VOL. 19 NO.

Electronic Design 12

FOR ENGINEERS AND ENGINEERING MANAGERS

JUNE 10, 1971

It's a tough year in Europe and in Britain, with sluggish sales, slowed R&D, fewer new product announcements and increasing competition from Japan. Heavily committed to exports, European electronic firms seek to expand their markets through common standards, the EEC and strong expansion abroad. See page 22.

Introducing: "The Portables" from HP

The 1707A—Fastest in Its Class

If you're looking for speed in a $2000 portable scope, then the new dual-channel HP 1707A is your baby. It gives you 75 MHz bandwidth (<4.7 ns risetime)—more than any other scope in its class. And you get 10 ns/div sweep speed, delayed sweep, and 10 mV/div over the full bandwidth. With this capability, you can measure T^2L or ECL pulse timing and propagation delay. Yet the 1707A costs only $1925.

And, you get this performance in a truly portable scope. The 1707A weighs only 24 lbs. And it can be powered from an internal, rechargable battery pack ($200)—or from any dc source from 11.5 V to 36 V, as well as any standard ac outlet.

Its low power requirement not only allows battery operation—but also eliminates the need for fans, or even dust-admitting vent holes. And although the 1707A is small and light, you still get a large 6 x 10 cm CRT viewing area—larger than competitive scopes. Compare the display brightness, too!

If you need even more measurement capability, a $125 option gives you our "lab package" which includes mixed sweep, calibrated delay, and external trigger input for delayed sweep. It also includes external horizontal input, and cascading capability at reduced bandwidth. (How's that for a bargain?)

Our new 1700 Series of portable scopes begins as low as $1680—for the dual-channel, 35 MHz 1700A (<10 ns risetime). Add delayed sweep, and you've got our 1701A, for only $1800.

The philosophy behind the 1700 Series is simple—providing the maximum in useful capability per dollar. The 1700A, 1701A, and 1707A offer wide flexibility, giving you everything you need for digital field service work. And they won't cost you a fortune. Compare them with anyone's competitive models—prove to yourself that the HP 1700's are the best values in portable scopes today.

For further information on "The Portables"—HP's new 1700 Series scopes—contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland. *Option 020 Shown. HP's lab version of the 1707A, $2050.

Scopes are changing.
Are you?

081/12A

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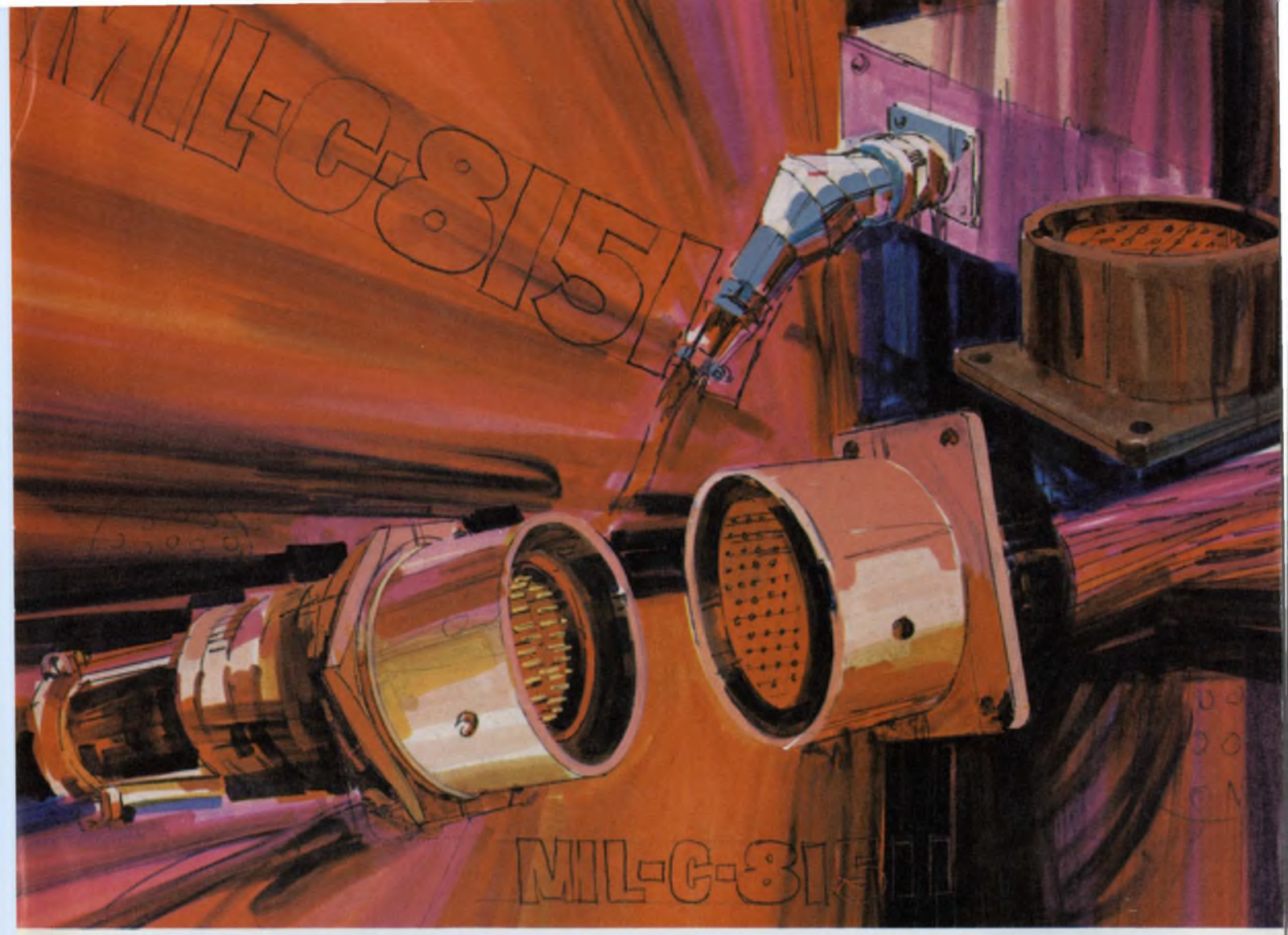

AT CINCH-NULINE WE DON'T REST ON OUR QUALIFICATIONS*

Cinch-Nuline works tirelessly to be sure its MIL-C-81511 connectors exceed the specifications. We are continually improving our material standards, upgrading our manufacturing techniques and inspection procedures. We don't relax—so you can be supplied with an even better connector than you expect!

Maybe that's why our customers are so pleased with the quality record of Cinch-Nuline MIL-C-81511 connectors.

This tri-services approved connector is rapidly becoming the standard for new aerospace programs. If your existing equipment must interface with these new systems, re-designing it to use MIL-C-81511 will solve many problems for you.

For detailed information on these subminiature connectors, contact your nearest Cinch Sales Office, or Cinch-Nuline, a division of TRW Inc., 1015 South Sixth Street, Minneapolis, Minnesota 55415; telephone (612) 339-8301. CN-7160

*Qualified to MIL-C-81511, Revision A on June 30, 1970, to Revision B on July 13, 1970 and to Revision C on March 1, 1971.

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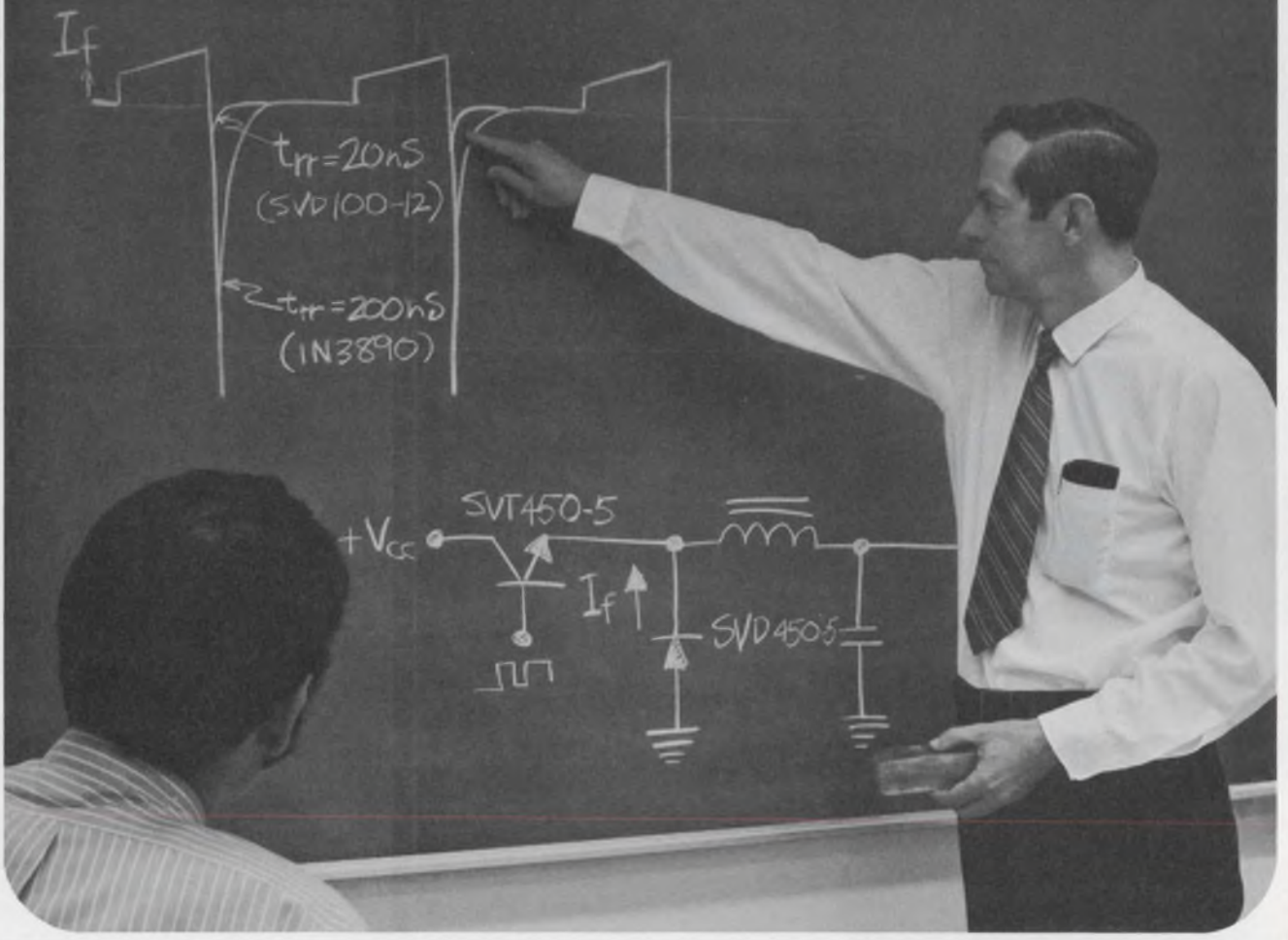

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TRW

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VOL. 19 NO.

Electronic Design 12

FOR ENGINEERS AND ENGINEERING MANAGERS

JUNE 10, 1971

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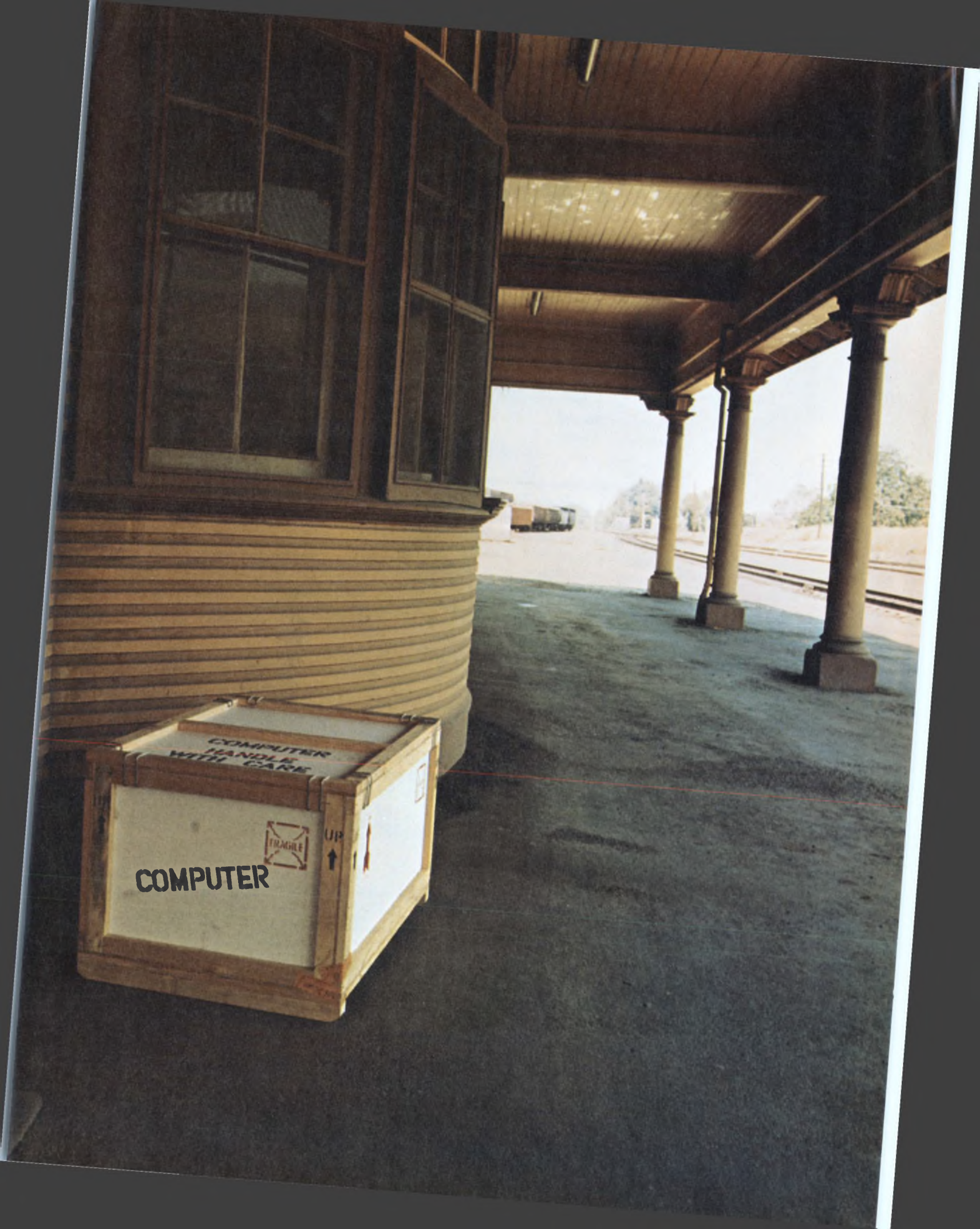
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letters

Some exceptions to LED article

Sir:

Regarding the article "LED: The No. 1 Challenger to Nixies in Digital Readouts" (ED 3, Feb. 4, 1971), I concur with the general tone but must take exception to the assertion that GaP is "potentially cheaper to manufacture [than GaAsP] because liquid phase epitaxy can be used." It is precisely for this reason—liquid phase epitaxy—that GaP will not be cheaper than GaAsP!

Let us examine the technology in making red GaP material:

(1) A GaP substrate must be used, and for this a high pressure, liquid encapsulation Czochralski puller, using pre-synthesized polycrystalline GaP, is used. GaAsP is vapor-grown on a GaAs substrate, which is grown from the elements via a seeded Bridgman technique. GaP single crystal presently sells for about $50/gram (in ingot form) vs less than $10/gram for GaAs. Time is not the cost factor in the growth of epitaxial GaP; cost of substrate is.

(2) The growth of red GaP material involves a two-step liquid epitaxial process for the highly publicized efficiency of this material. The junction is formed in this two-step process. Vapor-phase GaAsP is grown in a one-step process.

Beyond these reasons, it must be pointed out that vapor-phase GaAsP is amenable to conventional planar processes for the fabrication of monolithic displays of LEDs, whereas liquid-phase GaP is not.

For years we have been promised (and threatened) with cheaper, brighter (as opposed to more efficient) red GaP devices and displays. To date, this promise has not been fulfilled. True, claims of one-of-a-kind, highly efficient red GaP devices have appeared in the scientific journals, but no reports have appeared on what can be realized in production quantities of these devices.

Dr. Forrest V. Williams
Manager, Research and Engineering
Electronic Materials Dept.
Monsanto Co.
St. Peters, Mo. 63376

Sir:

One point that I must take issue with is this statement "on the minus side": "When LEDs fail, the display may black out suddenly and completely. Nixies usually fail gradually. The elements put out less and less light once they start to degrade."

The fact is that LEDs do not experience the catastrophic failures inherent with Nixie use, but rather the slow degradation of light output which you attributed to the Nixie. Hewlett-Packard's tests have indicated that the LEDs half-life —that is, the time required for the LED to be only half as bright for a given amount of current—is well in excess of 100,000 hours, probably one quarter to one-half million hours. A 3-dB change in brightness is about the minimum change that the human eye can detect.

Anyone purchasing an instrument with a LED display, such as the HP 3431A Digital Panel Meter, can reasonably expect the display to be fully functional 10 or 20 years from now.

Len Leeb
Field Engineer
Neely Sales Region
Hewlett-Packard
Palo Alto, Calif. 94303

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 850 Third Ave., New York, N.Y. 10022. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.

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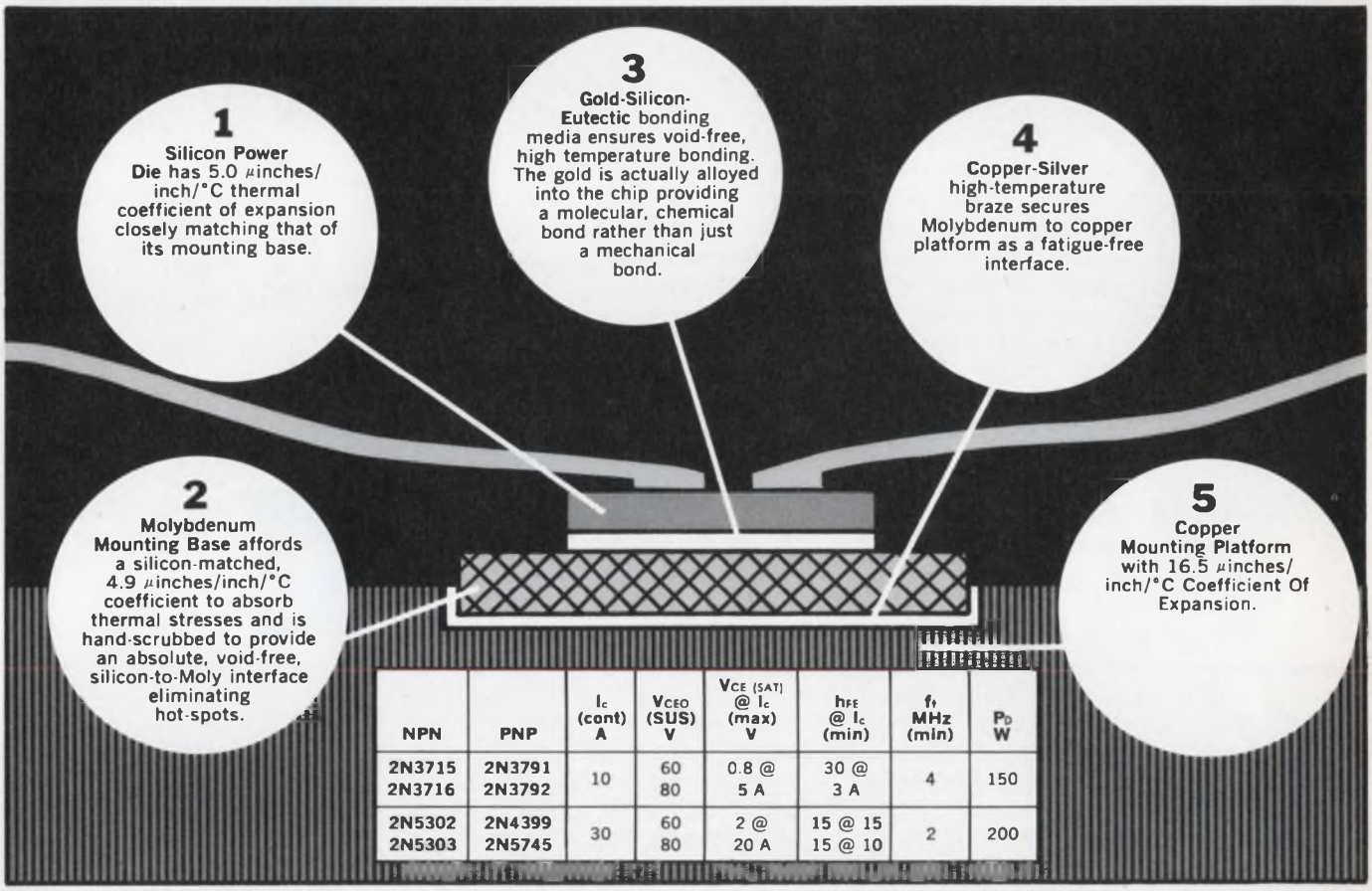

NPN	PNP	I_c (cont) A	V_{CEO} (SUS) V	$V_{CE(SAT)}$ @ I_c (max) V	h_{FE} @ I_c (min)	f_t MHz (min)	P_D W
2N3715 2N3716	2N3791 2N3792	10	60 80	0.8 @ 5 A	30 @ 3 A	4	150
2N5302 2N5303	2N4399 2N5745	30	60 80	2 @ 20 A	15 @ 15 15 @ 10	2	200

To order Hard Solder Construction, add "HS" designation; i.e. 2N3715HS

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. . . unless it's Motorola Hard Solder!

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How good is Hard Solder Power?

Good enough for several hundred, right-off-the-line devices to have shrugged off nearly *two million* device cycles at a ΔT_c of 65°C, P_{on}, P_{off} @ 2.5 minutes each of power cycling . . . with no catastrophic failures.

This figures out to better than a 0.04%/1,000-cycle failure rate — or, a 2.5 million-cycle Mean Time Between Failures!

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designer's calendar

JULY 1971						
S	M	T	W	T	F	S
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July 13-15
International Symposium on Electromagnetic Compatibility (Philadelphia). Sponsor: IEEE. Ralph Showers, Moore School of EE, Univ. of Pennsylvania, Philadelphia, Pa. 19104.

CIRCLE NO. 416

July 20-23
Conference on Nuclear & Space Radiation Effects (Durham, N. H.). Sponsors: IEEE & Univ. of New Hampshire. T. M. Flanagan, Gulf Radiation Tech., P.O.B. 608, San Diego, Calif. 92112.

CIRCLE NO. 417

AUGUST 1971						
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Aug. 17 - 19
Conference on High Frequency Generation and Amplification—Devices and Applications (Ithaca, N. Y.) Sponsors: Cornell Univ. et al. Joseph L. Rosson, Cornell Univ., Phillips Hall, Ithaca, N. Y. 14850.

CIRCLE NO. 418

Aug. 24 - 27
Western Electronic Show & Convention (San Francisco) Sponsors: IEEE, WEMA. WESCON Office, 3600 Wilshire Blvd., Los Angeles, Calif. 90005.

CIRCLE NO. 419

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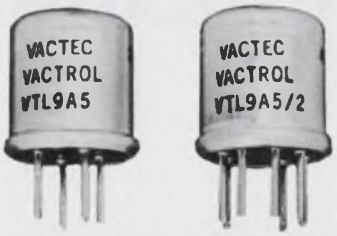

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Maximum cell power	200 mW — derate 4 mW/°C above 25°C — case
Isolation voltage	500V
Thermal resistance — case to ambient	40°C/W
Ambient temperature	—40°C to + 75°C

SPECIFICATIONS @ 25°C

Part Number	LAMP Volts	LAMP mA	PHOTOCELL RESISTANCE — OHMS (3) ON Light Adapted (max)	PHOTOCELL RESISTANCE — OHMS (3) OFF (min)	Cell Volts (max)
INCANDESCENT TYPES					
VTL9A1	1.5	50	400	10^7	100
VTL9A2	6.0	40	60	10^7	100
VTL9A3	10	14	250	10^7	100
VTL9A4	10	22	300	10^7	100
VTL9A5	10	22	1500	10^7	200
VTL9A9	6.0	40	200	10^7	300
VTL9A10	10	14	800	10^7	300
VTL9A11	12	25	600	10^7	300
NEON TYPES EXTERNAL RESISTOR REQUIRED					
VTL9B6	125 VDC*	1.5	300	10^6	200
VTL9B7	125 VDC*	1.5	800	10^7	300
VTL9B8	80 VDC*	.3	2000	10^7	300

*Breakdown V.

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Buy them all from WESTON.

For samples or complete details on any or all of these units, call 717-876-1500, or write Weston Components Division, Archbald, Pa. 18403, *a Schlumberger company*.

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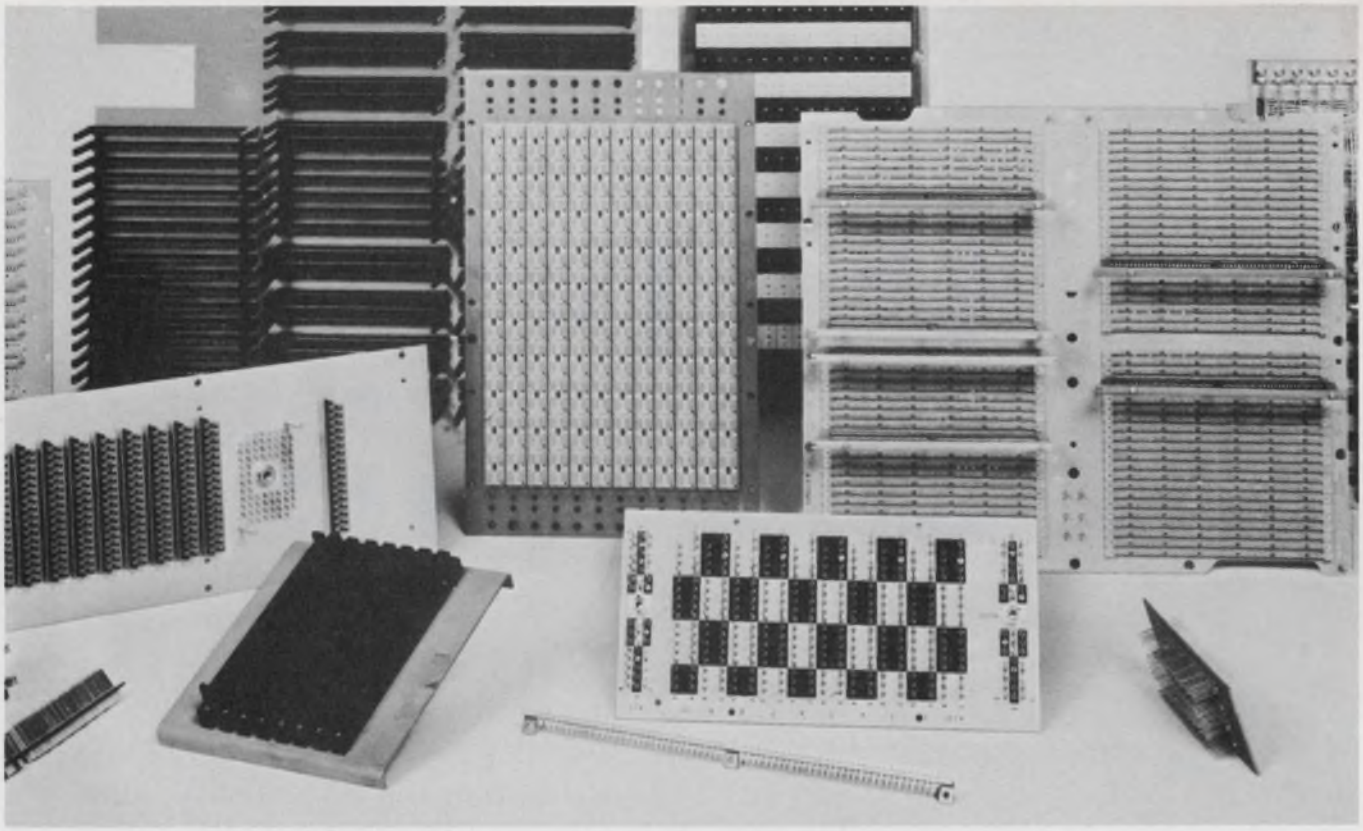

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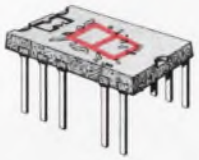

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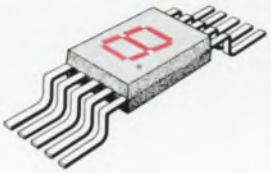

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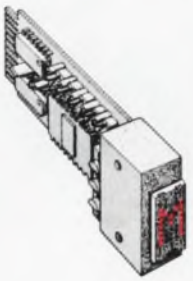

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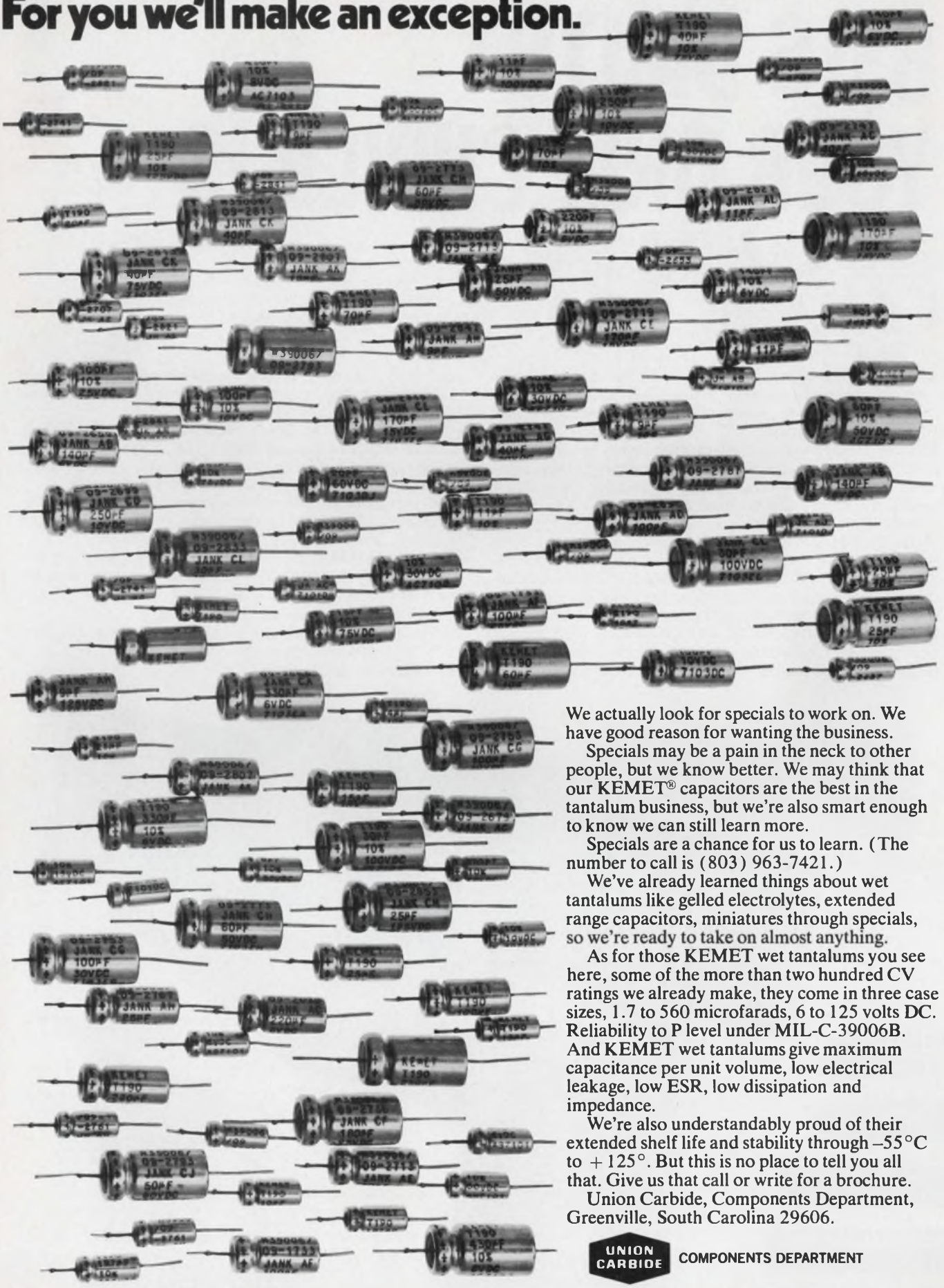

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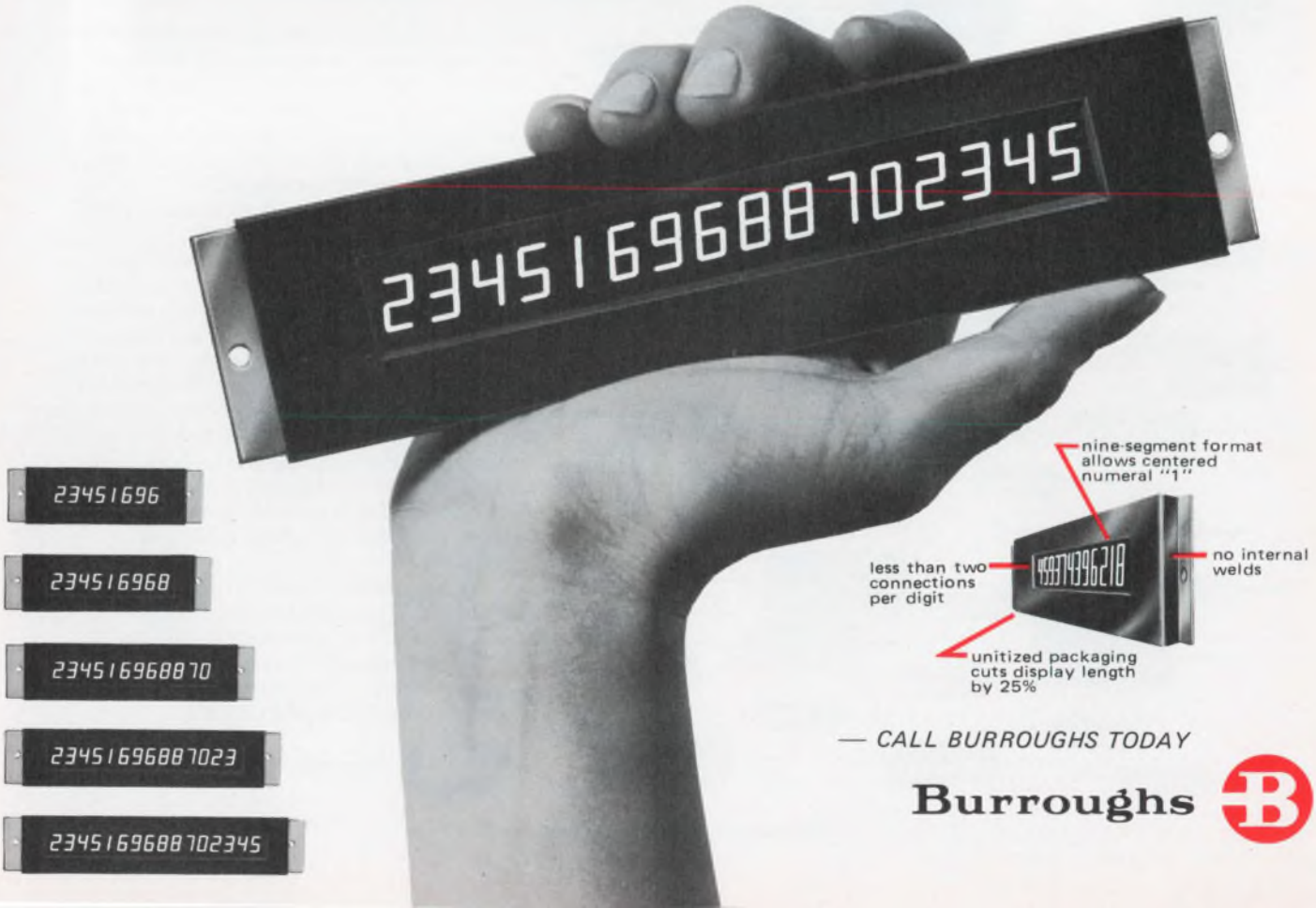

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news scope

June 10, 1971

Industry is cautioned U.S. won't bail it out

Electronics industry executives who are hoping for a massive Government program to compensate for NASA and Defense Dept. cutbacks are likely to be severely dissappointed, according to Walter H. Hinchman of the President's Office of Telecommunications Policy.

Speaking at the 1971 IEEE International Microwave Symposium in Washington, D. C., Hinchman characterized the space-exploration and national-security problems faced in the 1960s as external, and thus amenable to solution by a large, well-organized central authority. In the 1970s, he feels, the nation's primary concerns will be with internal problems, such as mass transit, crime and pollution. These problems, he explained, are best attacked on a local and regional level. In other words, Hinchman feels, the problems of the 70s will be solved by thousands of small decisions made by a variety of perhaps nontechnical personnel.

The recent NASA and defense cutbacks, Hinchman asserted, hurt the electronics industry in two ways: by cutting off "half" of the Government market and by leaving manufacturers with a specification-oriented attitude. In the 60s, he explained, industry was encouraged simply to meet a set of product specifications; the Government agencies did the systems work and worried about the end service.

In the 70s, Hinchman went on, the user will not be so sophisticated. He will simply have a problem—not a set of specifications. The company that prospers, therefore, will be the one that is service, not product, oriented.

"The major challenge facing the electronics industry now." Hinchman said, "is to take the technological advancements of the 60s and convert them into the marketable services of the 70s.

Solid-state clock solves battery-drain problem

Light-emitting diodes have made possible the design of timepieces without moving parts, but the power drain on batteries has posed problems. A new concept announced by Motorola offers a solution in a no-moving-parts clock that displays time continuously.

Two circles consisting of 72 light-emitting diodes make up the face of the clock. The outside circle has 60 diodes and marks the seconds and minutes. Each second or minute is marked by an apparently moving red light as the circuit switches power to the appropriate diodes in sequential fashion. The inside circle of 12 diodes marks the hours in the same fashion. With this arrangement, only three diodes are turned on at any one time. And with only two small batteries, the clock will run for a year.

Light-emitting diode clock has a face made of 72 diodes, arranged in two concentric circles. Two small batteries can operate the clock for at least a year, with the clock face displaying the time continuously.

Till now the only comparable timepiece proposed has been a digital display. An example of this is the Hamilton electronic watch developed by Electro-Data in Garland, Tex. But because of the power drain on the batteries, the display lights up only when the user depresses a button. Continuous display with digital readouts would necessitate frequent battery changing.

The Motorola clock was developed at the company's Semiconductor Products Div. Central Research Laboratories in Phoenix, Ariz. The concept was shown at the Electro-Optical Systems Design Convention in Anaheim, Calif.

Energy storage planned to save subway power

New York City's Metropolitan Transit Authority is working on a "semi-perpetual motion machine" that will save the energy, now lost, when the brakes of a subway train are applied. The "rescued" energy, which would have been dissipated in the brake shoes, would be stored and used to help power the train.

If the energy-storage device works well and the Transit Authority believes it will—it could cut in half the amount of electricity now required to run New York City's subways (a cost of approximately $40-million a year, representing 11 per cent of Consolidated Edison's badly strained generating capacity). It would also provide emergency power on board a train to get it to the next station if the electrical power should fail. And it would reduce the heat load in subway tunnels by 50%—a problem that is being compounded by added power being used to cool air-conditioned cars.

The device that will accomplish all this is a 600-pound flywheel that the train's deceleration activates to spin as fast as 14,000 rpm. The flywheel is made to turn by the back emf produced by the train's traction motor. The circuitry that con-

trols the direction of the current flow involves a dc-dc transformer, which employs semiconductor thyristors as choppers.

Design work has been performed by the Garrett Corp. of Torrance, Calif. Soon a contract for approximately $1.4-million is to be awarded to build, install and test two subway cars equipped with two flywheels each. Tests will take almost two years. Two-thirds of the funds for the entire project, which will cost $1.8-million, will be paid by the U.S. Dept. of Transportation. New York State will pay the rest.

A hot race for a change for IEEE presidency?

Who is Irwin Feerst? A Don Quixote jousting windmills? A Martin Luther nailing his petition to the church door? A Ralph Nader? Feerst is all of these and more—at least in the view of the hundreds who have so far signed his petition, which he hopes will place his name in nomination for the presidency of the IEEE.

Seldom, if ever, is the post hotly contested. All Feerst needs is 2625 signatures by July 30 to become a candidate. Ballots will be mailed out on or before Sept. 1, and the results of the election will be announced early in November.

Feerst, a former college professor and currently a consulting electronics engineer from Massapequa Park, N. Y. (368 Euclid Ave.), hopes to challenge Robert H. Tanner, vice president of the IEEE who has been nominated by committee for the presidency of the Institute.

In Feerst's view, the IEEE has neglected the well-being of its members because its leadership has alternated between academicians and industrial leaders, "neither of whom can afford the drain on their time or are capable of identifying with the needs of the membership."

Feerst proposes modeling the IEEE after the American Medical Association, particularly as regards to "legislating both the quality and quantity of entries into the profession.

He also would like to see a publication that would list typical salaries paid to engineers. Such a publication would also list companies that the institute believed were guilty "of unprofessional conduct to the engineering profession."

Laser winning converts as IC-trimming tool

Laser trimming for thick and thin-film ICs is being used more than ever. This observation was made at the 1971 Electronic Components Conference in Washington, D. C., at which several technical papers dealt with the laser as a trimming tool.

One paper, by Edward Swenson, manager of technical services for Electro-Scientific Industries, Inc., Portland, Ore. reported use of the laser to trim resistors to 0.01% accuracies. This compares with typical 0.1% accuracies attained with more widely used air abrasive techniques.

"The increasing use of hybrid and thin-film ICs has created a need for a precision trimming system, and the laser is filling that need," Swenson said. "There are some 30 to 40 laser installations at present, compared with only two or three about two years ago."

The total of air abrasive systems in use is approximately 400, according to the S. S. White Div. of Industrial Products, Inc., New York City, considered to be the leader in air abrasive systems.

Point-of-sale terminal offered by Uni-Tote

The highly competitive electronic point-of-sale equipment market has become even more competitive with the entry of the Uni-Tote Series 300 terminal, a third-generation, all-solid-state system. Uni-Tote is a division of General Instrument Corp. in Towson, Md.

Built with ICs, LSI, and MOS throughout, the Series 300 performs all the calculations needed for transacting a sale. It confirms the authenticity of account number and credit cards, and it notifies the clerk of errors on its Nixie flat-plane display panel. And, as with competing systems, it sends the information to a computer in the accounting department.

Uni-Tote plans to sell the unit for approximately $2800.

Data is fed into the initial Uni-Tote unit manually by the sales clerk, but the company is developing interface equipment that will accommodate automatic scanners if requested. Sweda's system uses a 'data pen reader' that reads magnetically-coded tags, and National Cash Register's 280 Series is equipped with a 'magic wand' — a fiber optic cable that reads color-coded bars on specially prepared tags (see "'Magic Wand' Terminal to Speed Store Sales," ED 21, Oct. 11, 1970, p. 46.).

Scheduled for delivery next March, the Series 300 will compete with systems now sold by the National Cash Register's plant in Dayton, Ohio; the Friden Div. of Singer Co., San Leandro, Calif.; Pitney Bowes-Alpex, Inc., Danbury, Conn.; American Rezitel Corp., San Carlos, Calif., and Sweda Div. of Litton Industries in Orange, N.J.

Matsushita challenges U.S. mini makers

A new line of minicomputers, peripherals and components has been announced by Matsushita Electric Corp of America, under its Panasonic brand name.

Intended for the OEM and systems market, the line now includes two minicomputers, a CRT terminal, a disc drive, custom input/output typewriter, photo and mark/sense reader, and keyboards.

Also offered by the Yokohama-based company are an $8000 Transactor—a data-handling system with a desk-mounted computer, typewriter and I/O paper tape—and a $1700 computator, or externally programmed desk calculator designed for inventory control, billing and data acquisition.

The minicomputers, MC7F and MC7S, are hardware and software-compatible, with Panasonic supplying full BASIC software and a custom software capability. The MC7F, which uses plated-wire memory, has a 600-ns cycle time and sells in small quantities for less than $8000 with a 4-K memory. The price of the MC7S, with a 4-K core memory and a 4-μs cycle time, is less than $5000.

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INFORMATION RETRIEVAL NUMBER 17

AN ON-THE-SCENE REPORT

For European electronics, things are looking down

European electronics is, indeed, following the U. S. industry into a slump. Almost a year after the managers of U. S. electronics firms reported a drop in business, European executives are doing the same.

At a time when U.S. companies see the first signs of an improving business climate, their counterparts in Europe talk of a poor short-term outlook and a devastated IC marketplace.

Europeans are introducing few new products this year, cutting their capital spending, and getting very nervous about Japanese and American competition.

One of their big problems is a small home market, and they look to the establishment of common standards and a widening of the Common Market to give them a larger production base.

Happily, not all market sectors are depressed. Computer peripheral gear, small computer memories and some telecommunication products are reported in good demand. And a business upturn is predicted for mid-1972, with increased telecommunications spending a prime factor.

European manufacturers glum

Guy Peyrache, delegate general for the French Syndicate of Radio and Electronic Parts and Accessories Manufacturers (SIPARE) in Paris, says the IC markets are being hit especially hard. The drop in IC prices has been as swift in Europe as in the U. S., and European managers are finding it very difficult to compete. Customers are withholding orders to wait for even lower prices, accentuating the business downturn.

Peyrache sees a small annual increase at best for the total French electronics market this year, and is especially worried about exports.

An abrupt drop of about 10% in semiconductor components business in the last quarter of 1970 is reported in Geneva by Richard Pieranunzi, manager of industrial marketing for Europe for Motorola Semiconductor Products, Inc. The drop was due primarily to rapidly decreasing IC prices, Pieranunzi says. He sees no market increase this year.

ITT's J. A. Browning, assistant export sales manager at the company's office in Essex, England, is pessimistic, too. "The markets will be tough in the U. K. for at least the next six months," he says. ITT is very active in display arrays, which are expected to be a lucrative long-term market. But Browning sees the Nixie tube replacement market as some years off.

A big part of the problem in the semiconductor business is overproduction. Henri Lerognon, director of electronic components for Thomson-CSF in Versailles, France, predicts: "Everyone will find the IC markets very tight for the next one or two years at least. The crisis faced by the semiconductor companies will be a long one."

Francis Carassic, MOS sales engineer for General Instrument, France in Paris, says that while prospects are poor for the French

"American and Japanese semiconductor companies face a crisis at home, and they're all trying to take a market position in Europe. Competition is fierce."—Henri Lerognon, director of the electronic components division of Thomson-CSF, Versailles, France, expects some semiconductor companies to go out of business, both in Europe and in the U. S.

Raymond Daniel Speer
Managing Editor

electronics industry as a whole, he hopes to see the first orders for production quantities of MOS ICs this year. So far, he says, MOS sales in France have been in sample quantities only.

And at the Paris components show, Salon des Composants Electroniques, Phillipe Rouaud, commercial director of Auriema France, complained of a low interest on the part of visitors. They tended to be blase', he says, and not interested in making purchase commitments.

Fewer new products

The business downturn and resulting pessimism have already led to a slowing of new-product introductions in Europe. At the Paris show many of the exhibitors frankly admitted that they had no significantly new products to display. Some, particularly in the IC business, pointed to the recession in the U. S. as the cause.

Yves Ricourt, marketing manager for Tranchant Electronique's Professional Div. in Clichy, France, reported that he saw very few new ICs. R&D in semiconductors has been very slow in the U. S. for the last year, he said, and the result has been fewer new products in the European markets, which are largely dominated by U. S. vendors.

Dr. Francis Jones, managing director of Mullard Ltd., London, put it this way:

"There's a cold wind blowing in the components business. I don't see any significant advances coming. The tube technology is mature, semiconductor technology almost so, and new technologies, such as lasers, don't show much promise yet in terms of return on investment. I'm cutting out several million dollars worth of investment in view of the poor business situation."

The Japanese: threat or not?

Jones sees companies based in the Far East, particularly in Japan, as serious competitors. "In the U. K., especially," he says, "in 10 years we're in a mess if the markets and our competitive position with the Far East don't improve." He expects the Japanese to take over the color TV business in Britain, for instance, in spite of organized labor's strong objections.

Managing Editor Raymond Speer recently returned from an extensive tour of electronics plants in Western Europe. This report is based on research in this country and abroad and on personal interviews with electronics executives in France, Germany, Denmark and Britain.

Jones expects the availability of cheap labor in the Far East to be the main threat to European components manufacturers. "Any technical advances we can make in our relatively mature product lines will not be significant when compared to the advantages of cheap labor," he says. "We just aren't able to meet their prices. It's a running battle to keep my people employed, when I must pay them five times as much as my competitors pay in Japan."

The Mullard manager reports that of 26 million IC devices sold in 1970 in Britain, roughly 18 million were imported. Of the total of solid-state devices sold, 58% were imported, as were 80% of the radios. A growing portion of these imports to Britain comes from the Far East.

Jones sees the components markets this way for the next five years: "It's going to be very tough for the people in advanced countries to earn a living in the electronics field."

But Lord Ian Orr-Ewing, past chairman of the Electronic Engineering Association in Britain, disagrees with this assessment of the Japanese industry.

"Labor costs are not lower," he says, "if you take into account the paternalism of the Japanese company. If you add the welfare and fringe benefits of the Japanese worker to his hourly wage, you end up with a figure not very different from that of Europe. The low cost of Japanese labor is being used as an excuse for inefficiency in Western Europe."

An added factor, he continues, is the bigger home electronics market of the Japanese—more than twice as large as that of any Western European nation.

"I'm worried that we're all going

"The Japanese have agreed to limit their exports into France—according to quotas we worked out—of consumer items such as tape recorders, radios and TVs. But they are strong competitors with us in the other countries in Europe."—Guy Peyrache, Delegate General, Syndicate of Radio and Electronic Parts and Accessories Manufacturers (SIPARE), and Syndicate of Tube and Semiconductor Manufacturers (SITELESC), Paris.

"There's a massive explosion coming in the field of acquisition, transmission and presentation of data. There's a great future in the communications business."— Michael Clark, managing director of Plessey Company Limited, London, England, sees telecommunications as one of the most promising electronic markets in the 70s.

to have great difficulty in meeting Japanese production economy," Lord Orr-Ewing says. "Their industry has achieved efficiency of scale—low per unit cost due to high-volume production—in many product lines, their workers have very high productivity, and their government provides excellent support for industry."

Plessey's William Haines, managing director of the company's Electronics Group in London, doesn't see the Japanese as serious competition either. He is pushing to take advantage of the market that Japan offers.

"We've given presentations to the Japanese Army, Air Force and Navy, offering our assistance in building their new defensive force," he reports. "They're a bit short on knowledge in the aerospace business. The Japanese are looking for know-how and licensing agreements, and we got across that we've got the expertise they need.

"We've got a senior executive in Japan and we're going to spend the next six months, with our feet firmly planted in Tokyo, choosing a Japanese partner to work with."

Haines, who is president of the Electronic Engineering Association in Britain, sees the Japanese as afraid of domination by the U. S. and obsessed with increasing sales in the products they produce.

European managers also look with some dread at the increasing presence of U. S. companies in Europe. Thomson's Lerognon reports that until lately Europe was a good, stable market for semiconductors but that the TTL price war and the efforts of U. S. manufacturers to keep up their volume by selling in Europe has created havoc.

Lerognon expects both American and European IC sellers to seek cooperative agreements—such as that between Motorola and SGS. Of the recently introduced Motorola MECL 10,000 line, he says: "We'll be obliged to compete."

The liaison executive of Plessey's Components Group, R. H. Spall, complains that U. S. companies have carried the IC price war to the point where "they're killing themselves."

Spall expects the depression in the semiconductor business to continue for years rather than months, and he also expects some business failures among semiconductor companies on both sides of the Atlantic.

Small market potential noted

One of the biggest problems that European electronics makers face is the small size of their home market. As Motorola's Pieranunzi points out, manufacturers can make optoelectronic devices, LSI, MOS, CMOS and MECL circuits, but it may not be good business for them to do so. They generally lag U. S. manufacturers by as much as a year in their introductions, he says, and the markets available to them in Europe are small and dominated by U. S. companies.

The solution, in the eyes of many Europeans, is a broadening of their markets through common European components standards and widening of the European Economic Community, or Common Market.

Mullard's Dr. Jones is pressing especially hard for adoption of the BS 9000 specifications scheme administered by the British Standards Institution. It provides not only for mechanical and electrical specifications, but also for closely controlled quality assurances.

Jones says that Europe has always lacked a common set of component standards, and he believes the adoption of BS 9000 specs would stimulate the electronics trade substantially. He is critical of military specs in both the U. S. and Britain, because only a very few components—he estimates 5%—are sold under these specs.

"We want a series of specs that will apply to all components except consumer items," he says, "and

that will include quality-assurance data."

Jones does not see the new specs as discriminatory against the U. S.; he feels manufacturers in the U. S. would benefit along with those in Europe.

Siemens' Peter Schurholz, export sales manager of the Components Division in Munich, agrees that the need for component standards is a pressing one. U. S. manufacturers adopted the IEC standards two years ago, he says, and Siemens changed its capacitor specs only to find that U. S. manufacturers don't really use the standards. In Europe today, he says, every country has its own standards and this must be straightened out.

Some sectors look good

Where are the bright spots in Europe's electronics business? In such areas as these: small memories, computer peripheral equipment and telecommunications.

Marcel G. Corminboeuf, sales engineer with Munzig International, Inc., a sales-representative concern based in Geneva, sees a potential market of $60-million this year in small-core and semiconductor memories in Western Europe, including Britain and Scandinavia.

Representing Advanced Memory Systems, Inc., of Sunnyvale, Calif., among other clients, Corminboeuf reports the memories are in sizes up to 65-K words with word lengths up to 36 bits. About 90% of these will be core versions, he says. They will be used in minicomputers and small central processors.

As for 1972 and 1973, Corminboeuf continues, look for an increase of 20% a year in the small-memory market, with Compagnie Internationale pour L'Informatique in France, International Computers Ltd. in London, Nixdorf in Germany and Philips in the Netherlands as major customers.

In peripherals, Mohawk Data System's Pierre Zambaux, director of the OEM Div., who sells interface and input/output equipment to EDP computer users, reports growth of 150% a year since his company began operations in France in 1967. Zambaux points to 4500 installations of equipment by his company in France since then.

Decline in Europe? Yes and no, says SRI

Stanford Research Institute in Palo Alto, Calif., which continually monitors business performance abroad, says European electronics sales may well decline in 1971, but it won't be because the total market is down. Rather, according to Ken Taylor, senior industrial economist at SRI, the sales dip for European companies will be caused by increased penetration of their markets by U. S. and Japanese companies.

The total electronics market in Europe will grow this year in all major sectors, SRI predicts, with the greatest rate of rise in data-transmission equipment (see table). Growth will be steady through 1980.

In the future, Taylor says, companies in Europe and Britain will have to emphasize cooperation among themselves if they are to combat the mass-production economies achieved by the Americans and Japanese.

Market sector ($ billion)	1970	1971	1974	1980
Professional equipment	7.0	—	—	23.0
Telecommunications equipment	1.5	1.7	2.3	4.3
Computer systems	2.3	2.8	4.7	9.7
Data origination & display	0.8	0.95	1.6	3.3
Data transmission	0.06	0.08	0.21	0.7
Test, measuring & analyzing inst.	0.75	0.825	1.1	1.8
Consumer equipment	10.0			28.0

SRI predicts continued growth in the electronics markets for Western Europe, including the Common Market and European Free Trade Association countries, Finland and Spain. The total market is divided into professional and consumer areas; only the sectors showing strongest growth in each group are included in the table.

Peyrache, the French industry spokesman, expects significantly increased spending for telecommunications by the French Government as part of its five-year plan (1970-1975) for general economic growth. He predicts the outlays for telecommunications will rise more than 20% a year, as part of a program to upgrade data and voice communication.

Schurholz sees growth of as much as 12% a year for the worldwide passive-components market, excluding the consumer sector, and expects to double Siemen's passive-component sales over the next five years.

And Michael Clark, managing director of Plessey Co., Ltd., London, sees telecommunications as one of the most promising electronic markets this year and beyond.

"There's a massive explosion coming in the field of acquisition, transmission and presentation of data," he says. "There's going to be a great future in the communications business.

"Historians of the future will call the 1970s the age of information. Never before has man had the ability to acquire, communicate and analyze so much information so readily. Whether you manage a hospital, army or manufacturing plant, you'll have the opportunity to make decisions based on enormous banks of information."

Despite the present gloom in the electronics marketplace, European managers see strong over-all long-term growth. They see signs of a business revival in the U. S. and expect an upturn in Europe in 1972.

Lerognon expects a boost in consumer electronics sales late this year as buyers anticipate the Olympic games to be held in Munich in 1972. The games will stimulate TV and radio sales, he feels, and consumer goods manufacturers will have to build inventory. The components market should begin to improve this September, Lerognon believes. ■■

Smaller, cheaper power ICs emerge with hybrid designs

Roger S. Allan
New Products Editor

WASHINGTON, D.C.—Hybrid power circuits are becoming more stable, much smaller in size and cost-competitive with discrete-component circuits of equivalent performance.

This observation by William Hittinger, vice president of the RCA Solid-State Div., Somerville, N. J., was borne out by papers presented at the 1971 Electronic Components Conference here. Hittinger spoke at the conference banquet. Two designers who presented papers at technical sessions pointed to these developments in the design of hybrid integrated circuits for power applications:

- A thin-film voltage regulator that dissipates 100 W internally in a 1.25 cubic-inch package—a 4-to-1 decrease in volume over similar discrete regulators.
- A 4-A thick-film regulator delivering 2 to 32 V from a standard TO-3 case for only $15—a price competitive with current discrete types.

Stretching power-density limits

Warren Schultz, a design engineer with General Electric's Aerospace Electronics Systems Div., Utica, N. Y., reported on the thin-film hybrid voltage regulator. A 10-A series type, it was an outgrowth of an aerospace computer application in which small size was important.

Designing this regulator with standard discrete components would have increased its volume four times because it would have been necessary to mount large power transistors on heat sinks to a bulky PC board. The control elements would be kept far away because of the heating effects of the power transistors, Schultz noted.

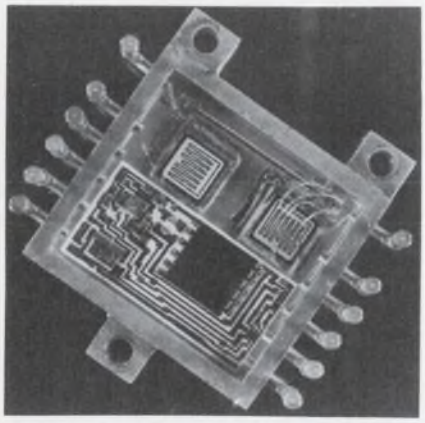
A major problem that had to be solved in achieving size reduction while maintaining 100 W of power dissipation was thermal isolation. This involved keeping the output transistors' heat currents from affecting the more heat-sensitive control elements.

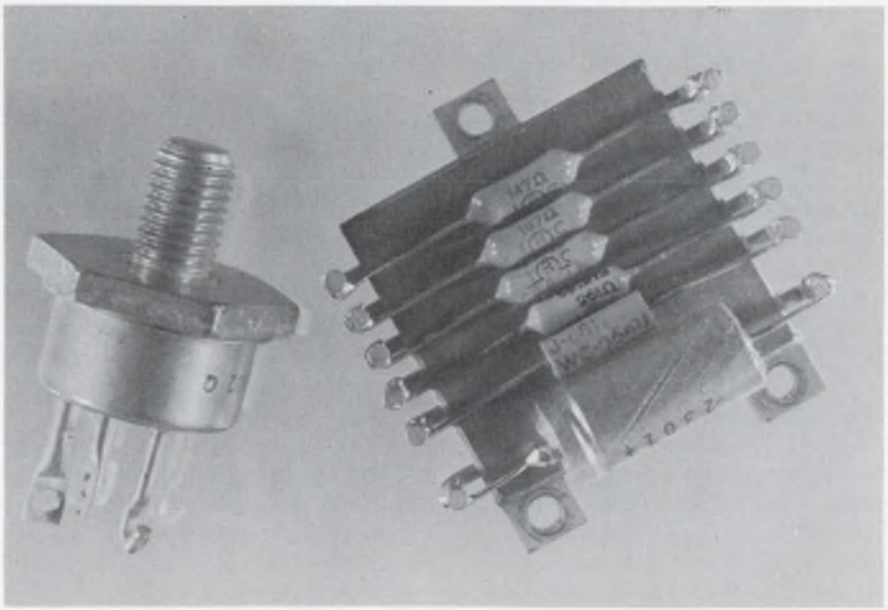
The problem was solved with the use of three separate substrates —two of beryllia for the output power transistors and one of alumina for the thin-film control elements. These were packaged into a nonstandard case, with the transistors' collectors electrically isolated from the case.

Tests showed that thermal impedance between the collectors' junctions and the case was less than 1°C/W—more than satisfactory heat dissipation.

Schultz employed power-trimming techniques. He adjusted resistor values by pulsing the thin-film elements with high currents for short periods. This pulsing current caused a physical property change in the resistors, which changed their values.

Schultz pointed out that the separate-substrate approach easily allows the control elements to be deposited on alumina substrates by





Power of 100 W is dissipated in a hybrid regulator. Beryllia substrates (top) hold two power chips. Packaged unit (right) is nearly the size of a TO-63. External terminals can be used to mount additional circuit components.

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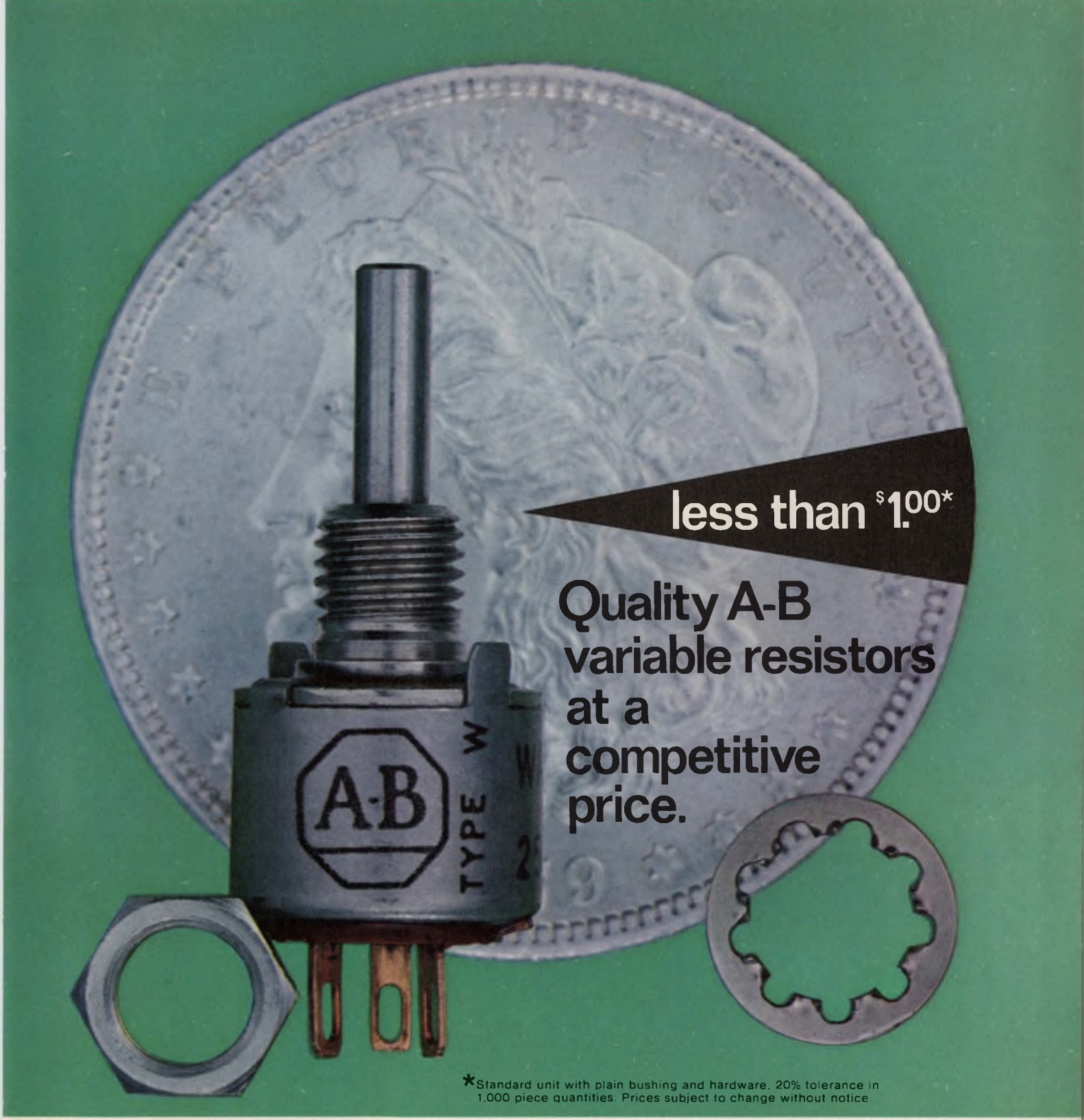

*Standard unit with plain bushing and hardware. 20% tolerance in 1,000 piece quantities. Prices subject to change without notice.

Type W variable resistors feature a solid hot molded resistance track for long operating life. Tests show less than 10% resistance change after 50,000 complete rotations. The noise level is low and the resolution is virtually infinite. Low inductance permits operation at high frequencies where wirewound variable resistors are useless. A lot of variable resistor for less than a dollar.

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proven methods for reducing costs.

"Power circuits lend themselves to hybrid techniques which eliminate long interconnecting wires and improve performance," Schultz told the conference. These wires are necessary in discrete circuits because the power transistors are kept on heat sinks on a PC board, away from the control components, through long interconnecting wires. This causes unnecessary voltage drops.

"The techniques that were used on this regulator can be applied equally well to other types of power circuits, such as linear power amplifiers, pulse-width-modulated amplifiers and high-current switches, to name a few."

Bringing hybrid costs down

In another paper at the conference, Ralph Engler, a design engineers with RCA Solid-State Div., described the thick-film voltage regulator that delivers 2 to 32 V and costs only $15.

A discrete regulator that would include identical performance would cost about $13, according to RCA. This price does not include the expense of several sets of specifications for the discrete regulator, as against only one set for hybrid types—costs that are difficult to document.

The hybrid regulator, designated TA7955, uses thick-film passive elements screened on an alumina substrate which is mounted directly to the TO-3 header through thermally and electrically conductive epoxy. The primary power transistor is attached to a copper heat sink brazed on the header. This method provides a thermal resistance of 2° C/W.

Rather than concentrate on exclusively thermally isolating signal and power elements, Engler used monolithic silicon temperature-compensating elements to minimize signal-element instability caused by heat.

A unique feature of the regulator is its two types of protection: foldback and crowbar.

A foldback circuit protects the regulator from excessive load currents caused by any shorting out of the load. This is a common technique most voltage regulators use.

The crowbar circuit protects the load from any overvoltage of the regulator should any of its components malfunction. This is useful for such voltage sensitive loads as logic circuits.

The crowbar function is designed on a separate alumina substrate, mounted in a second level above both the control elements and the output transistors.

The two-tier approach provides versatility for those applications where load protection is not too important. In such cases the crowbar circuit could be easily left out of the regulator assembly, further reducing costs.

A standard hermetically sealed eight-lead TO-3 case was chosen mainly because of its easy mounting, good heat transfer and low-cost characteristics.

Hybrid 4-A regulator includes a crowbar circuit on a second-level alumina substrate. Below the crowbar are the control elements on alumina and the power chip on a copper heat sink.

"The biggest problem in designing power hybrid circuits," Engler said, is to be able to marry two different technologies—film and power silicon—under one roof."

Differences over design approach

Robert Gold, manager of the microelectronics operation at Lambda Electronics, Melville, N. Y., expressed doubts about the methods used by Schultz and Engler to achieve thermal isolation and stability. According to Gold, maximum thermal isolation and stability for hybrid power voltage regulators can be achieved only when both the control and power elements are mounted separately, each on a substrate thermally coupled to the "outside world" through proper heat sinking.

This contrasts with both Schultz and Engler's techniques, where heat sinking of control and power elements is on the same package surface.

Gold recently designed a thick-film hybrid regulator that dissipates up to 85 W. It uses two separate heat sinks—one on top of the regulator for the power elements and one on the bottom for the control elements (see "Hybrid $20 voltage regulator handles 85 W in 2.5-in.^{3} case," ED 6, March 15, 1971, p. S34).

Other companies involved

The hybrid power circuit developments outlined at the conference are not the only ones that have been emerging in the industry. Several companies have been designing and selling such devices over the last few years. Among the leaders, TRW of Lawndale, Calif., has been making power regulators and amplifiers in thick-film hybrid form since 1969. These devices have internal power dissipation capabilities up to 50 W.

TRW uses mostly beryllia as the substrate material. The thick-film elements are designed as close as possible to their specified values, so that trimming them on the beryllia substrates, with its resultant toxic dust, is kept to a minimum.

Delco Radio of Kokomo, Ind., has been producing power hybrid devices since 1967, mostly for in-house use, to General Motors. These include thick-film circuits for automobile voltage-regulators, ignition systems and fuel-injection systems.

"The high ambient temperatures under an automobile's hood make the hybrid approach economically attractive for power circuits," says Dr. Frank Jaumot, Delco's director of R&D. "For instance, costs, compared to the discrete approach, are one-half those for fuel-injection control systems and two-thirds those of voltage regulators."

Most of Delco's applications involve the use of alumina substrates and thick-film materials. A few special applications, such as high-current ignition systems, involve the use of beryllia substrates and thick-film techniques. ■■

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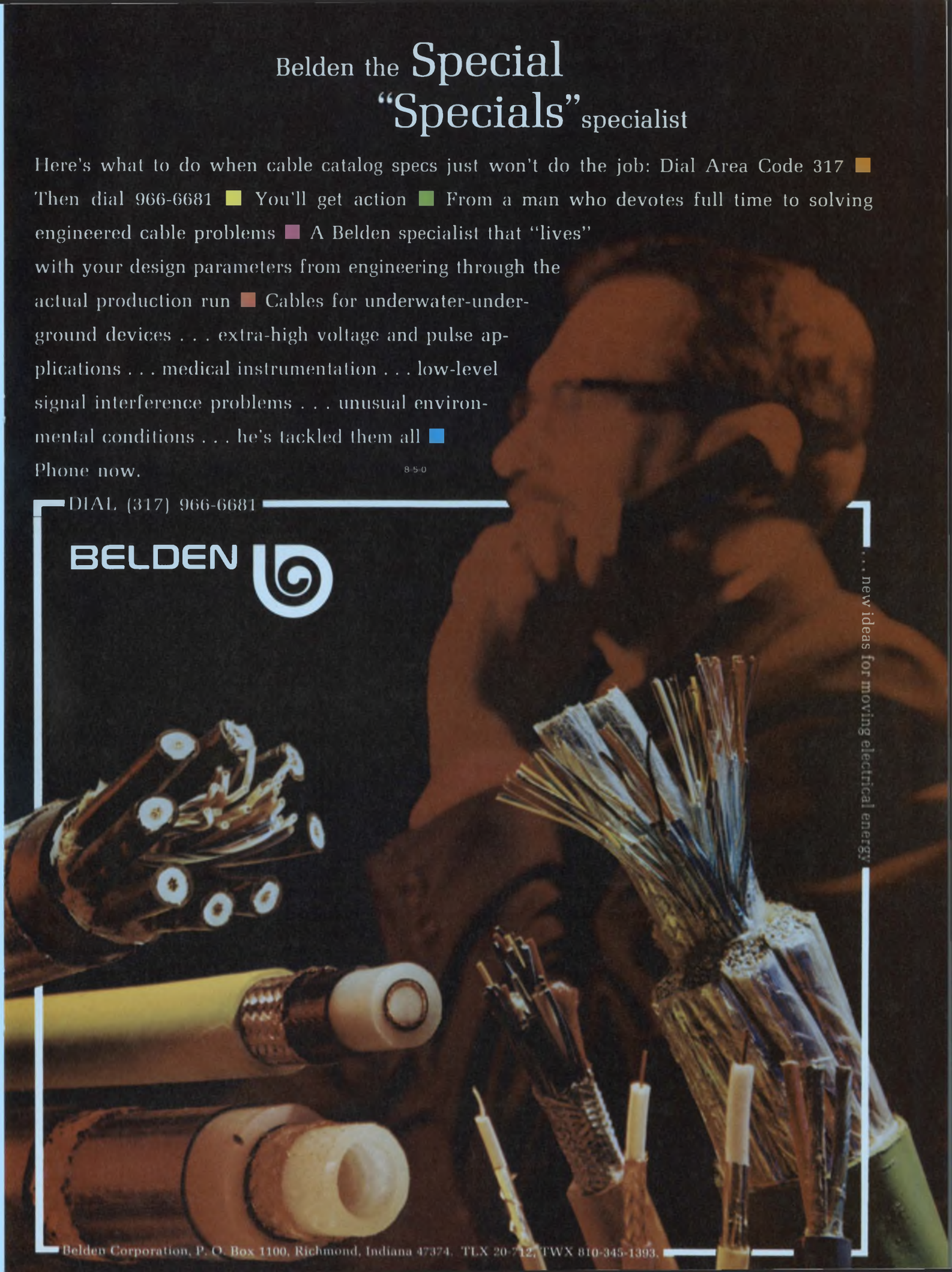

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Coast Guard gets an electronic ice 'bomb'

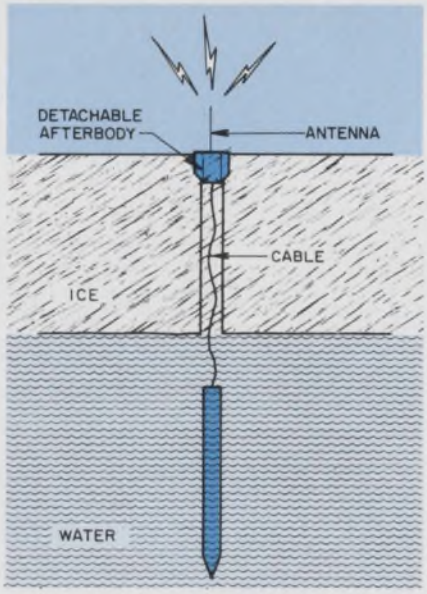
Measuring the thickness of sea ice has always been a laborious, and sometimes impossible, job to perform. The ice must be accessible by ship or helicopter, and it must be safe enough to hold a man and a hand-operated core drill.

Now it can be done easier and faster with an expendable penetrometer that is dropped from an aircraft. The instrument may even transmit data on other characteristics of sea ice as well.

The small, instrumented projectiles were developed by Sandia Laboratories in Albuquerque, N.M., and were tested last spring in the Arctic by the Coast Guard.

Shaped somewhat like a sharpened pencil, the penetrometers are 42 inches long, 2-3/4 inches in diameter, weigh 50 pounds and are equipped with tail fins.

Dropped in the tests from C-54 aircraft flying at 8000 feet, the penetrometers impacted at a velocity of 550 feet per second. This was sufficient to penetrate up to 12 feet of ice—the maximum thickness the experimenters expected.



Air-dropped penetrometer breaks apart on impact, leaving the antenna above the ice while the telemetry package goes down to the water.

As the penetrometers strike the ice, they pull apart, leaving the tail section with its whip antenna protruding above the surface. The forward section, which contains the telemetry package, continues to cut through the ice to the water below, letting out an electrical cable as it goes to retain contact with the antenna.

A standard piezoelectric accelerometer in the telemetry package senses the deceleration of the penetrometer as it goes through the ice, and a uhf transmitter sends the information to the aircraft for storing on tape. Back at home base, a computer converts the data to the thickness of the ice.

The telemetry package consists of a battery, voltage-controlled oscillator and the accelerometer. The package, potted in plastic to help mitigate shock, is about 15 inches long 1-3/4 inches in diameter and weighs two pounds. ■■

Photodiode arrays available by the yard

Linear arrays of photosensitive silicon diodes are now available by the yard and by the thousand, instead of by the inch and the hundred. Comprised of end-to-end arrays of 100 (or less) diodes each, these assemblies are made possible by a new, close-tolerance laser-trimming technique developed by Optron, Inc., Carrollton, Tex.

Principal applications of these extended arrays will be in optical character readers, says William Nunley, Optron's vice president. The arrays will permit scanning the 11-inch side of an 8-1/2-by-11-inch page, or a 22-inch IBM data sheet can be scanned in full width.

To date the principal method of making a long string of diodes has been to cut a thin, narrow strip of silicon from the long axis of an ingot. The strip is then processed to form diodes and is mounted on a substrate, to which connections are made.

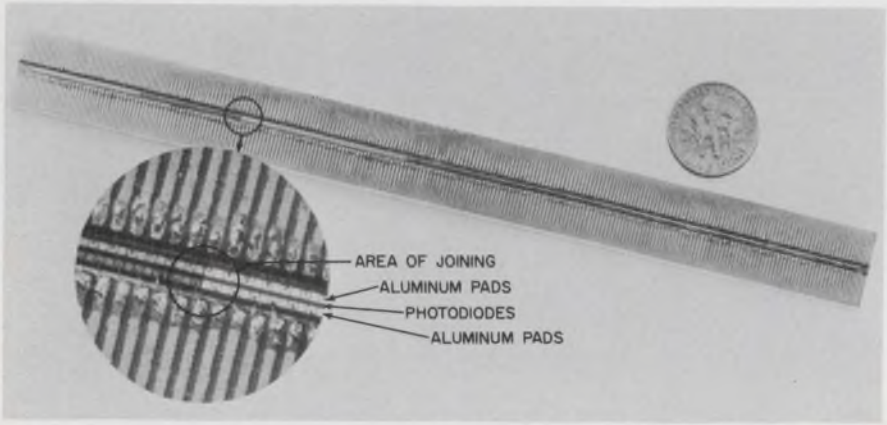
But the maximum length is 10 or 11 inches, because of ingot size limitations. And costs are highest for this approach.

With Optron's method, the length is essentially unlimited. And for a pieced equivalent of the 11-inch strip, the costs are roughly halved, Nunley says.

For the Optron device, monolithic arrays of 100 diodes are first made from narrow strips taken from two-inch wafers. These "slivers" are processed and the ends trimmed so they can be butted on the ceramic or PC-board substrate.

While this method seems obvious, Nunley says it wasn't used before because of the difficulty in trimming the silicon array ends accurately enough so they could be pieced together with the diodes precisely aligned on centers.

With the laser, the diode string strip can be trimmed to within 1.5 mils from an end. This provides a minimum of 3 mils between the edges of adjacent sensitive areas when the string is assembled on a substrate. ■■



This 6.3-inch array of 448 photosensitive silicon diodes is made of five smaller arrays. Each diode is 12 mils long by 11 wide, with 14 mils from center to center. The space between diodes is not more than 3 mils.

Our new tuning varactors pass the high Q test.

• Q of 2000 in small glass.

Model Number	Total Capac. @ –4V pF 1 MHz	Min. Total Capac. Ratio $C_{T_o}/C_{T_{VB}}$	Min. Q @ –4V @ 50 MHz	Case Style
45 Volt Units				
MA-45103	1.8	4.9	2500	Ceramic Pill
MA-45106	4.7	5.4	2000	Ceramic Pill
MA-45110	4.7	5.4	2000	Do-7 Glass
MA-45164	2.7	5.2	2000	Small Glass
60 Volt Units				
MA-45123	1.8	5.5	2000	Ceramic Pill
MA-45126	4.7	6.5	1500	Ceramic Pill
MA-45130	4.7	6.5	1500	Do-7 Glass
MA-45133	15.0	7.0	900	Do-7 Glass
90 Volt Units				
MA-45141	0.8	5.0	1500	Ceramic Pill
MA-45143	1.8	6.6	1500	Ceramic Pill
MA-45145	3.3	7.5	1000	Ceramic Pill
MA-45147	6.8	8.2	800	Ceramic Pill

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technology abroad

A new, more powerful minicomputer has been introduced by Philips of Eindhoven, The Netherlands. The computer—the P359—handles magnetically striped record cards measuring 6 to 16 inches wide, each of which holds up to 672 bits of information in the magnetic stripe. The system is available in two versions, one with main-core storage of 9600 bits, the other with 16,000 bits. The processor has a cycle time of 3.2 μs. Printout is at 40 characters a second on a 27-inch platen.

The feasibility of high-speed automatic data transmission for communication between police despatchers and mobile units will be studied by Britain's GEC-Marconi Electronics under a new contract. The system, expected to include a computer in each police headquarters plus teleprinters in police cars, has been proposed because police speech channels are overcrowded. The new technique will give patrolmen in the field fast access to centralized information. It will also allow them to transmit data on their own status to headquarters and will give them hard-copy records of messages received while they are away from the car.

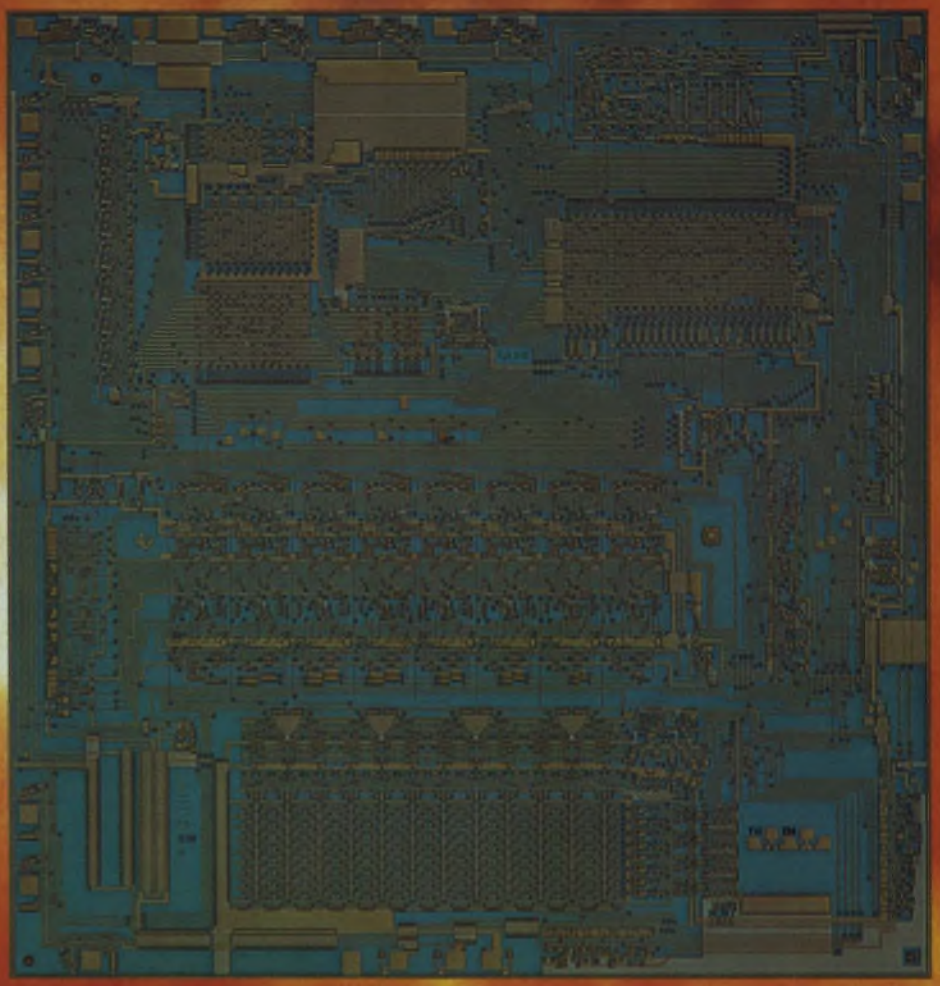
The inability of Great Britain to launch large geostationary communications satellites is having an adverse effect on the British communications industry. The British Black Arrow vehicle can launch relatively small satellites. However, rapid development of the communications satellite field indicates the need for testing with larger satellites, which would require larger launchers, such as the U. S. Thor-Delta. GEC-Marconi points out that such satellites are needed to test components that likely would be competitors on the world market. At present the British hold a fairly large share of the communications market outside the U. S. However, if they are to develop further in satellite communications equipment, they may be forced into either rejoining the European Launcher Development Organization or buying American systems.

A portable, battery-powered infrared camera for identifying hot spots in power lines and substations has been produced by Britain's Government-run power monopoly, the Central Electricity Generating Board. The temperature sensitivity is claimed to be 1°C at an ambient of 20°C. The camera, which can be mounted on a truck or stationary tripod, is aimed at potential trouble spots, causing an image to be directed on a rotating-disc chopper and scanner. Radiation is thus directed on an IR-sensitive cell, from which an amplified signal serves as an input to a CRT display.

Longevity for solar cells for the European research satellite ESRO-4 has been assured by a new protective glass developed by West Germany's AEC-Telefunken. The satellite, to be launched from California in September, 1972, has postage-stamp-sized glass covers to protect the solar cells from micrometeorites and radiation. However, radiation has discolored the glass in the past, reducing cell efficiencies. Multi-layer coatings were expensive and prone to delamination. These problems were overcome by adding a small amount of cerium oxide to the basic sand-limestone-dolomite glass mix. The resulting material is coated with magnesium fluoride as an anti-reflection measure. The technique was developed by Chance Brothers of Birmingham, England.

A windmill-equipped airship, tethered at the end of a 10-km cable in the region dominated by jetstream winds, has been proposed by the Soviet as a means of generating pollution-free power. The airship, 168 m long by 50 m in diameter, would carry a large rotating wheel and generators mounted inside the airship superstructure. The Russians believe the system would be useful in Siberia and parts of the Far North, where conventional power generation systems are very expensive.

The Thrust in MOS/LSI



Plus news from Texas Instruments about

Hybrid circuits: Fast, new clock driver

TTL/LSI: Low-cost 64-bit RAM

SC memories: High-speed 2048-bit RAM

Interface circuits: Short-circuit-proof MODEM line driver

Linear ICs: New super-beta op amps

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Diode arrays: 12 high-reliability coredrivers

MOS: the thrust is economy, complexity and volume.

TI has the capability—across the board.

MOS can put a computer on a chip.
MOS can cut system costs.
MOS can be economically customized and produced in big volume. Or small.

Just anyone's MOS? No. And that's why you should carefully compare manufacturers' capabilities.

Can they, for example, give you the full advantage of the complexity inherent in MOS—like putting 6,000 devices on a single chip? Can they optimize your system costs by building bigger, more complex chips—and still keep yields up and prices down? (See charts below.)

CPU on a chip

The device pictured here is a complete eight-bit parallel processor on a 215-by-225-mil chip. It includes an 8-bit parallel ALU with hardware, parity flags, an 8-bit accumulator with file registers, 8-bit program and memory address registers, and a multilevel program address stack. TI developed and is producing it for Computer Terminal Corporation for use in an "intelligent" terminal, the Datapoint 2200 terminal. With its associated random access memory system, the 2200 has the capabilities of a full 8-bit mini-computer.

TI leads the industry in the ability to produce complex devices on large, cost-efficient chips.

The next logical question concerns choice—can you get the devices you need? TI's standard catalog line is comprehensive (see opposite pages). If you need a custom design, we have the experience and the ability. TI has 183 circuits in production now and has produced more than 400 custom ROM masks. Process capability is broad. We're in production with P-111 standard high V_T, P-111 nitride low V_T, P-100 standard low V_T, P-self-aligned thick oxide, and P-self-aligned/silicon interconnect. We're in development with complementary, ion implantation, and N-channel processes. An extensive computer automated design facility allows TI to handle big design loads. Concurrent design capacity is three complete systems (averaging 20 circuits) and 15 individual devices. Thirty-five custom circuits in design at a time. Typical turn-around: individual chip (from logic)—3 months; complete system (from definition)—5 months.

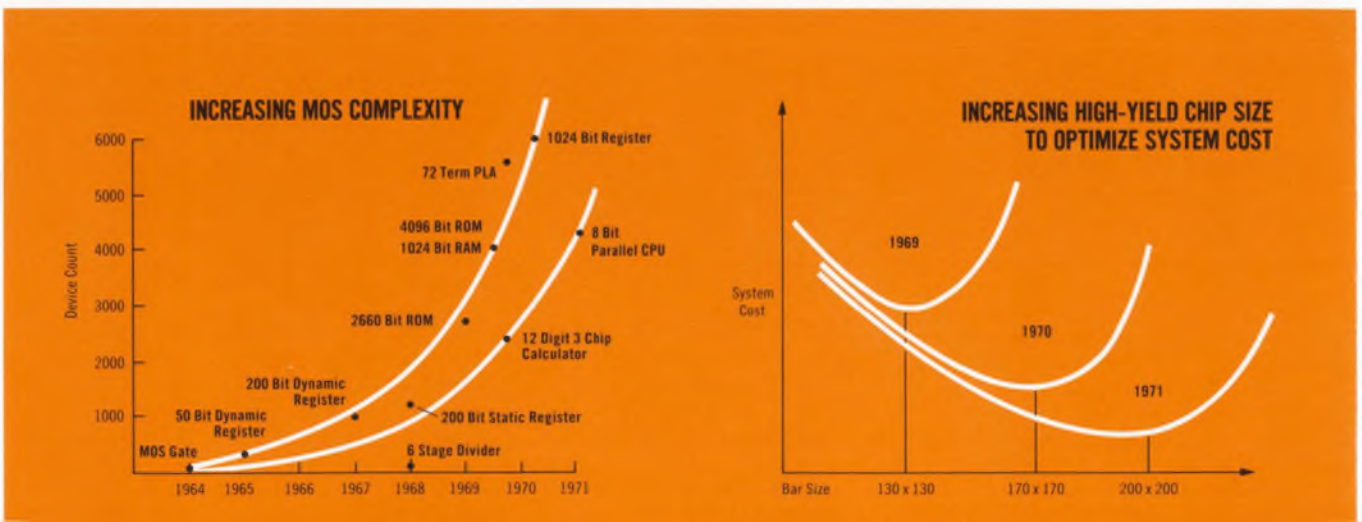
TI leads in the ability to provide the custom designs you need—on minimum time cycles.

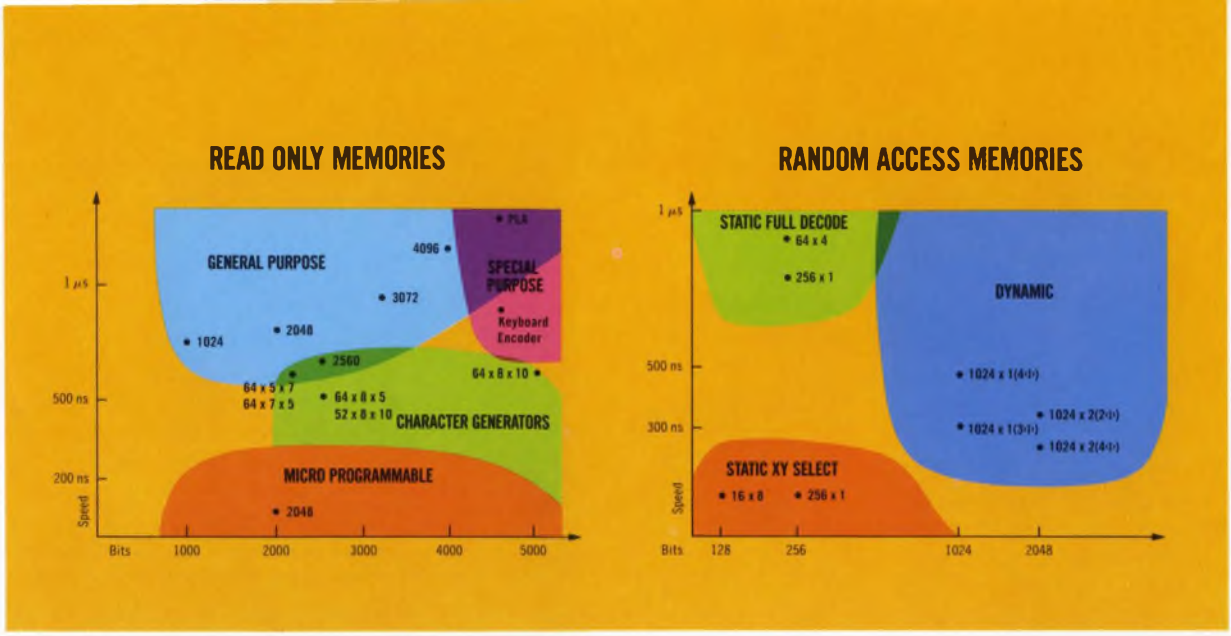
And what about production? Will costs be low and deliveries on schedule? TI's production capability is unequalled. Equipment is advanced...and highly automated. In addition, TI's simple, rugged and economical plastic package is well suited to mass production.

TI leads in volume production capability.

Finally, how efficiently can you work with your MOS supplier? At TI, our systems are flexible...and we've got enough breadth and depth to play it your way. We'll send engineers to your plant. Or you can send resident engineers to ours. We can do a turn-key job. Or we can pick it up anywhere along the line—from black box descriptions, algorithms, logic diagrams or partitioned logic. We'll second source from circuit diagrams, composites, rubies, or masks. We'll package chips.

If you need an MOS supplier, call your TI sales engineer. He'll give you the facts you need to compare us with the competition.





TI's standard MOS/LSI line offers widest selection, volume production.

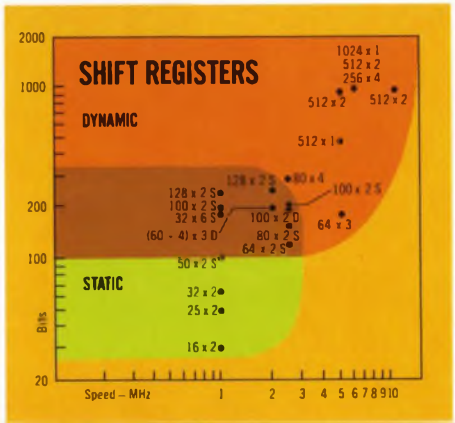
You'll find your biggest choice of standard MOS circuits in TI's line—the most comprehensive in the industry. Select from 27 shift registers, 13 read only memory families, 10 random access memories, and 7 logic circuits...all backed by big, advanced, highly automated, and cost-efficient production facilities. Package choice includes 14- to 40-pin plastic, 16- to 40-pin ceramic, TO-100, and TO-8.

Shift registers

TI offers both static and dynamic shift registers. Static shift registers feature speeds from DC to 3 MHz, complexities up to 500 bits, at an average 1000-piece price of 2¢ per bit. Dynamic registers have speeds to 10 MHz, complexities up to 1,000 bits, at an average 1000-piece price of 0.8¢ per bit. Example: the TMS 3409 JC/NC quad 80-bit dynamic shift register with a shift rate of 5 MHz and recirculate logic on the chip. Inputs and outputs are TTL compatible and no clock drivers are needed. Organization matches 80-column punched card formats (three 3409s can store data from an entire card). Trends: more circuitry on the chip (clock drivers and recirculate logic) and longer bit lengths.

Read only memories

TI's read only memories offer speeds from 350 ns to 1 μsec (fully decoded) and complexities from 1024 to 4096 bits. Prices (1000 pieces) range from 0.9¢ per bit to 0.25¢ per bit. Example: the TMS 2500 JC/NC 2560-bit static ROM. At 350 ns, it's one of the fastest available. The 2500 is organized as 512 words by 5 bits or as 256 words by 10 bits. It may also be used as a character generator organized as 64 characters, 5 by 7 format, or 32 characters, 9 by 7. It is programmable and fully TTL compatible. Trends: Larger bit sizes and more specialized products such as keyboard encoders.



Random access memories

Access times for TI random access memories range from 280 to 750 ns, with very low power dissipations. Complexities extend from 256 to 2048 bits. Prices average 0.8¢ per bit in 1000-piece quantities. Example: the 2048-bit TMS 4025 NC has an access time of 280 ns at a total power dissipation of 80 μW per bit. Output current is 2 mA. It's dynamic with on-chip decode. Trends: Larger, more economical circuits, higher speeds, lower power requirements. And soon, a smaller plastic DIP to increase circuit board density.

Logic circuits

TI offers catalog logic circuits with unique programming capabilities—combining the efficiency of custom design and the low cost of standard units. These standard programmable devices cover a broad range of applications. The trend, of course, is increased complexity. Coming soon from TI is a one-chip, 8-digit, 3-register full floating calculator—and shortly after, a two-chip, 12-digit, 4-register full floating calculator.

For more information concerning specific products (see list inside foldout), contact your local TI sales engineer.

oadest choice—by far—at TI.

Linear

Two new super betas expand your op amp choice.

With two new super betas, the SN52/72770 and the SN52/72771, TI plugs a performance gap in your op amp choice. These state-of-the-art devices fill in between general purpose types and the very expensive super betas. Each features an external low input bias current and offset current (see table). In addition, they have a significantly improved slew rate.

	SN52770/771	SN52741	SN52709
Input bias current (nA)*	8	80	200
Input offset current (nA)*	1	20	50
Slew rate (V/μsec)*	2.5	0.5	0.3

*All values are typical

The low input bias current and offset current make the SN52/72770 and SN52/72771 well suited for sample and hold, logarithmic amplifiers and other low level designs that are impractical using conventional devices. The high slew rate puts these two up front for applications with fast rise time signals and large signals at high frequency.

The SN52/72770 and the SN52/72771 are identical except the 771 is internally compensated. The 770 requires an external capacitor, which allows you to change the frequency of response for wider bandwidth or higher slew rate. Both come in a wide package choice, too, including TI's new space-and-money saving 8-pin DIP.

For data sheets on TI's two new super beta op amps, circle 253 on Reader Service Card.

Interface circuits

TI's MODEM line driver takes all short circuits, meets all RS-232C specs.

Anything more severe than an instantaneous short circuit knocks out most MODEM line drivers. But not TI's SN75150 dual line driver—it meets EIA RS-232C specifications to the letter, not just to the "intent." The SN75150 outputs are capable of enduring sustained shorts to ground or any voltage up to 25 volts in magnitude. Inputs are TTL/DTL compatible for ease in interfacing to logic systems.

The SN75150 dual line driver comes in TI's economical 8-pin plastic package. Use two in a 16-pin socket for quad applications. It's also available in the 14-pin ceramic or plastic DIP.

At the other end of the line, try TI's SN75154 quad line receiver. Available in the 16-pin plastic or ceramic package, it features a unique power supply arrangement that allows operation from either +12 or +5 volts. The inputs feature wide hysteresis for increased noise immunity and are capable of "fail-safe" operation. Outputs are TTL/DTL compatible.

For data sheets, circle 254.

TTL/LSI

Speedy, low cost, tri-state 64-bit read/write memory.

For high-speed buffer memories or scratch pad applications with non-destructive read out, check into TI's SN74189 read/write memory.

It is organized as 16 words of 4-bits and features tri-state outputs for very fast access times—typically, 15 ns from memory enable and 30 ns from the binary address inputs.

IC memory building blocks normally require an additional decoding at the system level to achieve the required organization and bit capacity. Conventionally, this system decode is implemented at the memory-enable. The 15 ns access times through the SN74189 memory-enable compensate for the added system decode delay time—permitting the total system read and write cycle time to approach the SN74189 cycle times. Typically this is 35 ns.

In addition, the tri-state outputs may be wire-AND connected to form memories up to 4096-words by n-bits.

Not only does the tri-state output provide the capacitive-drive capability of the double-end TTL output, but it also provides the convenience of wire-ANDing a number of outputs.

The SN74189 is organized identically to the SN7489 random access memory. It is pin compatible, and can be plugged in to upgrade existing systems in most cases.

For data sheet detailing this high-speed RAM, circle 255.

NEW—The integrated circuits catalog for design engineers

All the design data you need—not just summaries, but full data sheet information... 1,616 pages in all.

Covers everything in industry's broadest line—Schottky TTL, High-speed TTL, Standard TTL, Low-power TTL, MOS, ECL, DTL, SUHL, High-Noise-Immunity Logic, Radiation-hardened circuits, Hybrid circuits, Systems Interface circuits, Linear circuits, and the MACH IV high-reliability procurement system.

Fast, easy to use—indexed by number and function. Cross-reference guides, too. Full-size book with big, readable type.

For your copy—send $4.95 (check or money order only please) to Texas Instruments Incorporated, P. O. Box 5012, M.S. 84, CN9083, Dallas, Texas 75222.

Integrated Circuits: you'll find your br

TI offers most comprehensive MOS catalog line.

Your biggest selection of standard MOS circuits is at TI—66 of them. All are readily available.

For the data sheet on any MOS catalog circuit listed, please specify the device number and write Inquiry Answering Service, Texas Instruments Incorporated, P.O. Box 5012, M.S. 308, Dallas 75222.

MOS/LSI SHIFT REGISTERS

TMS 3000 LR Dual 25-Bit Static
TMS 3001 LR Dual 32-Bit Static
TMS 3002 LR Dual 50-Bit Static
TMS 3003 LR Dual 100-Bit Static
TMS 3012 JC/NC Dual 128-Bit Static
TMS 3016 LR Dual 16-Bit Static
TMS 3021 LR 16 + 4 + 1-Bit Static
TMS 3028 LR Dual 128-Bit Static
TMS 3101 LC/NC Dual 100-Bit Static
TMS 3102 LC/NC Dual 80-Bit Static
TMS 3103 LC/NC Dual 64-Bit Static
TMS 3112 JC/NC Hex 32-Bit Static
TMS 3113 JC/NC Dual 133-Bit Static
TMS 3114 JC/NC Dual 128-Bit Static
TMS 3304 LR Triple 66-Bit Dynamic
TMS 3305 LR Triple 64-Bit Dynamic
TMS 3309 JC/NC Dual 512-Bit Dynamic
TMS 3314 JC/NC Triple 60 + 4-Bit Dynamic
TMS 3401 LC/NC Single 512-Bit Dynamic
TMS 3402 LC/NC Single 500-Bit Dynamic
TMS 3406 LR Dual 100-Bit Dynamic
TMS 3409 JC/NC Quad 80-Bit Dynamic
TMS 3412 JC/NC Quad 256-Bit Dynamic
TMS 3413 LC/NC Dual 512-Bit Dynamic
TMS 3414 LC/NC Single 1024-Bit Dynamic
TMS 3417 JC/NC Quad 64-Bit Dynamic*
TMS 3419 JC/NC 9 x 128-Bit Dynamic*

MOS/LSI READ ONLY MEMORIES

TMS 2000 JC/NC 3840-Bit Programmable Logic Array
TMS 2200 JC/NC 5482-Bit Programmable Logic Array
TMS 2300 JC/NC 2560-Bit (256 x 10) ROM
TMS 2400 JC/NC 2240-Bit (64 x 7 x 5) Char. Gen.
TMS 2403 JC/NC 2240-Bit USASCII (7 x 5) Char. Gen.
TMS 2404 JC/NC 2240-Bit EBCDIC (7 x 5) Char. Gen.
TMS 2500 JC/NC 2560-Bit (256 x 10 or 512 x 5) ROM
TMS 2501 JC/NC 2560-Bit USASCII (64 x 7 x 5) Char. Gen.
TMS 2600 JC/NC 2048-Bit (256 x 8 or 512 x 4) ROM
TMS 2601 JC/NC 2048-Bit Test Pattern Char. Gen.
TMS 2602 JC/NC 2048-Bit USASCII to Selectric Selectric to USASCII
TMS 2603 JC/NC 2048-Bit EBCDIC to USASCII Char. Gen.
TMS 2604 JC/NC 2048-Bit USASCII to Selectric and EBCDIC Char. Gen.
TMS 2605 JC/NC 2048-Bit Quick Brown Fox Char. Gen.
TMS 2700 JC/NC 3072-Bit (256 x 12) ROM
TMS 2800 JC/NC 1024-Bit (256 x 4) ROM
TMS 2801 JC/NC 1024-Bit Priority Encoder
TMS 2900 JC/NC 1280 Bit*
TMS 4100 JC/NC 2240-Bit (64 x 5 x 7 or 32 x 5 x 14) Char. Gen.
TMS 4103 JC/NC 2240-Bit USASCII (7 x 5) Char. Gen.
TMS 4177 JC/NC 2240-Bit USASCII (10 x 7) Char. Gen.
TMS 4178 JC/NC 2240-Bit USASCII (10 x 7) Char. Gen.
TMS 4179 JC/NC 2240-Bit EBCDIC (7 x 5) Char. Gen.
TMS 4400 JC/NC 4096-Bit (512 x 8 or 1024 x 4) ROM
TMS 4401 JC/NC 4096-Bit Test Pattern
TMS 4880 JC/NC 2736-Bit 76 x 35 Char. Gen.
TMS 4886 JC/NC 2736-Bit USASCII (64 x 25) Char. Gen.
TMS 4900 JC/NC 66-Key, 4-Mode Static Keyboard Encoder*
TMS 5000 JC/NC 3600-Bit, 90-Key, 4-Mode Dynamic Keyboard Encoder*

MOS/LSI RANDOM ACCESS MEMORIES

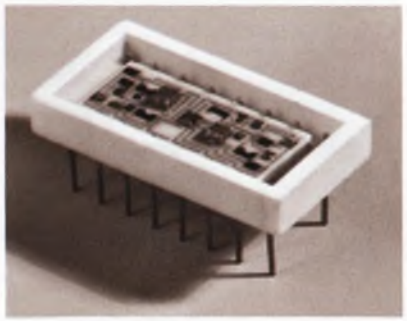
TMS 1101 JC/NC 256 x 1 Static
TMS 1103 NC 1024 x 1 Dynamic
TMS 4000 JC/NC 16 x 8 CAM Static
TMS 4003 JC/NC 256 x 1 Static
TMS 4020 JC/NC 1024 x 2 Dynamic
TMS 4022 JC/NC 1024 x 1 Dynamic
TMS 4023 JC/NC 1024 x 1 Dynamic
TMS 4025 NC 1024 x 2 Dynamic
TMS 4026 JC/NC 64 x 4 Static
TMS 4027 JC/NC 1024 x 1 Dynamic*

*To be announced.
Note: N = plastic, J = ceramic, L = plug-in type

Hybrid circuits
New MOS clock driver features fast switching.

TI's new HIC138 hybrid dual MOS clock driver drives high capacity loads (up to 750 p.f.) at switching speeds of 50 ns or less. It will fit neatly into your designs as the interface circuit between TTL or DTL logic levels and MOS clock inputs where fast switching into capacitive loads is required.

And it will save you either money or space. As a standard, it costs less than the custom devices often used. Available in a single, 16-pin hermetically sealed dual-in-line package, it saves considerable space when compared to the use of discrete assemblies. Put it to saving for you in com-



puter memories, static MOS circuits, dynamic MOS circuits and MOS memory arrays.

The HIC138 is completely compatible with TI's low-threshold MOS shift registers and has a low standby power of 30 mW per driver. Input supply voltage is +5 volts and −12 volts.

Get all the details by circling 250 on the Reader Service Card.

Schottky TTL
Growing fast with two new flip-flops.

Your Schottky choice has recently grown with the addition of two new dual J-K edge-triggered flip-flops – the SN54S/74S113 and SN54S/74S114. They each have a typical maximum input clock frequency of 125 MHz and a typical power dissipation of 75 mW per flip-flop.

These flip-flops allow you to upgrade existing designs. Just plug the Schottky version into existing systems for 100 MHz performance.

Your Schottky choice now also includes two quad 2-input NAND gates, a hex inverter, two triple 3-input AND gates, a triple 3-input NAND gate, two dual 4-input NAND gates, two 4-wide 4-2-3-2 input AND-OR-INVERT gates, a dual 4-input NAND buffer, a dual 4-input 50-ohm line driver/NAND buffer, a dual D-type flip-flop and a dual J-K flip-flop.

For additional data on the newest Schottky additions and the entire Schottky family, circle 251.

Semiconductor memories
High-speed, low power 1024 x 2-bit RAM.

The era of super-fast, fully decoded random access memories having large storage capacities and low power dissipation is drawing nearer. Take, for example, TI's new SMA2002, a 1024 x 2-bit RAM. It has a high speed of 125 ns access time with a power dissipation of only 0.6 mW per bit. It features static operation with no refresh needed and combines MOS/LSI storage with bipolar decoding, sense and write.

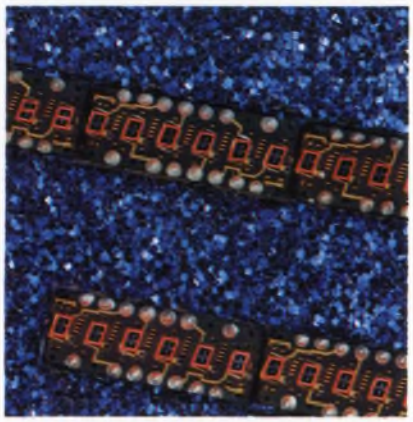
Fully TTL compatible, the SMA2002 can be connected in memory planes to increase bit capacity for buffer memories or for main frame memories.

If you would like a different organization, try TI's recently announced SMA2001, a 2048 x 1-bit high-performance RAM array.

For data sheets on the pacesetting SMA2001 and SMA2002, circle 252 on the Service Card.

New semiconductors expand your broad choice at TI.

Optoelectronics
New, 6-digit display in stackable, dual-in-line package.



TI's new, 6-digit display—the TIL306—may be used to construct data displays having any number of digits. Designed for end-to-end mounting with consistent character spacing, the TIL360 has sign, overflow and right-hand decimal capability.

TI can supply the TIL360 with any of the characters omitted, and any character may be interconnected to show sign.

A 7-segment device, the TIL-360 is ideally suited for small calculators or similar equipment where the display is multiplexed. Characters are easy to read, being 0.1" high and having a brightness of 150 footlamberts under normal operating conditions. The monolithic dual-in-line package is also easy to use and handle, thereby reducing your system assembly costs.

For more details, circle 256 on the Reader Service Card.

Power transistors
TI delivers a new, high-performance SOA series.

The chart below tells the improved performance story on TI's new, broad-choice, safe operating area (SOA) power transistor series. It's made possible by TI's new isothermal geometry used in the chips. And TI can deliver. Availability is excellent thanks to use of simple, reliable processing techniques that also bring you savings of up to 30%. Choose from 18 devices in three packages:

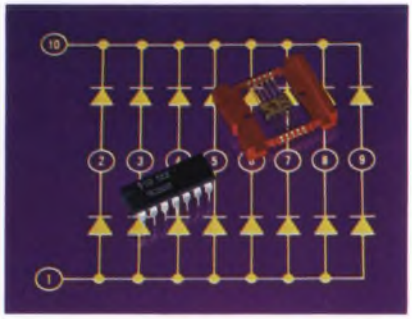
TO-59 Stud Mounted	TO-39 Lead Mounted	TO-61
2N4998	2N5147	2N6127
2N4999	2N5148	2N6128
2N5000	2N5149	
2N5001	2N5150	
2N5002	2N5151	
2N5003	2N5152	
2N5004	2N5153	
2N5005	2N5154	

PNP and NPN complementary pairs are included.

For data sheets, circle 257 on Reader Service Card.

Diode arrays
Highest reliability in widest available choice of coredrivers.

TI lays a lot on the line when you're selecting integrated diode array coredrivers for industrial, military or airborne computers. There are now 12 TI devices packaged in economical DIP plastic—TID121-124 (8-diode arrays), TID-125 and 126 (16-diode arrays), TID129 and 130 (dual 10-diode arrays) and TID131-134 (dual 8-diode arrays).



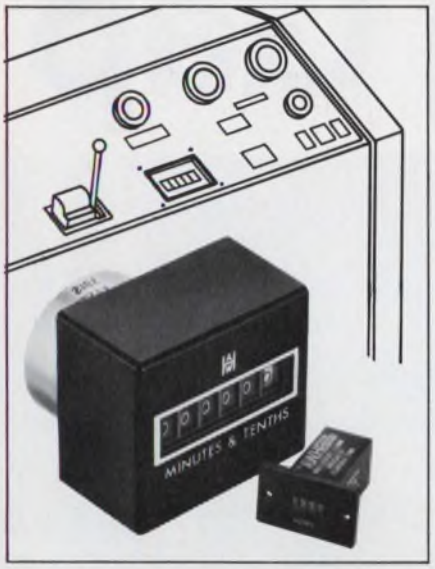
Reliability is outstanding because these coredrivers are manufactured like ICs. Thus, there are a reduced number of connections and glass-to-metal seals, better uniformity of device parameters, smaller size and less weight, no pressure contacts, no whiskers and no crossed bonding wires.

All 12 feature high-current switching diodes having a 500 mA coredriver capability with 10 to 20 ns recovery time and a low 4 to 7 p.f. capacitance. **For data sheets,** circle 258 on Reader Service Card.

For more information on any TI product, call your local TI sales engineer or authorized distributor. Or write Inquiry Answering Service, Texas Instruments Incorporated, P.O. Box 5012, M.S. 308, Dallas, Texas 75222.

TEXAS INSTRUMENTS
INCORPORATED

Compact design ideas for monitoring things.



TIME-BILLING MAINTENANCE

You can keep track of a lot of hours, minutes or seconds utilizing very little space with The A.W. Haydon Company's Elapsed Time Indicators. Choose from 21 standard size low-cost models or from a wide range of smaller units down to microminiature devices measuring only 37/64" square. Accurate digital readout is assured by precision Geneva gearing. These indicators operate from a wide range of power sources, both AC and DC, and are available in many mounting configurations. When you must monitor time for billing purposes, or maintenance programs such as lubrication, overhaul or recalibration, our indicators will do the job using a minimum amount of space. Write for complete technical information.

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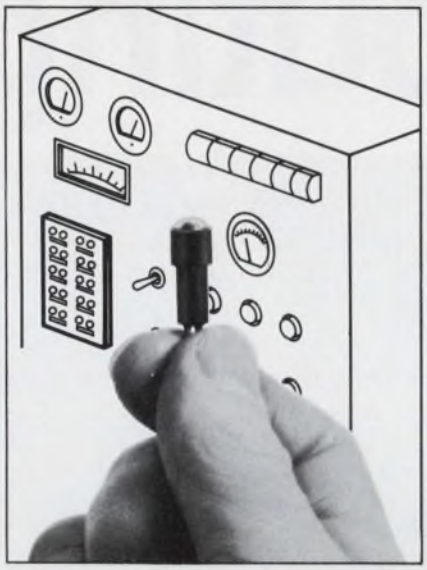

FAULT ISOLATION

These microminiature Fault Indicators not only signal a malfunction, but they "remember " that it happened, too. The electrically actuated display latches magnetically until reset. This "latch memory" assures positive isolation and indication of both transient and continuous malfunctions. The The A. W. Haydon Company's BITE (Built-In-Test-Equipment) Indicators are low power devices that operate on pulses of milliseconds duration and can be mounted directly on PC boards or grouped on remote panels. Their cost is unusually low for the function they perform.

You can design these BITE Indicators into your circuitry, or let our engineers design a complete fault isolation system for you. Write for literature, today.

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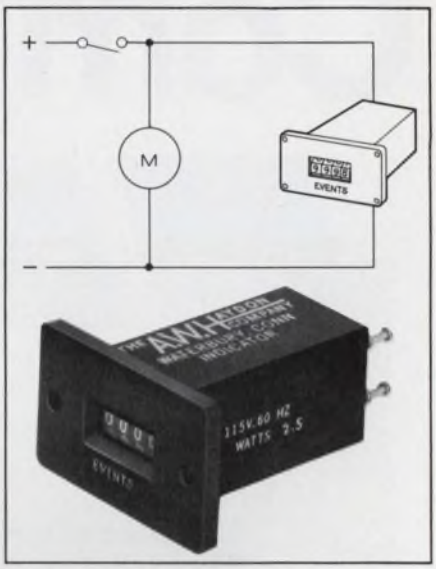

EVENTS-BILLING MAINTENANCE

If monitoring how many times anything has happened is a big problem, you don't need a big counter to solve it. This Events Counter, illustrated, is only 37/64" square x 1.250" deep. Yet, small as it is, it provides a 4-digit readout of up to 9999 events before recycling. Non-resettable, it is ideal for both billing and preventive maintenance programs because it is tamper-proof and provides a fast (1,200 cpm) accurate count of everything that has happened. It requires minimum power, too — only 2.5 watts max. at 115 VAC 60Hz. If you need high speed totalizing for data processing equipment, business machines, vending machines or production line machinery and operations find out about these miniature Events Counters. Write for literature.

INFORMATION RETRIEVAL NUMBER 93

THE A. W. HAYDON COMPANY

NORTH AMERICAN PHILIPS

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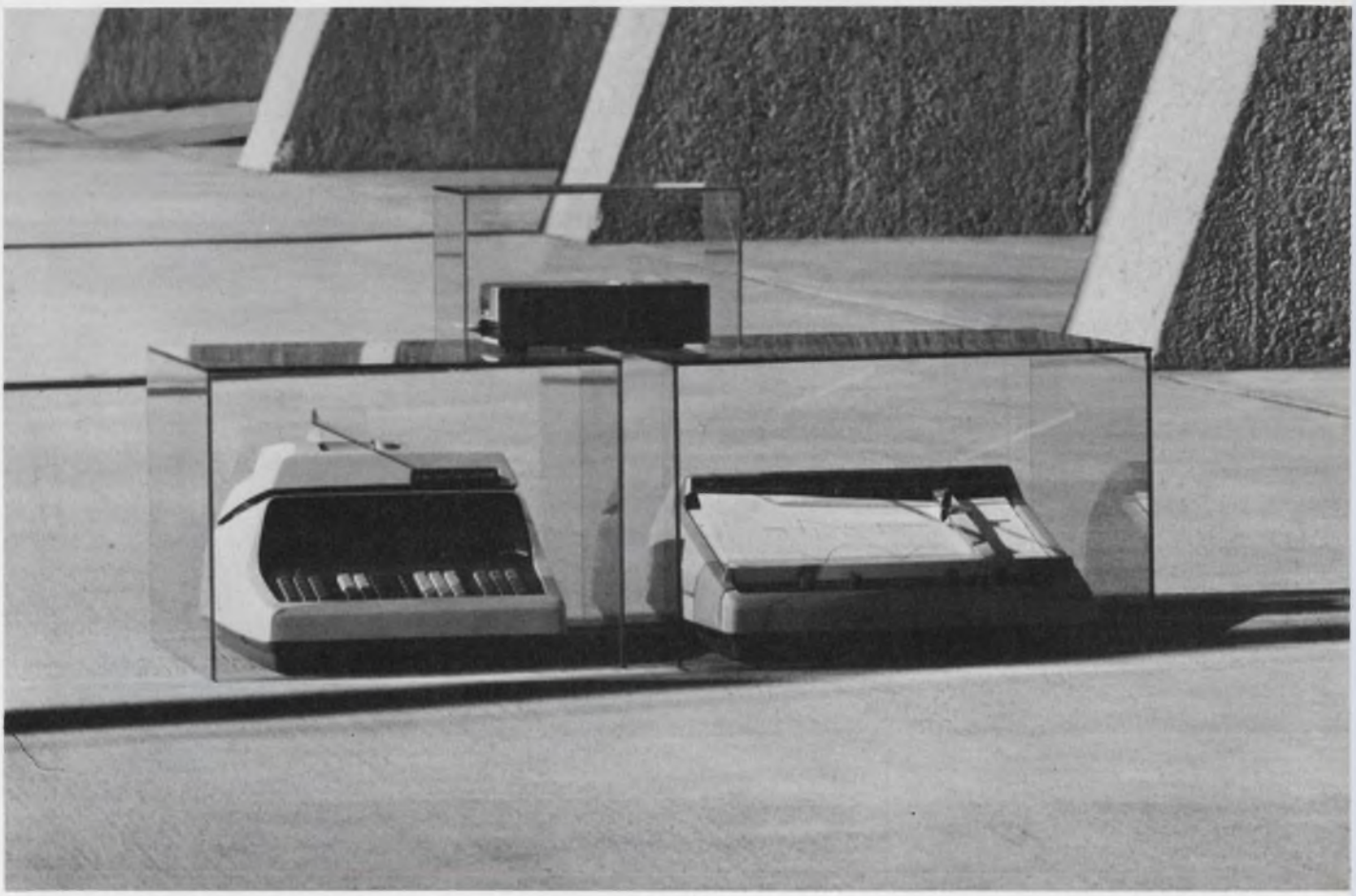
Bridge the Computing Gap



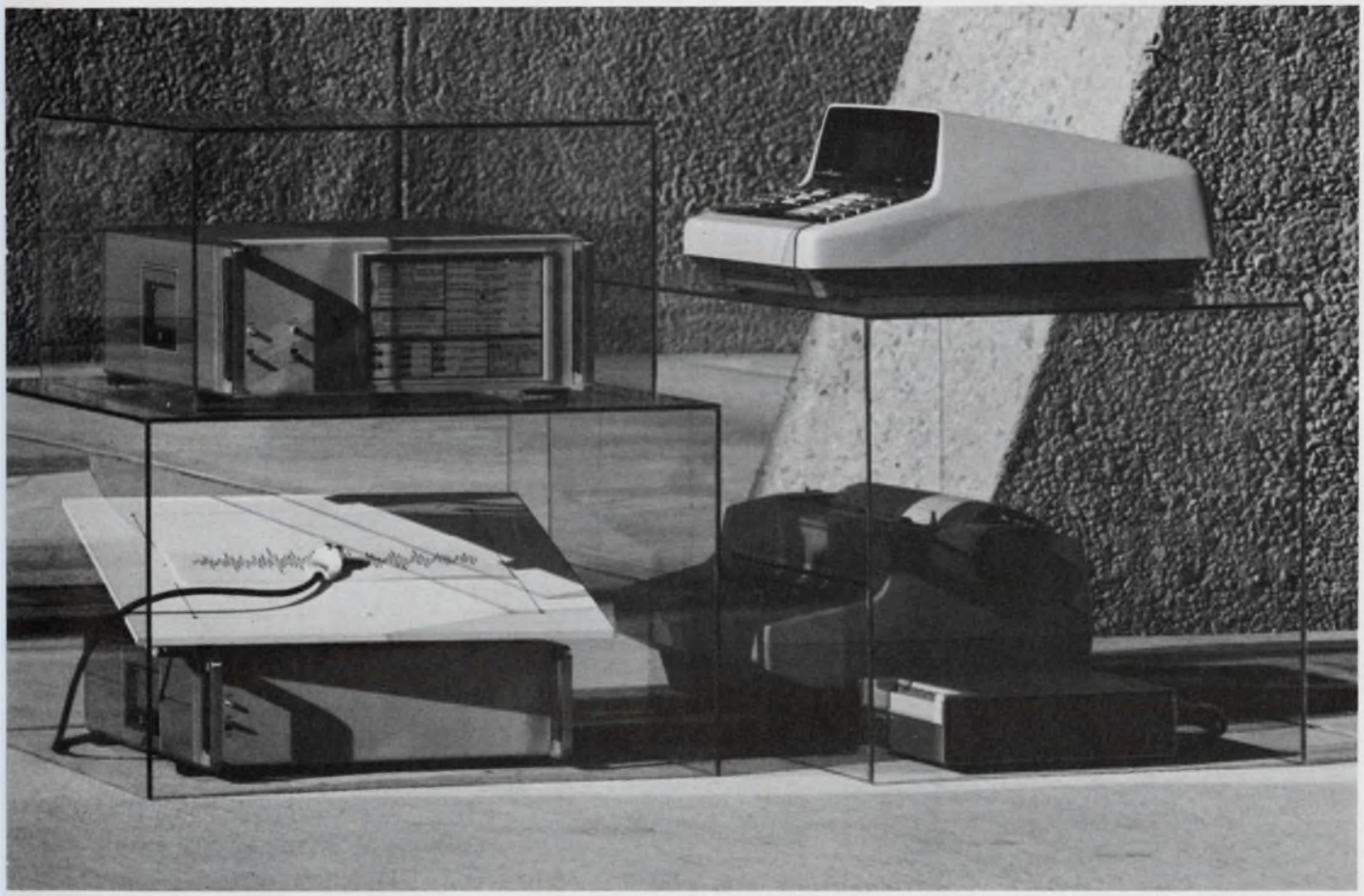
The HP Calculator System 9100. For People Who Demand More Than Just A Calculator

Chances are, you, like most other engineers, scientists, and businessmen, have found that a calculator alone isn't enough. Many times the tasks of entering data and putting solutions into useable form can eat up more time than the computation itself. That's why the HP Calculator System 9100 gives you more ways to enter your data, more memory to perform the calculations, and more ways to receive your solution than any other calculator on the market. This true system approach allows you to fit the right machine to your needs yet retain the low cost and ease of operation of a calculator.

For instance, if graphs and charts are important in your work, the System 9100 has the only X-Y Plotter on the market that can produce linear, log-log, and semi-log plots. Need a card reader? A large screen display? A strip printer? Formatted output? They're also available if you need them. Exclusive interface capability allows you to expand your system as your needs change – or add new peripherals as they become available. So, even if you bought the first 9100, you can take advantage of these new work-saving peripherals with no modification to your present equipment.

Now you can emancipate your time from big problems with long programs or large amounts of data. The **new 9101A Extended Memory** has the power you need to perform a 14 X 14

NEW 9104A Paper Tape Reader



matrix inversion, or find real and complex roots of thirtieth degree polynomials. The Extended Memory is the biggest in the business. Its 248 storage registers will store up to 100 programs (3472 program steps), yet programming is quick and easy since you use indirect addressing.

And you can emancipate your time from tabulating data and solutions. The **new 9106A Typewriter Interface** will couple your 9100 Calculator with an IBM Model 73 Typewriter for fast, formatted numeric printout.

Or, you can couple the **new 9107A Digitizer** to your 9100 Calculator and have a fast, automatic means for checking mechanical drawings, profiles, maps – or analyzing strip chart data. The Digitizer automatically converts lines or points on charts or drawings to digital data for instant analysis by your 9100 Calculator. Just enter the appropriate program in the Calculator, move the Digitizer's cursor over the data line, and the Calculator computes and prints out the solution you desire. Your imagination is the only limit to the application of this versatile data input device.

You can also couple your 9100 to a host of HP measurement instruments and automatic test systems. The new 9108A and 9108B Coupler/Controllers (not shown) will make your 9100 a true real-time, on-line data processing and control system.

All 9100 Calculators and Peripherals are backed by fully documented program packages – including a host of application Program PACs in many disciplines of science, engineering, and business – so your System 9100 goes to work the moment you take it out of the box.

You can put the System 9100 to work for you for as little as $1.11 per computing hour. Purchase, lease, and rental options are available for all System 9100 equipment. For further information, or to arrange a "hands-on" demonstration at your desk, write: Hewlett-Packard, P.O. Box 301, Loveland, Colorado 80537. In Europe: 1217 Meyrin-Geneva, Switzerland.

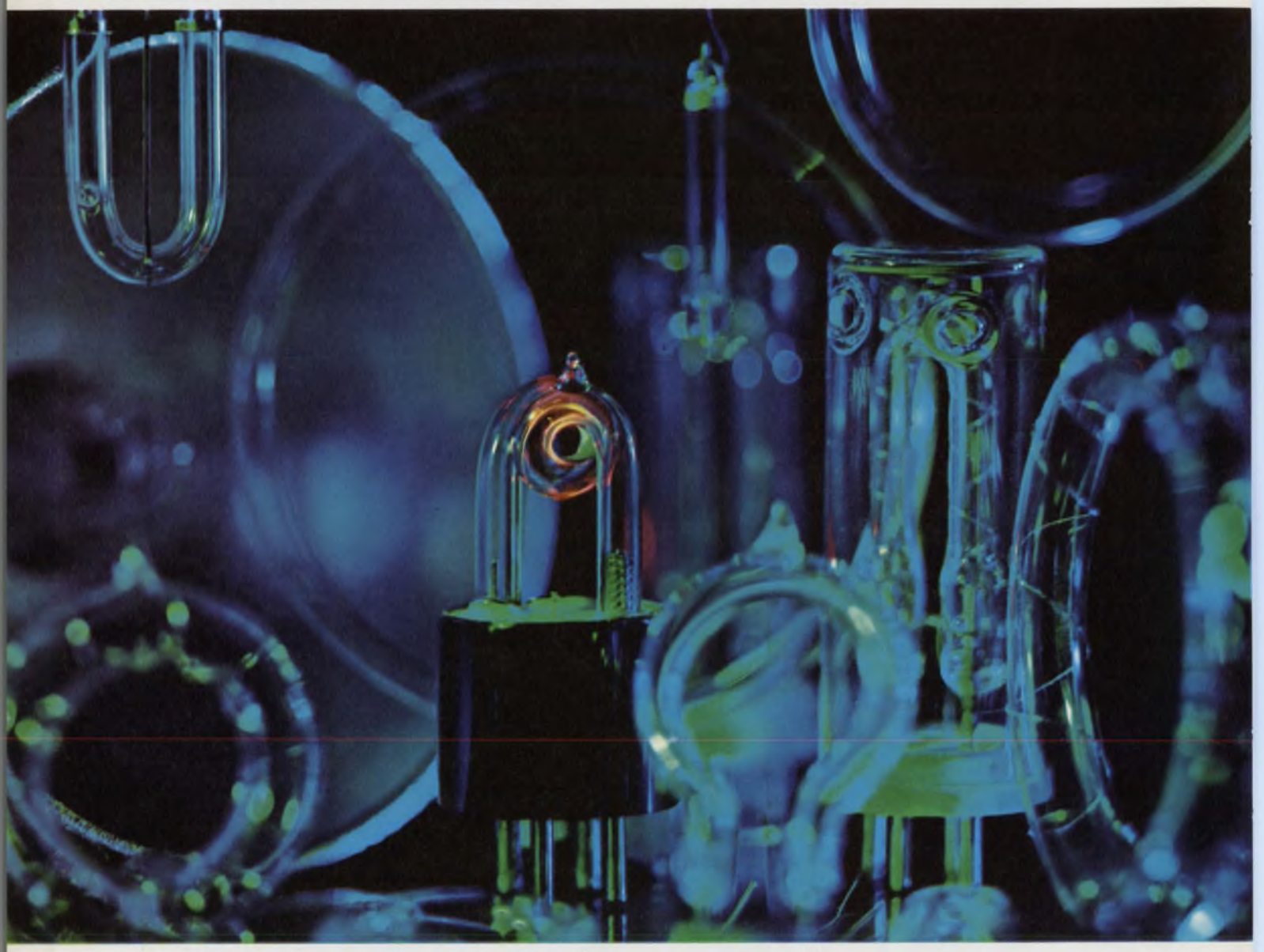
090/22A

HEWLETT hp PACKARD

HP CALCULATOR SYSTEM 9100

INFORMATION RETRIEVAL NUMBER 23

Siemens



These flash tubes produce bursts of sunlight from small amounts of power. We can put them to work for you.

Our xenon flash tubes produce high intensity light covering wavelengths from the ultraviolet to the near infrared. And they can be pulsed thousands of times as fast as incandescent lamps.

These characteristics plus a very high efficiency make them ideal for laser stimulation, aircraft anti-collision lights, beacons, timing devices, high-speed inspection systems and photographic lights.

We turn out these tubes by the millions in sizes and shapes to meet many different requirements. Some are low-cost units produced in high volume. Others, sophisticated, one-of-a-kind designs.

There's an answer to your problem in our files or experience. Tell Larry Boone about your needs.

Siemens Corporation, 186 Wood Avenue South, Iselin, N.J., 08830. (201) 494—1000.

Siemens. A three billion dollar name in quality products. SIEMENS

INFORMATION RETRIEVAL NUMBER 24

washington report

DON BYRNE, WASHINGTON BUREAU

DOT goes to electronics for city traffic problems

The Dept. of Transportation is exploring the use of electronics to locate and track public transit vehicles as they ply their routes on city streets. Tracking and immediate location would mean better schedule service, handling of passenger surges and response to emergencies, DOT says. In addition to transit vehicles, DOT says police cars, taxis, truck fleets, repair vehicles and even private cars should be able to make use of such a system when perfected. At present DOT has let contracts to the Cubic Corp. for $188,299; Teledyne Systems Co. for $184,488, and RCA for $202,823. Another contract is in the process of being negotiated.

Cubic will try to track the vehicles via a radio-frequency trilateration method; Teledyne by Loran-C, and RCA will use a signpost proximity system that emits a constant low-power signal picked up by a passenger vehicle and stored until queried by a computer. All three systems will make extensive use of computers. DOT said that a similar signpost system designed by Motorola is currently undergoing tests in Chicago.

National Environmental Data Bank backed by House

The House has passed a bill that would establish a National Environmental Data Bank for coordinating the "selection, analysis, retrieval and dissemination" of information relating to the environment. The system would include a network of new and existing data-processing facilities, both federal and private, tied to the central facility.

Rep. John D. Dingell (D-Mich.), sponsor of the bill, estimates that the program would cost about $5-million annually to run. Similar legislation passed the House last December but was not acted upon in the closing days of the Senate session. Senate sources said hearings on the legislation would be held in June. Passage is expected, even though the Administration has not supported the legislation. And no veto is expected.

A Governmental switch to microwave communications?

Two Government officials who represent the nation's largest telecommunications users say they will have to consider using private microwave systems if AT&T's Telpak bulk-service offering is abolished or if rates are greatly increased. In cross-examination during hearings by the Federal Communications Commission into AT&T's private-line rates, Brig. Gen. Lee M. Paschall, deputy director of command and control communications for the Air Force, and Robert M. O'Mahoney, commissioner of the Transportation and Communications Service in the General Services Administration, said that some sort of private system would be explored

if present rates went up sharply. General Paschall said he would look into new "mix," while O'Mahoney said the possibility of private microwave might be studied.

Army seeks to resume output of Pershing missiles

The Army is asking Congress for $42.3-million to resume production of the Pershing missile—one of the longest-lived missiles in any military inventory in the world. The Army says it needs the missiles to replace the 20 or so fired every year in practice. An Army spokesman said the service would also seek a $18.3-million modification of electronic units in the missile. These include the guidance-control computer, the main distributor and the missile inverter, which supplies electrical power for all on-board systems. About 70% of the difficulties with the missile are caused by these units, the Army said. The Pershing systems manager is Martin Marietta. The missile first went into service in 1962.

Navy pressing installation of new sonars

The Navy has awarded a $60-million contract to Sperry Rand for kits to modify the AN/SQS-23 sonar into an improved, long-range submarine-detecting gear known as AN/SQQ-23 sonar. Originally the Navy had planned to install the newer sonar on 180 of its destroyers, but budget cuts over the last three years and the retirement of some ships in the program have cut that number back to 65. Meanwhile Litton Industries has awarded a $30-million contract to General Electric for installing AN/SQS-26 sonars in nine destroyers that Litton is building. If all 30 destroyers that Litton has a contract for are built, the sonar contract could total $101 million.

Capital Capules: The Immigration and Naturalization Service reports **13,337 scientists and engineers immigrated to the U. S. during fiscal 1970,** an increase of 30% over the previous year. The largest percentage of new arrivals came from Asia. Immigration authorities attribute the total increase to an easing of the old quota system. The service expects a decline this year, as science and engineering immigrants are now required to have a job offer . . . . **The goal of Senate doves now seems to be** to limit the Navy's Ulms program to R&D only, halt deployment of MIRVs, stop modernization of the Minuteman missile, limit B-1 funding to design studies only, halt the deployment of the Safeguard antiballistic missile system, stop advanced research on MIRV guidance systems and cancel the Awacs program. This is in addition to already announced attacks on the F-14, F-15, C-5A and other systems . . . . **Space committees in the House and Senate have approved** a spending authorization for NASA that is slightly above the $3.27-billion requested by the Administration for the coming fiscal year. The House committee approved $3.43-billion, the Senate $3.28 billion . . . . **The Mitre Corp. of Bedford, Mass., has received a $4.8-million contract** from the Federal Aviation Administration for continuing work on its air traffic control automation program. The major job will be to develop specifications for linking the 20 air-route traffic control centers and 60 towers that are in the automation program. Mitre has been working with the FAA since 1963.

INFORMATION RETRIEVAL NUMBER 25 ►

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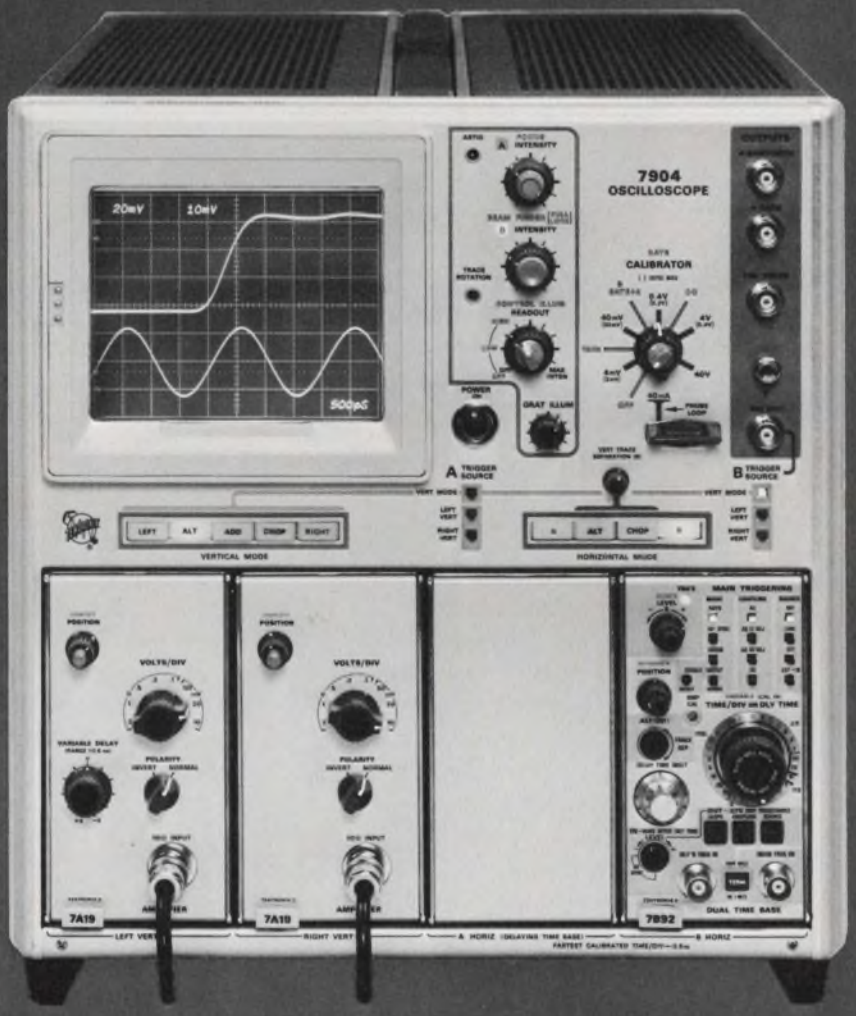

The new Tektronix 7904 Oscilloscope is power packed. With 7A19 Amplifier plug-in it offers a phenomenal real-time bandwidth of 500 MHz at 10 mV/div. And the ultra-high CRT bandwidth makes possible direct access offering 1-GHz bandwidth at a deflection factor of 5 V/div.

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Now you know why the amazing 7904 was the center of attraction at the 1971 IEEE Show.

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Address decoding is incorporated on chip providing 1-of-16 decoding from four address lines. Separate Data In and Data Out lines, together with a Chip Enable, provide for easy expansion of Memory capacity. A Write Enable is provided to enable data presented at the Data In lines to be entered at the addressed storage cells. When writing, Data Out is the complement of Data In.

Let's take a look at a typical system using the MCM4064L as a main frame store of 128-words by 16-bits. Total devices involved are 32 MCM4064L RAMs, 9 MC7404P Hex Inverters, and 1 MC4006P 1-of-8 Decoder.

To directly address the 128 words of memory would require seven address inputs. Since the MCM4064L has four address inputs, expansion is achieved by connecting the Chip Enable inputs of each device in a row, treating the system as an 8 row by 4 column array, and driving the 8 row lines with a 1-of-8 decoder (MC4006P).

Address lines A0 thru A3 are brought to all memory devices in the system via address drivers using a TTL fanout of 8. Each inverter/driver represents four, one for each bit A0 thru A3; thus sixteen inverters are required. The same scheme is used for the data input and output buffers. The four address bits A0 thru A3 are common to each memory and are used to address the corresponding word in each MCM4064L.

The output bit lines in each column are wire-ORed because the devices chosen by the Chip Enable signal are dominant. Lines B1 thru B4 in the leftmost column are brought out to four inverter/buffers as are the four data lines in the other three columns.

Other organizations can be used but in wire-ORing MCM4064L outputs, eight was chosen as an optimum trade-off between decreasing decoding time versus increasing access time due to capacitance. The system provides a total access time of less than 100 ns typical and interestingly, a typical cycle time of less than 85 ns.

Data is written into the memory by selecting one memory device in each row with the Chip Enable as was done for the read operation.

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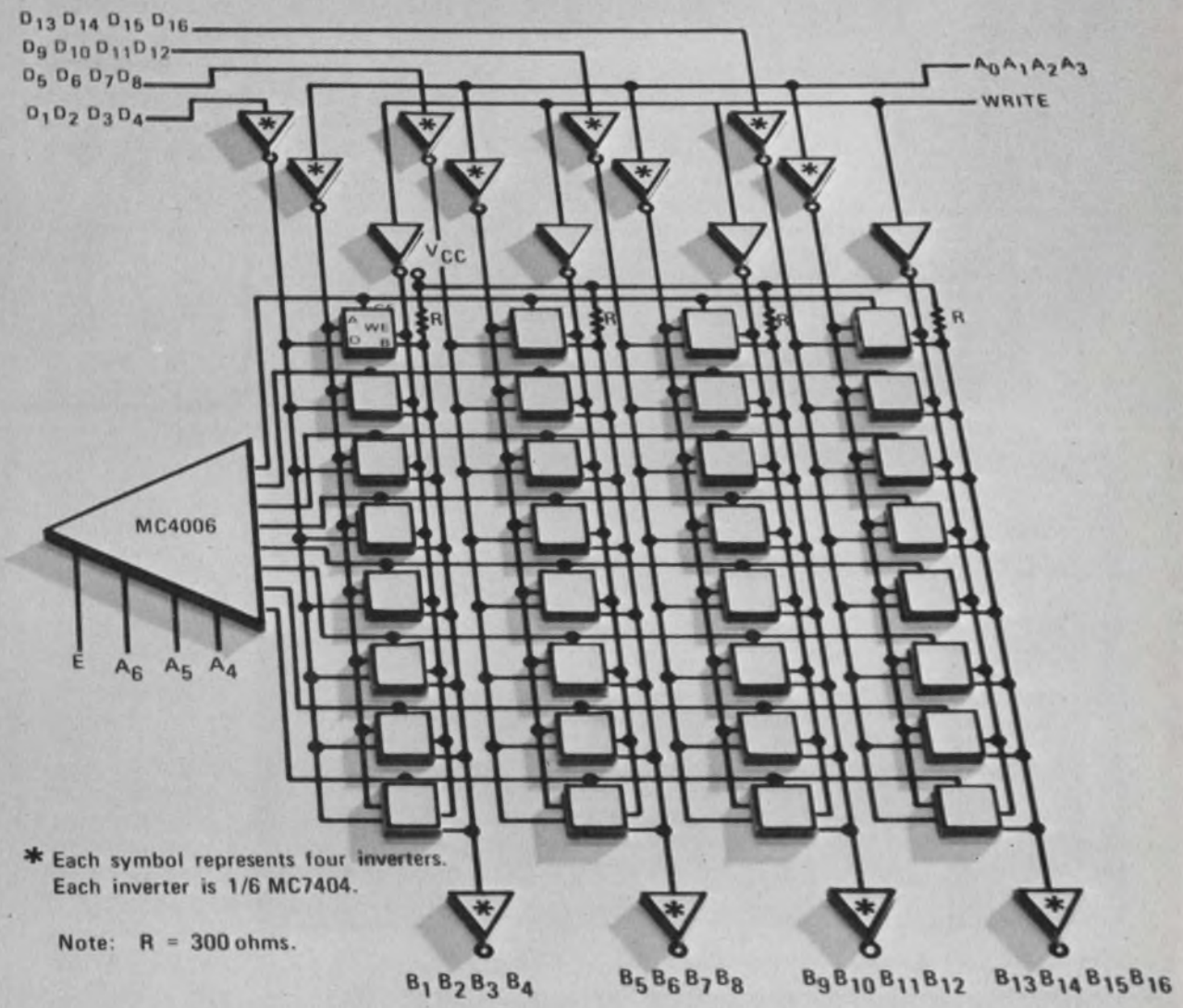

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INFORMATION RETRIEVAL NUMBER 26

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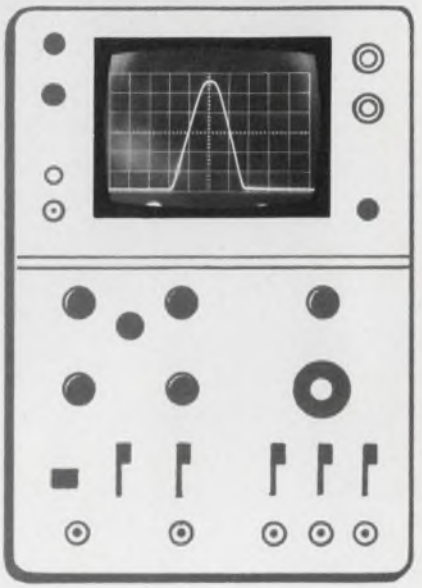

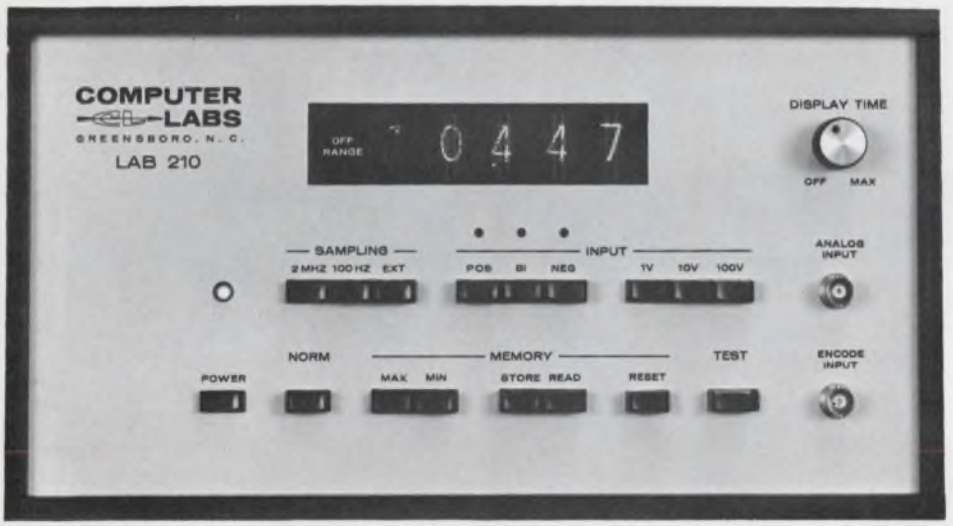

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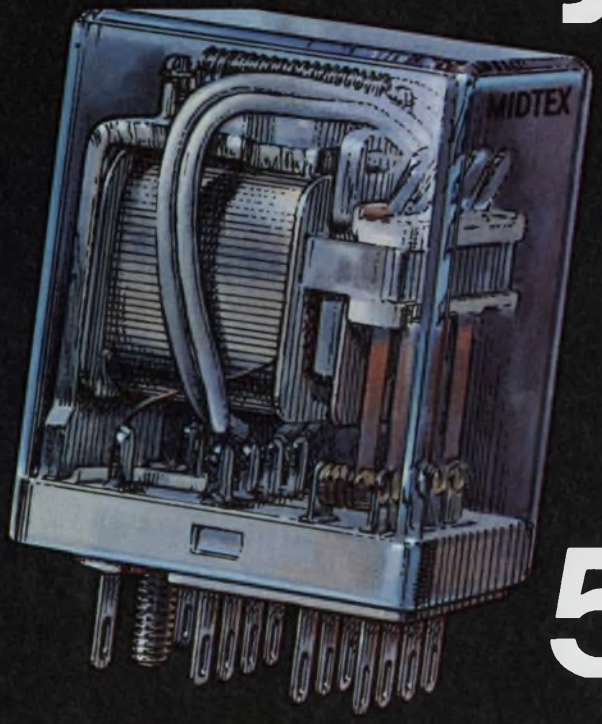
INFORMATION RETRIEVAL NUMBER 27

INFORMATION RETRIEVAL NUMBER 28 ►

Meet the cost cutter

New wire-wrap relay socket cuts costs up to 50% per connection



Here is the first wire-wrap® socket in the industry for a standard industrial relay. It can cut your connection costs in half because now you can wire-wrap industrial relays, too! It's another new idea from Midtex.

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INFORMATION RETRIEVAL NUMBER 29

editorial

All you 'train drivers' better start talking

Engineers have a serious identity problem. We've always believed this, and we're more than ever convinced after reading the responses to our recent poll of high-school seniors (see "Engineering Is Slipping as a Career Goal," p. 54).

In describing their thoughts on engineers and engineering, many of the students betrayed appalling misconceptions. And these students were assumedly a cut above average, taking science programs in their high schools.

If the same questions were asked of all high-school students, or housewives, or just "the man in the street," we're sure the answers would be even more discouraging. It would be silly, of course, to expect everyone to be familiar with all of the engineering disciplines, their purpose and their achievements. But it's equally silly for the engineering profession not to care when to large numbers of people, the word *engineer* means nothing but "driving trains" or "building bridges."

"Becoming an engineer isn't easy, and keeping up-to-date once you are an engineer can be even tougher. So it isn't unreasonable for an engineer to expect a certain degree of status, respect and security. When he doesn't get it, thoughts of collective action naturally set in, such as unionization or demands that professional societies promote the welfare of their members.

Such group actions have merit, in that they can bring pressure and resources to bear on the problem. They don't, though, do anything to establish the identity of the engineer or to boost his image among the population in general. And without a good, broad-based identity, engineers lose by default the support of the public—the very people who have benefitted so handsomely from the efforts of all engineers.

What's the answer? Obviously the engineering profession could use the services of a good public relations firm. But until someone, such as the professional societies, sees fit to foot the bill, we have a suggestion: Start giving talks to non-technical audiences.

Civic organizations, Boy Scouts, PTAs—they're always looking for speakers. Offer your services. The chairman may be surprised at first, but if you propose an interesting talk, you're as good as on. Tell them about your type of engineering. What it's done for them. What it's going to do for them. And how it's going to do it.

If each ELECTRONIC DESIGN subscriber gave just one talk in the next six months before 50 people, more than 3.7 million people would be reached. The results could be significant.

Frank Egan

FRANK EGAN

Put optoelectronic components to work in systems design

You'll find it no harder than any other design problem if you remember to consider the unique effects of light

A wide range of optoelectronic devices and options is available to the systems designer. He'll choose the best devices if he considers the key subsystem functional blocks present in any optoelectronic system.

The character and interrelationship of these functional blocks, how optoelectronic components fit into the blocks, the equivalent circuits for optoelectronic components and the limitations of optoelectronic devices—all must be understood before a system is designed.

Designing with optoelectronic devices requires a general understanding of spectrum and wavelength concepts, just as rf system design must consider the various ranges of the electromagnetic spectrum for propagation effects, attenuation and transmission over various ranges. But for most optoelectronic devices, the physical structure of the device is far longer than the wavelength involved.

Lin Wetterau, Manager, Standard Optoelectronic Devices, Texas Instruments, Inc., Post Office Box 5012, Dallas, Texas 75222.

A systems view of optoelectronics

The system designer sometimes is more comfortable with black-box components. Optoelectronics can be viewed quite simply in this way, if each optical and electronic function is realistically approached as an essential subsystem of a larger system (Fig. 1).

With the light source as a start, this system can be considered a transducer converting input power to optical power with a measurable transfer ratio or efficiency. Filters can be regarded as four-terminal structures that either absorb or reflect undesired light wavelengths. In a similar way, the transmission path can be considered an attenuator for most applications.

Detectors or sensors of light can be regarded as optical-to-electrical transducers, with gain added in a variety of ways following the detection. In some systems a lens may be considered as having gain, thus becoming also just another subsystem for optoelectronic designs.

Equivalent circuits to fit these black boxes can give a designer the insight to design systems; so let's examine several of these circuits.

This is the second of a two-part series offering handbook advice on optoelectronics. Part I, "Solid-State Optoelectronic Components Put Imagination in Engineering," appeared in the May 27 issue of ELECTRONIC DESIGN.

The diode as a light source

The semiconductor source is very often a diode. As such, it exhibits the forward and reverse characteristics normally found in silicon diodes. But there are important differences between a light-emitting diode (LED) and a silicon diode. With a LED, the light is emitted when the diode is forward-biased. For most GaAs and GaAsP diodes, the forward-voltage drop is slightly higher than expected in a good silicon diode operating at the same current. The reverse characteristics found in light emitters are largely neglected, since the light is generated with opposite polarity bias. Good practice usually leads to protecting the light emitter with external diodes, to prevent reverse-bias pulses from causing device damage or adding to the heat generated in the diode.

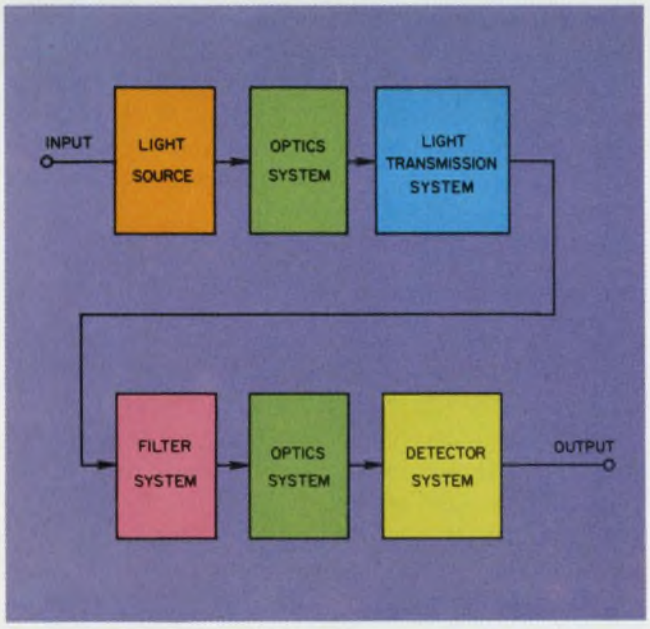
Evaluation of the output of a light-emitting diode can be frustrating, particularly if precise correlation is expected. The most consistent technique has been to use a large detector, collecting as much of the radiant energy as possible and comparing this detector against a reference detector. Use of lens filters and apertures tend to complicate the measurement, primarily because of the variations encountered in mechanical tolerance and alignment. A system such as that shown in Fig. 2 is most effective in measuring outputs of emitters.

Of course, the light-output rays and distribution energy vs solid angle is important for systems requiring large physical separation of source and emitter. To evaluate this aspect of emitters, measurement of power into small targets, represented by apertures, is often the fastest way to be sure that the output direction is within the system constraints.

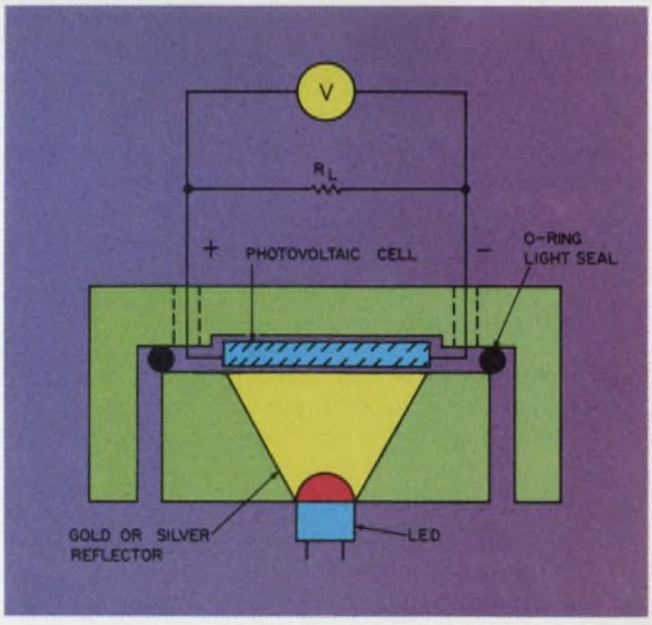
Detectors limit systems performance

The key to understanding the detector is its absorption characteristic. To function in the system, a detector must absorb the photon of light. The absorption creates hole-electron pairs in the semiconductor material. The effect of added carriers in the material changes either the current or voltage observed at the detector terminals or the over-all resistance of the detector.

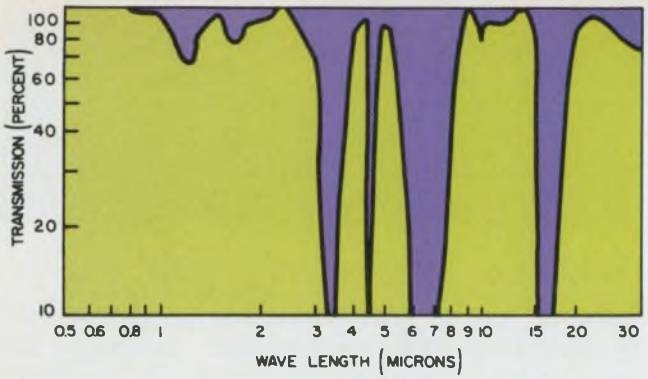
Devices with pn junction detectors depend on



1. **The character and interrelationship of the key segments** present in all optoelectronic systems must be understood before a system is designed. Each segment can be treated as a black-box component.



2. **The best method for evaluating the output of a LED** is to use a large detector, collecting as much of the radiant energy as possible and comparing this detector with a reference detector.



3. **Transmission losses are strongly frequency-dependent,** as shown by the nominal atmospheric transmission characteristics. Emitter characteristics should always be matched to the transmission media.

the junction characteristic to provide a variety of operational modes. The material and pn junction depth are usually selected on the basis of the wavelength of the light to be detected. The junction is tailored to be within one diffusion length of the surface where the light enters.

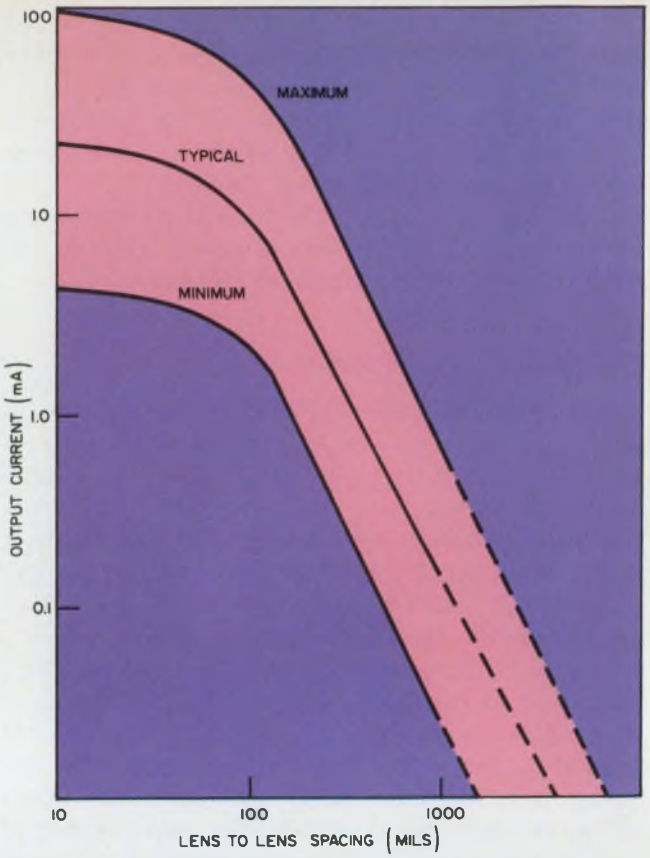
Most operational tradeoffs are made in the detector. In the detector, light absorbed in a depletion region is converted quickly to output current. Light within a diffusion length of the junction is also readily collected, but it takes longer for this current to appear at the detector output terminals.

Once again, the systems designer has a choice. He can design a circuit that uses most of the light absorbed within the device but that requires time for the output current to reach maximum. Or he can concentrate on light absorbed within the depletion region and emphasize that high-speed portion of the response, sacrificing the lower speed response of diffusing carriers from deep within a device. The optimum detector would have a tradeoff between quantum efficiency and speed.

In general, it is the detector that limits system performance. (For a discussion of detector characteristics, see "Which Photodetector Will Give Best Results," p. 50, this issue.)

Consider attenuation and absorption

The movement of light energy from the source to the detector is often somewhat confusing. The light travels in relatively straight lines, but absorption of light can occur because of a variety of things in the air, such as moisture, dust and smoke. There airborne particles reflect, and thus, scatter the light, which causes the signifcant part of the attenuation between light source and detector. Of course, for non-focused systems, the Inverse Square Law accounts for most of the decrease in radiant energy between source and sensor.

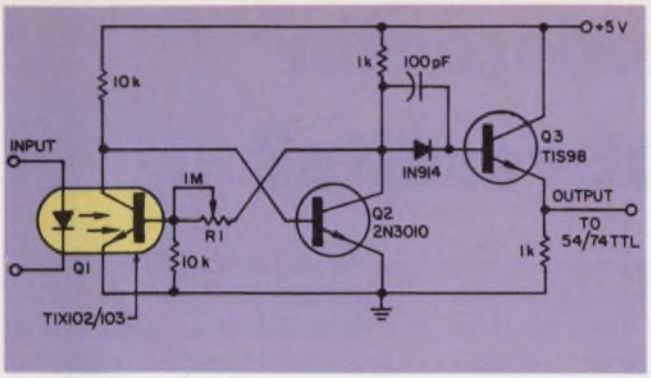


4. **The separation of source and sensor is the main factor** affecting transmission in many applications. The effect of lens-to-lens spacing is shown for a TIL24/LS600 coupled pair.

Significant absorption takes place in air at the wavelengths shown in Fig. 3. Most of these wavelengths are in the IR region and can be related to various components of the atmosphere. A much more subtle loss can occur with plastic materials, which have quite high absorption ranges in the near-IR range that almost exactly match the output of GaAs LEDs.[1] Such plastics often make good fiber-optic elements for visible light, while IR emitter transmission may be down an order of magnitude or more.

The functional blocks at work

Let's see how optoelectronic functional blocks work in a system. Suppose you want to design a read head for data input. Such a head, for collecting data stored on paper tape, corresponds to the system shown in Fig. 1. The mechanical spacing of data and sprocket holes to advance the tape are usually set by industry standards. The use of sources and sensors to locate these holes means consideration must be given to the size of the holes and the mechanical tolerances found in paper punches. The spacing of a source and sensor also must be considered, to provide proper distance to allow the tape to pass freely between



5. **A one-shot multivibrator will reshape pulses** that may have been distorted during transmission. Optoelectronic-coupled devices will eliminate ground loops in data-transmission systems.

the sensor and the source array.

Consider the sensor in the read head. If we assume silicon provides the cheapest approach, consider next the speed requirements. Input data rates for paper-tape machines seldom reach more than 1500 words per second. This requires a maximum sensor response time of several hundred microseconds. A phototransistor, like the LS600, would have sufficient response time to meet the input data rate, while also furnishing the high level output required to drive the following circuitry without additional amplifiers.

Now, what about the source? The GaAs LED source is the optimum spectral match for a LS600 sensor. It also is among the more efficient LED types, supplying adequate power to drive silicon sensors to maximum output. Response time between the source-sensor pair is limited by the phototransistor. The light-emitter response time is less than 200 ns.

Examining the transmission path block in the system diagram, we see that the key factor regarding transmission is the separation between source and sensor. Figure 4 shows the effect of separation of source and sensor on output current for a given input current. This graph considers many factors of the source and sensor design, including the lens on both devices. This coupling graph is usually experimentally derived for a source and sensor type, but it may be calculated, provided both source and sensor do not have lenses in their packaging.[2]

To restrict crosstalk between sensor and emitter, apertures may be desired. The packaging of the two devices selected for reading one channel includes a limiting aperture as a part of the lens. Further restrictions of the field of view of the pair may be desirable to provide a tape location tolerance between steps without having to accept changes in sensor output. The reduction in light reaching the sensor should be included in design of the coupled pair, as well as the added restriction on mechanical location of sensors and sources relative to the aperture.

Paper-tape dust will collect in and clog the holes, unless cover plates are used over the apertures. It is often possible to have the tape wipe the lens of the sensor on each advance to clear dust, provided a hard glass mat that will not abrade easily is used.

Interface amplifiers for coupling throughout the system can take a variety of forms, depending on how the data input is to enter the system. The word stored on the paper tape is advanced in parallel by the sprocket. It may then be read out by a strobe of the LEDs or phototransistors. Alternately, it may be read in parallel from the individual sensor channels. The LEDs could even be used to read a paper tape that was moving continuously, by strobing information keyed from sprocket location holes and regulating speed.

Use optically coupled devices for isolation

The design of systems requiring data inputs transmitted over appreciable distance requires consideration of the isolation of multiple grounds at sending and receiving terminals. Optoelectronic-coupled devices can provide this isolation. Understanding the limitations of the optoelectronic elements in such a coupler helps the system designer get the most for his money.

In this example, the functional blocks are all in one package; only the input/output terminals are available. Electrical isolation between input and output can be made at many kilovolts of dc, but usually 1.5 kV is adequate.

Forward-transfer current ratios of 0.5 to 2 are common, limited by the size of the active area of the detector, detector gain, the method of coupling to the emitter and emitter efficiency. Response times usually depend on the detector portion of the coupler. Here the system designer may trade coupling current ratios for speed, by using couplers with diode detectors instead of phototransistors.

Interface with the rest of the system can be obtained easily by making the output phototransistor a component of a one-shot multivibrator. This will reshape the pulse, which may have been distorted during transmission. This is illustrated in Fig. 5 for a typical optoelectronic coupler. This optoelectronic device provides functional replacement of low-current relays and small transformers with characteristics previously unattainable in either. ■■

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1. Brown, R. G., and Derick, B. N., *Applied Optics*, Vol. 7, No. 8, August 1968, pp. 1565-1569.

2. Berkowitz, D. A., and Tammaru, E., *Journal of the Optical Society of America*, Vol. 53, No. 11, November 1963, pp. 1292-1295.

Which photodetector will give best results?

In any optoelectronic application, the choice of the photosensitive device is critical. Operating characteristics and limitations vary widely among available devices. And the designer can pick from silicon photocells, photodiodes and phototransistors, selenium cells, cadmium sulfide and cadmium selenide photoconductors, and phototubes with photoemissive cathodes. Which will be best for your design?

Alfred Seck, Senior Applications Engineer, Centralab Semiconductor, 4501 North Arden Drive, El Monte, Calif. 91734

The reaction of a photosensor to a radiation source depends on the sensor spectral response and the spectral distribution of the energy from the source. All photodetectors which respond to radiation in the visible spectrum and show limited response to UV or IR radiation have many similarities. But they also exhibit different capabilities as well as different limitations.

Silicon pn junction devices may be operated in

Table 1. Operating characteristics of light-sensitive devices

Parameter		Fatigue or Hysteresis	Bilateral Electrical Characteristic	Maximum Operating Temperature	Maximum Voltage	Current Capability	Power Dissipation	Frequency Capability
Phototransistor Si (pnp or npn)		None	No	125°C	<50 Vdc	1–50 mA	50–400 mW	Up to 200 kHz 100 kHz (typical)
Photodiode Si		None	No	125°C	100–200 Vdc	Up to 1 mA at 200 mW/cm^2	Up to 50 mW	200 kHz (pin device up to 10 MHz)
Photo SCR		None	No	100°C	200 V_{BO} *See Note 1*	1.4 A	2 W	1 kHz
Photovoltaic & Photoconductive	Si	None	No	150°C	Vdc = 0.4–0.65 V_R = 1–5 V *See Note 2*	1 A *See Note 3*	Up to 400 mW *See Note 2*	50 kHz
	Selenium	Fatigue: Worst case: (R_{Load} ~ $R_{Int.}$) In general, it is a function of current density, illumination, temperature and time	No	Continuous: 85°C Intermittent: 100°C	Vdc ~ 0.6 V_R = 1–2 V *See Note 2*	150 mA	75 mW	5 kHz
Photoconductive Only CdS, CdSe		Hysteresis: Conductance is a function of the cell's previous exposure to light & duration	Yes	75°C	Up to 1000 V	10 mA–1.0 A	50 mW–25 W	1 kHz
Photoemissive (Phototubes)		Anode current decreases with time due to cathode depletion	No	75°C–100°C	2800 V (anode)	Up to 10 mA	10 mW–1 W	10 MHz Photomultipliers

NOTES: (1) V_{BO} – Breakover voltage
(2) Normal operating range
(3) Subject to an energy density limitation of 1.0 W/cm^2
(4) The range can be increased upward by decreasing the applied voltage
(5) Detectivity, D, is a measure of the minimum intensity of incident irradiance which will produce a signal level distinguishable from inherent noise of the device*

either the photovoltaic mode or with reverse bias applied (photoconductive mode). Phototransistors have inherent gain which provides higher outputs than junction devices for a given irradiance level.

Selenium cells has characteristics similar to silicon cells. Selenium is very efficient in the range of human vision. Cadmium sulfide and cadmium selenide photoconductors are inexpensive detectors of visible radiation.

Representative values of important parameters are listed in Table 1. The advantages that different photodetectors offer and typical applications are listed in Table 2. The cost of the devices tends to be low for selenium, cadmium sulfide and cadmium selenide devices; medium for silicon devices, and high for phototubes.

In Table 1 the response of the devices to a step-function change of input light intensity is characterized by the normal switching speed parameters. Rise time is defined as 10% to 90% of the change in output level, and fall time as 90% to 10%.

Silicon photocell and photodiode switching speed is limited by the RC time constant of the device's capacitance multiplied by the load resistance. In general, rise and fall times are approximately equal and have a value of about 2.2 RC. This is especially true for fully depleted devices. Rise and fall times may range from 0.05 to 100 μs for photodiodes. However, if the device is operated at very low bias voltage, minority carriers may not be depleted in the vicinity of the junction, and fall time may be increased by the amount of carrier lifetime. Further, fall time will not begin immediately upon cessation of

Rise Time and Fall Time	Spectral Response	Useful Operating Light Levels	Long Term Stability	Size	Absolute Spectral Sensitivity At Peak Wavelength	Peak Detectivity, D*, at Peak Wavelength (λ) *See Note 5*	Limiting Noise
2–100 μs	Visible to near IR	0.001–20 mW/cm^2	Good	Small	$I_C \sim \beta I \lambda$	Not available	Johnson and current noise
Up to 2 μs	Visible to near IR	0.001–200 mW/cm^2	Excellent	Smallest	0.3–0.65 A/W	2.5 x 10^{10} to 3 x 10^{13} cm (Hz)$^{1/2}$/W $\lambda \sim$ 900 nm	Johnson and shot noise
2 μs	Visible to near IR	2–200 mW/cm^2	Good	Small	Not available	Not available	Not available
0.5–100 μs	Visible to near IR	0.001 mW/cm^2 to 1.0 W/cm^2 *See Note 3*	Excellent	Medium	0.3–0.65 A/W	2.5 x 10^{10} to 3 x 10^{13} cm (Hz)$^{1/2}$/W $\lambda \sim$ 900 nm	Johnson and shot noise
1 ms	UV to near IR	0.1–70 mW/cm^2	Poor to good	Medium	Not available	1.2 x 10^{11} cm (Hz)$^{1/2}$/W $\lambda \sim$ 550 nm	The noise spectrum is unknown
0.2 to 100 ms	Visible to near IR	0.001–70 mW/cm^2 or 10^{-3} to 10^{+3} ft. C	Poor to good	Medium	Not available	CdS: 3.5 x 10^{14} cm (Hz)$^{1/2}$/W $\lambda \sim$ 500 nm CdSe: 2.1 x 11^{11} cm (Hz)$^{1/2}$/W $\lambda \sim$ 700 nm	Current noise
0.1 μs nominal	UV to IR	10^{-3} – 10 mW/cm^2 Phototubes; 10^{-9} –1 mW/cm^2 Photomultipliers *See Note 4*	Good	Large	P.E. tube (Cathode): 0.002–0.05 A/W high gain photomultiplier (Anode): 5 x 10^6 A/W	Not available	Shot noise

Table 2. Advantages and applications of light sensitive devices

Parameter	Phototransistor Si (pnp or npn)	Photodiode Si	Photo SCR	Photovoltaic & Photoconductive		Photoconductive Only CdS, CdSe	Photoemissive (Phototubes)
				Si	Selenium		
Advantages	• $I_C \sim h_{FE}I\lambda$ • Multisegment matching • Reasonably fast • GaAs, (LED) compatible	• Fast • Linear and logarithmic • Good multi-segment matching • Large voltage swing • GaAs, (LED) compatible	• Multisegment matching • Reasonably fast	• Power generating • No bias supply required • Linear or logarithmic response • Good multi-segment matching • GaAs (LED) compatible	• Excellent visible range response • Linear or logarithmic response	• High voltage • High power • Low cost • Visible range	• Linear response • Extremely sensitive
Applications	• Card and tape readers • Encoders • Isolators • Hybrid ICs	• Card and tape readers • Encoders • Isolators • Hybrid ICs • Counting and control	• Card and tape readers • Counting and control • Meter relays and watt-hour meters • Level controls	• Power sources • Card and tape readers • Security alarms • Counting and control • Isolators	• Photometry • Camera diaphragm controls • Relay drives • Power sources	• Street light controls • Camera exposure controls • Door openers • Counting and control	• Door openers • Counting and control • Low light level sensing

input light pulse. The devices will exhibit storage time, during which the light-generated carriers are still being swept out of the depletion region.

Silicon phototransistors exhibit normal transistor switching characteristics, except that "base current" is photo-induced. Rise time will be reduced by "overdriving" the device into saturation, but such operation increases storage time. Typical phototransistor rise and fall times are 2 to 100 μs.

Selenium-cell response time of 1 ms, typical, is limited by the RC time constant. Fall time is somewhat longer than rise time, but of the same order of magnitude.

CdS and CdSe cells exhibit rise and fall times of 0.2 to 100 ms, with decay time usually somewhat longer than the rise time. Slow response is caused by the presence of electron traps in the "forbidden" gap of these materials.

All discrete light-sensitive devices, with the exception of phototubes, are well suited for arrays. Small size, excellent long-term stability and fast response time make silicon devices suitable for arrays, and silicon device processing techniques permit design of monolithic arrays with tightly controlled dimensions.

For many applications, discrete elements may be assembled into arrays on a printed-circuit board, but in the majority of cases multiple active elements are diffused onto a single silicon substrate. Typical applications for these light-sensor arrays include punched-tape and card readers, star trackers, image scanning, optical character recognition, brightness-gradient trackers, high-speed optical switching and modulation-transfer-function analysis. Silicon arrays are used as couplers, utilizing the radiometric efficiency of a silicon active element, which is approximately three times greater with a GaAs irradiance than with a tungsten lamp operated at a color temperature of 280 K. ■■

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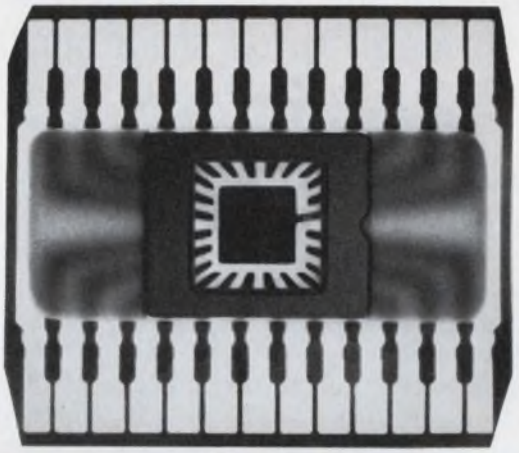

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INFORMATION RETRIEVAL NUMBER 30

Engineering is slipping as a career goal, a national sampling of high school seniors indicates, even though most students think highly of engineers.

Richard L. Turmail, Management Editor

"Engineering is an interesting profession when it's not submerged in the corporate power struggle; one's talents cannot emerge in such a restricted framework."

This opinion was not expressed by an IEEE member concerned about the image of his profession. It came from a 17-year-old senior in a Pennsylvania high school in response to one question in a survey conducted by ELECTRONIC DESIGN. The question: "What would you say to engineers if you could speak to an audience of thousands?"

The student's answer was one of many responses that reflected individual concern with engineering. From Wisconsin came this appeal:

"You should allow our social know-how to catch up with our technical know-how."

A girl in California summed up her frustration with the subject this way: "Engineering is one subject people don't know much about, and you ought to do something about it."

And a Massachusetts boy said grimly: "Get out of engineering while you still can!"

Attitudes and shortages prompt poll

To explore both the attitude of today's young people toward engineering and the reports of a possible shortage of technical talent over the next decade, ELECTRONIC DESIGN polled over 700 high school seniors in science classes scattered over the country. The survey also hoped to find out how many were planning to enroll in engineering schools.

In addition to the one above, the students were asked the following four questions:

1. How do you define engineering?
2. What do you think of when you hear the words "engineer" and "engineering"?
3. On a scale of 1 to 10 how do you rate engineers socially? Financially? Politically? Professionally?
4. What course of study are you planning to take in college?

Highlights of the findings reveal these apparent contradictions:

- Though many of the students appear to be indifferent to or intimidated by engineering, most rate engineers higher than some engineers rate themselves.
- Although 28% of the respondents are majoring in a technical course in high school, only 9% report engineering as their intended major in college.

Your future linked to youth's

Why should you care what youth thinks of you and your profession, or how many high school seniors do or don't enter engineering in the future? First, it's fair to say that what's good for your profession is generally good for you. So what these future leaders think of engineering could be of vital importance to you and your career.

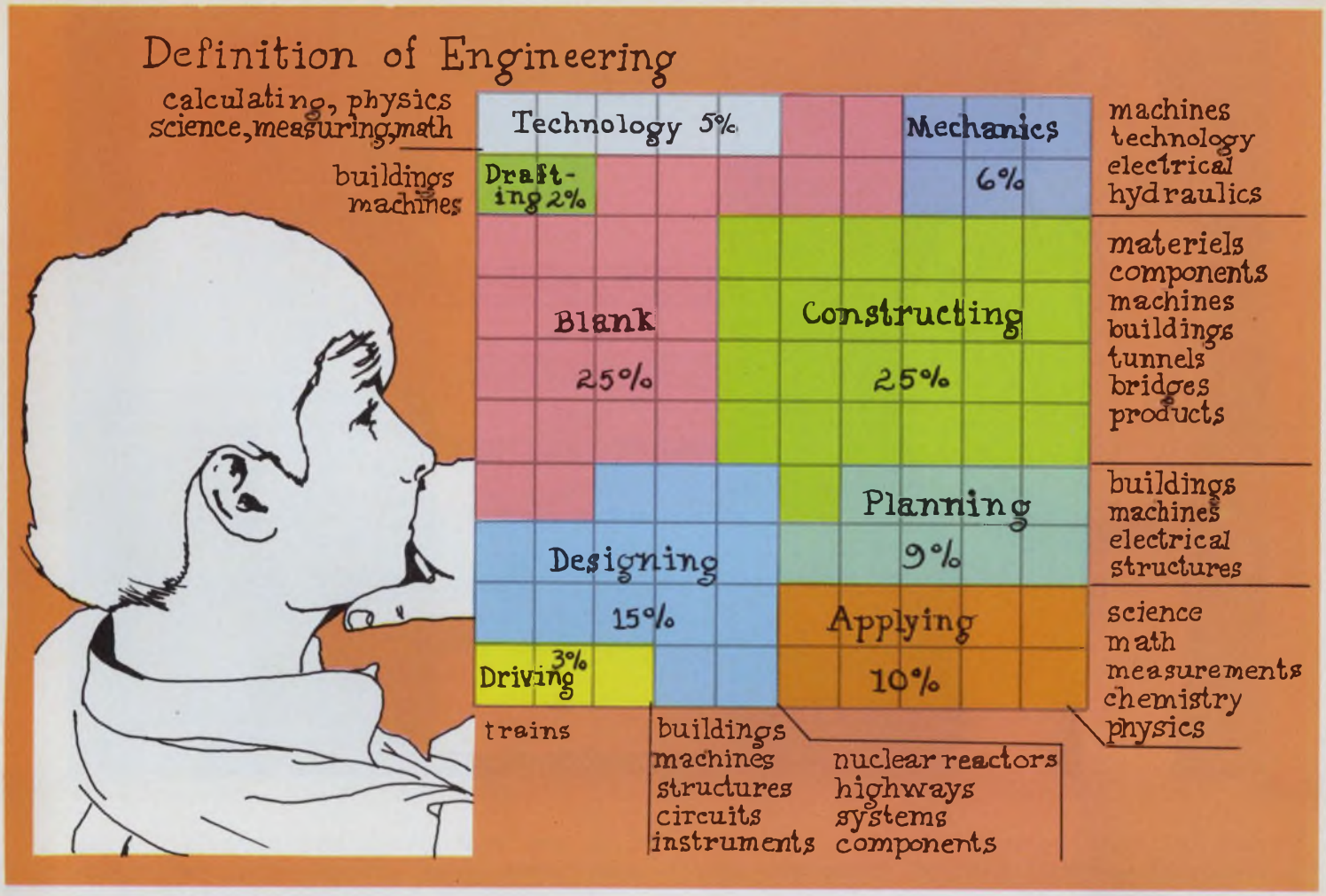
Young people today have already helped alter the face of technology in subtle ways. In cooperation with other groups, they've agitated engineers, for example, into at least thinking about social consciousness as a way of life, rather than just giving it lip service.

How do the students rate engineers socially, financially, politically and professionally? On a scale of 10, the average of all the scores came to 6.6. ELECTRONIC DESIGN felt this result could be weighed more accurately if it was compared

Coast-to-coast inputs

Students at the following schools were polled in the ELECTRONIC DESIGN survey:

Ayer High School, Ayer, Mass.
Anaheim High School, Anaheim, Calif.
Flowing Wells High School, Tucson, Ariz.
Germantown Friends High School, Philadelphia.
Jamaica High School, Queens, New York City.
Leland High School, San Jose, Calif.
Simon Gratz High School, Philadelphia.
Washington High School, Milwaukee, Wis.
Wichita High School North, Wichita, Kan.



with the ratings one group of engineers gave themselves. In answering the same question, engineers at a leading electronics plant in Colorado rated themselves an average of 5.8. The students rated engineers highest "professionally," while the engineers rated themselves highest "financially."

Some indifference uncovered

One of the most revealing findings in the survey is that many of the students appear indifferent toward or intimidated by engineers and/or engineering. Asked what they would say to an audience of thousands of engineers, for example, half of the respondents failed to reply, some saying in effect: "I can't tell them anything they don't know already." About 12% of the responses were outright negative—"Stop polluting the world," etc.

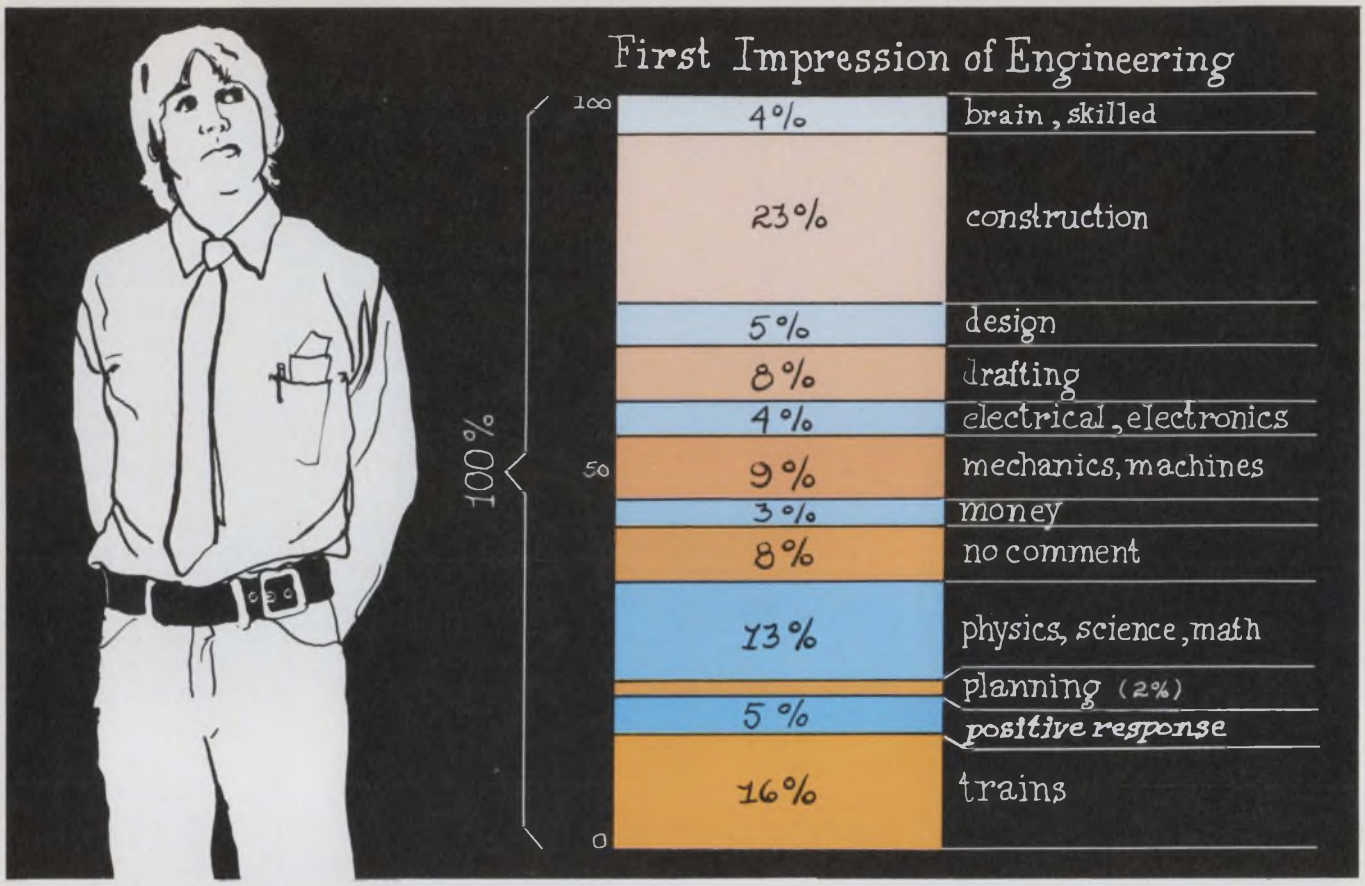
A few of the students suggested: "Increase efficiency and adaptability of products for a longer period of usefulness," "Think before you build" and "Get more involved in politics." Only about a quarter of the respondents made comments that could be construed as positive—"Keep up the good work," etc.

What do high school students think of when they hear the words "engineer" or "engineering"? One student in California replied "unemployment." Two of every five students reported that "construction" or "trains" was their initial impression. Only 4% of the students associated engineering with electronics. Some 13% noted that "physics," "science" or "math" came first to mind.

A majority of the answers to the impression question would have been suitable as definitions of engineering, but one-fourth of the respondents failed to answer the question: "How do you define engineering?" Many expressed concern that their definition would probably be incorrect. Some 25% defined engineering in terms of construction of either electronics, components, bridges, tunnels, machines or buildings. Engineering was variously defined as "designing," "planning," "applying," "drafting" and "driving" (trains).

Few plan engineering careers

About 28% of the respondents reported that they were majoring in some kind of technical course in high school. Two-thirds of these said



that they were majoring in "science," while the remaining one-third specified oceanology, electronics, physics and chemistry. "General academic" or "college preparation" majors accounted for 29% of the students. "English" was a distant third, with only 5% of the total response.

To keep these findings in focus, it should be remembered that only science classes were polled.

What about career goals? Nine of every 10 respondents indicated that they expected to go to college. Of these, 12% had decided on medicine and another 12% had decided on science.

About 9% of the respondents said that they planned to major in engineering in college. And, based on past performance, not all of these will go to college or will graduate as engineers if they do go.

Wesley J. Hennessey, dean of the School of Engineering at Columbia University has been quoted: "More than 70% of those who start engineering college never finish—on a national average. Some go into pure science or math, but the vast majority decide to take liberal arts."

We've been warned by the prophets of technology that if the number of young people going into the technical establishment continues to decline, the U. S. will soon become a second-rate technical power. Even now, despite the low demand for technical talent, the Nixon Administration has forecast a need for up to 80,000 more scientists and engineers in the next 10 years. Since new fields, such as socio-technology, urban engineering, ecology and bio-medicine are expected to expand, it would seem tragic if science students switched courses because of present unemployment in the aerospace and defense-oriented sectors.

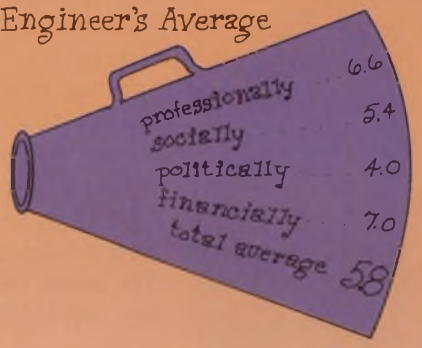
But science students have been steadily switching their major since national interest in technical developments peaked in the 1950s. At that time engineering degrees represented 20% of all baccalaureates; last year the figure slumped to 4%. From 52,732 engineering graduates in 1950, the total last year was 42,966. The chief reasons that students give for the growing exodus from technology: the specter of unemployment and a fear of being labeled a polluter.

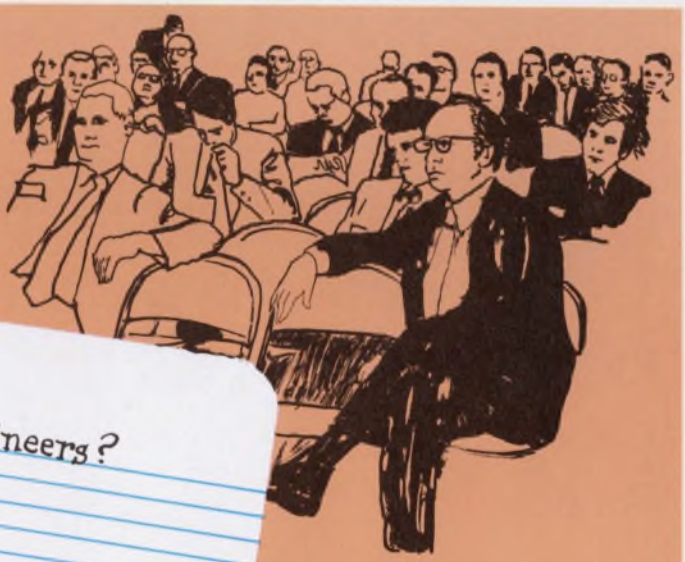
Realizing that there has been a reduction in recent years in the number of his students planning a career in engineering, Harold G. Kastan, chairman of physical science at Jamaica High School in New York City, explains it this way:

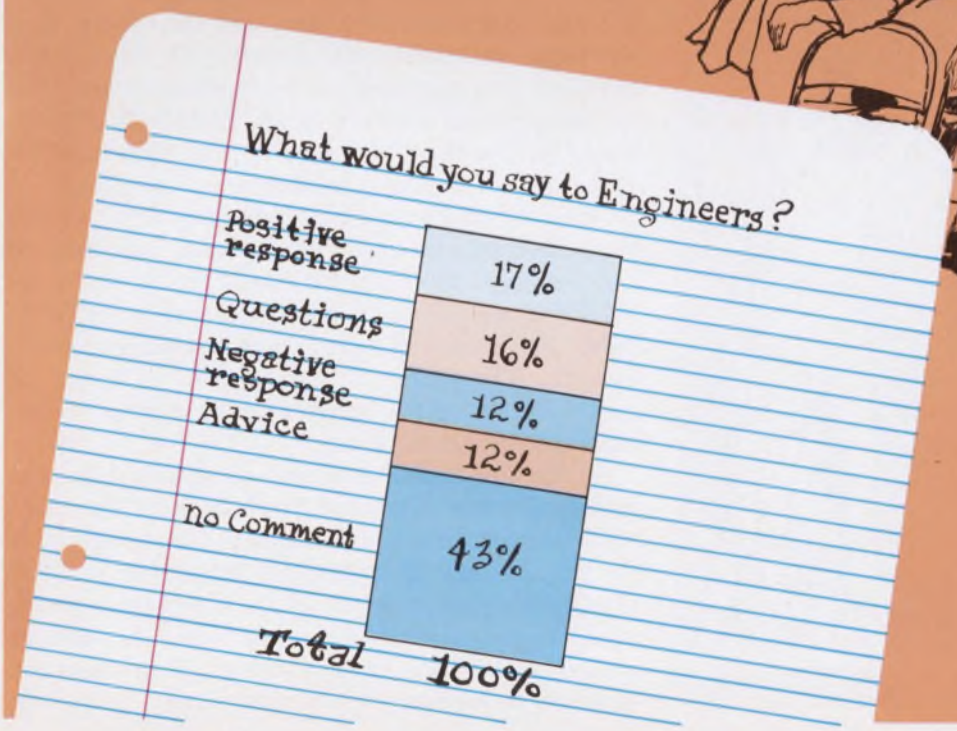
"The content and subject matter of engineering is growing more difficult; therefore the number of people who can handle it, and are willing to work that hard in school, is decreasing. Those with the capabilities are drawn away by the more remunerative and prestigious fields of medicine, college teaching and finance. When a kindergarten teacher in New York City with an M.A. can earn $16,000 a year after eight years of teaching, for example, why work and struggle to become

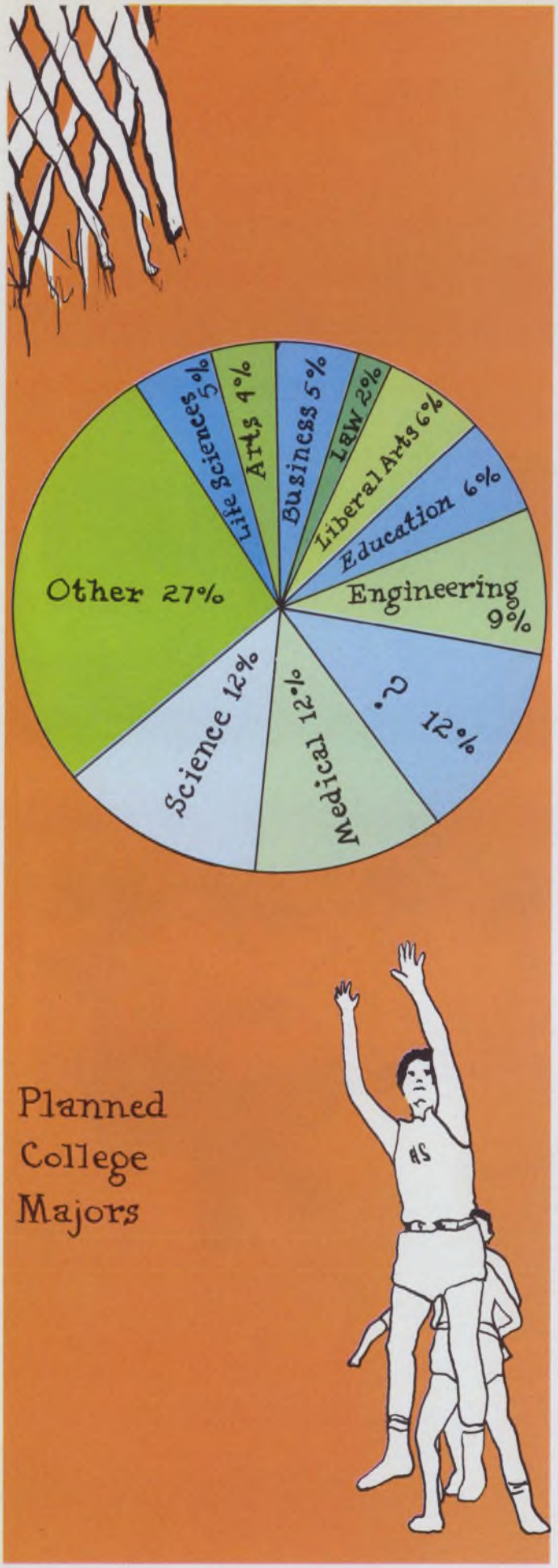
Rating of Engineers (1 to 10 scale)

	1	2	3	4	5	6	7	8	9	10	Ave.
Professionally	8	11	14	19	40	42	109	165	102	138	7.7
Socially	21	25	30	48	139	93	105	94	41	47	6.1
Politically	48	42	74	64	150	70	68	46	21	28	5.0
Financially	8	7	21	22	54	52	101	163	107	113	7.4
total average											6.6









an engineer?"

David J. Cutler, a science teacher at Simon Gratz High School in Philadelphia, explaining that his school "because of neighborhood boundaries and housing patterns . . . is 100 per cent black," says:

"The average student coming to us in the tenth grade performs on a sixth grade level in terms of verbal and quantitative skills. Although our academic students perform better, they are still lacking in the basic skills that make chemistry and physics easily acceptable disciplines.

"Engineering to most of our graduates is the least practical course to pursue in college. Mathematics acts as a deterrent to such enrollment. However, of the 12 seniors who were exposed to a specialized type of research program—our biomedical careers program—three expressed a desire to take engineering in college.

"It would take a strong selling job through visiting speakers to arouse the interest among black students to consider engineering as a career—first, because of the present decline in the need for engineers, and second, because of the limited opportunities for black engineers."

A need to upgrade the engineer's image

How can engineering recapture the students' esteem?

"To win public recognition and regard, a profession must be recognized as relevant to a culture's present and anticipated needs," says W. Alec Jordan, president of Alec Jordan Associates, Inc., New York, a public relations concern serving technical companies.

"The technology god is dead," Jordan says. "Our U. S. society is now moving rapidly toward the establishment of a new set of values that we must categorize as 'quality of life'. Let's establish how engineers and engineering are vital to the solution of our most distressing problems, by forming a coordinating organization concerned with public relations, not publicity.

"Its activities would be complementary to those performed by individual engineering associations and societies. Its first job would be to make an objective study about what the prevalent attitudes, opinions and trends are concerning engineering. Thereafter it would plan a series of goals to improve the image of engineering, with a timetable to attain them."

As for the students, a typical observation was made by one at Jamaica High School. He said: "Engineering must make itself more desirable for young students to become interested in it. It should offer some kind of job security, which seems to be very limited right now. Its salaries should justify the great amount of preparation required to become an engineer." ■■

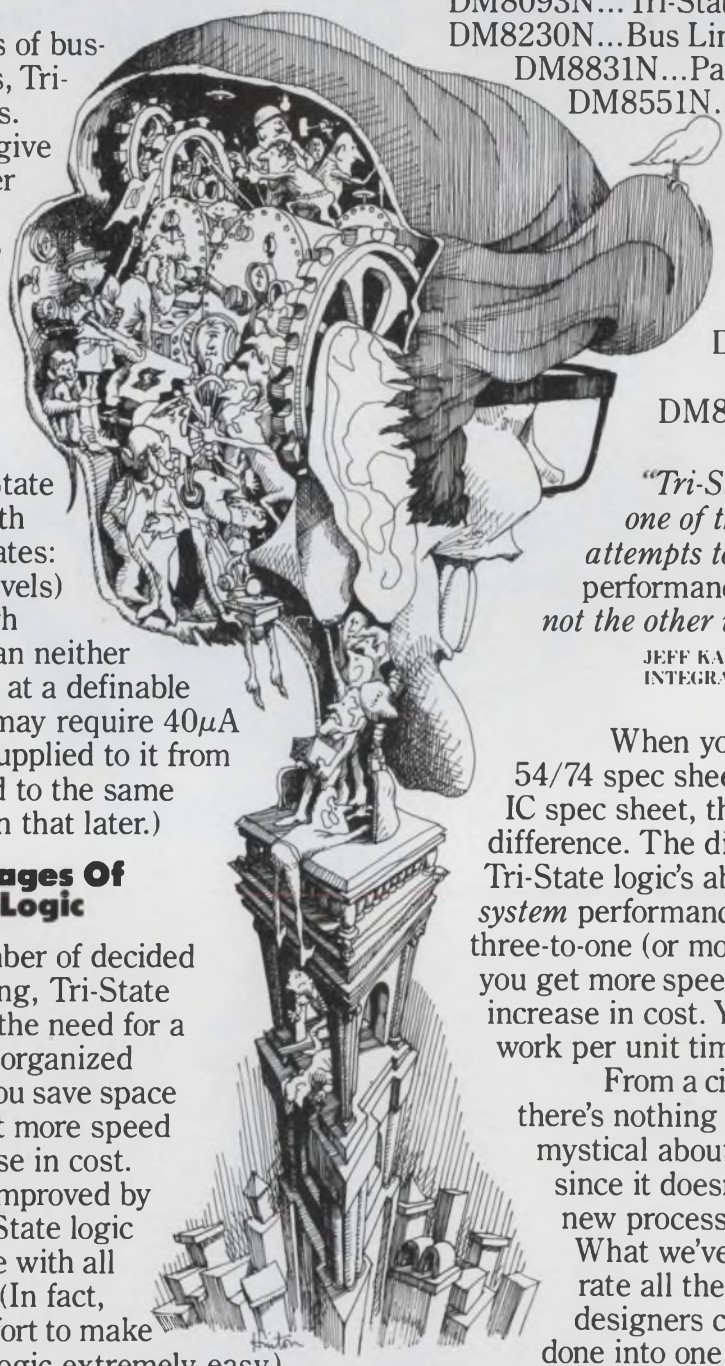
National presents the Tri-State-of-the-art.

(A timely, information-filled discussion of the National Tri-State logic scene featuring systems design input by Jeff Kalb and systems applications data by Dale Mrazek with introductory notes by Floyd Kvamme.)*

*Tri-State is a Trademark of National Semiconductor Corporation

"The first DTL devices were designed with passive pull-up. Then, to improve speed, you went to an active pull-up which caused havoc with the bus OR'able system. So, the next step in evolution was to use an uncommitted collector output.

Tri-State logic, then, is the next step beyond that.". FLOYD KVAMME, DIRECTOR OF MARKETING



To the designers of bus-organized data systems, Tri-State logic is good news. Tri-State logic devices give you all the speed, power and noise immunity of TTL plus the ability to interconnect outputs of similar devices to a common bus line.

Three States, Explained

Basically, a Tri-State IC is a logic element with three distinct output states: "0", "1" (normal TTL levels) and OFF which is a high impedance state that can neither sink nor source current at a definable logic level. (At most, it may require 40μA leakage current to be supplied to it from other devices connected to the same output line. But more on that later.)

The Advantages Of Tri-State Logic

There are a number of decided advantages. For one thing, Tri-State logic totally eliminates the need for a pullup resistor in a bus-organized system. Which means you save space and money. You also get more speed with no effective increase in cost. Noise susceptibility is improved by a factor of 10. And Tri-State logic is completely compatible with all existing 54/74 devices. (In fact, we've made a special effort to make conversion to Tri-State logic extremely easy.)

Tri-State Logic Is, At This Very Moment, Being Second-Sourced

Happily, other companies have jumped onto the Tri-State logic bandwagon. Which is good news for you. And good news for us, since it's always nice to be followed.

Speaking of second-sourcing, it would be well to list *our* devices so you can see what all the others are copying.

Right now, we have eight Tri-State logic devices. All available off-the-shelf. They are as follows:

DM8093N...Tri-State Quad Buffer
DM8230N...Bus Line Demultiplexer
DM8831N...Party Line Driver
DM8551N...Quad-D Flip Flop
DM8094N... Tri-State Quad Buffer
DM8214N... Dual 4-Line-to-1-Line Multiplexer
DM8598N...256-Bit Expandable ROM
DM8599N...64-Bit RAM

"Tri-State logic is really one of the very first attempts to relate systems performance *to circuit design, not the other way around."*.

JEFF KALB, DIRECTOR OF DIGITAL INTEGRATED CIRCUITS

When you compare a 54/74 spec sheet to a Tri-State IC spec sheet, there's really little difference. The difference lies in Tri-State logic's ability to improve *system* performance by a ratio of three-to-one (or more). In the end, you get more speed with no effective increase in cost. You also get more work per unit time.

From a circuit standpoint, there's nothing spectacular or mystical about Tri-State logic since it doesn't require any new processing techniques. What we've done is incorporate all the things that designers can do and have done into one overall *systems oriented* concept. A refinement of existing techniques specifically aimed at solving the problems of bus-organized data systems.

How It's Done

Actually, the concept of creating a

Tri-State TTL device is relatively simple. We've just provided a means of removing the drive current from the totem-pole output of the TTL device. The output then resembles two semiconductor junctions biased in the non-conducting or high impedance state. The only load they offer to the common bus line is the junction leakage which must be provided by the output of the device that's driving the bus line.

In addition, the inputs of many Tri-State circuits also disable and, in doing so, load the driver with only leakage current. In effect, this makes both output bussing and fan-out into other inputs virtually unlimited.

Thus, all Tri-State logic elements have been designed with a Darlington-connected power stage to provide a source current of at least 5.2mA in the logic "1" state (13 times the TTL norm of 400μA!). The lower output transistor sinks the 16mA normally required for a fan-out of 10 in the "0" state.

Some Interesting Calculations

A source current of 5.2mA in the enabled "1" state means that at least 128 Tri-State outputs can be bus-connected. If one output drives while 127 other outputs on the same line are inhibited, the maximum leakage current to be sourced is 127 x 40μA – 5.08mA. Which means at least three TTL loads can be driven with the minimum of 120μA remaining.

Another Tri-State logic benefit is that lines longer than 10 feet can be driven reliably, while standard TTL can drive only 10 to 12 *inches* of line before noise immunity becomes a problem. The higher power of the Tri-State IC output also improves "1" level noise immunity by a factor of 10.

Finally, one of the unique things about the Tri-State logic gating system is that it runs *in parallel* with the existing logic functions. It doesn't slow down the logic function itself while it's operating, it just provides a means of turning it off—in parallel. So, you're not adding any time to the system, you're really adding a control.

"One of the functions of Tri-State logic (as we were designing it) was to make any previously-designed MSI elements bus-structurable"..

DALE MRAZEK, DIGITAL APPLICATIONS MANAGER

Reduced to its most basic and flexible form, a Tri-State IC output is a special kind of gate. And so, the most universal Tri-State devices we've designed to date are the DM8093 and DM8094 Quad Buffers. With these buffers, any other TTL-compatible device or MSI module can be given Tri-State input or output characteristics. Using Tri-State Buffers, many logic circuits can be saved. For example, in Fig. 1, they operate in pairs on a single control line to perform the two-wide multiplex function so commonly needed in logic design. A comparison of this design with a standard design will show that an inverter and four 2-input NOR gates are saved in just this one subassembly. And, the subassembly can be expanded modularly.

More Nice Things You Can Do With Tri-State Logic

There are, obviously, many different

bus-structured systems applications using Tri-State devices. Some are relatively simple, others very complex. On this page we've diagrammed some typical applications. Each contains a Tri-State device or a series of Tri-State devices. All improve overall system performance substantially in addition to reducing the physical number of elements required.

Future Tri-State

Our eight Tri-State devices are just the beginning of a logic family which will continue to expand at a rapid rate.

And as we expand our line of devices, we are looking at each new function *not* from the standpoint of "Is this a nice function?"; but, rather, how does it fit into the system to make the system work better.

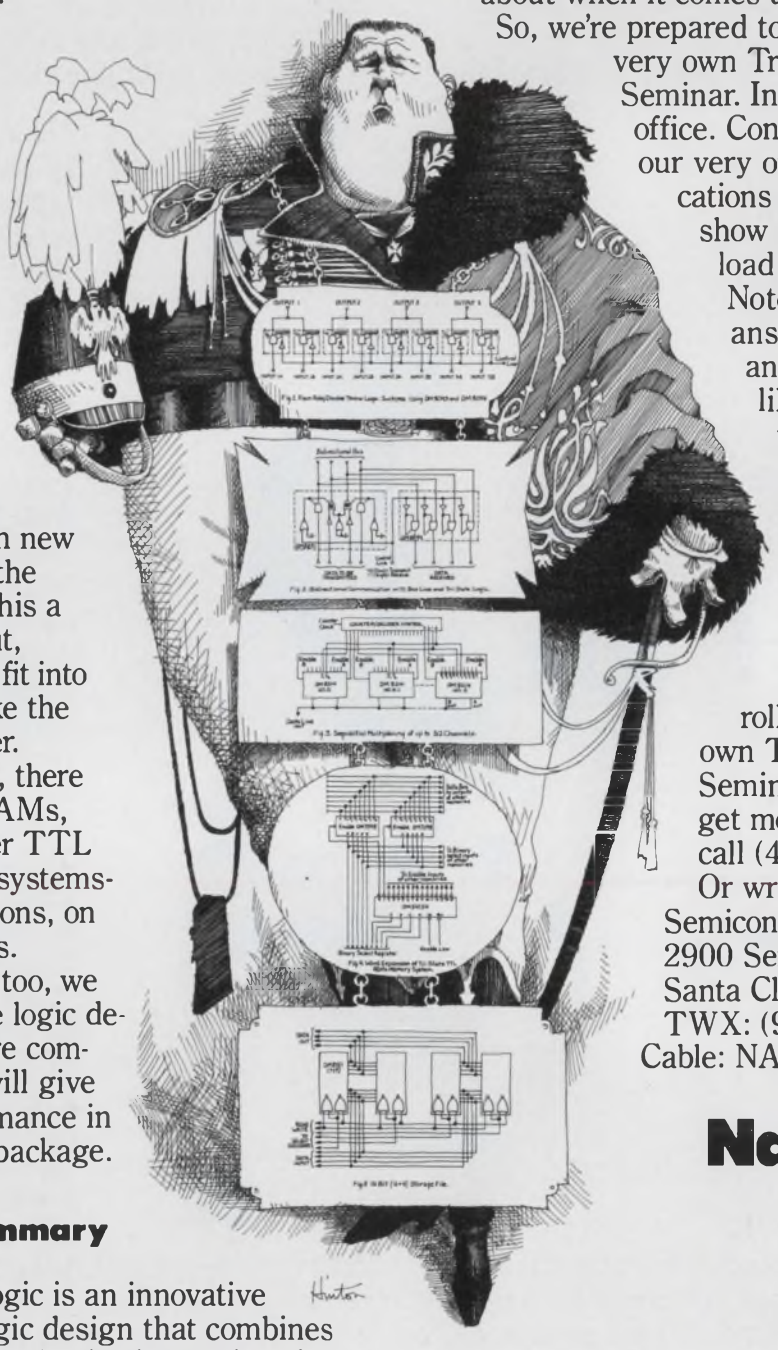
As a result, there are a variety of RAMs, ROMs, Low Power TTL devices and more systems-related MSI functions, on our drawingboards.

Very soon, too, we will offer Tri-State logic devices which feature common I/O, which will give even more performance in an already small package.

A Summary

Tri-State logic is an innovative new concept in logic design that combines the speed, power and noise immunity of TTL with the wire-OR'able flexibility required for real-life bus systems.

But even more importantly, Tri-State logic is a *systems-oriented* concept that not only simplifies the design and construction of bus-organized systems, but improves overall system performance by a factor of three-to-one.



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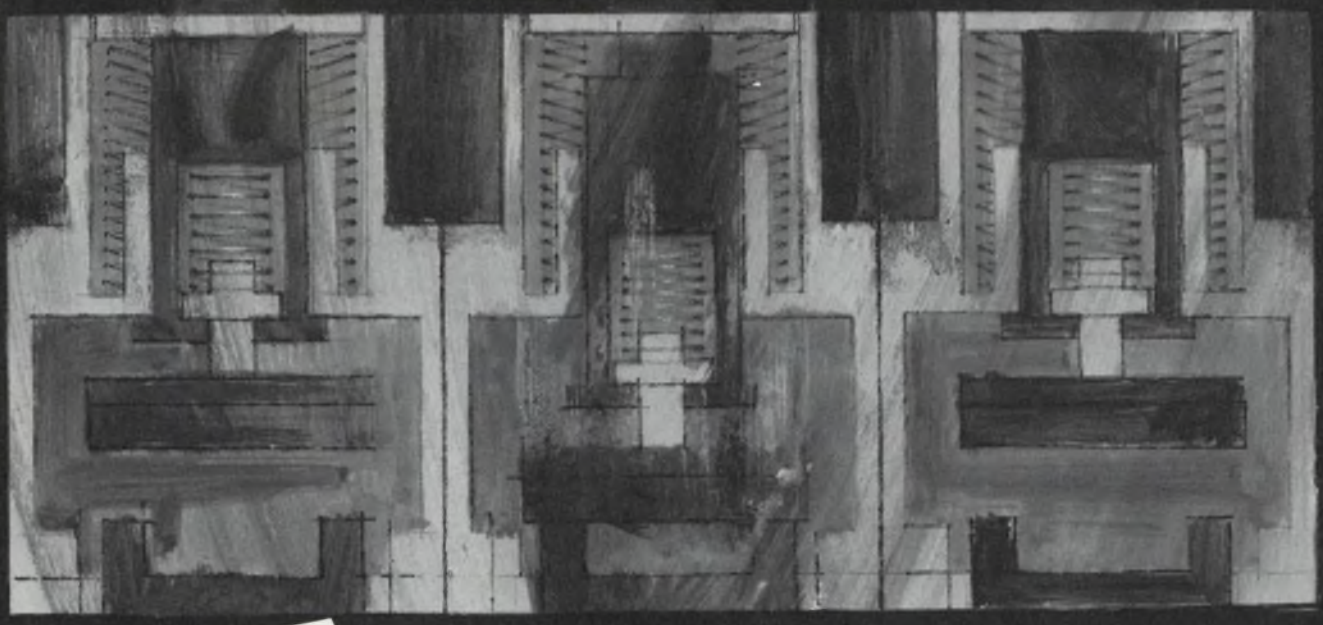

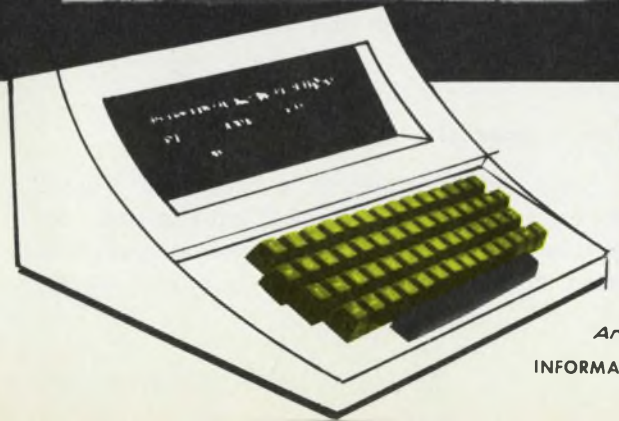

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To detect signals buried in noise, build a phase-locked receiver. It has few peers for this application, and it's not hard to design with this logical approach.

When a receiver must demodulate extremely weak signals—in deep-space telemetry, tracking and positioning systems; in satellite and airborne systems in which doppler effects must be avoided or measured—there's nothing quite as effective as a phase-locked receiver. It can linearly demodulate FM signals buried 20 to 30 dB in noise,[1] while conventional receivers would be captured by the noise.[2]

Building a phase-locked receiver may not be the simplest thing in the world, but it need not be a nightmare in the s-plane either.

Calculate the system requirements

Let's say that a satellite must receive a frequency-(or phase)-modulated 1600-MHz carrier at 13-W radiated power over a maximum distance of 2000 miles. Carrier center frequency tolerance is ±0.001%. Modulation frequency is 20 kHz at an index of 1.0 radians (±20 kHz deviation). Doppler is expected to be less than 1.2 kHz.

With this information, we can determine the receiver requirements, including the type of FM demodulator needed. There is, at this point, no reason at all for anticipating the need for anything but a conventional L-band receiver with a phase-shift discriminator. An initial block diagram might look like that of Fig. 1.

The first step is to determine the pre-detection signal-to-noise ratio (S/N), since the threshold of a limiter-discriminator receiver is about 10 dB above the noise power level (+10 dB S/N).

To do this, we must calculate both the signal and noise levels in the receiver's i-f amplifier. The signal level is found by computing the space attenuation for the frequency and distance in our example, and subtracting the result from the transmitter's radiated power. The i-f noise level is determined by first calculating the bandwidth of the i-f amplifier and then calculating the thermal noise power in that bandwidth.

The signal level at the receiver input for a frequency of 1600 MHz and a distance of 2000 miles is found as follows:

Space attenuation = 37 dB + 20 log f (MHz) + 20 log d (miles) = (37 + 64 + 66) = 167 dB.

Radiated power − space Attn.

= 13 W − 167 dB
= +41 dBm − 167 dB
= −126 dBm.

The required i-f bandwidth is calculated by adding the bandwidth of the modulated carrier to the expected doppler shift and the various drifts in both the transmitter and receiver. The calculation looks like this:

The total modulated spectrum width, BW, is given by Carson's rule as

$BW = 2(\Delta f + f_m) = 2(20+20) = 80.0$ kHz.

Transmitter freq. drift (±0.001%)	= 16.0 kHz
Doppler shifts	= 1.2 kHz
1st L. O. drift (1470 MHz ±0.002%)	= 29.4 kHz
2nd L. O. drift (119.3 MHz ±0.002%)	= 2.4 kHz
Total i-f bandwidth	= 129.0 kHz

To calculate the carrier-to-noise ratio, C/N, in the i-f, we must calculate the i-f noise power. This is given by KTB (dBm) + NF (dB), where K is Boltzmann's constant, T is the absolute temperature, B is the total i-f bandwidth and NF is the noise figure of the rf front end (antenna, cable, preselect filter, etc.).

The numbers are:

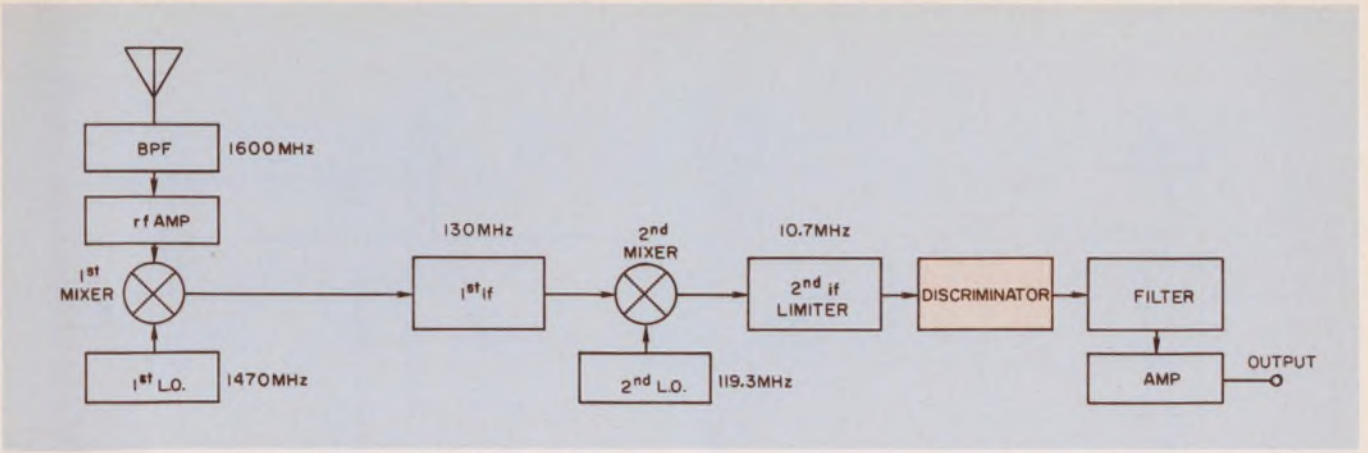
KT	= −174 dBm
B (129 kHz)	= + 51 dB
NF	= + 7 dB
i-f noise power	= −116 dBm.

Since the carrier power at the receiver is 126 dBm, the C/N in the i-f is −10 dBm. This is too low for a conventional phase-shift discriminator, so our satellite receiver will have to use a phase-locked demodulator.

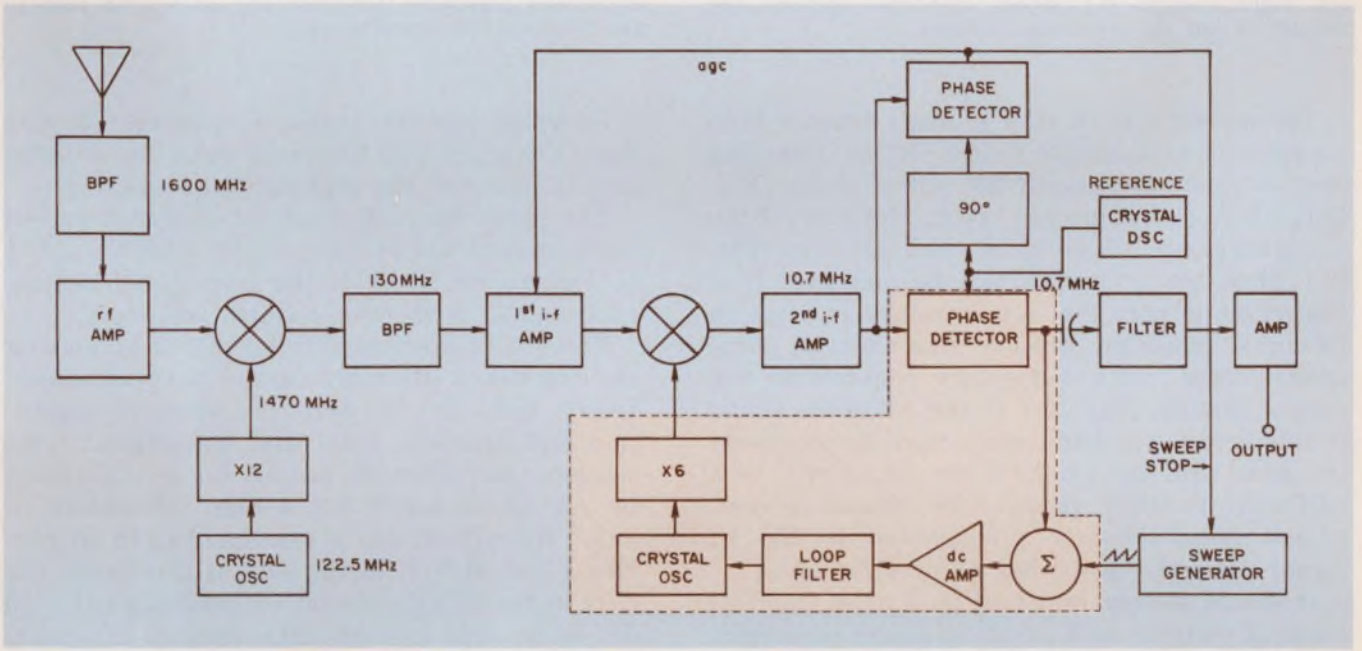
Use agc instead of a limiter

A typical block diagram is shown in Fig. 2. This receiver uses agc instead of limiting, because the agc signal can hold the output level constant even when the signal is buried in the noise.

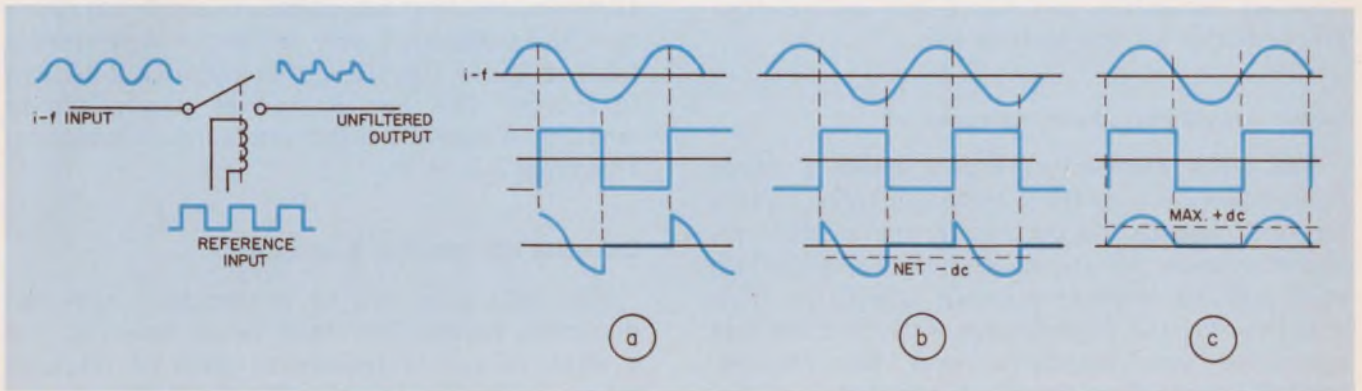
Paul H. Young, Senior Engineer, Cubic Corp., 9233 Balboa Ave., San Diego, Calif. 92123



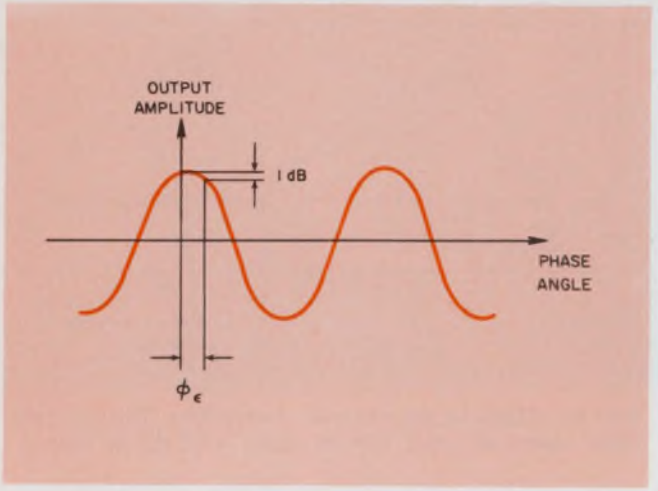
1. **Conventional L-band receiver uses a phase-shift discriminator.** Amplitude stabilization is performed by the limiting stages in the second i-f amplifier. The discriminator needs an input S/N of about +10 dB or more.



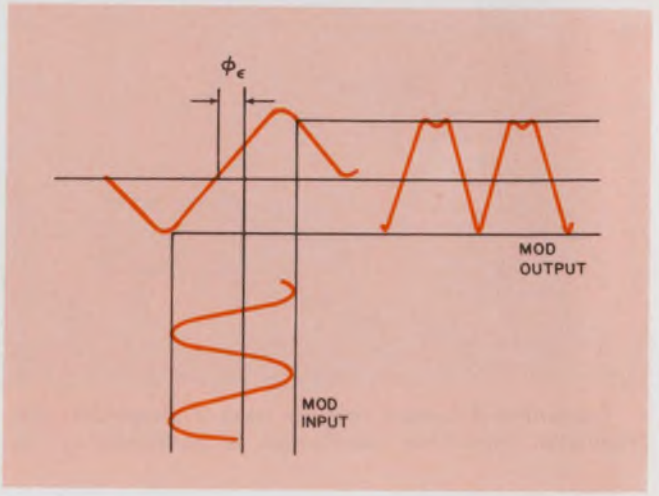
2. **This phase-locked satellite receiver uses quadrature agc.** The agc signal not only controls the gain of the first i-f amplifier, it also turns off the sweep generator when the loop has acquired the input signal.



3. **The phase detector can be thought of as a switch** that is opened and closed by the square-wave reference signal. For the waveforms shown, the reference and intermediate frequencies are equal and the loop is locked. When the signals are out of phase by 90° (a), a zero dc output results. If the phase is slightly advanced (b), a small negative dc output is produced. And when the signals are in phase (c), the result is a dc output proportional to the i-f signal level—exactly the kind of signal that is needed for agc.



4. **Increasing the static phase error, ϕ_ϵ decreases the agc signal.** ϕ_ϵ is the phase difference between the second i-f and the reference oscillator.



5. **Severe distortion results** if the modulation peaks exceed 90°, because they then will exceed the peak in the discriminator characteristic.

The easiest way to view a phase detector is to consider it as a simple switch. If the reference and i-f inputs are exactly 90° out of phase (Fig. 3a), a zero dc output will result. However, if the i-f advances in phase by a small amount (Fig. 3b), then the dc output will be negative. It is important to note that a momentary increase in i-f signal frequency will look like a simple phase advancement and a momentary negative dc will result. Finally (Fig. 3c) if the reference signal to this detector is deliberately made to be exactly in phase with the i-f, then the output will be a half-wave rectified voltage, the filtered dc component being directly proportional to the i-f signal strength—just what we need for agc.

It should be apparent that pure noise into this form of detector will result in a zero dc output. However, when the PLL is locked, this detector will produce a dc voltage directly proportional to the signal level, even when the signal is buried in the noise. True signal-level indication, reliable loop-lock indication and signal-only gain control are provided by quadrature agc.

Sweep acquisition allows narrower i-f

The block diagram of Fig. 2 shows a sweep circuit that controls the voltage-controlled oscillator until acquisition occurs. In our satellite receiver example, we can narrow the i-f bandwidth to 80 kHz by employing sweep acquisition. This will improve the predetection S/N by 2 dB and guarantee sure acquisition over the environmental temperature range. A calculation of unaided pull-in time for maximum frequency offset (49 kHz) and a loop noise bandwidth (BW_n) of 2 kHz (determined in the next section) gives

$$T = 4(\Delta f)^2/(BW_n)^3 = 1.2 \text{ s.}$$

Sweeping has two major advantages: It cuts down the acquisition time and, more importantly, greatly increases the probability of lock.

The sweep rate, $\Delta\dot{\omega}$, must not, however, exceed a maximum given by $\Delta\dot{\omega}_{max} = [1 - (S/N)_{loop}^{-1/2}]\ \omega_n^2$, where $(S/N)_{loop}$ is the loop signal-to-noise ratio and ω_n is the loop natural frequency.

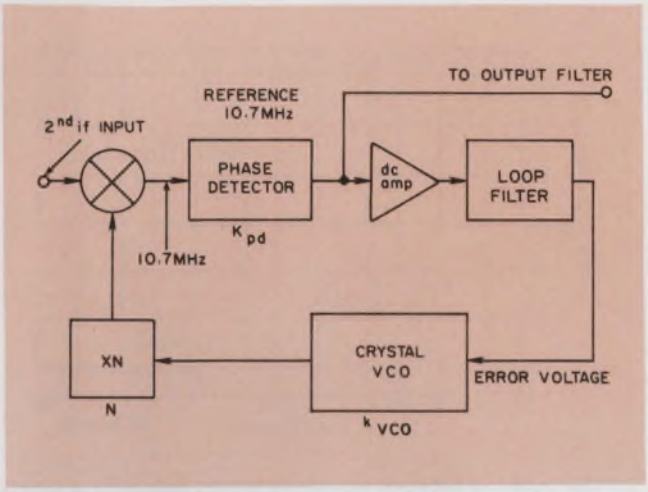
There is no advantage to be gained by making the loop bandwidth more narrow than necessary. Indeed, the wider the better in terms of acquisition and practical loop filter components (the capacitor can get quite large). Loop S/N should be +6 dB or better for a high probability of lock.[3] We will choose a loop bandwidth to provide a +6 dB S/N in the loop at threshold. The C/N in the 80 kHz second i-f bandwidth is −10 dB. So we need a 16-dB improvement, or a noise bandwidth of 2 kHz in our satellite receiver.

A note of explanation is in order. Since the second i-f bandwidth has been narrowed by 2 dB, the unmodulated C/N would seem to be −8 dB. However, the loop bandwidth is much narrower than the modulation and, as can be seen from a table of Bessel functions, this causes a 2-dB loss in energy. This loss in carrier power due to modulation must be taken into account when determining loop S/N.

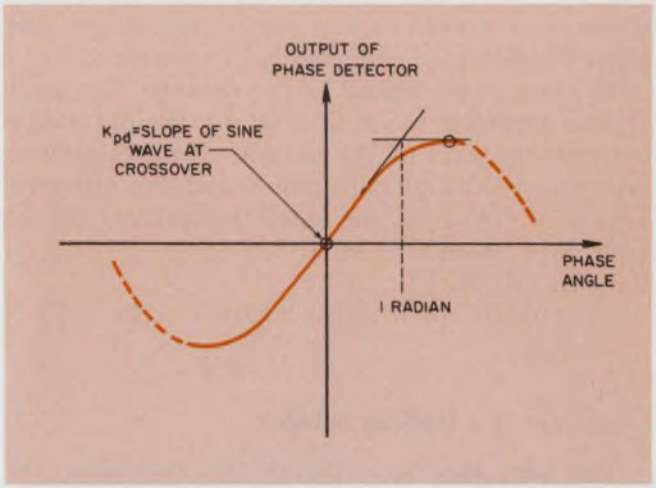
Calculate the required loop gain

The loop gain, K_v, is determined from the maximum permissible static phase error, ϕ_ϵ, for a given maximum frequency offset or tracking range, $\Delta\omega$, by the equation $K_v = \Delta\omega/\phi_\epsilon$.

Since, for this application, there is no specification on permissible doppler indication error, another criterion must be used. There are two important considerations for this simple satellite



6. **These elements determine the loop gain.** The ×N multiplier following the VCO multiplies not only the frequency but also the VCO sensitivity, K_{VCO}.



7. **The tangents to the peak and crossover points of a sine wave intersect at an agle of one radian.** Thus K_{pd} equals the peak value of the phase detector's output.

receiver—agc and modulation.

The more stringent requirement is in the agc. A typical receiver specification is that agc must keep output changes below 1 dB. Since for small angles, $\sin \phi \cong \phi$, a 1-dB change means that the the static phase error must be held to within 0.125 radians (Fig. 4).

A secondary consideration in this example is that the modulation peaks cannot be allowed to exceed 90° (1.6 radians) of deviation, as doppler, transmitter and local-oscillator frequencies drift with temperature and time, or severe distortion will result (Fig. 5). Consequently the static phase error ϕ_ϵ, must be kept well below 1.6 − 1.0 = 0.6 radians.

Computing the loop gain required to hold the static phase error to 0.125 radians, we get

$$K_v = \Delta\omega/\phi_\epsilon = (49\ \text{kHz})\ (2\pi\ \text{radians/cycle})/0.125$$
$$= 2.5\times10^6 = 128\ \text{dB}.$$

Now, how do we obtain the desired gain? There are four elements in the phase-locked loop that determine the loop gain: the phase detector, the dc amplifier (including the loop filter), the VCO and the VCO frequency multiplier (Fig. 6).

The phase-detector sensitivity, K_{pd}, can be measured by inserting an i-f signal at the desired operating level (below circuit distortion) and measuring the peak voltage of the low-frequency beat between the reference frequency and the i-f. This peak voltage is the volts-per-radian sensitivity of the phase detector, because the tangents to the peak and crossover points of a sine wave intersect at one radian (Fig. 7). A typical K_{pd} in a ±12-V system is 4 V/rad.

A very important point must be made here: The receiver must limit symmetrically. This is particularly true for a receiver which, when locked, will be held below limiting by the agc.

When a strong signal arrives at the receiver, the receiver is initially unlocked and no agc is available. Unsymmetrical limiting can cause an offset dc voltage out of the phase detector, which, when amplified by the dc amp, may be enough to force the VCO to a frequency outside of the acquisition range, thus keeping the loop from locking.

This phenomenon is called "push-away." Another form of push-away will be covered in the discussion on loop-filter design.

VCO sensitivity, K_{VCO}, can be measured by applying a dc control voltage and measuring the corresponding output frequency. A plot of frequency vs input voltage will yield K_{VCO} in Hz/V, which is converted to radians/V by multiplying by 2π radians/cycle.

Choosing the VCO frequency

The choice of VCO frequency and multiplication factor are not arbitrary. To achieve maximum VCO sensitivity, a frequency of less than 25 MHz must be chosen, so that a standard first-overtone crystal can be used. The "pullability" of a crystal is inversely proportional to the square of the overtone number. Thus a VCO with a third-overtone crystal has approximately one-ninth the sensitivity of a fundamental-crystal VCO. A VCO developed at Cubic Corp. for this frequency has a sensitivity of 2 to 4 kHz/V with excellent linearity.

VCO sensitivity will be increased by the multiplication factor, N, of the frequency multiplier chain, and consequently must be part of our loop gain computation. The multiplication factor ×6 was chosen for practical circuit reasons. Transistor multipliers at ×3 and ×2 are easy to build,

stable over severe environmental conditions and allow for filtering of unwanted harmonics.

The last loop element is the dc amp. The gain of this amplifier is set to make up the difference between the gain of the natural elements (phase detector, VCO and multiplier) and the required loop gain. Thus, in our satellite receiver, the dc amp gain should be equal to

$$K_{dc} = K_v/K_{pd}K_{VCO}N$$
$$= 2.5\times10^6/[4\ V/rad \times 2\ kHz/V \times 2\pi \times 6]$$
$$= 8.3.$$

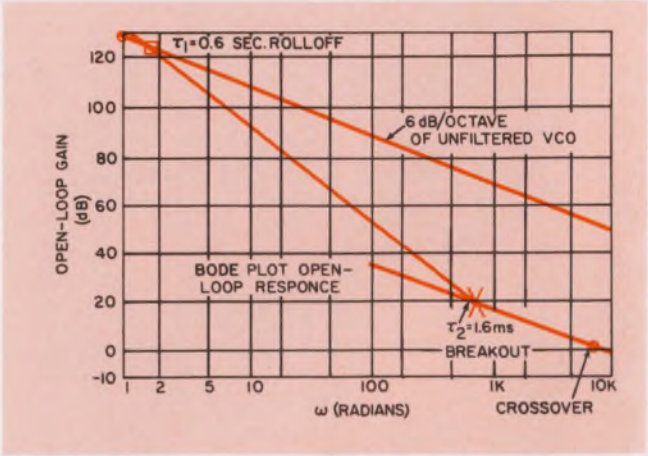
Loop filter is a lead-lag network

The next step is to design the loop filter. So far we have two points from which to construct an open-loop bode plot and to determine the loop filter components. All this could have been done by equations, but it is instructive to see what is happening. The first two points to place on a sheet of semi-log paper (Fig. 8) are $K_v = 128$ dB at 1 radian and the cross-over point (0 dB) at 1 kHz (6280 radians), which will make the closed-loop noise bandwidth equal to 2 kHz, as determined earlier.

Because of the integrating action of the VCO, the open-loop gain will fall off at 6 dB per octave (20 dB per decade). If no loop filter is added, the crossover point will be 2.5×10^6 radians (395 kHz), making a loop noise bandwidth of 790 kHz. A single RC roll off would result in an unstable loop because the loop woud be rolling off at more than 6 dB per octave at the unity loop-gain frequency. Stated another way, a servo loop oscillates if it has 180° of phase shift at unity gain. What is needed then is a roll-off followed by a breakout—that is, a lead-lag network.

Loop damping is determined primarily by the placing of the breakout point (τ_2) above crossover. If τ_2 is set 6 dB above unity gain, a damping factor of 0.707 will result. For our purposes, a more heavily damped loop is desirable—that is, τ_2 should be set with some margin for loop-gain variations caused by temperature, aging, etc. It is easy to see that if this break point were set 6 dB above unity, then a loop gain sag (say due to temperature) would put our receiver perilously close to uselessness.

The design will proceed by moving from the crossover point at 6280 radians on a 6-dB-per-octave line to +20-dB loop gain, where τ_2 is marked for the breakout (lead network). The choice of 20 dB provides comfortable margin and a damping factor of approximately 1.6. From this point a 12-dB-per-octave line is drawn to intersect the initial VCO slope. The intersection, τ_1, gives the time constant for the lag network.



8. **The lead-lag network response starts out with a steep drop** (12 dB per octave) and then breaks into a shallow descent to cross the 0-dB line at 6 dB per octave. If the 12-dB rate were maintained, the loop would be unstable.

To obtain the desired lead-lag characteristic, the active filter configuration of Fig. 9 can be used. We can assume that $R_1 = 62$ kΩ, including the output impedance of the phase detector. Then to get a dc amplifier gain of 8.3, R_2 must be chosen equal to 8.3×62 kΩ = 510 kΩ. And since $\tau_1 = R_2C = 600$ ms (from Fig. 8), $C = 600$ ms/510 kΩ = 1.2 μF.

Similarly $\tau_2 = R_3C = 1.6$ ms, yielding $R_3 = 1.6$ ms/1.2 μF = 1.3 kΩ.

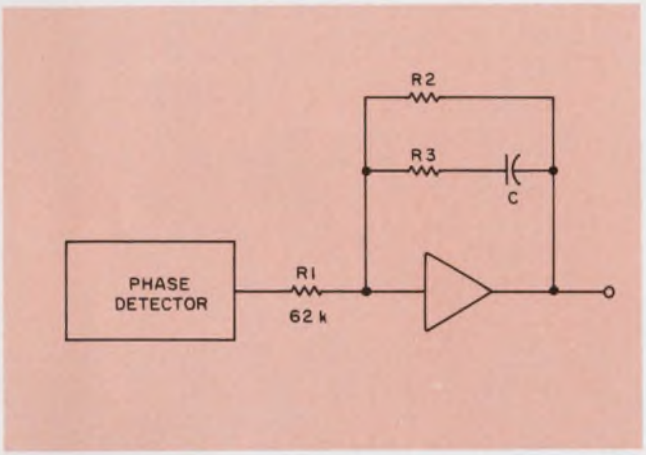
Care must be taken in the design of the VCO input to ensure that RC time constants are well away from the 1-kHz crossover point. Indeed, when a strong signal arrives at the receiver (for instance, during checkout or more importantly, if the loss of lock occurs when the satellite is at closest approach), and the receiver is initially unlocked, no agc will be available. The loop gain will then increase until receiver saturation occurs.

"Push away" may be a problem

The loop gain may be high enough to put an unforeseen corner (RC time constant) above unity gain. If this happens, the loop will be unstable and acquisition will not occur. This sometimes leads to push-away, where, during laboratory checkout, you try to lock the loop with a variable frequency generator, and the VCO actually pushes away as the carrier approaches the center frequency of the receiver.

The phase-locked receiver is now essentially designed. What remains is a review of design philosophy for the remaining blocks: rf amp, mixer, first L.O. and first i-f.

The received signal is filtered by a bandpass filter to prevent interference from external



9. **This active filter configuration combines the dc gain and lead-lag characteristics** needed by the phase-locked loop. Time constant $\tau_1 = R_2C$, and $\tau_2 = R_3C$. The amplifier can be a standard IC operational amplifier.

sources, including image frequencies. To achieve the required noise figure, a two-stage rf preamplifier is needed.

Since it is difficult to build printed-circuit rf amplifiers with high Q at this frequency, it is necessary to put the mixer diode in a high-Q cavity or filter. This is necessary because image noise is generated in the broadband rf amplifiers, even though the preselect bandpass filter is a virtual short at the image frequency. And this noise will reduce the receiver threshold by 3 dB. An added benefit of using a high-Q mixer is the reduction of first L.O. multiplier harmonics and other spurious signals.

The first local oscillator must be very stable and free from spurious oscillation. Therefore it is generated from a crystal and multiplied to the desired frequency. The basic oscillator frequency of 122.5 MHz was chosen to be low enough for a crystal, and the multiplication of 12 was chosen to allow the use of $\times 2$ and $\times 3$ transistor multipliers. The incorporation of $\times 2$ and $\times 3$ transistor multipliers is optimum for tradeoffs between stability, efficiency and harmonic filtering.

The first i-f of 130 MHz is high enough to eliminate image rejection as a problem, yet low enough to achieve reasonable gain, while allowing for temperature-stabilizing techniques in the design.

To achieve a well-defined and temperature-independent selectivity, each i-f amplifier stage is made broad, compared with the bandpass filter that precedes it.

The coupling transformers are designed to have a high turns-ratio, thus purposely mismatching the stages to minimize the amount of capacitance coupled from the input of one stage to the output of the preceding one. This is desirable because the capacitance changes with the agc voltage.

Attention to details like this is important, particularly for systems in which phase stability is paramount.

The design described here was developed for a Cubic Corp. program and led to a proven receiver. The design procedure has been successfully applied to many systems, particularly for distance and angle-measuring equipment that uses phase comparison techniques in aerospace applications. ■■

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Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'l find the answers in the article.

1. How big an advantage (in dB) does a phase-locked reeciver typically have over a conventional receiver in detecting weak signals?

2. What are the advantages of using a sweep acquisition circuit?

3. Why does narrowing the i-f bandwidth by 2 dB not improve the i-f C/N by 2 dB?

4. Which is typically the more stringent limitation on permissible static phase error: modulation or agc?

5. Why is it important that the phase-locked receiver limit symmetrically?

6. What is "push away"? Name two ways in which it can be caused.

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/7491 Shift ster	**9375/7475** Quad Latch	**9341/74181*** 4 Bit Arithmetic Logic Unit	**9316** Binary Counter	**9392/7492** Divide by 12 Counter
iport ster	**9334*** 8 Bit Addressable Latch	**9340** 4 Bit Arithmetic Logic Unit	**9310** Decade Counter	**9390/7490** Decade Counter
8 hift ster	**9314** 4 Bit Latch	**9324** 5 Bit Comparator	**9306** Up/Down Decade Counter	**9366/74193** Up/Down Binary Counter
Shift ster	**9308** Dual 4 Bit Latch	**9304** Dual Full Adder	**9305** Variable Modulo Counter	**9360/74192** Up/Down Decade Counter

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	9390/7490	●			●					●						
	9392/7492	●	●			●						●				
	9393/7493	●		●				●								●
SEMI-SYNCHRONOUS VARIABLE MODULO COUNTER	9305	●		●	●	●	●	●		●	O	●	O	●	O	●
SYNCHRONOUS UP COUNTERS WITH PARALLEL LOAD*	9310									●						
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INFORMATION RETRIEVAL NUMBER 33

The minicomputer and the engineer—Part 5

Peripherals expand your mini's capabilities

Peripherals turn minicomputers into minicomputer systems. They allow the user to communicate with the machine, and they display information in tabular or graphic form for interpretation or action.

They may collect data, or store it for future use. And they can let the mini communicate with other systems.

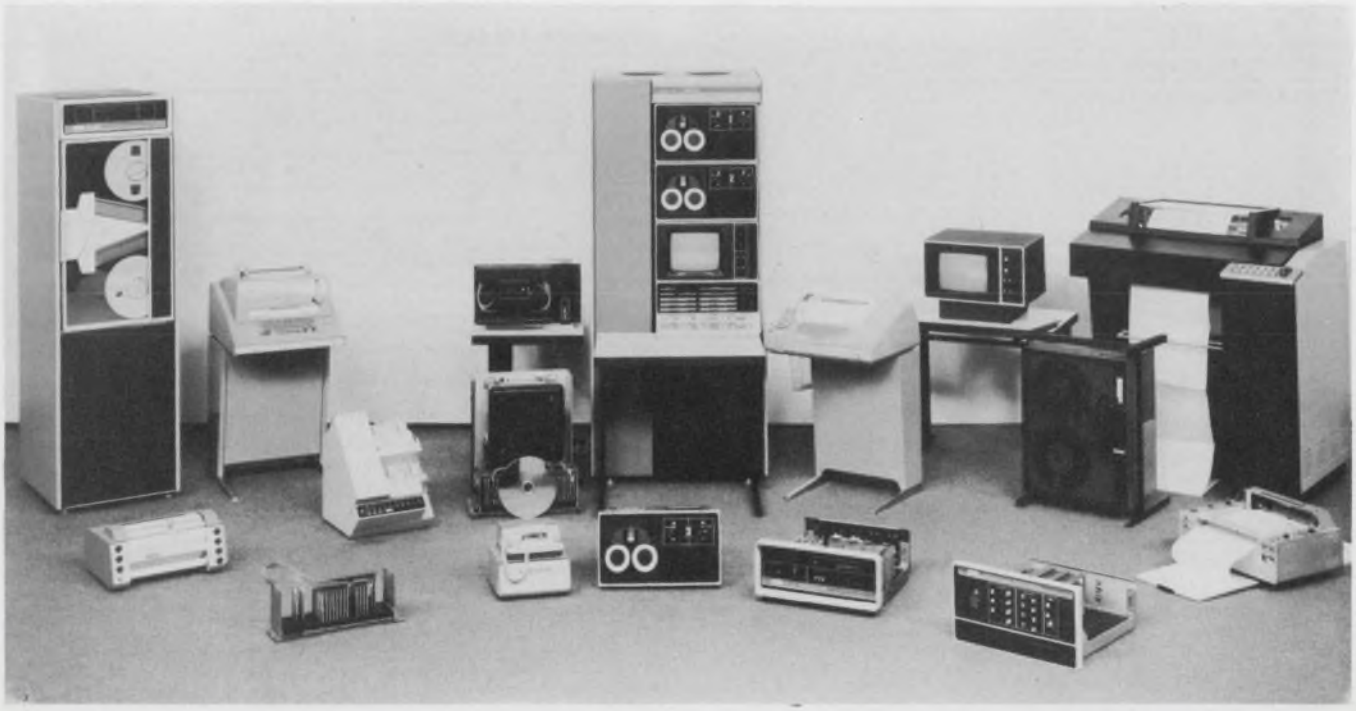
The wide range of modern minicomputer applications has led to an even larger variety of peripheral devices. Because so many different capabilities are offered, it is important to understand both the basic concepts and the relative merits of the various techniques used.

Grant Saviers, Engineering Manager, Peripheral Equipment, Digital Equipment Corp. Maynard, Mass. 01754.

Most important of the peripherals, of course, are those that enable you to input commands to the mini and receive results from it.

Teleprinters are the basic input/output device used with minicomputers. Almost all minicomputer manufacturers offer an interface for the Teletype Corp.'s ASR-33. This low-cost peripheral contains a paper-tape punch and reader and can perform a number of functions when used as an I/O device. It can provide typewriter-keyboard and paper-tape inputs to the computer, hard-copy printouts from the computer and punched paper-tape outputs from the computer.

The ASR-33 performs all the data-collection, storage and display tasks required of peripherals, but in a limited manner. Its operational speed is 10 characters per second, and it's built for light duty. Other teleprinters are available, with or



without the paper tape reader and punch, for heavy-duty operation—and with higher speeds.

Paper tape is widely used for data collection and data input to minicomputers. Tape readers and punches are relatively inexpensive, with the price closely related to performance.

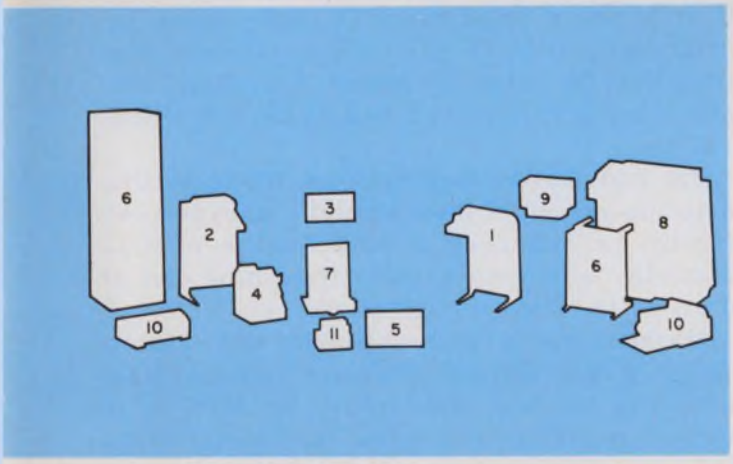
The tapes are one inch wide, and they use an eight-bit character code with holes spaced 10 to the inch. They are usually supplied on 1000-foot reels. Some high-speed punches and readers employ "fan-folded" paper tape. The tape can be stored efficiently and when run through a reader, it is refolded, ready for immediate use.

Tape readers come in two varieties: high-speed units (300 characters per second), with opto-electronic read heads, and mechanical readers, with speeds up to 120 characters per second. Paper-tape punches that operate at speeds up to 200 characters per second are available.

If the source of the data is an electrical device, and a delay in accumulating the data for processing is tolerable, it's easier to punch out the data on paper tape and carry it over to the mini.

Cards—both punch and "mark-sense"—are useful for batch inputs of printed information. The data can be keypunched onto a card. This is especially efficient for large volumes of well-organized data that appear in tabular form and are not subject to interpretation errors. A card reader must be used to input the data to the mini.

Another means of inputting data is to generate it in computer-compatible form to start with. A convenient way to do this is to use mark-sense cards. They are marked by pencil at the time that the data is generated. Then, through optical detection in a card reader, the data is transferred from the card into the minicomputer.



A wide variety of peripherals are available for minicomputers including: (1) standard and (2) heavy-duty teleprinters; (3) high-speed paper tape reader and punch; (4) punched-card reader; (5) mini and (6) standard magnetic disc memory; (8) high-speed line printer; (9) CRT display; (10) plotters; (11) modem for communicating with other computers. Many special peripherals are available for test and control applications.

Incremental magnetic tape or a cassette might be used in place of the paper tape. Incremental tape recorders are single-character-at-a-time devices, with speeds up to 1000 increments per second. Half-inch magnetic tapes are standard, with either seven or nine tracks.

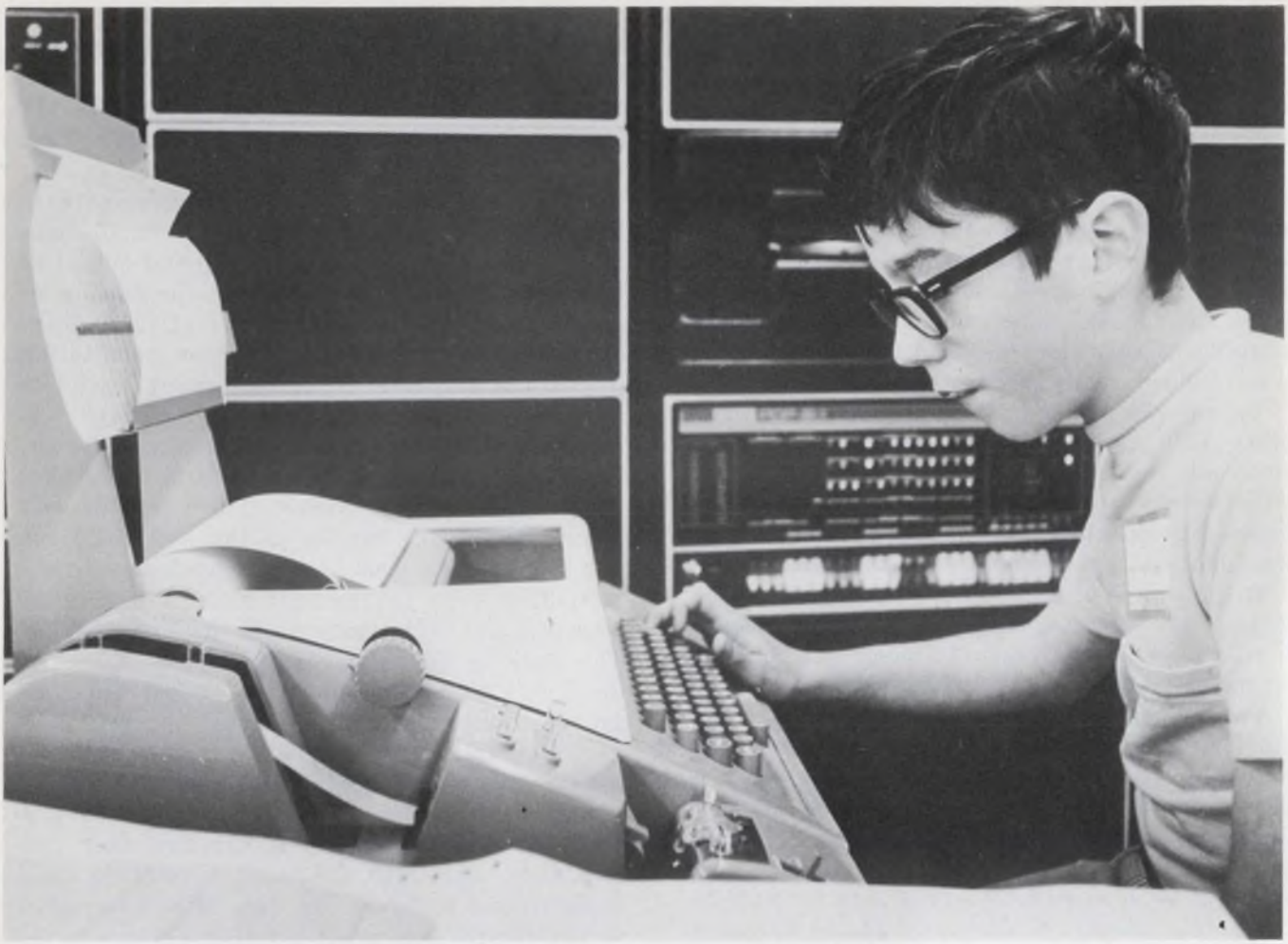
The CRT terminal has begun to compete with teleprinters in many applications. Small ones offer convenient high-speed editing and output at low cost. They are very popular for editing or examining rapidly large amounts of data. They can provide convenient ways for monitoring process-control data. Typically, many variables must be examined but nothing retained for reference. These terminals can also be very effective in order processing, inventory control or hospital patient-monitoring systems. They can present many alternatives rapidly to the user, who can key his selection back to the computer.

Another type of terminal that is useful for scientific and engineering use is the alphagraphic. This may be a storage oscilloscope or a raster-display CRT, combining the capabilities of graphics with characters. Graphic displays, such as bar graphs, line graphs, plots, or even isometric views, can be incorporated with alphanumeric information. Some of the new electrostatic or electrographic line printers offer this capability through dot-matrix printing and sophisticated software. An item often overlooked in purchasing nonimpact printing devices is the cost and availability of the paper.

For laying out prints, circuit cards, circuit design, or any type of computer-aided design, the precision CRT terminal, with interactive capabilities is useful. The display processor incorporates sophisticated hardware for displaying flicker-free images. Light pens and keyboards are used for computer-aided design or analysis of data.

The line printer is gaining favor for use with minis. Low-cost, 80-column line printers are a nice way to add volume alphanumeric output to the machine. It's advisable to examine seriously the merits of 80 vs 132 columns, even though 132 has been the industry standard. Not only is 80 columns wide enough for most jobs, but it is also compatible with the standard 8-1/2-by-11-inch paper that is used. A simple hammer mechanism is best, since this is the critical element for long life and good printing quality. The line printer also can produce multiple copies.

For real-time communication with other systems, the minicomputer must be interfaced with communications equipment. Designing a communications subsystem is as complicated as designing a computer system (see "A Designer's Guide to Data Communications," ED 9, April 29, 1971, p. C4). A common-carrier service and modem must be chosen, the mini must be interfaced with



You don't have to be a computer expert to use a minicomputer for problem solving. This 12 year old, Charles Hornig, learned programming while in the sixth grade. He is using the basic I/O device, Teletype Corp.'s ASR-33 teleprinter, to communicate with the mini. The ASR-33 has both tape and hardcopy outputs.

the modem, error-recovery techniques must be determined and operating programs must be developed.

Extend the mini's storage

Mass-storage devices can be used in two ways: for storing large volumes of data or as part of the operating system. For temporary storage of data, they can be considered as an extension of the mainframe memory.

A variety of combinations are available for capacity, access time, transfer rate and cost per bit. These are the most important performance characteristics to consider. Convenience, compatibility, interchangeability, capability for off-line storage and reliability are secondary features.

With a mini to be used for software development, consider using a cartridge disc, a cassette or magnetic tape as the mass-storage device. Because these devices have removable units for recording the data, additional data can be stored on-the-shelf at very low cost. The cassette may contain up to 100,000 characters. A cartridge disc may contain nearly two million characters.

With the broad range of storage capacities, there is also a broad range of performance. Industry-compatible or mini magtapes move tape from 15 to 75 inches per second. A cartridge disc allows access to nearly all data on the disc within 100 ms.

For high-performance systems, where getting data into and out of the computer's main memory rapidly, or examining a large volume of data hurriedly, is important, use a fixed head disc or drum as the mass-storage device.

Magnetic tape is the most popular way of interchanging data between computer systems. Magnetic tape has been standardized by ANSI as to format, recording techniques, tape construction, etc., to guarantee interchangeability between computer systems. It also tends to be the most reliable and least troublesome way.

The capacity of a nine-track, 800-bpi, 2400-foot tape is on the order of 80 million bits. Some minicomputer systems require magnetic tape for storing symbolic programs, since the volume of data is quite large and usually exceeds the capacity of

a cassette, mini magnetic tape or even a cartridge disc. However, even efficiently utilized magnetic tape has only about a third the storage capacity of a disc pack.

One of the most exciting peripherals at this time is the cassette tape unit. While actual use is not yet widespread, there is great interest in using this highly convenient, compact storage medium. Potential applications for a cassette-sized tape are in terminals, the dedicated memory in minicomputer systems, program development and editing.

Fixed-head mass storage is used in data acquisition applications, where large volumes of data must be accepted by the computer, processed rapidly and stored.

Some industrial data-acquisition systems that accept data from high-speed analog-to-digital converters use fixed-head discs to store data that is coming in from an experiment or manufacturing process.

The fixed-head disc also plays an important role in end-user operating systems and time-sharing applications. The disc is used as a temporary storage for programs that aren't being executed by the computer.

In a time-sharing application, transfer rate and access time to the disc are very critical. A memory that is being loaded from the disc cannot be used while the transfer is taking place. Therefore transfer rate is the most important parameter to consider if the use of core memory is to be at a maximum. Access time is important, since the processor must wait to start the transfer.

Some communication systems also use fixed-head discs to increase capacity for buffering messages. And very efficient multiplexing systems can be built around a fixed-head disc.

Discs and drums are functionally identical, but drums tend to be utilized in rugged or miltary applications, where high resistance to shock and vibration are required. The drum is inherently a much more rigid structure than a disc.

The disc usually has a cost advantage over the drum, because it is more efficient in bits per cubic inch and somewhat simpler in its mechanical structure. For fast access times, drums have been operated from 7200 rpm to over 20,000. However, some discs operate at 6000 rpm.

The moving-head disc is often used for storing large volumes of data that need to be frequently accessed. Typical applications would be in an on-line inventory system, order-processing system or a file storage for a resource-sharing system. In these applications rapid access, as with the fixed-head disc, is not so important. The system can continue normal operations while it is waiting for the data from the disc. The cost per bit with the moving-head disc can be an order of magnitude cheaper than with fixed-head systems.

Two types of moving-head disc have gained acceptance. One is the IBM 2315 cartridge, used on the 1130 and 1800 systems. This cartridge has found wide appeal because of its convenience, high capacity and simplicity. And capacity has been improved to about two million bytes in a cartridge that costs about $150. The cost per bit of a basic system consisting of a controller, drive and single cartridge is about 0.08 cent per bit.

For very large files, disc-pack drives that use the IBM 2316 disc pack or an equivalent are popular. These drives can be used to provide very large data bases for minicomputers. It is not uncommon to have minis with nearly a billion bits on line. With the disc pack, the cost per bit drops to 0.015-cent-per-bit range. But in spite of this very low cost, the enormous capacity of these drives put the typical cost to the user at more than $35,000. Applications include parts control, inventory systems, reservation systems, space-allocation systems and even small-business information systems.

The disc pack can also be used to interchange information with larger computer systems. It is a convenient way to carry around 240 million bits that can be accessed in less than 70 ms.

Will the pieces fit together?

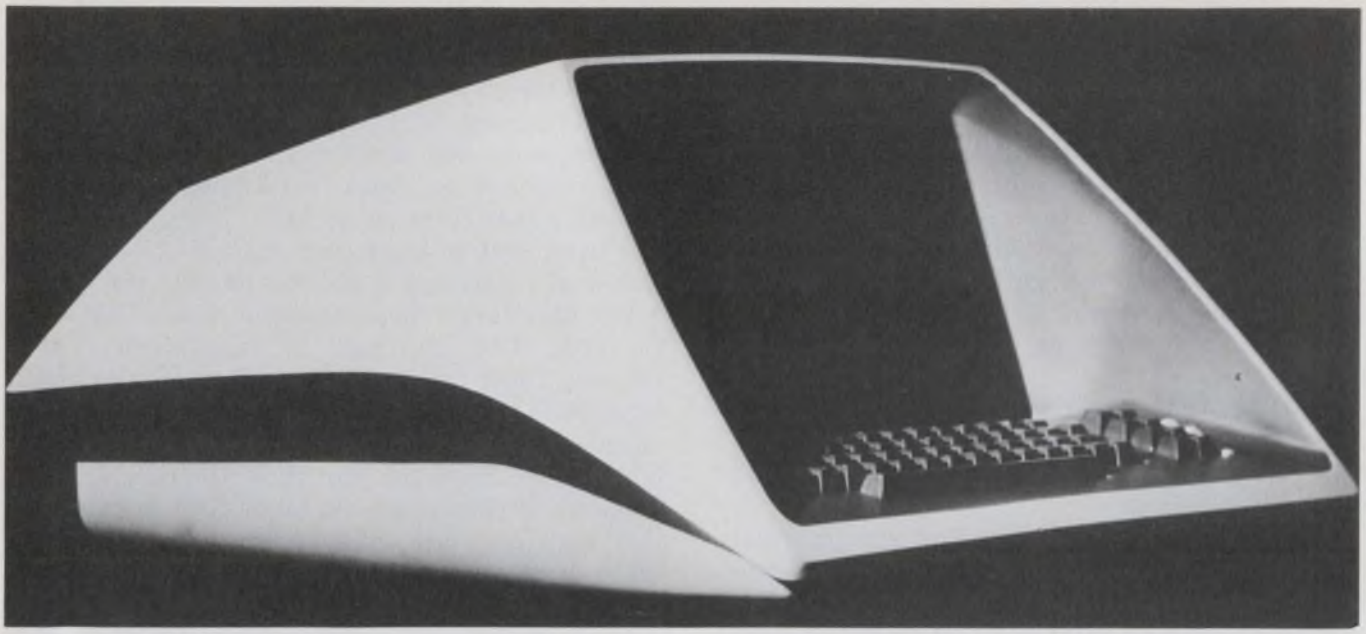
One thing sometimes overlooked in specifying peripherals for a system is the balance of capacity and transfer rates. Can they operate with one another? Can the system as a whole perform?

The problem becomes apparent if an ASR-33 and a cartridge-disc drive are interfaced to a mini. To save the contents of the disc on paper tape, in case of a programming error or head crash, be prepared to spend about three days and nights punching out paper tape.

Large fixed-head discs with nonremovable recording units should normally be backed up with removable units, such as a cartridge disc or tape drive. A cartridge disc backed up by another cartridge disc would permit copying from one disc to another.

The transfer rate is what really limits going from disc to paper tape. But one should also consider capacity; dumping a disc pack onto a cassette, for example, may take several cases of cassettes.

Another factor to consider is the computer's capability of supporting the transfer rate from multiple discs or from tape and disc. The large disc-pack drives have transfer rates of several megabits per second, which can severely tax the I/O bus of some minicomputers. The high-speed devices should have provision in their controllers for flagging latency problems, or for attempting the data transfer again if there is a latency conflict on the I/O bus.



Low-cost CRT/keyboard terminals have begun to compete with teleprinters in applications where the output is not retained. This Digital Equipment Corp. DECterminal I displays 20 lines of data at 72 characters per line on its 12-inch screen. It can handle transmission speeds of 300 baud and up to 2400 baud with options.

On low-performance peripherals, such as displays, printers and magnetic tapes, latency is not a problem. It can be with high-speed communication channels or on systems with high-speed scanners or fast a/d converters.

After deciding on a system's peripherals, it is wise to check the hardware requirements for the mini manufacturer's operating systems. Usually these systems require some minimal hardware configuration, such as a disc or other mass-storage device; some minimal amount of main memory; a terminal device; and, often, a line printer. Make sure that the mini maker offers his operating systems with more than one type of mass-storage device. Device-independent software offers the greatest operating flexibility.

Beware of specsmanship

Once the peripheral types are chosen, it requires detailed study to compare the specifications of different manufacturers. While easier to compare than minis, on the basis of published specifications, peripherals often are sold with "black magic" explanations.

There are more engineering disciplines involved in the design of a peripheral than in a mini. Materials, wear, lubrication, fatigue, vibration, servo-analysis, structural design and electronics —all need to be understood by designers.

Some solid common-sense analysis can be the best tool in evaluating peripherals. Make sure the equipment is locked if the power fails and is protected against operator error. In no case should the equipment or recording media be damaged.

Ask if the servo system has sufficient margins to remain stable as the unit wears. Salesmen make a great point of the fact that their equipment has no potentiometers that could accidentally become misadjusted. Contrary to the "no potentiometers" argument, a carefully selected adjustment often improves reliability by widening operating margins or eliminating many complex circuits.

A horsepower race has developed over the reliability of mass storage. The transient error rate is of little or no consequence if it's better than about one in 10^9 bits. For transient errors, the data can be reread.

To measure transient error rates of better than 10^{11} with significant statistical confidence requires tests of the disc for several weeks. Current technology permits error rates of about one in 10^{10} to one in 10^{11} for rotating mass-storage devices. Tape drives tend to be one to two orders of magnitude less reliable. It is important that the software anticipate errors by mass-storage devices, whether tape or disc.

The important criterion is not the transient error but how often the device fails in such a way that it can't be used, and how often undetected errors slip through. Cyclic redundancy checks are used in fixed-head files and most moving-head files, since they offer very strong error detection and an extraordinarily small probability of undetected error.

Manufacturing MTBF numbers can be quite misleading. Very few companies can quote true MTBF of machines in the field. A more meaningful number is the frequency of field service calls required to restore the equipment to operating condition. ■■

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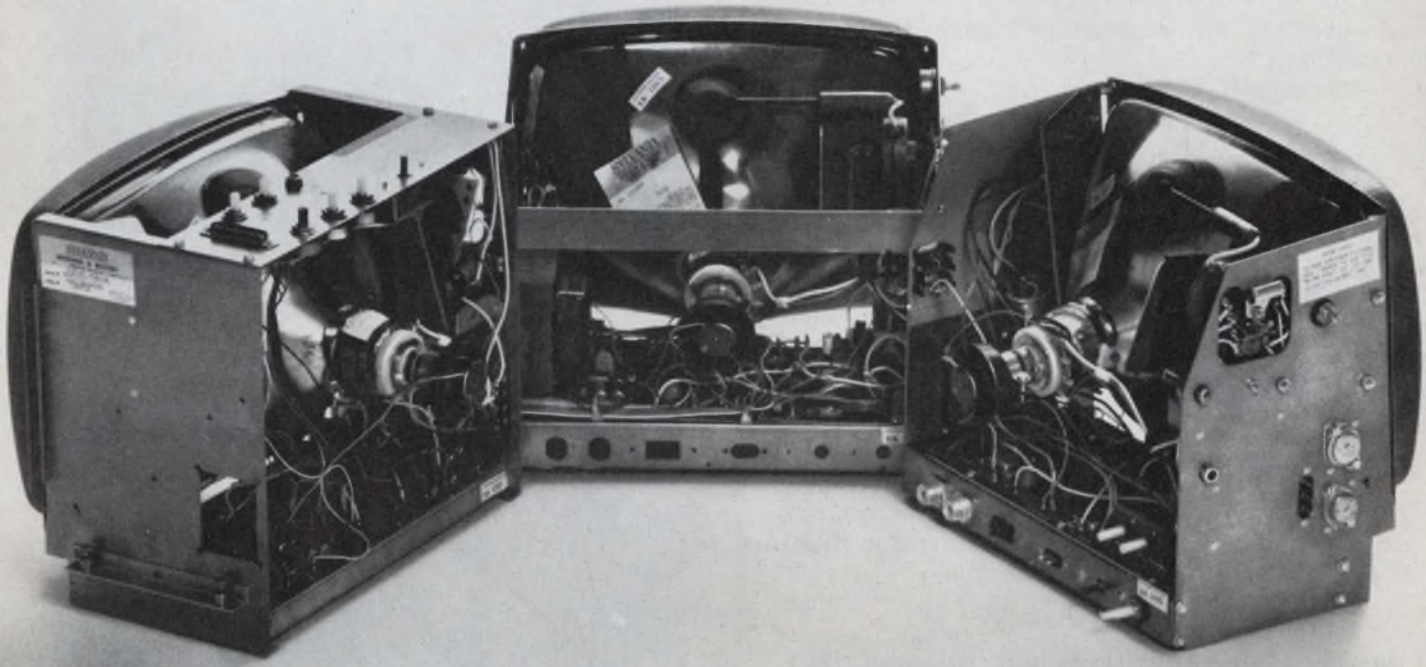

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ideas for design

Graphical approach helps design doubly loaded bandstop filters

The logarithmic plot of a not-too-well-known, but useful, equation helps to simplify the design of a doubly loaded single-resonator bandstop filter. The equation also eases filter adjustment for optimum tuning. Even the individual unloaded Qs of multi-resonator filters can be found by decoupling all resonators from the one in question.

The equation,

$$Q_u = \sqrt{\left[10^{(L_A)_{max}/20}\right]^2 - 2}/\omega_{3dB},$$

gives the resonator unloaded Q (Q_u) as a function of the fractional 3-dB bandwidth (ω_{3dB}) and the peak attenuation, $(L_A)_{max}$. These quantities are defined by the characteristic curve of Fig. 1a. The equivalent circuit (Fig. 1b) of a doubly loaded bandstop filter is also shown.

Plotting the above equation on log-log paper (Fig. 2) yields a group of straight lines, with unloaded Q as the dependent variable, the fractional bandwidth as the independent variable, and the peak attenuation as a third parameter.

When the peak attenuation is greater than or equal to 20 dB, the approximation

$$Q_u = 10^{(L_A)_{max}/20}/\omega_{3dB}$$

is valid. Curves for these high values of $(L_A)_{max}$ may be drawn in by simple interpolation. As an example, let us find the unloaded Q a bandstop filter must have to give 40-dB rejection at 2000 MHz, and at least 3-dB rejection at 1960 and 2040 MHz. First, we solve for the fractional 3-dB bandwidth:

$\omega_{3dB} = (f_2 - f_1)/f_0 = (2040 - 1960)/2000 = 0.04$. Reading directly from the graph, we see that Q_u must be at least 2500.

This design method is not restricted to any particular frequency region. It can be used for lumped-constant circuits, microwave circuits, or anywhere the equivalent circuit of Fig. 1b is valid.

Reference

E. G. Cristal, L. Young and B. M. Schiffman, "Bandstop Filter Formulas," *IEEE Transactions MTT*, Volume 15, No. 3, March 1967, pg. 195.

Harvey J. Hindin, Director of Engineering, ARRA, Inc., 15 Harold Court, Bay Shore, N. Y. 11706.

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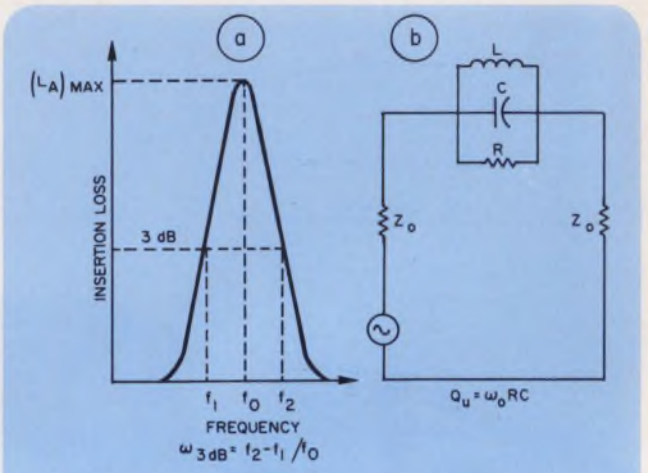
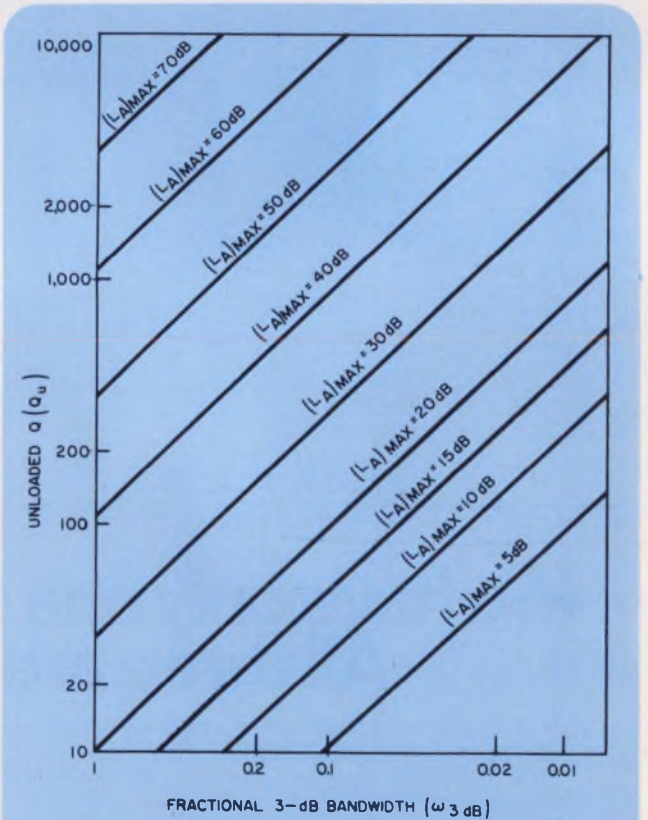


1. **The characteristic curve of a doubly loaded bandstop filter (a)** defines peak attenuation, $(L_A)_{max}$, and fractional 3-dB bandwidth, ω_{3dB}. The filter's equivalent circuit is shown in b.



2. **A log-log plot of unloaded Q vs fractional bandwidth** almost reduces bandstop-filter design to the reading of this graph. Once the band limits are set and the peak attenuation and resonant frequency are selected, the filter's unloaded Q can be found with a straight edge.

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Phase-detector/modulator operates from dc to 30 kHz

Here is a handy op-amp/FET phase-detector/modulator that functions well for ±5-V inputs from dc to over 30 kHz. The circuit is doubly balanced and has minimum carrier and signal feedthrough.

The basic circuit (Fig. 1a) consists of three resistors, an ideal op amp and a carrier-modulated switch, S_1. Assuming ideal components, we can see by inspection that when S_1 is open

$$e_1 = e_3 = e_4 = e_0,$$

and therefore $e_0 = + e_{in}$.

With S_1 closed,

$$e_3 = e_4 = 0,$$

and $$e_0 = -e_{in}$$

The transfer function of $e_0 = \pm e_{in}$, where the ± sign is under the control of carrier f_2, is the equation for a switching type of phase-detector/modulator. For a phase detector, $f_1 = f_2$. For a balanced modulator, $f_1 \neq f_2$.

A practical circuit (Fig. 1b) uses an n-channel FET with a low ON resistance and a low drain-gate capacitance. In addition the op amp should be a high-slew-rate type with a similar high-frequency response at both inputs.

An amplifier that can operate at higher frequencies than the 709 used will extend the useful range of the circuit. If the application is not critical, R_1 can equal R_2, and R_4 can be omitted.

Figure 2 is a plot of the input and output waveforms for a phase detector when $f_1 = f_2$.

Allan G. Lloyd, Holobeam, Inc., 560 Winters Ave., Paramus, N.J.

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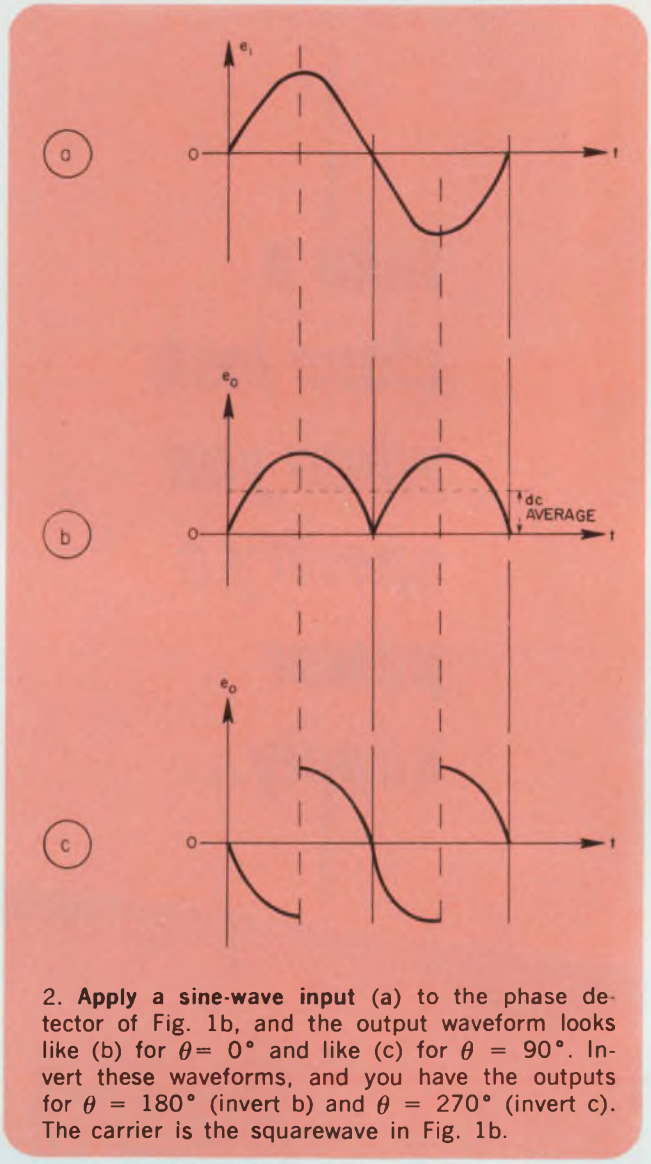
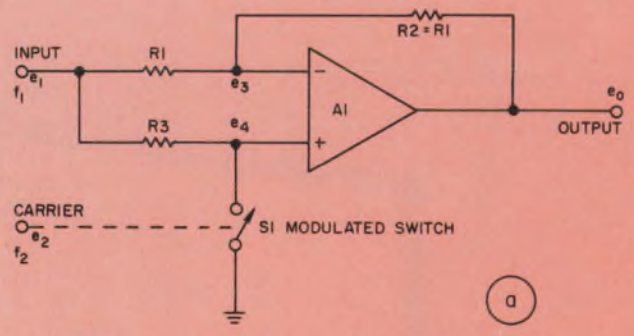
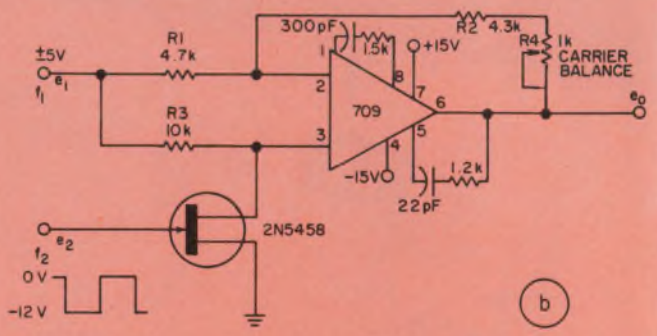


2. **Apply a sine-wave input** (a) to the phase detector of Fig. 1b, and the output waveform looks like (b) for $\theta = 0°$ and like (c) for $\theta = 90°$. Invert these waveforms, and you have the outputs for $\theta = 180°$ (invert b) and $\theta = 270°$ (invert c). The carrier is the squarewave in Fig. 1b.



1. **You can build a phase-detector/modulator** (a) with only an op amp, a carrier-modulated switch and a resistor network. For a phase detector, the input signal and the carrier have equal frequencies.



For a balanced modulator, the two signals have unequal frequencies. A practical version (b) of the basic circuit performs well from dc to 30 kHz with input signals up to ±5 V.

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- ☐ More coming.

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INFORMATION RETRIEVAL NUMBER 38

Low-power clock generator delivers independent outputs

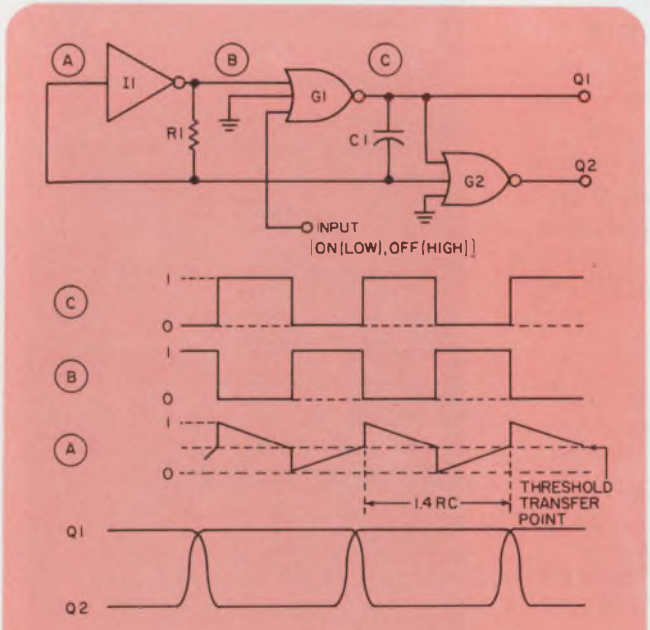
A two-phase non-overlapping clock generator can be designed using fewer components and dissipating less power than other schemes. The generator (see diagram), which can be built with one RCA COS/MOS CD4000D circuit, operates from supply voltages of 5 to 15 V. It even can be externally controlled by applying a dc voltage to gate G_1. Its prime application is providing clock pulses for dynamic p-enhancement-mode logic systems that depend upon charge storage for data retention.

When the output of G_1 is high, point A is also high (because of the coupling capacitor C_1) and point B is low. Resistor R_1 is returned to the output of inverter I_1 to provide a ground path for discharging C_1. When point A reaches the threshold of I_1, point B goes high, point C goes low, and the capacitor is negatively charged. The resistor now provides a path to the supply voltage for C_1.

As the capacitor charges towards the supply voltage, the potential of point A again passes the transfer point of the inverter. At that instant, the circuit changes state, and the cycle repeats. The time required to complete one cycle is 1.4 RC. Gate G_2 delays the leading edges of the waveform at point C. Typical range of values for R1 is 50 kΩ to 1 MΩ; for C1, 100 pF to 0.05 μF.

John Sgro, Senior Technician, American Electronic Laboratories, Inc., P.O. Box 552, Lansdale, Pa.

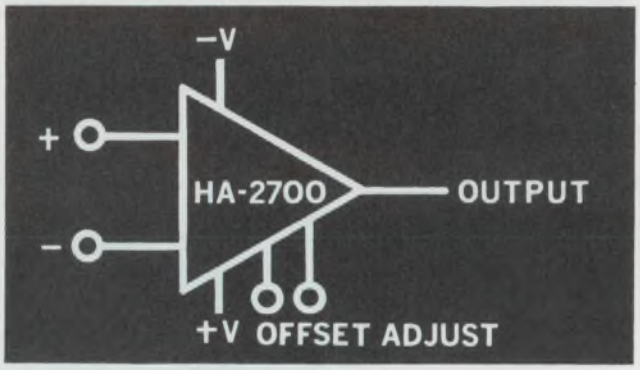
VOTE FOR 313



One complementary MOS circuit is all that you need to build this clock generator, along with a resistor and a capacitor. The two outputs are non-overlapping and opposite in phase.

new

4th GENERATION OP AMP.



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- Input Bias Current — 5.0nA
- Power Supply Range — ±5.5V to ±22V
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- Offset Null Capability
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*100 to 999 unit price.

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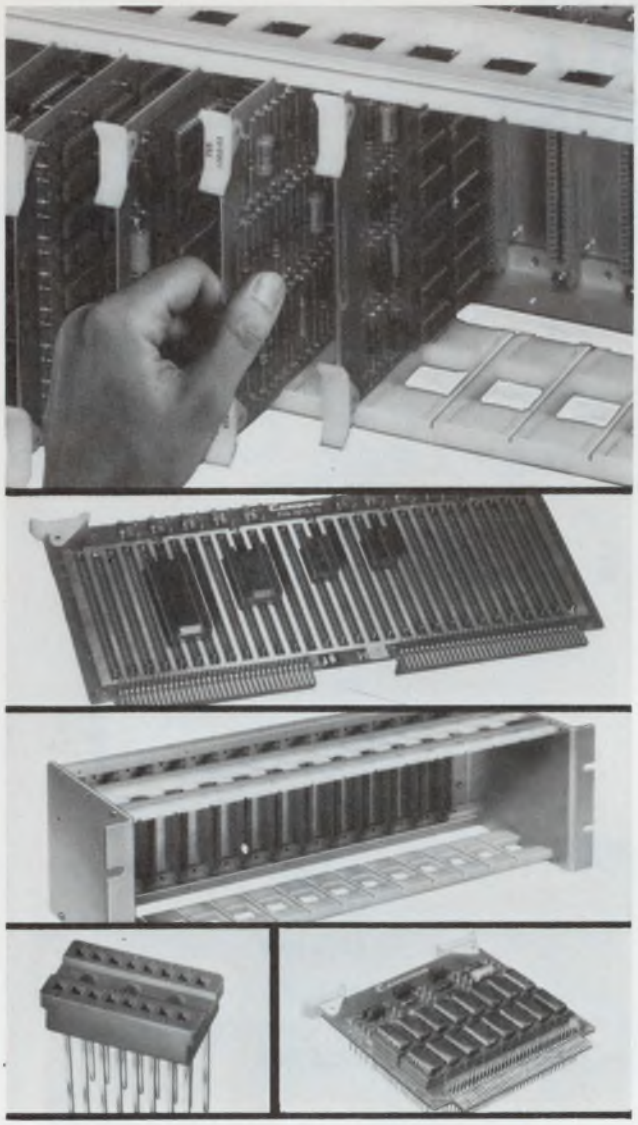

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INFORMATION RETRIEVAL NUMBER 41

Vary one-shot's pulse width over 1600:1 controlled range

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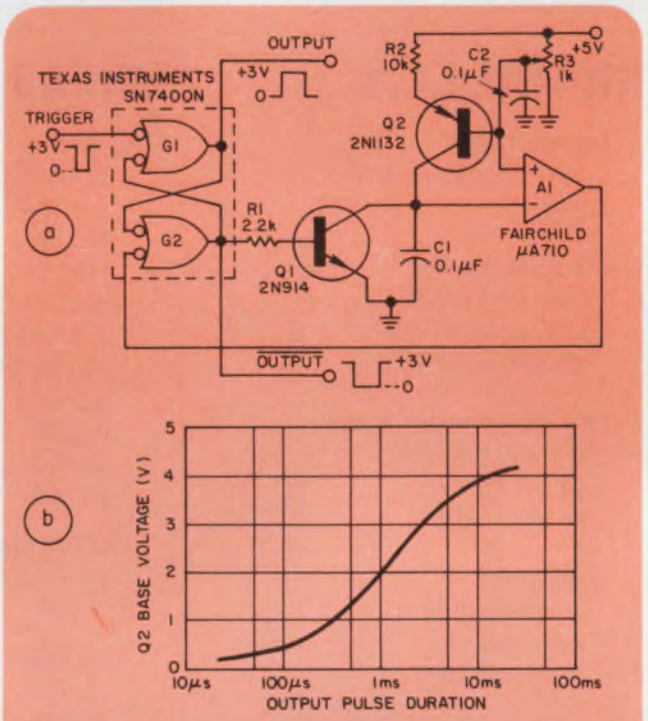

This dual-output monostable (a) permits direct control over pulse duration by changing the setting of potentiometer R_3. Both capacitor (C_1) charging rate and comparator (A_1) threshold level are used to vary output pulse width. The curve (b) shows the control range of 1600:1.

IFD Winner for February 18, 1971
Ivaras P. Breikss, Principal Engineer, Honeywell Inc., Test Instruments Div., 4800 E. Dry Creek Rd., Denver, Colo. 80217. His idea "Low-Cost Tri-Function Generator Delivers Precise Tiangular Wave" has been voted the Most Valuable of Issue Award.
Vote for the Best Idea in this Issue.

grated circuits and a few discrete components.

A trigger pulse sets the flip-flop (gates G_1 and G_2), turning OFF transistor Q_1. This allows capacitor C_1 to charge through the current-source transistor, Q_2. When the voltage across C_1 reaches the threshold level established at the noninverting input of voltage comparator A_1, the comparator output (normally in the logic ONE state) switches to its low level, resetting the flip-flop.

Transistor Q_1 is then driven into saturation, providing a discharge path for C_1, and returning the circuit to its quiescent condition. Either output of the flip-flop may be used as the one-shot output, depending on the polarity desired.

The duration of the output pulse is essentially the time required for C_1 to charge to the set threshold. This design uses both the charging rate and the threshold level to vary pulse width.

The adjustment is accomplished by means of potentiometer R_3, which establishes the base voltage (V_b) of Q_2. For example, when V_b is low, the charging current to C_1 is high, and the threshold is low, resulting in a narrow output pulse. A higher V_b causes a lower charging current, a higher threshold, and a significantly wider output pulse. The equation for the output pulse width, t_o, is:

$$t_o = R_2C_1 \frac{V_b}{5 - (V_b + 0.7)}$$

It should be noted that if R_3 is to be remotely located, capacitor C_2 should be included to remove noise from the control line.

Thomas L. Hershey and G. A. Dunn, Electronics Engineers, Department of Defense.

VOTE FOR 314

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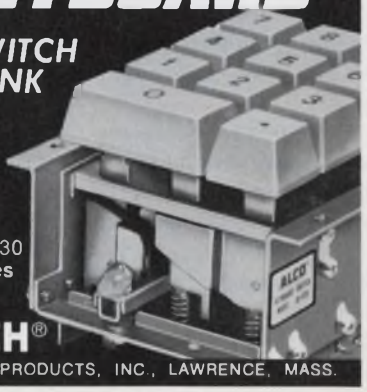

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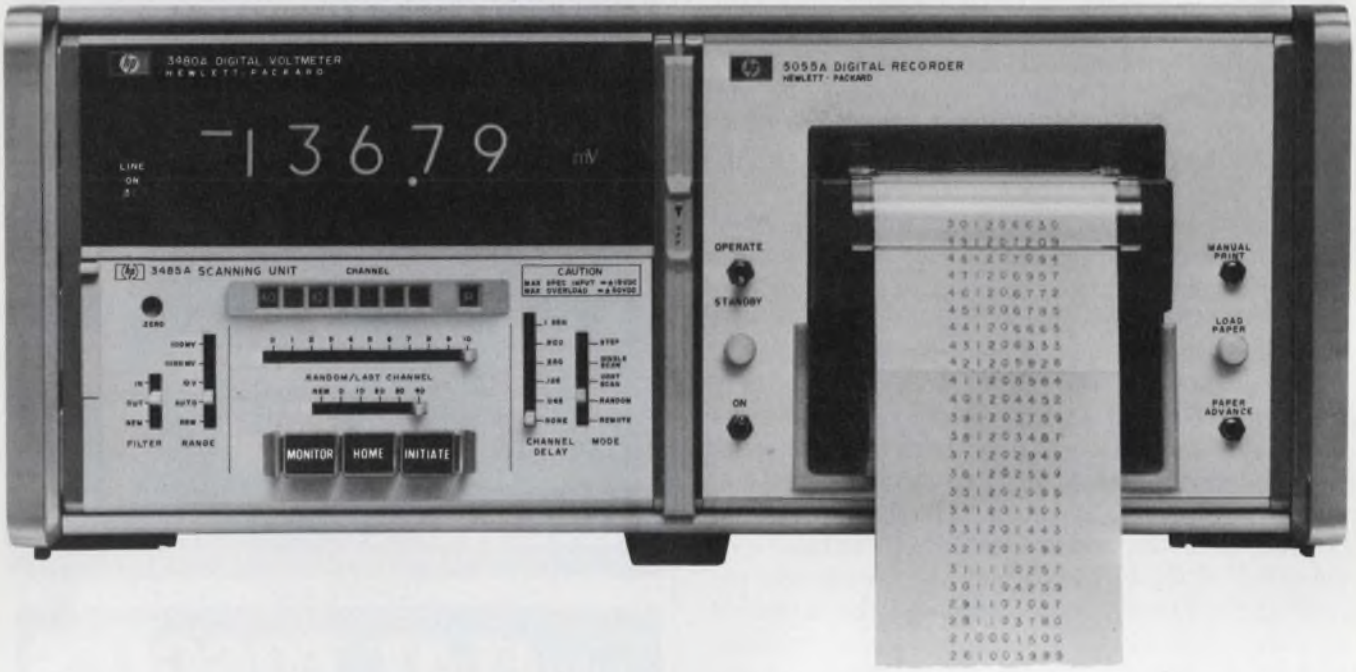

It costs $4,475.

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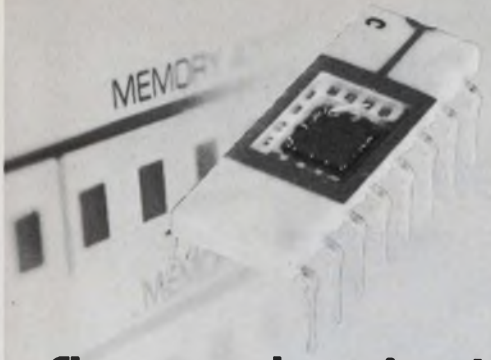
DIGITAL VOLTMETERS

INFORMATION RETRIEVAL NUMBER 42

INFORMATION RETRIEVAL NUMBER 43 ►

Designing computer memory systems?

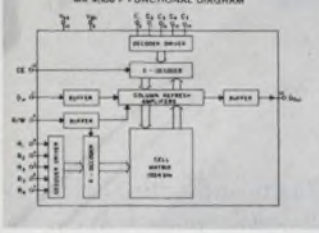


Choose industry's only TTL compatible 1024-bit RAM

It's the most advanced semiconductor memory component available.

You can improve performance and reduce costs of memory systems for mini-computers and peripherals—mainframes too!—with MOSTEK's new MK 4006 P dynamic random access memory. This new design is made possible through MOSTEK's exclusive ion-implantation process . . . *enabling both depletion and enhancement mode devices to be incorporated on the same silicon chip.* In the MK 4006 P MOSTEK has combined process leadership with creative design to bring you a whole bag of new features.

MK 4006 P FUNCTIONAL DIAGRAM



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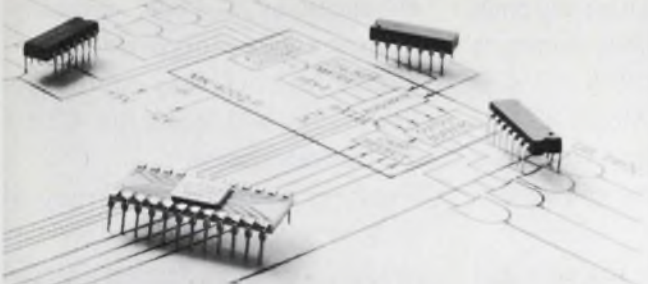

MOSTEK'S 64x4-bit MOS static RAM

Don't buy more bits than you need for those small buffer memory applications. MOSTEK's MK 4002 P 256-bit static RAM is organized as 64 4-bit words. Perfect for such requirements as data acquisition, key-to-tape and tape-to-printer buffers; in short, any application where you need temporary storage of data.

Don't get the idea that the 4002 is any slouch in performance, though. Access time is less than one microsecond . . . even up to +75°C. Memory operation is static so no refresh clocks are required. And power dissipation is low, typically less than 200mW.

Plus, MOSTEK's exclusive low-threshold ion-implantation process gives you full TTL/DTL compatibility . . . no need for external components or interface circuitry. We even put pull-up resistors on the chip for driving from TTL gates . . . and all four outputs have a TTL fan-out of 1. If your system requirements grow, additional packages are easily wire-OR'd thanks to the four chip-select inputs.

Got the message? MOSTEK makes it easy for you to use MOS. Call today for information and fast delivery of all the MOS components you need to Gordon Hoffman at our home office (214) 242-1494, or contact your nearest Sprague Electric Company office or representative.

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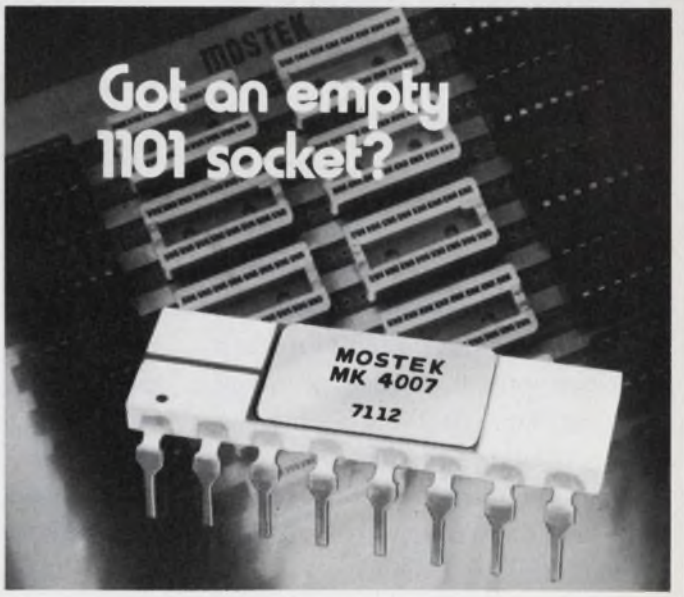

Got an empty 1101 socket?

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

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

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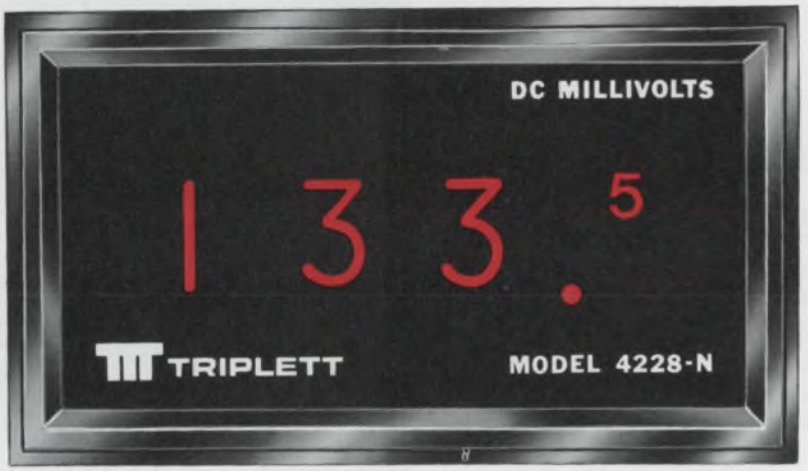

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Designed for OEM applications as well as R&D, production, quality control, maintenance and education use, Triplett's line of digital panel meters combine compactness, convenience and capability with characteristic Triplett accuracy and quality.

To 2 Watts power consumption (for reduced heat and increased reliability) and positive over-range and reverse polarity indications, Triplett's Model 4228-N adds a unique (patent pending) 2¾-digit display that effectively doubles the accuracy and resolution of 2½-digit instruments . . . at the cost of 2½-digits. Accuracy is ± 0.25% of reading ± 1 digit.

The Model 4228-N is a real value at $140, so call your local Triplett Sales/Service/Modification Center or Triplett sales representative right now. Either will also be pleased to demonstrate two companion products: Triplett's Model 4225-N at $125 which merely omits the neon lamp "1" (thus reading to 995) and offers ± 0.50% ± 1 digit accuracy; and the Model 4220-N at $110 — a 2-digit instrument (reading to 99) with ± 1% ± 1 digit accuracy.

Mounted in the same size case and boasting the same low power consumption and positive over-range indication, Triplett's 3½-digit Model 4235-F adds auto-polarity (with polarity indication) display hold capability, high input resistance (from 10 to 1,000 megohms depending on range) and a 3½-digit single-plane seven-bar fluorescent display. For many users, the wide-angle viewing capability — enhanced by a green, circularly-polarized viewing window that eliminates confusing internal reflections — will make the 4235-F the obvious choice.

Boasting a voltage accuracy of ± 0.10% (current ± 0.15%) of reading ± 1 digit, Triplett's Model 4235-F sells for $240. Its companion, the 3-digit Model 4230-F, is $220. More information, or a free demonstration of both models, is available from your Triplett Sales / Service / Modification Center or your Triplett sales representative. Triplett Corporation, Bluffton, Ohio 45817.

Model 4235-F $240

1. 3½ digits with auto-polarity.
2. Low Power Drain — provides low operating temperature and long-lived reliability.
3. Single-plane, Seven-bar Readout — for accurate, wide-angle readability.

TRIPLETT

Manufacturers of the World's most complete line of V-O-Ms.

INFORMATION RETRIEVAL NUMBER 44

new products

Silicon-on-sapphire 3300-bit $64 ROMs access in 20 ns

North American Rockwell Microelectronics Co., 3430 Miraloma Ave., Anaheim, Calif. Phone: (714) 632-2231. P&A: see text.

Using its silicon-on-sapphire (SOS) process, North American Rockwell, is making available custom-encoded 3300-bit ROMs with access times of 20 ns and low single-unit prices of $64. The price includes the encoding fee.

These SOS memories use diode arrays—128 columns by 40 rows—which are custom encoded by North American Rockwell with a laser micromachine tool.

The laser tool removes diodes at specified locations, depending on the customer's specifications. It is controlled by a punched tape, obtained from punched cards that are supplied by the customer. Typical encoding turn-around time is said to be 24 hours for the 3300-bit ROMs.

Diode memories made with the SOS technique offer many advantages. These include large density, low power dissipation, organizational flexibility and low cost, in addition to high operating speeds.

Diodes can be arranged in the 3300-bit memories to produce matrices of one to 35-bit words. And since each diode exhibits junction capacitance of only 0.02 pF, large arrays can be assembled without accumulating significant stray capacitance.

Power dissipation is low—only 0.06 mW/diode typical for the 128-by-40-diode arrays.

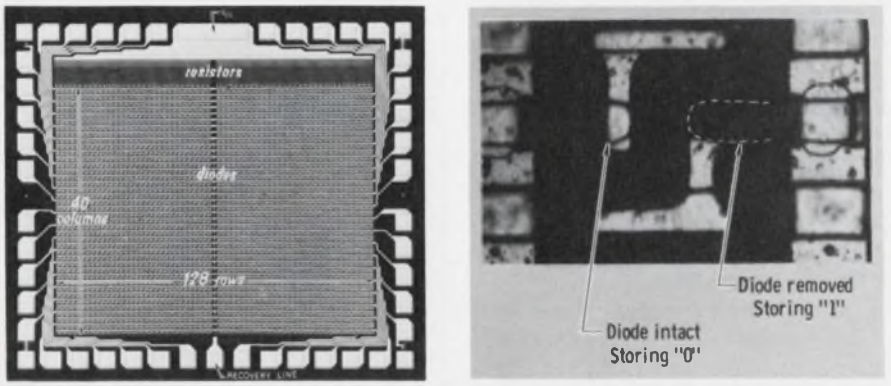
Variations in the number of diode rows and columns are contemplated. At present, up to 400,000 diodes per square inch is the practical limit for laser encoding, according to North American Rockwell.

Densities up to 1,000,000 diodes per square inch are said to be possible when encoding is performed with a custom mask.

And with custom-mask encoding, production quantities of ROMs are expected to be priced in the range of 1/2¢ per bit.

The new 3300-bit ROMs are bipolar, TTL, DTL, ECL and RTL compatible. They operate from +8 and +6-V lines over the temperature range of 0 to +70°C. Storage temperature range is −55 to +150°C.

Packaging is in standard 42-lead flatpacks. CIRCLE NO. 260



Silicon-on-sapphire ROM chip (left) contains an array of 40 by 128 diodes for a density of 3300 bits. Results are depicted of the ROM's custom encoding by a laser tool (right). Left arrow shows an intact diode, for memory state ZERO, while arrow on right shows the diode removed by the laser, for memory state ONE.

Monostable multi uses 50 mW at 50% duty cycle

Texas Instruments, Inc., 13500 N. Central Expressway, Dallas, Tex. Phone: (214) 238-2011. P&A: from $1.54 (100 quantities); 3 wks.

A new low-power TTL monostable multivibrator with retriggerable and clear functions, the SN54L/74L122, dissipates only 55 mW at a 50% duty cycle and a 40-ns propagation delay. Dc triggering is from gated low-level and high-level active inputs.

CIRCLE NO. 261

Dual 100-bit registers dissipate 0.4 mW/bit

Advanced Micro Devices, Inc., 901 Thompson Pl., Sunnyvale, Calif. Phone: (408) 732-2400. Price: $4 (100-unit lots).

A pair of MOS dual 100-bit silicon-gate shift registers, the Am14/1506 and Am14/1507, dissipate 0.4 mW/bit at 1 MHz. Both operate to 2 MHz. The Am14/1506 has an open-drain output while the Am14/1507 is designed with a 20-kΩ pull-up resistor.

CIRCLE NO. 262

High-speed IC dividers dissipate but 600 mW

Plessey Electronics Corp., 170 Finn Court, Farmingdale, N. Y. Phone: (516) 694-7377.

New IC low-power-consumption (600 mW) dividers are available. The SP602 is a 500-MHz divide-by-2 IC. The SP603 and SP604 toggle at 400 MHz and 300 MHz, respectively. The SP601 is a 100-MHz divide-by-4 circuit.

CIRCLE NO. 263

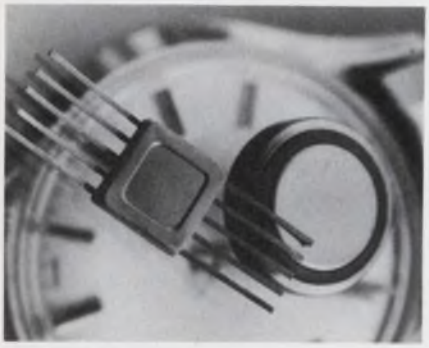
Npn/pnp transistors are monolithic arrays

RCA, Solid State Div., Route 202, Somerville, N. J. Phone: (201) 485-3900. P&A: $1.89, $1.89, $1.69, $1.79, 49¢ (100-unit levels).

A line of 5 high-current transistor arrays, each on a monolithic substrate, is available. Three npn arrays, CA3081, CA3082 and CA3083, are useful for high-current applications. Two arrays, CA3084 (pnp) and CA3086 (npn) are for processing systems.

CIRCLE NO. 264

COS/MOS timing circuit runs on 1.3 to 15 V

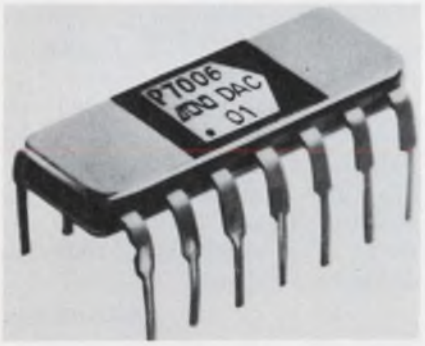


RCA, Solid State Div., Route 202, Somerville, N. J. Phone: (201) 485-3900.

A 23-stage COS/MOS electronic timing circuit that operates from a 1.3-V mercury cell to a 15-V battery is available. Designated TA6030, it is intended for use in watches, clocks and similar timing applications. This universal static frequency divider IC contains two inverter output drivers, three zener diodes for voltage regulation and transient protection and input inverters.

CIRCLE NO. 265

Single-chip 6-bit d/a is priced down to $9.95



Precision Monolithics, Inc., 1500 Space Park Dr., Santa Clara, Calif. Phone: (408) 246-9222. Price: see text.

The monoDAC-01HS 6-bit single-chip d/a converter is priced at only $9.95 each in 2000-piece quantities. It is available in a silicone DIP that contains a voltage reference, ladder network, current sources, switches, and an internally compensated op amp. Operating temperature is 0 to +70°C, power consumption is 250 mW and settling ime is 1 μs.

CIRCLE NO. 266

4-kHz 80-dB op amp works from ±2 V V_{cc}

TRW Semiconductor Div., 14520 Aviation Blvd., Lawndale, Calif. Phone: (213) 679-4561. P&A: $8; stock.

A new IC op amp with a 4-kHz bandwidth and 80-dB gain in TO-99 or 14-pin DIP cases operates from ±2 V_{cc}. The MP112 has adjustable current and satisfactory operating characteristics at a total current drain of 20 μA.

CIRCLE NO. 267

Level shifter pair propagate in 15 ns

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. Phone: (408) 732-5000. P&A: $26, $16.30; stock.

The DH0034/DH0034C are two level shifters in TO-5 and hermetic DIP packages each with typical propagation delays of 15 ns to logic 0 and 35 ns to logic 1. The DH0034 operates from −55 to +125°C and the DH0034C from 0 to +85°C.

CIRCLE NO. 268

MOS 256-bit RAM dissipates 250 mW

Mostek Corp., 1400 Upfield Dr., Carrollton, Tex. Phone: (214) 242-1494. Price: $14 (100 quantities).

A new MOS 256 by 1-bit RAM, the MK4007P, features low power drain of only 250 mW. Its supply voltages are +5 V and −7 to −15 V. Access time is under 1 μs over the temperature range of 0 to +75°C. The RAM is offered in a 16-pin ceramic DIP.

CIRCLE NO. 269

Arithmetic logic unit has carry lookahead

Advanced Micro Devices, Inc., 901 Thompson Pl., Sunnyvale, Calif. Phone: (408) 732-2400. Price: $12 (100-unit quantities).

A four-bit arithmetic logic unit features an internal carry lookahead system. The Am9340 operates over four-bit word lengths at 20 and 25 ns for addition and subtraction, and of 47 ns over 28-bit words.

CIRCLE NO. 270

Line driver/receiver operate from 5-V lines

Qualidyne Corp., 36099 Tahoe Way, Santa Clara, Calif. Phone: (408) 738-0120. Price: $5.50, $4.50 (100-lot-quantities).

A new dual differential line driver/receiver pair, the QC 7820/8820 and QC 7830/8830, operate from 5 V over −55 to +125°C. The driver performs dual four-input NAND and AND functions. The receiver packs two separate units on one chip.

CIRCLE NO. 271

Dual 100-bit register spans 250 Hz to 3 MHz

Intersil, Inc., 10900 N. Tantau Ave., Cupertino, Calif. Phone: (408) 257-5450. Price: $10.

A new dual 100-bit dynamic shift register, the IM7706/7707, operates over a broad spectrum of 250 Hz to 3 MHz at room temperature. It consists of a normally off p-channel MOS monolithic IC.

CIRCLE NO. 272

Arithmetic logic unit adds 4-bit words in 32 ns

Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-3563. P&A: $7.77 (100 to 999 units); stock.

A new TTL/MSI 4-bit arithmetic logic unit offers a worst-case addition for four-bit words in 32 ns. The 9341/54181 has carry lookahead and performs all 16 logic operations on two variables, as well as 16 arithmetic operations.

CIRCLE NO. 273

FET-input IC op amp squeezes bias to 1 pA

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. Phone: (602) 294-1431. P&A: $15; stock.

Model 3503C is a high-performance FET-input IC op amp with bias current of only 1 pA max at 25°C. This hermetically sealed TO-99 op amp is pin-for-pin compatible with type 740 and 741 op amps. Its common-mode input impedance is 10^{13} Ω.

CIRCLE NO. 274

From the same design and manufacturing team who brought you the industry's most respected op amps and converters.

Our new line is the best and most complete – from the low cost 432 (2% accuracy, slewing rate 45v/usec.) to the high performance 422 (3db bandwidth to 5MHz, slewing rate 120v/usec.) The 427 offers accuracy of 0.1% full scale and offset drift of only 0.2mv/°C. Model 530 is the first complete IC multiplier, with 1% accuracy. And there are others.

It can be confusing, especially if you know how many things multipliers can do besides computation. Like rectification, phase-sensitive demodulation, automatic level control, rms power measurement, phase-locked loops.

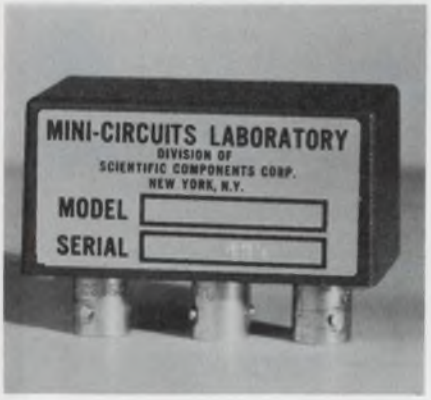
So while we were building our multipliers, we wrote a booklet – a 16-page guide to the theory and applications of multipliers which is extremely helpful, surprisingly impartial, and free. It's called "Evaluating, Selecting, & Using Multiplier Circuit Modules for Signal Manipulation & Function Generation," but just ask for "the multipliers booklet." Analog Devices, Inc., Norwood, Mass. 02062. (617) 329-4700.

ANALOG DEVICES

INFORMATION RETRIEVAL NUMBER 45

Where did all the multipliers come from?

High-performance 1000-MHz balanced mixer costs $29.95



Mini-Circuits Laboratory, Div. of Scientific Components Corp., 2913 Quentin Rd., Brooklyn, N. Y. Phone: (212) 252-5252. P&A: see text; stock to 2 wks.

A new double-balanced mixer for the 0.5 to 1000-MHz frequency range costs only $34.95 (4 to 10 units) and $29.95 (100 units), roughly one-third the price of similar units with the same bandwidth, noise figure, conversion loss and isolation characteristics.

The ZAD-2 mixer performs throughout most of its specified frequency range with a low conversion loss of 5.5 dB. At 1000 MHz, the conversion loss decreases to only 7.0 dB, as shown by the curve below.

Over the lower portion of its frequency range, isolation is typically greater than 45 dB. As the curve below indicates, isolation is approximately 30 dB at 1000 MHz. The ZAD-2 mixer has a typical noise figure of 6.0 dB.

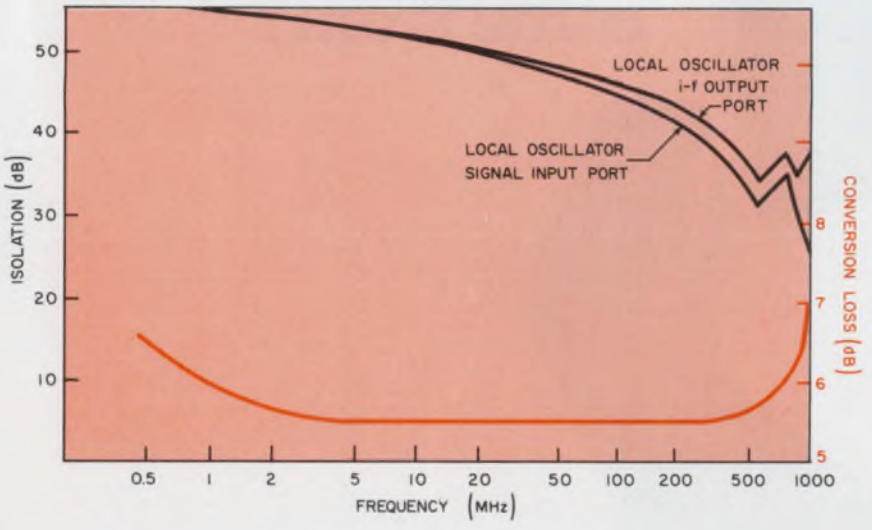
It can accept up to 50 mW of total input power and up to 40 mA of total input peak current. Both operating and storage temperature ranges are −55 to +100°C.

The ZAD-2 is supplied with BNC to TNC connectors as standard items at no extra charge. For an additional $10, 3-mm SMA connectors can be provided.

The new mixer is double shielded in a die cast aluminum case for maximum rfi/emi protection. Overall dimensions are 1.4 by 1.15 by 2.25 in. Each unit is warranteed for one year

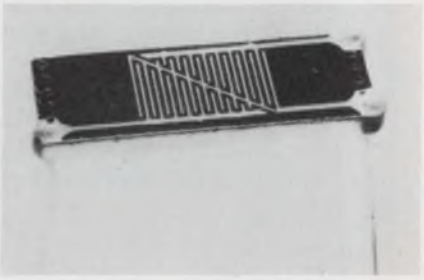
For those users who have a mounting application, a 3.25 by 1.4 by 1.15-in. mounting bracket can be supplied at $1.50. It includes four 0.15-in. dia. mounting holes.

CIRCLE NO. 275



A new 0.5-to-1000-MHz double balanced mixer, costing as low as $29.95, exhibits high-performance characterists. Its conversion loss (bottom curve) is mostly flat at about 5.5 dB throughout most of its frequency range. The top curve shows the mixer's isolation.

CdS/CdSe photocells complement servos



Moririca Electronics, Ltd., 205 Tozuka-machi, Tozuka-ku, Yokohama, Japan. P&A: $1.40; 1 month.

Photobridge sensors are CdS and CdSe photocells that act as displacement elements for servos. They continuously sense displacement direction and magnitude and offer zero change in element-to-element resistance ratio under source level variations. They also offer zero-position recovery error under input voltage variation when a bridge circuit is connected. Spectral ranges are 6000 Å (MB1101) and 7000 Å (MB1151).

CIRCLE NO. 276

Sensor-LED assemblies detect light energy

Optron, Inc., 1201 Tappan Circle, Carrollton, Tex. Phone: (214) 242-6571. P&A: $12; stock.

Two new sensor-LED assemblies —an encoder and mark sense reader—are designed for the detection of interrupted or reflected light. Each contains a GaAs IR source and a silicon phototransistor. The OPB120 is the encoder and the OPB125 the reader.

CIRCLE NO. 277

Low-noise-figure amps span 20 to 1000 MHz

Avantek, Inc., 2981 Copper Rd., Santa Clara, Calif. Phone: (408) 739-6170. P&A: from $15; 30 days.

Three new low-noise-figure and wide-dynamic-range amplifiers are models UA-142, UA-143 and UA-441. They cover 20 to 100, 100 to 500 and 500 to 1000 MHz, at noise figures of 2.0, 2.5 and 3.0 dB, respectively.

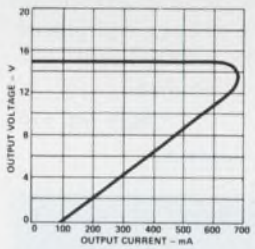
CIRCLE NO. 278

EEP announces...

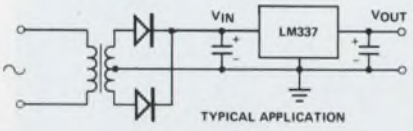
3 NEW VOLTAGE REGULATORS & 35 Linear IC's

LM335: 5V, 600 mA (min.)
LM336: 12V, 500 mA (min.)
LM337: 15V, 450 mA (min.)

- load regulation less than 1%
- overload & short circuit protection
- high temperature stability
- low output impedance
- excellent transient response



LM337 15V OUTPUT VOLTAGE VERSUS OUTPUT CURRENT



TYPICAL APPLICATION

PRICE $	1-24	25-99	100	1000
LM335	3.15	2.90	2.50	2.25
LM336	4.70	4.00	3.60	3.25
LM337	4.90	4.10	3.70	3.35

DELIVERY: from stock

20-page Applications Bulletin furnished with each order.

EEP offers high quality, fast delivery and low prices for these standard linears.

ORDER NO.	1-24	25-99	100-999
LM100	13.50	10.00	8.90
LM101	11.00	8.80	7.25
LM101A	12.40	9.90	8.15
LM102	15.00	12.00	10.00
LM105	20.00	16.00	13.90
LM107	19.00	17.00	14.00
LM108	42.75	34.00	28.50
LM108A	64.00	51.30	42.75
LM110	15.00	12.00	10.00
LM111	18.00	14.40	12.00
LM200	9.00	7.50	6.50
LM201	7.50	6.00	4.95
LM201A	8.00	6.40	5.30
LM202	9.00	7.20	6.00
LM205	14.00	11.00	9.00
LM207	13.00	11.00	9.00
LM208	28.50	22.00	19.00
LM208A	47.50	43.70	38.00
LM210	9.00	7.20	6.00
LM211	11.25	9.00	7.50
LM300	5.40	4.25	3.60
LM301A	2.75	2.20	1.80
LM301AN	2.75	2.20	1.80
LM302	4.50	3.60	3.00
LM305	4.50	3.70	3.00
LM307	5.80	4.60	3.75
LM308	13.25	11.40	9.50
LM308A	26.50	22.80	19.00
LM309	3.15	2.90	2.50
LM309K	3.15	2.90	2.50
LM310	4.85	3.90	3.25
LM311	4.85	3.90	3.25
LM703L	1.00	.85	.70
LM723	5.85	4.65	3.90
LM723C	2.90	2.30	1.90

Write for complete specifications. **FOR IMMEDIATE DELIVERY,** call or send order today to:

EUROPEAN ELECTRONIC PRODUCTS

10150 W. JEFFERSON BLVD., CULVER CITY, CALIFORNIA 90230 (213) 838-1912

INFORMATION RETRIEVAL NUMBER 46

Thrifty data-logging system handles 100 analog inputs

Monitor Labs, Inc., 10451 Roselle St., San Diego, Calif. Phone: (714) 453-6260. P&A: see text; 30 days.

A new low-cost teleprinting data logging system with data entry, programming and control logic starts from a basic $2995 and will scan, digitize and record up to 100 analog inputs. It uses a wide range of optional accessories and plug-in 10-channel scan cards.

The Model 7100 system will increment, accumulate and record digital events, maintain and record time and measure frequency. It will interface, control and record outputs from many other instrumentation.

It can be pre-programmed with its own keyboard and tape punch to offer full random access of input channels, complete control of internal measuring instruments, insertion of time, frequency and digital event data and recording-format control.

With an optional acoustical or hard-wired coupler, the 7100's built-in teleprinter operates as a computer terminal. Data tapes generated by the system can be transmitted to a remote computer.

After analysis and processing, the results can be delivered back to the system for recording on both the printer and the eight-level ASCII-code tape punch.

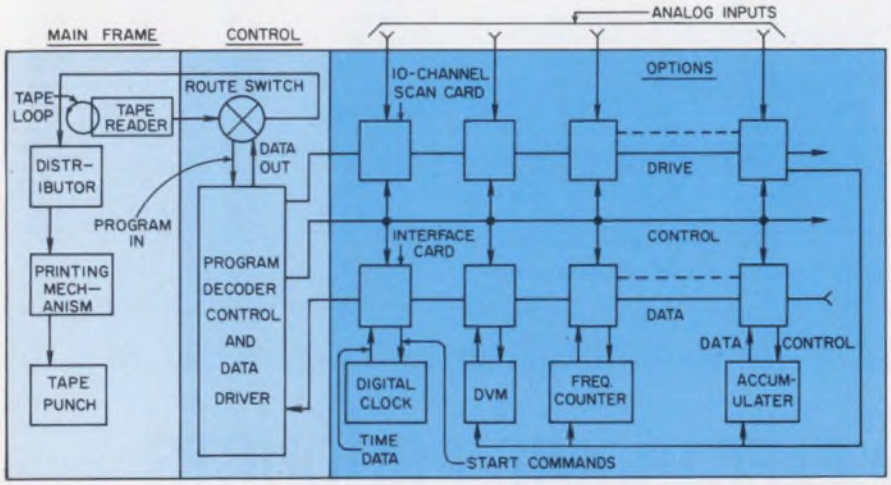
Options include a digital voltmeter, a clock, an event accumulator, a frequency meter, an incremental counter, up to 100 analog channels, up to 26 digital input characters and interfaces with other instruments.

A 20-channel system with clocks and a DVM costs about $3400. A similar 100-channel system costs about $5500.

The new system is ideal for such applications as meterological data acquisition, remote-controlled computer terminals, laboratory data logging, medical data gathering, chemical analysis as well as process and air pollution monitoring.

A 19-in. wide by 3-1/2-in. high by 20-in.-deep overhead equipment console may be ordered with or without options installed.

CIRCLE NO. 279



The 7100 data logger processes 100 analog inputs with optional 10-channel cards. Other options include a clock, DVM, counter and accumulator.

Graphic terminal has 11-in. display

Tektronix, Inc., Box 500, Beaverton, Ore. Phone: (503) 644-0161. P&A: $8800; 3rd quarter, 1971.

The 4002S is an interactive complex graphic and high-density alphanumeric computer terminal with an 11-in. split-screen CRT display. Data can be entered at a keyboard which accommodates all 128 ASCII codes or at a plug-in auxiliary port. The port accepts interactive graphic units utilizing a joystick and other analog input or acquisition devices.

CIRCLE NO. 280

Asynchronous modem transmits at 4 kbits/s

Phonocopy, Inc., Box 1459, Boulder, Colo. Phone: (303) 444-5900.

The PH-4000 ND asynchronous binary modem transmits video over dial-up lines in half-duplex modes at 4000 bits/s. Error rate is 1 part in 10^4 at a signal-to-noise ratio of 20 dB.

CIRCLE NO. 281

Display readout system controls many monitors

Applied Digital Data Systems, Inc., 100 Marcus Blvd., Hauppauge, N. Y. Phone: (516) 231-5400. P&A: from $1340 (no monitor); 60 days.

The MRD-200 memory raster display accepts data from any sequential source, stores it in its memory, and displays it on TV monitors at one or more locations. Additional monitors can be added by coaxial cable connections.

CIRCLE NO. 282

A new exciting concept in RF instrumentation

An RF generator, frequency stabilizer, and counter--all in one

925 SIGNAL GENERATOR

with Signalock™

Signalock is a new, patented technique that *automatically* corrects for frequency drift. When you set the Tune-Lock® switch to the Lock position, the generator's fundamental RF oscillator is locked to the built-in frequency counter's crystal time base. Signalock compares the *actual* frequency output to the *selected* frequency data which has been stored, and produces an error voltage to correct oscillator drift. The result is an unprecedented frequency stability of ±10Hz.

The 925 Signal Generator covers the frequency spectrum from 50 kHz to 80 MHz. It provides leveled calibrated RF power from 0.1 uv to 3 volts. The integral *6-digit* frequency counter, incidentally, can be used to measure external frequencies while the generator is operating.

Contemplating a synthesizer or synchronized RF generator? Take a look at the exciting new Signalock 925 by LogiMetrics. It brings a higher level of sophistication to RF instrumentation while reducing equipment costs.

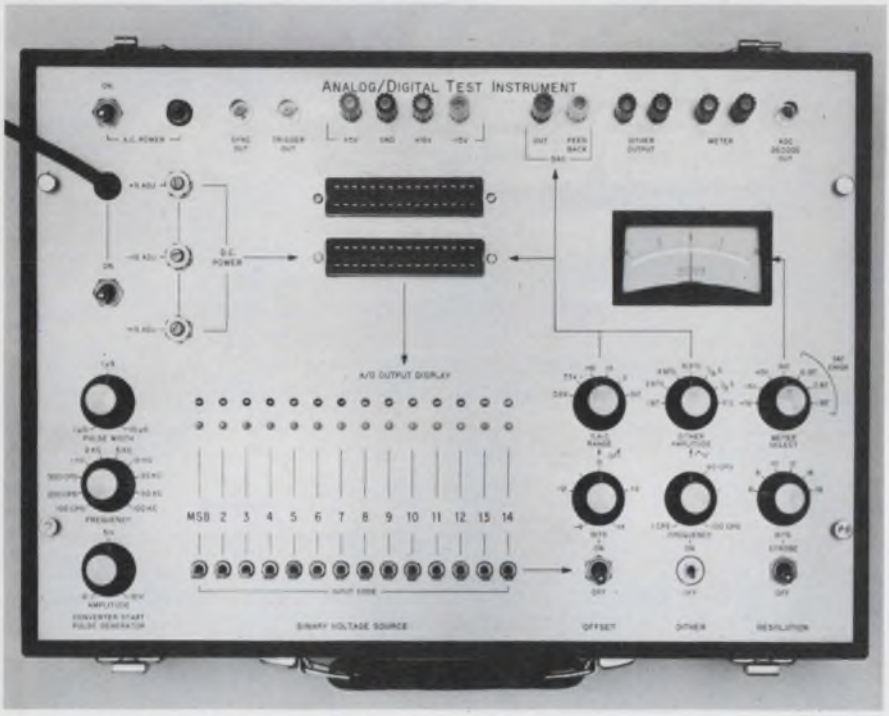
all for $2975

LogiMetrics INC.

A Subsidiary of Slant/Fin Corp. ■ 100 Forest Drive, Greenvale, New York 11548 ■ Phone: (516) 484-2222 Telex 96-1371

INFORMATION RETRIEVAL NUMBER 47

Unique portable instrument tests a/d and d/a converters



Pastoriza Development Laboratory, 369 Elliot St., Newton Upper Falls, Mass. Phone: (617) 527-2340. P&A: under $5000; 6 wks.

Quick, easy and accurate testing of a/d and d/a converters for static and dynamic characteristics is now possible, thanks to a new portable tester developed by the Pastoriza Development Laboratory, Newton Upper Falls, Mass.

The tester is equipped to do both absolute measurements of total error, gain error or offset error, and is also capable of measuring differential linearity and noise.

A converter user can now evaluate both differential and absolute-accuracy conditions to fit his specific application.

Another important tester feature is its display capability. An auxiliary scope can be hooked up to the tester and a two-dimensional plot of a converter's input vs output displayed.

The heart of the tester is a precision 12-bit binary source, with operator input controlled from the front panel by 12 switches.

Two independent power supplies are included to provide converters under test with ±15 and +5 V. These voltages may be monitored with the tester's analog meter.

The tester also contains a 100-kHz pulse generator for a/d convert commands and d/a strobe signals. It may be operated from a manual button. Pulse width and amplitude are each controlled from 0.1 to 10 μs and 0 to 10 V, respectively.

An ac triangular-waveform generator is also included in the tester to scan the a/d input over a small range and provide the two-dimensional input-vs-output display on a scope.

All digital numbers—a/d outputs and d/a inputs—are displayed on a group of 16 front-panel light-emitting diodes.

A resolution switch is provided for setting the resolution of the converter under test from 6 to 12 bits. All other settings and readings are then normalized to the least-significant bit.

CIRCLE NO. 283

Three-digit DVM fits in the pocket

Kruger & Eckels, Box 681, Pasadena, Calif. Price: $750.

Just turn on the switch, attach the ground wire and probe, and the new model 20 pocket DVM is ready to measure and display 1 mV to 999 V with correct polarity and range. Twice each second the incoming signal is checked for polarity and range. Data is displayed with an automatically placed decimal to three significant figures. This new auto-ranging DVM has 0.1% accuracy and four ranges. It runs on a battery for 8 h.

CIRCLE NO. 284

High-accuracy DMM claims a $595 price

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 493-1501. P&A: see text; June, 1971.

A new high-accuracy (from ±0.25 for ac and ±0.1% for dc) digital multimeter features a $595 price. Model 3469A makes average ac measurements from 1 mV to 500 V full scale over 20 Hz to 10 MHz, resistance measurements from 1 Ω to 10 MΩ full scale, dc measurements from 100 mV to 1000 V full scale, and dc current from 1 μA to 100 mA full scale.

CIRCLE NO. 285

Simpson® has the world's largest selection of PANEL METERS and METER RELAYS

with famous Simpson STAY-ACCURATE QUALITY

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STACKABLE EDGEWISE
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***NEW* 3½" STACKABLE EDGEWISE METER**

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***NEW* 3½" EDGEWISE CONTROLLER**
Many features.
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AGM DIVISION

MANUFACTURERS OF THE WORLD FAMOUS SIMPSON 260®

3-1/2-digit multimeter measures true rms

Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio. Phone: (216) 541-8060. Price: $845.

The model 3310 3-1/2-digit multimeter measures true-rms ac voltages and currents with a computing converter. It measures 100 μV to 1 kV ac (to 50 kHz) and dc, ac and dc currents from 100 nA to 1.999 A and resistance from 100 mΩ to 199.9 MΩ. It also measures decibels from −45 to +65 dBm.

CIRCLE NO. 286

3 and 4-digit DPMs are truly economical

Datascan, Inc., 1111 Paulison Ave., Clifton, N. J. Phone: (201) 472-2800. Price: see text.

Two new DPMs, the 3-digit 420 and 4-digit 740, retail at economical prices. The 420 costs $109 (1000 units), $114 (100 units) and $124 (single units). It is 0.2% accurate and resolves 100 μV. The 740 costs $250 (100 units) and $300 (single units). It is 0.05% accurate.

CIRCLE NO. 287

Low-cost RC oscillator spans 18 Hz to 200 kHz

Kikusui Electronics Corp., 200 Park Ave., New York, N. Y. Phone: (212) 973-7152. P&A: $85; stock.

The model ORC-27A RC oscillator, combined with a Wien bridge network, features coverage from 18 Hz to 200 kHz in 4 ranges with a calibration accuracy ±2% +1 Hz. It has 5-V-rms sine, 10-V-pk-pk square and 10-V-pk-pk complex waves.

CIRCLE NO. 288

5-1/2-digit multimeter resolves to 10 μV dc

Precision Standards Corp., 1701 Reynolds, Santa Ana, Calif. Phone: (714) 546-0431. Price: $995.

Model DM55 5-1/2-digit DMM has four separate dc and ac-voltage ranges with dc accuracy of 0.005% and 10-μV resolution. Ac accuracy is 0.1% with 10-μV resolution. Five resistance ranges are available, each with 0.02% accuracy Resolution is 0.01 Ω. Overranging of 100% may be obtained in each range. Out of range indication is provided for all functions and ranges.

CIRCLE NO. 289

Ac 3-1/2-digit DPM has 100-kHz response

Digilin, Inc., 1007 Air Way, Glendale, Calif. Phone: (213) 240-1200. Price: $199.

A new ac voltage and current DPM with 3-1/2 digits features an average responding ac converter and a three-pole active filter for fast response from 40 Hz to 100 kHz. Designated type 2330, it provides input resistance of 22 MΩ at 30 pF. Accuracy is 0.2%.

CIRCLE NO. 290

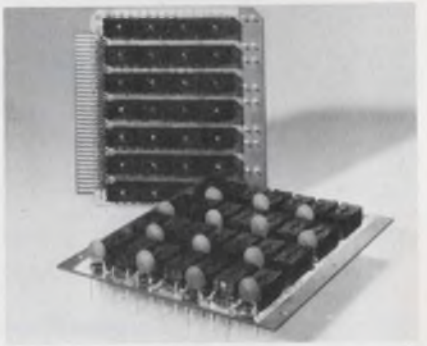
Tri-waveform generator costs only $295

Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge, Mass. Phone: (617) 491-3211. P&A: see text; stock.

A new low-cost function generator, which provides sine, square and triangular waveforms over a frequency range of 0.2 Hz to 3 MHz, costs only $295. Designated model 5000, its max output for all functions is 20 V pk-pk.

CIRCLE NO. 291

Multi-shaped PC boards fit any requirement

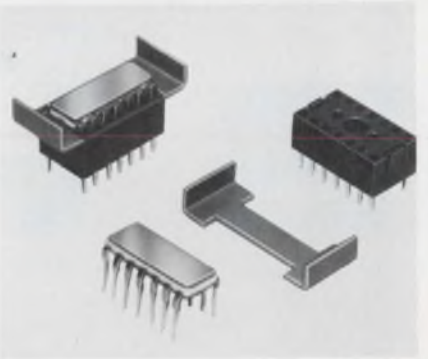


Scanbe Manufacturing Corp., 3445 Fletcher Ave., El Monte, Calif. Phone: (213) 579-2300.

New PC boards are available in any shape, size or configuration depending on requirements. V_{cc} and ground planes are plated on opposite sides of the boards with optional or committed V_{cc}/ground pins. Any number of pins may be provided to mount discretes or decoupling capacitors. I/O systems of any type can be provided, such as edge-board connectors and pins.

CIRCLE NO. 292

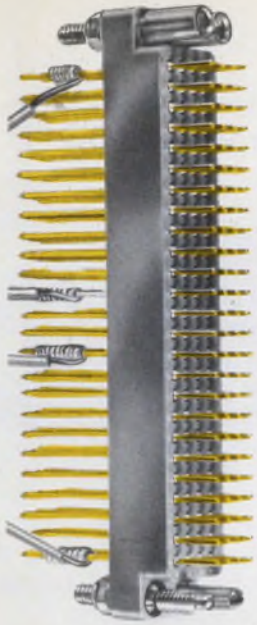
DIP heat sinks fit 14 to 42-pin units

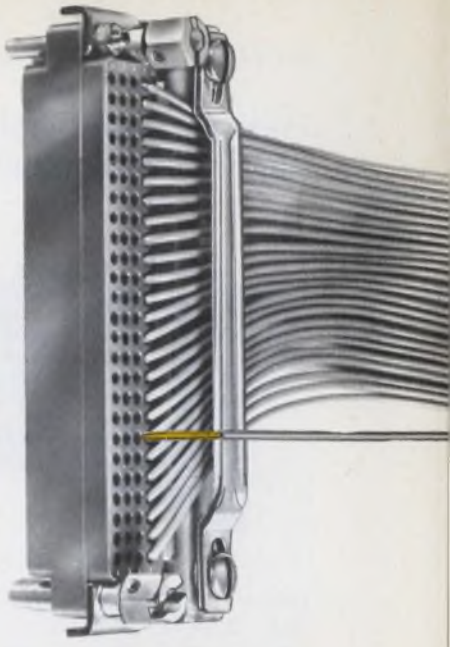


Astrodyne, Inc., 353 Middlesex Ave., Wilmington, Mass. Phone: (617) 272-3850.

A new series of low-cost heat sinks is designed for use with 14 to 42-pin DIP ICs. The 2906 series heat sinks are held between the DIP and its socket by the DIP's pins. Three small projections on the underside of the heat sink insure an optimal fit and heat transfer. Temperature rise is limited to 40°C at 0.3 W and to 50°C at 0.8 W with natural convection.

CIRCLE NO. 293





up tight

OVER INTERFACING BACK PLANE
SOLID WIRE AND STRANDED CABLE

Let U.S.C. proven High Density Wire-Wrap*/ crimp connector GR-RGR series bring you fast, fast relief.

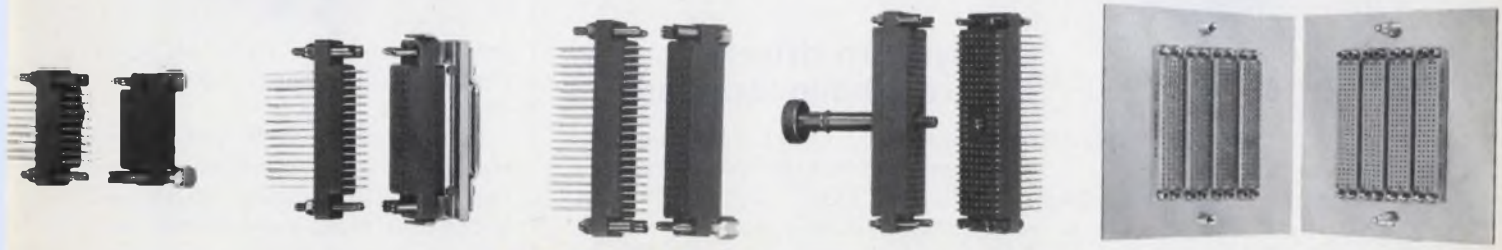
The new growing family of GR-RGR series now offers you 20-40-60-80-100-150‡ contact versions and modular connector versions of 200-300-400-800 contacts.

The GR-( )MISL-WW male offers wire-wrap contacts with .025 square tails on .100 grid pattern designed for automatic wire-wrapping. (100 contact version illustrated above.)

The mating RGR-( )FIK female offers crimp type, rear removable contacts for #22, #24 or #26 wires, and is available with hoods and cable clamps.

The features in these connectors are covered by U.S. and foreign patents.

‡*Center screwlock version*



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U.S. COMPONENTS INC.

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Be Sure To Visit Us In Booth 4616, NEPCON '71, East, N.Y. Coliseum, June 15-17.

INFORMATION RETRIEVAL NUMBER 49

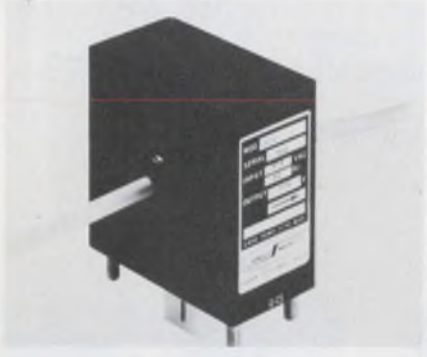
Hexadecimal display has 9 bar segments

Industrial Electronic Engineers, Inc., 7720-40 Lemona Ave., Van Nuys, Calif. Phone: (213) 787-0311. P&A: see text; 4 wks.

A new nine-bar-segment hexadecimal display is the series 1020 which uses two lamps for displaying 0 through 9 and A through F. This low-priced display (only $3.10/unit) features single-plane viewing from 15 ft, 1 to 6 optional caption messages, a choice of 5 screen colors, minimum behind-the-panel depth and no mounting hardware.

CIRCLE NO. 294

Current limiter module slips over cables



Arnold Magnetics Corp., 11264 Playa Court, Culver City, Calif. Phone: (213) 870-7014. Availability: stock to 3 wks.

A new current limiter designated RAL, limits ac current in a cable, when the cable is passed through a hole provided in the limiter's body. The model RAL is small in size—only 3 by 3 by 1.56 in.—and noise free. It can be used with 100 to 140 V rms at 60 Hz and can control currents up to 8 A.

CIRCLE NO. 295

Displays and counters have 2, 3 or 4 digits

Computer Products, Inc., 1400 Gateway Dr., Fort Lauderdale, Fla. Phone: (305) 933-5561. P&A: from $75 (2 digits); 15 to 30 days.

The DCD600 series decimal counting and display units are available in 6 basic models: 2, 3 or 4-decimal digits and with or without the decimal decade counters. The models with the decade counters accept serial count input pulses, and the models without the counter accept 8-4-2-1 BCD input data.

CIRCLE NO. 296

Tiny timing modules are priced under $30

Gould Ionics, Inc., Box 1377, Canoga Park, Calif. Phone: (213) 341-1040. P&A: see text.

Economy and simplicity are featured in the B series ESD timing modules with unit prices under $30 in 1000 quantities as well as ±0.5% repeatability. Sizes are one cubic inch each. The modules span a timing range from 5 s up to 2.5 million s.

CIRCLE NO. 297

Synchro drivers are 10-min. accurate

Computer Conversions Corp., 6 Dunton Court, E. Northport, N. Y. Phone: (516) 261-3300. P&A: $295; stock to 4 wks.

A new series of repairable synchro drivers feature ±10-min accuracy and output over-current and short-circuit protection. The DCS-401/drivers convert any two dc inputs from −10 to +10 V into three-wire synchro outputs.

CIRCLE NO. 298

Digital temp indicator is accurate to ±0.2°F

Howell Instruments, Inc., 3479 W. Vickery Blvd., Fort Worth, Tex. Phone: (817) 336-7411. Availability: stock to 6 wks.

A new low-cost digital indicator for panel mounting, designed to measure temperature and many other parameters, offers standard accuracy of ±2°F for most thermocouple types. The H600 has a digitally controlled linearization network with 0.002%/°C change in ambient temperature. Its high noise rejection eliminates the need for a guard wire.

CIRCLE NO. 299

Lab supply regulates current and voltage

Scintillonics, Inc., Box 701, Fort Collins, Colo. Phone: (303) 482-4752. Price: $165.

The VC series 20-W power supply features two precision voltage and current-regulating modes selected by a front-panel switch. Adjustable current limiting and overvoltage protection are standard features. Four models range from 0 to 15 and 0 to 120 V dc. Line and load regulation is 0.035% and ripple and noise is 1 mV rms/0.3 mA rms.

CIRCLE NO. 300

Ac line-voltage sensors respond in only 1 ms

California Electronic Mfg., Inc., Box 555, Alamo, Calif. Phone: (415) 932-3911. P/A: $48; 2 wks.

Better than 1-ms response is the capability of the new models 825 and 826 Linesensor ac over and under-voltage units, respectively. They sense preset values within 80 to 115 V ac (826) and 115 to 150 V ac (825), 50 to 60 Hz.

CIRCLE NO. 301

24-V-dc regulator supplies 200 V dc

General Dynamics, Electro Dynamic Div., Box 2566, Orlando, Fla. Phone: (305) 323-1260.

The PWR-101 is a dc-to-dc converter that accepts a 24-V dc input and provides a 200-V dc output at 30 mA for use with neon-type indicators. It is designed for applications where a high voltage and a small current are required.

CIRCLE NO. 302

15-bit integrating a/d resolves 5 μV/bit

Multitech Automation Products, 583 Monterey Pass Rd., Monterey Park, Calif. Phone: (213) 282-3161.

Model 316 integrating a/d converter is a 15-bit bipolar, fully guarded unit with 5-μV/bit resolution and 1000-V input isolation. Its CMRR from dc to 1 kHz is 140 dB and normal mode rejection of line frequency noise is infinite.

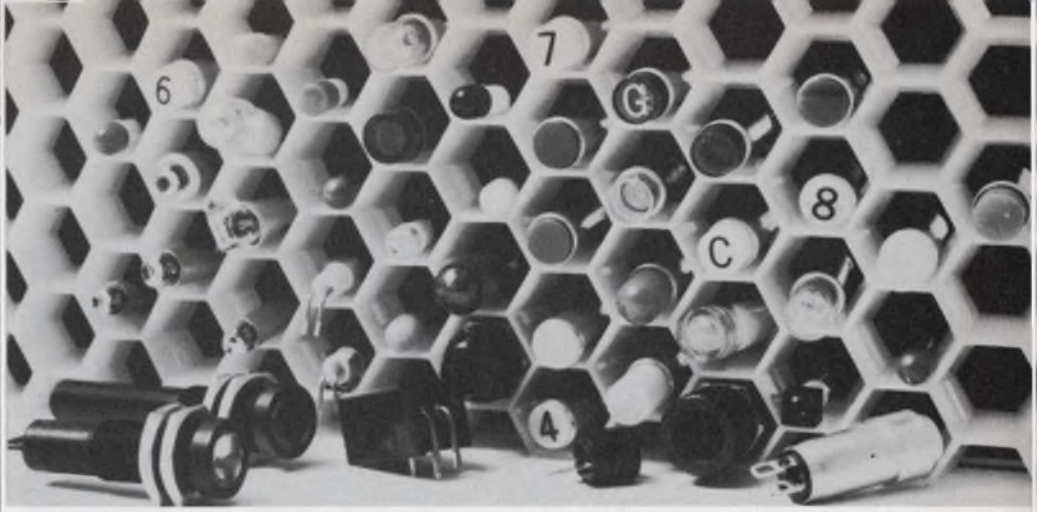
CIRCLE NO. 303

Synchro converter is remotely controlled

North Altantic Industries, Inc., Terminal Dr., Plainview, N. Y. Phone: (516) 681-8600. P&A: from $20,000; 8 to 12 wks.

The model BB-54 resolver/synchro-to-digital converter operates completely under remote computer control, with digital inputs that specify whether it should handle resolver or synchro forms of input data.

CIRCLE NO. 304



3 DAY SHIPMENT

What's your experience with INCANDESCENT CARTRIDGE INDICATORS? High cost and late delivery is the usual answer!

If you're looking for a reliable source, call off the hunt cause we've got a hive full. CHICAGO MINIATURE'S Incandescent Cartridge Indicators are the HIGHEST QUALITY products available anywhere and they feature the LOWEST COST and BEST DELIVERY in the industry. Couple this with complete mechanical and electrical interchangeability with "competion" and you have almost the full story.

In addition, our Incandescent Cartridge Indicators are offered in 4 cap styles, 2 cap materials, 7 colors (transparent or translucent). They're available in a wide range of voltages and you'll get a few extras, like long life, pin polarization and hot stamp legends (upon request).

Remember, the butyrate caps are color matched to industry standards and we will SHIP WITHIN 3 DAYS of receipt of order on quantities up to 500, on T-1¾ Incandescent Cartridges.

For application assistance contact your Chicago Miniature Sales Representative. For local procurement, contact your nearby Authorized Chicago Miniature Distributor.

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4433 N. Ravenswood Ave.,
Chicago, Illinois 60640
(312) 784-1020

a GENERAL INSTRUMENT company

THE LIGHTING BUGS

INFORMATION RETRIEVAL NUMBER 50

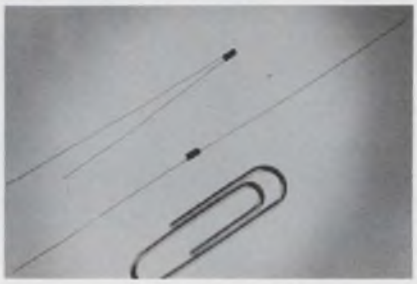
Tiny indicator glows in 3 different colors

Chicago Miniature Lamp Works, 4433 N. Ravenswood Ave., Chicago, Ill. Phone: (312) 644-2255.

A new lighted indicator lamp offers three different colors in variable sequence. The CM 41 series Tri-A-Lite appears white in the off position and takes on color only when an input voltage is applied to one of its number-coded contacts. Color sequence is variable with positioning of the mounting pin configuration, and can be predetermined by the user.

CIRCLE NO. 340

Tantalum capacitors are truly miniature

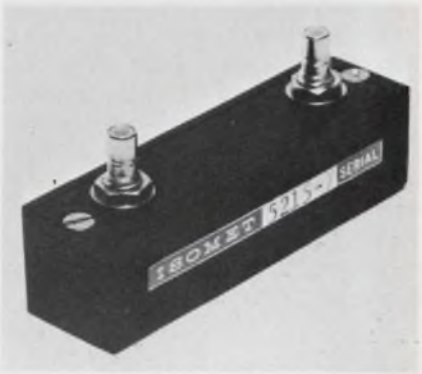


Dickson Electronics Corp., 8700 E. Thomas Rd., Scottsdale, Ariz. Phone: (602) 947-2231. Price: see text.

A new series of ultraminiature solid tantalum capacitors are available in case sizes of 0.05 by 0.04 by 0.1 in: with capacitance values of 0.0047 μF at 20 V through 0.47 μF at 2 V. Designated the ZZ series, the new mylar-case capacitors are available with axial or plug-in radial leads. Tolerances are 5%, 10% and 20%. Unit prices are as low as 50¢ for 1000-piece quantities.

CIRCLE NO. 341

Digital glass delay line operates at 100 MHz



Isomet, 103 Bauer Drive, Oakland, N. J. Phone: (201) 337-3811. Price: 5¢/bit (1000-unit lots).

The model 1024 glass delay line with 10.24 μs delay operates at 100 MHz. Insertion loss is typically 20 dB and spurious response is better than 20 dB. Bit frequency is 100 megabits/s, source and termination impedances are 50 Ω and storage capacity is 1024 bits. The delay line is very compact measuring only 2-1/8 by 5/8 by 5/8 in.

CIRCLE NO. 342

New Solid State Switch

Ageless
Responsive
Rugged

Multiply switch life with the new 5 AMP Solid State Switch from Grayhill.

Absence of moving parts, contactless operation assures infinite switch life with proper use. Provides immediate response to a low current control signal.

Close any pair of external contacts to actuate the low power control circuit —and remotely locate the solid state switch at the load to save costs, reduce weight and simplify circuitry.

Completely sealed in a compact, self-contained unit. Equipped with integral heat sink. Shrugs off high shock, corrosion, moisture. Resistant to 20 G's vibration in a range of 10 to 2000 Hz. Dielectric strength: 1500 VAC, device to ground (case) AC or DC.

Like to know more? Write, or phone for literature on the Grayhill Solid State Switch Series and for our latest general engineering catalog: Grayhill, Inc., 565 Hillgrove Ave., La Grange, Ill. 60525 (312) 354-1040.

Grayhill
pioneers in miniaturization

INFORMATION RETRIEVAL NUMBER 51

HAVE YOU TRIED MAXI?

Maxi-Switch keyboards solve problems.

Strong, No-Flex Construction • Permanent Button Alignment • Inexpensive Double-Shot Buttons • Crisp, Consistent Glass Reed Switching • Available In Keystrips Or Completed Keyboards USASCII, EBCDIC Or Special Encoding • Optional Bi-Level Reed Switching

Give Maxi-Switch a try.
Write for free literature.

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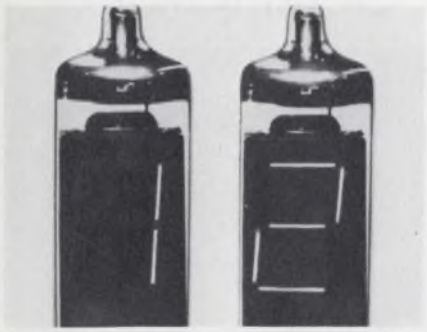
See Maxi in EEM for 1971

INFORMATION RETRIEVAL NUMBER 52

12-V 7-segment tubes cost down to $3.90



Apollo Corp., 5-1, Togoshi 6-Chome Shinagawa-Ku, Tokyo, Japan. P&A: see text; 45 days.

DA-600 incandescent seven-segment readout tubes operate over 10 to 12 V dc and cost down to $3.90 (1000-piece lots). They are suited for motor-vehicle, marine and other installations that operate from any 12-V storage battery system. Two types are available: pin type (compatible with 10-pin TO-5 IC sockets), and lead type (for PC board mounting). Brightness of 10,000 foot-lamberts is adjustable.

CIRCLE NO. 343

3pst guarded relay has only 1 μV offset

Multitech Automation Products, 583 Monterey Pass Rd., Monterey Park, Calif. Phone: (213) 282-3161.

A miniature 3pst low-thermal offset relay is the model 180 for microvolt-level switching, with a thermal offset voltage of 1 μV. It is fully guarded and has less than 0.01 pF of capacitance between contact and coil.

CIRCLE NO. 344

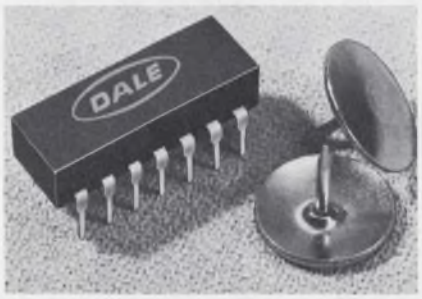
Mercury switches ease keyboard building

Mechanical Enterprises, Inc., 5249 Duke St., Alexandria, Va. Phone: (703) 751-3030. P&A: from $1.75; stock.

New MC-210 keyboard switches are available as individual units for customers who want to build their own keyboards. The new switches employ a mercury switching element that provides a no-bounce output compatible with solid-state or IC logic circuitry.

CIRCLE NO. 345

Pulse transformers come in 14/16-pin DIPs



Dale Electronics, Inc., Box 609, Columbus, Neb. Phone: (402) 564-3131.

New pulse transformers are available in 14-pin (PT-14) and 16-pin (PT-16) models. Both new models are available with an inductance range of 1 μh to 2 mh. Temperature stability of ±10% and tolerance of ±20% are available over an operating temperature range of −55 to +125°C. Other specifications include leakage inductance as low as 0.2% of primary inductance, interwinding capacitance as low as 3 pF and an ET product up to 10 V-μs.

CIRCLE NO. 346

TO-55 hybrid relay houses control circuits

General Electric Co., Data Communication Products Dept., Waynesboro, Va. Phone: (703) 942-8161.

A new hybrid transistor-size crystal-can relay is available with all its control circuitry inside a hermetically sealed TO-55 can. The circuitry includes a transistor driver and a transient suppressor diode.

CIRCLE NO. 347

PC board slide switch takes up little space

Siemens Corp., 186 Wood Ave. S., Iselin, N. J. Phone: (201) 494-1000. P&A: $2 (250-piece lots); stock.

A new miniature 10-position programming rotary slide switch for PC boards includes non-shorting contacts and covers less than 0.35 in.² of area. Changing programs can be done by the twist of a small screwdriver.

CIRCLE NO. 348

Now the famous 829 has a "G" for good measure!

Calibrate or Measure with the

RFL Model 829G

RFL's famous 829, for 15 years the industry calibration standard, now gives way to the new 829G — still the industry calibration standard, but now it's twice as useful. The 829G provides a precision source of AC and DC volts, amps and ohms — plus precision measurements of these parameters from external sources. It offers four-terminal sensing in both source and measurement modes, and high accuracy, resolution and regulation, with 5-digit readout. 5 ranges of AC or DC, 0.1 to 1000V. 6 ranges of current, 100 uA to 10A. 50, 60, 400, 1000 Hz AC plus EXT. And many other features — all for just $3,350. ☐ Write for complete data today. RFL Industries, Inc., Instrumentation Div., Boonton, New Jersey 07005. Tel: (201) 334-3100 / TWX: 710-987-8352 / CABLE RADAIRCO, N. J.

RFL Industries, Inc.

INFORMATION RETRIEVAL NUMBER 53

Our double balanced **mixers** *go flat*

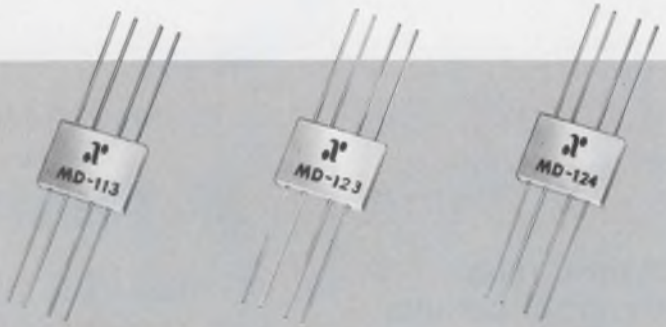
MD-125
0.5 to 500 MHz

WIDE DYNAMIC RANGE

HIGH ISOLATION

LOW CONVERSION LOSS

LOW COST — from $29



MD-113
10 to 1000 MHz

MD-123
10 to 3000 MHz

MD-124
DC to 200 MHz

Small causes for excitement are these subminiature double-balanced, nickel-plated mixers in ANZAC's Flat-Pack housings for strip-line and dual-in-line mounting. Rugged, RFI shielded and hermetically sealed, they are designed to withstand severe environmental conditions and are competitively priced.

These mixers may be used as a frequency converter, phase detector, double side-band suppressed carrier modulator, pulse modulator, frequency doubler or a voltage/current variable attenuator.

For complete engineering specifications, prices and delivery from stock, call your Anzac Representative or Art LeMay at (617) 899-1900.

MAC-50 DOUBLE-BALANCED MIXER
0.2 — 200 MHz

MLF-3 DOUBLE-BALANCED MIXER
0.2 — 200 MHz
7.5 db conv. loss

HFK-472 DOUBLE-BALANCED MIXER
5 — 2200 MHz

MHF-3 DOUBLE-BALANCED MIXER
5 — 500 MHz

ASM-10 DOUBLE-BALANCED MIXER
0.2 — 600 MHz

anzac ELECTRONICS
Division of Adams-Russell

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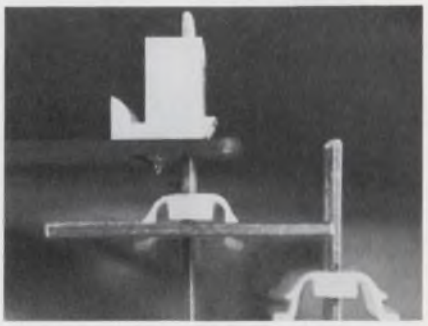
INFORMATION RETRIEVAL NUMBER 54

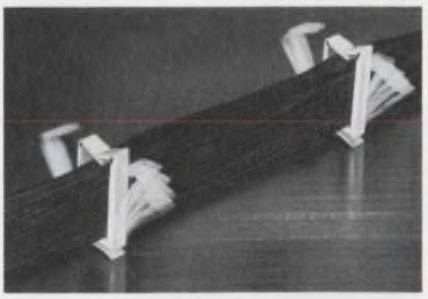
evaluation samples



Multi-circuit wafers

A chassis-mounted wafer assembly that handles 2 to 18 circuits with wire-wrap terminals is the latest of the new PC Conectcon connectors made by Molex Inc. The wafer connection enables the product manufacturer to have an integrally mounted system for panel feed through the chassis to a PC board that may be either perpendicular or parallel. Terminals mate with a plug-in Conectcon female, connect with the PC board, and extend through it for wire wrapping termination. The wafer snap-locks without mounting hardware in a panel 1/16-in. thick. Free samples are available. Molex, Inc.

CIRCLE NO. 349



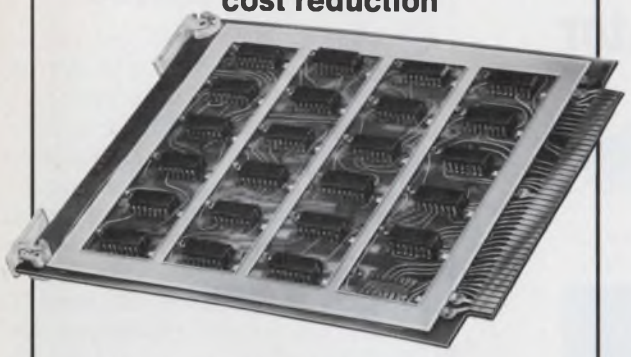
Locking wire fasteners

Samples of a new line of locking saddle fasteners that hold wire and cable loads in position on electrical and electronic equipment are available. The new saddles are easily inserted by hand without tools. Pointed flanged tips compress to snap firmly into a 0.187-in.-dia. hole where the saddle is braced permanently in position by an arched clip base. Each locking saddle is reusable and may be reloaded if wires are removed for service or equipment is rewired. Richlok Corp.

CIRCLE NO. 350

Mini/Bus by Rogers

For noise and cost reduction



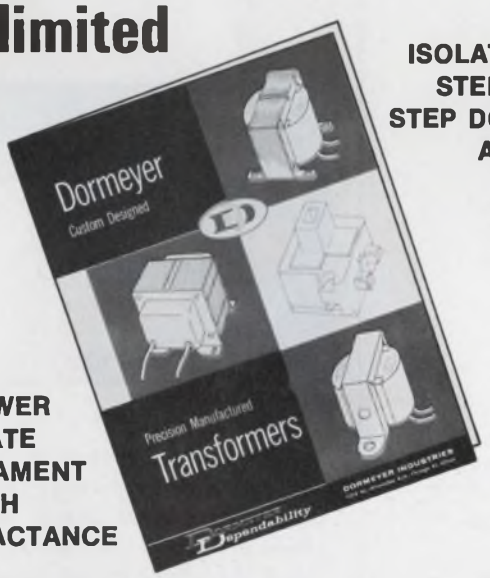
A small, voltage-distributing busbar for PC card application, each Mini/Bus gives you built-in capacitance . . . noise-cutting capacitance that means more reliable, compact circuit packaging at a fraction of multilayer prices. Write for data.

Rogers Corporation / Rogers, Conn. 06263

INFORMATION RETRIEVAL NUMBER 55

Transformers Unlimited

ISOLATION
STEP UP
STEP DOWN
AUTO



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INFORMATION RETRIEVAL NUMBER 56

DECODING
FLUID FLOW
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100 and **New 400 Point,** Real Time

CORRELATION & PROBABILITY ANALYZERS

Your application problem goes in . . . the answer comes out. That's just about how quickly our real time 100 and 400 point Correlation and Probability Analyzers work.

These all digital, high speed processing instruments provide Correlation (auto and cross), Signal Enhancement, and Probability (density and distribution).

■ 100 and 400 point models ■ Unique word position allows wide dynamic range (18 bits) ■ Digital bin readout for accurate time and amplitude measurements ■ "Clip" mode capability allows rapid analysis of low level signals ■ Digital Averaging—Linear, Integrate & Dump and Digital Exponential modes ■ Built-in precomputation delay ■ High resolution 400 point model for accurate cross power measurements with SAICOR Spectrum Analyzer (400 point correlation function required for 200 line spectrum analysis)

Write for 20-page Bulletin TB-14 "Correlation and Probability Analysis."

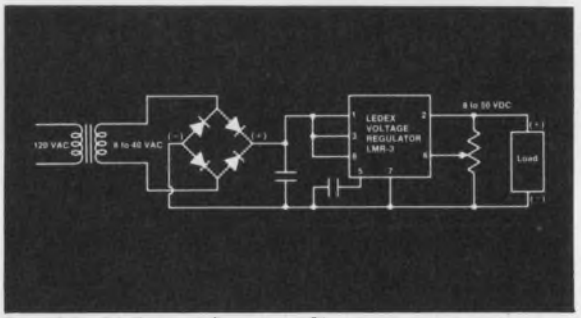
SAICOR

SIGNAL ANALYSIS INDUSTRIES CORP.
595 Old Willets Path, Hauppauge
New York 11787 ■ (516) 234-5700

INFORMATION RETRIEVAL NUMBER 57

Another new Ledex thick-film circuit 100 watt voltage regulator

LMR-3 VOLTAGE REGULATOR
now available from the shelf.



Typical Application and Connection Diagram

Typical Specifications (T_A = 25°C)

Parameter	Typ.	Max.
Input voltage	—	60V
Output voltage	8 to 50V	
Load current	1 Amp	2 Amp
Line regulation basic mode	0.3%	1.0%
Load regulation basic mode	0.5%	1.0%
Power dissipation	10 Watts	25 Watts

This thick-film voltage regulator consists of a series regulator and elements capable of regulating 8 to 50 volt DC power supplies, up to 100 watts. It will regulate your voltage supply to within less than 1% tolerance.

The LMR-3 is packaged in a low profile TO-3, .250" maximum. It can also be used as a driver for higher current regulators.

Fast Custom Design

We're equipped to give you fast design and prototype service on any custom hybrid microelectronics package. Our engineers will come to you, if that's what you need.

You'll find our delivery dependable and our production standards among the highest in the industry.

The circuit described above is now stocked. Ask for catalog sheet. Or, for the whole story on our capability, write for brochure, "Custom Hybrid Microcircuits."

Specialists in hybrid microelectronic circuits

LEDEX

LEDEX INC.

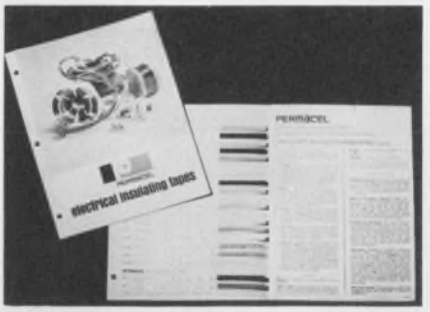
123 Webster Street, Dayton, Ohio 45401, phone (513) 224-9891

INFORMATION RETRIEVAL NUMBER 58

design aids

IEEE symbols standard

Want to know what the correct graphic symbol is for a phototransistor? Or how about a self-interrupting flasher switch or a chopper? The answers are in the latest copy of "IEEE and American National Standard Graphic Symbols for Electrical and Electronic Diagrams." This 88-page document is a valuable handbook to have. It clears up misunderstandings and confusions as to what specific symbols designate and what symbols one should use for indicating any device in electrical and electronic circuits. The book is divided into 23 sections, from "Acoustic devices" to "Windings," listed on a contents page for easy reference. It is available from the Institute of Electrical and Electronic Engineers, 345 E. 47th St., New York, N. Y., 10017, at a single-copy price of $11.50.



Insulating tapes

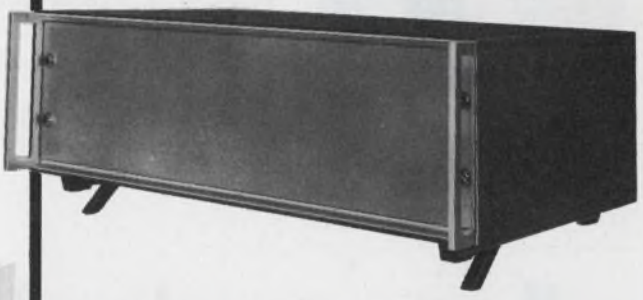
A fold-out card that shows a full range of electrical insulating tapes is available. This handy reference guide gives the description, composition and benefits of paper, film, vinyl, cloth, laminated and TFE electrical tapes. Next to each product listing is an actual swatch of that particular tape. In addition, the card has a reference chart on specialty electrical tape products and one on military specifications of pressure-sensitive electrical tapes. Permacel.

CIRCLE NO. 351

COMPLETE PACKAGING CAPABILITY

DELIVERY FROM STOCK

D SERIES VEROCASE



NEW modern, low profile instrument cases in ALL STANDARD PANEL HEIGHTS from 1¾" to 10½". Cases are 12½" deep and only ¾" higher than standard panels. They feature removable louvered bottom and rear panels, tilt-up feet and have a textured vinyl finish. All models are available FROM STOCK with or without handles.

vero **VERO ELECTRONICS INC.** TWX510-227-8890
171 BRIDGE ROAD, HAUPPAUGE, N. Y. 11787 TEL: 516-234-0400
CANADIAN AGENT: CHAPMAN ELECTRONICS AGENCY, P.O. 481, KINGSTON, ONTARIO • TEL: (613) 389-1025

INFORMATION RETRIEVAL NUMBER 59

"Celco superfast" DYNA YOKE

When CELCO talks about "superfast" recovery times, we mean 5 μsec to 0.1%.

We mean 4 μsec when you need it. And three . . . if your display designs call for it.

Or, you can plan your precision CRT display around 2 μsec recovery time to 0.1%.

We're even talking about 1 microsecond recovery time. To 0.1%. Now that's *really* a "superfastDYNAYOKE". But you'll be hearing a lot more about that soon enough!

Tremendous amounts of data in very short times can now be produced on the CRT face of wide-band magnetic deflection high resolution CRTs. With CELCO "superfastDYNAYOKES".

If you have designs like these on a 66° CRT with 1-7/16" neck, CELCO has a "superfastDYNAYOKE" to fit it for a *superfast* display.

2μs Recovery Time To 0.1%

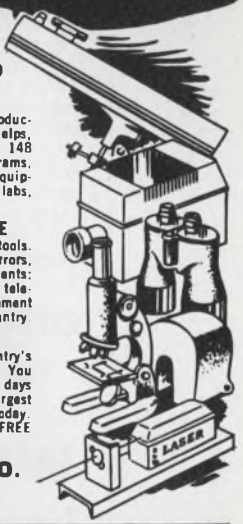
Celco CONSTANTINE ENGINEERING LABORATORIES COMPANY

INFORMATION RETRIEVAL NUMBER 60

FREE CATALOG!

148 PAGES • MORE THAN 4000 UNUSUAL BARGAINS
SCIENCE • OPTICS • SPACE

1000's OF HARD-TO-FIND BUYS FOR INDUSTRY.



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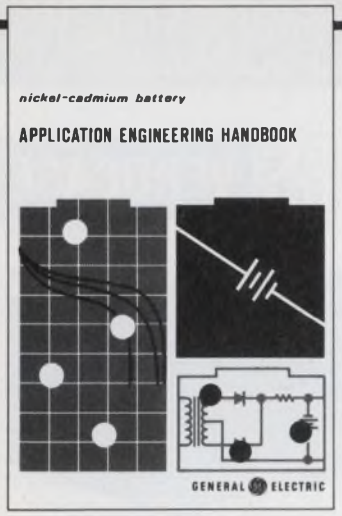

Here's a new, comprehensive manual of interest to all designers—200 pages of application information.
To find out how you can order this unique engineering handbook, circle the number below on the reader service card. Or write—General Electric Company, P. O. Box 114, Gainesville, Florida 32601.

GENERAL ELECTRIC

all you need to know about nickel-cadmium rechargeable batteries

INFORMATION RETRIEVAL NUMBER 62

ZIPBOND

New bonding liquid joins materials in 60 seconds. No mixing, heating, solvents or catalysts necessary!

One drop per square inch does it. Economical: One ounce equals a quart of epoxy or adhesive.

Perfect for production line—In case of equipment breakdown you can make emergency repairs on the spot in sixty seconds. Zipbond joins ferrous and non-ferrous metals, plastics, glass, rubber, wood, porcelain and "exotic" metals with a lasting, colorless and transparent bond.

Unaffected by weather or temperature.

one tiny drop gives you weld like bond in 60 seconds

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Mpls., Minn. 55414
Please rush more information on Zipbond.

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Firm_____
Address_____
City_____
State_____ Zip_____

INFORMATION RETRIEVAL NUMBER 63

application notes

Analog gate design

A new application note, "Designing With Analog Gates," shows how hybrid analog gates can be used to obtain extreme isolation between a control or a switching signal and information. This eight-page guide covers ac and dc swing, interfacing with TTL, and the use of referral resistors. Teledyne Semiconductor.

CIRCLE NO. 352

Digital logic handbook

The popular 400-page "Applications Memos" digital logic handbook is once again available. This paperback handbook contains an introduction to digital logic and discusses digital considerations by family, decoding and steering, counters, shift registers and memories. It also includes interface and display elements, linear considerations, timing circuits, and parallel data handling. Signetics Corp.

CIRCLE NO. 353

Impulse analysis

A 28-page booklet analyzes the practical aspects and advantages of shock or impulse signals in both the time and frequency domains. B&K Instruments.

CIRCLE NO. 354

Frequency sweeping

Techniques on how to use present-day function generators to make swept-frequency measurements are explained in an application note. Clarke-Hess Communication Research Corp.

CIRCLE NO. 355

Four-watt audio amp

A new application report describes a 4-W-rms-output audio-frequency amplifier (into 16-Ω load) which has dc-coupled stages. The output stage uses a complementary symmetry pair of silicon transistors. A diagram and charts are included. AEG-Telefunken Corp.

CIRCLE NO. 356

The Facit 3851 input/output typewriter is provided with remote controlled tabulation.

The tab stops can be set and cleared by remote control. This permits changing the column configuration while the machine is in operation.

There is further interesting information on the new Facit 3851 in this publication.

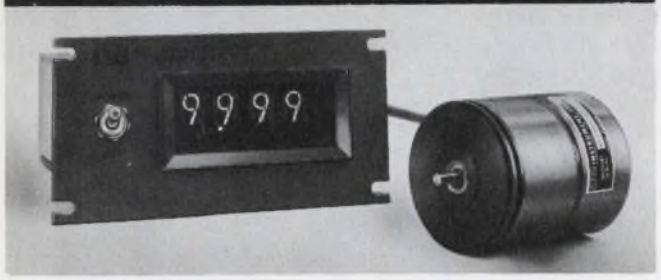
Facit 3851 – the conventional typewriter with input/output

For further information, contact
in US: Facit-Odhner Inc., 501 Winsor Drive, SECAUCUS, New Jersey
outside US: Facit AB, Albygatan 102, 171 84 Solna, Sweden

INFORMATION RETRIEVAL NUMBER 64

NOW! A COMPLETE SHAFT ENCODER & DISPLAY SYSTEM

$995



The LEM Instrument Corporation Model EDS-170 is a complete high-reliability position measuring system consisting of a unique absolute shaft encoder, a compact display and an interconnecting cable. NO ADDITIONAL EQUIPMENT IS REQUIRED.

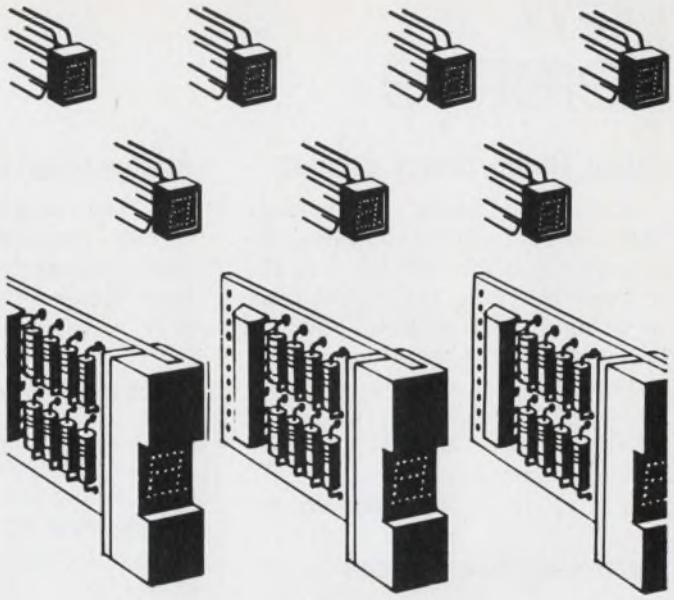
The display accepts the BCD (8421) output of the encoder, translates and displays the position information in parallel decimal form on gas discharge tubes. All necessary power supplies and circuitry are built in. Auxiliary BCD outputs are available as are many other options and models.

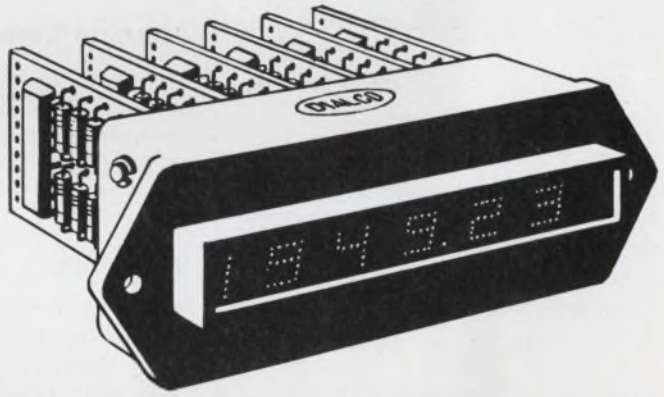
All LEM encoders feature low torque and inertia, low noise, FAR FEWER BRUSHES, non-ambiguous output, and long trouble-free life. Request new data sheet.

Total Range: 00.00 to 99.99 revolutions
Resolution: 0.01 revolution
Encoder Starting Torque: 0.12 oz-in maximum
Power Required: 115 V, 60 Hz, 10 watts max.

LEM INSTRUMENT CORPORATION
Subsidiary of TWIN DISC, INCORPORATED
20 Sarah Drive, Farmingdale, New York 11735
Phone (516) 293-7240

INFORMATION RETRIEVAL NUMBER 65





Dialight– supermarket for solid-state (LED) readouts.

Dialight's DIODE-LITE(TM) line gives you complete design flexibility with LED reliability. Start . . . or stop . . . wherever you like. Choose from DIODE-LITE readout modules . . . these modules incorporated in readout packages with IC-compatible decoder/drivers . . . or complete display assemblies of 1 to 10 readout packages mounted in a bezel frame with window. Three character heights: .125", .205" and .625". Supermarket pricing and availability too.

Write for the DIODE-LITE Data File. It spans the entire LED spectrum . . . light sources, cartridges, indicator lights, illuminated pushbutton switches and readouts. Just what you'd expect from Dialight.

DIALIGHT

DIALIGHT CORPORATION, A NORTH AMERICAN PHILIPS COMPANY
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INFORMATION RETRIEVAL NUMBER 66

new literature

Allied Radio Shack catalog

Allied Radio Shack's new spring/summer 1971 electronic parts, accessories and kits catalog No. 212 is available. This 116-page catalog is a handy buying guide for the builder, hobbyist, experimenter or anyone wanting a full selection of electronic parts, accessories, maintenance items and kits. Allied Radio Shack.

CIRCLE NO. 357

Light-sensitive devices

A 32-page catalog furnishes a complete listing of standard light-sensitive devices. Solar Systems, Inc.

CIRCLE NO. 358

Solid-state devices

A new 20-page condensed catalog profiles solid-state products that include chips, discretes, hybrids and optoelectronic devices. Centralab Semiconductor Div.

CIRCLE NO. 359

Alumina substrates

Ultra-smooth alumina substrates for electronic applications are described in a new brochure. Materials Research Corp.

CIRCLE NO. 360

Sensor photocells

A brochure describes new sensor silicon photovoltaic cells that peak at 555 nm, the green region of the visible spectrum, providing a spectral response curve identical to that of the human eye. Sensor Technology, Inc.

CIRCLE NO. 361

CRTs

Characteristics of more than 80 CRTs are contained in a new catalog. Included are many types together with an equivalents list, phosphors guide and translation of CRT terms into French, German, Italian and Spanish. The M-O Valve Co., Ltd.

CIRCLE NO. 362

Analog/digital filters

A new short-form catalog describes precision variable analog and programmable filters. Rockland Systems Corp.

CIRCLE NO. 363

Scan converter tubes

Scan converter tubes and their use as memory elements in signal and data processing applications are detailed in a publication. Industrial Products Div., Hughes Aircraft Co.

CIRCLE NO. 364

Alumina ceramics

A new brochure contains data on high-alumina ceramic products. Diamonite Products Mfg. Co., Div. of U. S. Ceramic Tile Co.

CIRCLE NO. 365

Inductors

A data sheet describes two series of side-lead toroidal inductor coils. Coils range in inductance values from 0.01 through 10 μH. J. W. Miller Co.

CIRCLE NO. 366

Attenuator/modulator

A technical data sheet describing a new p-i-n diode attenuator/modulator is available. The diode provides voltage-controlled attenuation or modulation over a wide dynamic range and broadband frequency range in the matched mode. General Microwave Corp.

CIRCLE NO. 367

Computer family

A new 100-page book enables users to configure and price computer systems matched to most real-time measurement and control applications. The handbook spans nine members of the computer family that feature on-site expandability from minicomputers priced under $10,000 to multi-processing systems priced over $300,000. Modular Computer Systems.

CIRCLE NO. 368

Lafayette catalog

Lafayette Radio Electronics Corp. is making available its new 116-page 1971 summer catalog 714. The catalog introduces Lafayette's new four-channel amplifiers, tape decks and adapters. Also included is a complete line of electronic marine gear, portable radios, speakers, tape player/recorders and stereo headphones. Lafayette Radio Electronics Corp.

CIRCLE NO. 369

Tachometers

A new 12-page bulletin describes a full line of tachometers for speed measurement and control equipment, and tachometer accessories for industrial and process-control applications. The Electric Tachometer Corp.

CIRCLE NO. 370

Microwave devices

New microwave and metal-glaze components are described in a catalog. The 24-page booklet provides technical data, photographs, charts and schematics on more than 130 devices including coaxial and stripline components, flange terminations, microstrip components, and rod, disc, metal-glaze and thick-film chip resistors. EMC Technology, Inc.

CIRCLE NO. 371

Timers

Catalog HD12C describes all types of timers—electromechanical adjustable reset, interval or delay reset, hand set interval, cam-actuated single and multiple-switch repeat cycle, and solid-state delay or interval types. General Time Corp.

CIRCLE NO. 372

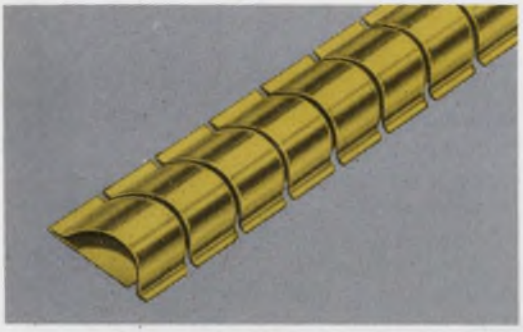
Wire and cable

A new 40-page catalog features 134 new electronic wire and cable products. Cables are grouped by type and principal application throughout the catalog. Belden Corp.

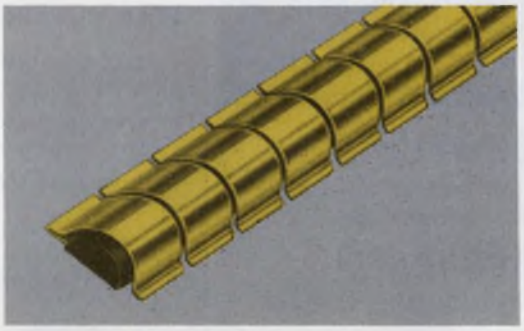
CIRCLE NO. 373

When RFI problems get sticky, try sticky fingers®

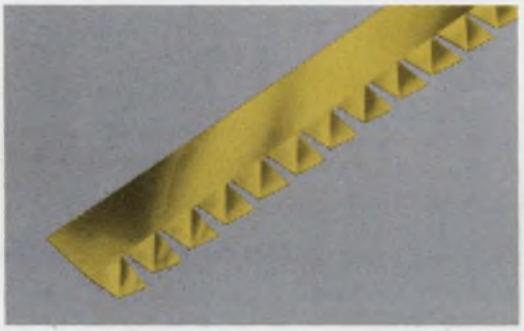
Attaches faster, shields better than anything else!



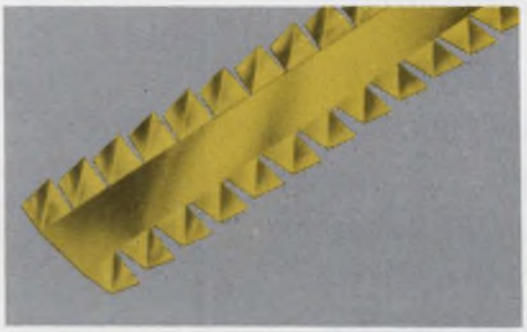
SERIES 97-500 The original Sticky Fingers with superior shielding effectiveness.



SERIES 97-510 Provides even better magnetic shielding with Magnefil® insert strips.



SERIES 97-555 New Single-Twist Series for use when space is at a premium. Measures a scant ⅜" wide.



SERIES 97-560 New ½" wide Double-Twist Series, ideal for panel divider bar cabinets.

Now you can specify the exact type beryllium copper gasket that solves just about every RFI/EMI problem. Perfect for quick, simple installation; ideal for retro-fitting. Self-adhesive eliminates need for special tools or fasteners. Write for free samples and catalog.

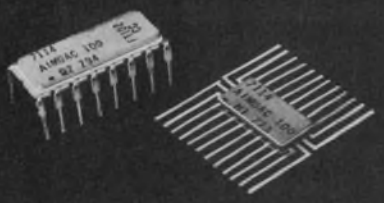
INSTRUMENT SPECIALTIES COMPANY, Dept. ED-65

Little Falls, N.J. 07424

Phone—201-256-3500 • TWX—710-988-5732

INFORMATION RETRIEVAL NUMBER 67

ANNOUNCING!



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Just add op-amp

ACCURATE!
Linearity — 10 bits ± ½ bit

FAST!
Settles to ½ LSB in 375 nS max.

LOW COST!
$23.80 @ 100 pieces

FEATURES

- −55° to +125°C Performance
- ±6V to ±18V Operation
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REMEMBER

monoOP-01 Fast Settling op-amp is the perfect companion to the AIM DAC-100

- 0.7 μsec settling to 0.1%
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- 18nA Input Bias Current
- $3.65 @ 100 pieces

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INFORMATION RETRIEVAL NUMBER 68

NEW LITERATURE

Process control

A new two-color 290-page catalog contains a complete listing of 10,000 process control devices, including those that start, switch, sense, count and indicate. The quick-reference fully indexed catalog contains product photographs, outline drawings, dimensions and weights. General Electric.

CIRCLE NO. 374

Wire markers

A new catalog describes a complete line of stock and custom sleeves for wire marking as well as for insulating, binding and encapsulating. W. H. Brady Co.

CIRCLE NO. 375

Ac controllers

A 12-page brochure contains specifications and price information on a line of solid-state ac controllers. Hamlin Electronics, Inc.

CIRCLE NO. 376

Gases

A new 114-page catalog on specialty gases, completely indexed and cross-referenced, describes more than 170 different compressed gases and standard gas mixtures, plus over 80 items of equipment for gas handling, blending and analysis. The catalog also contains a low-temperature physical properties table, measurement conversion charts and safety references, each related to the gases listed. Air Products and Chemicals, Inc.

CIRCLE NO. 377

Hard-copy displays

A two-page data sheet contains descriptions and full specifications for 6-in. hard-copy displays. Alden Electronic & Impulse Recording Equipment Co., Inc.

CIRCLE NO. 378

Zener diodes

A six-page zener diode selection guide details more than 700 zener diode types in various packages, voltages and currents. Microsemiconductor Corp.

CIRCLE NO. 379

ICs

A new 20-page condensed IC catalog describes voltage regulators, clock drivers, ladder switches, amplifiers, power amplifiers and hybrid switches. General Instrument Corp.

CIRCLE NO. 380

Semiconductor fuses

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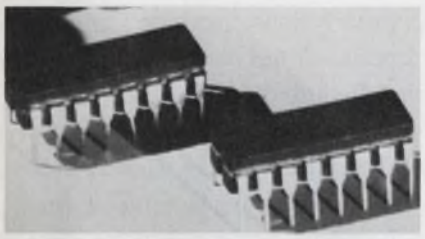

Motorola Semiconductor has expanded its **MECL 10,000 logic series** with two new ceramic DIP ICs: the MC10110L dual 3-input/3-output OR gate and the MC10111L dual 3-input/3-output NOR gate. To be introduced later this year are a 256-bit fusible-link ROM, a 64-bit RAM, a look-ahead carry block and 10 other complex functions.

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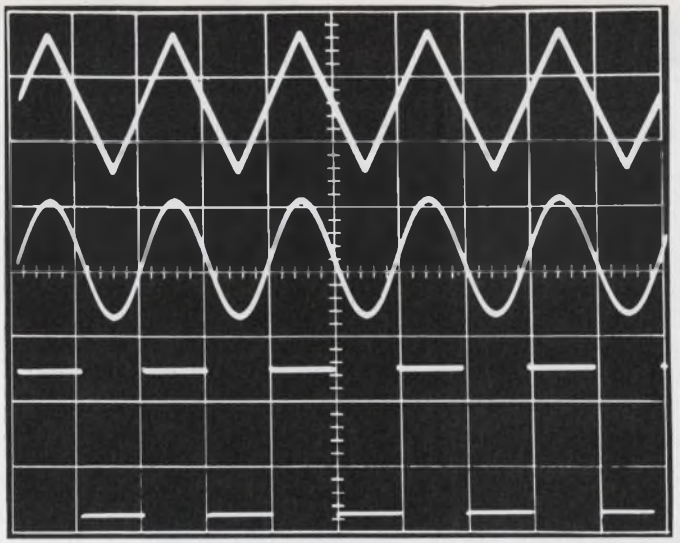

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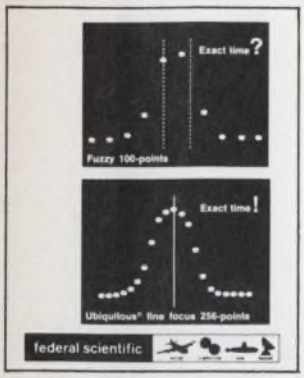

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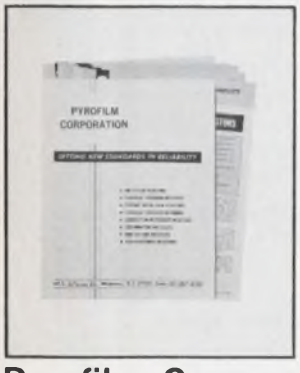

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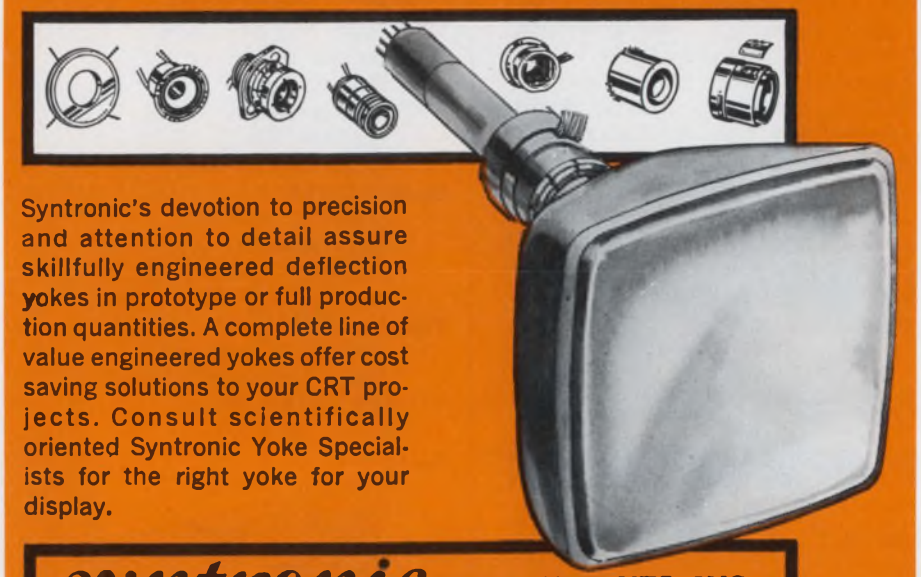

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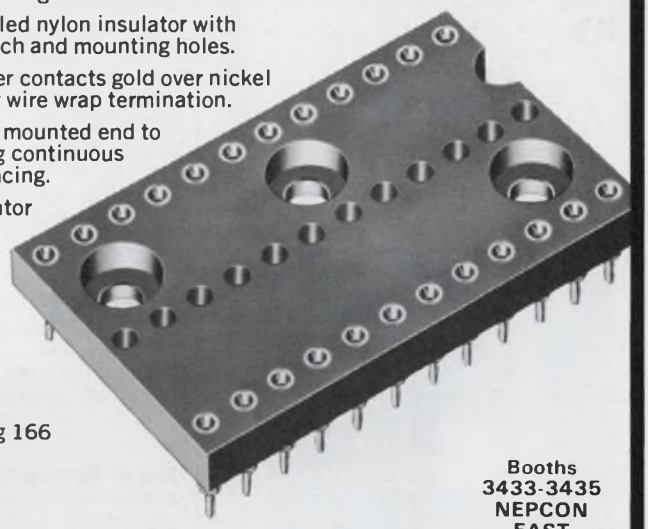

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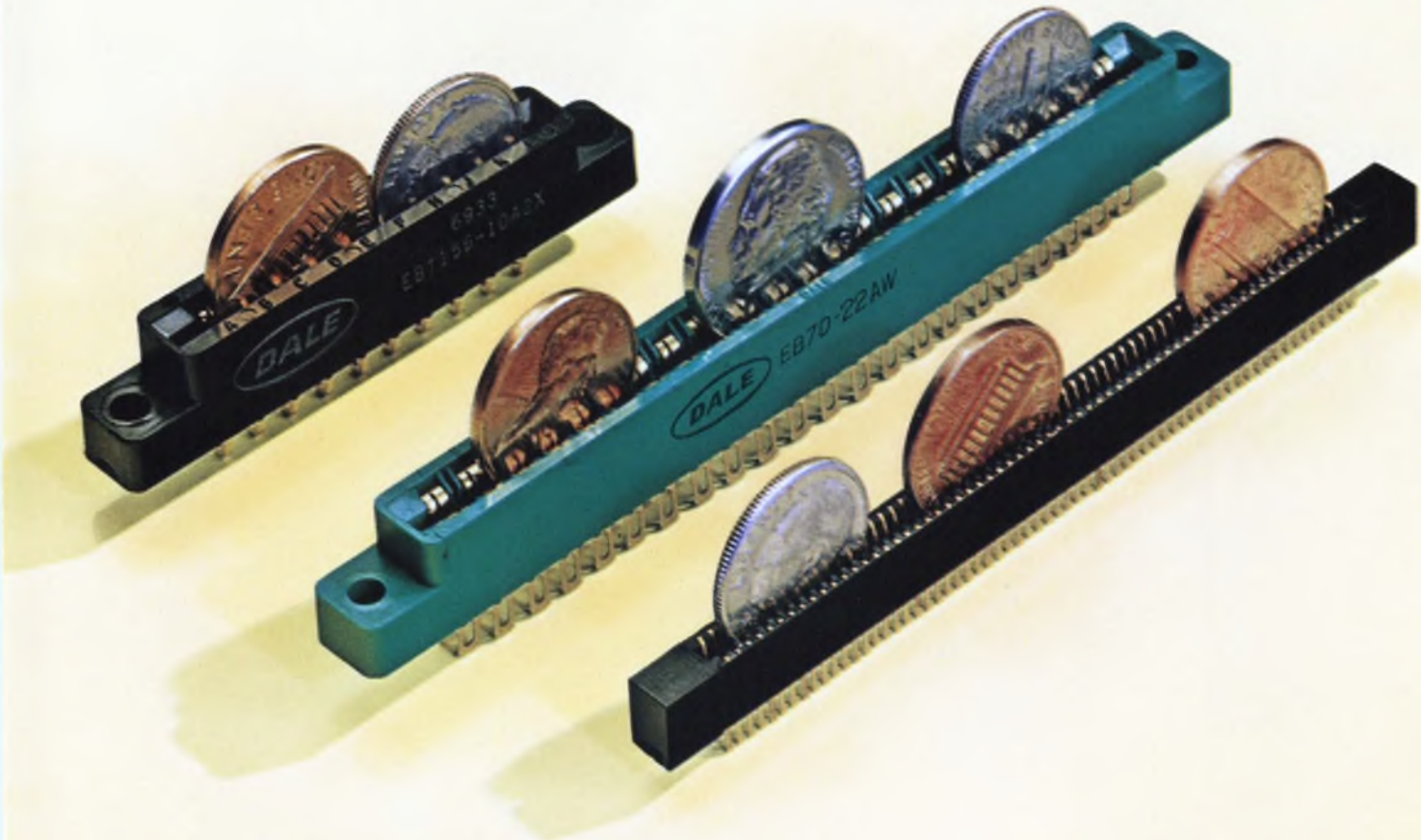

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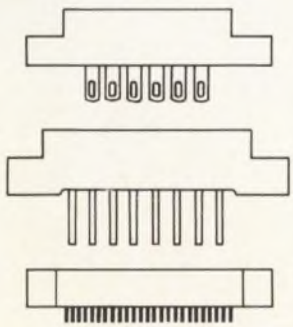

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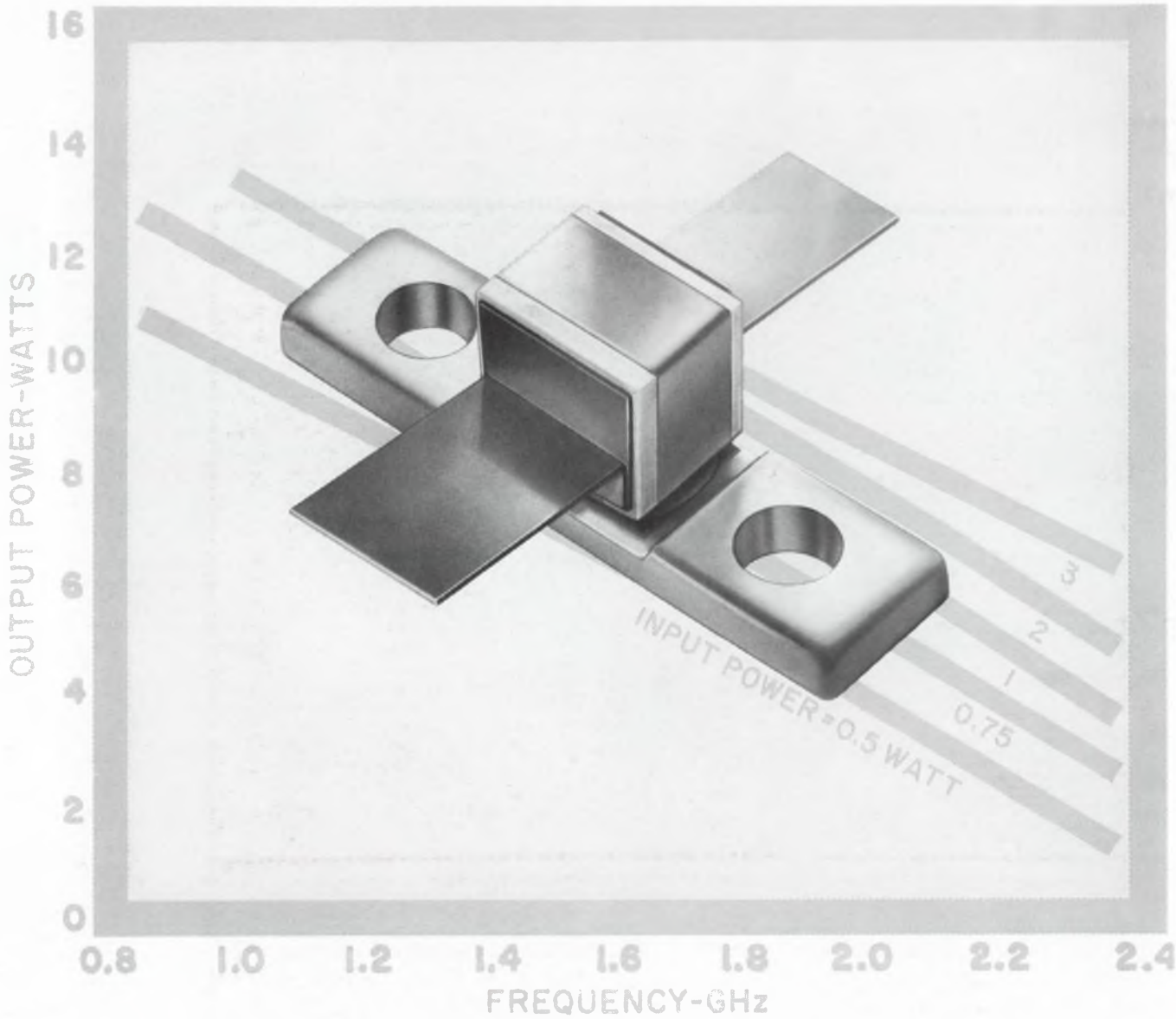

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