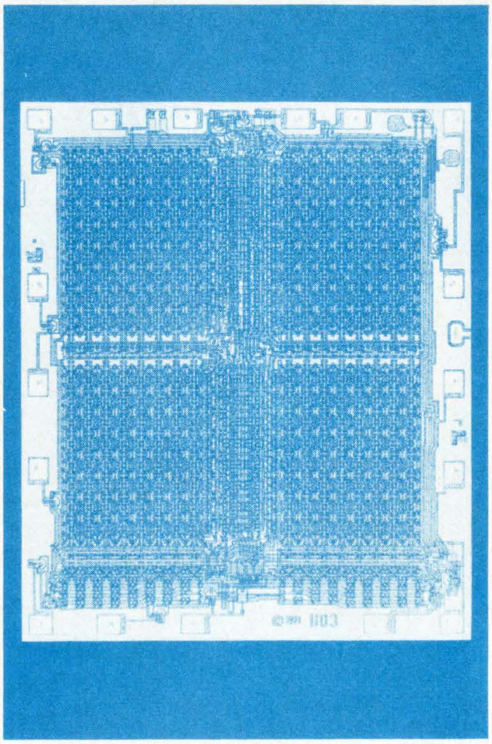


Product development profile

The Intel 1103: The MOS memory that defied cores

A young company banked on a silicon-gate p-channel dynamic MOS random-access memory to replace cores in mainframes: a Honeywell team aided in the design, which has become an industry standard

by George Sideris, *San Francisco bureau manager*



☐ Next month, Intel Corp. will start reducing production of the 1103 random-access memory and phase in an easier-to-use replacement, the 1103A. The new chip, which can be slipped directly into 1103 sockets, has simpler timing procedures and higher speed, and it is TTL-compatible. When the original 1103 design is retired in a year or so, the frontier days of solid-state memory development will end. But the trends set by the 1103 in 1970 will probably continue through the decade.

The 1103 showed that dynamic MOS RAMs could compete with cores in the computer mainframe and peripherals markets. It firmly established semiconductor-memory organization in multiples of 1,024 bits. And it made silicon-gate MOS the dominant process technology throughout the world of non-IBM memories. Few contenders for the market created by the 1103 depart radically from that concept.

Fairchild's 709 amplifier and Texas Instruments' 7400 TTL gate, two other landmark circuits, have been used by more engineers than the 1103. However, Intel's RAM is unquestionably the greatest economic success. Intel's second-source list reads like a "Who's Who in the Semiconductor Industry."

Costs drop

Since the 1103 was introduced at $60, cost and volume curves have quickly intersected like two parabolas. This year, 6 million 1103s will be shipped at an average price of $4—0.4¢ a bit—estimates A.C. "Mike" Markkula, Intel's sales manager.

True, 6 gigabits is small, compared with core volumes. But huge numbers of solid-state RAMs will be used in new computers. Moreover, 4,096-bit versions of the silicon-gate dynamic RAM built with a high-density n-channel cell structure—costing still less per bit—are already being aimed at that market. And with the 1103-type RAM, megabyte solid-state add-on memories are becoming commonplace in the IBM System/370 peripheral market.

Perhaps the 1103's true measure is that system designers have been willing to struggle with its idiosyncracies for months at a time because it is economical. "They hate it, but they use it," Markkula jokes. Others have used more pungent phrases to describe the 1103. But whatever phrase is used, the fact is the 1103 was the first widely used device that put 1,024 bits of memory on a chip in a form that was economical for the user.

The Intel and Honeywell Inc., design teams who developed it accepted the system design difficulties in order to cram 1,024 bits on a manufacturable chip. Timing with the 1103 is difficult because it requires overlapping cycles that are timed to narrow windows. However, the quirks will be retired with the 1103, Intel promises.

Early explorations

In 1968, when Intel was spun out of Fairchild Semiconductor, it was widely predicted that semiconductor memories would find a $500 million market in the 1970s and perhaps a $2 billion market in the 1980s. Robert Noyce, formerly Fairchild's general manager, and Gordon Moore, who was engineering manager and R&D director at Fairchild, started Intel with that market as their goal.

However, a review of memory technology convinced them that none of the then-popular concepts could catch up quickly with the falling cost curve of core memories. They decided to pursue Schottky TTL for a quick entry into the small, high-speed memory market and silicon-gate MOS for the longer haul into the mainframe market.

The silicon-gate technology was then developmental. The first definitive paper was published in 1968 by Bell Telephone Laboratories researchers, but some of Intel's founders had begun their silicon-gate work in 1967 at Fairchild. Fairchild's initial silicon-gate product was a multiplexer, though [*Electronics*, Sept. 15, 1969, p. 67].

Noyce and Moore, already contemplating 1,024-bit RAMs, foresaw silicon-gate MOS as the most likely solution to chip-density and yield problems. In addition, the silicon gate's low threshold voltage offers high speed and can be made bipolar-compatible.

Intel's MOS staff cut its teeth on silicon-gate design with the 1101, a 256-bit static RAM introduced in 1969. Initial yields of good chips were pleasantly high—10% or better, compared with an anticipated range of 2% to 5%. Metal-gate yields were then running around 5%.

The 1101 was a significant advance. It could be operated directly by system logic because it had TTL-compatible address decoders and sense amplifiers on the chip. Low logic overhead made it useful in small systems, but the complex static cell structure (Fig. 1a) made the 1101 too slow and costly for mainframe memories.

A new trail

Static RAMs were the style in 1968. In the proceedings of the 1968 Fall Joint Computer Conference, for example, the only paper that discussed solid-state memories covered static RAMs. The author, W. B. Sander, of Fairchild, accurately predicted: "Both (bipolar and MOS) will be developed, and the final edge of one over the other will require some dramatic development in one of the technologies."

At Intel, M. E. "Ted" Hoff Jr., a young Ph.D. from Stanford University, devised a simple dynamic storage cell. It needed only three transistors, compared with the conventional four (Fig. 1b). More importantly, the intraconnections, which in conventional cells occupied more room than the transistors, were sharply reduced.

Since the cell promised three to four times the density of a static design, Noyce, and Moore started a team developing dynamic RAMs. Leslie Vadasz, Joel Karp, and Hoff were assigned to design circuits with variations of the cell. (Vadasz, the team leader, is now Intel's engineering manager, Hoff is applications research manager, and Karp, long a mainstay in Intel's design staff, has recently joined Intersil Inc.)

They worked mostly on three versions: 1102, 1103, and 1104. The 1102 (Fig. 1c) and 1103 (Fig. 1d) were 1,024-bit designs (Fig. 2 is the chip diagram) that could be paralleled to form 1,024 words with any number of bits per word. The 1104, a 512-bit device, was soon rejected as not cost-competitive (it was later produced experimentally to test n-channel processes).

At first, the 1102 was deemed the most promising design. Hoff wrote an article about it [*Electronics*, Aug. 3, 1970, p. 69]. Karp and William Regitz, then a Honeywell engineer, described it in a paper at the 1970 International Solid State Circuits Conference. But at the conclusion of system trials in 1970, the 1103 got the nod.

Another bullet that had to be bitten during the conceptual design stage was the fact that, unlike static RAMs, dynamic operation would raise system overhead and design costs. However, core memories also have

The RAMs to come

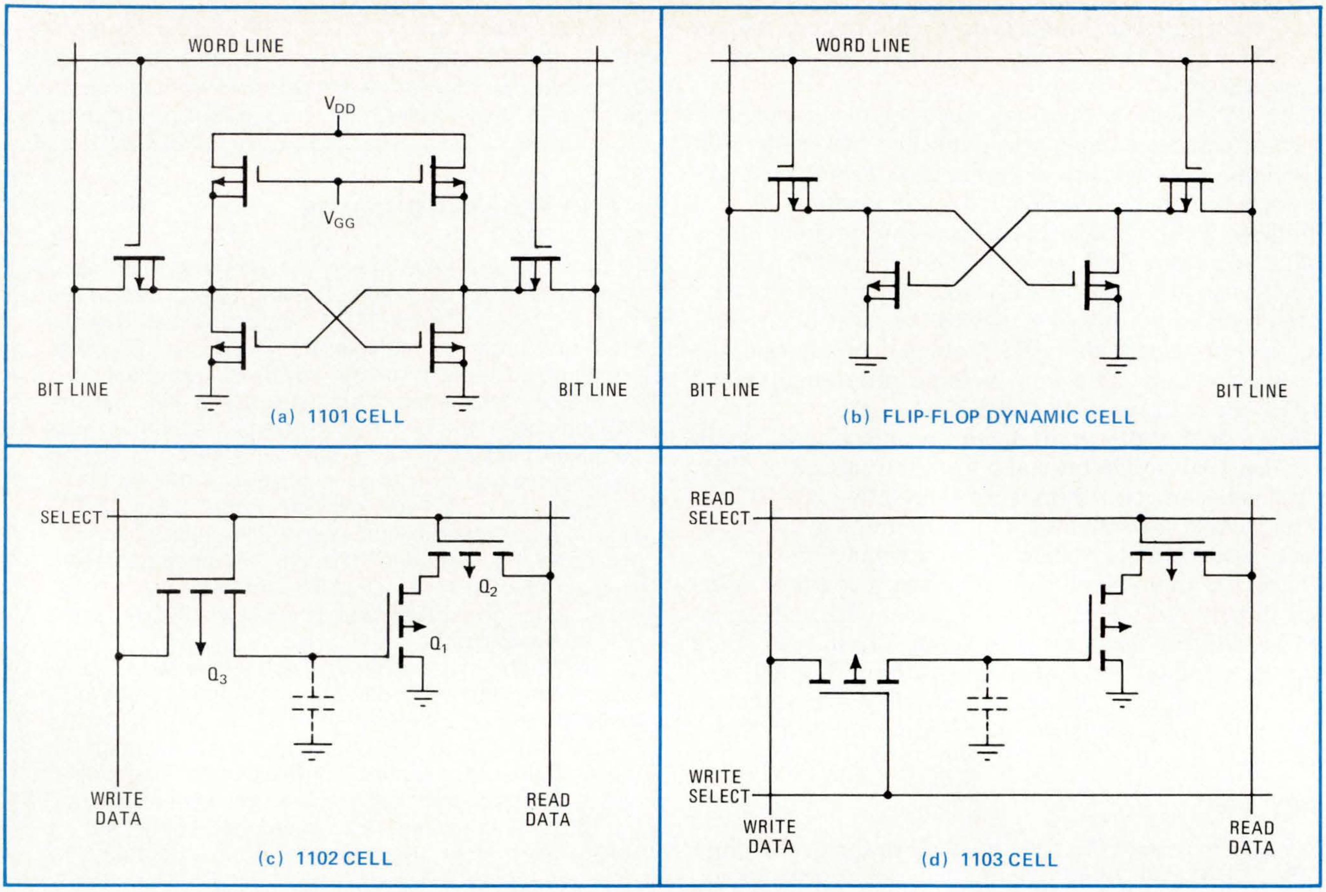
The Intel Corp. 1103 merely blazed the trail to mainframe computer memories. Coming closely behind are several more efficient MOS random-access devices that are larger by multiples of 1,024 bits. Two with quadrupled capacity are already nearing production.

Microsystems International Ltd., on its own, has enlarged the 1103 to 4,096 bits with n-channel substrates, doubling the chip size. And Intel has started pilot-line production of an n-channel 4,096-bit RAM. Conceptually, this RAM is similar to the 1103A, retaining a three-transistor cell and single-clock operation. However, the n-channel design is TTL-compatible and has an on-chip sense amplifier—features that will enable it to go further than the 1103A in reducing memory overhead.

The n-channel design makes it only about 50% larger than the 1103. Its chip measures 137 by 164 mils, compared with the 1103's 113 by 139 mils. The chips will probably cost about four times as much as the 1103 to manufacture, but the overhead reduction will make them less costly at the systems level (a rule of thumb is that, once a chip reaches 100 mils on a side, each 15% increase in area approximately doubles processing cost.)

Intel will introduce a medium-speed version of the 4,096-bit RAM this summer, following up with a high-speed version later in the year. Whether or not these, too, will become industry standards is still moot. This time, memory-system designers will have a choice of many RAMs. But each one builds on the basic 1103 concept—a simple dynamic cell.

Undoubted originals. Robert Noyce and Gordon Moore, founders of Intel, join in admiring some of the first 1103s produced.



1. Shrinking cells. Static cell used by Intel in 1101 RAM was too slow and costly for mainframe memories (a). Leapfrogging conventional dynamic cell designs (b), the 1102 and 1103 1,024-bit RAMs contained three-transistor cells (c and d). Though smaller in area because it had one select line, the 1102 cell was rejected in favor of the easier-to-make 1103 design.

high overhead costs–divided among many bits. The team went for broke.

To increase speed, the team opted for large logic swings in hopes of winning additional cost-performance tradeoffs in the inevitable comparison with cores. The decisions were to require multiple clocks (Fig. 3), powerful drivers, level shifters, sense amplifiers, timing and control subsystems, and other support circuitry shown in Fig. 4.

The dynamic design promised brutal noise levels and noise-related problems in system control, timing, and sense circuits. Heavy capacitive loads would have to be driven at rates around 1 volt per nanosecond, assuring large current surges in the printed-circuit traces. Then, there were such complications as cell-refresh and volatility (loss of data) to be considered.

The 1103 requires three clocks with carefully timed overlays: precharge, cenable (chip-enable) and write. Precharge was not really an innovation, Vadasz remarks. Precharge and cenable are comparable to an MOS shift register's 0_1 and 0_2 clocks–one charges up the MOS capacitances so that the nodes can be discharged very rapidly or not be discharged in the following logic operation.

Of more lasting importance, Vadasz thinks, is a technique of building into the MOS transistors varactor diodes that bootstrap the logic levels. Once Intel's secret method of speeding up decoders, varactor bootstrapping is periodically rediscovered, he notes.

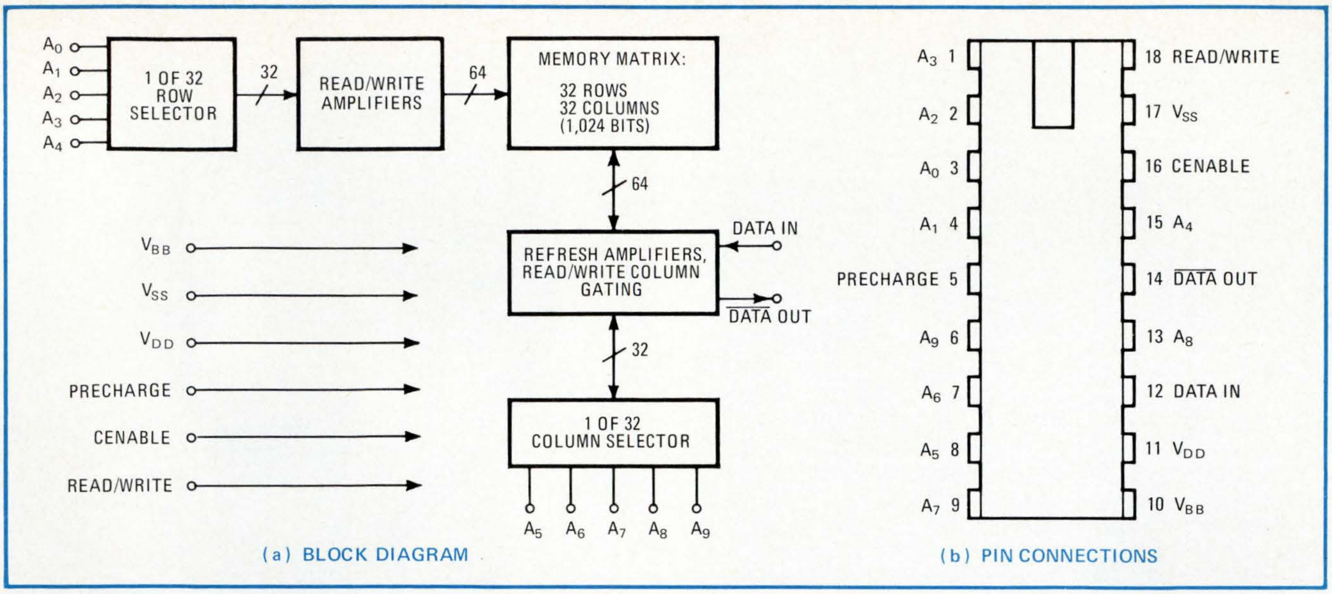
Uncertain whether or not the designs would work well in a memory system and reluctant to choose between the 1102 and 1103 arbitrarily, Noyce and Moore sought the opinions of potential customers. Here the risk that industry gossips might cause damage by broadcasting the design ideas was less immediate than the risk of expending large amounts of time and money on a design that might fail.

A new partner

Honeywell's interest in developing a standard product to compete with cores coincided with Intel's. If either the 1102 or 1103 evolved into an industry standard, Honeywell would be assured a supply of low-cost components. Other semiconductor manufacturers would surely second-source any circuit chosen by major computer manufacturers.

Honeywell assigned to the project a group at the computer plant in Framingham, Mass. William Jordan was group leader, William Regitz the principal components designer, and Henry Bodio the systems engineer (Regitz went to Intel as manager of MOS-memory engineering in 1971, then Jordan became manager of Intel's new Systems division, and Bodio joined the division as engineering manager).

In effect, Jordan's group acted as the non-IBM-computer industry's semiconductor-memory steering committee. They helped Vadasz' team firm up timing specifications, skew tolerances, control configurations, and a



2. Chip block. Outline of the 1103 chip is identical with the 1103A, except for the latter's elimination of precharge.

host of other system design aspects during 1969 and 1970.

But the 1102 and 1103 were largely paper designs when the work started, Jordan recalls. "We worked right along with Vadasz's group." First, they assembled 16-bit prototype cell arrays. When those were debugged, 1,024-bit arrays were prepared. Finally, prototype systems were assembled.

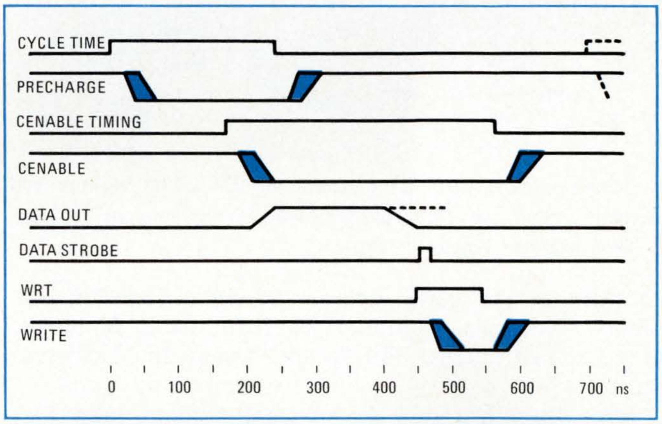
As the quirks became known, they were compensated for by changes in chip or system design. For instance, certain address sequences that "bombed out" stored data forced chip changes. Timings sensitive to process or temperature variables might be compensated on the chip and in the system logic. The 1103 is sensitive to certain system operating conditions, involving, among other things, certain combinations of line-charging rates, addressing patterns, and timing patterns. Determining how to avoid these problems through system design took much of the group's time.

At Intel, thousands of chips were "wrung out." Known also as characterization, wringing-out means that chips, produced in batches under varying processing conditions, are tested under every conceivable combination of operating conditions. One objective is to find out what process controls give the best yield to the customer's specifications—and in this case, the customer was to be the computer industry. Thousands of performance curves were laboriously prepared.

The showdown

The 1102 emerged from development first. It was the more advanced concept and fitted on a smaller chip, which could eventually mean higher yields and lower cost. Early in 1970, Jordan presented Honeywell's engineering manager with an H516 minicomputer with an 1102 memory instead of the standard core memory. Soon afterwards, the 1103 design was completed.

"We chose the 1103 because it was the more conservative," Vadasz reports. Jordan indicates that Honeywell decided to buy the 1103 because of fears that 1102 might have yield problems that would impede sec-



3. Cycle slowdowns. The 1103's complex timing diagram is now world-famous. This simplified version shows how system skews and tolerances add nearly 200 nanoseconds to the basic cycle time.

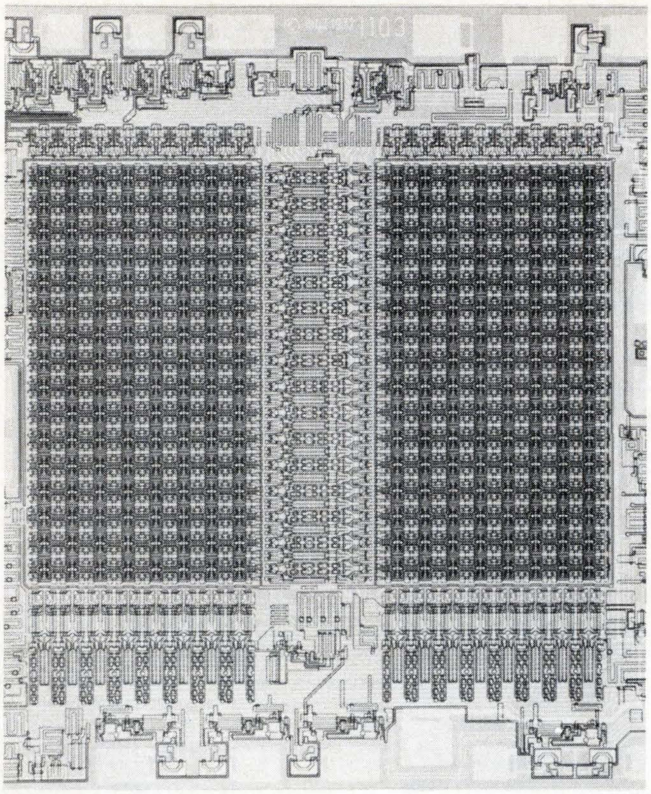
ond-sourcing (the 1103 has two operating voltages, while the 1102 cells operated at three voltage levels and required tighter tolerances).

"We decided on the part with the highest confidence level," says Jordan. "Today, we would probably choose the 1102, but that is academic now. The whole key was to settle on a standard part in order to realize the economies of scale in high-volume production."

The 1102 was also somewhat slower than the 1103. Was that a factor? No, says Jordan, because both were fast enough to compete with 18-mil and 20-mil cores. Besides the speed difference became slight, once system delays and skews were added to basic operating times (see Fig. 4).

Intel quickly established a second source. Microsystems International Ltd. took a license. In return, Intel helped MIL buy equipment and set up a plant, and Intel also supplied mask sets and taught MIL to make the 1103. In a short time, the Canadian company was more than a second source—MIL became Intel's chief competitor.

Markkula says of companies that have copied the design without the formalities of licensing, "I stopped



4. New standard. Retiring tne venerable 1103 will be this improved version. Called the 1103A, this improved version is faster, TTL compatible, and has simpler timing.

counting at 18." They include Fairchild, Texas Instruments, Motorola, National Semiconductor, Signetics, General Instrument, Philips, and American Micro-systems.

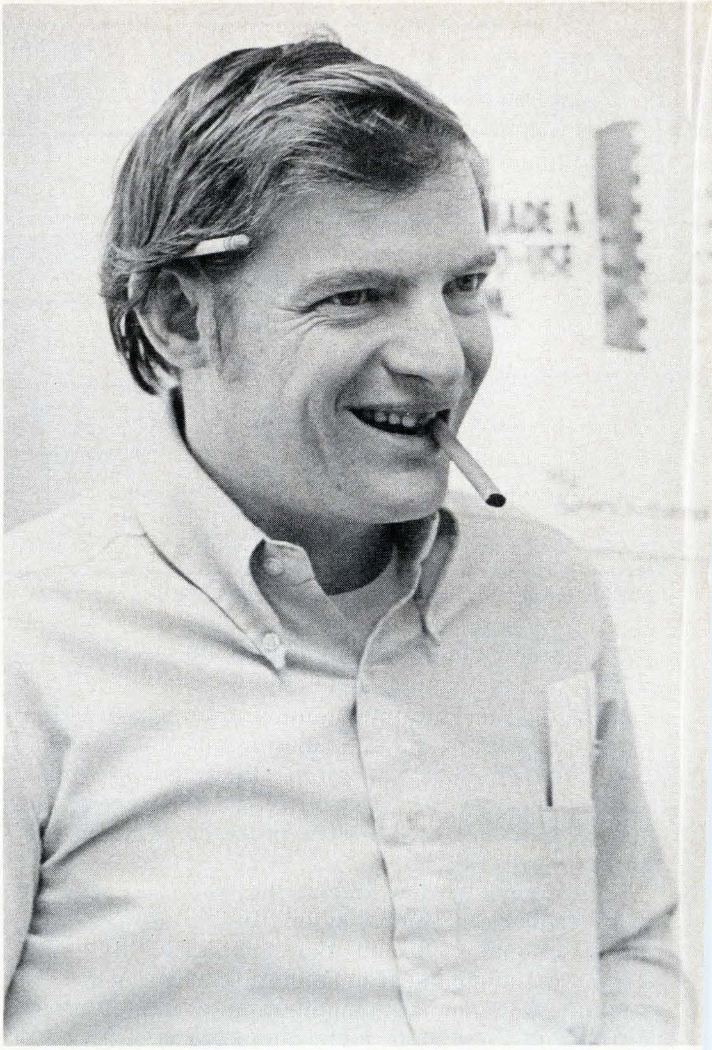
Even though a number of small-systems manufacturers adopted the 1103 quickly ($3.9 million worth of 1103s were sold in the latter part of 1970), bigger companies hung back to make evaluations and design studies. Mainframe computer shipments started building up in mid-1972. Among major systems containing 1103s, Markkula lists the Digital Equipment Corp. PDP 11/45, Burroughs 7400, Texas Instruments Advanced Scientific Computer, Univac 9480, and the Honeywell 5800. Intel itself is penetrating the IBM market–Jordan's Systems division makes a 9-megabit add-on memory for IBM Systems/370-155 and 370-165.

The 1103 has also generated a kind of sub-industry of producing special clock drivers, address latches, and other support circuits. These have helped bring overhead costs down to a small fraction of a cent per bit.

Round two

When the dust of development settled, Hoff wrote a 28-page note to explain the operation of the 1103. It was sprinkled with warnings about operating conditions that could cause the 1103 to malfunction, and it recommended ways to solve those problems.

To spare system designers further grief–and to make the 1103 more competitive–Intel began redesigning the 1103 late in 1971. The result was the 1103A, scheduled for introduction in May of this year after only six months of wringing out and system trials. Among the



Circuit fixer. At Honeywell, William Regitz helped debug the 1103 and built prototype array assemblies.

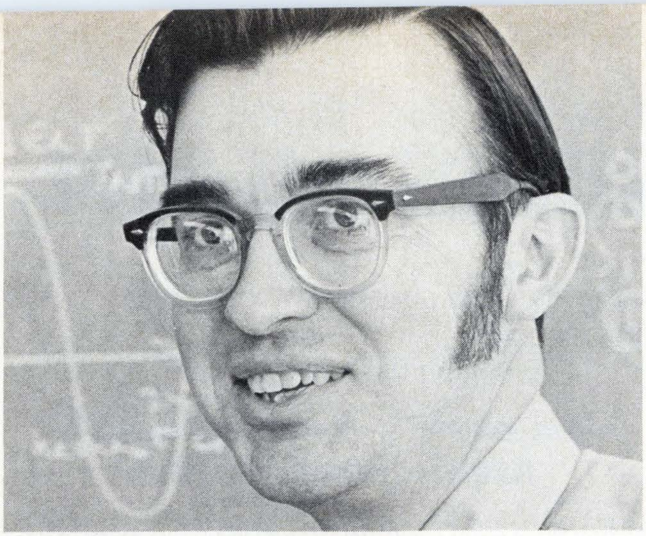
changes cited by the designers are:

- Precharge and critical timing problems are gone.
- Sensitivity to process, temperature, and timing variations is reduced.
- Access time is almost halved in system operation.
- Address buffers are on the chip.
- Standby power is 1/40th that of the 1103, and operating power drops more rapidly with clock frequency.
- The chip is smaller, promising higher yield and lower cost than the 1103 might achieve.

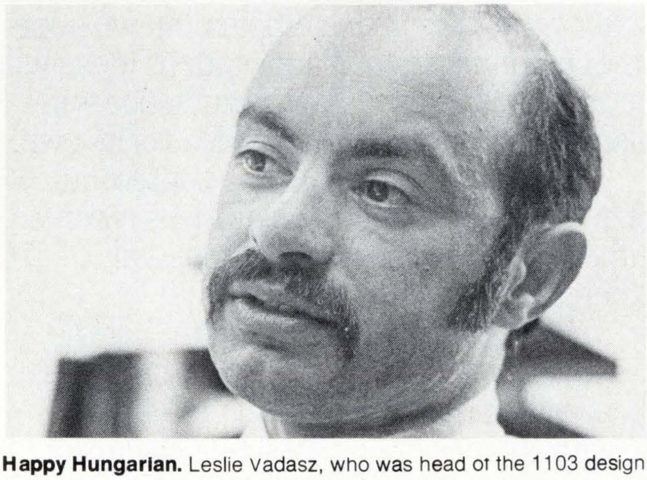
But, Regitz stressed, the 1103A was developed as a direct "socket replacement" for the 1103. Existing system designs need not be changed because:

- Package pinouts are the same (the precharge pin is not connected to the chip).
- Cycle time is the same.
- Cell design and refresh methods are the same.
- Clock formats are the same (except that precharge can be removed).

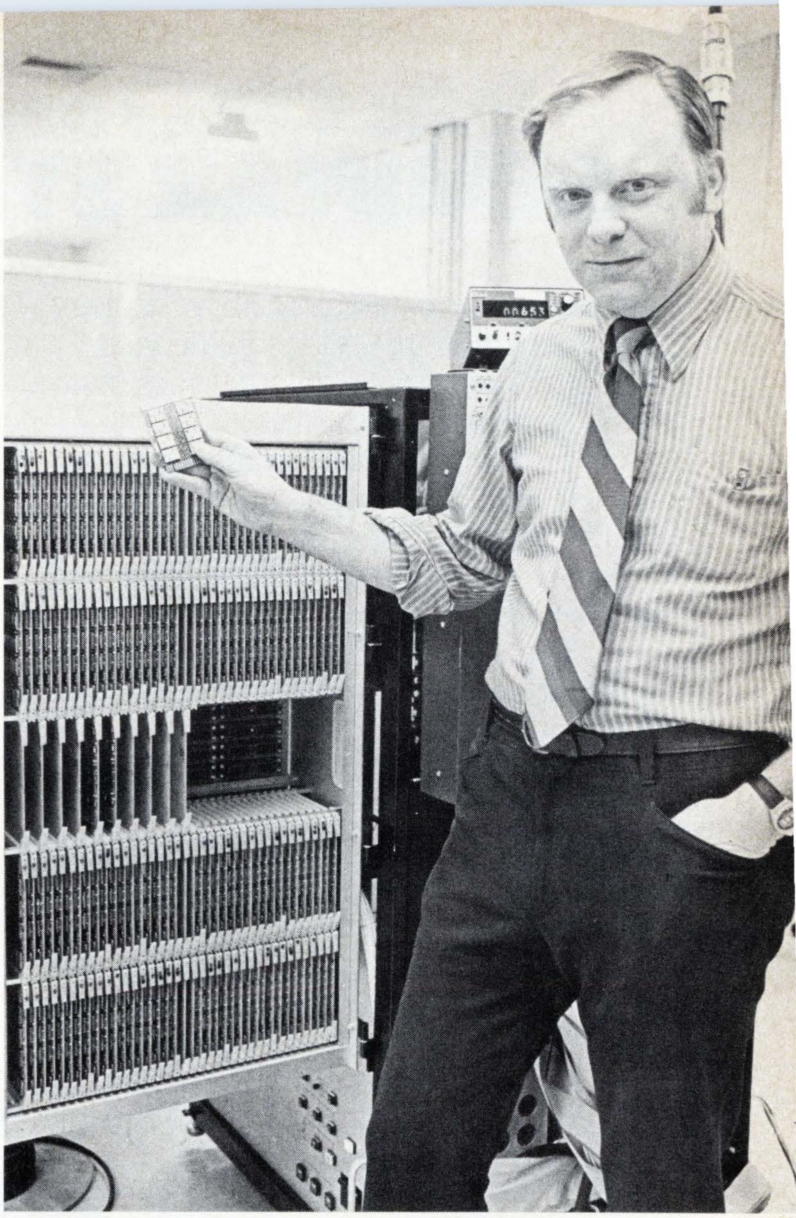
Regitz calls the 1103A a single-clock RAM. On the leading edge of cenable, one-shots and other chip delays take the place of an 1103 system's timing overlaps. The chip itself controls timing sequences. When the read pulse or write clock arrives, the chip is all set up for



Cell mate. Ted Hoff is credited with inventing the three-transistor cell that sparked the 1103 dynamic design.



Happy Hungarian. Leslie Vadasz, who was head of the 1103 design team, now manages all Intel engineering.



Systems man. William Jordan led the Honeywell group that tried out early 1103 designs in computer memories.

the operation. When cenable goes off, inverters on the chip keep the logic nodes charged (cells are refreshed as in the 1103, however).

For the older chip, the address input had to be stabilized with latches throughout the cycle time. Now, inputs are picked up by a buffer register on the chip. The buffers are isolated within 100 nanoseconds of the onset of cenable. After that, the addresses can vary without affecting decoding.

A system with an 1103-type timing controller need not be redesigned. But if the cycle is tightened to reflect elimination of precharge, overlaps, and skew tolerances, access time will drop from about 450 to 250 ns and cycle time from about 675 to 650 ns, Regitz estimates.

To conserve power in an 1103 system, precharge had to be decoded (addressed to selected memory segments) and unselected segments switched into a power-down mode. Not counting driver and control-logic dissipations, power consumption averaged 300 mW per chip without precharge decoding and 100 mW with decoding.

In operation, the 1103A consumes full power only during cenable transitions. The chip is driven through dynamic buffers that dissipate little dc power. The on-chip logic is all made of low-power dynamic circuits controlled by cenable. When cenable turns off, the chip drops into a low-power mode automatically.

Even though the 1103A is more complex than the 1103, the chip is smaller. Familiarity with silicon-gate processing allowed the designers to shrink the cells to 1.8 square mils—exactly the same area as single-transistor cells that are proposed for 4,096-bit RAMS,Vadasz points out.

He ruled out single-transistor cells since they require special sense amplifiers on the chip and would have made the 1103A incompatible with system designs based on the 1103.

Regitz adds that the 1103A is more tolerant of processing and temperature ranges than the 1103 because of the on-chip timing controls. The timing circuits tracks better in monolithic form. "We wouldn't produce the 1103A—we'd stick with the 1103—if yields were not improved," he asserts.

Although the 1103 is near retirement, Markkula doubts that it will fade away before 1980. The 1103 concept is not yet fully developed, he points out. But Intel's original goal of developing a standard RAM has merely been amended to one of providing a smooth transition from one standard part to the next. □

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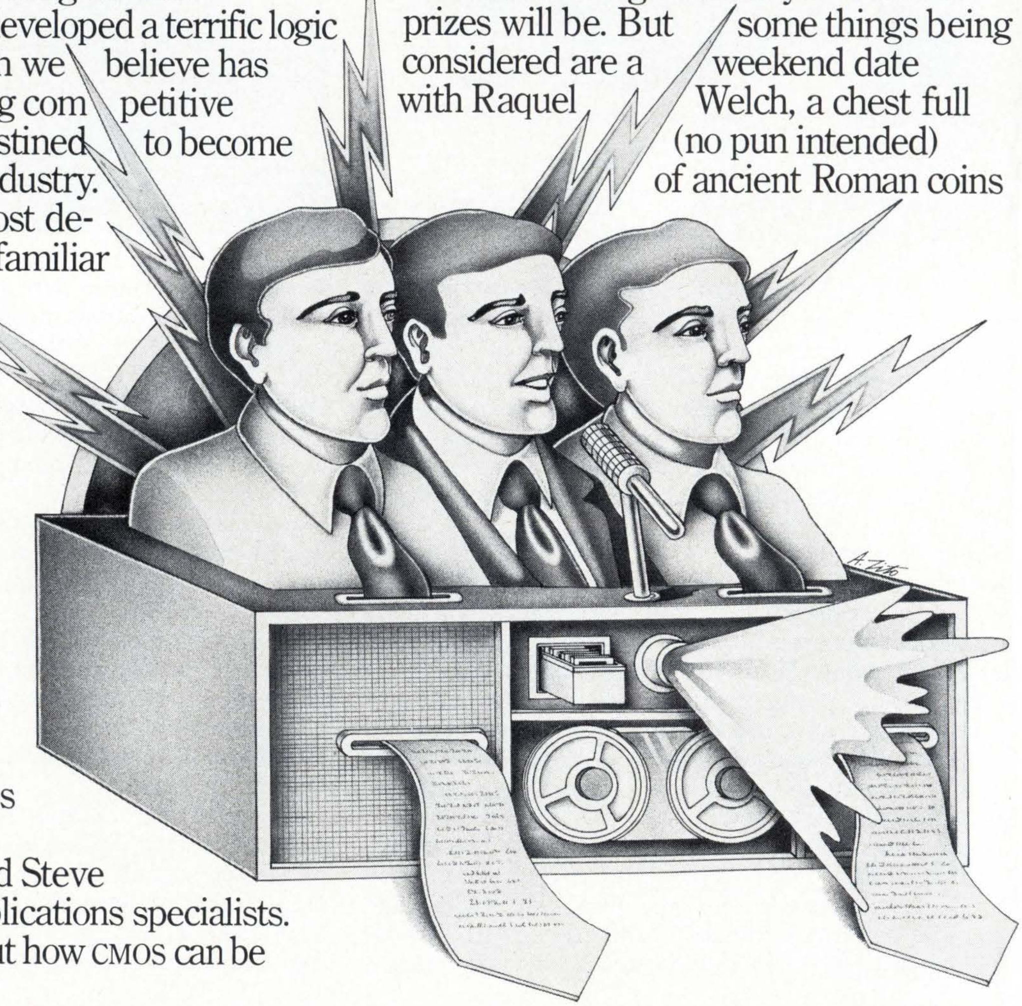
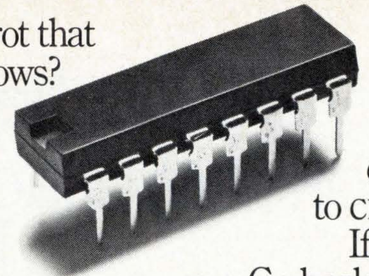
In fact, we'll be making a contest out of it. For the best applications ideas received, either at the seminars or later by mail, there'll be lots of neat prizes.

We haven't figured out yet what the prizes will be. But some things being considered are a weekend date with Raquel Welch, a chest full (no pun intended) of ancient Roman coins



worth a million dollars, and a parrot that speaks 14 languages. But who knows? We may end up settling for a box of popcorn and two tickets to a rerun of The Sound of Music.



Here's your homework.

Here's a very basic primer on CMOS to help get you ready for the seminar.

You may take notes.

CMOS dissipates low power. Typically, the static power dissipation is 10 nw per gate, compared to a typical dissipation of one mw for an LP T²L gate. A 100 to 1 power savings will be realized when changing a system from LPTTL to CMOS, or 1000 to 1 from standard TTL to CMOS.

CMOS has a propagation delay of 25 to 50 ns through a typical gate.

CMOS has a controlled rise and fall time as opposed to T²L saturated logic, which greatly simplifies system design.

There's less noise generated. The output current spiking caused by devices switching logic state is only 2 to 3 mA by CMOS while bipolar approaches 20 to 40 mA. CMOS 54C/74C also has a higher noise margin than 7400 TTL: 1 volt instead of .5V.

CMOS can operate over a large power supply range of 3 to 15 volts. This means that lower cost power supplies can be tailored to the application and tight regulation is not necessary.

It costs more, but it's cheaper.

CMOS will show a systems cost savings when the following facts are taken into account: smaller power supply, less power supply regulation, fewer bypass capacitors, simpler design because of controlled rise and fall time, and simplified power distribution resulting in reduced cost because of low noise and low current.

Its lower power dissipation reduces costs by cutting down on fans and associated cooling equipment.

NATIONAL.

Surprise quiz.

How much power savings will typically be realized when changing a system from TTL to CMOS?

If you don't know, shame on you. Go back seven paragraphs.

The 7400 design tricks and applications you know and love.

Finally, the National 54C/74C line consists of CMOS parts which are pin and functional equivalents of many of the most popular parts of the 7400 TTL series.

The pin outs and functions are familiar to the design engineer because he's designed with the 7400 for years. With CMOS he can take full advantage of the learning curve he went through years ago because he already knows the 7400 design tricks and applications.

This is one of many important advantages of our CMOS over the competitive CMOS.

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And we've got it.

In the past ten months we've introduced twenty-seven 54C/74C products, and another 18 will be introduced by the end of 1973.

This makes a total of 45 54C/74C products that will be available to designers this year. But complete systems can now be designed with the products we have now.

Your invitation.

Our distributors will be making many of the arrangements for the seminars, but if you'd like to be sure you're invited, mail us the coupon below.

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☐ I think your CMOS seminar idea is dumb, but I'd like to attend anyway.

☐ None of the above. In 15 words or less________________

☐ I think your CMOS seminar idea is dumb/terrific (circle one) and/but I don't want to/can't attend but send me further details about CMOS, including data sheets and applications notes.

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Overlaid memory simplifies programs, has hidden nooks for diagnostics

Storing critical and special routines in a read-only memory protects them from harm, but individual words or routines can be altered if the read-only module overlays a conventional read-write memory

by James F. Townsend, *Honeywell Information Systems Inc., Billerica, Mass.*

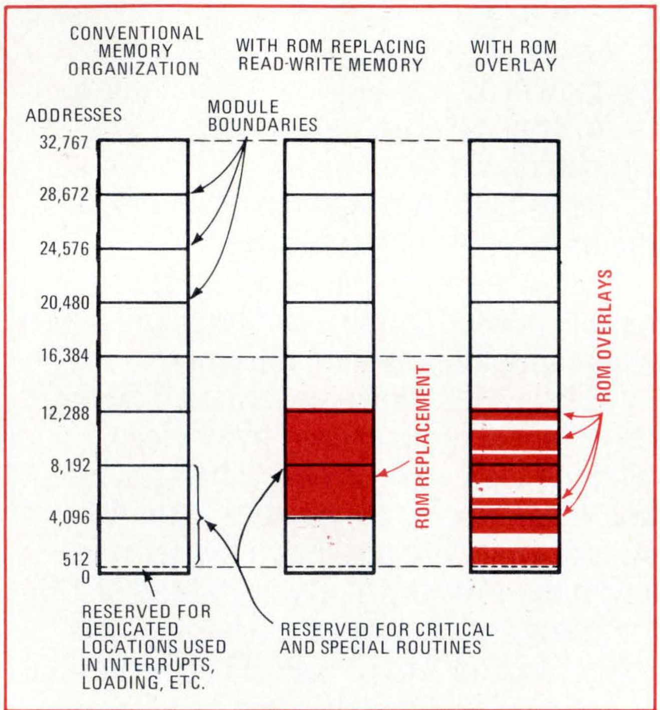
☐ Significant increases in computer software efficiency can be obtained by a new technique, called overlaying, that combines read-write and read-only memory. With this technique of overlaying read-only onto read-write memory, the system designer can intermix the two types of memory on a word-by-word basis, and thus combine the flexibility of read-write memory in general-purpose applications with the reliability and permanency of read-only memory in dedicated applications at nearly the lowest addressable level.

Standard routines stored in the ROMs can work with direct rather than indirect addresses, thereby saving much valuable read-write storage space. And since the routines are stored in ROMs, they are protected from accidental alteration. The overlay can also store diagnostic and maintenance routines that are needed only occasionally. ROMs of as few as 265 words can be used in overlay, although the standard pluggable module is 2,048 words.

Overlaying is an improvement on the direct replacement of read-write modules by read-only modules, which has been used increasingly for the past several years in minicomputers for dedicated applications. In such computers, the program, once loaded into the memory, is likely to stay there indefinitely, so that putting the program in a read-only memory protects it from everything except the memory's physical destruction. In contrast, general-purpose computers load different programs, execute them, and dump, often once every few minutes. In the latter case, even a slight fault in hardware or software can create a program bug that leads to difficult problems.

Programs in read-only memories, of course, can't be altered; they must be completely debugged before being committed to the read-only form. Making read-only and read-write memory modules interchangeable, therefore, facilitates program-debugging while protecting the perfected programs.

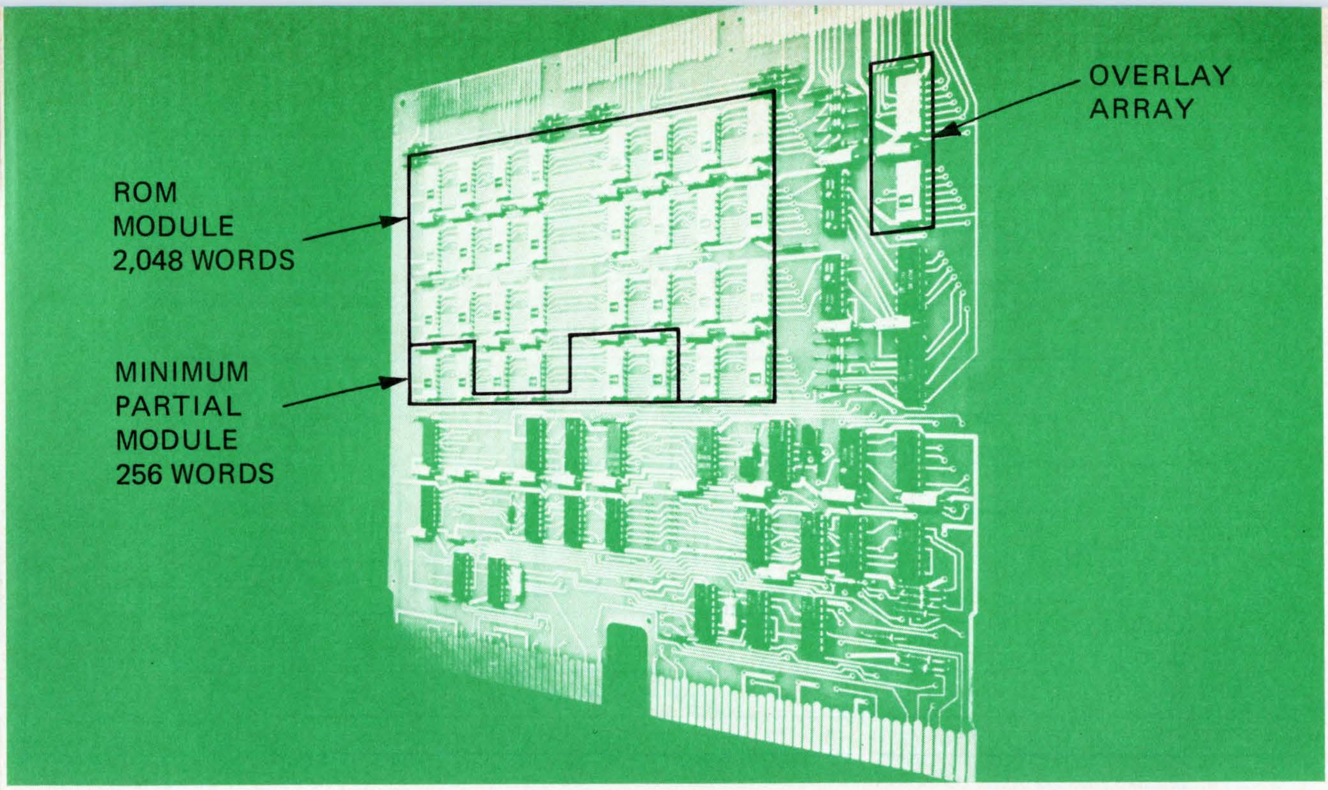
But read-only modules usually come in clumps of 1,000 or more words. This leaves the system designer with the choice of making his program fit economically into these big clumps, or living with the hazards of read-write memory in a dedicated application. If he chooses the former alternative, he may find that one of several read-only modules contains dozens or hundreds of unused locations or that a software routine is only a few words too large to fit into a single module, and it overflows into an adjacent read-write memory module.



1. Three alternatives. Most software systems reserve certain portions of the main memory, usually with low addresses, for dedicated and critical tasks (left); remaining memory is available for the user. The critical routines, for protection, are often stored in read-only memories, but the ROM modules are large and must match main-memory module boundaries (center). However, when the ROM overlays the main memory (right), critical routines, perhaps with alterable segments, can be freely scattered among read-write locations.

Now, with the overlay technique, the system designer is free to intermix read-only and read-write words whenever and wherever he likes. A dedicated program, after debugging, can go into the read-only memory, but it can still contain words here and there that can be altered; other routines that are properly kept in the read-write memory can include fixed instructions in their midst. Data bases and look-up tables can benefit in the same way.

In the Honeywell System 700 central processor, the overlay technique improves software flexibility and power. Loaders and other critical routines are rendered immune to all disturbances—power transients, software



2. Overlay key. In this implementation, ROM module is 2,048 words, but the minimum ROM block is 256 words. To permit overlay by individual words, an extra 2,048-bit overlay array (upper right) is added to the module, identifying each word as "valid" or "not valid."

errors, and improper operating procedures—that do not physically destroy the memory, but the read-write memory is still physically present (Fig. 1).

Powerful but inefficient alternative

Without the benefits of overlaid read-only memory, mixtures of fixed and alterable instructions require the programer to resort to indirect addressing. While under some circumstances, indirect addressing is a powerful programing tool, it can also be a nuisance and a source of program inefficiency. In a program, an instruction with a direct address consists of a command plus the address of the operand upon which that command is executed. When an indirect address is used, the address is not that of the operand, but of a word containing the address of the operand.

Sometimes many levels of indirect addresses are necessary. When that happens, the instruction contains the command plus the address of a word containing the address of a word containing the address of a word; this sequence continues until the command eventually locates its designated operand.

A routine in a read-only memory may include an instruction for an operand in a location that depends on the circumstances at the particular time the routine is executed. Obviously, the address of this operand must be alterable; without an overlay, the only way it can be altered is by keeping it outside the ROM and going to it from the instruction via an indirect address.

Another advantage of the overlaid memory is that the read-write module can be brought into use, even when overlaid, for diagnostic and maintenance routines and other special operations that are performed only occasionally.

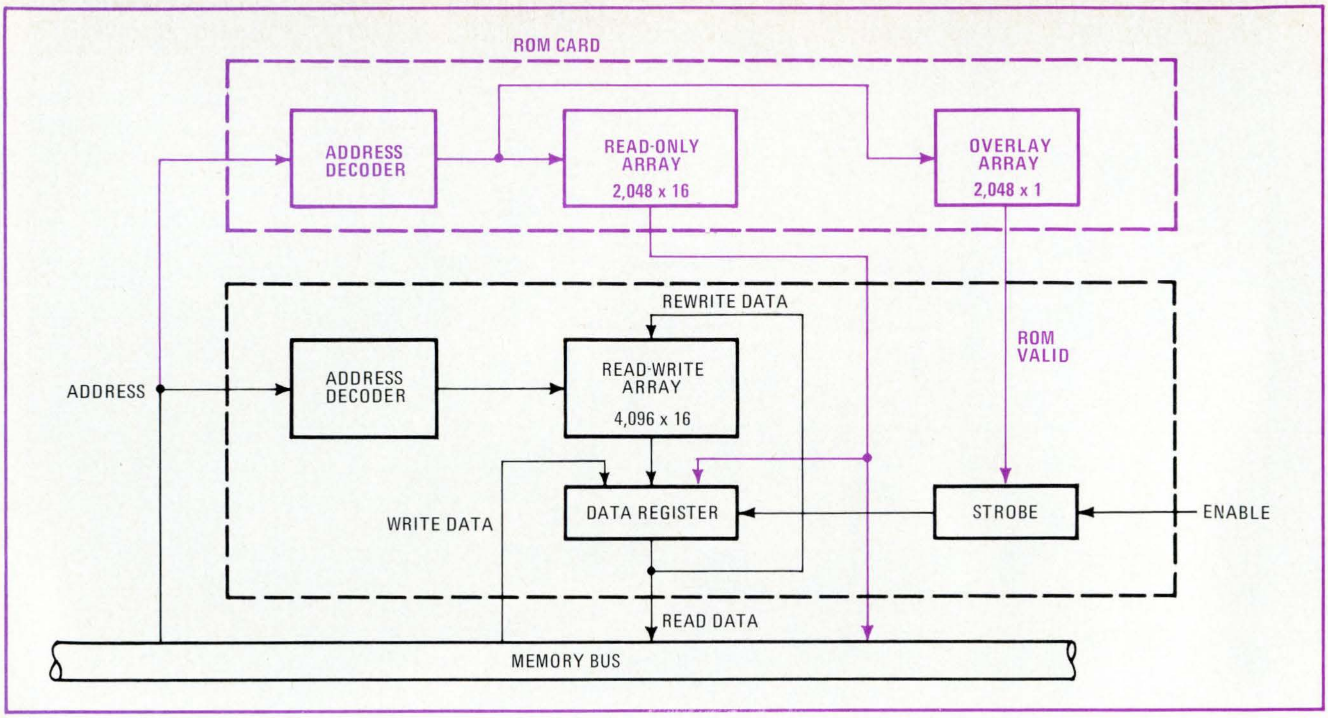
The read-only memory modules are assembled from 256-word by 4-bit bipolar ROMs. Since the word length in the System 700 is 16 bits, four ROM packages operating in parallel provide 256 words to overlay an equivalent number of read-write words. This is the minimum block size of an overlaid memory; however, the ROM comes in modules of 2,048 words—that is, eight blocks or 32 IC packages (Fig. 2). Partial modules of 256, 512, or 1,024 words can be installed within any range of 2,048 addresses that begins with 0, 2,048, 4,096, or any other multiple of 2,048.

Pin-compatible 512-word-by-4-bit ROMs are being contemplated for use in the overlaying modules, although they are not yet available in that size. They would require only a minor modification of the control logic in the module and would double the module capacity, decrease power dissipation per bit, and reduce the cost per bit.

Either ROMs or PROMs

Read-only memory can be installed in either masked or programable form. The latter is normally used during the prototype and debugging stages of a system design, and the program is changed over to the masked form when volume of production and confidence in memory contents justify it. The programable ROMs are not alterable in the field at present, and they are not erasable.

Since the read-write-memory module size is 4,096 words, two read-only modules are required to overlay one read-write module. Each word in the read-write memory includes 18 bits, and the two extra bits are parity bits for the two bytes in the word. However, parity checking is an option in the System 700; when it is not installed, these extra bits remain unused. Read-only memory modules contain no parity bits. However, if the option is installed, parity is calculated on read-only-memory output, and the extra bit accompanies each



3. Overlaid connections. Read-write memory is conventional in every respect (black). Data from overlaid read-only memory (color) enters data register and is copied back into read-write array. Overlay array identifies the ROM words for which overlay occurs.

byte to the memory bus and on to the system.

In a normal memory cycle, lasting 775 nanoseconds and involving only a read-write word that has not been overlaid, the memory operates in the conventional way. Data is taken from the addressed location during the first half-cycle and, if the operation is a read, placed in a memory data register (Fig. 3). From this register, the data is transferred to the memory bus and thence to the processor or elsewhere in the system. Also from this register, the data, during the second half-cycle, is rewritten into the addressed location, which was erased in the process of reading. If the operation is a write, the data removed during the first half-cycle is lost; the data to be written, having previously been placed in the memory data register from the memory bus, is stored in the addressed location during the second half of the normal memory cycle.

Substitution by overlay

However, if the addressed location is covered by an overlay, the read-write memory goes through its normal cycle, but its output is suppressed. In its place, the read-only output goes into the register with approximately the same timing as the data from the first half of the read-write cycle. From the register the read-only output is copied into the read-write memory. Thus, over a period of time, a randomly addressed read-write module acquires a copy of the data in the read-only module that overlays it.

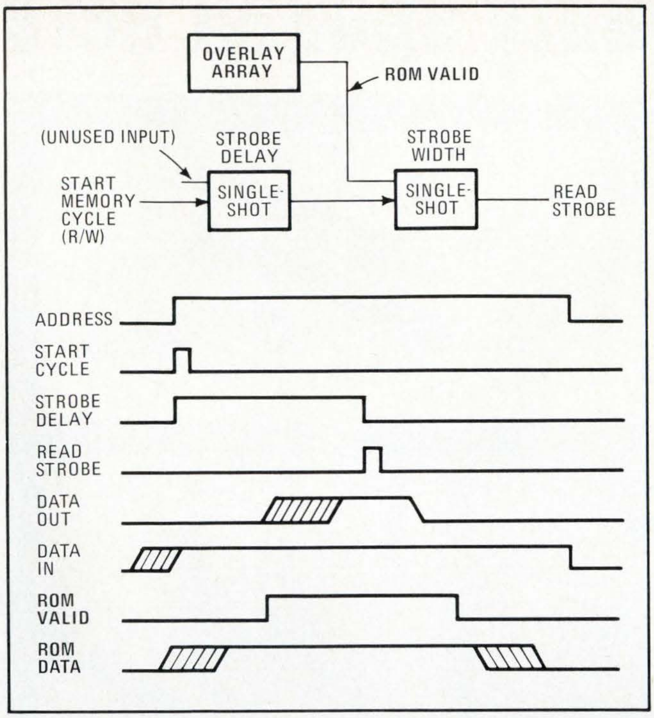
In general, no more than a small proportion of either read-write or read-only memory can be economically included in an overlay scheme. To put it another way, most of both memory forms should lie outside the overlaid region. Because the computer still needs large amounts of read-write memory for such operations as normal instruction modification, data manipulation, and indexing, no purpose is served by trying to overlay these areas.

Furthermore, although a properly designed overlay adds significantly to system performance, an overlaid read-write location isn't normally accessible, so that the user gets one location for the price of two. Obviously, if carried to an extreme, this would represent too much paid for too little capacity. Contributing to this potential imbalance is the fact that, if a particular routine in read-write memory needs only one overlaid read-only word, the user is obliged to install a minimum of 256 words of read-only memory because that is the size of the block packaged in integrated form; of these, 255 would be unused.

Word-for-word overlay

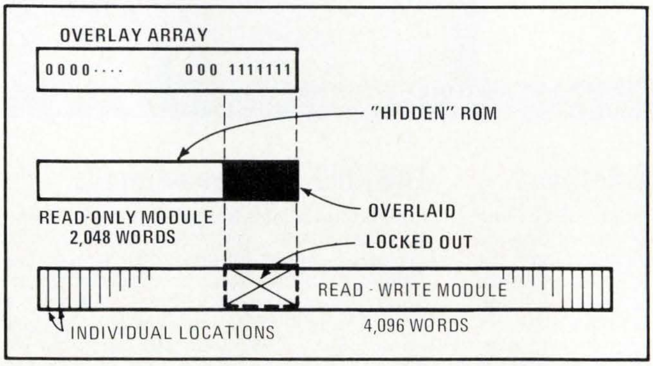
But even though the minimum block size of a read-only overlay is 256 words, the overlays need not be used only in such large clumps. On the contrary, individual words can be overlaid or not, as desired, by the inclusion of two more read-only-memory ICs in the module, besides the 32 that actually store the data. These two ICs, called the overlay array, provide 2,048 more read-only bits—one for each word in the module. These are the same type of 256-by-4 ICs used in the main ROM array, but their outputs are gated by part of the address so that they look from the output as if they were a single 2,048-by-1 array.

The one output signal, called "ROM valid" is connected to the second of two single-shot circuits in the controls of the read-write module (Fig. 4). The first single-shot controls the delay of the read strobe relative to the beginning of the memory cycle, and the second controls the strobe width. Both single-shots have two inputs, but in the absence of an overlay, only one input is used on each.



4. Strobe suppression. To accomplish the overlay, the data coming from the read-write memory is suppressed by a "ROM valid" signal that prevents the read strobe from being generated. The read strobe otherwise would set read-write data into the data register.

5. Hidden ROM. When a large block of the ROM module is not allowed to overlay the main memory, as determined by the overlay array, it is available for diagnostic and special routines. These are retrieved with a manual switch that overrides the overlay array.



With the overlay installed, if the addressed word generates the "ROM valid" signal, the second single-shot is disabled and the strobe pulse is not generated, which means that the data read from that location in the read-write memory is not set into the memory data register, and data from the read-only memory effectively takes its place. Since from the output of the overlaid memory, the operation looks like a clear-write operation, the data from the read-only memory ends up loaded into the read-write memory.

Hidden ROM

With the capability of overlaying individual words comes the inaccessibility of certain words in the ROM because the overlay array says for the corresponding address, "ROM *not* valid," and because the minimum block size is 256 words. Where blocks of such potentially wasted words occur, a "hidden ROM" can contain diagnostic routines at virtually no cost (Fig. 5).

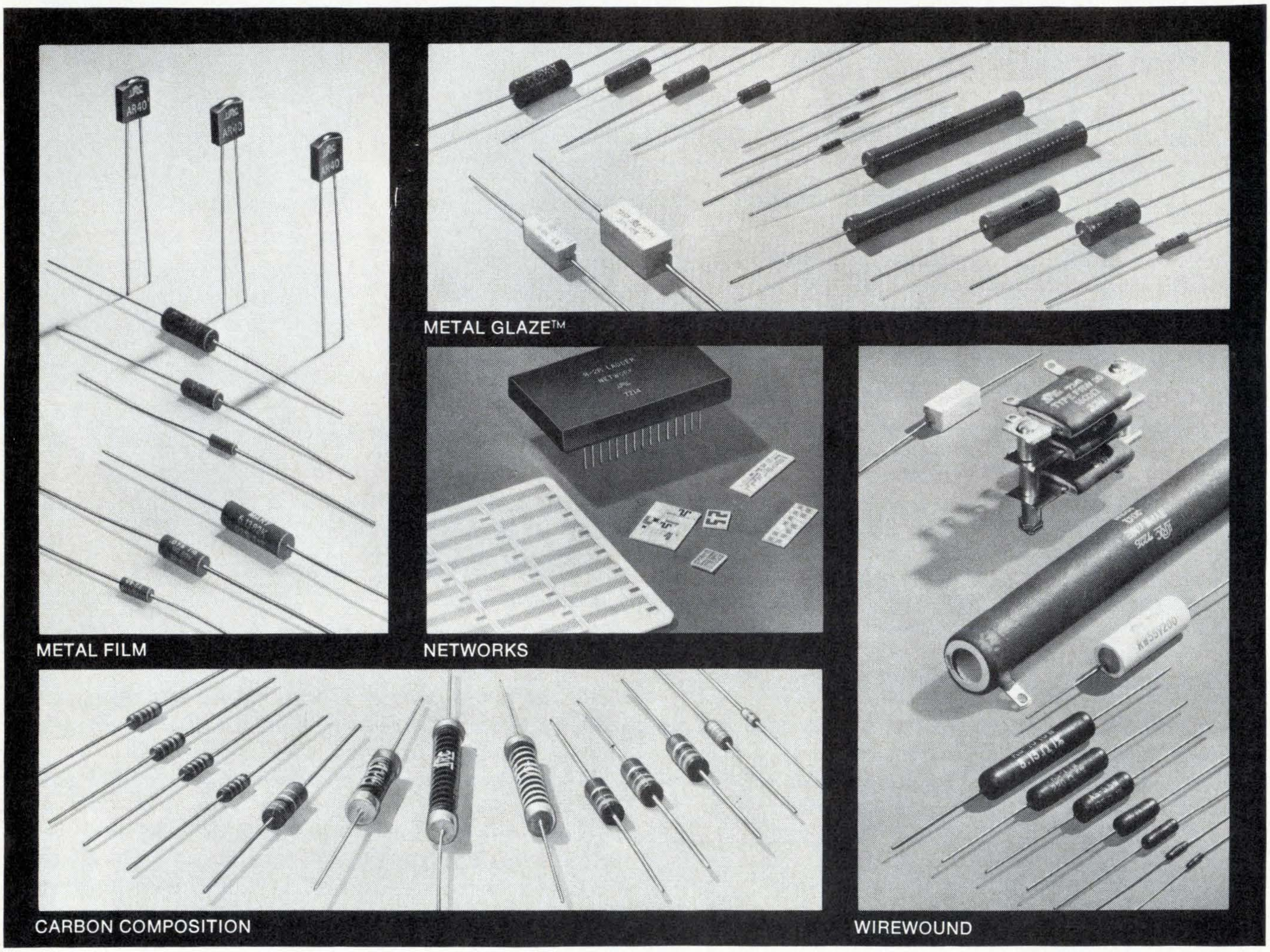
6. Honeywell System 700. Central processor has a 78-instruction repertoire, a real-time clock, and other features. Its high performance is due in part to its use of a read-only-memory overlay.

Suppose that only one word of a block of 256 contains data that overlays the read/write memory. The corresponding bit in the overlay array is 1, but the overlay array bits corresponding to the other 255 bits are all 0 because only the read-write memory is used for those addresses. With the aid of a three-position maintenance switch that can override the control of the overlay array, such otherwise unused read-only locations can contain routines that are never used by the programer, but may be vital for diagnosis by a field engineer.

These routines might conventionally be loaded separately from punched cards or magnetic tape carried by the engineer, or they might be kept on a storage medium such as one of the several types of "floppy disks" that have appeared on the market recently. But with the hidden ROM, they can be kept permanently in the machine and transferred to read-write memory at a moment's notice.

The maintenance switch that permits the use of the hidden ROM would ordinarily be kept in its "normal" setting. But it can be changed to either of two other settings: one which turns off the "ROM valid" line, then locking out the overlay array and permitting a conventional memory diagnostic program to be loaded in the usual way to check out the read-write memory, and one which forces the "ROM valid" line to 1 for all addresses, thus overriding the overlay array and bringing out all the data in the hidden ROM. By cycling the memory through all the ROM-overlaid addresses with the switch in the ROM-only setting, the special routines in the hidden ROM are transferred to the read-write memory, whence they can check out the rest of the machine. □

Total resistor capability spoken here



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Scope detects narrow pulses with its triggering system

by Peter T. Uhler
Tinker Air Force Base, Midwest City, Okla.

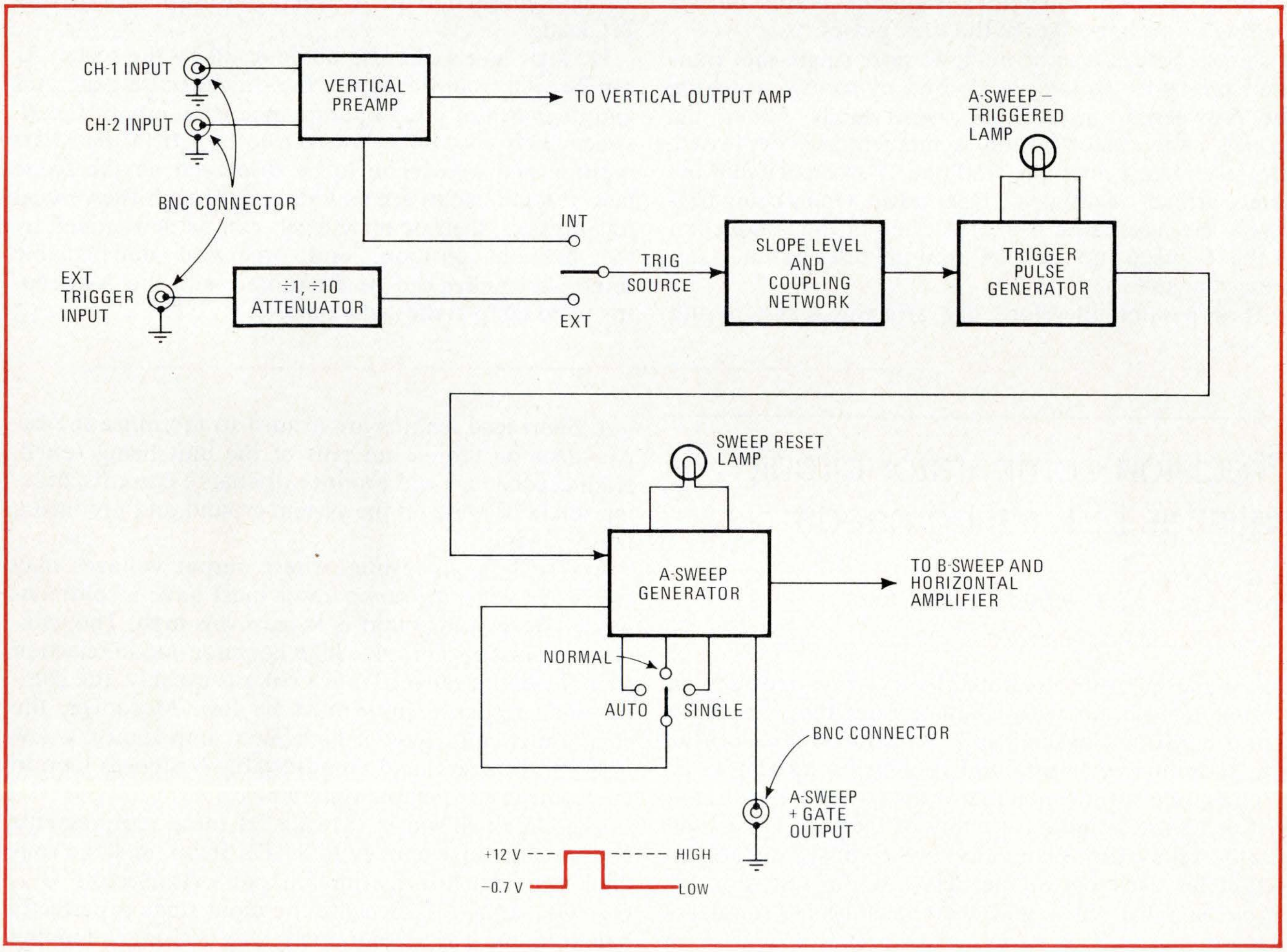
The presence of single narrow pulses can be easily detected by an average oscilloscope without the need for special probes or adapters. By simply operating the instrument in its external-trigger mode, the scope can be made to display short-duration pulses, troubleshoot logic ICs, store a one-time transient permanently, or record transient hits. The scope's own triggering system and front-panel lamps detect the pulses.

Usually, special probes are required to detect the presence of short-duration pulses in complex logic-IC systems. These narrow pulses generally have very low repetition rates or even occur singly, making them difficult to observe on even the fastest storage scope.

What has been overlooked, however, is that the triggering system of the average scope can readily duplicate the function of these special probes while providing much more flexibility. Most modern scopes employ solid-state amplifiers coupled to tunnel-diode trigger-pulse generators, enabling them to respond to very-short-duration pulses. Such triggering systems are essential to allow triggering out to and beyond the stated bandwidth of the instrument.

Good triggering systems are designed so that if the signal can be displayed at all, the trigger generator will initiate the sweep. For example, the triggering system in the Tektronix 453A-series oscilloscope, which has a rated bandwidth of 60 megahertz, will trigger to beyond 200 MHz when signals are fed directly into its external-trigger input.

Although the measurement techniques described here apply mainly to the 453-series dual-trace scope, they should be suitable for most high-quality lab scopes with bandwidths of 50 MHz or greater. For the most part, the triggering system in these scopes can be considered to function like the one shown in the figure.



Scope triggering system. In its external trigger mode, an oscilloscope can detect pulses that are only a few nanoseconds wide. The front-panel A-sweep-triggered lamp acts as a visual monitor, lighting when the trigger pulse generator responds to a trigger signal input. Because the lamp stays lit for awhile, it acts as a pulse stretcher, enabling the operator to detect the narrow trigger signal.

Trigger signals can be either routed through the vertical preamplifier or applied directly to the external-trigger input. The latter approach bypasses the relatively bandwidth-limited preamplifier and allows the triggering system to operate to full bandwidth. All trigger signals then pass through the slope and level comparator into the tunnel-diode trigger-pulse generator, which starts the main (A) sweep.

The front-panel A-sweep-triggered lamp, along with its associated sensing and driving circuitry, monitors the trigger-pulse generator, lighting for about 100 milliseconds each time the generator recognizes a trigger signal. This one-shot characteristic of the lamp monitor effectively stretches out short-duration trigger signals so that the operator can easily detect their presence.

Just by observing this lamp, therefore, single-event pulses (that are coupled directly into the external trigger input) with amplitudes of under 250 millivolts and durations on the order of a few nanoseconds can be detected. Transistor-transistor-logic signals can also easily be coupled into the external-trigger input with a standard 10× probe. (If the Tektronix type P-6061 miniature 10× probe is equipped with a type 015-0201-00 DIP IC probe-tip adapter, the scope/probe combination becomes a compact and effective logic-IC troubleshooting tool.) The setting of the trigger-slope and level controls determines whether triggering occurs on the leading or trailing edges of the logic pulses.

The scope can also be made to store single-shot transient pulses for as long as desired by simply switching the A-sweep to its SINGLE sweep mode. When the scope's sweep reset button is momentarily depressed, the reset lamp goes on, and the A-sweep circuit becomes armed, awaiting a trigger pulse. Upon being triggered, the reset lamp is extinguished at the completion of the A-sweep and stays off until the reset button is depressed again.

The operator, therefore, can arm the A-sweep, and leave the scope unattended. The reset lamp will go off only when triggered, and it will stay off until it is manually reset. This feature is especially useful for detecting "once-in-a-lifetime" transient pulses.

Additionally, the scope can be transformed into a recording transient-hit monitor by connecting a chart recorder or suitable event counter to the A-sweep gate output and setting the A-sweep mode to its NORMAL position. While the A-sweep is not sweeping, the gate output rests in its low state. Upon initiation of the A-sweep, this output goes high and remains there for the duration of the sweep. The gate output returns to its low state as the A-sweep resets itself, and the cycle is completed.

The duration of the positive-going gate pulse equals the sweep time per division times the sweep length, plus any inherent time delays. A sweep time of 10 milliseconds per division over a sweep length of 10 divisions will cause a positive output pulse of approximately 100 ms at the gate output. This is ample time to produce a sharp time-mark on most slow-moving chart recorders—such a time-mark will be produced each time a transient triggers the A-sweep.

The transient-recognition threshold of the scope can be set initially by using an auxiliary pulse generator or power supply and adjusting the scope's trigger slope and level controls appropriately. If necessary, a buffer can be connected to the A-sweep gate output for driving TTL loads.

Dc logic levels can also be detected by the scope. As can be seen from the figure, the trigger-pulse generator and its indicator lamp operate independently of the A-sweep. This allows the A-sweep to be left in the AUTO position and a baseline to be displayed on the scope face. If logic signals are now routed through the vertical preamplifier, their dc logic levels can be determined by the baseline position, and otherwise undetectable single-shot pulses can be monitored with the A-sweep-triggered lamp at the same time. □

Precision comparator circuit satisfies LSI testing needs

by George Niu
Fairchild Systems Technology division, Palo Alto, Calif.

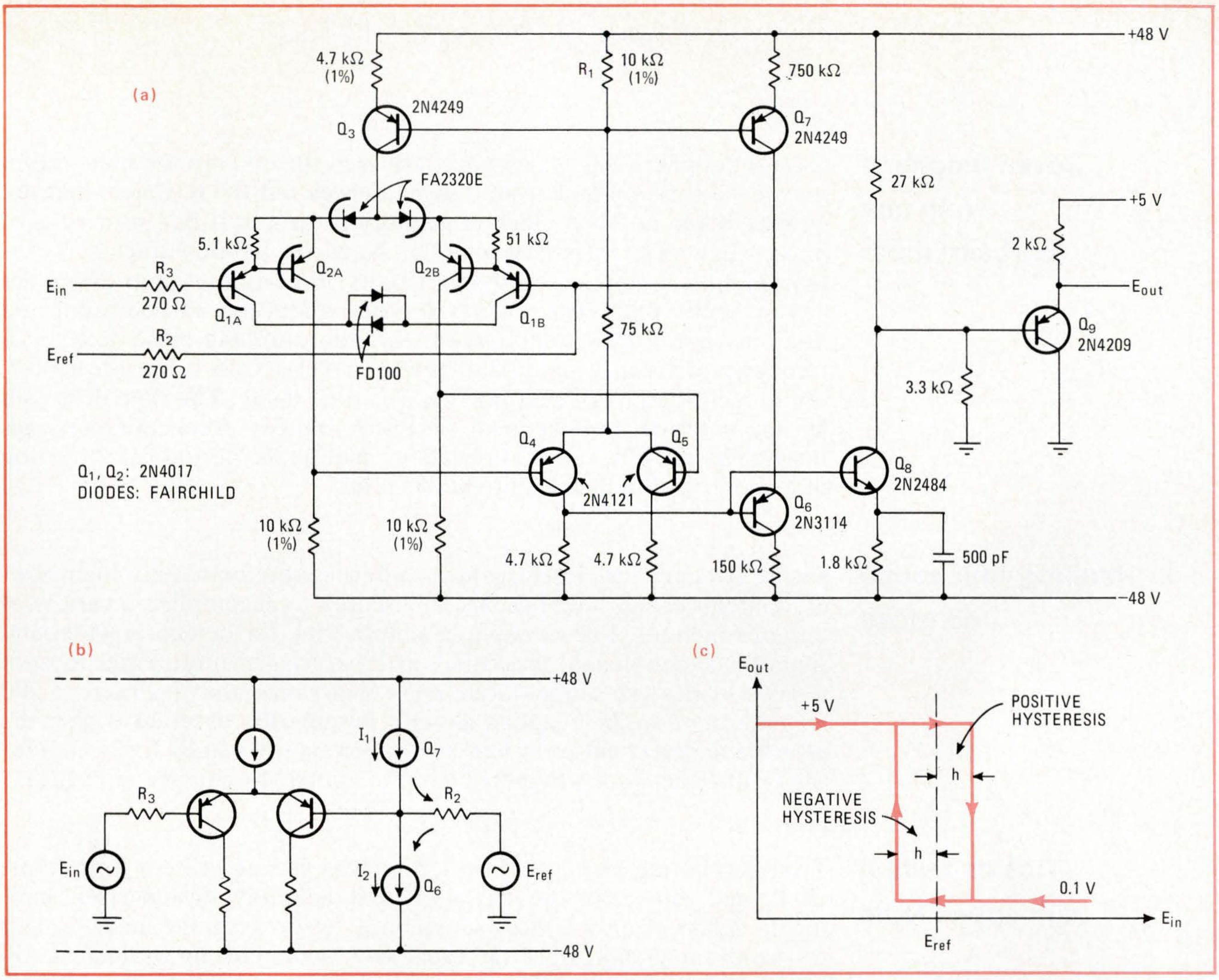
Testing large-scale integrated-logic arrays requires an analog comparator with characteristics that cannot be found in an off-the-shelf unit. To perform state-of-the-art LSI testing, you must build your own comparator.

The modern LSI functional-testing system needs low-cost comparators because many of them must be used in any test system. Generally, two comparators are required for each pin of the device under test. For example, in a 240-pin system, there must be 480 comparators.

Another consideration is miniaturization—a basic requirement for an LSI test-system comparator that allows it to be mounted as close as possible to the device under test. Short lead lengths are a must to minimize the capacitance on the output pins of the unit being tested. High capacitance will produce discharge currents, causing spikes or noise on the system ground and producing faulty readings.

For MOS-circuit testing, where output voltages may reach ±30 volts, the comparator must have a common-mode voltage range that is at least this high. The comparator must also provide high common-mode rejection over the entire range. To test circuits quickly, the comparator's response time must be low. Moreover, the comparator must have a high input impedance, a low input bias current, and an adjustable hysteresis loop to overcome unpredictable system noise.

The circuit shown in (a) satisfies these requirements and provides an accuracy to 0.01%. Its input stage contains two matched Darlington pairs (transistors Q_{1A}, Q_{1B}, Q_{2A}, and Q_{2B}). Because the input stage is perfectly balanced and has an extremely high resistance looking into its constant-current source (transistor Q_3), a high common-mode rejection ratio is obtained. The first and second stages (transistors Q_4 and Q_5) form a "negative



Designed for LSI systems. High-performance inexpensive comparator (a) meets the special requirements of testing LSI circuits. Besides a fast response and a high input impedance, the comparator has a wide common-mode voltage range, making it ideal for use with MOS circuits. It also provides (b) an adjustable hysteresis loop (c) to avoid false readings due to system noise.

common-mode feedback" circuit through resistor R_1, reducing the current drift in the first stage's constant-current source.

Transistor Q_6 provides positive feedback and supplies a current that enables the comparator's hysteresis to be adjusted with the current flowing through transistor Q_7. The hysteresis is controlled by the currents from transistor Q_6 and Q_7 and the value of resistor R_2, as shown by the equivalent circuit in (b). If the currents from Q_6 and Q_7 are kept fixed, the hysteresis loop can be adjusted by changing only the value of R_2. This resistor can be conveniently located away from the rest of the comparator circuit, permitting an adjustable hysteresis to be obtained easily.

The output stage (transistors Q_8 and Q_9) provides a level-shift for interfacing to DTL or TTL circuits. If the input voltage, E_{in}, is lower than the reference voltage, E_{ref}, a high (logic 1) output signal is obtained. When E_{in} is higher than E_{ref}, a low (logic 0) signal is present at the output.

Under quiescent conditions, both E_{in} and E_{ref} are shorted to ground, and transistor Q_6 is reversed-biased. Since Q_6 is off, current I_2 is zero, and the current (I_1) from transistor Q_7 must flow through resistor R_2. The voltage drop across R_2 then produces the positive half of the hysteresis loop drawn in (c).

As input voltage E_{in} is increased, the positive half of the hysteresis must be overcome before the output can switch from high to low. When the hysteresis is overcome, transistor Q_6 turns on, and current I_2, which is twice the value of current I_1, flows through Q_6 to the negative supply voltage. At the same time, the current through resistor R_2 changes direction, reversing the polarity of R_2's voltage drop. This produces the negative half of the hysteresis loop. To switch the comparator output back to the high state, the negative hysteresis must be overcome in the same manner as the positive half is overcome.

Because of the action of the two differential pairs at the input, the real hysteresis experienced by input voltage E_{in} is half of the IR drop across resistor R_2. The total hysteresis, therefore, will be equal to the actual IR drop across R_2. □

Engineer's notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.

Engineer's newsletter

Seven functions from one (bargain) timer

Circuit designers who've always considered the op amp the most useful inexpensive design tool around should **check out the IC timers that are now available at 75¢ a piece in quantity** from a half-dozen or so suppliers—Signetics, Intersil, Motorola, National Semiconductor, Texas Instruments. Compare this for flexibility: the original chip (Signetics 555), which contains two comparators and a flip-flop, can be connected as a one-shot, a free-running multivibrator, a missing-pulse detector, a frequency divider, a modulator (PWM or PPM), and a test sequencer, not to mention its original function as a time delay. **The time delay, set by an external resistor and capacitor, ranges from microseconds through hours.** Innovative applications include the periodical activation of a deodorizer in bathrooms and hospitals.

Making your scope do tricks

Smart designers are learning how to harness the extremely high-powered circuit capability of their oscilloscopes to accomplish a variety of design functions. For example, a simple trick for detecting wideband signals is to couple into the scope's external trigger input. Since most of today's scopes use tunnel-diode pulse generation that operates at 200 megahertz or so, **by coupling directly through the external trigger it's possible to detect pulses as narrow as a few nanoseconds.** Just watch for the front-panel sweep-triggered lamp to light. (More tricks on p. 121).

Tips on testing high-speed logic

Troubleshooting high-speed logic boards is getting to be a formidable challenge, especially the new ECL and Schottky designs that have toggle delays of only 1 to 2 nanoseconds. So do keep the leads to your test equipment short since **the capacitive loading of the equipment will often mask the presence of narrow pulses.** Making calibration standards with good boards for comparison won't hurt either.

This minicomputer will moonlight on making memories

Here's a bit of useful fallout from H-P's new top-of-the-line 2100 minicomputer, which has variable microinstructions instead of the fixed microinstructions usual on microprogramed computers. That feature **lets you use the 2100 to load a solid-state random-access memory from a disk file** or, with the aid of a pulse-programing attachment called a PROM writer, to fuse new patterns into a read-only memory.

More power to the programer

You'd better either brush up on your programing skills or acquire some, now that microprocessing is becoming the handy and cost-effective way of generating logic. Three single-board computers based on one-chip microprocessors showed up on the market within the past month, and within the next year they'll be coming out of the woodwork. They've so inexpensive—under $1,000 in most cases—and so easy to fit into any design that **before long you'll be drawing program flow charts instead of logic diagrams.**

Ohm's law again

An ordinary digital voltmeter, together with an ordinary FET, which makes a dandy constant current source, can be used to measure resistance. The result is a **readily available digital ohmmeter.**

tions — so you need only one mechanical assembly step instead of four.

Raytheon Semiconductor delivers the first *true* Quad 741 Op Amp — so you can get twice your money's worth with the new 4136.

Reader Service No. 241

54/74 MSI

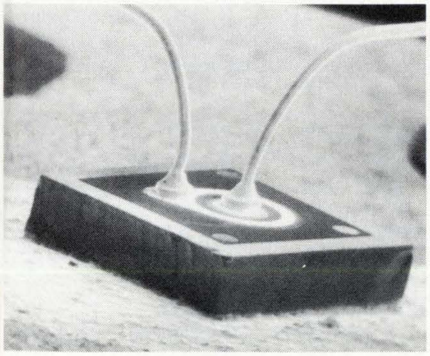
Raytheon Semiconductor now offers a reliable second source for the 54/74 MSI line. We have more than 24 types, including these hard-to-get ones:

54/74123	54/74163	54/74181
54/74150	54/74174	54/74194
54/74160	54/74175	54/74195
54/74161		

In addition, we have our own 54R/74R products — which give you higher performance with no change in price or operating requirements. If you're an engineer who wants more out of the commonplace 54/74, just place an "R" on your order.

Reader Service No. 245

A Look at Our New Hi-Rel JAN TXV Transistors



Microscopic inspection assures defect-free hi-rel JAN TXV transistors.

Raytheon Semiconductor now offers you 29 types of hi-rel transistors with "precap" inspection at lower costs and with faster delivery. Designated JAN TXV, each transistor is 100% inspected with 30- and 100-power microscopes before it's hermetically sealed. This precap visual inspection prevents visible contamination or defects which could affect long-term reliability.

In addition, for those transistors not listed in the military JAN TXV listing, Raytheon Semiconductor offers R TXV transistors tested to the same standards as JAN TXV.

For hi-rel as well as standard small-signal silicon transistors, take a look at Raytheon Semiconductor.

JAN TXV Devices

JAN TXV 2N718A	JAN TXV 2N2904A
JAN TXV 2N918	JAN TXV 2N2905
JAN TXV 2N1613	JAN TXV 2N2905A
JAN TXV 2N2060	JAN TXV 2N2906
JAN TXV 2N2218	JAN TXV 2N2906A
JAN TXV 2N2218A	JAN TXV 2N2907
JAN TXV 2N2219	JAN TXV 2N2907A
JAN TXV 2N2219A	JAN TXV 2N2920
JAN TXV 2N2221	JAN TXV 2N3019
JAN TXV 2N2221A	JAN TXV 2N3057A
JAN TXV 2N2222	JAN TXV 2N3250A
JAN TXV 2N2222A	JAN TXV 2N3251A
JAN TXV 2N2369A	JAN TXV 2N3553
JAN TXV 2N2484	JAN TXV 2N3700
JAN TXV 2N2904	

Reader Service No. 243

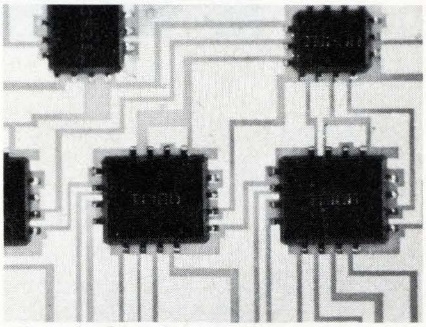
How Hi-Rel Beam Leads Can Lower Hybrid Costs

In the majority of applications Raytheon Semiconductor hi-rel beam lead devices can reduce the costs of your hybrid modules.

One big factor is bonding. Beam lead bonding is far less complicated than the bonding operation for conventional chips or dice, so your operator needs less training. You'll get higher yields when bonding beam leads, too. That's because Raytheon Semiconductor's beam lead devices are hermetically sealed by nitride passivation. This minimizes the chance of damaging the chip during the bonding operation.

With Raytheon Semiconductor beam lead devices, the hybrid designer can obtain greater packaging densities. And more parts per module mean greater manufacturing economies.

If you have a hybrid circuit that requires high reliability but you



Beam lead bonding techniques are simpler and permit closer spacing of chips.

thought you couldn't afford beam lead devices, contact us. Raytheon Semiconductor may be able to offer you the best of two worlds with our beam lead know-how.

Reader Service No. 242

Attention! Now a Military 256-Bit Bi-Polar RAM

Raytheon Semiconductor introduces a full MIL 256-bit TTL random access memory. The device is not only guaranteed to operate at specified DC parameters but also AC parameters over the entire temperature range of −55°C to +125°C.

Designated RR5300, it is a fully decoded bi-polar read/write RAM organized as 256-words by 1-bit. Readout is non-destructive, and data is maintained in the array without regeneration.

The access time from address to output is 85ns over the full MIL temperature range. Power consumption is a low 475mW. At present the RR5300 is available in a ceramic 16-pin dual in-line package; a flat package version will be offered in the future.

For more information, contact your nearest Raytheon Semiconductor sales outpost.

Reader Service No. 244

Raytheon Semiconductor, 350 Ellis Street, Mountain View, California 94040. Phone (415) 968-9211.

RAYTHEON

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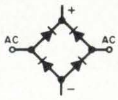
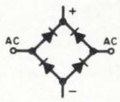
3. Whose standard delivery time on bridges is 4 weeks?

4. What is the lowest price you should pay for a quality 1.5 ampere, 400 volt, single-phase bridge?

5. If  = 

and  = 

, why doesn't  =  ?

ANSWERS: 1 thru 3: General Instrument. 4: 25¢* (For any one of General Instrument's "W", KBP or KBD bridges). 5: Because it will cost you more to buy and assemble the rectifiers into a bridge than to buy an assembled bridge from General Instrument.

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If you have any questions of your own, you can call Bob "Buster" Brown, product line manager, toll-free at 800-645-1247. In New York State call 516-733-3234.

*Conditions of Sale (Applicable only in the continental United States): Minimum Order Quantity—10,000 units scheduled within 60 days.

For complete information write: General Instrument Corporation, Dept. B, 600 West John Street, Hicksville, N.Y. 11802, or call, In New York: 516-733-3333; in Chicago: 312-338-9200; in Los Angeles: 213-641-7411. In Canada, call or write: General Instrument Canada, Ltd., 61 Industry Street, Toronto 337, Ontario, Canada, Tel: 416-763-4133. In Europe, write: General Instrument Europe S.P.A., Piazza Amendola 9, 20149 Milano, Italy. In the U.K., write General Instrument (U.K.) Ltd., Cock Lane, Highwycombe, Buckinghamshire, England. In the Far East, write General Instrument of Taiwan Ltd., P.O. Box 22226, Taipei, Taiwan.

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New products

C-MOS forges monolithic analog gate

New high-voltage process creates chips for common switching functions, carrying monolithic technology a step further into industrial system design

by Laurence Altman, Solid State Editor

The designers of industrial and process-control systems are eagerly awaiting monolithic versions of the analog components to go with the digital chips they already use. Monolithic designs are clearly the way to go for analog circuits, too, because they are cheaper, and the great advances in monolithic differential amplifiers, operational amplifiers, comparators, digital-to-analog converters, timers, and phase-locked loops, all testify to this trend.

One exception stands out: the simple analog gate, which generally has been built with the more expensive module or hybrid techniques or, if it does come in monolithic form, generally requires a complex and expensive technology, such as dielectric isolation. An improved C-MOS technique has now put the analog gate within the reach of simple monolithic processing. Intersil, using a high-voltage process, has built a family of gate chips that provides all the common switching functions: single-pole single-throw, single-pole double-throw, double-pole single-throw, double-pole double-throw, and four-pole single-throw (see table).

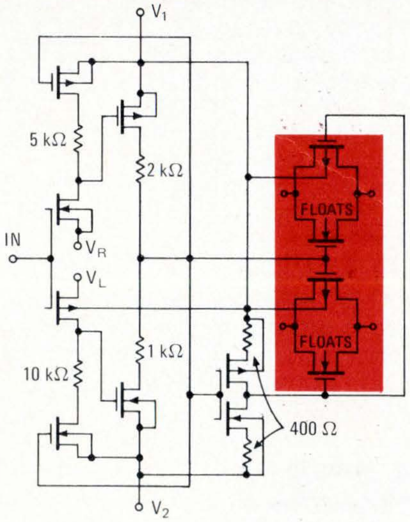
According to Jack Gifford, manager of Analog Products at Intersil, these devices provide "ease of use and performance advantages not previously available from monolithic solid-state switches." Gifford points out that the improved C-MOS technology provides input overvoltage capability—±25 volts can be applied without damage to the device. This is important because most often the switch will be driven by the output of an op amp, which normally is as high as ±5 v.

A key feature of Intersil's IH 5040 series of gates is that they will not latch up or self-destruct. Latch-up has been a frequent and thorny problem with monolithic analog gates. Up to now, most analog gates and multiplexers manufactured with standard C-MOS technology have suffered from it; they go into a non-operative state and will recover only if both the power supplies and the input are removed and reapplied in a specific order.

Technically, latch-up occurs when a negative-going analog signal is applied to either the drain or source of an MOS transistor whose negative-potential gates are at zero voltage. Since analog switches are frequently used to interface with different systems and subsystems, these conditions occur surprisingly often, especially if independent parts of the system or subsystem have independent power supplies. To make matters worse, latch-up conditions need only occur briefly, as transients, to put the freeze on.

Floating bodies. During a latch-up condition, a negative potential on the analog input or output causes a high-current path to exist from the source, through the forward-biased body of the FET, to the drain junction of the n-channel device. This path, coupled with an SCR effect that will occur between the n-type and p-type field-effect transistors in a C-MOS device, causes the latch-up.

Intersil's answer is to enlarge the C-MOS process to incorporate an additional diode in the connection going to the body of the n-channel FET. The cathode of this diode is then tied to the positive-going gate, so that the body is floating (see schematic below). The diode not only blocks the big current path but also prevents the SCR from turning on. As a further precaution, processing changes also have been incorporated which reduce to less than 1 the beta product of the npn-pnp C-MOS transistor combination (when β exceeds 1, an SCR is formed). Now,

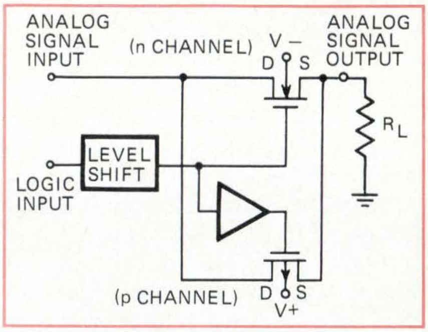


INTERSIL PART NO.	TYPE	R_{ON}
IH5040	SPST	75 Ω
IH5041	Dual SPST	75 Ω
IH5042	SPDT	75 Ω
IH5043	Dual SPDT	75 Ω
IH5044	DPST	75 Ω
IH5045	Dual DPST	75 Ω
IH5046	DPDT	75 Ω
IH5047	4PST	75 Ω
IH5048	Dual SPST	30 Ω
IH5049	Dual DPST	30 Ω
IH5050	SPDT	30 Ω
IH5051	Dual SPDT	30 Ω

even when an excessive overvoltage is applied that could break down the blocking diode, the SCR effect will not occur.

It should be noted that before the floating-body design, solutions to the latch-up problem involved using either a more expensive manufacturing process (like dielectric isolation), or external components (such as current-limiting resistors), which always added complexity and often compromised performance.

Other important features of the switch series are: they can switch more than 20 V peak to peak from ±15-V supplies; they are compatible with all commonly used logic—TTL, DTL, C-MOS, p-MOS; they have the all-important break-before-make switching feature; their leakage current is less than 1 nanoampere; they're fast (less than 1 microsecond), and their on resistance is low (only 30 ohms).



Analog switch. Latch-up is avoided by floating gate with extra diode (not shown).

Worth stressing is the 5040 series' ultra-low-power operation—quiescent current requirement is less than 100 microamperes. The feature stems from the low-power, 40-V C-MOS process.

The break-before-make feature of the gates also eliminates the external logic normally required to avoid channel-to-channel shorting during switching. It's done by extending the on time (typically 500 nanoseconds) so that it exceeds the off time (250 ns typically), insuring that an on channel will be turned off before an off channel can be turned on.

Large-quantity prices are in the $2-per-channel range.

Intersil Inc., 10900 No. Tantau Ave., Cupertino, Calif. 95014 [338]

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Components

DIP houses two relays

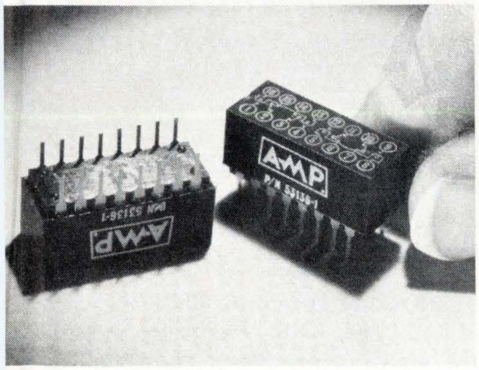
Units in tiny package can be driven by TTL or DTL; contacts rated at 2 amperes

When equipment design requires transistor-transistor or diode-transistor logic to directly drive circuits that must switch up to 2 amperes (resistive) at up to 150 volts dc, a dual in-line package developed by AMP Inc. and containing two identical high-speed relays may be the answer.

The DIP, which is specially designed for mounting on printed-circuit boards, packs two independent double-pole, double-throw relays into a space 0.9 inch wide, 0.36 in. long, and 0.4 in. high for a volume of less than 0.13 cubic inches. The relay package is priced at $5 each in production quantities, and AMP claims that it offers the most switching capability per unit volume of any device on the market.

Pull-in time for the high-speed electromechanical unit is 5 milliseconds maximum, including bounce, and 4 milliseconds on dropout. The coil resistance is 100 ohms, and it is rated for a maximum operating voltage of 7.5 V. The drive power required is 170 milliwatts. Pull-in voltage is about 4.1 V, and dropout voltage is approximately 2 V.

The relays' low-contact resistance and medium-current capability make them suitable for multiplexing, as well as for power switching. Mounting options include solder, Wire-Wrap, and Termi-Point. Lead spacing is conventional for a 16-pin DIP: the input-output pins are on 100-mil centers, and rows are spaced 300 mils apart. Cross-section of the pins is 8 by 20 mils, and weight of the device is 0.143 ounce, the company says.

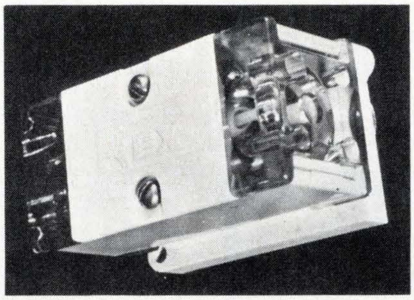


Delivery time is six to eight weeks.

AMP Inc., Harrisburg, Pa [341]

Air-control components perform logic functions

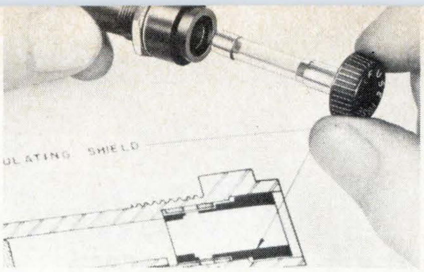
A series of miniature air-control components can perform logic functions. The nonmetallic devices, called Minivalves, fit into standard electrical control boxes and limit-switch housings, and they mount behind electrical push buttons. Thirty components plus regulator and pressure gauge mount in a 17-by-20-inch panel box. Taper-lock fittings connect valves to a ¼-inch plastic tubing.



ir Valves Division, Rexford Inc., 1760 Maplelawn Blvd., Troy, Mich. 48084 [345]

Fuseholder protects against shocks

A shock-safe fuseholder, type 345001, is designed with an electrical insulating shield that completely encloses the contacting-ring section of the fuseholder side terminal. Electrical continuity is established by a bayonet-style fuse-extractor knob through a slotted section of the electrical insulating shield. The fuse-extractor knob is connected to the contact ring by depressing and rotating it 90° after fuse insertion.



Littlefuse Inc., 800 E. Northwest Highway, Des Plaines, Ill. 60016 [344]

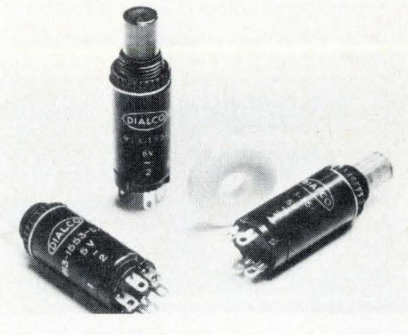
T transformer measures 0.75 by 0.75 by 0.6 in.

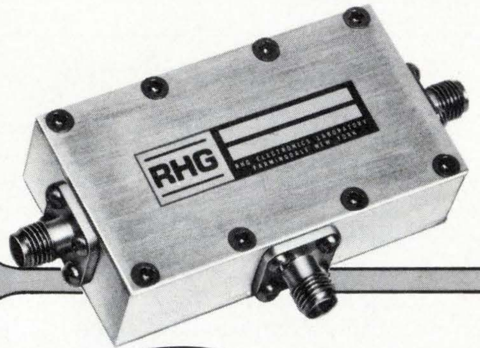
A precision Scott T transformer, model 12393, converts synchro information into resolver information and is used for synchro-to-digital, digital-to-synchro, synchro-to-linear outputs, and similar computer interface operations as well as analog-to-digital applications. Measuring 0.75 by 0.75 by 0.6 inch, the unit operates over the temperature range of from -55 to +125°C and input is 11.8 volts rms line-to-line. With 400-hertz synchro information, standard output is 6 V sine- and cosine-resolver information. Price is $19 each in 100 lots.

Magnetico Inc., 6 Richter Ct., E. Northrup, N.Y. [343]

Momentary-action switch uses LED light source

The series 913 miniature momentary-action switch has a light-emitting diode for its light source and operates from a 5-volt dc supply, but external resistor can supply voltages over this rating. The switch is suitable for application where extra-long life or low power is required. It is available in either normally open, normally closed, or two-circuit versions, and it is supplied with a long cylindrical lens cap with an internal

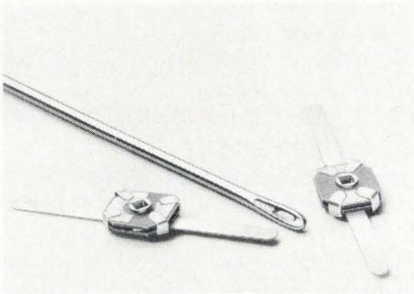




Fresnel ring for uniform light distribution. Price is $2.59 each in 1,000 lots for normally open and normally closed types and $2.73 for the two-circuit versions.
Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237 [346]

Trimming capacitors are microminiature types

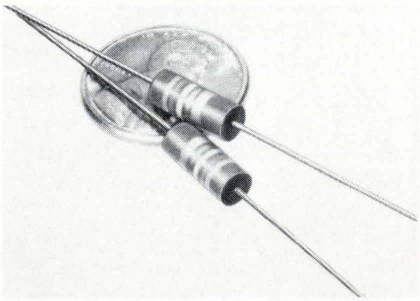
The Thin-Trim is a microminiature variable capacitor for applications from quartz-crystal watches to phased-array microwave ICs. The model 9402-4 has a capacitance range of 3.0 to 12.0 picofarads and a Q of less than 750. It is 0.140 inch in diameter and 0.030 inch thick. It is tuned from the top with a miniature dielectric tool.



Price is $3.05 in 1,000 lots.
Johanson Manufacturing Corp., 400 Rockaway Valley Rd., Boonton, N.J. 07005 [347]

Molded inductors provide electromagnetic shield

The model IMS-5 molded inductor meets the requirements of MIL-C-15305D, Grade I, Class A, and is provided with an electromagnetic shield. Inductance range is from 0.10 microhenry to 100,000 μH, and inductance tolerance is ±10%. Self-resonant frequencies are from 250 to 0.11 megahertz, and rated dc current is from 1,790 mA to 11 m. The IMS-5 is 0.410 inch long by 0.162 in. in diameter. Price is 46 cents each in quantities of 1,000.

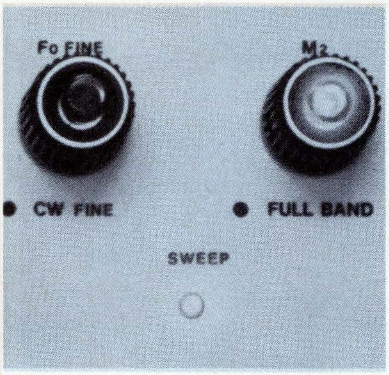


Dale Electronics Inc., Dept. 860, Box 609, Columbus, Neb. 68601 [349]

Flat-top lamps mount on circuit boards

The T-2 TU-PIN series of subminiature flat-top lamps for status indication and related systems are for mounting on printed-circuit boards. They may be used in a va-

The Big Sweep 100 kHz-18 GHz.

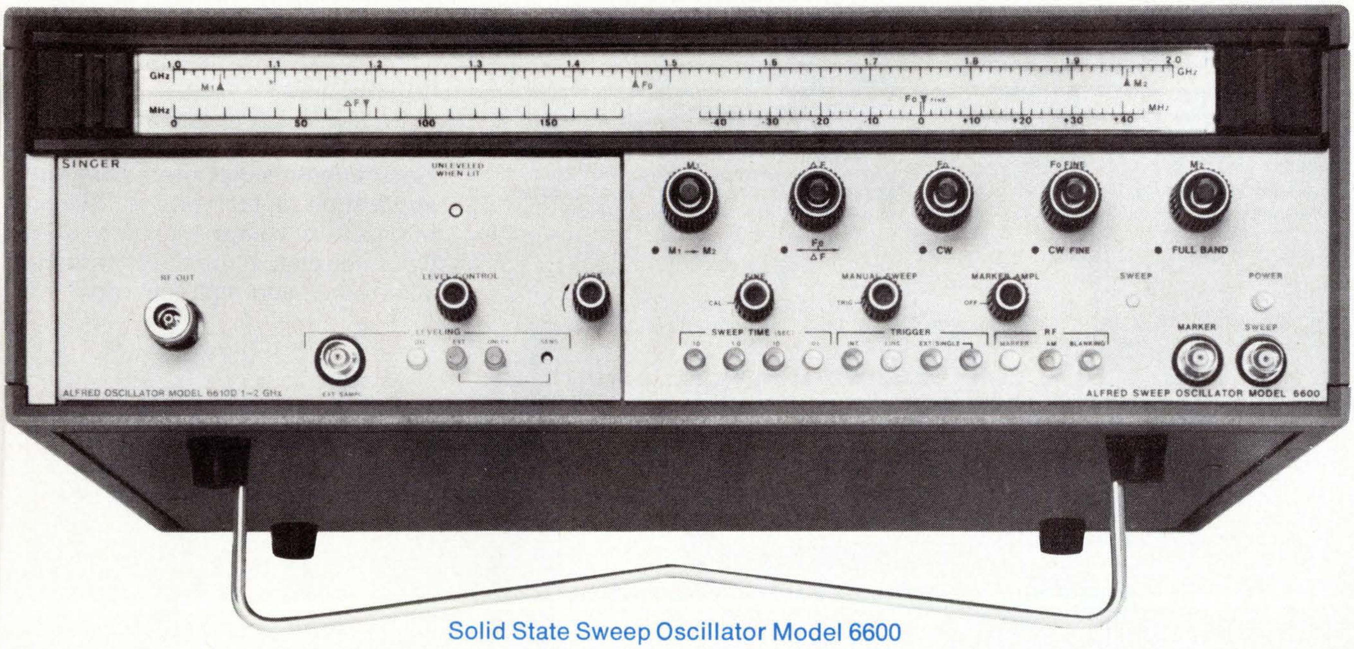


It's a whole new generation of solid state sweep oscillators from Singer.

The 6600 Sweep Oscillator with its wide selection of plug-ins covers the 100 kHz to 18 GHz range. Below 1000 MHz, you have as many as three units from which to choose the one best suited to your application. One model includes a power-set meter adjustable over a 140 dB range for applications requiring sweeper *and* signal-generator-like performance. Microwave plug-ins are pin-leveled, internally or externally, all the way up to 18 GHz. And with a 20 dB power control range. But there is much more than exceptional performance to the 6600.

The uncluttered front panel with its lighted, push-button controls, makes operation self-evident and confusion-free. With four sweep modes, full band, marker, △F, and manual—each with frequency markers—the 6600 sets a new standard for ease and flexibility of operation.

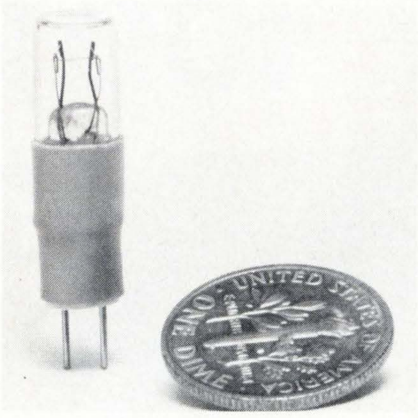
Take a little time to find out more about the big sweep. Write for complete data bulletin now.



Solid State Sweep Oscillator Model 6600

SINGER
INSTRUMENTATION

The Singer Company, Palo Alto Operation • 3176 Porter Drive, Palo Alto, Calif. 94304 • Telephone (415) 493-3231 riety of applications, such as panel-display of logic functions and busy-lamp applications. The flat-top bulb allows maximum end viewing. Seventeen voltages from 4 to 48 v are offered, with current ranges from 17

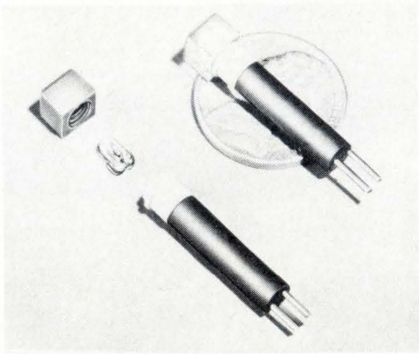


to 80 milliamperes. Mounting construction makes the T-2 series interchangeable with Sylvania's T-1 ¾-inch bi-pin types. Price is 36 cents each in 1,000-lots, and delivery is from stock.

Sylvania Miniature Lighting Products Inc., West Main St., Hillsboro, N.H. 03244 [348]

Miniature indicator light incorporates resistor

A line of miniature indicators provides intense neon brightness with application of 115 volts ac. The entire unit is comprised of a Mini-Brite housing, a standard wire-lead neon lamp and snap-on caps. The



subminiature housing also incorporates a ⅛-watt encapsulated resistor with various life expectancies. Price is $1.30 each for one to 99 pieces.

LVC Industries Inc., Bloc-Lite Division, 135-25 37th Ave., Flushing, N.Y. 11354 [350]

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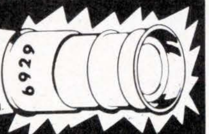

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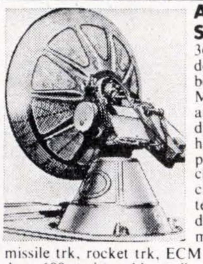

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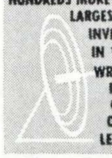

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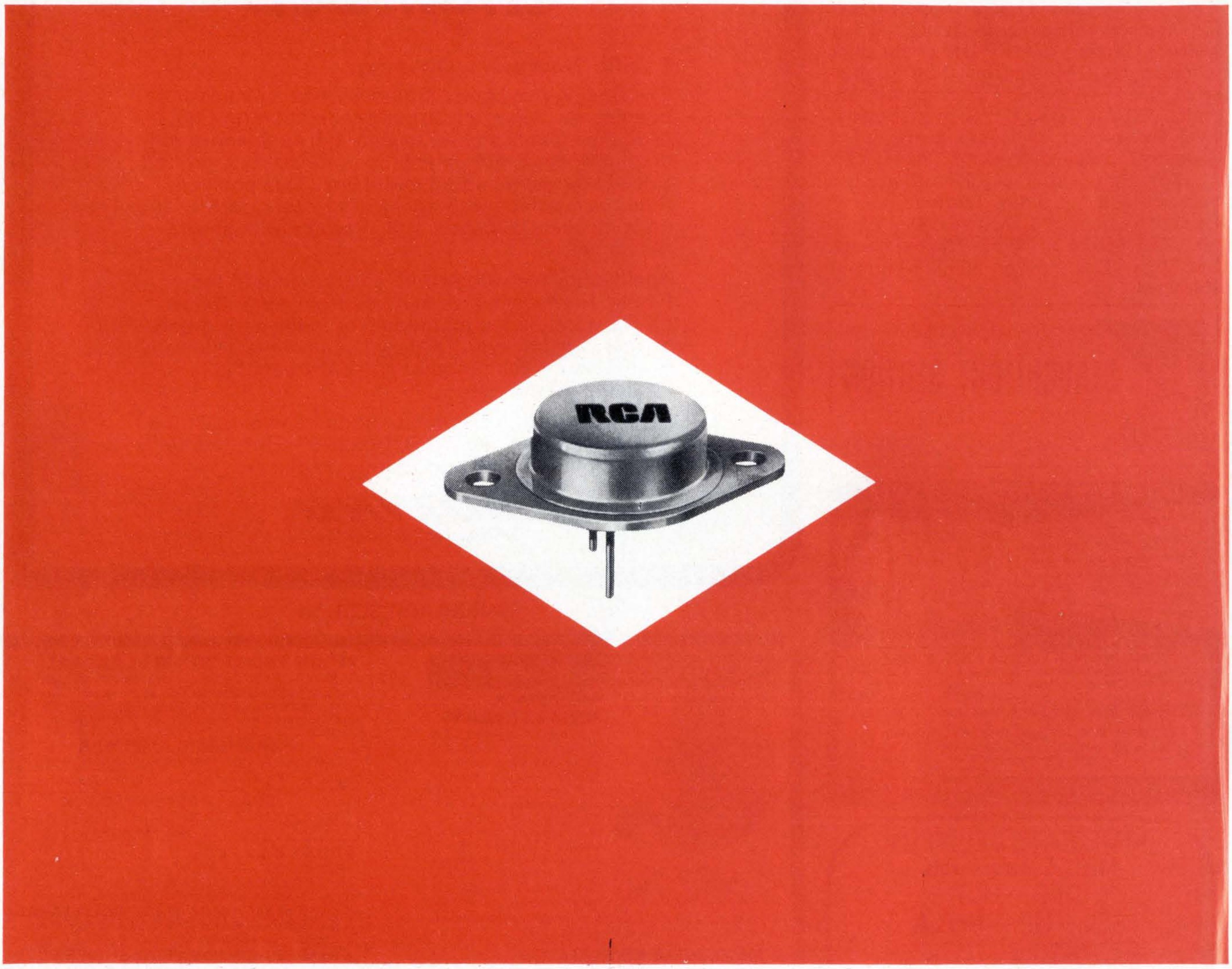

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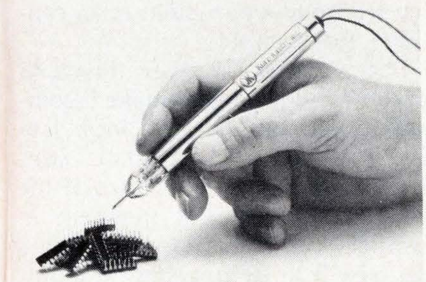
Instruments

Probe built for C-MOS

Unit designed for logic families from 5 to 15 volts; uses three-lamp readout

Now that complementary-MOS is being used more extensively in equipment, there's a need for a C-MOS-logic probe to give engineers and technicians the capability for



fast system-checkout in field service, quality control, bench service, and some design steps.

Kurz-Kasch Inc. has developed such a probe—the LP-570, designed for positive logic families from +5 to +15 volts. Like earlier Kurz-Kasch probes, this new version uses a multilamp display concept, and the three-lamp incandescent display located near the probe-tip flashes white for logic lows, red for logic highs, and blue for positive- or negative-going excursions, says Tom Barth, general manager of the firm's Electronics division, Dayton, Ohio.

"Crossover points float with the power supplies," Barth explains. "Logic lows are 0% to 30% of a V_{DD}, and logic highs are 70% to 100% of a V_{DD}." The probe will detect open circuits and will identify deadband, that is, there is no display for logic levels from 30% to 70% of V_{DD}.

Input impedances are greater than 10 megohms at either logic low or high and "on a test bench setup, we're able to capture pulses of 100 nanoseconds in duration, independent of rise and fall times, for a frequency response of about 9-megahertz bandwidth," Barth says. Internal circuitry, including two RCA COS MOS chips and a handful of discretes, stretches narrow pulses to 200 milliseconds for display.

The probe clips onto the appropriate power pins and derives its power from the system under test. Current drain is 20 milliamperes in standby; maximum drain for full display is 140 mA. Kurz-Kasch plans an all-solid-state LED version, the LP-575, featuring a total maximum drain of 30 mA under full display conditions, at some sacrifice in display. Both probes are protected for lead reversal and overvoltage.

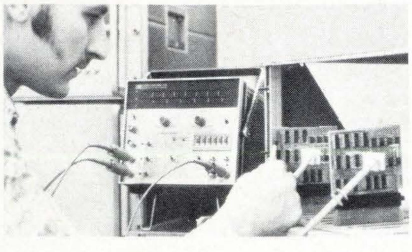
The insulated probe, which is magnetically shielded, is ⅝ inch in diameter by 5¾ in. long, with a test-probe tip 0.08 in. in diameter, tapering to a needle point. The firm offers a series of probe adapters for various wire-wrap configurations. Power leads are 26¾ in. long and are terminated in miniature alligator clips.

The LP-570, available June 15, will sell for about $80, and the LP-575 will be in stock 60 days later at about $90.

Kurz-Kasch Inc., 2876 Culver Ave., Kettering, Ohio 45429 [351]

Analyzer displays logic states in real time

The oscilloscope is the time-honored tool for displaying analog waveforms for examination. For digital waveforms, however, it leaves something to be desired. How, for example, does one examine the



343,929th bit of a digital data stream on an oscilloscope? Or how does one examine the bits immediately preceding an error condition if one doesn't know where in the bit sequence the error occurs?

One answer to these problems, and many others that involve the display of digital logic states vs time, is Hewlett-Packard's 5000A logic analyzer. Loosely speaking, the analyzer is the digital equivalent of an oscilloscope. Instead of an internal time base, it uses the master clock of the system under test, so it displays logic levels as functions of clock intervals—regardless of the actual repetition rate of the clock.

The analyzer's analog of a scope's vertical axis is a pair of inputs that are connected, through high-input-impedance amplifiers, to two rows of 32 light-emitting diodes. After receiving a trigger signal, the analyzer uses the clock input to strobe the data inputs and display their logic states on the LED arrays. A turned-on LED indicates a logic 1, a turned-off LED indicates a logic 0.

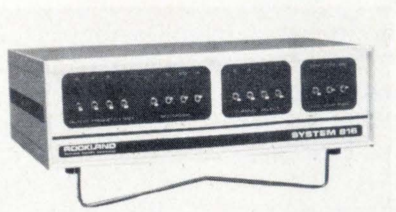
To examine a 32-bit sequence far downstream from the trigger input, the analyzer is equipped with a delay register that acts like an oscilloscope's delay generator except that it counts clock periods instead of time. And, because the analyzer is constantly monitoring and storing the input data while waiting for a trigger signal, it can display the 32 bits preceding the trigger—if the user wants to examine the events that led up to a particular error condition, for example.

The analyzer's voltage threshold levels are adjustable to make it compatible with all popular logic levels—RTL, DTL, TTL, HTL, ECL, MOS, and C-MOS. Input impedance of the basic instrument is 1 megohm in parallel with 25 pF. Divider probes can raise it to 10 megohms in parallel with 10 pF. Maximum system clock rate is 10 MHz.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. 94304 [352]

Programable filter system handles up to 16 channels

A programable multichannel analog filter system is meant primarily for band-limiting signals prior to sampling and a-d conversion. Up to



16 filter channels with cutoff frequencies from 10 to 150 kilohertz are provided. Roll-off is 48 decibels per octave.

The standard Butterworth low-pass configuration of the System 816 can be altered to high-pass, making it possible to form bandpass and band-reject filters by cascading two channels.

The system mainframe is priced at $750. Each filter card costs $650. Deliveries begin in June.

Rockland Systems Corp., 230 West Nyack Road, West Nyack, N.Y. 10994 [401]

Electrolytic recorder has 128-kHz bandwidth

When standard facsimile recording techniques are combined with an array of 512 individually addressable fixed recording styli, the result is a chart recorder that adds high speed to intensity modulation. The model 200 electrolytic recorder offered by ITT Electro-Physics Laboratories Inc. has a passband extending from dc to 128 kilohertz, an input resistance of 3.3 kilohms, and an all-electronic, adjustable sweep-control system. Sweep rates can be varied from 500 microseconds per inch to 200 milliseconds per inch in 10 overlapping ranges.

The 512 fixed recording styli are spaced over an 8-inch recording span at a uniform density of 64 to the inch. Each stylus is powered by an individual driver circuit, which weights the marking current proportional to the input voltage. This configuration gives the recorder a great deal of flexibility. It can, for example, be used in radar imaging applications with radar range measured along the X-axis, return signal strength plotted as intensity, and time measured along the Y-axis. It can also record the spectrum analysis of a comb-filter response.

ITT Electro-Physics Laboratories, Inc., 9140 Old Annapolis Road, Columbia, Maryland 21045 [340]

Frequency counter measures from 5 Hz to 220 MHz

The model 151A is a small crystal-controlled frequency counter capable of measuring from 5 Hz to 220 MHz. The counter provides display storage with a memory circuit that

holds the prior count as a new one is being made. Display is a seven-digit LED array with a built-in self check and a half-life reliability of 100 years. The unit is equipped with two inputs, selectable by a dc switch on the sensitivity pot mounted on the front panel. Gate time choices of

100 ms and 1 s are available. The 151A is 4½ in. wide, 2 in. high, and 8½ in. deep. Price is $795, and an optional 10-hour battery pack with charger is priced at $200.

United Systems Corp., a Subsidiary of Monsanto, 918 Woodley Rd., Dayton, Ohio 45403 [353]

Component tester handles to 1,000 units per hour

A components tester for incoming inspection, laboratory, or assembly line is used for measuring, matching and rejecting components. Designated the E-2 comparison bridge, the unit allows about 0.1% error and handles up to 1,000 components per hour.

Hathaway Industries, Box 45381, Southeast Station, Tulsa, Okla. [354]

Transmission level tester works from 50 Hz to 15 kHz

The model 420 transmission-line test set weighs 35 pounds and is designed for easy operation. The instrument measures return loss, attenuation, impedance, frequency response, and noise. Test results are displayed on a built-in oscilloscope. Features include swept or single frequencies from 50 Hz to 15 kHz, stepped attenuation control on both transmitter and receiver, and lighted display grid. Price is $1,995. A

noise-measuring option is priced at $345.

Wavetek, Box 651, San Diego, Calif. 92112 [355]

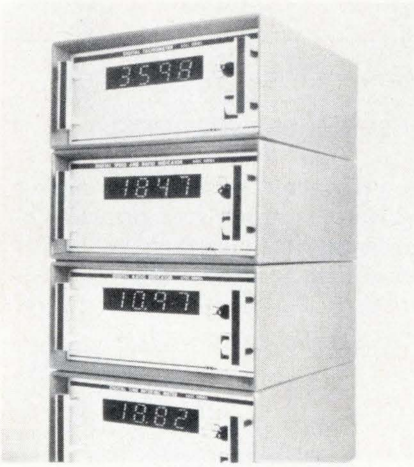
Frequency response analyzer covers 0.005 Hz to 10,000 Hz

Measuring amplitude ratio in decibels and phase shift in degrees, the model 911A-DS single-channel frequency-response analyzer covers the range of 0.005 to 10,000 Hz, with over 100:1 rejection of noise and harmonics. The unit can sweep frequencies and simultaneously plot the amplitude ratio and phase shift versus log frequency.

Bafco Inc., 717 Mearns Rd., Warminster, Pa. 18974 [356]

Modules measure ratio, rate, time interval

A digital line of rate, ratio and time-interval measurement indicators in modular packages provides the user with the functions required to speed

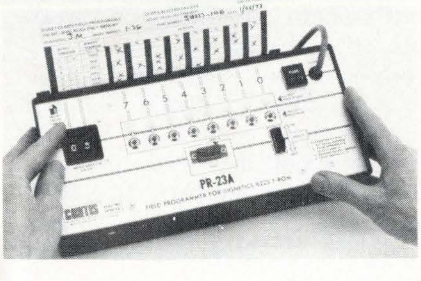


up machine operation without great expense. Units are available with speed readout or ratio readout or both. Other units provide time interval or speed difference or draw indication. Applications include counting parts per minute and cycle times.

Dynapar Corp., 1675 Delany Rd., Gurnee, Ill. 60031 [358]

ROM programer built for Signetics 256-bit device

A portable field programer for the Signetics 8223 256-bit field-programable ROM is called the PR-23A



and allows manual programing of the Signetics device in the laboratory or in the field. To program one, the operator places a blank device in the test socket, selects the proper octal word address, and presses one of eight output push buttons to open the selected fusible link. The program sequence is automatic and independent of operator timing, to ensure uniform program conditions. A typical pattern can be programed in about five minutes. Price of the programer is $199.50.

Curtis Electro Devices Inc., Box 4090, Mountain View, Calif. 94040 [359]

Packaging & production

Test system is modular

Programable checkout isolates faults in cards, LSI arrays, and subsystems

Equipment manufacturers seeking a low-cost programable tester may find it in the Data Test Corp. model 570, which will be introduced at the National Computer Conference, June 4 to 8, at the Coliseum in New York City. The model 5700 isolates faults in mixed-logic cards, screens LSI arrays, tests cables, and exercises such subsystems as line printers, disk memories, and chip sets.

The minimum version tests TTL, DTL, and low-voltage MOS with pulse patterns generated by a 40-line code generator at rates to 2 megahertz. The test program, loaded manually into a 1,024-word memory, runs 128 drive, sense, and power-supply-pin circuits. This version costs about $18,000.

Testing capability can be added modularly to a capacity of 16,384 words of memory, a maximum of 1,024 pins, pin circuits to test ECL and other devices, a dozen programable power supplies and instruments, a tape-cassette reader for bulk program storage, and a minicomputer. Computer options include an on-line Nova, a Nova time-shared by several testers, and a modem through which any computer can be time-shared.

If a computer isn't used, the console displays fault signatures to indicate which outputs of the device under test were false during an exercise sequence. A fault-signature dictionary lists the predictable signatures and their causes. Data Test says that about half of all faults found in typical logic assemblies can be identified by signatures.

Unpredictable faults are isolated manually by attaching test probes to the device in the assembly, exercising the unit, and counting pulse transitions at each node. The operator simply probes back along the path from the faulty output until the probe head displays a count that matches a count recorded at the same node when a good unit was exercised during a setup run.

A computer will make these comparisons automatically. It can also be programed to guide placement of the probes by the operator, make discrete tests, and test internal nodes through the probe head. The latter method is used when nodes cannot be fully tested through the normal input-output pins.

Testing can be simplified by a cylindrical test head that rotates through a 120° arc. A board plugged into the head can be flipped between a lap position, handy for probe attachment, and an easel position for inspection of wiring under the board. Most malfunctions in board assemblies are caused by solder bridges, which can be removed in the easel position while the operator checks to make sure the removal clears the malfunction.

Two test heads may be used to test large boards with two edge connectors. If one head is put atop the cabinet and rotated down to face the one in the cabinet, the board can be checked in the easel position.

Data Test supplies test-executive, assembly, encoding, and setup programs with computer-controlled configurations of the system.

Data Test Corp., 822 Challenge Dr., Concord, Calif. 94520 [391]

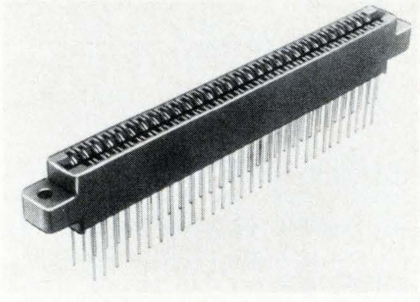
Programable solid-state load dissipates up to 1,000 W

Working in a constant-current mode to test dc power regulators, a programable solid-state load dissipates up to 1,000 watts in the voltage range of 2 to 50 V dc and a maximum current of 110 amperes when derated per the power-dissipation curve. If higher current-level testing is desired, units can be hooked up in parallel. There are two modes of operation: constant-current and constant-resistance, which can be used independently or with one as a limit for the other. The two modes have amplifiers and control circuitry that are coupled in parallel.

Acme Electric Corp., Cuba, N.Y. 14727 [394]

Connector series designed for solderless wrapping

For programed solderless wrapping applications, 0.100-grid printed-circuit-board connectors have 0.025-inch-square terminals. The connectors are designed to be inter-



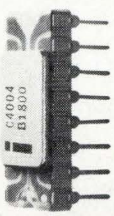
changeable with commonly used components. The series 186-295 units are available in position sizes 5/10 through 60/120, and have a low-contact-resistance bifurcated bellows-form contacts.

Methode Electronics Inc., 7447 W. Wilson Ave., Chicago, Ill. 60656 [396]

Dual-pin plug requires no patch cords, jumpers

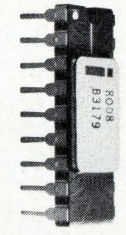
A dual-pin plug for Sealectro's matrix-board programers is available with shorting-type and skip-type pins, which reach selected junctions on multiple decks. The unit permits rapid connection between buses without the need for patch cords or wired jumpers. The modules are secured in place by detent-type pins, which are silver-plated;

THE MICRO COMPUTERS



Intel's 4004 4-bit central processor typically replaces about 90 TTL MSI and SSI packages. It's the heart of the MCS-4 set of four micro computer devices—which includes a 2048-bit ROM with a 4-bit I/O port, a 320-bit RAM with a 4-bit output port and a 10-port shift register for I/O expansion. They fit together without any interfacing circuitry to make complete systems with 32K bits of ROM and 5K bits of RAM. Using a few simple interfacing devices, you can build much larger systems with up to 96K bits of ROM.

Intel's 8008 8-bit central processor typically replaces about 125 TTL MSI and SSI packages. It's the heart of the MCS-8 micro computer set—which includes standard Intel ROMs, RAMs and shift registers. The central processor can directly address 16,000 8-bit bytes stored in any combination of these memory devices. The processor has interrupt capability, operates asynchronously or synchronously, and can perform as many as seven nesting sub-routines. Systems require some interfacing circuitry.



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8. **Fortran IV Assembler.** Gives you the assistance of any general-purpose computer in developing MCS-4 programs.
9. **Fortran IV Simulator.** Permits any general-purpose computer to simulate the micro computer you are designing.
10. **Users Manual for MCS-4.** This 176 page manual tells you all you need to know to use MCS-4 components successfully.
11. **Library of Programs.** Contributed by users, free to users.

FOR MCS-8™ SYSTEMS

1. **Prototyping Board, SIM8-01.** Forms operational microprogrammed computer with Intel's erasable PROMs in place of mask-programmed ROMs. Holds up to 16k bits of PROM and 8K bits of RAM.
2. **PROM Programmer, MP7-03.** Intel erasable PROMs plug into this board for programming using a teletypewriter.
3. **SIM8 Hardware Assembler.** Eight PROMs plug into SIM8 board, enabling the prototype to assemble its own programs.
4. **System Interface and Control Module.** Interconnects all other support hardware and a TTY for program assembly, simulation, PROM programming, prototype operation, and debugging. Intel MCB8-10.
5. **Chip-Select and I/O Test Program.** On PROM which plugs into prototyping board, Intel A0801.
6. **RAM Test Program.** On PROM that plugs into prototyping board, Intel A0802.
7. **Bootstrap Loader.** Enables you to enter data or a program into the RAMs from a teletypewriter paper tape or keyboard, and execute the program from the RAMs. Consists of three PROMs (A0860, 861 and 863) that plug into the prototyping board.
8. **Fortran IV Assembler.** Gives you the assistance of any general-purpose computer in developing MCS-8 programs.
9. **Fortran IV Simulator.** Permits any general-purpose computer to simulate the micro computer you are designing.
10. **Users Manual for MCS-8.** This 128 page manual tells you what you need to know to use MCS-8 components successfully.
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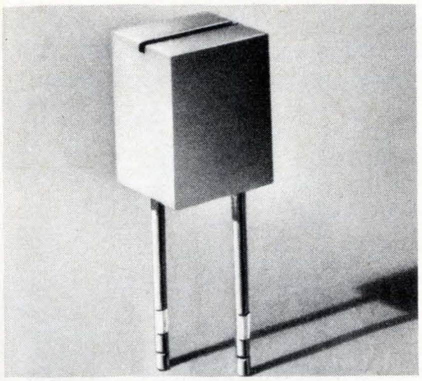
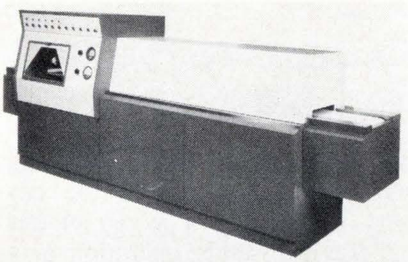


gold is available on special order.
Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543 [397]

Conformal coater for pc boards has two nozzles

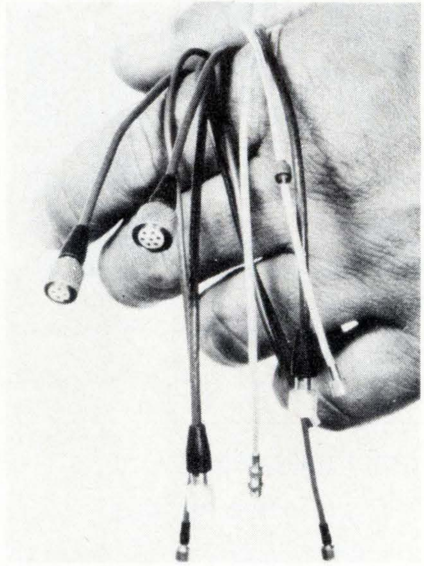
An automated self-cleaning spray unit applies conformal coatings on assembled printed-circuit boards. Two reciprocating nozzles are angled to coat evenly around components. Circuits travel on a paper



throw-away conveyor, which unrolls from the loading end and is rerolled at the unloading end. An air-dry process follows the spraying application to level and drive off fast solvents.
In-line Technology Inc., 30 Mill St., Assonet, Mass. 02702 [399]

Multicontact connectors have hermetically sealed mounts

A line of ultraminiature 4-, 7-, and 12-contact connectors features hermetically sealed panel mounts and are designed for applications in high-density packaging, aerospace systems, integrated circuits, instrumentation, transducers, and medical equipment. Simplified assembly is also a feature, made possible with factory-preassembled parts requir-



ing a minimum number of operations. Price is as low as $2.75 in quantities over 1,000.

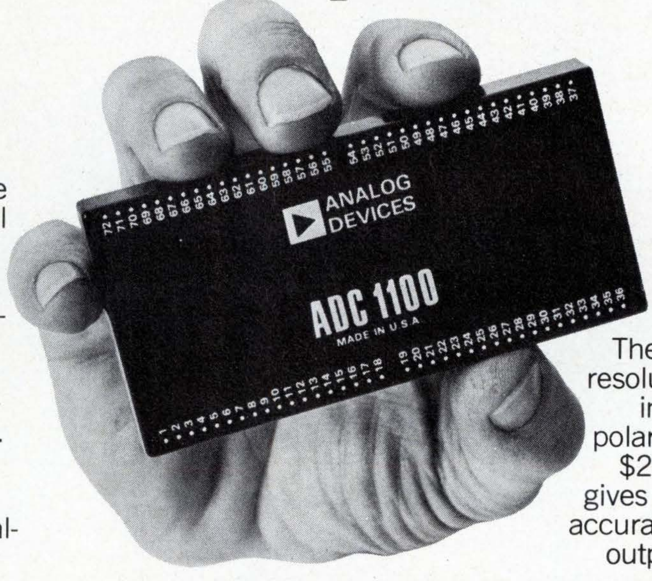
Microtech Inc., 777 Henderson Blvd., Folcroft, Pa. 19032 [398]

Console provides both stereo plotter, digitizer

A digitizer console, called the model GDC/5000, combines all the circuitry needed for a stereo plotter and digitizing table operation in a single cabinet. The unit consists of an alphanumeric keyboard, verifier, three-axis display, fixed address, three axes preset, utility counter, and magnetic-tape unit. Four modes of operation are possible.

Instronics Inc., Bridge Plaza, Ogdensburg, N.Y. 13669 [400]

And here's another of our low-cost solutions to your conversion problems.



This 5-volt A/D converter gives you dual-slope noise immunity and BCD-plus-sign output for only $67/100's. The ADC1100.

If you're converting for a remote display, or if you've got a special display requirement, this converter was made for you.

Maybe you're timesharing a display with several data sources. Or rescaling the converter output to display pounds, gallons, rpm, or other engineering units. Or using a special display you designed yourself.

Then meet the ADC1100. A dual-slope converter with a 3½-digit BCD-plus-sign output and automatic zero correction. It'll give you normal mode rejection of 40dB (up to 120dB with a phase lock loop circuit). Plus 5VDC operation and guaranteed monotonicity. And the ADC1100 is equally well suited for feeding a computer.

That's an awful lot for only $67 in 100's. ($99 in singles.)

But after all, we're the people who wrote the book on converters. So you expect a lot from us.

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Two high-resolution, high-accuracy, A/D converters that can save you time and money. Both with parallel and serial outputs, both with user-selected input ranges. The ADC10Z has 10-bit resolution and accuracy, 20 μsec (max) conversion time, for $67 in 100's. The ADC12QZ converts in 40 μsec (max), gives you 12-bit resolution and accuracy—$92 in 100's.

Two low-cost general-purpose D/A converters. The DAC10Z provides 10-bit resolution and accuracy, built-in IC output amplifier, unipolar or bipolar outputs—only $27 in 100's. The DAC12QZ gives you 12-bit resolution and accuracy and five user-selected output ranges for only $47 in 100's.

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Analog Devices, Inc., Norwood, Mass. 02062

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21303

Subassemblies

Hybrid design shrinks converter

Synchro-digital devices also consume a third less power than discrete designs

Applying hybrid-circuit technology, ILC Data Device Corp. has produced a line of synchro converters that are dramatically smaller and consume far less power than discrete-component equivalents. Data Device's new H-series is a tenth the size of the modules in its conventional A-series line. And power consumption is reduced by two thirds—to less than 1 watt for a complete synchro-to-digital converter channel.

Both tracking synchro-to-digital and digital-to-synchro converters, using the same type II servo-loop approach as in the A-series, are available. The s-d converters come with 14- or 16-bit resolution, resulting in accuracies of ±5.3 minutes and ±1 minute respectively. Parallel digital output voltage levels are compatible with diode-transistor and transistor-transistor logic.

Input rates for the 14-bit converter can vary to 1,440° per second with full accuracy; up to 360° per second for the 16-bit unit. Either positive or negative power-supply voltages can be specified. D-s converters are also available in 14-and 16-bit designs, with worst-case accuracy to within ±4 min.

Five separate hermetically sealed, 24-pin dual in-line modules—measuring 2.2 by 0.6 by 1.5 inches high—are combined to form an s-d converter. The modules consist of most-significant-bit and least-significant-bit function generators, octant switch, error processor, and up-down counter. A solid state Scott-T synchro-input module in a 16-pin dual in-line package is also included. A complete d-s converter can be made up of four of these same modules. Multiplexed hybrid synchro converters are also available.

Operating range for the H series units is -55° to +105°C. And they're supplied to MIL-STD-883, level C requirements; level B qualification is available at extra cost. In addition, the modules meet the dimensional requirements of the standard hardware program sponsored by the Naval Avionics Facility at Indianapolis, points out Stephen A. Muth, product manager for data converters at DDC.

Key to the hybrid design is the availability of complementary metal-oxide-semiconductor chips, he says. Without them, the "circuits would have run very hot and we would have had to divide up the converters into more modules to distribute the power. Or we would have had to rely on different packaging with more heat sinking."

Most difficult was the design of the up-down counter. It's a straightforward circuit, but "it calls for five layers of conductive patterns because of the number of interconnection wires," Muth explains.

Another point he makes is that the hydrid design is easier than the discrete to produce. "There's not as much trimming required on the production line compared with the discrete modules."

Price of the hybrid H-series is relatively high—$1,800 for a complete s-d channel compared to $990 for an A-series unit. But Muth expects the price to come down as volume picks up. Eventually, a channel might sell in the $200 to $300 range.

ILC Data Device Corp., 100 Tec St., Hicksville, N.Y. 11801 [381]

Nine-digit panel display is MOS LSI-compatible

A nine-digit numeric display panel, with ¼-inch-high characters and multiplex operation, interfaces directly with MOS LSI circuits. Planar in configuration, the display is aimed primarily at hand-held and desk calculators. However, it is applicable to a variety of multidigit equipment applications such as frequency counters. The display reads out in orange, and red is available through the use of filters. Price of the panel display is $15.70 in quantities of 1,000.

Sperry Information Displays, Box 3579, Scottsdale, Ariz. 85257 [383]

A-d converter does 4-bit conversion in 40 ns

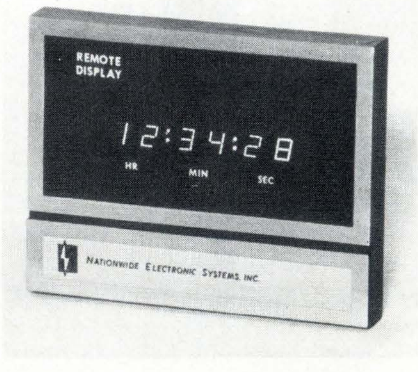
The model ADC-4B25-MHz analog-to-digital converter can be used in video-digitizing, pulse analysis, high-speed data-handling and X-ray analysis applications. The converter is 3 inches wide by 5 inches long by

1 inch deep, and it uses a parallel/serial/parallel conversion scheme. The unit can handle a four-bit conversion in 40 nanoseconds (throughput rate is 25 MHz). Price is $1,250.

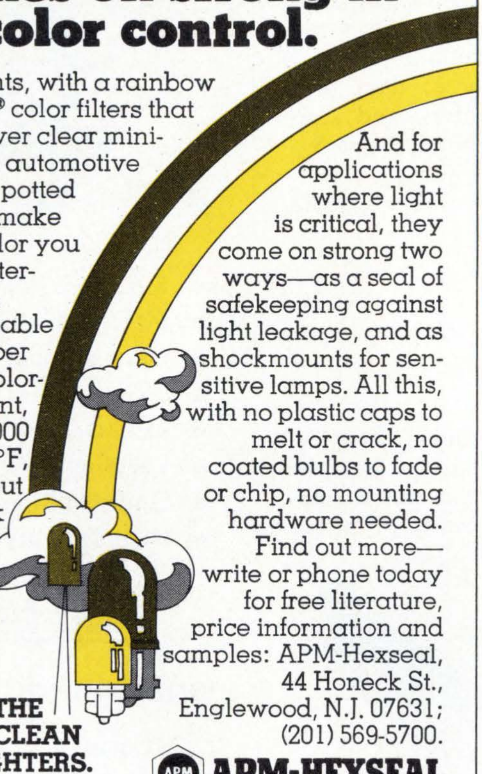
Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021 [384]

Remote display is 9/16-inch thick, mounts on panel

The Slimline remote display provides up to six digits of 0.270-inch-high LEDs from any TTL-DTL source of parallel 1,248 positive true BCD data. The display is 9/16-inch thick



The Color Guard comes on strong in color control.



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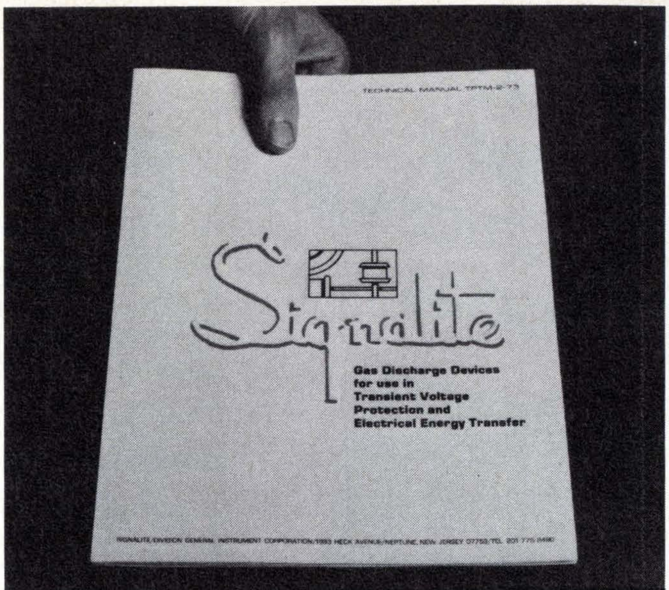

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329

Circle 196 on reader service card

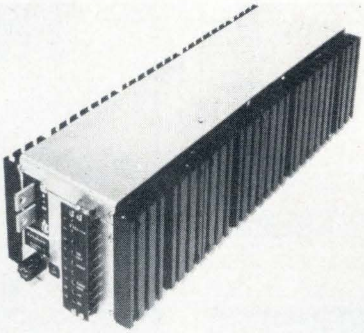
Circle 153 on reader service card

and mounts on the panel so that no space is required behind the panel. The unit is available in a variety of formats for display of data from digital clocks, counters, and stopwatches. Power requirement is 5 V dc ±1% at 300 mA.

Nationwide Electronic Systems Inc., Rte. 53, Itasca, Ill. 60143 [386]

Modular power supply delivers 500 watts

Designed to provide high power levels in space-restricted systems, the 668 series of modular power supplies delivers 500 watts of power



over the operating temperature range of −20°C to +40°C with no moving air required. Efficiency is 70%, and combined line and load regulation is ±0.2%. The model 668A-05 offers 5 volts at 100 amperes output and accepts 102 to 130 V ac or 198 to 256 V ac input without circuitry changes required. Price is $750.

Trio Laboratories Inc., 80 DuPont St., Plainview, N.Y. 11803 [389]

Sample-and-hold module offers low feed-through

With a low feed-through of 1 millivolt maximum for a 20-V step, the model 4853 sample-and-hold amplifier provides an aperture time of ±1 nanosecond. Acquisition time is rated at less than 1 microsecond to 0.01%. Applications include multichannel data-acquisition and distribution systems, pulse stretchers, d-a and a-d converters, and digitally controlled process-control systems.

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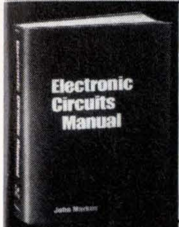

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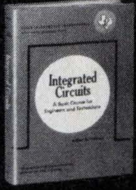

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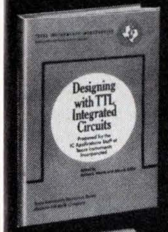

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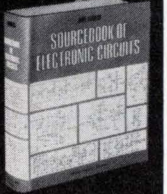

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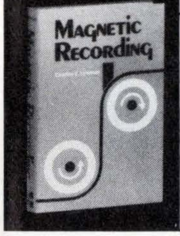

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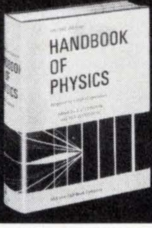

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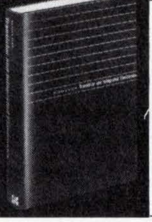

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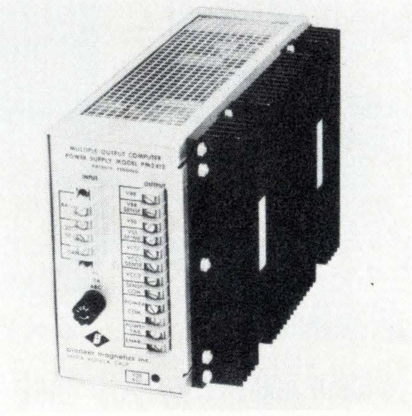
New products

Price is $125 each in small quantities, and this drops to $99.50 in 100-lots.

Teledyne Philbrick, Allied Dr. at Rte. 128, Dedham, Mass. 02026 [385]

Uninterruptible power supply is for volatile memory systems

Aimed at volatile semiconductor memory-systems applications, an uninterruptible power supply is part of the PM 2400 line of OEM multiple-output computer power supplies. The model 2412 is a 140-watt

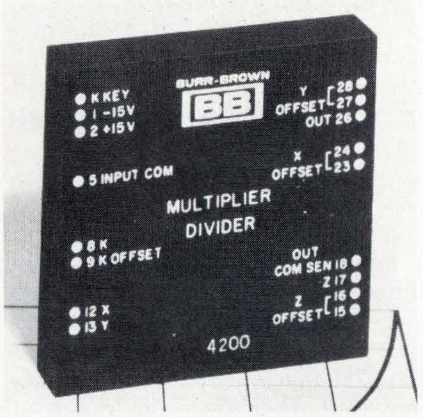


convection-cooled converter that provides power for up to 32,000-word-by-18-bit or 65,000-by-9 MOS RAMs at worst-case temperatures. The unit furnishes no-break power over power outstages of 20 milliseconds or longer.

Pioneer Magnetics Inc., 1745 Berkeley St., Santa Monica, Calif. 90404 [388]

Analog multiplier has accuracy to within 0.1%

The model 4200 pulse-modulation analog multiplier provides an untrimmed accuracy guaranteed to within 0.2%, and external trimming improves this specification to within a guaranteed 0.1%. Maximum total error drift over the full operating temperature range of −25°C to +85°C is 0.02%/°C and 0.005%/%

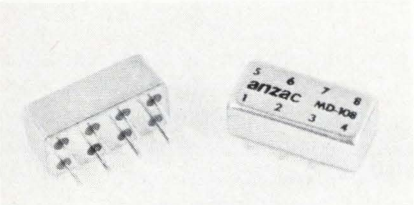


supply change. The unit features an absolute maximum input rating of ±30 volts, and rated output is ±10 v at ±5 milliamperes minimum. All semiconductors in the multiplier are hermetically sealed to ensure reliability. Small-quantity price is $129.

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706 [387]

Low-priced double-balanced mixer is broadband

Priced at $7 for a single unit, the model MD-108 broadband double-balanced mixer is packaged in a subminiature, eight-pin, relay-header configuration. The unit pro-



vides local-oscillator and rf port bandwidths of 5 to 500 megahertz and an i-f port bandwidth of dc to 500 MHz. Conversion loss is 7.0 dB maximum from 5 to 150 MHz and 9.0 dB maximum from 150 to 500 MHz. The unit can be microstrip- or stripline-mounted.

Anzac Electronics, Division of Adams-Russell, 39 Green St., Waltham, Mass. [389]

New products/materials

A two-part gold epoxy, designated Epo-Tek H-81, is for chip bonding in microelectronics applications. Conductivity rating is from 0.0005 to 0.0009 ohm-centimeter. The material cures in five minutes at 150°C, 15 minutes at 120°C, or 90 minutes at 80°C. Pot life is two days, and shelf life is a minimum of two years. Price is $80 for a ½-ounce evaluation kit.

Epoxy Technology Inc., 65 Grove St, Watertown, Mass. 02172 [476]

A family of laser-trimmable thick-film resistor compositions, called the Certi-fired 1300 series, has a thermal resistance coefficient of less than 250 parts per million per degree centigrade over the range of −55 to +125°C. Trimmed resistors drift less than 1% in sheet resistivities, and individual compositions can be blended to obtain resistivities intermediate to the six values offered.

DuPont Co., Wilmington, Delaware [477]

Ultra-Bond 52 is a single-component 3,000°F alumina-base adhesive with the ability to bond to ceramics and metals, such as stainless steel, aluminum, and copper. The material comes in a premixed paste and can be used after drying at room temperature. It works in almost any atmosphere, including hydrogen, and has a dielectric strength of 250 volts per mil. Price is $25 per pint or $40 per quart.

Aremco Products Inc., Box 145, Briarcliff Manor, N.Y. 10510 [478]

Encapsulation of semiconductor and solid-state devices without the use of a junction coating to separate the device from the encapsulating medium is provided by Eccomold 4119 and 4125 molding powders. This is possible because the materials exhibit low ionizable extractables in water, thereby eliminating corrosion of the devices while providing a moisture seal, and mechanical and thermal protection. Material 4119 is priced at $1.70 a pound and 4125 at $1.94 a pound in 2,500-pound lots.

Emerson & Cuming Inc., Canton, Mass. [479]

New literature

D-a converters. Cycon Inc., 1080 E. Duane Ave., Sunnyvale, Calif. 94086. Series 9 digital-to-analog converters are described in a four-page catalog that provides technical specifications and applications information. Circle 421 on reader service card.

Printed-circuit assemblies. Ansley Electronics Corp., Old Easton Rd., Doylestown, Pa. 18901, has issued a data sheet describing Free-Flex flexible printed-circuit assemblies. [422]

Recording systems. Bulletin 1250H from the Brush Division, Gould Inc., 3631 Perkins Ave., Cleveland, Ohio 44114, is an eight-page publication on analog and digital recording systems for industrial, medical, military, and scientific applications. [423]

Data systems. A 12-page technical brochure describes the H4200-series digital data system available from Howell Instruments Inc., 3479 W. Vickery Blvd., Fort Worth, Texas. 76107 [424]

Strip printer. Facit-Addo Inc., 501 Winsor Dr., Seacaucus, N.J. A data sheet provides design and technical data on the model 4552 alphanumeric strip printer. [425]

Indicating devices. Condensed data and specifications on elapsed-time indicators, events counters, fault indicators and stop clocks are contained in four-page bulletin MR-102-R3 from North American Philips Controls Corp., Cheshire, Conn. 06410 [426]

Thermal cutoffs. A family of thermal cutoffs for backup protection in electronic devices is described in a 12-page brochure from the 3M Co., Box 33600, St. Paul, Minn. 55133. The brochure gives capabilities and performance characteristics, as well as applications notes. [427]

Epoxy compounds. Two epoxy compounds having low coefficients of thermal expansion are described in a data sheet from Bacon Industries Inc., 192 Pleasant St., Watertown, Mass. 02172 [428]

Data set. Tele-Dynamics Division, Ambac Industries, 525 Virginia Dr., Fort Washington, Pa. A 1,200 bit-per-inch data set is described in a two-page product bulletin that provides specifications and operations information. [429]

Time-code formats. A handbook on time-code formats with detailed information on the 22 most common time codes is available from Moxon Inc., SCR Division, 2222 Michelson Dr., Irvine, Calif. 92664. Reference time, typical time frames, index count, index markers, and other data pertinent to each time code is provided. [430]

Switches. Oak Industries Inc., Switch Division, Crystal Lake, Ill. A bulletin describes the operation, specifications, and pricing of the illuminated and nonilluminated push-button-switch lines. Engineering specifications, performance data, line drawings, photographs, and a lens selection guide are included. [431]

Control transmitter. The electrical outputs of a synchro or resolver-control transmitter that can be simulated by the SS and RS series of synchro standards and resolver standards are described in data bulletin SRT-6 available from Singer Instrumentation, 2311 S. La Cienega Blvd., Los Angeles, Calif. 90016 [432]

Line-printer subsystem. Custer Research Inc., Box 305, Fleetwood, Pa. A lineprinter subsystem for the HP 2100 series processors is described in a product bulletin. [433]

Power-supply line. Lambda Electronics Corp., 515 Broad Hollow Rd., Melville, N.Y. 11746. A 196-page catalog and handbook details the company's power-supply line and includes a section on power-supply applications. The book also includes information on power components, power kits, power instruments, and applications. [376]

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