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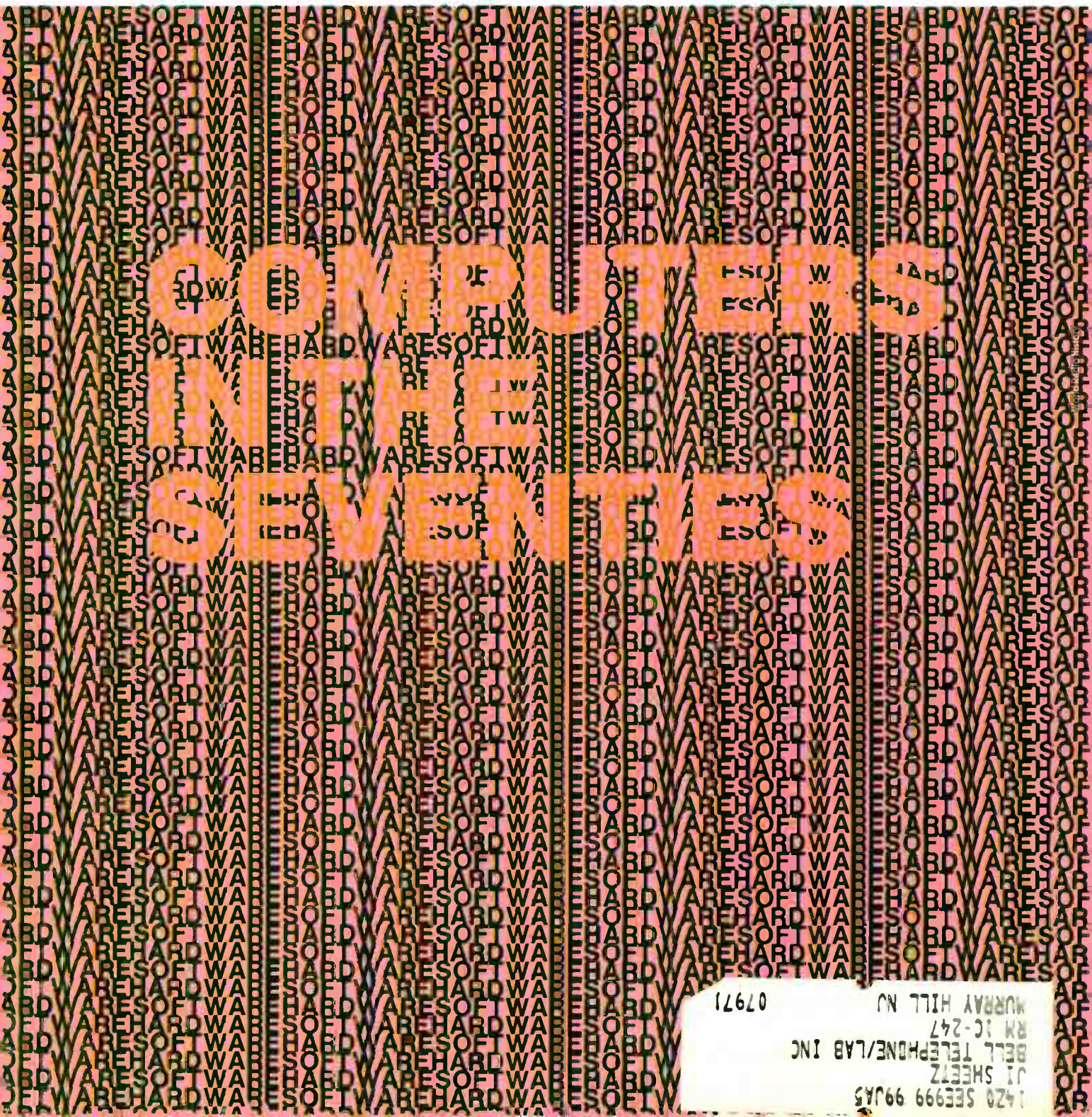
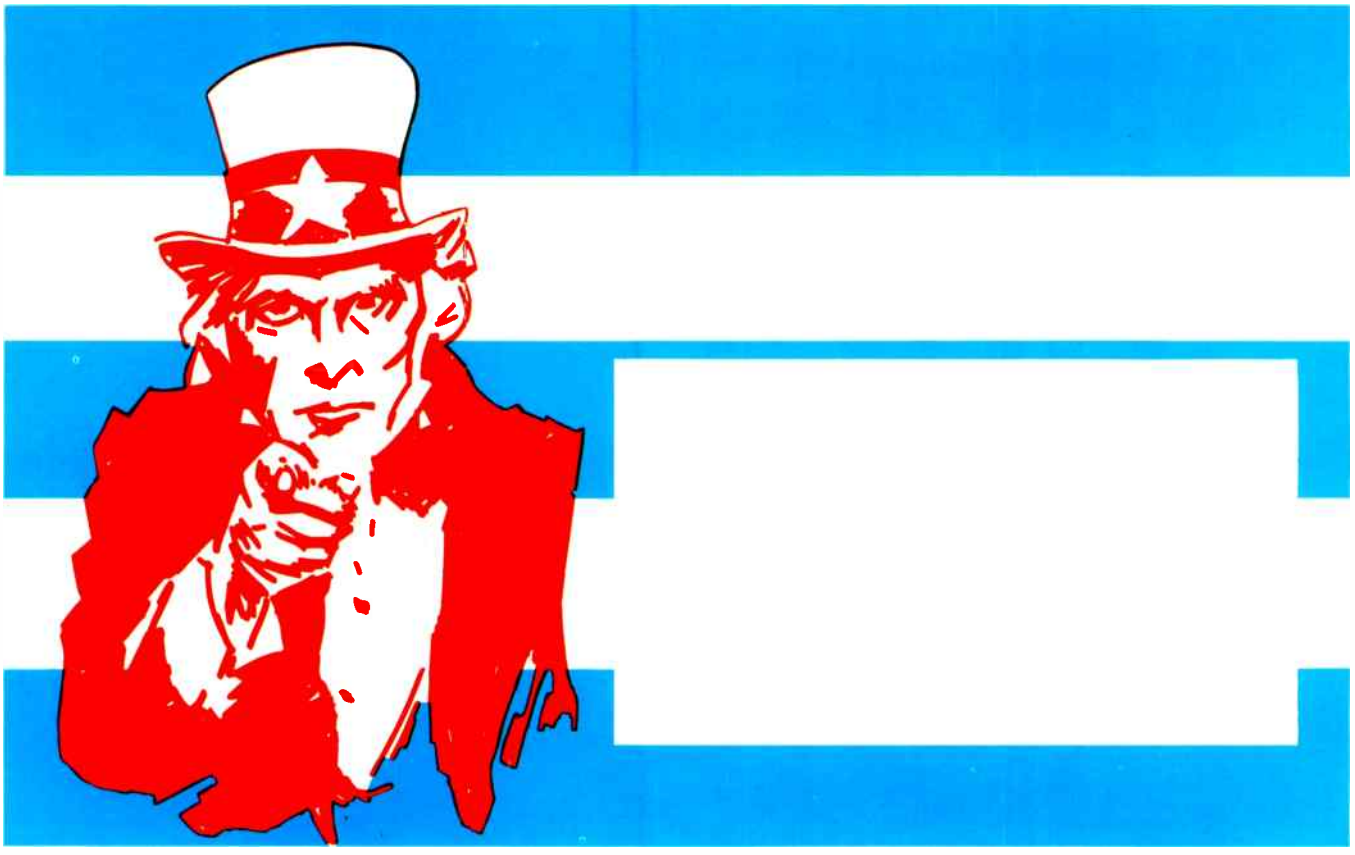
Electronics





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Electronics
The International Magazine of Electronics Technology
September 13, 1971

Volume No. 44, Number 19

Electronics

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Publisher's Letter

Every issue of *Electronics* presents a challenge to our art director, Fred Sklenar, in the form of the cover, which must graphically capture the essence of a major story in that issue; be original and artistically sound, and excite the reader's curiosity.

The cover story for this issue was easy to pick: Computers Editor Wally Riley's 24-page report on "Computers in the Seventies" (see p. 61) dominates the technical feature section. But how to meet the other requirements? Sklenar likes to make an editorial statement on his cover designs, and the leggy blond programers so prominently featured in much computer promotional art just didn't fill the bill. And most computer hardware is ho-hum, artistically speaking. Appropriately, Sklenar turned to the computer itself to help solve his problem.

He took his cue from a major point in Riley's article—computer technology in this decade will be strongly influenced by the need to overcome the long-standing software problem. Part of this will be accomplished by putting more of the software into hardware, and it was this hardware-software merger into the computers of the seventies that Sklenar tried to capture graphically. The field of type spelling out "hardware" and "software" was set by computer—on the surface, not a demanding task, but almost impossible to accomplish by conventional typesetting with the precise spacing required. Judicious choice of color change to bring out the title rounded out the human contribution to the job.

Although it worked well, we don't think we're quite ready to trade Sklenar in for an IBM 370.

Riley, a bearded ex-IBMer, spent two months gathering material for his report from a worldwide mix of hardware and software experts.

Larry Armstrong, *Electronics*' self-styled "burgeoning markets" editor who works out of our Washington bureau, wrote the coal mine story on p. 103, although his experience with that industry is limited to a 25-cent tour of the coal mine in the basement of Chicago's Museum of Science and Industry.

His story reflects dozens of interviews with the sons of coal miners who comprise the management of the U.S. Bureau of Mines, and with electronics company officials whose coal mine expertise stretches back only a year or two. One of those officials, Bendix's Louis Paine, sums the industry's problems up best, according to Armstrong. "The miner is using almost every sense he has to operate a continuous coal mining machine," says Paine, program manager for remote-control mining work at Bendix Research Laboratory, Southfield, Mich. "And we have quite a long route to go to duplicate that complex interplay of senses."

Since joining the Washington bureau, Armstrong has ferreted out technology in seemingly unlikely Government agencies. "You'd be surprised at the discrete pockets of electronics you can dig out of the Departments of Interior, Justice, Commerce, and HEW," he claims.

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Readers comment

EIA and metrication

To the Editor: With regard to some comments made about the Electronic Industries Association in the Washington Newsletter [Aug. 2, p. 36], it would be helpful to look at the record of our association in supporting conversion of the U.S. to the world metric system. EIA was one of the first major organizations to present a comprehensive position showing member support for metrication. The presentation was submitted at the Commerce Department's Metric Study Conference No. 1 in Deerfield, Mass., Aug. 17-21, 1970. Based on a membership survey, EIA supported increased use of the metric system and said: "The sooner it is started, the less costly it will be." Most companies favored a fixed time period for metric conversion, with 10 years the average length of time proposed. We have continued to cooperate fully with the Commerce Department, providing appropriate industry resources. We therefore believe that we have given strong support to the metric survey study.

With regard to our position on proposed legislation in the area of international voluntary standards (S. 1798 and H.R. 8111) also mentioned in the newsletter, we gave a forthright statement reflecting the deep-seated and legitimate concern of the U.S. electronics business community. We are continuing to study the proposed legislation.

V.J. Adduci
President
Electronic Industries Association
Washington, D.C.

On time

To the Editor: An Electronics Review article [Aug. 16, p. 38] stated that the first shipments of the IBM 3330 disk storage were promised by the second quarter of 1972. In fact, the initial 3330 shipments to customers were made right on schedule last month.

R.C. Dorn
Product marketing manager
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People

A man with a history of running successful operations, or getting rid of them if they're not, has stepped into the presidency of Electronic Arrays Inc., the Mountain View, Calif., maker of MOS arrays, at a time when the company has to plug the dollar drain. Mois Gerson succeeded Samuel Nissim, who became chairman, in late July, but

Gerson: Make them profitable or else.

Gerson's already moving swiftly to make sure the company's mainstay MOS/LSI business remains sound.

"My background is operations" Gerson says, "and that includes everything from making a piece of hardware from engineering design to getting the product out the door." Gerson isn't new to running a multifaceted company, having directed more than 14,000 persons as senior deputy director of operations for McDonnell Douglas's Missile and Space Systems group.

His first job upon joining Electronic Arrays in February 1970 was director of corporate operations. He was to make a cohesive entity out of the firm's own Semiconductor division; Monographics Inc., an East Palo Alto, Calif., mask maker; Xintel Corp., the Chatsworth, Calif., manufacturer of LSI testing equipment; Monolithic Memories Inc., a bipolar semiconductor memory house in Sunnyvale, Calif.; and Electronic Arrays' Systems division in Woodland Hills, Calif. The latter also spawned a calculator maker—International Calculating Machines.

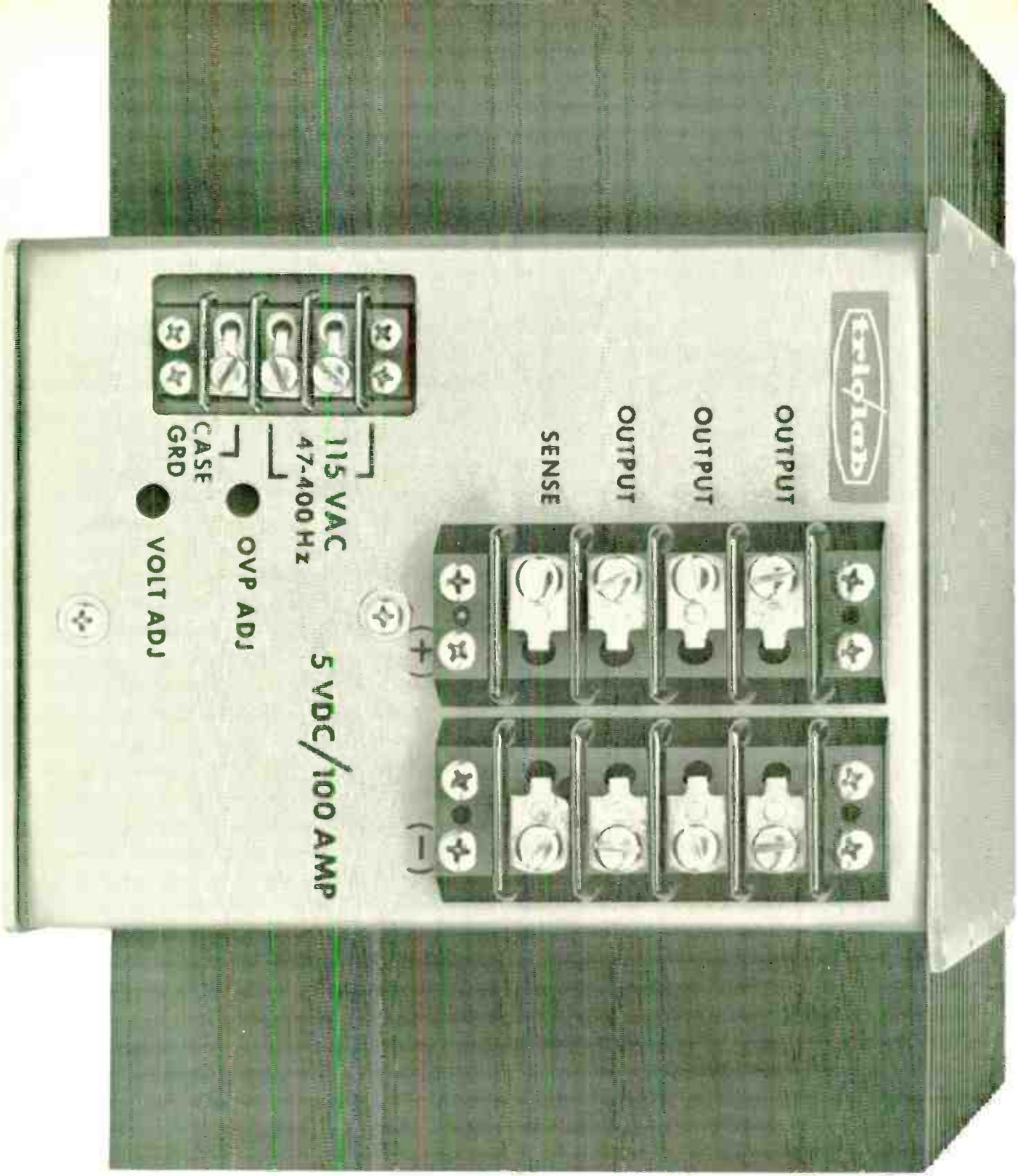
As Gerson moved up the ladder—first to general manager of the Semiconductor division and then to executive vice president of the parent firm—he quickly became aware that all was not right outside the Semiconductor division, and he's been moving to correct the problems. He helped cure cash flow ills by borrowing on receivables. He also helped negotiate a private placement.

Monographics is being operated by the parent company until it can be sold; it isn't unprofitable yet. Gerson says there have been "some slippages" in getting cash to Xintel, but "there's an indication of one of their backers is willing to carry them" until the fledgling firm generates some sales. And any of three options could bail out, or result in the sale of, International Calculating Machines. Gerson smiles, though, when he talks of Monolithic Memories. The company has "all the finances it needs; it's a plus for us in that we've already got cash from stock sales," Gerson says.

It's clear that he won't let any of the other companies further sap Electronic Arrays' resources. He says: "Sure we've got problems, but I don't see any that can stop me."

Tradition is associated more often with political than with engineering families. But there are exceptions. For example, Donald M. Jansky, now 31 and senior engineer in the White House Office of Telecommunications Policy, traces the family's connection with communications back to his grandfather, who was a professor of electrical engineering at the University of Wisconsin.

Of the grandfather's four sons, "the oldest, C. M., was the founder of Jansky & Bailey, communications engineering consultants, back in the 1930s; his younger brother, Karl Jansky, was the man who made the original discovery of radio astronomy at Bell Laboratories in 1932; then my father, who was 18 years younger than the oldest, got not



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only an engineering degree but also a law degree and practiced before the Federal Communications Commission for 25 years."

Like offspring of other famous families, Don Jansky remembers there was a time when he used to wince at those who began conversations by asking, "Are you related to . . .?" At one point he even contemplated changing his name to Johnson, the Anglo-Saxon equivalent of Jansky, which is Czech. But that flight of youthful fancy is long past, he says, and he now holds that a famous name can be helpful early in life "by opening some doors. But once you are inside, you're on your own."

Donald Jansky's labors in four years at OTP and its predecessor reflect a diversity of interests, ranging from state communications and educational TV systems, cable communications—a subject of strong Federal interest now [*Electronics*, Aug. 16, p.109]—and satellite communications. After gaining his BSEE from Dartmouth's Thayer School of Engineering in 1963 and a master's degree from Johns Hopkins University, Jansky worked at Jansky & Bailey (now part of the conglomerate Susquehanna Corp.) designing state TV systems for Kentucky and New York. In the latter case, he recalls, the study's cost estimates pushed the New York Telephone Co. into coming up with a new intrastate tariff that reduced charges for the system by about one-third from the tariffs initially proposed. "Some of the other things I did with Jansky & Bailey included work in space, working on a NASA contract—an engineering economic study" of earth stations, their location in the spectrum, and their size and costs.

His overriding interest at OTP is some of the uncharted areas of telecommunications relationships between the civil and military sides of the government and between the Government and private groups on the civil side. He is assisting in development of a Federal capability in electromagnetic compatibility analysis comparable to the military's 10-year-old Electromagnetic Compatibility Analysis Center.

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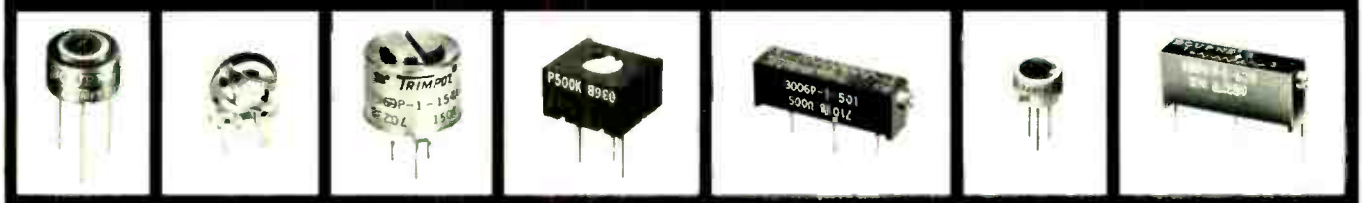

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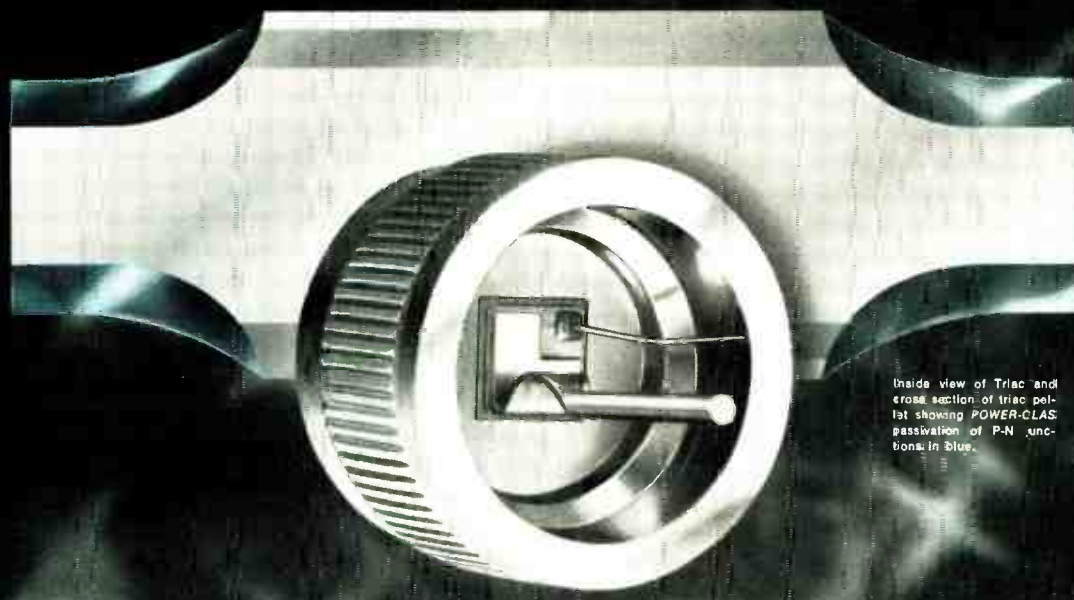
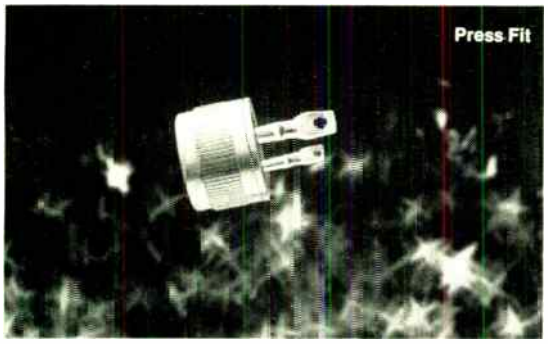


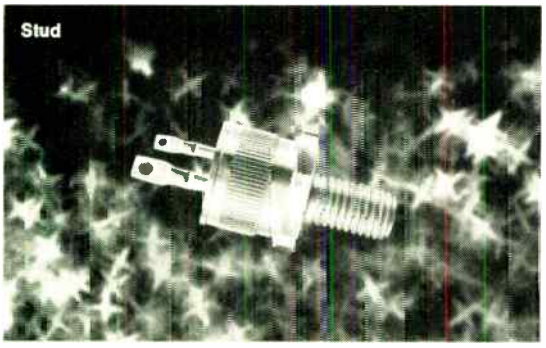
Inside view of Triac and cross section of triac pellet showing *POWER-GLAS* passivation of P-N junctions in blue.

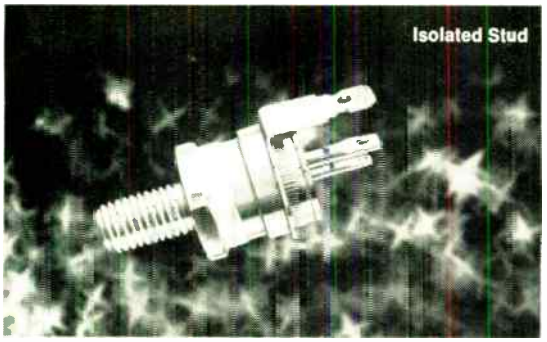
Having introduced the triac in 1962, who is better qualified to improve upon the original? General Electric solid state research has provided the answer with a proprietary glass formula and deposition process that improves upon the normal passivation techniques. GE's new ***POWER-GLAS*** process makes the clear difference. It provides for an intimate void-free bond between the silicon chip and the matched glass. The resulting stable low level off-state current significantly improves performance and reliability.

POWER-GLAS

6, 10, 15 Amp Metal Can Triacs Available Now At Competitive Prices.







Now General Electric introduces a new triac series which capitalizes on GE's new ***POWER-GLAS*** process . . . the new SC240, SC245 and the SC250 series at 6, 10, 15 amperes respectively with voltage ranges of 200, 400 and 500 volts each. This new series features very low off-state currents (typically less than 100μa) and high commutating dv/dt (4v/μsec.). Like other GE triacs, the new series comes in three industrial packages . . . Press Fit, Stud and Isolated Stud.

GE's ***POWER-GLAS*** is the clear difference—adding greater reliability and increasing AC blocking life stability.

POWER-GLAS TRIAC PRICES (1000 UNIT LEVEL)

PACKAGE	RATING	200V TYPE	400V TYPE	500V TYPE
PRESS-FIT	6A	$1.63	$2.11	$2.37
STUD	6A	1.83	2.31	2.57
ISOLATED STUD	6A	2.53	3.01	3.27
PRESS-FIT	10A	1.98	2.35	2.81
STUD	10A	2.18	2.55	3.01
ISOLATED STUD	10A	2.88	3.25	3.71
PRESS-FIT	15A	2.10	2.49	2.98
STUD	15A	2.30	2.69	3.18
ISOLATED STUD	15A	3.00	3.39	3.88

The prices above for the SC240, SC245 and SC250.

Write for your copy of "IMPROVED TRIAC RELIABILITY THROUGH ***POWER-GLAS***" for the full story on improved performance under worst case electrical stress conditions.

More *Power-Glas* Semiconductors To Come.

Additional new series of SCR's, Triacs and other semiconductors with the GE ***POWER-GLAS*** process will be introduced soon. To familiarize yourself now with the superior performance of the new GE Triac Series, send for product specifications. For prices and availability, call your local GE authorized distributor.

GENERAL ELECTRIC

FREE TRIAC SAMPLE & RELIABILITY REPORT

Mail this coupon attached to company letter head to:

GENERAL ELECTRIC
SEMICONDUCTOR PRODUCT DEPARTMENT
Inquiry Clerk, Electronics Park, Bldg. 7 Box 49
Syracuse, New York 13201

Please send one ☐ 200V or ☐ 400V TRIAC:
RATING: ☐ 6A ☐ 10A ☐ 15A

NAME_____
FIRM_____ POSITION_____
STREET_____
CITY_____ STATE_____ ZIP_____

OFFER EXPIRES SEPTEMBER 27, 1971

40 years ago

From the pages of Electronics, September 1931

Our European cousins are quite frank in their comments on the American "midgets" now being imported into the markets of the Continent.

The bad taste of much of the cabinet work is criticized, but the technical excellence is praised. Particular mention should be made of the method being used to adapt U.S. sets to the European long waves by adding an "infradyning" tube, working on a fixed frequency, so that the normal tuner becomes the intermediate frequency amplifier and must be tuned to the summation wave.

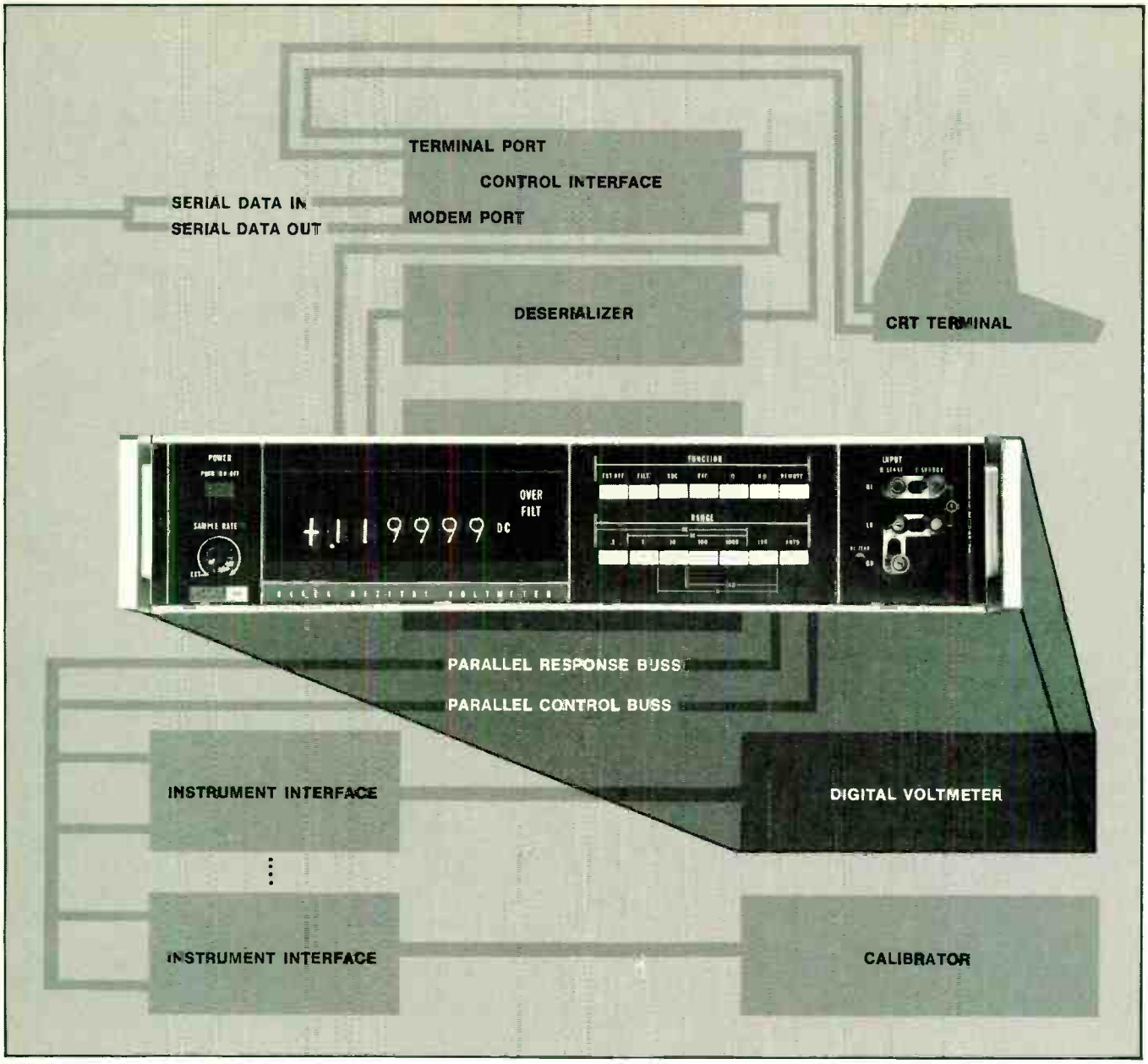
In New York and other cities television is now being made into a stock-selling racket, preying on the savings of the ignorant, trusting public to an extent that has already attracted the attention of the District Attorney's office.

Regiments of stock salesmen are being hired to call on such lists and sell securities under the pretense of letting the investor share in legendary profits.

The dollar value of the research laboratory is receiving increasing attention from hard-thinking business men, in times of changing conditions. Out of the research laboratory has come a flood of new ideas, and products. The business world now knows that "research pays!"

It is significant, therefore, that research activities in the electrical field as carried on in some of America's foremost research institutions are to be shown at first hand to 100 businessmen and bankers this fall during a tour of laboratories sponsored by the division of engineering and industrial research of the National Research Council.

New York City's Police Department has been authorized to spend $125,000 with which to equip all squad cars, police launches, and the force's two airplanes with radios. Although it has one longwave radio station for its harbor police, New York City has never radioized the rest of its force.



The new systems DVM with the big accuracy spec (0.004% for 90 days, 0.01% per year).

Here's the systems DVM with all time 24 hour, 30 day, and year long accuracies. It's the new Fluke 8400A with certified specs, autoranging on all parameters, options galore, and superior systems compatibility.

Five ranges of dc from 0.1v full scale to 1,000v with **0.004% accuracy** for 90 days and 0.01% for one year guaranteed. We give you five full digits plus "1" for 20% overrange. Featuring modular construction, the new DVM is only 3½" high by 19" wide. Resolution is **1 microvolt.** The Fluke 8400A will make 33 readings per second with a 3 millisecond aperture sample and hold. A switched filter on all ranges provides better than 65db noise rejection.

Any or all of the following options can be added at any time.

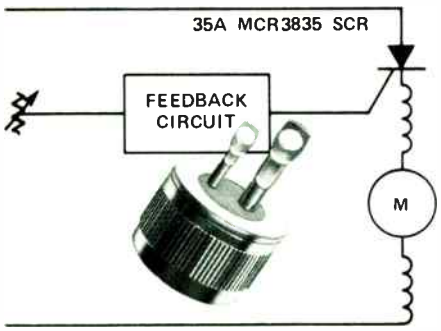
Seven ranges of 4 terminal resistance from 10 ohms to 10,000K ohms. Four ranges of ac from 1 to 1,000 volts with 0.05% accuracy to 10 KHz, ac/ac ratio and 4-wire dc/dc ratio, isolated data output. And **the 8400A will remember its remote control instructions** for convenient computer communication.

Base price is $2,450.

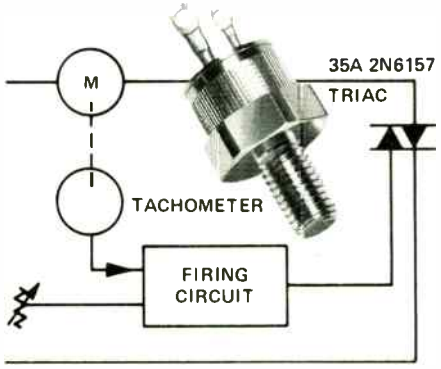
FLUKE®

Fluke, Box 7428, Seattle, Washington 98133. Phone: (206) 774-2211. TWX: 910-449-2850
In Europe, address Fluke Nederland (N.V.) P.O. Box 5053, Tilburg, Holland.
Phone: (04250) 70130. Telex: 884-50237/In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2 4TT. Phone: Watford 27769. Telex: 934583.

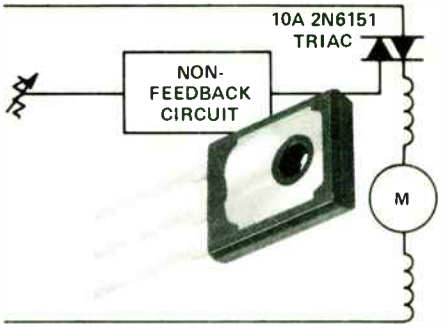
A Good Thyristor Can Be A



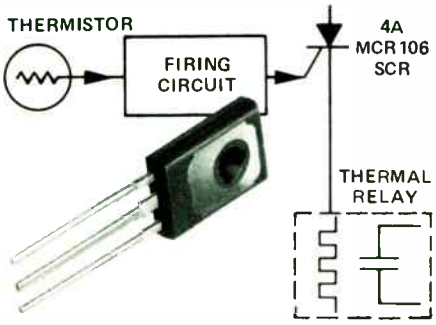
HALF-WAVE CONTROL WITH FEEDBACK — Universal ac/dc; food mixers, blenders, portable tools, floor polishers, and sewing machines.



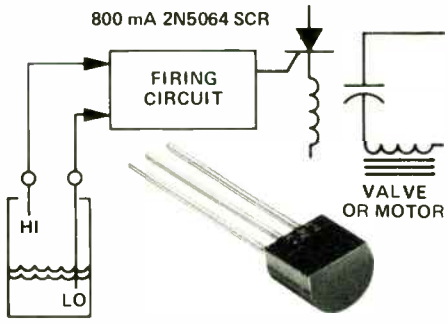
FULL-WAVE CONTROL WITH FEEDBACK — Universal ac/dc with any load, shaded pole or permanent split capacitor with fan/blower load; automatic washers, conveyor belts, air-conditioners, clothes dryers.



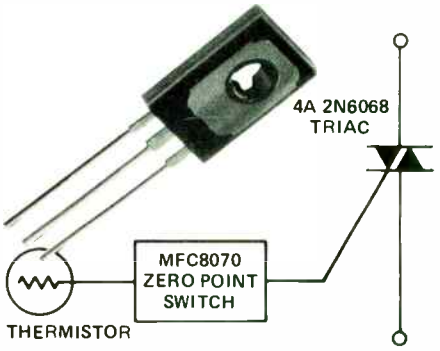
FULL-WAVE CONTROL WITH NON-FEEDBACK — Universal ac/dc, shaded pole, permanent split capacitor; blenders, food mixers, portable tools, floor polishers, sewing machines.



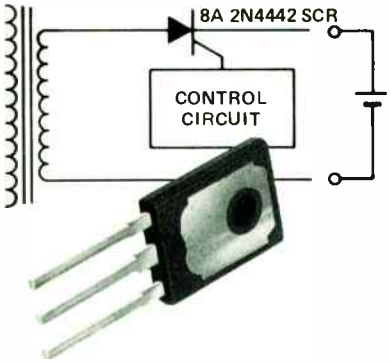
TEMPERATURE CONTROL—Hair dryers, ovens, environmental controls, electric frypans, ranges, heaters and toasters.



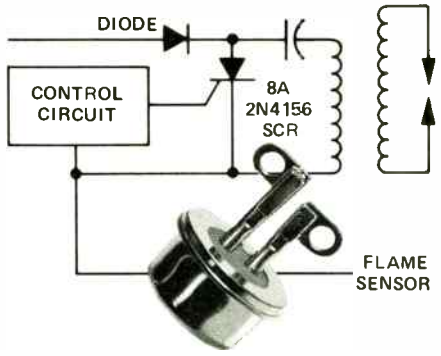
LIQUID LEVEL CONTROL — Industrial applications, dishwashers, automatic washers, humidifiers, dehumidifiers, vending machines, water softeners.



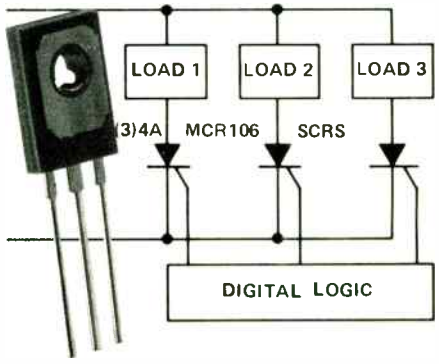
SYNCHRONOUS SWITCHING — Electric blankets, coffeemakers, frypans, ranges, electric heating and water heating.



BATTERY CHARGING — Shavers, knives, emergency lighting, toothbrushes, automotive, clothes brushes.



CD PULSE APPLICATIONS — Furnaces, water heaters, automotive/marine ignition, clothes dryers, room heaters.



SEQUENCING APPLICATIONS — Vending machines, automotive/aircraft, dishwashers, automatic washers, oven timers.

*Trademark Motorola Inc.

Good Anything

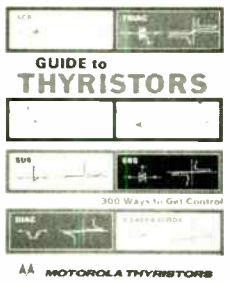
. . . like the new 2N6068 plastic Triac offering 1,000 watts of full-wave power-handling in heat, light and speed control . . . reliably . . . at low cost! This Thermopad* device is priced at only 86c, 100-up, yet offers all these advantages: 4 A/600 V maximum ratings — dual-mode gate firing — 3.5°C/W thermal resistance — and glass-passivated, hermetic die construction for higher voltage yield and the cleanest, most uncontaminated plastic-device junctions you can bet your design on.

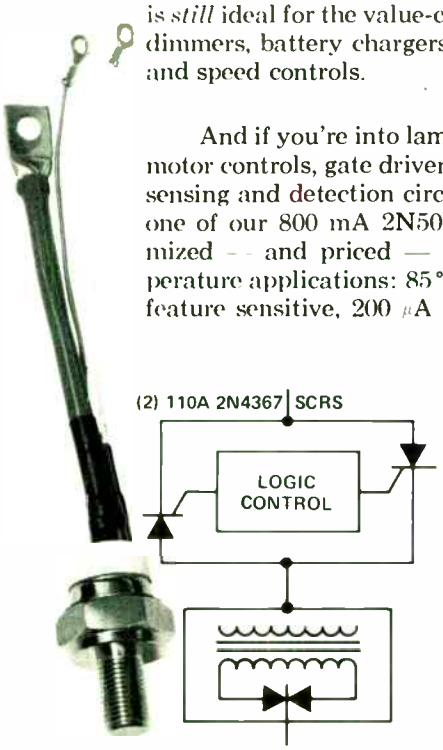
. . . or the popular, industry-standard 8 A 2N4151 metal Elf* SCR that still provides the ultimate in design flexibility and mounting ease combined with rugged compactness and reliability! It's still the smallest of any comparable SCR, still offers six different, hermetic case configurations and is *still* ideal for the value-conscious designer of lamp dimmers, battery chargers, flashers, power supplies and speed controls.

And if you're into lamp and relay drivers, small motor controls, gate drivers for larger thyristors and sensing and detection circuits, you'll want to select one of our 800 mA 2N5060 Unibloc* SCRs, optimized — and priced — for 3 different case temperature applications: 85°, 110° and 125° T_C. They feature sensitive, 200 μA triggering, low-as-30-cent 100-ups and fill out a line of more than 3 dozen economical signal thyristors! Big power requirements? How about a new, 110 A RMS 2N4361 SCR that spells QUALITY in the only ways that count: pressure-contact encapsulation . . . freedom from thermal fatigue . . . guaranteed 100 V/μs dv/dt . . . 1,600 A surge protection . . . high-temperature (300°C-tested) alloy materials . . . hermetic ceramic seals . . . all-diffused junctions contoured for longest voltage creepage . . . 1,400 V blocking voltage.

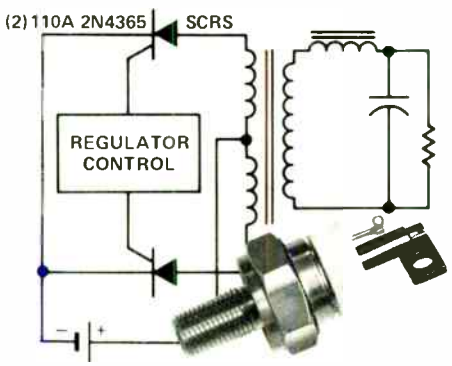
There are others — scores of plastic and metal SCRs and Triacs offering you the exact degree of full- or half-wave, stepless power control you want, from 25 to 800 volts in 17 different package styles. Whatever thyristor you want . . . in the volume you want . . . at the price you can afford . . . from the biggest discrete device warehouse you can find!

See your Motorola distributor or write on your company letterhead to P. O. Box 20912, Phoenix, Az. 85036, for your "Guide To Thyristors" — a comprehensive, new look at selection, symbols, characteristics, definitions, uses and cross-referencing of today's thyristors. Motorola thyristors. Great for anything you want!

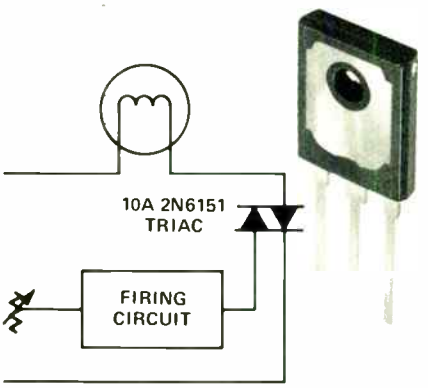




WELDING — Spot welding with automatic cycle determination.



DC-TO-AC CONVERTER — Low-voltage DC to high-voltage AC servos, fluorescent lighting.



LIGHT DIMMING — For full-on, full-off light control in home, office, business.

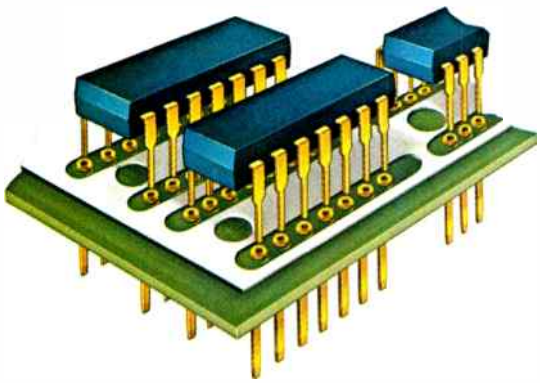
MOTOROLA THYRISTORS
— 300 Ways To Get Control

IC panels: by the piece... or

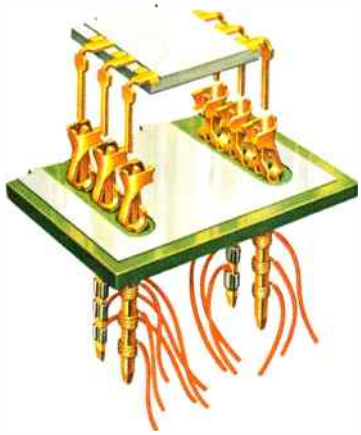
AMP gives you two ways to go for building the IC panels you want, economically.

Make them yourself.

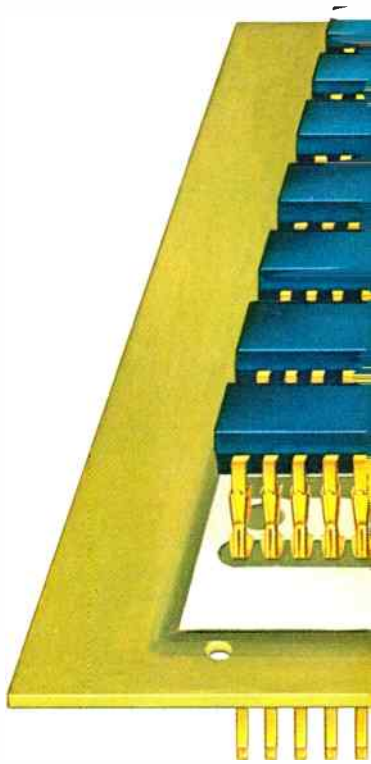
We'll supply all the mounting components you need.
Miniature spring sockets, IC receptacles,
DIP headers and strip receptacles.
And high-speed machines to apply them in your plant.

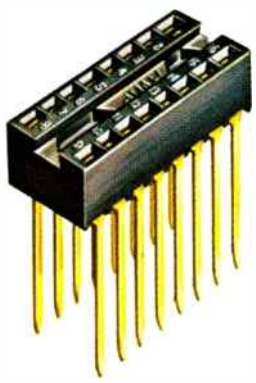


Miniature spring socket • inner spring exerts constant pressure on lead end for maximum retention and conductivity • wide bell-mouth for easy entry • low profile • flare lip for stop • accepts DIP leads and round leads .010″ to .040″ diameter • available with wrap-type or TERMI-POINT* clip-type posts, also solder version.

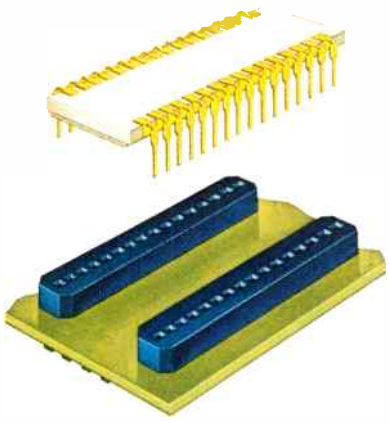


IC receptacles • accepts .022″ round leads and .022″ x .040″ rectangular leads • has wide contact lead-in—unique anti-overstress feature assures good contact • available with wrap-type or TERMI-POINT clip-type posts • solder version available.





DIP headers • ideal for low-cost, high density packaging • built-in overstress design • bell-mouthed entry for easy insertion of IC's • 14 and 16 leads • available with wrap-type or TERMI-POINT clip-type posts • solder version available.



Low profile DIP header and DIP strip receptacles • only .150″ high • housings are self-containing for solder operation • header accepts standard 14 and 16 pin DIP's • strip receptacle available in 4 position through 22 position DIP patterns.

*Trademark of AMP Incorporated.

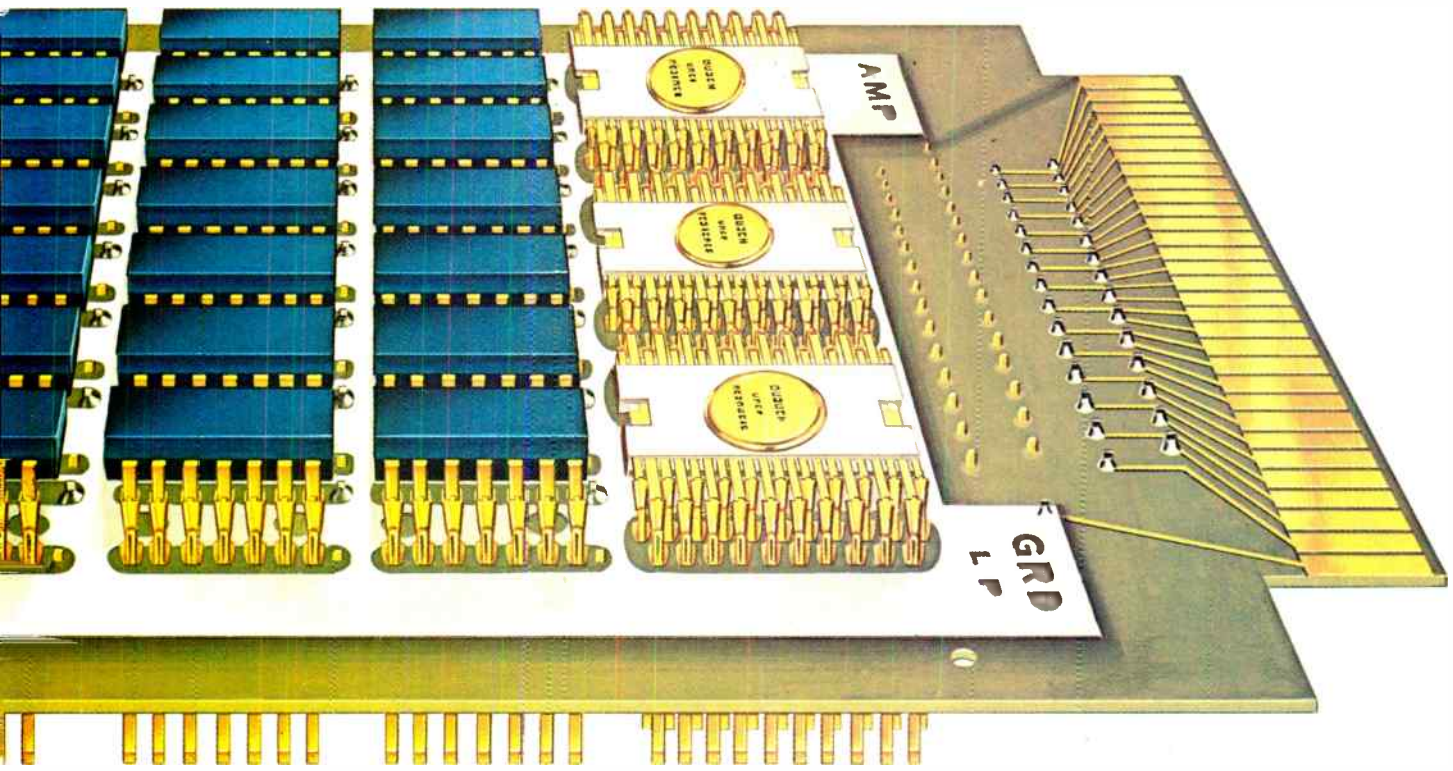
Ampeconomation
COST SAVINGS BY DESIGN WORLDWIDE

by the boardful.

Have us make them for you.

Finished IC panels made to your specifications and ready for you to insert IC packages.

Fact is, we can take your IC panels to the final step and supply them pre-wired with wrap-type point-to-point wiring, or our own TERMI-POINT clips.



Either way you get all the reliability you need plus the benefits of AMPECONOMATION . . . high-speed AMP automated application machinery that gives you the greatest number of reliable connections at the lowest installed cost.

For details that can help you make a choice write:
AMP Incorporated, Harrisburg, Pa. 17105

AMP
INCORPORATED

Manufacturing and Direct Sales Facilities in: Australia, Canada, France, Great Britain, Holland, Italy, Japan, Mexico, Puerto Rico, Spain, Sweden, United States and West Germany.

Panel space shrinking?

Solve your space problems with our dual section variable resistor; it's only 1/2 inch in diameter.

Allen-Bradley Type GD. The most compact two-section variable resistor available today. The same diameter and only a fraction longer than our popular single-section Type G. Type GD resistance tracks are solid hot-molded elements for long life. Noise level is low and resolution is virtually infinite. Low inductance. Usable at frequencies far beyond the range of wirewound variables. Ideal for use as bridged pad (T or L) attenuators. Entire unit immersion sealed. Available in resistance values from 100 ohms to 5 megohms through your appointed A-B electronics distributor. Or write for publication 5213: Allen-Bradley, Electronics Division, Milwaukee, WI 53204. Export: Bloomfield, N.J. 00703. In Canada: Galt, Ontario.

NEW DIMENSION ELECTRONICS

ALLEN-BRADLEY

A-B QUALITY

Circle 20 on reader service card

Meetings

International Telemetry Conference, Instrument Society of America, Electronic Industries Association; IEEE, Washington Hilton Hotel, Washington, Sept. 27-29.

Seminar on Telecommunications; IEEE, Mexico City, Oct. 6-9.

Second IFAC Symposium on Multivariable Control Systems; IEEE, Duesseldorf, Germany, Oct. 11-13.

Switching & Automata Theory; IEEE, Michigan State University, East Lansing, Mich., Oct. 13-15.

National Electronics Conference; IEEE, McCormick Pla., Conrad Hilton Hotel, Chicago, Ill., Oct. 18-20.

1971 Region 8 Convention—Eurocon; IEEE, Le Palais de Beaulieu, Lausanne, Switzerland, Oct. 18-22.

Annual Electronic Connector Symposium, IEEE, Cherry Hill Inn, Cherry Hill, N.J., Oct. 20-21.

Electronic & Aerospace Systems Convention; IEEE, Sheraton Park Hotel, Washington, D.C., Oct. 25-27.

1971 Joint Conference on Major Systems, IEEE; Disneyland Hotel, Anaheim, Calif., Oct. 25-29.

Int'l Electron Devices Meeting; IEEE, Sheraton Park Hotel, Washington, D.C., Oct. 27-29.

CALL FOR PAPERS

Internation Symposium on Fault-Tolerant Computing, IEEE, Massachusetts Institute of Technology, Boston, June 19-21. Nov. 1 is deadline for submission of papers to Prof. Gernot Metze, Coordinated Science Laboratory, University of Illinois, Urbana 61801.

International Symposium on Acoustical Holography, IEEE, U. of California, Santa Barbara, April 10-12. Nov. 1 is deadline for submission of summaries to Glenn Wade, Department of Electrical Engineering, University of California, Santa Barbara, Calif. 93106.

Introducing the little counter that can.

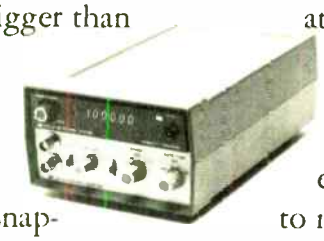
It can become four different systems.

It can go anywhere you do.

It can protect you against obsolescence.

It can make buying and maintaining a counter less expensive than ever before.

Meet the Hewlett-Packard 5300, the snap-together counter that's not much bigger than the palm of your hand. It has six digit accuracy, solid state display and autoranging. It'll make period, frequency, time interval and ratio measurements, operate on its own snap-on battery pack and drive a printer. Prices start at only $520.



If everything sounds too good to be true, we'll tell you how we did it: snap-together construction that lets you choose the module that makes the counter you want and also avoid obsolescence. Plus the most advanced LSI circuitry ever used in a counter. That means you get a compact instrument with high reliability, performance and versatility at a cost lower than ever before.

To make the counter you need, take the $395 mainframe and add any of the following 4 modules (more are on the way). They lock right onto the mainframe in an instant.

- 10 MHz frequency module. Direct frequency counting to greater than 10 MHz. Model 5301A, just $125.
- 50 MHz all-purpose module with period average, time interval, and ratio functions. Model 5302A, $250.
- 500 MHz frequency module, both 50Ω and 1 MΩ impedances. DC to 500 MHz. Model 5303A, only $750!
- Time interval module with features you'd expect to pay twice as much for: 100 ns resolution; attenuators and slope and trigger level controls on both channels; counting to better than 10 MHz; period averaging. A unique "time interval holdoff" feature lets you ignore electrical pulses between the events you want to measure. Model 5304A, $300.

You ought to be able to take a counter as small and useful as the 5300 anywhere. And you can. All you have to do is snap on the battery pack (Model 5310A, $175) for 4 to 8 hours worth of cord-free operation. The pack fits between the mainframe and any module. The system's rugged dust-proof aluminum case resists almost any of the bumps it might get in the field.

The 5300 is one system you have to use to appreciate; there is simply no other way. To get you started we'd like to send you more information on this amazing instrument. Just call your nearby HP field representative or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

02104

HEWLETT hp PACKARD

ELECTRONIC COUNTERS

Take your pick.

You're sure to find exactly what you want.

Simply because MICRO SWITCH has a larger selection of toggles to pick from. With an almost limitless choice of size, circuitry and toggle action.

There are miniatures (Type TW); environment-proof (Type TL); magnetically held (Type ET); rocker button (Type TP); standard sized (Type TS); and assemblies with sub-miniature, high capacity or hermetically sealed basics (Type AT). Many of them designed to meet military specifications.

More special features, too, right off the shelf. Like shape-coded and color-coded bat handles, each in a variety of lengths. A choice of locking configurations as well as a choice of mounting bushings and hardware. And several types of terminations, including an Integrated Wire Termination System (IWTS).

For more information, call your MICRO SWITCH Branch Office or Authorized Distributor (Yellow Pages under "Switches, Electric"). Or write for Cat. 51.

MICRO SWITCH
FREEPORT, ILLINOIS 61032
A DIVISION OF HONEYWELL

Circle 24 on reader service card

MICRO SWITCH products are available worldwide through Honeywell International.

Electronics Newsletter

September 13, 1971

Fluke, Tektronix to sell computer-controlled testers

Two established "names" in the instrument business, the John Fluke Manufacturing Co. of Seattle and Tektronix Inc. of Beaverton, Ore., are entering the computer-controlled tester business.

Fluke's system, called the Terminal/10, has been designed to automate final production testing and verify and calibrate electronic instruments and subassemblies. The major advantage of Terminal/10 is that, unlike most other automatic test systems, it doesn't require a dedicated computer—it operates as a true computer peripheral tying into the asynchronous port. If the user already has a computer, Terminal/10 can be dropped in without modification. It can also be purchased with a computer (a PDP-8 or PDP-11) and the computer can be used with other peripherals for other functions. The PDP-11 can handle 16 terminals—Terminal/10's or any combination of peripherals.

Tektronix says its LSI tester is four times faster than anything else on the market. It can test four-phase MOS circuits at a 20-megahertz clock rate. The basic unit can handle 64 pins—either inputs or outputs—or 128 pins with 64 fixed inputs and 64 fixed outputs. Called the S-3160, the system is controlled by a PDP-11. It will probably be shown for the first time at the 1972 IEEE Show.

Self-scanner with 256 elements rivals TV resolution

A monolithic, 256-element, self-scanning optical array has been developed by Reticon Corp., Mountain View, Calif. The largest available self-scanning array built to date, the device is also the only one to contain both the video amplifier and shift counter on the same chip.

The silicon gate MOS chip is packaged in a glass-topped, ceramic 16-pin dual-in-line package together with a TTL driver circuit making the device TTL-compatible. With 256 elements, the resolution of an image produced by the chip is equal to or better than that of a standard television set. This makes the device a natural for document facsimile transmission systems, and for other applications where character or page reading is required—zip code readers, for example.

Reticon, a recently formed company that will specialize in opto-electronics, says this new array will soon be in volume production and samples have already been shipped.

Arinc to ponder its own network

Plans for a $257 million nationwide microwave-coaxial cable communications network for the air transport industry will be considered Sept. 22 by directors of Aeronautical Radio Inc., the air carriers' communications company based at Annapolis, Md. The Arinc plan [*Electronics*, Apr. 12, p. 38] not only will offer users three times the capacity of the Telpak private-line net now leased from AT&T, but will save an estimated $50 million a year in charges and eliminate the uncertainties of future tariff increases, contends Arinc chairman John S. Anderson.

The system study, by Collins Radio Co., predicts that airline communications requirements in the U.S. "will grow threefold between 1970 and 1980," says Anderson, "at which time the annual leased cost of facilities at present rates will exceed $140 million." The comparable private-line system would cost an estimated $90 million.

Arinc directors will be briefed on "recent refinements in its study and recent developments in regulatory requirements" of the Federal Com-

munications Commission, says a company official, indicating that Arinc is not ruling out the possibility of buying some or all of its services from special-service common carriers such as Datran or Microwave Communications Inc.

Lasers ordered for lab system

Spectra-Physics, the Mountain View, Calif., laser manufacturer, has received what it calls a "volume order" for argon lasers from an East Coast biomedical engineering company. The lasers are the heart of an automatic blood-cell-counting system that will sell for about $10,000; blood-cell counting has been one of the most difficult laboratory tasks to automate. The system may be shown at the convention of the American Academy of Ophthalmology and Otolaryngology in Las Vegas starting Sept. 20.

RCA to introduce small computer

RCA's soon-to-be-announced computer will be a small machine, but not a minicomputer as rumored. It will have the same architecture as the RCA 2, 3, 6, and 7, announced a year ago, and will rent for about $5,000 a month, against roughly $7,500 for the RCA 2. The new entry will be called the RCA 1—which implies that the company doesn't expect to bring out anything smaller in this series in the foreseeable future.

Motorola to build H-P MOS memory

Hewlett-Packard's Loveland division has granted a contract to Motorola Semiconductor Products to second source the 4,096-bit n-channel MOS read-only memories that H-P uses in its new Series 9800 Model 10 programable calculator [*Electronics*, July 19, p. 32]. H-P developed the chip in-house and is currently producing what it needs in Loveland, but Motorola is expected to supply an additional 90,000 to 100,000 units over the next two years. The agreement also allows Motorola to offer the ROMs nonexclusively to other customers, but the company has not yet decided whether it will.

H-P decided to go to n-channel chiefly to attain high speed: the ROM offers a 250-nanosecond access time. Also, H-P reports it is getting "extremely high yields" in production. Failure rates are running at about 0.25% per 1,000 hours, and Hewlett-Packard says that 0.1% will be attainable soon.

Addenda

Fairchild's Microwave and Optoelectronics division has developed a package for phototransistors that is only 50 mils wide, 100 mils long and 80 mils high. Using this small package in a 10-by-12-transistor array, the division has produced a reader for Kimball merchandise tags that it hopes will sell for $120. Previously, merchandise tags could not be read directly. Standard phototransistors in large packages were combined with fiber optic bundles producing very complex assemblies. The new tag reader has not been put into production yet, but developmental samples are available. . . . A Southern California minicomputer company, Omnicomp Computer Corp., that was all but counted out a year ago because it couldn't find venture capital [*Electronics*, Aug. 31, 1970, p. 33] has survived its initial financial woes. The Santa Ana firm has delivered its first Omnus 1, a 16-bit machine that incorporates 256 registers to give it an unusually large instruction set. The price was $10,500. The company has just moved into a manufacturing facility.

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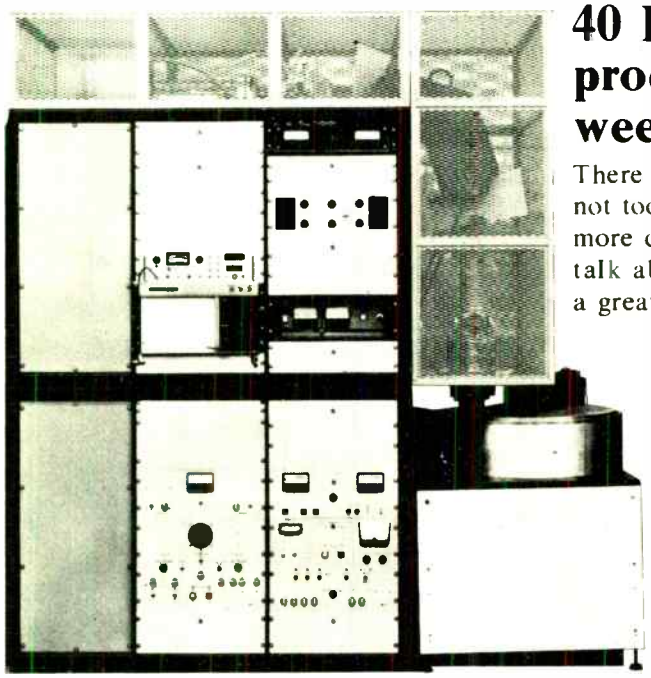

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A breakthrough in counter/display circuits!

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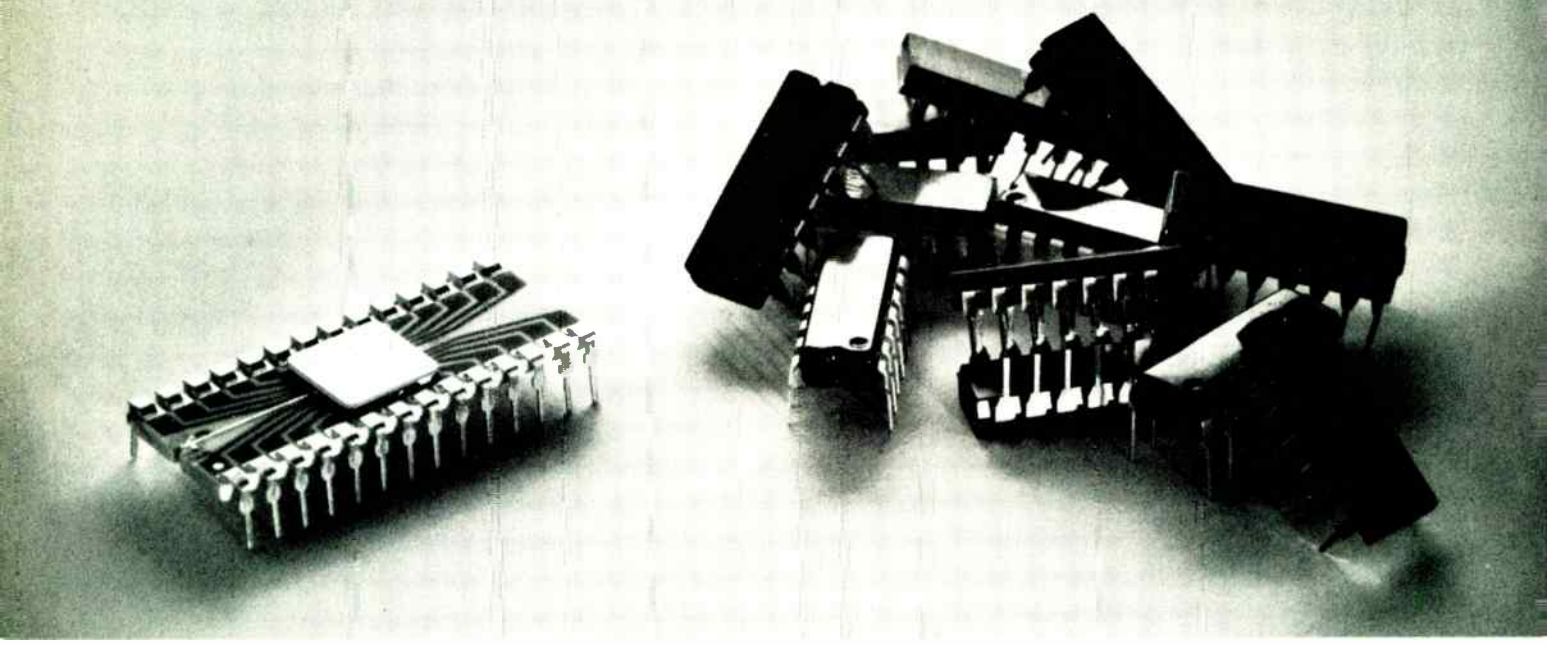

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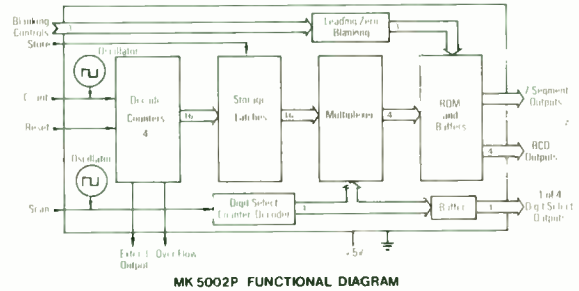

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Circle 28 on reader service card

Diode laser's on right track for car pollution

TI uses lead, tin, telluride to obtain proper wavelengths of auto exhaust emissions in work for GM project

Not long ago lasers were technology looking for applications, but now the uses are finding them. For instance, they are practically the only way to measure the constituents of air pollution because they can be made to emit conveniently at the absorption wavelength of the common pollutants. If the laser beam is absorbed, the pollutant is present. Then, by correlation techniques, the kind and amount of pollution can be determined.

The problem is to build a compact laser system that emits in the right spectrum, which generally means at 4 to 10 microns. Gas and dye lasers will do this, but they're bulky, as well as difficult and inefficient to operate. On the other hand, the typical small diode gallium-aluminum-arsenide lasers emit at too long a wavelength, typically 9 microns.

The solution may have been found at the Texas Instruments Central Research Laboratories in Dallas under a contract from General Motors. The job was to develop a compact diode laser emitting throughout the spectral range of the major pollutants found in automobile exhausts—4.2 to 10 microns. The pollutants are carbon monoxide at 4.2 microns, carbon dioxide at 5 microns, and the unburned hydrocarbons at the longer wavelengths.

TI researchers have developed a new kind of diode injection laser. It is similar to the old GaAlAs laser except that its materials are lead, tin, and telluride. The wavelength of its emission can be tailored simply by varying the amount of tin. The heavier the tin concentrations, the shorter the wavelength.

The GM scheme is to put an array of lasers (say five) together with a suitable one-for-one array of detectors in the path of the exhaust. Each Pb-Sn-Te laser diode would be doped with enough tin to make it emit at the absorption line of one of the pollutants.

TI has built several experimental models and has the diodes lasing at the required wavelengths. The trick was to make the diode laser operate in the continuous-wave mode required by spectroscopy, which is very difficult in this material system. TI engineers are cooling the laser to about 28 Kelvins, and hope to be able to run cw at higher temperatures—the temperature of liquid nitrogen, for example.

GM, which is also looking at other approaches, is pushing the project because it must meet stringent pollution standards by 1975.

Manufacturing

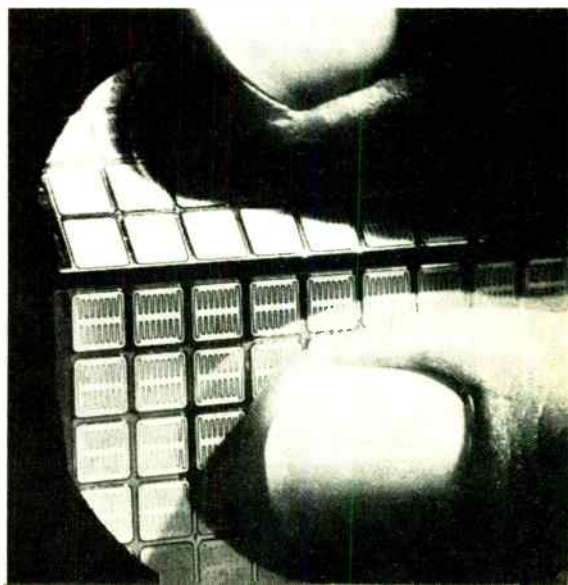
Laser scribers find willing users

A little more than a year after the first laser system developed specifically to scribe silicon wafers was installed at Motorola's Semiconductor Products division in Phoenix, [*Electronics*, Nov. 23, 1970, p. 70], laser scribing has taken hold as a production-proven technique at many semiconductor houses, and spawned heated—albeit narrow—battles for capital equipment dollars.

By the dozen. The system installed at Motorola to scribe zener diode wafers is the model 601 Laserscribe, made by Quantronix Corp., Smithtown, N.Y. Since last July, Quantronix has delivered two more of the $55,000 machines to Motorola, and Richard T. Daly, Quantronix president, says his firm has installed "about a dozen" of the units in all. Moreover, he says he has dozens of firm orders, and maintains that they're coming from the top half-dozen firms in the semiconductor industry, though he identifies only TI besides Motorola.

But Quantronix doesn't have the field to itself. Electroglas Inc., Menlo Park, Calif., has to deliver 11 laser wafer scribers by Nov. 19, says G. E. Lucus, corporate marketing

Quick break. Fresh from Quantronix model 601, wafer is cracked after scribe.



director. The Electroglas machine, like the Quantronix scribers, uses a neodymium-doped YAG laser, and is priced just a shade under the Quantronix units at $54,750. In addition to the 11 systems to be delivered this fall, Electroglas also has shipped scribers to TI's facility in Munich, Germany, and to Electronic Controls Corp., Dallas. Lucus adds that one of the 11 to be delivered by Nov. 19 will go to AEG-Telefunken in Germany, and that an Electroglas system is also being evaluated by Motorola.

And there's a third company ready to introduce two versions of a laser scriber in 30 to 60 days. The Korad department of Union Carbide Corp.'s Electronics division will price its entries at "just under $50,000 and just under $40,000," says William Thurber, general manager of Korad in Santa Monica, Calif. The difference between the two units is that the less expensive one has a tungsten-halogen pump lamp for the laser, which has less power than the one driven by a krypton lamp.

Korad has extensive experience in laser manufacturing, and is particularly strong in YAG laser technology. Just how well the company can do with a fully integrated system remains to be seen. Korad lasers have been used in homemade silicon scribers at North American Rockwell Microelectronics Co., among others, and it's likely that there has been some cross-fertilization between the two companies. Thurber claims to have one firm order from "one of the major companies in the electronics industry."

For keeps. Quantronix has improved the throughput rate of the model 601 in an upgraded version, the model 602 Laserscribe. Daly says that every company that has evaluated a Quantronix laser scriber wants to keep it—but not necessarily for better yields in the scribe-and-break operation, touted as one of the big benefits of laser scribing. While there is a yield improvement, Daly believes more semiconductor houses are interested in getting rid of the microcracks caused by diamond scribing, leading to failure in the device as these cracks propagate during thermal changes.

For every three Quantronix orders in the U.S., there's one from overseas, Daly says. He thinks the Administration's new economic policy could have three effects on the market for laser scribers. The first would be to make the machines 10% cheaper for overseas companies because the customer will be paying in devalued dollars. The second could be that overseas customers won't buy because the 10% surcharge on imports may curtail their U.S. market for devices scribed abroad. Finally, the third might be to make the machines 10% cheaper for U.S. firms if Congress ratifies the President's proposed investment tax credit plan.

Daly sees his market continuing for two or three years, and envisions all major semiconductor manufacturers adopting laser scribing of silicon wafers. "But I don't think there's room for three companies in the market," he adds.

Meetings

Wescon's cloud has silver lining

The 1971 Western Electronic Show and Convention completed its four-day run late last month and bore out earlier grim forecasts, [*Electronics*, Aug. 16, p. 58]. Attendance fell to 24,800, down nearly half from the 45,000 in San Francisco two years ago, and off 17% from the 30,000 visitors some Wescon officials were predicting. There were only 551 booths, far below last year's 999 and 1969's 1,199.

But there were positive results from the industry's No. 2 meeting, according to some exhibitors and to Wescon show management. Visitors stayed longer at the show, the lower attendance weeded out many of the marginal attendees, and companies that did exhibit received more attention because some of their competitors were absent.

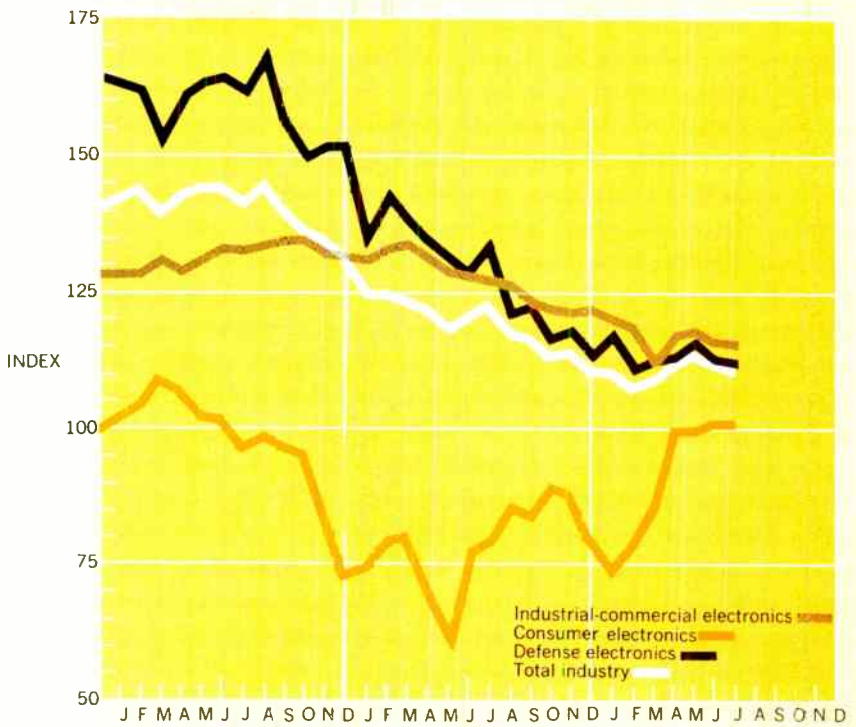
The pattern of visits changed somewhat from previous years, says Ted Shields, Wescon's assistant general manager. Normal stay for Wescon registrants has been six hours, he says, but this year's activity indicated that people were staying eight or nine hours and more of them came back for a second day. His indicators showed that many booths were still quite active until 9 p.m. closing time Aug. 25, and, instead of the doldrums that usually set in early on Friday afternoon, the last day, a number of booths were still busy until after the show's 5 p.m. closing time.

As for the technical sessions, Shields says "though there was some sparse attendance at some of them, six sessions had standing room only."

The two halls making up the Wescon exhibit this year were like two different shows. The components and microelectronics exhibits in the Civic Auditorium seemed to be getting very little attention, especially in comparison to the very busy booths in the downstairs Brooks Hall, where the instrumentation, circuit packaging, fabrication equipment, and computers and calculators exhibitors were.

Glen Madland, president of Integrated Circuit Engineering Corp., which has exhibited in the components section for about eight years, summed up his impression of the components and microelectronics exhibits with two words that were echoed by many others: "Very quiet." A spokesman for Burr-Brown Research Corp., however, says his firm benefited because its competitors weren't there. "We made a couple of fairly sizable direct sales, which we don't usually do at shows," he notes. Burr-Brown's booth attendance was down about 400 from the 1969 Wescon total, but it registered a slightly higher percentage of show attendees. The quality of Burr-Brown's booth visitors was better than usual, too. "The people who came and looked were really interested," he adds.

Movement. Monsanto Electronic Special Products of Cupertino, Calif., also exhibited its light-emitting diodes and other display products in the components section. It



Electronics Index of Activity

Sept. 13, 1971

The index backed off in July, dropping 0.6% from the revised June figure to 111.6. This put the total industry 5.6% behind the same month a year ago. Two of the three major components turned down to cause the overall decline. Defense production was off 0.6% while industrial-commercial electronics fell 0.5%. Consumer output held steady.

Segment of Industry	July '71	June '71*	July '70
Consumer electronics	101.8	101.8	80.2
Defense electronics	112.7	113.4	125.6
Industrial-commercial electronics	116.1	116.7	127.8
Total industry	111.6	112.3	118.2

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

also was "quite happy with the traffic through our booth," says Gary Breeding, marketing services director. He estimates Monsanto got 12% to 13% of the total show attendees, and that 25% of them generated specific inquiries for product information.

While these reactions were exceptions to the rule in the components and microelectronic arena, Brooks Hall was another story. Companies exhibiting liquid crystal displays and electronic calculators got considerable play.

Visitors to the calculator exhibitors' booths showed that they were potential customers by repeatedly asking prices for the desktop or hand-held models.

A spokesman for North American Rockwell Corp's Electronics Group estimates that 7,000 to 10,000 persons visited the multifaceted booth, were liquid crystals, bubble domains, and silicon-on-sapphire products got most of the attention. "We were very happy with the response, considering we were back at Wescon for the first time in several years," he says.

The same sentiment was expressed by John Fluke Manufacturing Co. A spokesman for the Seattle instrument maker says, "We were pretty happy with the show and with the attendance. Traffic held up well, and we had good quality. The geographical distribution was better than last year because the Japanese continent was down and there were more people from Canada, France, Spain, and Israel." Total number of qualified visitors to the Fluke booth, however, was down about 8% from last year's Los Angeles show.

For bellwether Wescon exhibitor Hewlett-Packard Co., "results were mixed; some of our booths were mobbed and others were disappointing," a spokesman says. Calculator and computer products drew heavily, frequency synthesizers drew only moderately, and HP Associates' light-emitting diode display products drew lightly, he notes.

The spokesman added that he was pleased that the show was under one roof.

David Methvin, president of Computer Automation Inc., says the show "surprisingly, was pretty active" for the maker of minicomputers and circuit board testers. Digital Equipment Corp. was the only other computer maker exhibiting. Methvin adds that his salesmen "were in seventh heaven" precisely because of this situation. "Anyone who had an interest in computers gave it all to us and DEC. It was a good show," he observes, "and we'll probably be in the next one."

Patents

New licensing policy could be boon to business

Will new patent regulations, which permit Government agencies to grant exclusive licenses, turn into a bonanza for industry? The answer,

says one industry observer, is that "companies will have to overcome the 'not invented here' psychology if they want to benefit from the new regulations." But, cautions another, "Who knows what's available behind the door?"

President Nixon finally opened that door when he handed down a new patent policy, ending the traditionally nonexclusive licensing practices that characterized agency interpretations of the old patent policy. "Over half the patents owned by the Government were developed by Government employees," explains James E. Denny, director of the Office of Government Inventions and Patents in the U.S. Patent Office, "and industry has never had a crack at those."

Exclusive. Perhaps more important, the changes in the patent policy, first suggested to the White House in 1968, give agency heads the power to grant contractors at the time of contracting greater, even exclusive, rights to inventions spawned by Government-sponsored research—if the agency feels that exclusivity is necessary to insure commercial development of the invention, or if the Government's contribution to the invention is small compared to the contractor.

"The key is to accomplish the transfer of technology from the Government to the public," Denny says, "and not to collect revenues, although the policy probably will be interpreted broadly enough that royalties can be collected if an agency thinks that's important." He adds that foreign licensing of Government-owned patents will continue on a royalty basis. Moreover, the Government will retain nonexclusive, nontransferable, paid-up rights to make, use, and sell the inventions that it has licensed to contractors.

The next step is for the Administrator of General Services to prescribe licensing regulations for promoting the utilization of these patents. One such set of guidelines, drafted by the Federal Council for Science and Technology, is now circulating among the agencies for comment. The GSA regulations, which officials expect to be published in six months to a year, may require Government-owned patents to be offered on a nonexclusive basis for perhaps two years before applications for exclusive grants can be considered. Or they may permit exclusivity for a period of time less than the patent life, just long enough for a company to recoup development costs, or require that the grantee spend a specific amount of money each year toward the invention's development. "In any case," Denny says, "it will not be an out-and-out divestiture of property."

At the Pentagon, the first signs of the new patent policy will surface in the negotiation of greater rights to inventions developed under military funds in new contracts. DOD has the largest portfolio of patents—some 12,000, an official there estimates—and expects to start pushing them to industry, although it will not say what shape that promotion will take. "We expect an increased interest," a procurement policy official says, "but not an overwhelming, land-office rush."

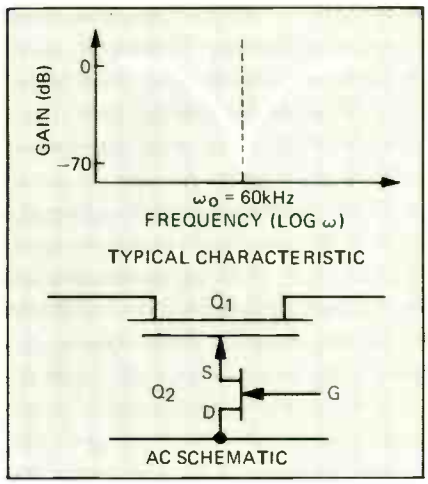
Components

Notch filter features constant depth

An integrated notch filter with a constant notch depth over its entire operating frequency range has been developed at the University of Virginia. What's more, the device can be tuned linearly from 50 to 115 kilohertz with a dc bias voltage.

The developers, Robert Mattauch and Harry Benz, say that the filter should sell for less than $1 packaged. They hope to explore arrangements with a manufacturer.

The device makes possible total electronic tuning in such circuits as amplifiers and phase-shift oscillators, as well as in instruments like wave and spectrum analyzers. It would replace the frequently used method, in critical circuits, of trying components until the proper tolerances are found. With instruments, the usual way is to mechanically move an inductor slug.



Constant. Tunable notch filter for critical circuit and instrument applications.

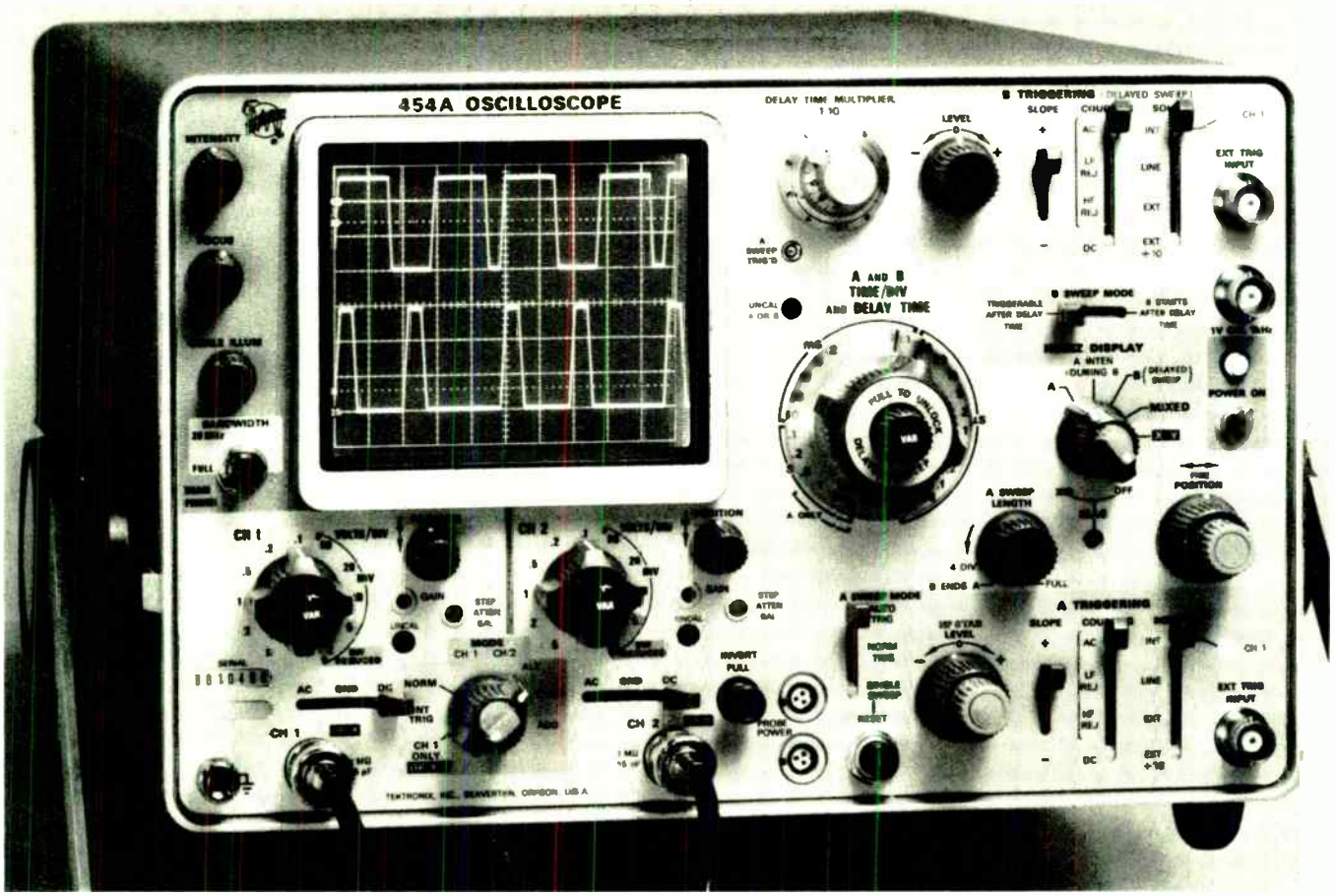
The monolithic filter consists of two specially designed n-channel insulated-gate MOSFETs. One (Q_1 in the diagram) has a long channel to simulate the behavior of a distributed-parameter system, like a transmission line. The other, Q_2, is geometrically matched on the chip to Q_1 and has its drain terminal isolated from the common MOSFET substrate.

Two dc voltages are required to tune the device—one between the drain of Q_2 and the substrate, another between Q_2's gate and the substrate. The drain bias, which is about 1.5 times the gate bias, varies from 3 to 17 volts over the filter's tunable range.

Lasers

Spin-flip device could play role in SST story

The quiet voice of the National Bureau of Standards' Measurements Laboratory in Boulder, Colo., may yet be heard in future debates about the supersonic transport. Long adept at using laser emission to measure the absorption spectra of various atmospheric constituents, scientists at the Boulder laboratory are eyeing a new kind of tunable laser—a spin-flip Raman-effect unit just developed by Bell Laboratories—whose ability to emit at the



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The New 454A has even more built-in performance and measurement ease than its field-proven predecessor. Here are just a few of many examples.

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Max Sweep Rate	5 ns/div	2 ns/div	2 1/2 times more horizontal resolution
FET Inputs	No	Yes	More stability—More reliability
Max Def Fact @ 150 MHz	20 mV/div	10 mV/div	Measure lower amplitude signals at higher BW
Max Def Fact	5 mV/div	2 mV/div	2 1/2 times more gain
Calibrated Mixed Sweep	No	Yes	More display capability
Maintenance	Easy	Easier	More on-site measurement time
Color-Coded Panels	No	Yes	More operating ease
150-MHz Probe	Yes	Yes	It's easier to handle Still—maximum BW at the probe tip

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absorption lines of many atmospheric pollutants should allow the experimenters to determine the extent of damage, if any, that the plane would cause.

Because the big planes—whether Anglo-French, Russian, or American—would fly about 10 miles above the earth in the ozone-rich portion of the atmosphere, their exhaust would convert some of the ozone to nitric oxide. Just how much nitric oxide is already in the atmosphere has never been determined. If there are great quantities, a little more produced by an SST wouldn't matter much. But if it is not present naturally in great quantities—as claimed by some critics of the SST project—the amount created by the craft could cause a severe imbalance in the atmosphere and even destroy the ecology of the high sky.

Tuned in. The NBS scientists feel that they can settle the controversy by designing airborne measurement equipment using the spin-flip laser source tuned to the spectral absorption line of nitric oxide. By measuring how much laser light is absorbed by the nitric oxide in the atmosphere, the quantity present can be determined. Most important, this technique takes only 5 seconds to detect 0.01 part per million in a gas volume of only 1 cubic centimeter. Thus, even if only small quantities are present naturally, they could be measured and compared to the amount that might result from SST flights.

The spin-flip laser is ideal for this purpose because it's easily tuned (by varying the magnetic field, say from 30 to 40 gauss on a cube of indium antimonide) and is stable and compact. The idea is to design a laser and detector unit that could be flown through the ozone with and without SSTs present. The NBS scientists have ordered the laser's magnet and hope to set it up and have molecules radiating by Christmas. And if their laboratory experiments are successful, they feel they could get something into the air not long after that.

The measurement technique most likely would follow the Bell Labs work. There, the spin-flip Raman laser consists of a carbon monoxide pump, emitting continuously at one of the vibration bands of carbon monoxide. Pump power is about 0.7 watt. The CO beam is focused on an indium antimonide sample in a magnetic field; the radiation passing through the material is the tunable spin-flip Raman radiation that's used in the special measurements.

Average power of about 50 milliwatts can be obtained in a tuning band of around 5,000 angstroms by changing the magnetic field from 20 to 55 kilogauss. The Raman output is the focus on a nitric oxide gas absorption cell with typically 15 MW useful light available, sufficient for accurate absorption detection. The Bell researchers have already measured 20 ppm of nitric oxide in nitrogen, with an integration time of only 1 second. Extrapolating from this, the Bell scientists feel that concentrations as small as 0.01 ppm can be detected. And that's what NBS scientists in Boulder are excited about.

Consumer electronics

Petition for quadcasts awaits FCC decision

The battle over what four-channel stereo broadcast approach will become the standard has started. The first petition for a decision on a discrete channel scheme is in the hands of the FCC. If the commission decides to consider it, which seems likely, it will give notice of a proposed rule making, and here's where the battle will begin.

It could take the FCC a while to make a decision on four-channel broadcasting. If it decides this month to consider the petition, "it almost certainly will bring in every other developer of four-channel equipment," one commission official predicts. The standard-setting jurisdiction also could be shifted to the National Association of Broadcasters.

Whichever discrete four-channel technique is approved, however, it faces another battle—this time in the marketplace. The competition here is the four-to-two-to-four channel matrixing system which can be broadcast over present two-channel equipment. In most cases, this approach doesn't require FCC approval and there already is some broadcasting.

The first petition for FCC rule-making came from Pacific FM Inc. (KIOI-FM in San Francisco), after two months of on-the-air tests and six months of test data analysis on the approach developed by Quadracast Systems, Inc., San Mateo, Calif. [*Electronics*, March 1, p. 71].

Basically, Quadracast differs from two-channel transmission (which employs a matrixing technique and rely on encoding broadcast material before the transmitter and decoding it at the receiver) by adding subcarriers to the existing 38 kilohertz signal: at 38 KHz and at 76 KHz. Thus, there are three suppressed subcarriers: the two at 38 KHz and in quadrature modulation.

In the main 0-to-15 KHz band, the left front, left rear, right front, and right rear signals are all present. This enables the listener with a monophonic radio to get the full program material. On the first 38-KHz subcarrier, the left front plus the left rear—minus right front and minus right rear—are sent. With the information on this subcarrier and in the main band, two-channel stereo receiver owners get the full two-channel material.

The second 38-KHz subcarrier contains the left front, minus the left rear and minus right front, plus right rear. At 76 KHz the subcarrier contains the left front, minus the left rear, plus the right front, minus the right rear. All four signals can be combined and decoded into four discrete channels by a receiver equipped with a decoder developed by Quadracast. This gives the listener true four-channel sound.

The tests have shown, according to the petition, that with the four-channel system, channel separation is from 35 to 40 decibels—the FCC requires 29.7 dB minimum—and subcarrier-to-main-carrier crosstalk is 55 to 60 dB down—the FCC requires at least 40 dB. Frequency re-

Bell & Howell & Heads You Win

"Wow! We've done it! A super headed recorder/reproducer like nothing nobody's ever seen!"

This from one of our brighter back room boys as he charged into our office.

"Take a look guys. 2MHz performance at 60 ips. Realize what that means? Perfect recording with half the tape. And at about $200 a reel, that's a cash register full of saved bucks."

"Not bad."

"And it's so good we've given the record head a whompin' 5,000 hour warranty."

"Well, I think we got something to work with. Anything else?"

"Yeah, those are both industry firsts from Bell & Howell."

"And?"

"Well, it has the usual 14 channels. 15/16 to 240 ips and stuff like that, in the conventional format."

"Ummm, who uses the thing?"

"R&D types mostly. It's about as sophisticated as you can get. They use it for aircraft tests. Cars To pull down whole libraries of data from field recorders. That sort of thing."

"Sounds like a heckuva machine."

"System."

"Okay, system. So what do you call the super headed system?"

"The VR3700B."

"Wow. That really tells it like it is. Okay, we'll do an ad. But first I'll flip you for coffee. Call it."

"Heads."

"You win."

"Hey, not a bad headline for the..."

"Are you kidding? Beat it. Sheez, can you imagine."

Read about it. Bell & Howell, CEC/Instruments Division, 360 Sierra Madre Villa, Pasadena, California 91109.

CEC/INSTRUMENTS DIVISION

BELL & HOWELL

Circle 35 on reader service card

Electronics review

sponse is 50 to 15,000 hertz.

Quadracast is now working with a West Coast integrated circuit manufacturer on the design of a monolithic chip to perform the decoding function.

Quadracast says the difference in making a stereo tuner and a four-channel tuner will be about $2 to $3 in OEM quantities; a converter for existing units will cost $10 to $20 for OEMs.

Solid state

Arsenic and a new American transistor

With an added marketing incentive from Washington, where the Government has reshaped its economic policies to put a premium on buying American, Fairchild's Microwave and Optoelectronics division is turning out a broadband transistor that formerly was available only from Japan. The device, operating at 1 gigahertz and above, had been supplied by Nippon Electric Co., but a new process has planted Fairchild firmly in the market.

Customers are electronic countermeasures builders, who need low noise and a wide operating frequency range. And what may be best of all, says Michael Hackworth, general manager for transistor and circuit products, is the price. "We originally priced it at about 30% below Nippon. But with the added 10% surtax and the possible 10% advantage we may gain with the floating dollar, we could come in at 50% lower."

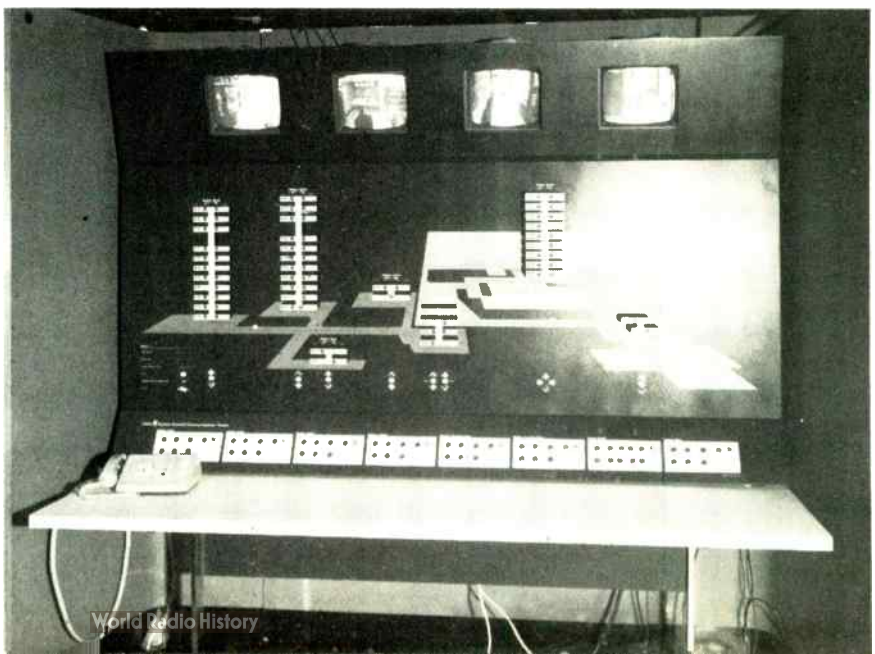
The new process employs arsenic for the emitter diffusion instead of phosphorus, and the result is a device, says Fairchild, that is equal to Nippon's at 3 GHz and better at 4 GHz. Explains John A. Archer, a researcher at the device physics and development department at Fairchild: "Arsenic emitter transistors have a base transit time two to three times smaller than that of phosphorus emitter devices. This reduction results in higher f_t and f_{max}, and in a reduced noise figure. f_t of 15 GHz and f_{max} of 26 GHz have been obtained." Archer points out that either parameter can be optimized by choosing the proper collector doping and thickness. "For typical microwave applications, both must be high." Such a device would have f_t of 7 GHz, f_{max} of 22 GHz, and a 4-decibel noise figure at the 4 gigahertz level.

Commercial electronics

Electronic orderlies hasten hospital automation

They still have to wait for the elevator—but they don't visit among themselves, quit at 4:30, or ogle the nurses.

Quiet orderly. Computer simulation of installation slated for Harper-Webber Medical Center in Detroit. Carts are guided by snap-in diode boards that sense path embedded in floor.



Lowest distortion

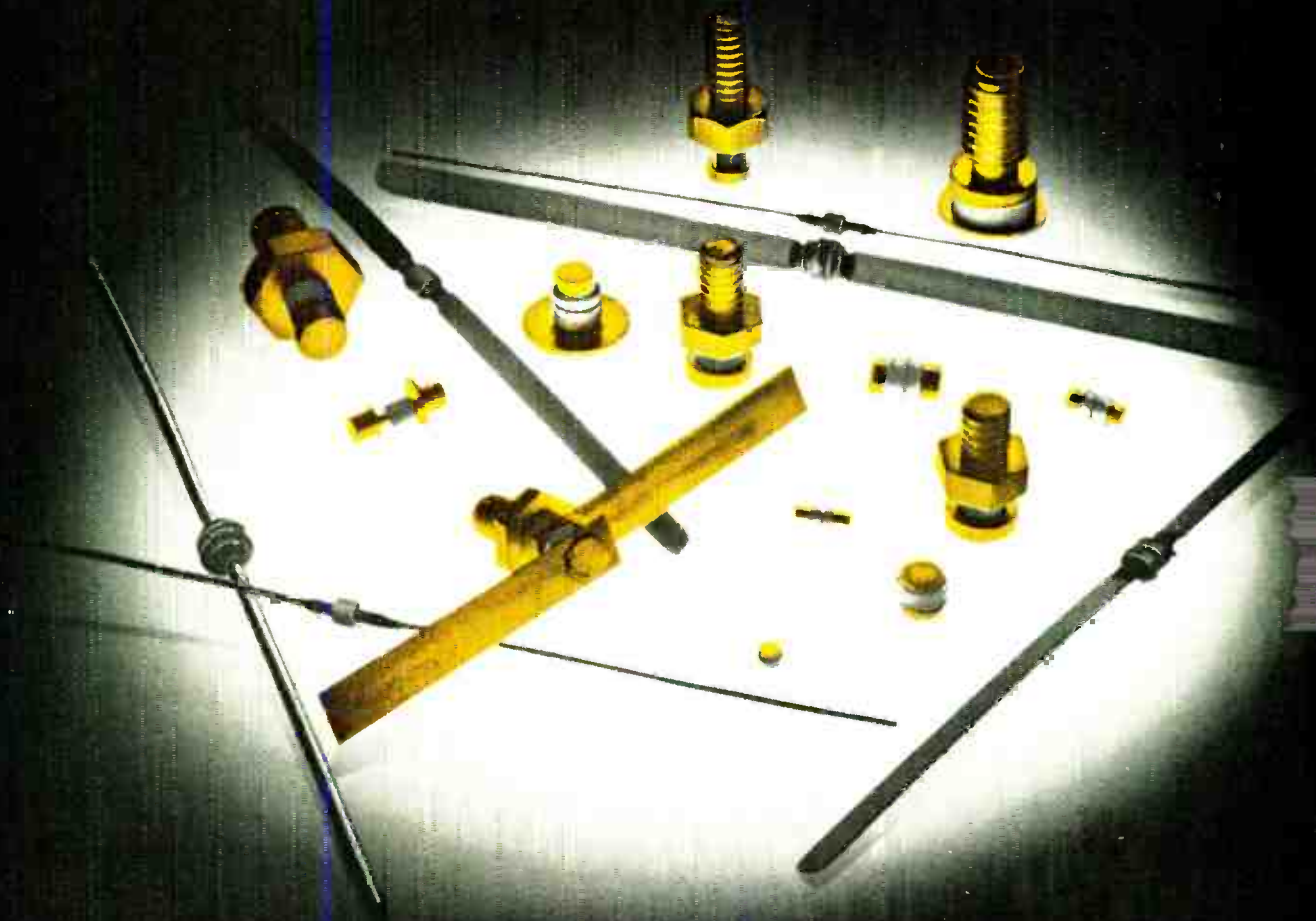
and low cost in PIN diodes

If you are designing a VHF or UHF system with strict harmonic or intermodulation product requirements, Unitrode PIN diodes, with industry's longest carrier lifetime (1-10 μsec typical) will put your mind at ease.

In addition to the low insertion loss and high reliability aspects on Unitrode's fused-in-glass PIN diodes, we can now offer the additional advantage of low distortion switching and attenuating. By controlling certain key parameters in our patented manufacturing process we can guarantee second and third harmonic levels of 90 db below fundamental and intermodulation products as low as 60 db. This guaranteed low distortion performance costs no more. (Available under 90¢ in quantity.)

Applications from HF through UHF include TR switches, duplexers and receiver protectors in military and commercial two-way communications systems. They also reduce distortion in AGC loops and tunable filters in CATV systems.

For further information, samples and applications assistance, call Bob Tremblay at (617) 926-0404 or write Unitrode Corporation, Dept. 10 C 580 Pleasant Street, Watertown. Mass. 02172



UNITRODE

Circle 37 on reader service card

Electronics review

Add to that increasing labor costs and a decreasing supply of unskilled hospital employees, and it's easy to see why hospital administrators are turning to automated materials-handling systems to move hot meals, laundry, trash, pharmaceuticals, and surgical supplies through the hospital.

Hospital officials say they expect such systems to pay for themselves over seven or eight years. Consultants for the new 800-bed Harper-Webber Medical Center in Detroit estimate that the $2.25 million system they are installing will do the work of 60 people, and the Westinghouse Health Systems department, in its report on a new generation of military hospitals [*Electronics*, June 21, p. 32], recommends that consideration be given to completely automated systems in 200-to-300-bed and 700-to-800-bed hospitals.

The Harper-Webber system, manufactured by Detroit's Jervis B. Webb Co. for the American Sterilizer Co.'s Amsco Systems division, consists of 500-pound, 5-foot robot carts guided by snap-in, diode boards that sense paths embedded in the floor. The sensing device electronically compares the phase of signals received by a reference coil and corrective signal coil from braided guide wires.

The paths emit signals at either 6.5 or 10 kilohertz, and the diode boards can be programed to select the proper signal to turn corners, or automatically restart after a stop of predetermined length. Built-in block patterns prevent collisions at intersections.

The carts can also travel vertically in passenger elevators equipped with a vertical series of photo-receptor cells that matches a series of lights on the cart's side. A special tiller control allows the robot to be automatically moved off the guide-path and the cart element can also be used as a normal hospital cart by rolling it off the automatic base unit, which contains the electronic sensors and power supply. The carts can even be programed to go to a battery charge area as the service is needed.

Companies

Calculator price drop may yet save a maker

A company that helped force desktop calculator prices well below $200 because its parent corporation needed cash is still hanging by a tenuous thread. But International Calculating Machines, the Woodland Hills, Calif., subsidiary of Electronic Arrays Inc., may yet snap back [*Electronics*, July 19, p. 18]—precisely because of its own and Electronic Arrays' cash flow difficulties—and set a new trend in prices to boot. The reason: the price cuts forced on ICM by Electronic Arrays' cash flow problems have resulted in a purchase order for 75,000 machines. But they won't be built unless $1 million is raised.

ICM was formed late last year as an all-American company to challenge Japanese competition [*Electronics*, Feb. 15, p. 37]. Its first machine, the ICM 816, uses six MOS/LSI chips made by Electronic Arrays, and the complete calculator is assembled at the Woodland Hills site of Electronic Arrays' Systems division. But the machine carried an initial $395 price tag at a time when prices for this class of calculator were beginning to drop in special sales at discount stores.

ICM intended to provide machines to OEMs only. Then its first customer, Caltype Corp., a Los Angeles office machines wholesaler, couldn't pay under terms that called for ICM to deliver 2,000 machines a month; so ICM found itself with a big inventory. That's where it stood just before Mois Gerson (see p. 8), was moved into the presidency of Electronic Arrays.

Gerson says 2,000 machines still in production at ICM are being finished, bringing the total of 816s produced to 6,500. Of that number, 5,500 were sold to a distributor who sold them to a Palo Alto, Calif., retailer to help alleviate the cash bind at Electronic Arrays; the firm also borrowed and had a private stock placement. But it's believed the cal-

Thank you

for showing us that engineers still appreciate creative design. Design that isn't measured by how many jazzy junctions and metallurgical miracles you can cram onto a chip of silicon. Design that goes back to the fundamental constraints of circuits, functions and economics.

Three months ago, the engineering team which had labored so long to produce the first major instrument breakthrough in five years agreed that the job was done. So we called in the toughest bunch of critics in the business — the editors of the leading technical magazines in electronics.

We told them, and showed them, what we had done: gone back to fundamentals and developed a *completely new generation of digital multimeters*. We showed them original, patent-applied-for circuits that achieved orders-of-magnitude improved performance, at a *fraction* of the cost of the circuits then in use. Circuits that made it possible to actually cut the selling price of a premium-grade 5½ digit multimeter by 50% or more . . . while significantly reducing the component count, and thereby greatly enhancing reliability.

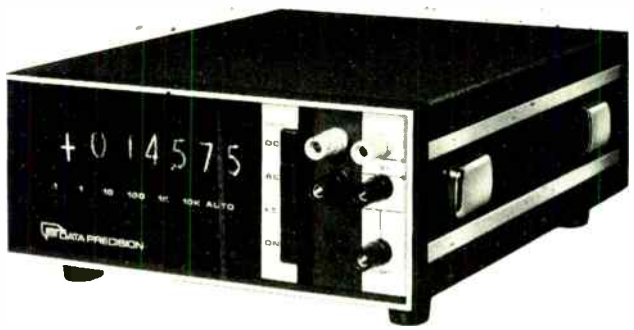
Then we showed them a vastly improved package . . . easy to use, convenient to calibrate . . . a package that saved half the size and more than half the weight that burdened earlier premium-grade DMM's. And just for good measure, we showed them a compatible family of 4½ digit designs, at equally startling savings.

They came. They saw. They probed. They challenged. (We must have explained our new TRI-PHASIC™, ISOPOLAR™, and RATIOHMIC™ circuits dozens of times.)

And then came the editorial critiques. Admittedly, we're not in the best position to be objective, but cooler, less involved colleagues tell us that they cannot remember ever having seen such a *consistently enthusiastic* editorial response to a new family of instruments.

But the story doesn't end there. The phone began to ring steadily. Letters poured in. We got firm purchase orders even before our catalog was printed. Our first production run was sold out before we had provided a single field rep with a demo unit. And the response continues to exceed all reasonable expectations.

There isn't sufficient space on this page for complete specs, or competitive comparisons, just enough to show you one of our beautiful new 2000-Series Digital Multimeters. But please write or call. We'd like to show you what the excitement is all about. Data Precision Company, Audubon Road, Wakefield, Massachusetts 01880.
Phone (617) 246-1600



Model 2540, 5½ digits. DC volts, AC volts, Resistance, Voltage Ratio. Auto-ranging. Auto-Polarity. Isolated BCD outputs. Remote triggering. Remote ranging. Basic accuracy ±0.001% f.s. ±0.007% rdg ±1 l.s.d. for 6 months. One-piece price: $1,195.00

DATA PRECISION
...years ahead

culators were sold to the distributor for about $100; his retail price was $139.50. The machines sold out quickly, and few of the other 1,000, which other retailers have been offering at $169, can be found.

Gerson wants to retain ICM as part of Electronic Arrays. He and Earl Gregory, vice president and director of marketing for Electronic Arrays' Semiconductor division, are convinced that both their firm and the retailers can make a profit with a four-chip evolution of the 816, designated the 816A, built with plastic-packaged chips.

The quandary now is how to meet the purchase order for 75,000 machines—including the 816, 916A, and two newer models, the 820 and 120. Gerson says he has three options: outright sale of ICM, a joint venture that would provide both a cash infusion and a marketing organization familiar with business machines, or maintaining ICM as a subsidiary "provided we enter a contract through which payment for the calculators would reduce our financial burden," Gerson says.

It's known that Eldorado Electrodata Corp., Concord, Calif., is interested in buying ICM. Eldorado is an instrument manufacturer that has its own inexpensive calculator in the works. Electronics Arrays officials won't say who has ordered the 75,000 machines, but Gerson indicates that he's running out of patience and will probably choose any of the three options that materializes first. "We've waited three months already," he says, "and that's too long."

Regardless of the option selected, the ICM experience has hastened the drop in desktop calculator prices.

Computers

Speech recognition system handles service calls

Computer: "What is your terminal type?" (beep)

Engineer: "2 . . . 7 . . . 0 . . . 1."

Computer: "Type 2 . . . 7 . . . 0 . . . 1. Understood. Is this correct?"

This is part of a sample conversation between an IBM computer in Raleigh, N.C., and an IBM customer engineer telephoning from somewhere in the country. It's possible because of IBM's first operational use of speech recognition. The system, Automatic Call Identification, is designed to troubleshoot the company's tele-processing equipment.

The new system automatically answers and identifies calls coming into IBM's Tele-processing Test Center in Raleigh. It then switches the call, much like a telephone operator would, to the line that has the proper routine for testing the type of terminal being serviced. In the example, it is a model 2701 data adapter. IBM says that by automatically routing the calls, instead of using an operator, more efficient use is made of the incoming phone lines.

The system has a 13-word vocabulary—the numbers 0 through 9, and the words zero, yes, and no—and is programed to recognize one word at a time. Its signals are recognized by an experimental general-purpose frequency spectrum analyzer built around a filter bank approach. Groups of filters cover the frequency spectrum across the 3,000-hertz telephone bandwidth.

The voice signals are converted to a digital pattern and compared with patterns stored in a disk file. The system will recognize anyone's speech; it doesn't have to be "trained" by first hearing the vocabulary words.

For the record

Space Co-op. Working groups of NASA and the Soviet Academy of Sciences hope to complete agreement on technical specifications for compatible rendezvous and docking systems when they meet in Moscow in late November. Exchange of information and ideas will continue before the meeting, covering general methods and techniques for rendezvous and docking, radio and optical reference systems, communications systems, life support, and crew transfer and docking assemblies. At their first meeting at Houston in June, the groups agreed in principle on technical solutions and requirements and solutions.

A bilateral agreement on space cooperation could mean significant contract modifications to future U.S. manned orbital spacecraft, particularly the Skylab workshop scheduled for a May 1973 launch. Projected first test of compatible systems, says NASA, could dock an Apollo-type spacecraft with a Soviet space station of the Salyut class, followed by the docking of a Soviet Soyuz-type vehicle with Skylab.

Split. Honeywell's reorganization into two worldwide operating units, Information Systems and Control Systems, is designed to make the units as autonomous as possible. Corporate headquarters will remain in control of organization and executive personnel selection, financing, accounting, basic research, legal matters, and public affairs, while other areas are being shifted to the two operating units. There will be some personnel changes and cutbacks in the corporate branch.

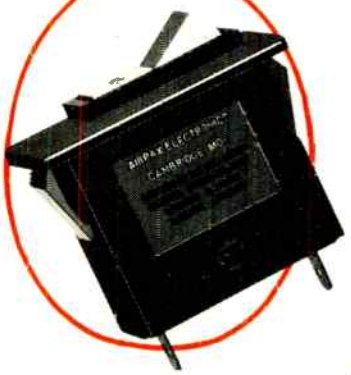
Line forms. Prime candidates to fill the now empty slot of U.S. Patent Commissioner are Donald W. Banner, patent attorney at Borg-Warner, Chicago, and head of the American Bar Association's patent, trademark, and copyright section, and Robert Gottshalk, now acting head of the Patent Office and a GAF Corp. lawyer until coming to Washington to take the number two position under William Schuyler Jr. Banner was second choice when President Nixon picked Schuyler, and is generally rated higher on managerial ability than Schuyler.

Shuttling. Space avionics equipment competition for NASA's space shuttle program is expected to be unaffected by the dispute that has arisen over award of a $500 million shuttle engine contract to North American Rockwell's Rocketdyne division. The forecast by NASA and industry sources is based on the premise that the program will go forward using proposed engine designs and related electronics regardless of who ultimately builds the huge engines.

AIRPAX

TYPE 203 ELECTROMAGNETIC CIRCUIT PROTECTORS

203

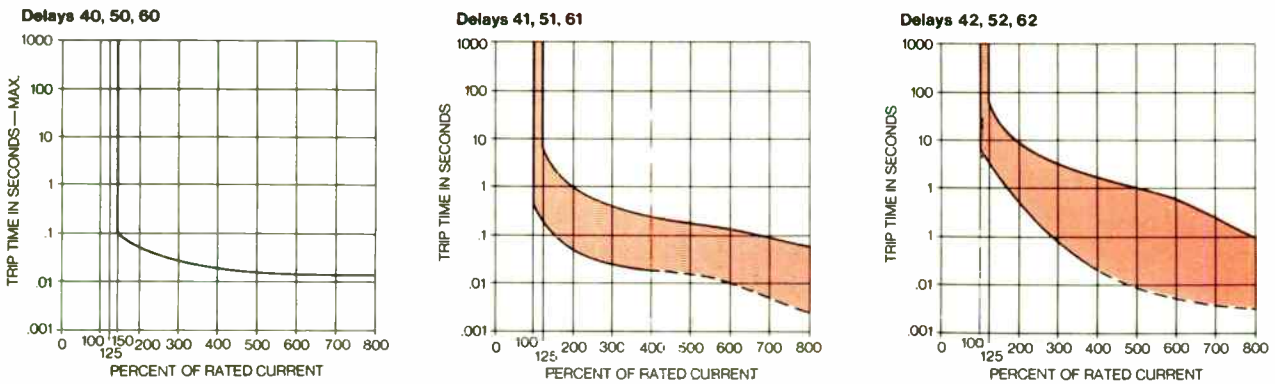


Type 203 front panel mount electromagnetic circuit protectors are designed for use in computers, computor peripherals, copying machines, air conditioners, marine controls, and other high-quality industrial and military equipment where accurate, reliable protection is demanded.

FEATURES

- Snap-in front panel mounting for fast, economical installation
- Optional flush mounting available
- Single rocker actuator for 1, 2 or 3-pole assemblies
- Selection of color combinations
- 50V DC and 250V AC (50/60 or 400 Hz)
- Current ratings from 0.020 to 20 amperes
- Choice of inverse time delay or instant trip

Trip Time vs Percent Rated Current @ 25°C



Delays 40, 41 and 42 are for use in 400 Hz systems; delays 50, 51 and 52 are for use in DC systems; and delays 60, 61 and 62 are for use in 60 Hz systems.

For complete details, specifications and application examoles, call or write:

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model 10

A New Programmable Calculator That Can Perform 10 Simultaneous Equations Yet Costs Only $2975.

That's right, the new Hewlett-Packard Model 10 is the *most powerful* desk-top computing tool on the market, and it costs nearly half as much as its nearest competitor. That's just the beginning. The Model 10 is also the *most versatile* programmable calculator. The modular structure of the Model 10 allows *you* to specify the capability you need to match your particular problem-solving situation. With the Series 9800 Model 10, you can:

Design your own keyboard with special plug-in modules that give you single keystroke solutions for statistics, mathematics, or special functions for a host of disciplines. The Statistics and Mathematics Function Blocks include Read-Only-Memories, so they do not draw upon the main calculator memory.

Specify the memory size you need. In basic configuration, with a program memory of 500 program steps *and* a separate data memory of 51 storage registers, the Model 10 can solve 10 simultaneous equations. If you need more memory initially, or if growing demand warrants a larger capacity, both the program and data memories are easily expanded with simple plug-in modules. You can get a Model 10 with 500, 1000, or 2000 program steps *and* 51 or 111 data storage registers.

Select the display options. Now you can choose a Model 10 Calculator with Display only, with the silent Strip Printer for basic hard copy, or with the *exclusive HP Alphanumeric Printer* and have the ability to automatically label data and solutions.

Add peripheral equipment to complete your system. The Model 10's ASCII compatible I/O structure allows you to interface with such work-saving peripherals as a Marked Card Reader, Paper Tape Reader, Formatted Output Typewriter, or X-Y Plotter.

Together these features add up to one thing for you—*a truly personal computing system*—a system that gives you the power to literally put your hand on the answer in the fastest, most economical manner.

Features. Price. Versatility. We say the Hewlett-Packard Series 9800 is the best desk-top computing system now, and in the foreseeable future. But don't believe us; ask our competitors. Or write for more information or a "hands-on" demonstration right at your desk. Hewlett-Packard, P.O. Box 301, Loveland, Colorado 80537.

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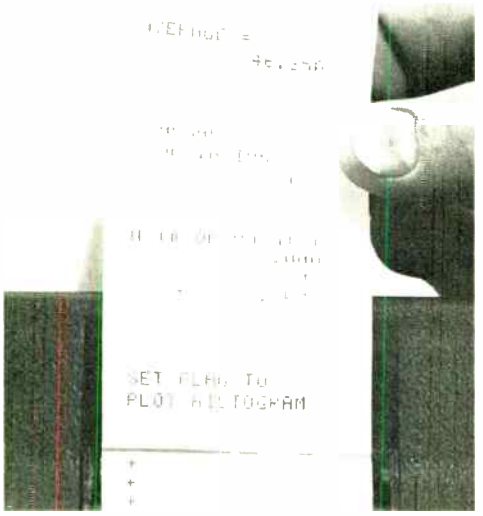
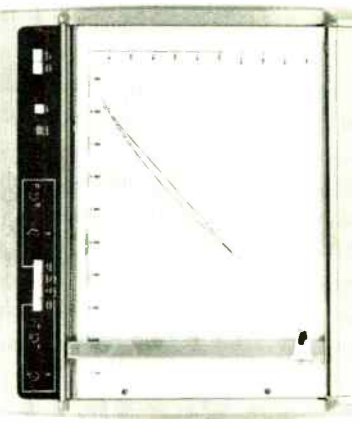
HEWLETT hp PACKARD

CALCULATOR PRODUCTS



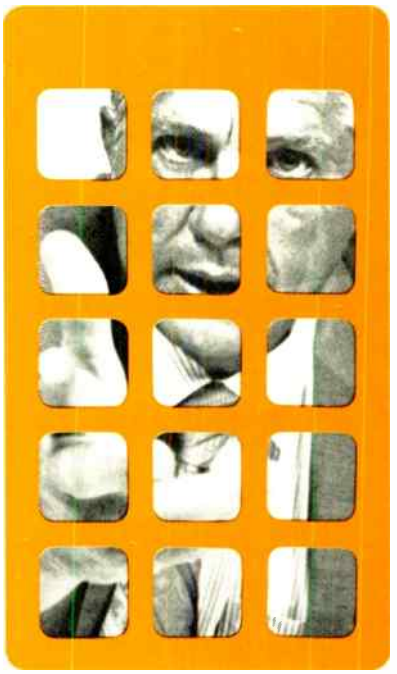
*The **exclusive** Alphanumeric Printer automatically labels data and solutions.*

*Interchangeable Keyboard Blocks Include **Statistics**, **Mathematics**, or **User Definable** Functions.*



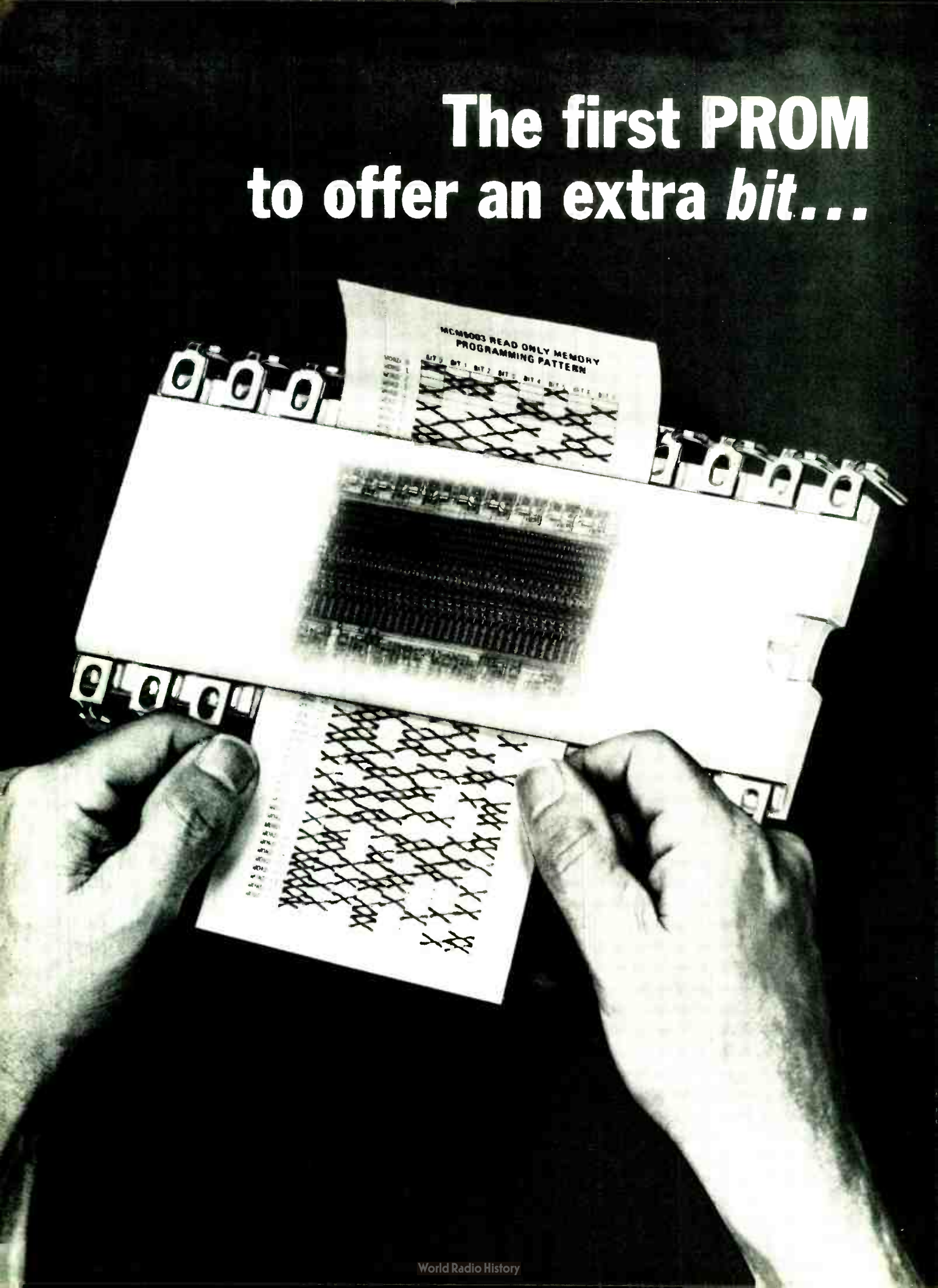
Model 62 X-Y Plotter generates linear, log-log, and semi-log plots,automatically.

SERIES 9800



YOUR PERSONAL COMPUTATION SYSTEM

The first PROM to offer an extra *bit*...



...for greater reliability!

Introducing the MCM5003A, the industry's first field-programmable ROM with a built-in reliability factor. Basically a 512 bit bipolar device organized as 64 eight-bit words, the MCM5003A offers "instant customizing" by merely "blowing" nichrome resistors and thus breaking metalization links. The blown links change the initial logic "0" state to a logic "1" state to meet specific program requirements.

A *bit* more for reliability

Since unprogrammed ROM's have all outputs low regardless of address, testing does not detect many faults in amplifier inverters, address decoders, memory array and sense amplifiers. Special consideration is required in the areas of Program Element Testing, Functional Testing and AC Testing. To solve these problems, Motorola expanded the memory from a 64 word, 8 bit memory to a 64 word, 9 bit memory with the 9th bit dedicated to testing.

By blowing some of the 9th bits, we can assure that the links can be blown without using up any of the normal 64 x 8 bit array. With some of the links blown, functional and AC performance testing is now possible. This is important in that all of the 64 x 8 bit array elements are in a logic "0" state regardless of the address selected, and no way would be available to determine whether the functions are correctly operating without the 9th testing bit.

The MCM5003A circuit contains six address inputs to select the proper word and two chip enable inputs, as well as outputs for each of the eight bits. Supplied in a hermetic 24-pin dual in-line ceramic package, the MCM5003A has positive enable with open collector outputs. Another version, the MCM5004A, has positive enable with 2.0 kilohm pullup resistors on the collector outputs. Both devices are MDTL/MTTL compatible and access times are less than 75 ns.

By stocking the MCM5003A you can work up custom microprograms, lookup tables, code and number conversions without the worry of turnaround time and costly mask charges. And speaking of costs, either the MCM5003A or 5004A is available for $45.00 (100-up price) — less than 9¢/bit. Programming can be accomplished at your facility, through your distributor, or here at Motorola.

Take advantage of the MCM-5003A's "instant customizing" by calling your local Motorola distributor for evaluation devices today. Or write to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036. We'll send complete specifications plus our latest application note describing several programmers that can be built specifically for programming the MCM5003A/5004A.

It'll pay to evaluate the MCM5003A . . .

A Memory To Remember For Reliability

Motorola can now supply memories to meet your specific requirement, whether it be high-speed, low power, or custom products. In traditional Motorola fashion we can draw from the technologies of MOS (Ion-Implanted, Silicon Gate CMOS, N-Channel) or advanced bipolar techniques — each technology offering specific advantages to meet your application.

MEMORIES TO REMEMBER

RAMs				
DEVICE	**FUNCTION**	**TECHNOLOGY**	**ORGANIZATION**	**ACCESS TIME**
MC1680/81	4 Bit RAM	ECL - BiPolar	2 x 2	< 4 ns
MC1682/83	4 Bit RAM	ECL - BiPolar	2 x 2	< 4 ns
MC1684/85	4 Bit CARAM	ECL - BiPolar	2 x 2	< 4 ns
MC1036/37	16 Bit RAM	ECL - BiPolar	4 x 4	< 50 ns
MC4004/5	16 Bit RAM	TTL - BiPolar	16 x 1	< 25 ns
MCM4064	64 Bit RAM	TTL - BiPolar	16 x 4	< 60 ns
MCM1170	64 Bit Static RAM	Metal Gate P-MOS	16 x 4	500 ns
MCM14505	64 Bit Static RAM	Metal Gate CMOS	64 x 1	200 ns (typ.)
MCM1173/72	1024 Bit Dynamic RAM	Metal Gate P-MOS	1024 x 1	400 ns
ROMs				
MCM4001 (XC170/171)	128 Bit ROM	TTL - BiPolar	16 x 8	< 45 ns
MCM4002	256 Bit ROM	TTL - BiPolar	32 x 8	< 50 ns
MCM4004	1024 Bit ROM	TTL - BiPolar	256 x 4	< 60 ns
MCM4006	1024 Bit ROM	TTL - BiPolar	256 x 4	< 50 ns
MCM5003A/4A	512 Bit PROM	TTL - BiPolar	64 x 8	< 75 ns
MCM1130	2240 Bit Static ROM	Metal Gate P-MOS	Open Option	500 ns
MCM1131/32	2240 Bit Char. Gen.	Metal Gate P-MOS	Col. Sel. 64 x 35 (5 x 7)	500 ns

MEMORIES TO COME

RAMs				
DEVICE	**FUNCTION**	**TECHNOLOGY**	**ORGANIZATION**	**ACCESS TIME**
MC10140	64 Bit RAM	ECL - BiPolar	64 x 1	< 15 ns
MCM4256/7	256 Bit RAM	TTL - BiPolar	256 x 1 / 128 x 2	< 60 ns
MCM2372	1024 Bit RAM (1103 Equiv.)	Si-Gate P-MOS	1024 x 1	300 ns
MCM2374	1024 Bit RAM (1103-1 Equiv.)	Si-Gate P-MOS	1024 x 1	180 ns
MCM2377	2048 Bit RAM	Si-Gate P-MOS	2048 x 1	360 ns
ROMs				
MCM4003	512 Bit ROM	TTL - BiPolar	64 x 8	< 75 ns
MCM4005	1024 Bit ROM	TTL - BiPolar	1024 x 1	< 50 ns
MCM4007	1024 Bit ROM	TTL - BiPolar	512 x 2	< 50 ns
MC10139	256 Bit PROM	ECL - BiPolar	32 x 8	< 17 ns
MCM5005	1024 Bit PROM	TTL - BiPolar	256 x 4	< 60 ns
MCM1110	2048 Bit ROM	Metal Gate P-MOS	256 x 8	600 ns
MCM1120	2240 Bit ROM	Metal Gate P-MOS	64 x 7 x 5	700 ns
MCM1140	4096 Bit ROM	Metal Gate P-MOS	512 x 8	700 ns
MCM1150	2560 Bit ROM	Metal Gate P-MOS	256 x 10	600 ns

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Circle 45 on reader service card

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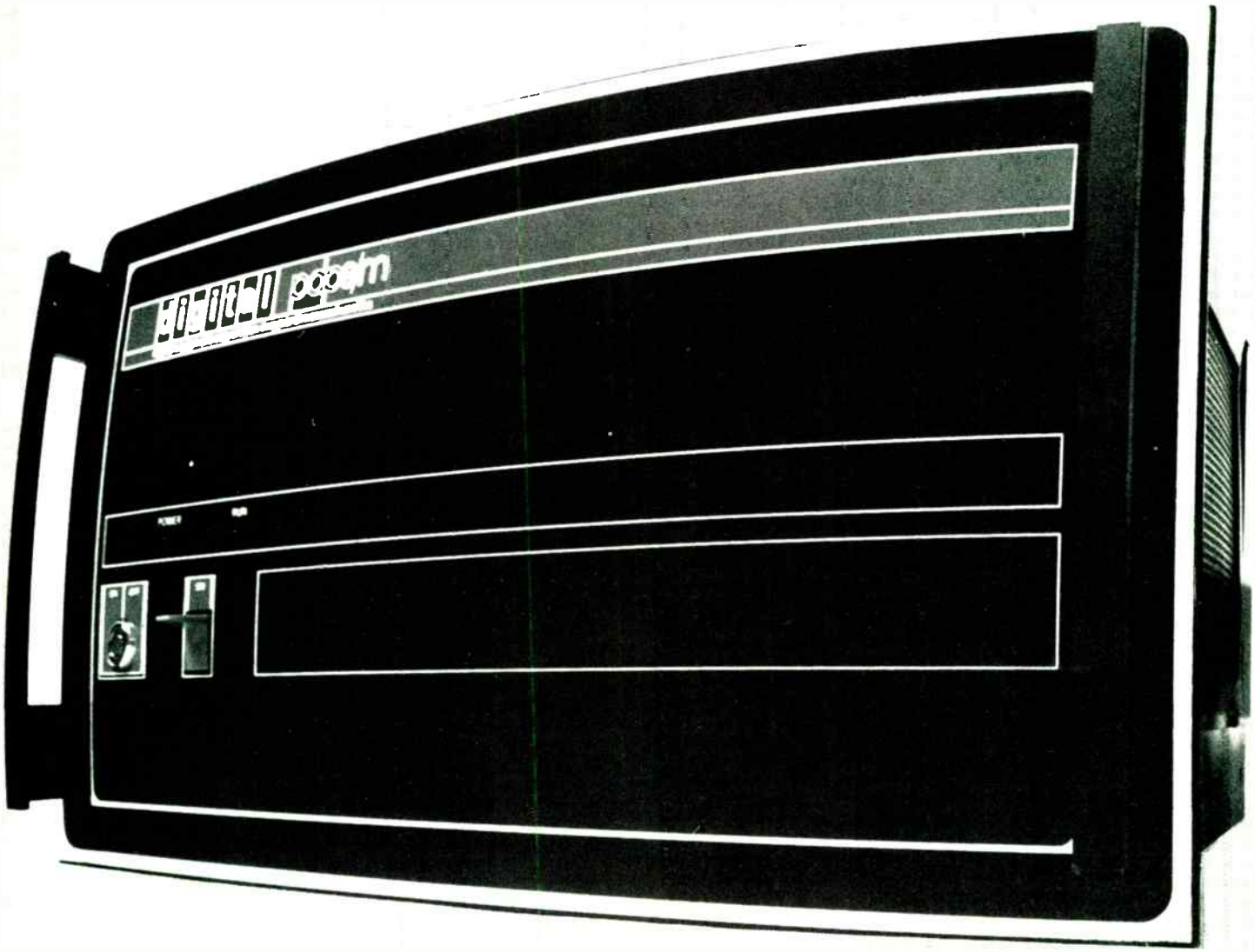

On your left, the 12-bit PDP-8/M. On your right, the 16-bit PDP-11/05. Our brand new additions to the world's most popular families of minicomputers.

Complete computers — at incredibly low prices. Like $3,069.00 for the 11/05, and $2,362.00 for the 8/M in quantities of 100. Even the discount schedule is new. Very attractive.

In addition, they're compatible with the rest of the family members. Their options. Their peripherals.

They have the features of their bigger brothers. And, a full instruction set. OEM-oriented architecture. Both the UNIBUS™ architecture of the 11/05 and the OMNIBUS™ architecture of the 8/M permit easy, flexible configuring and interfacing. Real pluses for the OEM.

They're built with the kind of reliability that comes easy after delivering over 11,000 minicomputers.

OEM Yardsticks

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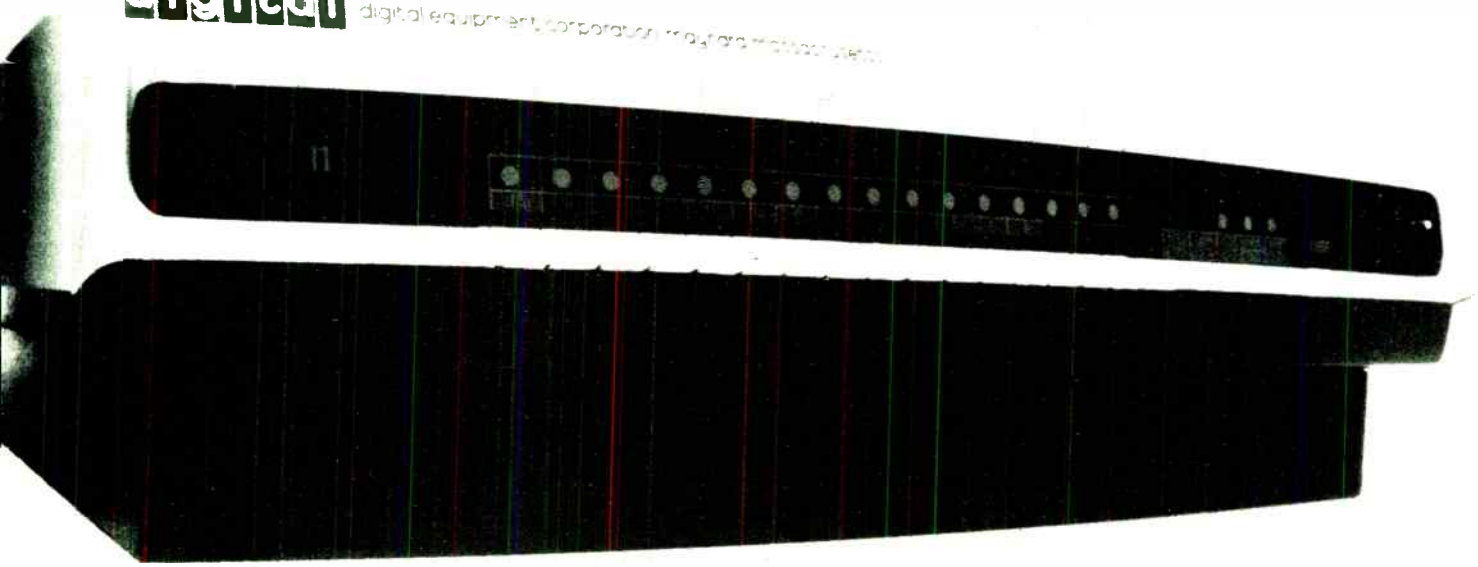

And, they're supported with more field backup than you can get anywhere else. Worldwide.

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digital

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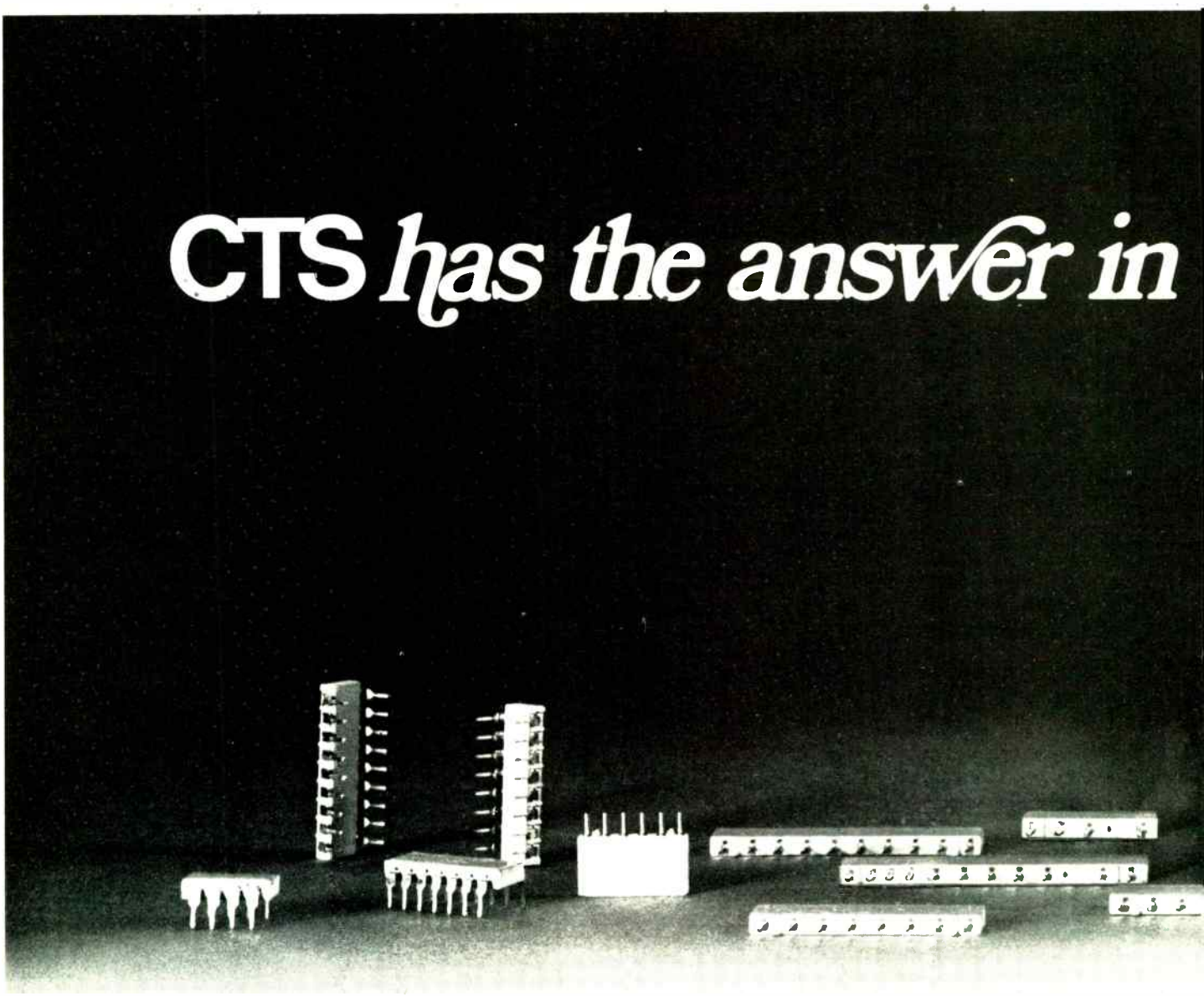
CTS *has the answer in*

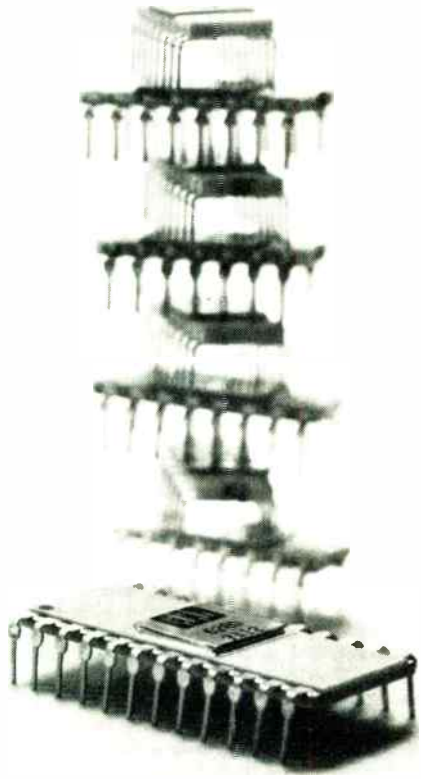


You name it—we have the exact cermet resistor network size and characteristics you need. Here's the choice you get right now: our *750 line* includes: .100" centers with 4, 6 & 8 pins; .125" centers with 2, 4, 6 & 8 pins; and .150" centers with 4 through 13 pins. And we're working on new designs right now!

All compact, extremely stable and highly reliable.
Recently we packed even more circuitry into our *760 series,* giving you a choice of four popular space-saver packages: 8, 14, 16 and 18 flat lead styles. Packed with up to 17 resistors per module with flat leads standard (round leads on request).

Eight for One ROM Sale

Introducing the world's first 8K bit bipolar read only memory.



Sooner or later someone was bound to do good things with bipolar memories. We did it sooner. Think about it. That's a lot of memory on one little chip. Even MOS can't touch it. With our new MM6280 you can replace eight 1K ROMs or 32, 256 Bit ROMs. Quite a savings when you consider one masking charge vs. eight, reduced P.C. card area, fewer interconnections, lower power requirement, lower insertion costs, and so on and so on.

On top of all that, it's got 100 nsec access time and nibbles only 60 microwatts per bit of power. It has four enable lines so you can go to 16K words without adding additional decoding. And no clocks are required because it is static.

What can you do with this big bipolar ROM? Plenty. You can use it to store the full 128 ASCII character set, row or column scan, put multiple trig functions in one package (including sine, co-sine, tangent and co-tangent); build a mighty powerful microprogrammed CPU or achieve high accuracy look-up tables.

A few detail specs:

- 1024 words by 8 bit
- 60 microwatts per bit
- 100 nsec access time
- 4 enable lines
- 160 microamps address input current
- DTL/TTL compatible
- Fantastic price: .7¢/bit in hundred quantity

Pick a winner, write, call, TWX or telex for full data. Do it quick!

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Washington Newsletter

September 13, 1971

Air Force's RFP for B-1 avionics at last on the way

The Pentagon has backed the Air Force's decision on who will have management responsibility for the avionics subsystem on the B-1 strategic bomber. North American Rockwell, prime for the potential $11.1 billion program, had challenged the service's plan to make the avionics subcontractor responsible for "overall design and performance of the entire avionics systems prototype," and so had stalled the issuance of requests for proposals. The NR complaint was dropped when the Pentagon assured the company it could work closely with the B-1 Systems Project Office awarding the contract. The winner will develop or subcontract off-the-shelf equipment for the prototype B-1 computer, software, controls and displays, and the stores management system. More than 11 avionics suppliers, including NR's Autonetics, will be competing for the estimated $100-150 million involved.

Aiding the case for the controversial bomber and the passage of its fiscal 1972 funding through Congress was the public disclosure that the Russians already are flight-testing a new bomber of the B-1 class.

Waste-water control, monitoring is new automation market

Process computers and instrumentation for the automation of waste-water treatment may turn into a lucrative environmental market, according to an Environmental Protective Agency source, who estimates that electronic monitoring and control equipment will cost at least $450 million, and may go as high at $2.2 billion if the degree of automation reaches that in other bulk-processing plants, such as petroleum refineries. "The U.S. should spend $31 billion by 1976 to meet water quality standards as they now exist," he adds.

The new instrumentation needed to tap that market is discussed in a report by the American Public Works Association and General Electric's Re-entry and Environmental Systems division, which EPA will release this month. In part, the study recommends development of on-line sensors for monitoring suspended solids, biochemical oxygen demand, and mercury, plus spectrographic sensors for phenols and trace oils.

Estimates show import tax won't curb Japan

The impact of the 10% import surcharge will be "considerably less than dramatic in the long run" for the electronics industry, concede Commerce Department officials, who say that it probably won't affect Japanese penetration of U.S. markets because of large factory-cost differentials. First tentative estimates indicate that electronics imports may run only $50 million behind last year's $1.84 billion. Short-term effects, however, will hit selectively at small U.S. importers and assemblers.

Probe threatened of tactical missiles in Navy and Army

Pentagon efforts to hold down escalating costs and improve performance on several tactical missile programs by redirecting them are being closely followed on Capitol Hill. In fact, members tracking military spending see investigative opportunities. For example, the Navy has phased out General Dynamics' Standard ARM air-to-surface missile, and instead wants to spend more than $10 million this year for a follow-on weapon called HARM (for high-speed advanced radiation missile), dividing the money about equally between hardware and systems technology development. Moreover, the service wants to double spending to correct defi-

ciencies in the shipborne Terrier, Tartar and Talos missiles, to keep them in the fleet until Harpoon becomes available in the middle of the decade. **The call for another $31.2 million spending for the 3T "improvement" program for the General Dynamics and Bendix projects has Congressional critics angry in view of the $791 million spent thus far.**

On the Army side, various programs are under scrutiny, particularly two Raytheon projects, the improved Hawk air defense missile, and SAM-D, its planned successor. The basic Hawk, now being phased out, reportedly had only a 20% kill probability, and Congress appears unimpressed with Improved Hawk test performance so far—and with a $728 million program cost projection. Questions about the SAM-D, on which close to $230 million has been spent with Raytheon on R&D to date, cropped up after what Congressional staff sources believe were unrealistic Army efforts to sell the ground-to-air missile also as an ABM weapon.

Local jobs plan for technologists slips despite aid

The Nixon Administration is finding that more than money will be needed to open up new jobs for engineers and scientists in state and local governments. **Though the Emergency Employment Act, signed in July, allots $1 billion in this fiscal year to the creation of state and local jobs for an estimated 130,000 unemployed at all levels of skill, "the opportunities for technologists so far number only a few hundred,"** says William Haltigan, who oversees the effort at the Labor Department.

Edward David, the President's science adviser, is urging his state counterparts "to go out and do missionary work" on behalf of such specialists as systems analysts and engineers and their potential for contributing "some high technical competence to local government." The difficulty, in David's view, is that "the whole idea of analyzing how local government operates to look for efficiency and economies is new."

Nixon group cites need for engineers in health care

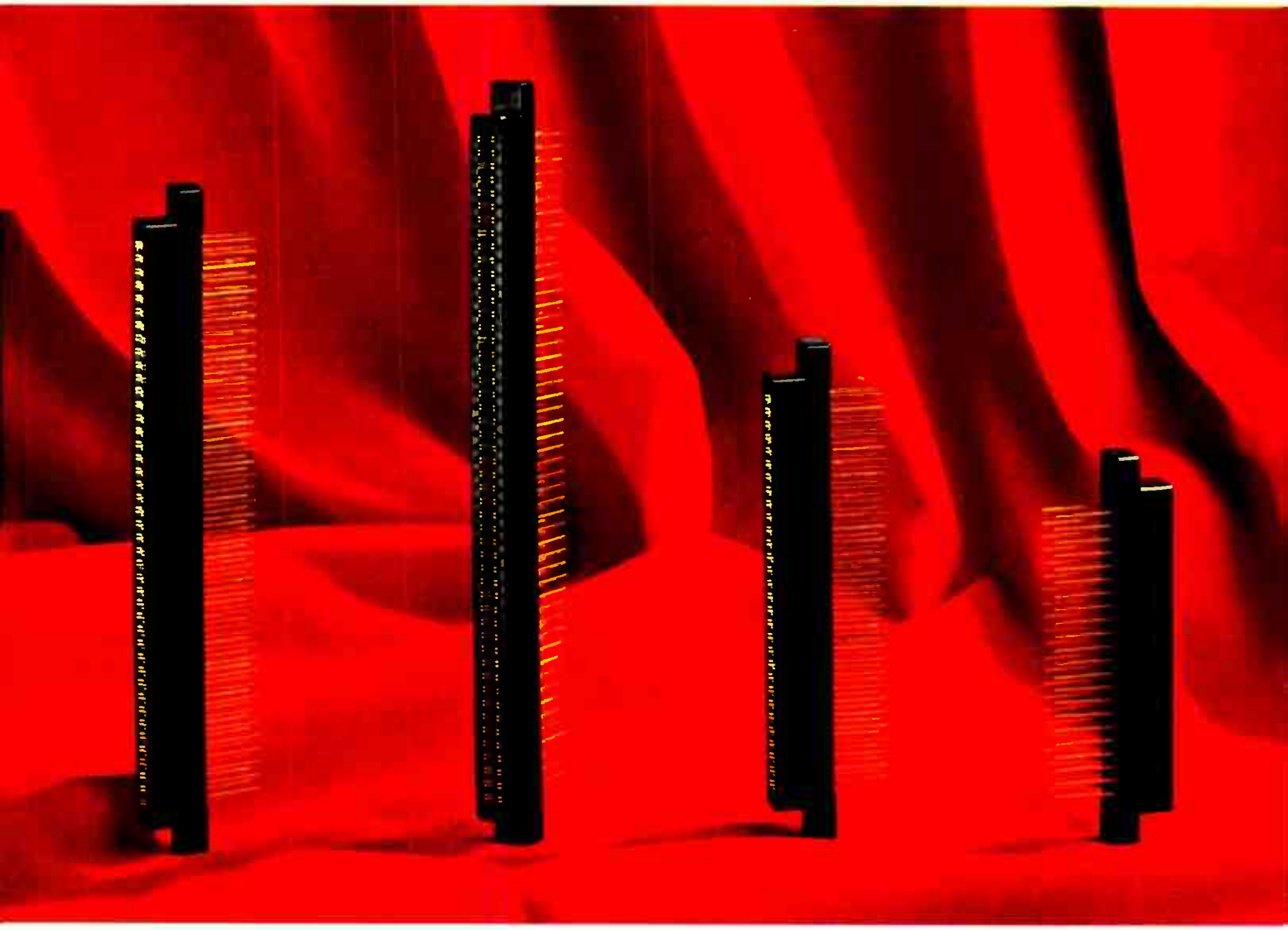
A special advisory committee on redeploying scientists and engineers in the health care field will make its final report to the President's Advisory Council on Management Improvement in mid-September. The group, charged with studying the quality and not the logistics of retraining engineers for biomedical work, in part concludes **the medical profession needs substantial high-quality technical help, especially with the increasing instrumentation used in patient diagnosis and monitoring.** Moreover, doctors are no longer unhappy about admitting qualified engineering professionals to their ranks after a comparatively modest retraining program, adds an insider.

Though many of the council's recommendations for procedures to sharpen Government efficiency are never released, this one may surface in a report to the President on health care management.

Addenda

The Air Force has appropriation approval for a $1.34 million, optical physics laboratory at Hanscom Field, Mass. The only one of its kind, it will perform infrared studies of gases generated by missile plumes and nuclear bursts in the upper atmosphere, for application in defensive target discrimination and offensive weapons guidance. . . . **The Electronic Industries Association plans to close its West Coast office in Los Angeles on Oct. 15** to cut overhead costs. Few member companies regret the action, apart from some of the large aerospace electronics corporations belonging to the Government Products division.

A new cost-saver...



to wrap your wires around.

Here's a new family of miniature pc connectors from Amphenol for wire wrapping applications. They cost you less because we've engineered new industrial grade materials into these connectors, yet retained all the same features found in military connectors.

Contact spacing is on a .100 X .200, or .125 X .250 grid and the connectors are available in 22-, 30-, 43- and 50-position models with either grid spacing.

These new 225 Series connectors have bifurcated bellows contacts for smooth, positive, 2-point mating action no matter how irregular the board surface. The bellows exert firm pressure on the pads even under extreme vibration and shock conditions. You get thousands of insertions and withdrawals without a failure.

We can also give you this new low-cost connector with solder terminations on .156 centers. And there's a QPL version to MIL-C-21097B, too.

Call your Amphenol salesman or distributor; he'll show how inexpensive it is to wrap your wires around a great connector. Or write us. Amphenol Industrial Division, The Bunker-Ramo Corporation, 1830 South 54th Avenue, Chicago, Illinois 60650.

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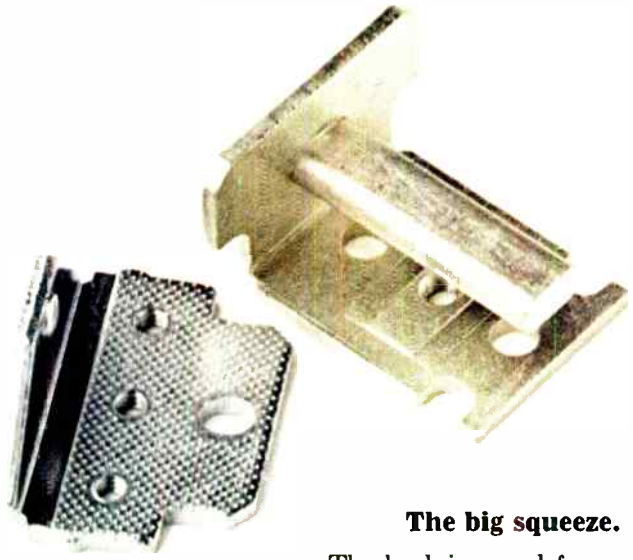
Circle 53 on reader service card

Reliability is 756 little dents and one big one.



The big squeeze.

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

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

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

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

A different kind of coil.

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

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

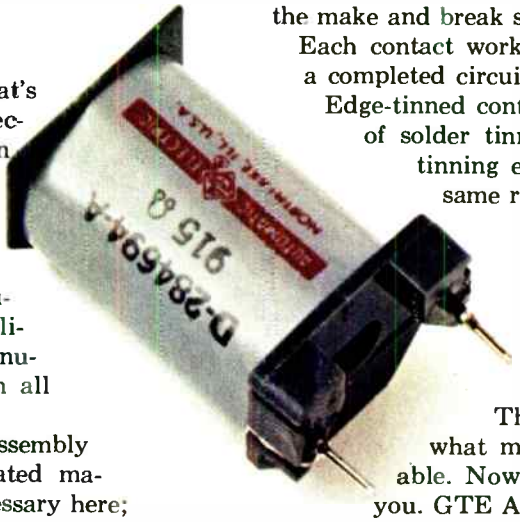
The coil is wound on the bobbin automatically. No chance of human error here.

We didn't forget the solder.

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

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

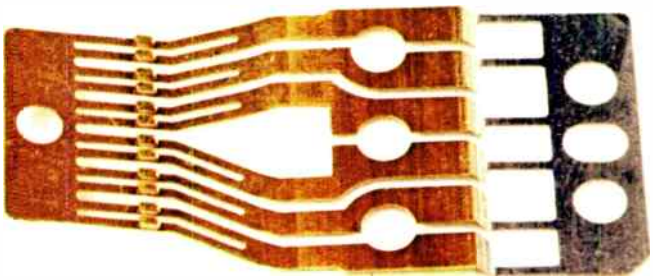
Finally, we wrap the whole assembly with extra-tough, mylar-laminated material. A cover is not really necessary here; but why take chances?



Springs and other things.

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

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



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

Two are better than one.

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

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

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

Etc. Etc. Etc.

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

GTE AUTOMATIC ELECTRIC

Circle 57 on reader service card

By 1979, French pictures will be seen live in Cameroon.

In the decade ahead, electronics will be bringing the nations of the world closer together. Socially. Economically. Maybe even politically.

Right now the countries of Western Europe are collaborating on a high-capacity communications satellite system to handle television, air traffic and picturephone networks all over Europe, Africa and the Middle East.

So, by the end of this decade, nations that not too long ago used drums for communications will have picturephone service. Major sports events, such as the 24 hours of LeMans, will be beamed live to such obscure countries as Cameroon, Dahomey, Togo and Tanzania. While Sundays in Swaziland will be spent watching live bullfights from Spain.

Fact is, two-thirds of all electronics production and consumption will be outside the United States.

Who are the master minds masterminding these international changes?

Our readers.

Among them, more than 19,000 subscribers in 110 countries outside the United States. From Australia to Zambia. The very men who are spreading the electronics market to every corner of the world.

Every two weeks, Electronics presents them with a complete, up-to-the-minute picture of the state of the technology. Including a special international section spotlighting the latest electronic innovations as compiled by our editors in Russia and Japan, as well as Europe.

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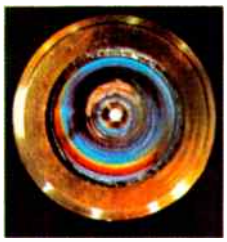

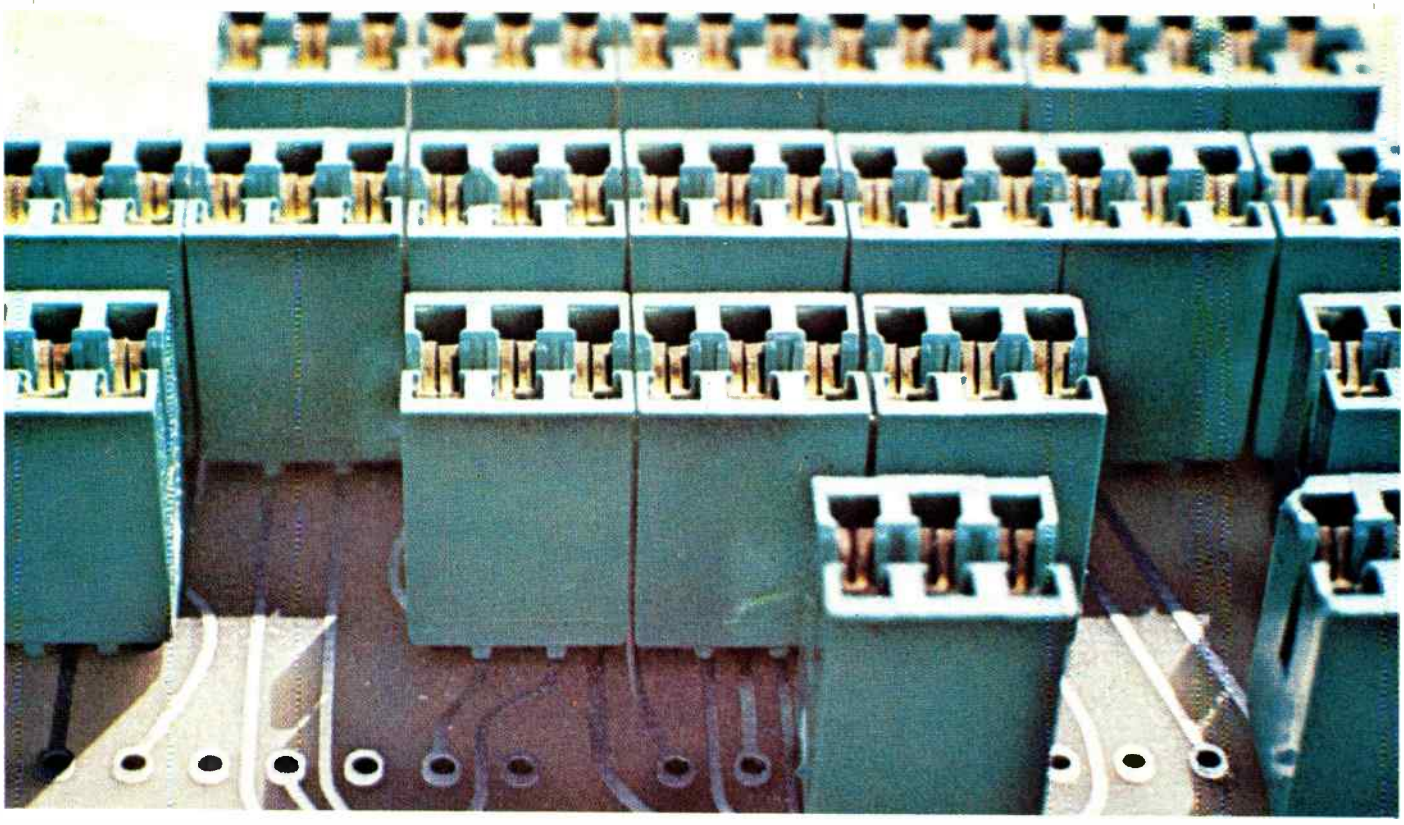

A NEW DIMENSION IN P.C. BOARD CONNECTING

Solderless connector modules with .156-inch spacing. In two sizes: all with dual readout contacts—center modules with six, and end modules with four. With these two sizes, you can custom design your connector to accommodate just about any size p.c. board.

Without soldering.

Simply push the contact tails of these Mojo™ connectors through the plated through holes of the p.c. board. And you'll have a gas tight, corrosion proof, vibration immune connection that's as electrically and mechanically sound as the best soldered joint. But more easily assembled than any soldered connection. More economically. And without the heating problems that automatic soldering methods often impose.

And Mojo gives you more.

Such as preloaded contacts that firmly grip the p.c. card, but keep their distance when the card is removed. Easily accessible square wire-wrapping posts in the event you have to make any extra back-panel interconnections. And you'll move smoothly and economically from prototype to production with just two connector modules to carry in inventory.

Did we say just two modules? Sorry, we meant four. Because Elco still makes available Mojo connectors with contacts at .150-inch centers. Same specs, same special features as the new .156-inch. Just that little .006-inch difference.

For full details and specifications on Mojo connectors, contact:

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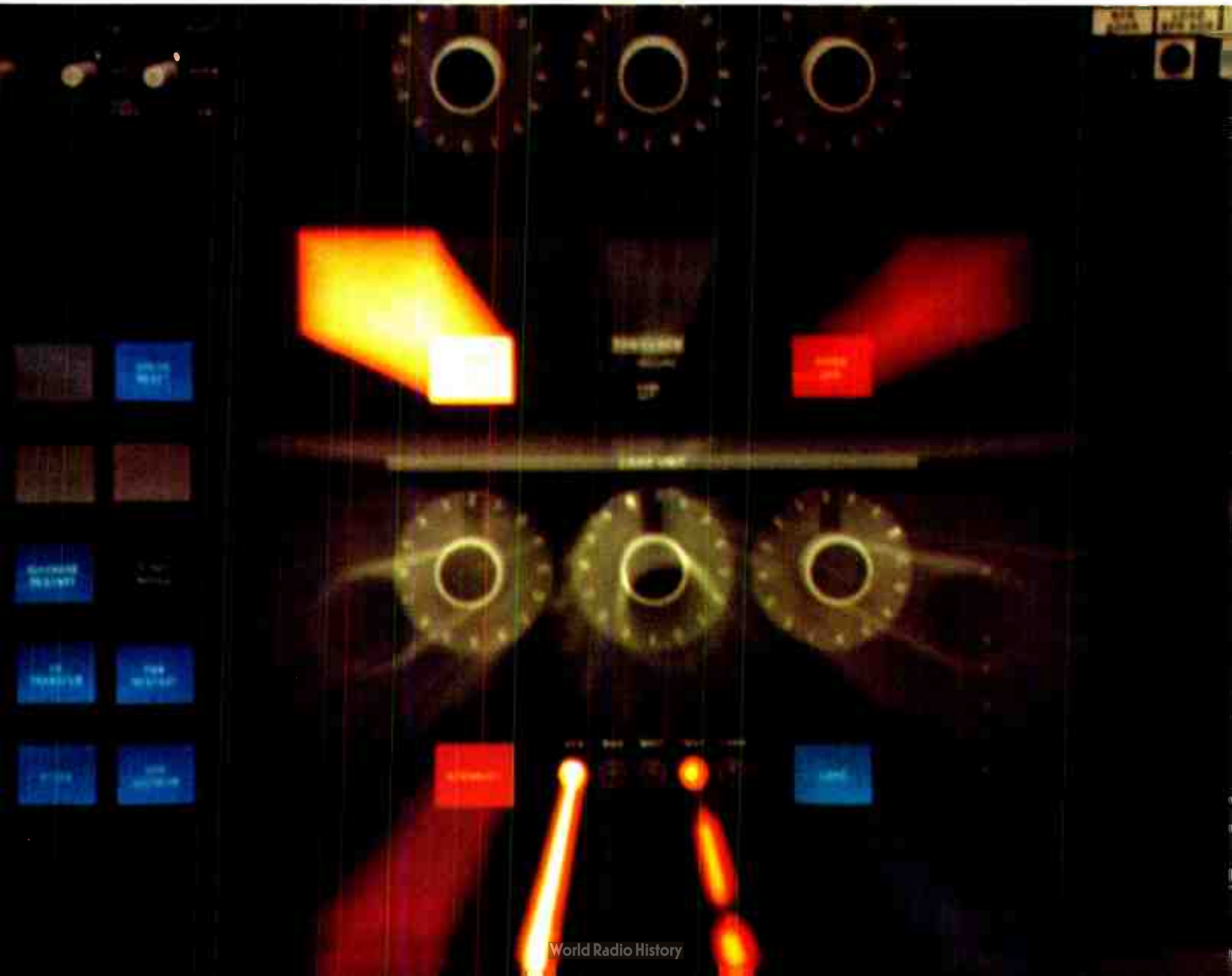
Wanted for the '70s: easier-to-program computers

Software problems and semiconductor technology will set the pace of the '70s, says this Special Report. Whichever computer architecture is used, systematized programing remains the most urgent need, though LSI is helping out with firmware. Cores will lose ground, while processors will have to learn how to keep the faster memories busy.

by Wallace B. Riley, Computers editor

1. Evolutionary growth. Adaptable to changing needs without requiring basic redesign, IBM's System 370 is a growth vehicle that will keep pace with new applications. (Photograph courtesy of IBM Systems Development Division, Poughkeepsie, N.Y.)



2. Sizable difference. Digital Equipment Corp.'s PDP-11/05 computer exemplifies the shrinking size of new machines. It's shown here in front of DEC's PDP-10 in a maximum configuration.

□ Of all the problem areas in computer technology of the '60s, software was far and away the worst. And of all the solutions prophesied for the '70s, those involving software are the most far-reaching, and could even alter the structure of the industry.

Everyone is agreed on the need to turn programing from something "handcrafted by elves in the Black Forest," as Morton Bernstein, assistant manager of advanced development at System Development Corp., Santa Monica, Calif., describes it, into a systematic, engineering discipline, built round a core of basic principles, in which all programers can be trained and from which new languages can be deliberately evolved for specific purposes. But no one is agreed on how near this situation is. "It's a job for the universities," say some, while others, more pessimistic, think it will take an Einstein or a Maxwell to bring order out of the existing chaos.

At present the disorder is such that it will affect industry trends well into the '70s. The surging interest in minicomputers is partly due to software difficulties with larger and more complex machines. The growth of firmware as a substitute for operating software and the experimentation with macroinstructions in hardware are largely prompted by the hope of limiting the areas in which software errors can run riot. Some even predict the disappearance of the distinction between programers and engineers, and the emergence of the computer engineer, skilled in both disciplines.

Worst of all is the expense. At an American Management Association conference last year, Robert McClure, president of Telpar Inc., a Dallas consulting firm, presented a diagram showing that, though the cost per hardware gate has dropped by two orders of magnitude since the middle 1950s, the cost per software instructions has remained just about constant, at around $10. This constancy itself has been achieved only because a decreasing execution cost offsets the growing number of instructions required per system and the growing cost of preparing those instructions with solid state technology.

In other areas, the pressures on data processing technology are less severe. Internal pressures stem from the ongoing debate on how best to organize computers from within. Can a network of minicomputers adequately substitute for a large computer? In a multiprocessor, is a pipeline organization of processors, as in Control Data Corp.'s Star-100 approach, preferable to a parallel organization, as in the Illiac 4? Are there some things that only a single, large machine can accomplish? Research at Iowa State University on Fairchild's radically new Symbol computer could provide the '70s with unexpected new inputs.

External pressures stem largely from the rapidly evolving semiconductor technology and from the changing character of the marketplace. Large-scale integrated circuits, for instance, are helping solve some problems at the same time as they are complicating the situation in other areas. As read-only memories, they made feasible the adoption of microprograming that is helping supplant some supervisory software and also increasing the versatility of processors. As buffer memories, too, they are improving the performance and speed of computers. On the other hand, the '70s will see the answer to the question of whether they can ever really replace core memories. Possibly, too, integrated circuits may yet help to simplify peripheral equipment, which is still largely electromechanical and by now absorbing an increasingly large proportion of the cost of a computer installation.

Other technologies could also make inroads in memories—notably magnetic bubble and beam-addressable memories, which could appear in commercial form by the end of the decade.

The impact of these technological advances is likely to be braked only by the still somewhat uncertain economic outlook and by the inertia-like effect of investment in existing technology. Failure to make a dent in software costs is especially critical since it makes the buyer in today's economic climate particularly anxious to cut costs wherever else he can.

"Users are going to acquire the capability to evaluate the bang per buck in what they buy," observes Jerome Larkin, marketing vice president of Advanced Memory Systems Inc., Sunnyvale, Calif. "They are going to stop buying equipment just because it sports the latest technological gimmick—they'll ask what the gimmick will do for them and check its cost and then buy—as like as not a plainer model."

Obviously the manufacturer who stands to lose the most in the trend toward user sophistication is International Business Machines Corp. Plenty of people used to buy machines from IBM just because it was IBM. Today, given impetus by IBM's "unbundling" or separation of its software from its hardware offerings in 1969, and by the coincidental offering by independent peripheral equipment manufacturers of machines that were plug-to-plug compatible with IBM's, at very attractive prices, a trend is already under way toward mixed installation of equipment from several manufacturers.

Architecture of the '70s

As computer technologists meet the software challenge, the distinction between engineers and programers may disappear. "Within 10 years from now," says Yaohan Chu, professor of computer science at the University of

Maryland, College Park, just outside Washington, D.C. "we'll have people engaged only in computer engineering. The increasing interest in firmware—machine control through read-only memories—during the past few years is part of this trend: engineers design the read-only memories containing firmware, but programers are likely to decide their contents."

"Along with the computer engineers," predicts Chu, "there will emerge the computer architect. Just as today you ask an architect to design a house, you will ask a computer architect to design a system. And just as the building architect combines materials and equipment from several sources, the computer architect will put together a system using elements from several different manufacturers."

As a result, says Chu, manufacturers will become more specialized: though IBM will always be IBM, and always produce excellent machines, perhaps in fewer categories than today, smaller companies will tend to evolve into highly competent mainframe builders, or bulk storage builders, or punched-card and printing equipment builders, and so on.

This condition will arise gradually, though it may be well along by 1980. One reason is that the program

Toward better software

by Jack Goldberg, Stanford Research Institute, Menlo Park, Calif.

Consider the attitude of consumers toward an industry whose products typically have these characteristics:

- When delivered, they are almost certain to have defects.
- Though made for the same end use and produced by accepted professional designers, some perform ten times worse than others, may cost more than twice as much, and take more than twice as long to deliver.
- Building a totally new one is often better than modifying an existing one.
- Moving one to a new environment often necessitates a major overhaul.
- The output per member of a team of designers tends to plummet when the team size increases beyond four.

The product is software, and it has these characteristics because the demand for new programs is very high, the problems of design are truly difficult, and the prevailing art of software design and production is undeveloped. And the consumers are indeed concerned because of the increasing role of software in computer systems—and because of the increasing penalties that system buyers must pay when the software costs skyrocket, or the software is late, or it doesn't work.

Professional programers, who are very conscious about this state of affairs, have coined the term "software engineering" to emphasize that programing ought to be an orderly process. Another term, "rugged programs," by analogy with rugged hardware, suggests the qualities that should follow from good programing practices.[1]

Tools for a new programing methodology are being developed in several places, and the prospects for substantial improvement are good. Some significant work being aimed at the betterment of programing languages, and at the use of logical methods to debug and verify programs, is quite likely to have results that will influence future computer design.

A recent estimate attributes at least half of the more common varieties of program error to weaknesses in the source language. Some of these errors may be avoided by improving just the language alone, others by combining language improvements with protective hardware. For example, in Fortran, if the index of an array accidentally exceeds the array size, irrelevant data will be treated as array elements, with no alarm. This problem could be avoided by providing hardware to check array bounds, plus language constructs to specify the range of an array index.

Program debugging is perhaps the least scientific programing task, although tricks of great ingenuity and power are often used. The most common aids are programs to insure that the syntax rules of the program language have been followed. Other aids monitor a program's execution in various ways, but their effectiveness depends heavily on the skill of the programer using them. Conversion of the debugging art to a science is essential, but it will occur only if the problem receives serious attention.

Since programs never seem to be totally debugged, the thought that a program might be proven correct may be startling. In fact, it has already been done for some small but useful programs.

One scheme for program-proving is based on the program's flow chart.[2]. Appended to it is a set of assertions at the beginning, end, and at various other points in the chart, that state what relationships among the program variables should apply at those points. A formal proof is constructed to show that the computational steps in the flow chart, from beginning to end, carry out all changes that pairs of successive assertions imply.

The scheme contains some sizable difficulties. For example, the creation of assertions is very critical, since they must correctly express the programer's intent and be amenable to an efficient proof process. The proof process itself must be "clever" enough to avoid endless detours into trivialities.

Since program-proving involves a good deal of detail,[3] it is reasonable to concentrate, first, on methods that could be applied to small, simple straightforward programs, such as heavily used subroutines, routines responsible for extremely critical functions like process control and security, and microprograms. (Proving microprograms, of course, is tantamount to proving machine hardware.) For large programs, the proof of certain properties—short of complete correctness—may be useful. For example, a given pair of program variables may be proven independent, or a set of events may be shown to occur in a specified order, or the program may be shown not to get into an endless loop in handling a certain range of input data.

This kind of debugging involves a great deal of logic manipulation, one of many forms of non-numerical computation that are growing in importance. If future computers were designed for such work, they would simplify program proving and other debugging processes.

In general, investments in hardware that can make programing better and easier are sure to bring a good return.

References

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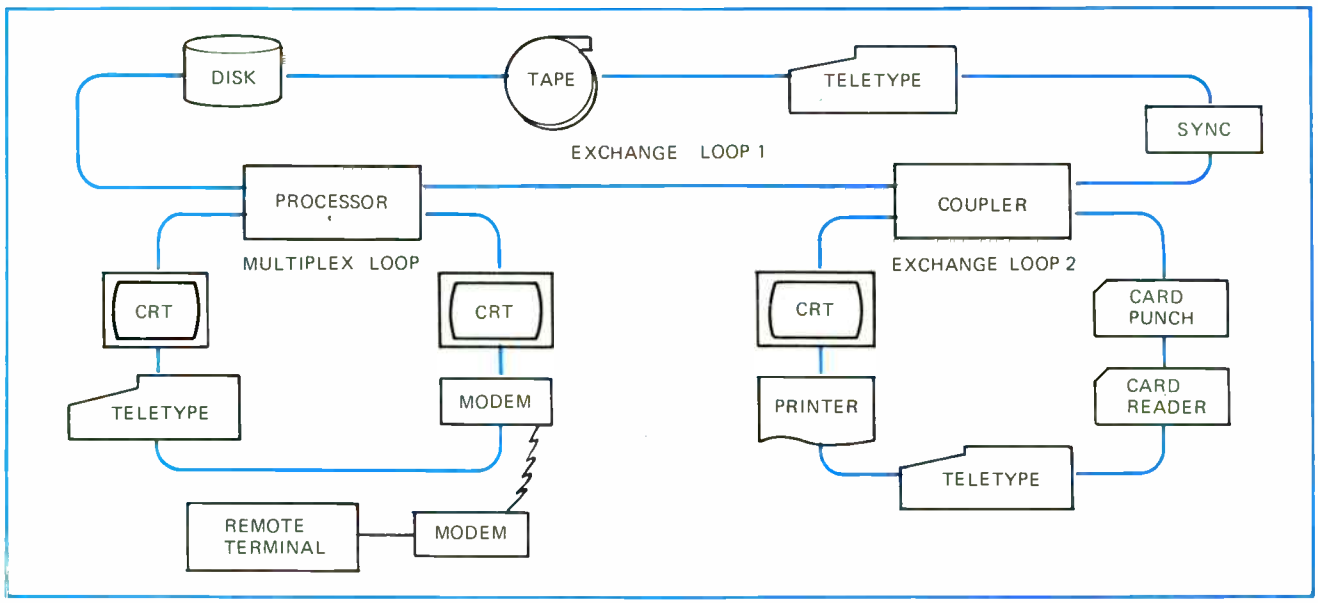


3. A modular model. Collins Radio Co.'s C-System computer is an example of a powerful system assembled by modular design techinques.

managers in the large computer companies, if advised to design as computer architects, would insist that they already design their new systems from the architectural point of view. And these people will have to be persuaded to change their ways.

Another brake on the emergence of the computer architect as a profession is the fact that most computers are rented, not bought—thanks to a market custom established by IBM. "If you buy a complete system you lay out a large sum of money all at once," says an industry observer, "and you'll go to considerable lengths to make sure you get the most for your investment—you'll hire an architect, for example. But on a rental basis, you're inclined to settle for less than your optimum requirements—particularly if you can move up to something better on short notice."

Even so, now that mixed systems are becoming less of an exception, renters, too, are more likely to be aware of their advantages, and this again favors the emergence of the new profession.

But the computer architect will still find software a problem and a challenge, if it's handled more or less the way it has been. Some claim the challenge can be met, at least in part, by using minicomputers, which generally require relatively simple programing—and whose prices are tumbling.

For example, James J. Orris, director of product management at Varian Data Machines, Irvine, Calif., contrasts his company's 1970 model 620/i at $10,000, with today's 620/L for $5,400. The only differences between them, apart from price, are a few minor changes in components and some improved manufacturing techniques.

Even if prices were not dropping, however, the market would be growing rapidly because the proliferation of minicomputers increasingly affects people's daily lives. Sooner or later there'll be a minicomputer on the market that's made on one board and uses a rotating memory; it'll be slow, but it'll also be inexpensive—perhaps only a few hundred dollars. Somebody, somewhere, is going to make such a minicomputer before very long; and when that happens, "many people will find the personal or household computer a necessity," says Bernstein of System Development Corp., "and it'll open up a whole new segment of the industry."

Hands-on use by all sorts of people, directly in their own offices or even in their homes, is one of minicomputers' most important advantages. They are small enough not to take up too much space. They are priced about as much as a new car, yet they have the same capability today that million-dollar computers did 20 years ago.

Although minicomputers don't normally have large memories, they can obtain access to large files through data communication, and this removes a major obstacle to their use. "By this means," says Ruth Davis, director of the Center for Computer Science and Technology at the National Bureau of Standards, "a lot of the need for standardization disappears. The things that are easy to do, people can do on minicomputers any way they please, whereas standards become that much more important for data communication and for large data bases, file structures, and the like. Nobody foresaw this kind of thing five years ago, but for the next five years it'll be extremely important."

Of course, Davis is in an excellent position to see that standards of the second kind are established. One of her problems is streamlining the machinery for implementing a standard once it has been proposed; another is specifying a standard that will achieve its aim without stifling industry. She's working closely with the Office of Management and the Budget and with the General Services Administration, and intends to have essential standards established by mid-1974.

Possibly computers will get not only smaller but very much larger, leaving today's middle range nearly empty. Alan Clemmetsen, chief engineer of Arcturus Electronics Ltd., Blandford Forum, Dorset, England, says this will occur for economic rather than functional reasons—because the demand for small machines is expected to mushroom, they'll go into mass production, their price will drop, and then, he says, "it will be cheaper to buy three or four small machines than a

single middle-sized machinee of equivalent power." Adds Brian Gaines, reader in electrical engineering at Essex University, England, a group of linked minicomputers can often support far more terminals than one big machine, thereby avoiding the problems of queuing simultaneous requests from a number of different terminals.

Clemmetsen and Gaines have lots of company, in Britain and elsewhere. For example, at the annual conference of the Association for Computing Machinery, early last month, Frederic G. Withington, senior staff associate of Arthur D. Little, Inc., predicted a "tug of war between dispersal of computing power (with minicomputers) . . . and centralization in giant remote centers . . . both extremes developing at the expense of the traditional, middle-sized, stand-alone computer." And even RCA, which is going after the middle-sized computer market, recognizes the inevitability of this trend. "I've been predicting this polarization for five years," says L.E. Donegan, vice president and general manager of the Computer Systems division at RCA. "It hasn't happened as quickly as I once said it would; but the only real question is how fast—not if."

Donegan expects that the polarization will take shape in five years and be quite clear by the end of the decade. Meanwhile, RCA's aim at the middle range is short-term; it will expand its present line of computers in both directions within the next year [see Electronics Review].

Modular popularity. In minicomputers, modular design has already taken such a hold that it is probably a significant trend and may spread to larger computers. In the modular concept, major functional subassemblies are interconnected along a bus and have several electrical conductors in common. To communicate with another module, a "sending" module places the desired signal plus an address on one or more lines; the two travel to all the modules attached to the bus, but only the addressed module responds.

The power and complexity of systems built this way is almost unlimited, especially as they may include several processors, each specialized to a different task. Moreover, they are very flexible—a user need buy only as much capability as he actually needs, tailor it to specialized applications, and add to it as necessary. The computer designer, too, may upgrade his designs in smaller chunks, and the user is free to buy those new and improved chunks if and when he needs them.

An example of a large modular system is Collins Radio Co.'s C-System (Fig. 3), in which subassemblies are connected serially along a single cable. Transmission is at very high frequencies, fast enough not to degrade the performance of the individual modules, which work in parallel by bit.

A very ambitious modular design, proposed by Tudor Finch, head of the digital device integration department at Bell Laboratories, Murray Hill, N.J., would be capable of large-machine performance at potentially low cost. It would consist of several small special-purpose task processors, made from 10 to 100 LSI chips each, and interconnected along a circular bus, as shown in Fig. 4. One processor would be dedicated to receiving tasks and data from the outside world, another would transmit results to the outside, and a third would control access to a very large memory—perhaps half a million 64-bit words—that would serve all the special-purpose processors.

This is a pretty far-out idea—but it resembles other machines that have already been built or proposed. The bus organization suggests Digital Equipment Corp.'s PDP-11 and other modular systems, the circular bus brings to mind Collins Radio Co.'s C-System, and the multiple processors are like those in the Illiac 4.

But some problems can be handled only on the large machines, regardless of software difficulties. James Thornton of Control Data Corp. knows of plenty (see page 75). The so-called Grosch's Law, formulated by Herbert R.J. Grosch nearly 20 years ago, is often cited to back up this idea. The "law" is usually misstated: "The performance of a computer system is proportional to the square of its cost." In this form it is no longer valid, because of the amount of peripheral equipment now used in computer systems. Robert S. Barton, professor of electrical engineering at the University of Utah and a recognized computer consultant, says, "I don't think the concept, 'The faster and bigger it is, the better it is,' is true any more. It can't be true when the semiconductor industry is on the verge of a mass production capability, and when the vast majority of computer problems just aren't huge."

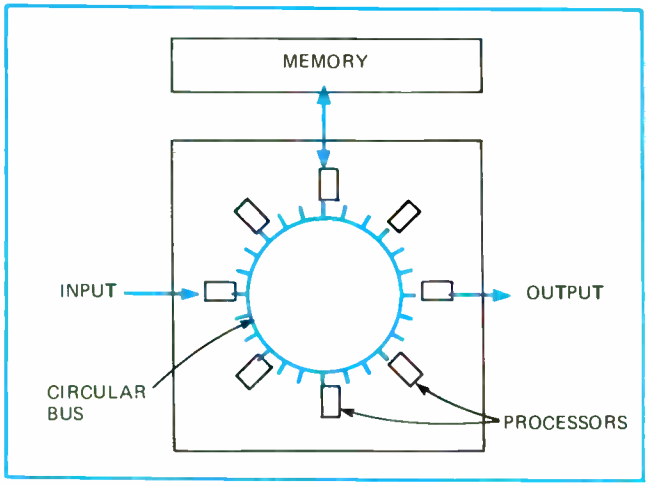
But Grosch, now at the National Bureau of Standards' Center for Computer Sciences and Technology, says his original formulation was, "If you want to do it twice as cheap, you have to do it four times as fast." He insists that it would still be valid except for inefficient operating software and unnecessary peripherals. He cites a present-day corollary to the law: "No matter how clever the hardware design, the software boys will fritter it away."

Nevertheless, the big problems are still there. "The market we see today is even bigger than we thought it was when the 6600 computer came out," says CDC's Thornton. "Today there are 25 installations that have more than one of them." (EDP Industry Reports, a computer industry newsletter, estimates that about 100 CDC 6600's have been sold.)

Many of these large installations are in computer utilities, where the central computer services a network of remote terminals in customer offices. And Frank Sullivan, director of guidance, control, and information systems in NASA's Office of Advanced Research and Technology cites the problem of transferring a spacecraft from one orbit to another under some constraint such as minimum fuel expenditure. "It may cost more to segment that kind of problem into parts for minicomputers than to go ahead and write straight code for a big machine," he says.

Even here, however, the large machines are being challenged by networks of minicomputers. Advantages are cited for both, and it's still not certain exactly where the tradeoff comes. Undoubtedly some problems can be solved adequately only on very large machines. Undoubtedly also large machines are now processing problems that could be handled quite well, and at lower cost, on a network of interconnected small machines or on a single small machine.

One of the most important advantages of a computer



4. Big ambition. Proposed design for large, powerful computer system of great flexibility has array of specialized processors surrounding a communications ring and sharing a large memory array.

network is that it permits various groups to make use of one another's work. Just a few years ago this wouldn't have been thought possible. Today it's being actively investigated, and soon it'll be in common use. "We've learned how to write better compilers now," says J.C.R. Licklider, professor of electrical engineering at the Massachusetts Institute of Technology, "so the programs we write in Fortran and other languages are much closer to being machine-independent than they were not long ago." As a result, in a network, it's easy to use a routine stored in somebody else's machine for one's own application, without having to rewrite or adapt it for one's own machine.

But there's one disadvantage, too. Probably the biggest one is—once again—the software involved. And "there's more to organizing a system than just plugging a bunch of minis into one another," adds Varian's Orris.

"Frankly, I don't think minicomputer networks are the best way to do any job," says Rex Rice, director of memory systems operations in the Systems Technology division of Fairchild Camera and Instrument Corp., Sunnyvale, Calif. "People who try it are looking for an easy way out of a tough problem, and they're going to get bogged down in software for the network just as they got bogged down in software for a big machine." Rice, of course, has an ax to grind for his Symbol machine (see page 82) which he hopes will do much to solve the software problems of the sixties.

One engineer at the French national computer-maker, Compagnie Internationale pour l'Informatique (CII), who asked to remain anonymous, can't see networks or minicomputers replacing large machines. Rather, he thinks, there's a bigger future for the mini as a supplement to the big machine than as a replacement for it. "The mini can relieve the strain on the big computer, freeing it for more noble work," he says.

Closely related to minicomputer networks is the concept of distributed processing, where functional sections of a processor are not necessarily all in one rack or cabinet, and where each section is sometimes not much different from a minicomputer. And in one embodiment of this concept the distributed sections are on-line terminals. "Although there's an excellent argument for centralizing a data base," says Linder C. Hobbs, a southern California consultant, "there's none for centralizing processing capability. Remote access to systems through on-line terminals is already a reality, and increasing, creating a need for more communications capability and for 'smart' terminals." Thus the trend is toward decentralization—if not toward individual terminals, then definitely toward satellite processors. These satellites would perform most of the routine computation, but would forward big problems to a central processor, which, incidentally, would not itself necessarily have to be large, especially for business applications.

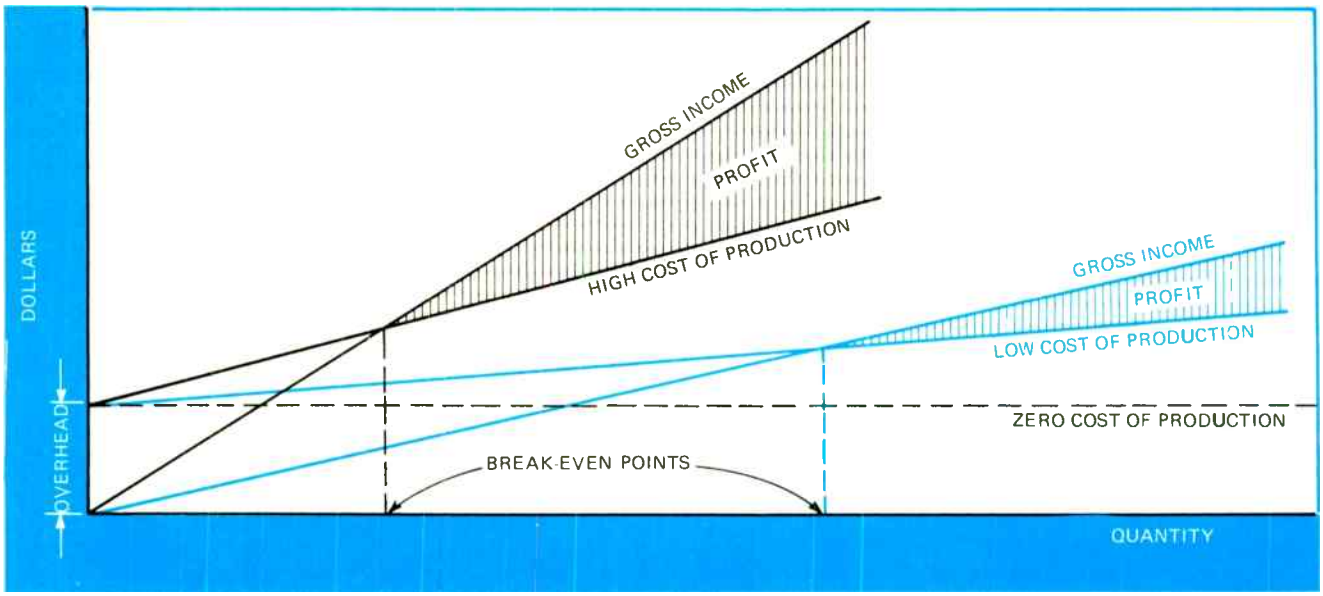
One advantage to this kind of distributed processing is that the terminals retain a modicum of processing capability even when the central processor is out of commission. With "dumb" terminals, when the central processor goes down, the whole system goes down.

William H. Howe, manager of the device test systems department of Fairchild's Systems Technology division, expects use of such distributed processing to increase in manufacturing operations. It requires small, inexpensive memories to store the necessary data locally, where it originates, and an equally inexpensive processor to assist in uniting the memory to the network. "These local memories and small computers are going to be sprinkled around amongst machines, processes and people the way on-off switches have been used in the past," forecasts Howe. Simply collecting, reducing, and disseminating information is a handy way to control local inventories, and when properly set up this function can cut inventory cost substantially; "but it has no real impact on the operation of the company," he adds.

Parallel and pipeline. It is only a short jump conceptually from minicomputer networks to distributed processing. And it's only another short jump to the two basic approaches to design of very large machines: parallel and pipeline organization. In the first, several independent processors work at the same time on different problems, or on different parts of the same problem. An example is the Illiac 4, which comprises 64 processors, each with its own local memory, plus a control unit, a conventional general-purpose computer to handle input-output operations, and a large high-speed drum for bulk memory. Parallelism on a smaller scale is also used by Burroughs Corp., builders of the Illiac 4, in the design of its commercial machines.

In the pipeline approach, there are also several processors, but instead of functioning independently, they are arranged so that the output of one is the input of another. Thus the processors in a pipeline work in sequence on massive parts of a problem, and every part at some time passes through every processor. When the pipeline is "full," the processor at the end may be producing results at very short intervals, but the actual time taken by a particular increment of a problem to "flow" through the pipeline may be considerably longer. The best-known current example is Control Data Corp.'s Star-100 computer, an acronym for string array. (This is not to be confused with Jet Propulsion Laboratory's Star computer, from self-testing and repair.)

Burroughs is unquestionably committed to multiprocessors or parallel processors, on the grounds that any reasonably large problem can be divided into the



5. Point of no return. It's possible for prices to follow manufacturing cost only up to a point, for as this happens the break-even point increases. Eventually the break-even point gets so far out that no reasonable return on capital investment is possible.

smaller pieces that such a system can handle. "A lot of work in military, command-and-control and avionics applications is divided up and processed on a single multiprogramed computer," says John T. Lynch, Burroughs' director of advanced development at Paoli, Pa. "But we think multiprocessing is a more cost-effective use of available resources than multiprograming."

Multiprograming is the running of several different programs on a single processor, more or less simultaneously. But what the processor does is run one program until it encounters a condition, such as calling for data from an input device, that requires it to wait for a few milliseconds. Rather than idling during that time, it switches to another program. But in multiprocessing, no program has to wait except when two or more processors require simultaneous access to the same memory module, at which time a priority circuit imposes a queue upon the processors, delaying things for no longer than a few microseconds.

"As an example of what can be done with multiprocessing," says Lynch, "we found a set of 17 tasks in a command and control environment that were being executed on three large processors with a total of 262,000 words of memory. These were tasks like input-output processing, displays, communication, radar data processing, and so on. We put the 17 tasks on 17 special-purpose processors, each small, and each with only 1,000 words in its memory, of the same number of bits per word as the three large machines.

"But we didn't actually build 17 different machines. We used one general-purpose machine, smaller than the three used previously, with a special set of 17 microroutines in a reloadable control memory—firmware, if you will."

But others think the pipeline approach is the best way to design a fast general-purpose machine. Gene M. Amdahl, who worked for some time in IBM's advanced systems lab in Menlo Park, Calif., but now heads his own development company in Sunnyvale, Calif., says the parallel approach is too specialized. "A computer that works well with regular problems is nice," he says, "but not very helpful in irregular problems—the kind that people need to solve most of the time. After all, a machine is judged by what it does poorly, not by what it does best."

Perhaps the best-known proponent of pipeline systems is James E. Thornton, who is in charge of Control Data's Star-100 computer, the pipeline system. "It's important to recognize the similarities as well as the differences between these two approaches," says Thornton, emphasizing that "both projects aim at solving the same kind of problem."

Meanwhile, the single big machine that's neither a pipeline nor a multiprocessor has a place, too, handling problems that take many hours to solve, no matter how they're tackled—determining the stress on the wing of a jumbo jet, for example. A big machine can devote all its time to such a problem, and between times can be used on smaller problems, provided it can be fed data fast enough and still run economically.

Most of the larger manufacturers produce a range of machines from small to large, and for reasons of economics must use one architecture for them all. Few are willing to go out on a limb with a fancy new architecture, except perhaps on an experimental one-shot basis. John Pinkerton, manager of performance evaluation at International Computers Ltd., Putney, England, says accordingly, "The Illiac 4 is a bit of a blind alley." What's more, he points out that it would be commercial suicide for any but the largest companies to introduce an architectural change suddenly, no matter how bright its engineers' ideas are, because its customers would be unable to expand and update their older equipment. IBM found this out the hard way when it introduced the System 360.

A rather unusual view is that of Leo E. Groosman, deputy manager of the small computer division of Philips Gloeilampenfabrieken, in Apeldoorn, the Netherlands, who says, "For a long time the computer industry has been selling customers Rolls-Royces to transport

potatoes," meaning too much machine for the customer's needs. As a result, Groosman thinks computers will become more and more specialized. But he's also quite sure that the basis of all computer design—the concept of a stored program and a sequential approach to problems—will remain unchanged. "We're so loaded with hardware and software based on this concept that there's no possibility of change," says Groosman. "We can continue to bring down size—even to the point of a one-chip computer, which I think will be commercially available in seven to 10 years—and increase software sophistication, but the basic concept will remain."

Customers' needs. The direction that computer architecture will take during the 1970s will be influenced by users' demands, as well as technology. Users are, of course, demanding a way out of the software jungle. Yet they don't appear uninterested in the big machine. For example, Burroughs Corp. reports that customers are showing a lively interest in acquiring more Illiac 4s after the first giant computer has been delivered some time this winter.

On the other hand, computer users outside the aerospace field don't show much interest in fault-tolerant computers (computers that can keep going at essentially top performance even if some parts fail) even though the design theory of such computers is well advanced. This isn't too surprising. For what the user wants is usually economy plus performance just a little bit better than what he has.

The minicomputer is a case in point. "Ten years ago," says Gerhard Hollander, a Fullerton, Calif., consultant, "nobody considered the idea of a minicomputer seriously." But then Digital Equipment Corp. brought out the original PDP-8, priced remarkably low for its time. That broke the ice; today minicomputers represent the form of computer technology in greatest demand, and machines of similar capability to the original PDP-8 cost almost an order of magnitude less than that pioneering machine. "What's important is not what's possible, but what's possible economically," concludes Hollander.

Gene Amdahl is in agreement: "What can be done technically must wait on economy. The use of microprograming is a prime example. First proposed in 1951, it didn't show up in a commercial machine until 1964, in the System 360."

Another concept that's desirable economically is time-sharing, which is likely to take over much of the role of the traditional service bureau. "The original time-sharing organizations set up their own systems," says Laszlo Rakoczi, vice president of Standard Computer Corp., Santa Ana, Calif., "and each had its own way of running its system. At that time the independent service bureaus, in order to compete with IBM's subsidiary, the Service Bureau Corp., had to be IBM-compatible. But the time-sharing option now available for the IBM operating system software package will favor the setting up of in-house time-sharing systems, and therefore the pull-back of business that formerly went to service bureaus.

"But service bureaus as a class won't go out of business," Rakoczi continues, pointing out that "already they're carrying out much of their business in a remote-batch mode that often offers better response time than that available with IBM's time-sharing package."

Time-sharing could also overcome some software difficulties if minicomputers become as popular as they're expected to during the '70s. Fairchild's Rex Rice foretells a need for much extra software, which in turn will generate a serious need for either "a way to bypass the need for software, or much better input-output capability to get it in and out of the computer." One solution would be to put most of the software in a big central processor, which already has extensive input-output capability, and then to use it in a time-sharing mode.

This approach presupposes the development of the necessary improvements in the communication capabilities through which the minicomputer obtains remote access to the central system. But Rice insists that minicomputers should not themselves be used as terminals. "It just adds one more layer of software to an already confused mess at the center," he emphasizes "and it's a confession that the existing central software is inadequate."

Even the granddaddy of time-sharing systems has lots of room for improvement, at least in the eyes of one experienced observer. Project MAC at MIT, in business now for eight years, is still just beginning to learn what it can and cannot do. For example, researchers at Project MAC have only recently discovered how important it is to limit the number of accesses to files in the project's storage facility, and to limit the size of these files. They learned that as queues build up, the demands on storage increase in proportion to the square of the number of requests, and not linearly, as had previously been supposed. "It's really tragic," says the observer. "The project has siphoned off such enormous resources, and could have accomplished so much more if the nature and extent of the problems had been recognized much earlier—as I think they should have."

Telefactoring, in which computers enhance human capability remotely, will be an important area in a few years, according to Ruth Davis of the National Bureau of Standards. Computers will be used along with today's remote manipulators, in both the gross and the high-precision senses; that is, they'll control such things as pouring molten steel into ingot molds and pushing bacteria around in experimental colonies. Perhaps, more romantically, where Russian space experts in 1971 monitor and control their Lunokhod lunar vehicle from a control center on the earth, later in the decade a lunar vehicle of Russian, American or other nationality will carry a computer with which it can decide for itself where it will go.

At MIT, Licklider is working on tools and techniques that will replace or supplement such artifices as the charts and doodles that people use to support this thinking. These tools and techniques can put ideas together more efficiently than is even conceivable with paper and pencil. Licklider cited the example of the graph of an equation, changing dynamically as coefficients in the equation are altered.

Equipment has already been designed, at least experimentally, to permit such doodling in three dimensions. But Licklider feels that two-dimensional techniques will be as important, at least initially, partly because it corresponds more closely to what people are used to.

In this respect, Licklider disagrees with Hollander. "As soon as people see that something can be done that they think is important, it'll catch on quickly. They did this once, for example, with on-line programing; they'll do it again when the right technology comes along."

Processors of the '70s

The historical mismatch between processor speed and memory speed is disappearing, and because of this processor designs will probably develop rather differently from the way they've done in the past. Till recently, processors always were faster than memories. Now they are approaching a limit imposed by the speed of light, and memories are beginning to catch up as semiconductor arrays come into frequent and large-scale use.

Consequently, whereas most processors were formerly able to use several cycles to process a word produced by one memory cycle, it's getting harder and harder for the processor to keep the memory busy, and so a new form of processor inefficiency is appearing.

Of the various design changes that could take up this slack and also improve the overall performance of commercial equipment, the best understood are error correction and fault tolerance. Error correction requires the inclusion of enough redundancy in data to permit its reconstruction in the event of a transient or permanent component failure. Fault tolerance is the inclusion of spare components or subassemblies that can be switched into a system automatically to maintain system performance at a high level.

Most of the work in these areas to date has been for military and aerospace applications. But already the work done on a computer to be used in the Grand Tour, in which a spacecraft will be flown past a series of outer planets in the solar system, is attracting outside interest. It is being actively investigated by a Los Angeles hospital that would like to adapt the design of a computer in its intensive care unit, where a failure could mean a death. The concepts are also directly applicable to computers controlling vehicles in a mass-transit facility.

In error correction, as distinct from mere error detection, a lot more is known than is generally used. However, a few large computers do use a little in their memories. "And even error detection isn't often applied where it would be very useful," says Algirdas Avizienis, a member of the computer science faculty at the University of California, Los Angeles, and also of the technical staff at the Jet Propulsion Laboratory, Pasadena, Calif. "The arithmetic unit of a computer is the one place that ought to be checked and isn't."

Error detection is mainly used on input-output and data communication channels, and where data is transferred from point to point within a computer—to and from memory or between registers. The most common form of error detection is parity, in which an extra bit, either 1 or 0, is added to each word to insure that the total number of 1 bits is odd. A word that is found to contain an even number of bits is known to have an error, but because the site of that error is unknown it cannot be corrected.

Only one machine, Avizienis says, has ever had an error detection unit appended to its arithmetic unit, and that was the Raydac, built in the late 1940s. It had a modulo 31 residue check, in which five extra bits were added to each word to make it numerically divisible by 31. Avizienis has incorporated a modulo 15 residue check, requiring four extra bits, in his Star computer, the one being developed for the Grand Tour mission [*Electronics*, July 19, p. 91; Sept. 4, 1967, p. 41].

In fault tolerance Avizienis doesn't foresee any technical breakthroughs over the next few years, although it will surely develop further. He's more interested in

Slotnick on computers and society

Perhaps best known as the moving spirit behind the Illiac 4 computer, Daniel L. Slotnick, 39, also represents a transformation in the engineering outlook. As such, he is acutely conscious of man's deteriorating natural and social environment, and is actively working to apply technology to reverse the process.

Five years ago, in the early stages of planning the Illiac 4 project, Slotnick, professor of computer science at the University of Illinois, told a visitor, "The guiding principle of my life is to build the fastest possible computer. I don't care whether there's any particular need for a machine like that—I'm just going to build it."

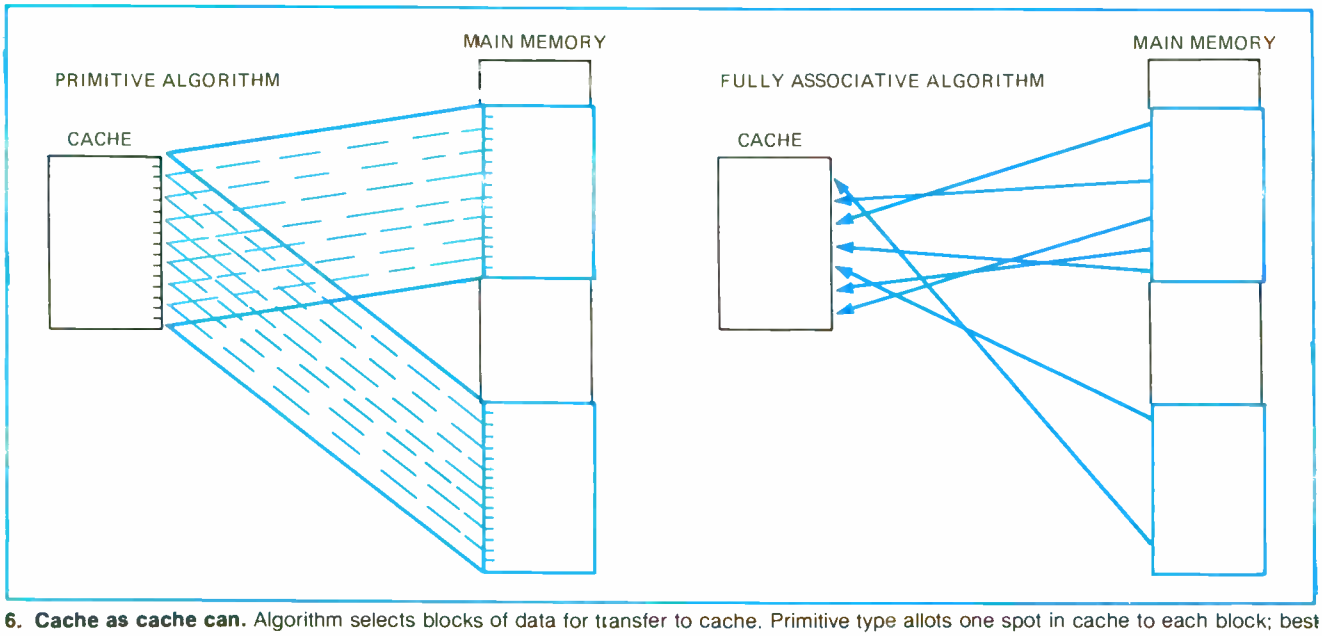
Now Slotnick, director of the university's new Center for Advanced Computation, has turned about. He's come to recognize that if science and technology don't attack our real problems, it can't justify itself. "Pure technology isn't satisfying any more," he says in explanation. "I still work at it, but only in overseeing my graduate students' research projects. It's fun, but it's like dessert: there's no meat and potatoes in it."

As a result, he's become closely involved in a number of "real problems" of 20th-century society and its environment. For example, he's a consultant to a state-wide resource-planning project, which will eventually permit a planner to obtain from a computer a printed list of the available sites in a given area that meet the planner's specifications for, say, a shopping center or a new highway or an airport.

Such a resource-planning project has two major technological requirements, says Slotnick. One is a sophisticated interactive graphic display system—but a system not beyond today's state of the art. The other is a way to measure the available resources, and this is far below the required level. "How many fish are there in Lake Michigan?" asks Slotnick. "How would a new sewage disposal plant in Chicago affect them? Nobody knows." When a farmer exposed day after long day to the noise of a diesel tractor becomes deafened, in what other ways is the man affected? Does he become, perhaps, less than human because he can no longer enjoy Brahms or the singing of the birds?

"We can measure the darnedest things at the subatomic level," says Slotnick, "but we can't measure what's in the air that kills us!"

Most interestingly, the technology to attack problems like these requires large computers, so that Slotnick's new interest isn't really a complete turnabout after all. Economic studies that work out the interactions between industries, occupations, national requirements and national priorities involve enormous amounts of computations with optimizations, matrixes, linear programing—you name it—and this kind of thing is exactly what the Illiac 4 was designed to solve.



6. Cache as cache can. Algorithm selects blocks of data for transfer to cache. Primitive type allots one spot in cache to each block; best would permit access to any block from any spot, using fully associative memory. So far only partly associative caches can be built.

spreading the word about what's already known, scanty though it may seem. Yet few people seem to be interested, in spite of the fact that none of the work in the field is classified.

Fault tolerance will require two important and interrelated developments in future processors: a need for function-monitoring hardware, and a need for error correction circuits that have an output integrated with the machine controls and so don't need external help in following up errors. To include error correction circuits would be of dubious value if they only interrupted the machine and called in an executive program, or worse yet notified the human operator. They would be much more efficient, and more than pay their own way, if they triggered a hardware monitor that noted the failure for possible later action. "Monitoring hardware is included in the design of Star," says Avizienis, "and it's very simple; it would be so easy to use elsewhere."

Memories of the '70s

Memories are the most volatile area in computer technology—yet the ferrite core seems set to go on and on. Though its demise is repeatedly predicted, it succeeds in improving its speed and price almost yearly.

The goal, of course is high speed. But is there really a need for it? Varian's Orris feels that only a very few people require a memory that cycles in less than 2 microseconds. But Linder Hobbs doesn't share that opinion. "Speed in memories has always been the main thing, and it always will be," he says. He maintains that a fast memory's principal advantage is that it permits a component reduction without a loss in performance. As an example, he cites the transfer of characters from a telephone line into a memory. On the line the characters are in bit-serial format, and if the memory is fast each bit can be stored as soon as it arrives. But a slow memory requires an external register to assemble the characters in a register before they can be transferred in parallel into the memory.

Core memories, the mainstay of computers for perhaps 15 years now, will probably remain important at least through the '70s. Richard J. Dadamo, president of the Electronic Memories division of Electronic Memories & Magnetics Corp., predicts that core memories, his division's major product, will continue to get bigger, faster, cheaper, and more reliable. Traditionally military systems are subjected to severe physical and thermal shock tests, and their reliability will continue to improve as designs are refined still further over a period of time. But industrial users are approaching military specifications in some respects, and Dadamo suggests that the distinction between the two may soon almost disappear. (Reliability in this context is to be distinguished from fault tolerance; it is measured in terms of the mean time between failures and is only one of many considerations entering into fault tolerance.)

As for competition from other technologies, semiconductor memories at present are primarily a complement of cores, not a replacement. The millions of hours of field experience with core memories won't be attained by the semiconductor people for a long time. Core memories with cycle times of 500 ns are common today, and at this speed they'll hold off semiconductor arrays for a while. And Electronic Memories is working on still faster stacks using 14-mil and 16-mil cores.

Louis B. Horwitz, executive vice president of Xerox Data Systems, El Segundo, Calif., is sure that cores will remain a major memory element for some time, if for no other reason than inertia. "They can be sold for around 1¢ a bit or less, but semiconductor memories, despite their makers' claims, aren't anywhere near 1¢ a bit yet," he says. He's confident that cores will eventually have 300-ns cycle times, at reasonable prices.

"In spite of the challenge of advanced technologies, the ferrite-core memory market will continue to grow," says Gross. "Ampex is producing 100 million cores a week now, and that rate appears to be growing exponentially." Curiously, the development of ICs is benefitting not only semiconductor memories but also the

competition, because the cost of the drive and sense circuits, which is a significant part of the cost of a core memory, is dropping rapidly. "Because of this, the best bet for semiconductor memories is in the smaller sizes—under 10,000 bits—at least in the immediate future," Gross says.

What about plated wire? "A superb technology," is Horwitz's comment, "but ten years too late. We spent two and a half years on plated wire before dropping it. We felt it had the prospects of a relatively short technological life."

Univac, the leader of plated wire in commercial machines, doesn't share the viewpoint—but then it made its principal investment some years ago. "For us, now, plated wire is the most economical way to go, and we'll stay with it as long as it stays economical," says George Fedde, manager of advanced manufacturing techniques at Univac. "Meanwhile, we're always looking for ways to cut its cost, and to improve its density." Univac now packages the wires 60 mils apart, and is working on ways to get it down to 30 mils. In the laboratory, wires have been packaged as close as 10 mils, with bits 20 mils apart along the wire. This gives a total packing density of 5,000 bits per square inch, which Fedde says is about the same as packaged semiconductor arrays. Still, he admits that semiconductor memories will give plated wire a "horse race" over the next few years.

Others, who lack Univac's investment in plated wire, already see a clear advantage in semiconductor memories. Gene Amdahl, for instance, thinks semiconductor memories will be out in front in terms of both price and performance within a year. Already he cites Intel and Advanced Memory Systems as having introduced products that are very attractive—in part because they recognized that a semiconductor memory need not look like or operate like a core memory.

Likewise, semiconductor memories give an important boost to the concept of distributed processing. "With core memories," says Hobbs, "the bigger the memory, the lower the cost per bit, because of economies in assembly and the smaller quantity of peripheral circuitry. But this isn't true of semiconductor memories beyond the individual chip. It costs very little more to buy 32 memories of 2,000 words each than one memory of 64,000 words."

In a true distributed processing system, of course, a certain degree of cross access is necessary, which implies either that the individual small memories can transmit data to one another or that they have multiple ports. But this isn't a difficult problem. One way to get around it would be to construct the system with, say, 16 of the small memories, each with its own processor, and one 32,000-word unit accessible to all processors.

"Computer manufacturers should be excited about semiconductor memories," says Utah's Bob Barton, "because they can buy small chunks of storage and distribute them; they shouldn't be arguing 60-ns versus 90-ns access times." He thinks the economics of the semiconductor industry will force a de-emphasis on processing in favor of storage at the hardware level during the next few years.

Gordon E. Moore, executive vice-president of Intel Corp., Santa Clara, Calif., thinks people will soon learn how to take advantage of the special properties of semiconductor memories, such as their capability for distribution, parallel access, organization into very long words, and brute-force high speed where it's called for. "It's okay for the time being to replace a ferrite-core memory one for one," says Moore, "but that's not the way to get the most out of the memory. There's more to it than just getting a 0.1¢-per-bit difference in cost."

Volatility remains a serious problem with semiconductor memories. "An unexpected power failure can wipe you out completely," says Horwitz of XDS. There are ways of restarting a job in the middle, and the aerospace companies, in particular, have invested large sums in software that can quickly recover from any such calamity. But the ordinary user can't afford this expense; and if his system is time-shared, and a hundred programs are on line and a hundred files are open at the moment of a power failure, he's got an enormous task to restart all those routines.

Clemmetsen of Arcturus Electronics in England agrees that a nonvolatile semiconductor memory is a necessity, and will be developed with silicon nitride technology. With this technique both the memory and the processor could be made with the same technology, thus reducing costs. And Gaines, his fellow countryman, agrees with him, except that he feels that minicomputers with all-semiconductor main memories will be common first, volatility and all. Gaines thinks that volatility needn't be a problem if a nonvolatile backup, such as a disk, is available in the system. Nevertheless, Moore doesn't think volatility is a serious problem in semiconductor memories, except in military applications. "There's always a way to reload," he says, "and not many people even depend on the controlled shutdown that's available with cores. In any case, it's relatively easy to add standby power with a small battery."

But with or without volatility, the market outlook for semiconductor memories is rosy. Larkin, the marketing vice president of Advanced Memory Systems, describes it as the most "elastic" that has appeared in a long time—elastic in the way the economist uses the term. "If you cut the cost in half, the demand doubles," he says, "and if you reduce the cost to a quarter of its former

7. Girl at work. Displays like the Univac Uniscope pictured below are already a familiar part of the business world. But soon, predict many in the industry, minicomputers may be entering the home and becoming as essential a part of daily life as the automobile.

level, the demand quadruples." As large-scale integration brings down the cost, Larkin believes that elasticity will create a corresponding demand, and that there's a lot of room for expansion.

But not everybody agrees. For example, Gerald A. Maley, senior engineer in the exploratory technology department at IBM's Components division, Hopewell Junction, N.Y., feels that, although the prospects for an enormous market are very good, the cost is already near a point of diminishing returns. Figure 5 shows that, as costs decrease and selling prices follow them, the break-even quantity increases sharply, eventually attaining a wholly unrealistic level. "Cost has already come down over a period of years by orders of magnitude," Maley says. "It can't go much further and still permit suppliers to make a return on their investments."

Instead, Maley thinks the semiconductor memory industry will soon have to add functions to its product, other than mere data storage. This will increase the cost of the product, but could materially decrease the cost of the system in which the product is used. Maley's pet added function is the latent image, a base of fixed data that lies beneath the conventional active data of a semiconductor memory [*Electronics*, Aug. 16, p. 82] and survives power failures and other catastrophes.

John Pinkerton of ICL, however, says it's not easy to see what extra functions would be useful, except in an associative memory—and that's expensive, even in LSI, because of the amount of logic it requires.

Perhaps the semiconductor memory's greatest usefulness at present is as a fast buffer between a ferrite-core main memory and a processor. There it enhances the performance of the system, and its volatility is less of a problem, because it can be quickly refilled from the main memory.

How much performance is improved depends on the algorithm by which the buffer is kept filled, and the algorithm in turn depends on the size of the buffer, the ratio of its speed to the main memory's, and the width of the data path connecting main memory and buffer.

A specific version of the high-speed buffer is known as a cache memory. It seems particularly useful now because it allows semiconductor arrays to extract high performance from other types of memory before LSI versions are available in large enough quantities and at low enough cost to take over the memory function entirely.

Basically the cache memory stores blocks of data for quick access by the processor. It works because both the words of data processed by a program and successive instructions in the program are usually stored near one another, so that a large block transferred from the main memory into the cache is likely to keep the processor busy for some time.

The operation of the cache requires an algorithm for selecting the blocks of program and data for transfer to the cache and for determining when they may be eliminated from the cache. The most primitive and also the cheapest method is to have one and only one spot in the cache for each block from the memory (Fig. 6), but it breaks down easily if the proportion of data to instructions isn't just right, and has never been used in any actual machine.

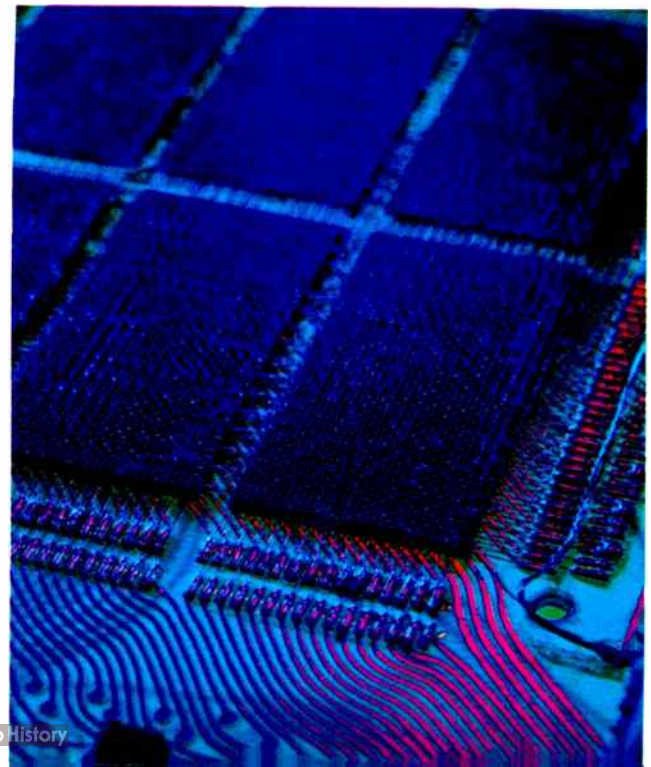
The most efficient approach would be to use a full associative memory, which would permit access to each page of data, regardless of its position in the cache or when it was brought in (Fig. 6). Unfortunately, such memories are not available today in the size and performance ranges or in the quantities needed for the computers that use the cache concept. There won't be a fully associative cache before the end of the decade.

Two compromises have been used so far. In the IBM System 360 model 85, the first commercially available machine to use a cache, several large blocks are brought in as units, and accessed associatively by block. This scheme works, but it requires the whole block to be used for the cache to achieve its maximum efficiency. In the later 360/195 and in the 370/155 and 165, the cache is in effect divided into smaller pieces, and the same small block of data is transferred simultaneously into several of these sectors. If the sectors were small enough, this approach would be identical to the fully associative cache. But the intermediate size is practical and, according to Donald H. Gibson, manager of technical support for large systems at IBM's System Development division, Poughkeepsie, N.Y., permits a level of performance not very far short of that of a fully associative cache.

The concept seems to be viable wherever the machine cycle is less than 100 ns and where the memory capacity is more than 10 million bits. Technological limitations prevent data from being brought in from such a large memory fast enough for such a processor to use it, except with the help of the cache. Moreover, a new structural design, of which the cache is an example, is needed because the market continues to push for higher and higher performance.

Had IBM not decided to go to the cache, what other alternatives existed? The approach tried in the System 360 Model 67—a combination of hardware and software that implemented its capability for relocation—gave the user of the machine effective access to the entire memory. He could write his programs accordingly, re-

8. Heart of the matter. Cores, the mainstay of memory technology since the '50s, are threatened by semiconductor arrays, but may last out the '70s because of their low cost, respectable speeds.



gardless of what other tasks the machine was performing concurrently. But this hybrid approach didn't work too well.

A fully software approach is used in some machines—notably the Control Data 7600, which has a fast core buffer in front of its main memory. But this buffer functions very like a conventional main memory backed up by a large core array; the operating system software keeps track of the data, moves it as required (actually before it is required) out of the slow memory into the fast memory, and returns the results to the slow memory. Large core storages are offered by independent memory manufacturers as add-ons for IBM and other computers; but IBM discontinued its own LCS some time ago in favor of direct access to reasonably fast units through the cache.

Even larger bulk storage units—magnetic disks, tapes, and the like—have always had to be addressed by block. One full block is transferred into the memory and its individual words or bytes addressed at that point, by means of software. If the direct access to data in a bulk unit were under hardware control, a computer would probably need a larger address format; for example, the 24 bits in the standard 360-370 instruction might be replaced by 32 bits, for a maximum of 4 billion bytes. This would either sacrifice compatibility or require programs employing the enlarged address capability to use indirect addressing extensively.

The cache concept can also be applied to large semiconductor arrays. A bipolar cache could, and probably soon will, be used with a large, slow MOS main memory just as well as with a core memory. The idea also applies to a core memory backed up by a magnetic drum. This scheme was described at the IFIP Congress 68 in Edinburgh, Scotland. It made the core memory seem to have the vast capacity of the drum, or, conversely the drum seem to have the speed and random access of the core memory. There is no reason why the two schemes couldn't be combined to provide a high-speed bipolar cache backed up by a larger, slower core or MOS memory, in turn backed up by a still larger and slower drum memory. This is simply an extension of the old memory hierarchy idea, which involves keeping the most frequently used data close at hand in a small, fast memory that may have a high cost per bit, while using successively larger, slower, cheaper memories with longer access times for data that's less likely to be needed on short notice.

Although the idea of the hierarchy is old, the makeup of the hierarchy constantly changes. From that point of view, the cache may turn out to be a transient member of the hierarchy.

In contrast, the concept of virtual memory is assuming ever more importance at the slow end of the hierarchy. As requirements for memory capacity become greater and greater, accompanied by larger bulk memory units and by faster main memories, the virtual memory concept will become the ordinary instead of the extraordinary way of locating individual programs and their data.

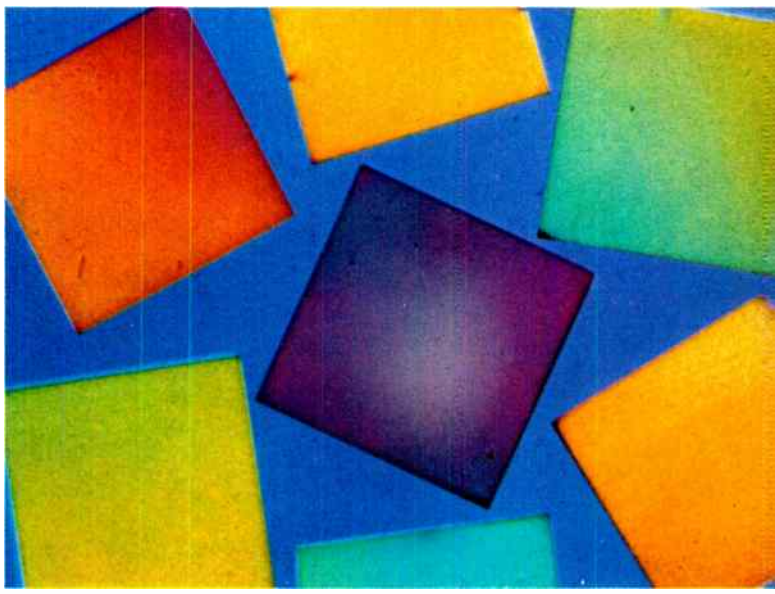
Multiple users of a single computer can rapidly exceed the physical capacity of the main memory, so that their overflow must be kept on some form of bulk memory and switched in and out as required. No user's entire program and data are in the main memory at one time; those parts that are in the main memory may not be in contiguous blocks; they are returned to bulk memory only when they are "bounced" by something of higher priority, and when reloaded from bulk memory they may not go into the same block as before. Because the supervisory program has to keep track of all these program pieces switching around, it makes no difference how large an individual program is, or how it addresses its data: it becomes completely independent of physical memory, and is limited only by the machine's addressing capability—in the System 360 and 370, for example, more than 16 million bytes, and in RCA Corp.'s current machines, 8 million bytes.

In the area of bulk memories, machines like IBM's 3330 disk drive, the first of which are just now being delivered, will be the mainstay of the 1970s. Today's workhorse version, the IBM 2314 and equivalent compatible machines, are good for another couple of years, in the opinion of Robert J. Daniel, planning manager at Information Storage Systems Inc., Cupertino, Calif. Daniel expects they'll be helped along by double-density versions, of which examples have already been announced by ISS, Marshall Industries, and Century Data Systems. The machines use the same disk pack as the 2314, but squeeze twice as many tracks onto each surface, by recording two where the standard IBM format has one.

"But even the 3330 and its equivalent will be going downhill during the latter part of the decade," says Daniel. "It may be supplanted by an improved version, or it may yield to magnetic bubbles by that time. But I personally think there's lots of life left in the oxide-coated disk, and that bubbles won't really get down to the cost-per-bit level of disks before 1980."

John Kiernan, manager of peripheral development engineering at Univac, thinks that at least one more product cycle could be extracted from the oxide-coated

9. Material importance. Samples of lanthanum-doped zirconate-titanate (PLZT) have same composition and thickness. Different orientations in polarized light produce changes in color.



Hopper against the big machine

When the Data Processing Management Association decided to establish a "computer sciences man of the year" award, the first recipient was a woman—and a very well-qualified woman she is. Grace Murray Hopper has an extraordinary list of accomplishments, which range from work on the electromechanical, automatic, sequence-controlled calculator at Harvard University in the '40s, through a lengthy stint at Eckert-Mauchly Computer Corp. (see page 79) and at Univac, to service in the United States Naval Reserve. Presently she is a commander in the Naval Reserve, serving in the Information Systems division, while on leave from Univac, where her title is staff scientist, systems programing.

She is outspoken on the topic of misuse and improper design of large computers. "We're building dinosaurs," she says. "Those big machines will collapse of their own weight sooner or later. They should be split up the way a corporation president splits up his company into divisions. No successful executive insists on making every decision himself, or on reading every piece of mail. Rather, he delegates authority to his employees and devotes his own time to coordinating their activities." She thinks it's ridiculous to tie up a high-performance processor while, for example, swapping programs in and out of bulk storage, or sorting records while its floating-point arithmetic unit stands idle.

Comdr. Hopper feels that such jobs should be assigned to minicomputers, specialized ones if necessary, and connected by a message switch that would permit each to use the others' results. The system wouldn't need interrupt routines—"you could tie as many minis as you need into the system," she says, "and if you got too many 'busy' signals you could just add more computers to the system."

She pooh-poohs the manufacturers who claim to be using this approach now in the design of their systems, because those systems still need central control units and operating systems. "It's humbug to say there has to be a central control system," she asserts—"it's another way of saying, 'We've always done it this way, so it has to be done this way.' The people who run the system are the real central control, and they can't be put into hardware."

The kind of system of which Comdr. Hopper is thinking would be available in three years, she says, if only the users would demand it. The technology is here now—she cites such instances as the Nova line from Data General Corp. and System IV/70 from Four-Phase Systems Inc.

disk toward the end of the decade. After that, he sees another technology, and mentions magneto-optics as one of the more likely prospects.

"But there's a need for something else sooner," Kiernan points out. "Right now and in the immediate future, mainframe memories of various technologies are selling for around 1¢ per bit, and maybe can get down to 0.1¢ per bit before very long. Meanwhile our mass memories, on moving mechanical media, are running about 0.001¢ per bit. They have access times in the tens of hundreds of milliseconds. What'll fill this gap—something at 0.01¢ per bit with an access time of 1 to 5 ms? A rotating disk with a fixed read-write head?"

Coming over the horizon are a number of new memory technologies that may take their place alongside, or replace, the three most common current forms, core, plated wire, and semiconductor. Of the newcomers, the two that have aroused the most interest are magnetic bubbles and beam-addressable memories.

The magnetic bubble memory consists of a pattern of spots of magnetic material, such as permalloy, deposited on top of a garnet film. Magnetic domains within the garnet, usually long wavy strips, are compressed into a circular shape by an external magnetic field. In the absence of the permalloy spots, these circular domains, called bubbles, would exist at random locations throughout the film. But because the spots tend to concentrate the field, the bubbles are attracted to points of field concentration. When the external field rotates in the plane of the film, the bubbles can be made to move about in the film, jumping from spot to spot as the points of concentration change.

Because a bubble can represent a stored binary 1, and the absence of a bubble a 0, these garnet films show great promise as memories. They are potentially much less expensive than present-day main memories, and much faster than magnetic-disk bulk storage systems.

Peter I. Bonyhard, a supervisor in the fundamental memory components department at Bell Laboratories, sees the bubble memory as occupying an important place in memory hierarchies, along with the cache, before the decade is out—perhaps within a few years.

The simplest hierarchy comprises only the computer's main memory and one or more magnetic tape drives or disk units, with a library of tape reels or disk packs backing them up. Additional hierarchical levels might be general-purpose registers closely integrated with the processor, a fast buffer memory between the main memory and the processor, and a large slow core-storage unit between the main memory and the peripheral tape or disk units.

But even with all these levels in a memory hierarchy, there is still a difference in access time of three to four orders of magnitude between the all-electronic bulk memory and the electromechanical peripheral storage unit. This gap, which sharply reduces the efficiency of the memory hierarchy, could be filled by the magnetic bubble memory.

Bonyhard cites the following example to show how the bubble memory could fill this gap:

In a two-level hierarchy of memories M_1 and M_2 with access times T_1 and T_2, the ratio of the number of words found in M_1 to the number in M_2 is the "hit ratio," called h, and should be a fraction between 0 and 1. Over a long period of time the average access time is

$$T_1h + T_2(1 - h)$$

If T_2 is much larger than T_1, then h should be close to 1; otherwise the long access time of M_2 will swamp any advantage of M_1.

In many applications the organization of the data files insures that the ratio is close to 1. In others, it can be made close to 1 by making M_1 large; but since M_1 is likely to be expensive, that defeats the purpose of having the hierarchy. But by adding a third memory to the hierarchy, with an intermediate access time and an intermediate cost per bit, the magnitude of the hit ratio is less critical.

The magnetic bubble memory is an excellent candidate for such an intermediate memory, if its cost can be

suitably reduced—as it probably can. It'll be capable of very respectable bit-transfer rates, and it'll be economical in smaller sizes. Where disks have a minimum economical size of 10 million bits and sell, even at that capacity, for perhaps $5,000, bubble memories should be economical at a megabit or less for a few hundred dollars. Bonyhard says it'll be "just the thing for minicomputer manufacturers, who don't need and can't use the larger capacities of most magnetic disks."

Since the magnetic bubble memory operates by shifting bubbles within a film of garnet, it is subject to one of the disks' disadvantages—a given bit may not be available at the readout point at the moment it is requested. On a disk, that data on an addressed track isn't available until the starting point is rotated under the reading head—a delay that can add up to 100 milliseconds or more. Likewise, a bubble would have to circulate through the film along a path determined by the pattern of permalloy spots to a sensor spot. This is not quite as rigid an arrangement as in disks, because bubbles can be made to move in two dimensions within the film, switching tracks under control of external signals.

Bell Laboratories is working on a skeleton model that will have a bit transfer rate of 100,000 per second, well below what the experimenters know is possible. By the end of 1971, the Bell researchers expect to have completed the skeleton, in the sense that although it will be designed for a capacity of several megabits, they do not intend to build all the bubble substrates needed for such a large unit—only enough to demonstrate that it works. Other organizations both inside and outside the Bell System are expected to develop the technology further in terms of applications and manufacturing capability, while Bell Labs works at building up the transfer rate to a megahertz or higher.

Obstacle. "One thing that may hold up the development," says Bonyhard, "is obtaining the necessary raw materials. A few years ago, for example, silicon was hard to get; but now you can buy it in large quantities for making ICs. We'll have to be able to buy garnet, and significant amounts of certain rare earths, the way we buy silicon now." But once the materials are available, actual fabrication is easy—only three layers in a simple pattern, as compared to 15 diffusions or more plus several layers of metalization in an IC.

George Pulliam, manager of physical sciences in the research and technology divisions at Autonetics, believes that bubble memories have a great future in both commercial and military applications—he expects them to be inexpensive, to dissipate little power, occupy small volume, and be highly reliable. He expects new memory organizations will be derived from the peculiarities of bubble technology, such as the addition of logic to individual memory cells to create an inexpensive associative memory. Autonetics, in fact, came up with some improvements ahead of Bell Labs, Pulliam claims. The company has contracts to develop prototypes of bubble memories for possible use in deep-space missions, planned for late in the decade.

Another promising new development is the beam-addressable memory, which consists of a film of magneto-optical material deposited on a suitable substrate and illuminated by a laser. To write data on the film, a laser beam focused down to a tiny spot heats the film above its Curie temperature, and an external magnetic field governs the direction of magnetism of the film when it is permitted to cool down again. The heating and cooling cycle takes only microseconds, because the film is very thin. To read the recorded data a lower-powered laser illuminates the magnetized spot, which rotates the polarization of the beam in one of two ways; then a detector on the other side of the film translates the rotation into a binary 1 or 0.

Two approaches to this form of memory have been used. IBM has used a film of europium oxide, because EuO has a very strong specific rotation (number of degrees per unit thickness) and is transparent. But its Curie temperature, even when it has been doped, is so low that the memory has to be operated at cryogenic temperatures. Furthermore, the magnetic easy axis of EuO is parallel to the plane of the film; the necessary rotation can only be obtained by directing the light onto the film at a sharp angle. This reduces the output signal, and focusing the beam on a tiny spot at a sharp angle is quite difficult. Nevertheless, IBM has built a rotating

Thornton for the big machine

One of the two corporations most closely identified with the birth of the computer in the late 1940s was Engineering Research Associates Inc. It was formed by a group of ex-Navy officers who had gained experience in large-scale computation during World War 2. (The other company was Eckert-Mauchly Computer Corp.—see page 79: both later became parts of Univac.) It was ERA that introduced James E. Thornton to computer technology, after his graduation from the University of Minnesota in 1950. Ever since then, he's been turning out one big machine after another, and is currently working on one of the biggest of them all—Control Data Corp.'s Star-100 pipeline machine.

As vice president of the company, and manager of its advanced design laboratory near St. Paul, Minn., he's all for the concept of big machines and their applications. "Any big data-management application requires a big computer," he says. "The task is to find the data and move it somewhere."

Because of tasks like this, he points out, some big machines are being bought just to provide access to big storage capacities. "The need for large storage provides pressure for high performance a lot more quickly than is commonly realized," says Thornton. He believes that this fact alone will act to change the nature of minicomputers; they'll have to come with large memories, which will provide the impetus to beef up the machines' performance.

This need for large memories is not a transient thing. "People don't seem to be using paper any more," he says. "They just stick everything into the computer; and because they do, they need trillion-bit memories." But he adds that the need for still larger units will be very limited.

When asked whether a couple of dozen minicomputers could do the job of one $3-million CDC 6600, as some have suggested [*Electronics*, Mar. 29, p. 56], he says that might be true if the job were such as to bog down the 6600 in transferring data to and from storage. "But if the job requires such a large storage unit, to be hung on either the 6600 or a network of minicomputers, the memory costs you a good part of what you save on the minicomputers," he cautions.

magnetic disk memory using this principle.

At the Honeywell Research Center in Hopkins, Minn., experimenters have done similar work with manganese bismuth, which has a Curie temperature of +360 C and so works at room temperature, and which also has an easy axis perpendicular to the film, permitting light to be directed at it vertically. Although its opacity and its low specific rotation are disadvantageous, Honeywell scientists feel it has much the more promising of the two magneto-optic memory materials.

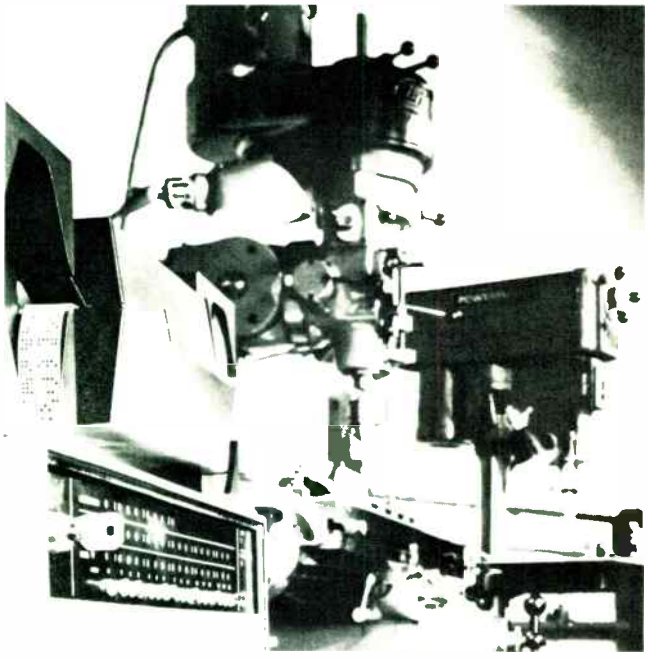
In connection with the memory work, IBM has constructed 20 separate lasers on a single structure about 1 inch long and ⅛ inch wide. It permits the parallel reading of several spots in an array of magneto-optic material so that a machine built around this technology can be character-oriented instead of bit-oriented.

Ampex is also investigating a beam-addressable memory, using a three-layer coated tape and the reflection of polarized light, not the transmission. The three layers are permalloy, copper, and an alloy of cobalt, nickel, and phosphorus.

Although some work is still going on at IBM using EuO, George Fan, who has done much of IBM's beam-addressable memory work, says the principal effort is with another magneto-optic material (which he would not identify), requiring temperatures somewhat below room temperature but not cryogenic.

The principal application of these magneto-optic beam-addressable memories would be in "archival stores," which contain large quantities of information only occasionally referred to, and never or almost never updated. In an archival store, loss of data is intolerable, because the store contains the only copy; and this is why EuO isn't suitable as a medium for such a store, because a failure of the refrigeration equipment could destroy all the stored data in a matter of hours.

10. Getting everything taped. Direct numerical control of machinery is an application of computers that is becoming increasingly popular and therefore is growing in importance. The computer shown here is one of Data General Corp.'s Nova line.



IBM has abandoned one of its early projects in the archival store area—the trillion-bit Photostore, of which only a few were built. This machine recorded data in the form of spots on photographic film; there were 146,000 spots in a cell about ¼ in. square, 32 cells on a "chip" of film measuring 1⅜ by 2¾ in., 32 chips in a plastic box, and up to about 7,500 boxes in the Photostore. Although the Photostore worked, and those that were installed in customer's locations are still working, IBM felt it couldn't compete against magnetic tape in terms of cost, reliability and performance. In Fan's opinion, magnetic tape is the competing technology for archival stores, because master tapes are stored away and never updated—whereas disks, as a rule, are frequently updated.

Don Bush, marketing manager at Precision Instrument Corp., Palo Alto, Calif., would question the statement that magnetic tape will be the competing technology for archival store. He points to his company's Unicon, an archival store capable of holding up to a trillion bits, like IBM's Photostore. The availability of this unit was announced over two years ago, but the first one is only just now about to be shipped; one more is on order, and a third is on option.

The Unicon contains a laser, with a beam that is split into two parts for independent operation on two Datastrips (Precision Instrument's trade mark). Each strip is a length of polyester film 4-¾ in. wide coated with rhodium and recording 11,000 tracks down its 31¼-in. length. Data is recorded on the tracks at approximately 6,000 bits per inch, in the form of tiny holes burned into the rhodium film by the laser. Since a hole can't be erased, the Unicon is an archival store that can be updated but not rewritten. There are 25 Datastrips in a pack and 18 packs in a carousel. To read or write data in a particular location, the carousel rotates until the proper pack is under a selection mechanism, which pulls the right strip out of the pack and wraps it around a drum. A small carriage holding a mirror moves across the drum to direct the laser beam onto the addressed track, and the last fine tuning of the beam is done by a galvanometer mechanism that tilts the mirror slightly.

The Unicon is more than a large memory. It is a complete film management system, containing a small computer to process the data read from the strips and to format it for the computer which the Unicon services. Bush is confident that the Unicon represents a viable high-capacity memory concept for the next ten years. For one thing, it's here, with the first units ready for shipment. He feels that the beam-addressable memories won't be ready for the market for several years, and that when they make it they'll be less permanent than the Datastrips with their little holes.

A magnetic bulk memory called Terabit based on the principle of the video tape recorder is being offered by Ampex. It achieves a packing density of 700,000 bits per square inch, and scans the magnetic tape with a rotating head; as the tape moves 1,000 inches per second, the average access time is 15 seconds. At the 1971 International Conference on Magnetics, John C. Mallinson of Ampex predicted that the Terabit would have the capability of doubling its packing density within

five years and quadrupling it in ten years.

For completeness, charge-coupling should also be mentioned, since it's a means of data storage that excites semiconductor specialists; charge-coupled devices in a memory can operate at 10 megahertz and dissipate only 5 microwatts per bit, and offer the prospect of 10 times faster when better lithographic techniques are used. They're capable of storing up to a million bits per square inch [*Electronics*, June 21, p. 50].

Peripherals of the '70s

Electromechanical peripheral equipment is waiting for the same kind of precipitous price dropping that has made integrated circuits such an important part of today's electronic systems. This is the opinion of Richard Rabin, vice president and general manager of graphics and data systems at Varian Data Machines, Palo Alto, Calif., who says, "Large-scale integrated circuits first became attractive to the military and aerospace people because of their excellent reliability." This factor was what both built up their volume and dropped their cost—a regenerative phenomenon.

"Somewhere out there somebody is available to start a similar process with electromechanical equipment. To a certain extent it's under way already—low-cost equipment has appeared recently for use with minicomputers. When the cycle really gets going, price of input-output gear will drop like those of ICs."

Louis B. Horwitz of XDS agrees. "There's an enormous challenge for industry here," he says. "Circuits are dropping in cost. Memory is dropping in cost. We're faced with a processor of negligible cost surrounded by expensive and troublesome peripheral equipment." In Horwitz' view, the challenge is to design peripherals with a price/performance ratio that drops the way that of the processor has dropped.

Meanwhile, peripheral equipment has been growing in importance practically since the beginning of the computer age. In 1955, for example, of every dollar spent on hardware, 20¢ went for peripherals; in 1965 the ratio was more nearly 50-50, and by 1975, if not sooner, it will be 80-20—the reverse of the 1955 figure.

Much of this growth is due to increased interest in remote on-line computing, which requires communication channels and a multiplicity of terminal devices. Much of it is also due to the increased raw power of central processors, which require more and fancier peripheral devices to provide them with enough data and to absorb their output.

But a significant need for the classic input-output device remains, and they will remain important through the next decade, although in some cases their forms may change. The backbone of the computing business for many years has been the unit record, and its most common form the punched card. But while the production of punched cards continues to increase, in many applications new forms of unit records and of data entry equipment threaten to supplant them.

An important rival of the punched card is the optical character reader. Several companies have entered the field, some not as successfully as others. But somehow the concept doesn't have quite the glitter it did a few years ago. For one thing, IBM extended the life of the punched card by introducing a new 96-column version with its System 3. Had it chosen to do so, IBM could have opened a market of some kind for OCR, although probably not to serve the market that the System 3 is designed to serve.

Meanwhile the keyboard-to-tape concept, which Mohawk Data Sciences pioneered, and which enjoyed a burst of popularity a few years back, is continuing to grow. New forms of keyboard-to-tape machines are introduced from time to time, along with keyboard-to-disk and other combinations. There's even a new kind of keypunch for cards now and then. None of this helps the OCR market, and OCR technology itself continues to be plagued with the problems of implementing scanning functions, standardizing formats, and reducing error rates and high costs.

There's a great need for a good printer that can turn out multiple copies quietly at high speed while requiring little maintenance. Univac's Kiernan says, "Some users of our 9000 series computers pay more for paper than they do for computer rental." Most printers are impact types which are almost invariably noisy and wear out quickly. Various forms of nonimpact printers showing up now in remote terminals are for the most part based on electrostatic or thermal techniques. But they are usually character-at-a-time printers and therefore limited in speed. For on-site use, line printers are necessary, and often multiple copies are desired, making impact printers the only economical method to date. But Kazuji Hashimoto, general manager of the large-scale computer division of Hitachi Ltd. in Japan, says a cost-effective nonimpact printer is possible in three or four years—probably an ink-jet, chemical, diazo, or electrostatic type.

A technological factor likely to influence printer design over the next few years is the continuing decrease in IC cost. One printer in which the extensive use of ICs reduces substantially mechanical complexity is Potter Instrument Co.'s model LP3000 [*Electronics*, May 25, 1970, p. 47]. While it is an impact printer, each impact prints only one dot of a 5-by-7 dot matrix. The tiny imprint coupled with the high repetition rate of successive impacts means that the hammer actually vibrates rather like the tip of a loudspeaker cone—in fact, the drive mechanism is quite similar. Only 12 hammers are used, each spanning 11 print positions. This simple mechanism unloads much of the work onto the electronic circuitry, which is inexpensive enough to make complex electronics and simple mechanics pay off.

Fairchild's Rex Rice sees a serious problem ahead in input-output equipment for minicomputers, caused directly by extending the use of minis from primarily scientific applications and from process-control monitoring into general-purpose work. "When this happens," says Rice, "these computers are going to need a great deal of additional software, and there'll be a serious need for one of two things—a way to bypass that need for software, or much better input-output capability to whip software routines into and out of the computer as they are needed."

There's a lot of interest in adding hardware to peripheral devices, notably bulk storage machines, to increase

their capability at low cost without falling back on software. An important example of this capability is error correction—not just detection. Error-detecting codes are old hat; tapes, for example, have always had parity bits written along with every character, and cyclic codes that detect errors are common in magnetic disks. Tapes also often have a longitudinal redundancy check (LRC), which in combination with lateral parity can often isolate erroneous bits in a block of data read from tape. But both the LRC and the cyclic code operate after the fact—the faulty data has already been transmitted to the computer's memory before the error information becomes available. Error-correcting codes, on the other hand, can often invert faulty bits as they go by, so that at the output of the correcting circuit no error within the handling capability of the circuit ever appears. Or, equivalently, the only errors that will appear at the circuit's output will be big ones.

Necessary extra. Another function that can and should be added to the controllers of input-output devices is a means of direct access to main storage, which bypasses the central processor and doesn't impede the processor's own access to storage except in rare cases. Further, the controller could be made to perform a string of simple instructions on incoming data, such as checking for exceptional conditions in the data, reformatting it for computation, and so on. "These things almost have to be done to relieve the central processor of a large input-output overhead," says Bob Daniel of ISS.

What about new peripheral equipment? "One of the things we're doing at Project MAC now," says MIT's Licklider, "is putting together a hardware-software system that expresses your ideas, shows you what happens, and lets you back up and try again if necessary." The principal equipment that Licklider and his associates are working with is the powerful Evans and Sutherland Computer Co.'s LDS-1 display—LDS stands for Line Drawing System—beefed up with improvements conceived and executed at Project MAC. For instance, they use a better character generator than the one that comes with the machine.

Another system, similar in some ways to the LDS-1, is the Adage Graphics Terminal, made by Adage Inc. The AGT uses hybrid analog-digital circuits, whereas the LDS-1 is all digital. Originally designed for use by research organizations for swirling around mathematical equations and their graphical equivalents, the AGT has been modified for commercial use in practical applications. Indeed, industrial users now make up the major part of the customer base for the terminal.

Based in part on experience with this terminal, Thomas G. Hagen, senior vice president of Adage, feels that on-line conversational systems are finally getting off the ground, after a period of false starts and flurries of interest. "This big new flap of data communications seems to be real," Hagen says, "so that on-line interaction appears to be more and more real—particularly if the cost of minicomputers and peripheral equipment continues to drop as it has recently."

Some early on-line conversational systems, which are still in use to some extent, depended on teletypewriters and similar equipment as terminals. These are capable of two-way communication at about 10 characters per second, and are limited to messages of no more than about 200 characters. But on-line graphics is much more powerful, and its capabilities account for the new applications in which it's showing up. It must handle the equivalent of thousands of characters, sketch data at bit rates much greater than any typing rate, and therefore needs a much wider data transmission channel than the teletypewriter-oriented system. Consequently, the AGT and similar displays have to be used either with a wide channel to a host computer, or in a stand-alone mode with only a standard telephone line to allow remote batch processing. Of these two options, the first is expensive, so the second is the one more likely to be used. The AGT is in fact a stand-alone unit. But Hagan anticipates that more processor power will little by little become available in the unit itself, because of present cost trends in memories and small computers.

"People demand a low-cost terminal, and they formerly dismissed graphics as being too expensive," says Hagan. "But now the price trend for both terminals and computers is down, and things that used to be daydreams are becoming feasible."

Firmware in the '70s

Microprograming, which was first thought of in the 1950s, had matured enough by the 1960s to give birth to one of the decade's more important ideas—firmware. The term refers to a collection of microprograms in a control memory, which usually takes the form of a read-only memory. In such a collection, hardware (the memory plus the logic gates it controls) combines with software (the programs and routines that utilize the computer's capabilities) to improve the machine's speed and efficiency.

Alternatively, firmware can be viewed as control information that, being contained in a read-only memory, can be altered much more easily than if it were implemented in hardware. The memory can be physically replaced, while the hardware would require extensive rewiring, yet it is not as evanescent as software.

This use of microprograming, to alter the machine image of a general-purpose processor, is described by Jack Lynch of Burroughs Corp. as the key to the direction of Burroughs' future large machines. He calls the microprogram the "common engine," providing computing power to a wide variety of specialized applications. "It's a way to build a lot of functions into a small design using large-scale integrated circuits," he says. "It solves the problem of producing many different parts in small volume, because the differences between parts are reduced to differences in the microprogram. By this means anything from a digital controller up to the level of the Illiac 4 can be built."

Moreover, firmware compels a desirable orderliness in thinking. "A habit of orderly thinking imposed by microprograming leads to an orderly design, which in turn may produce a simple control system," points out Gene Amdahl.

The idea was originally proposed as a control means in large computers. But it is becoming more and more important in minicomputers, for two reasons: first, sections of control memory can be made much smaller

than those of the main memory, and can be replaced at very low cost; and second, a small increase in the size of the control memory allows a substantial reduction in the size of the main memory, and considerably increases the machine's performance.

Clemmetsen of Arcturus Electronics predicts that the firmware idea may be expanded till the distinction between memory and processor disappears. In his view it's possible to build a minicomputer with a dynamically alterable microprogramed instruction set that could be changed from time to time—perhaps even by the user. Eventually as much as 70% of the processor functions now carried out by logic gates could be realized in storage elements that function as combinational logic—an extension of the idea that many complex logic functions can be implemented as truth tables stored in read-only memories [*Electronics*, Jan. 5, 1970, p. 88].

Brian Gaines has a similar view, except that he doesn't call this prospect an extension of firmware. When nonvolatile semiconductor read-write memories eventually become available, he says, read-mostly operations will become just another part of main store operation and won't be distinguished from it in any way.

Not an answer to everything. But not everybody thinks firmware is the answer to a designer's prayer. If firmware is piled into a design almost to the point of creating a special-purpose machine, it won't be cost-effective. In addition, microprograms imposes a time penalty on the machine, because the microinstructions must be taken out of the control memory and permitted to set up the data paths for the subsequent micro-operation in the next machine cycle. There are tricks for avoiding or reducing this penalty—for example, staggering the control memory cycles relative to the machine cycles—and in any case it's offset by the fact that wired-in control information also takes time to propagate through a series of logic gates.

Gerhard Hollander points out another disadvantage: "it's expensive—memory costs are dropping, but logic costs are dropping faster." He believes that firmware is only an interim step, and that a better total design philosophy is the use of functionally distributed computers.

Linder Hobbs dismisses firmware as a logic design trick, not a system technique. The only exception is when the firmware is stored in a read-mostly memory—a memory into which new data can be written electrically, but at a much slower writing than reading speed. Depending on just how the facility for occasional writing is implemented, a microprogram in such a memory could enable a machine to change and adapt its own operation to changes in its environment.

Up to now, however, almost all firmware has been taken the form of read-only memories. Some of these memories have been physically rather larger, but as semiconductor technology progresses, they're shrinking rapidly to a manageable size.

This trend is also reducing the cost of firmware, which in turn encourages its use in small computers. "When read-only memories get cheap enough," says Varian's Orris, "they'll unquestionably be the only reasonable way to implement controls in minicomputers." Varian is already using read-only memories extensively in its machines, which it sells as subassemblies to manufacturers of other equipment. Since the identical machine goes to several customers, the programing of the read-only memory is inexpensive. Even if a particular OEM customer requests a specific instruction set, and therefore a custom read-only memory, Varian can provide it at reasonable cost—but this doesn't happen often.

For this reason, Orris thinks, reloadable control stores

Eckert on making haste slowly

Twenty-five years ago J. Presper Eckert, then a graduate student at the University of Pennsylvania's Moore School of Electrical Engineering, completed the world's first digital computer. It was called the Eniac, an acronym for electronic numerical integrator and calculator. Directed by faculty adviser John W. Mauchly, the project had been under way for two or three years. The two men later went into business as the Eckert-Mauchly Computer Corp., produced the Binac computer for the U.S. Census Bureau, and were acquired by Remington Rand—itself later to become part of the Sperry Rand Corp.

Today Eckert, now 52, is vice president and technical adviser to the president of the Univac division of Sperry Rand. He stays away from radical predictions about computer technology, preferring to point out the correctness of his earlier prophecies.

For example, alluding to the IEEE Computer Conference in 1968, where he and two other computer pioneers, Brian W. Pollard of RCA and Max Palevsky of Scientific Data Systems (now part of Xerox Corp.), formed a panel to assess the outlook for large-scale integration in computers, he says, "In 1968 I said LSI would move slowly. I was right. Today it's working nicely in small machines, and large machines using it will evolve slowly. Its problem in large machines is that they require speed, and speed in ICs requires designs that are hard to produce with high yield, and therefore don't lend themselves to LSI."

He's not down on ICs as such. "If we were to build the Univac 1 today using ICs instead of vacuum tubes, we could do it with maybe 700 ICs—compared with the modern large computer, which uses perhaps 40,000," he says. The Univac 1 was the first machine produced after Remington Rand acquired his original firm.

Eckert doesn't think much of today's standard representation of data. "I believe the 8-bit byte is inefficient," he says, "because it has too many bits. It's replacing the older 6-bit binary-coded decimal representation because, as a power of two, it's easier to handle in shifting and conversion operations. The 8-bit code has a short-term advantage, but over the long term the extra two bits will take up space in the memory as long as we have our alphabet."

Standard computer programing languages don't fare much better in his opinion. "It would be nice to standardize," he says, "but the only standard so far is IBM's PL-1, and it hasn't worked too well. It tries to be too many things for too many people. Specialized languages work better today." Eckert thinks that not enough is known yet about languages to permit a good standard to be established without stifling innovation. Nor does he expect the necessary knowledge will be acquired in 10 years. "Maybe in 20 years," he says, hopefully.

He and Mauchly parted company in 1950, when Mauchly started his own consulting firm in preference to working for Remington Rand. But Mauchly's firm was itself acquired just this past summer by the Dynatrend Corp., of Springhouse, Pa.

don't have much of a future in Varian's kind of machine. Customers don't particularly need them, and generally they are volatile and require reloading every morning—which means the addition of a card reader or other input device to the system.

Hobbs doesn't think much of reloadable control stores either. He cites another minicomputer manufacturer, who uses a standard data pattern in braided read-only memories (small transformer arrays) in his machines. Though he retains the capability to wire up custom braids, very few of his customers request it, Hobbs says, concluding that if they don't need the special wiring, they don't need the reloadability.

But Hobbs and Orris to the contrary, there are excellent reasons for using reloadable control memories. Alan Clemmetsen of Arcturus Electronics points out that, with read-only memories, the microprogramed instruction set must be predetermined at the factory, but in a reloadable memory this capability can be left for the user to establish statically in his own location, or even made to change dynamically by programing.

Rex Rice of Fairchild sees the use of reloadable control memories "exploding" when their cost is low enough—no more than twice the cost of read-only memories. "But it's a chicken-and-egg proposition," says Rice. "The cost won't drop until people start using them in quantity, and people won't use them until the cost drops." Nevertheless he sees them in general use before 1980.

Gordon Moore is sure that users will demand such a memory more and more vociferously. He feels that they won't change the pattern often, but that when they do want to change the pattern, they'll want to very badly. "There's a fantastic need for this," he says, "and all kinds of crazy ideas—blowing fuses and the like—that don't fill the bill at all."

Reloadable memory takeover. Laszlo Rakoczi of Standard Computer Corp. thinks that the reloadable control store has such large advantages for system checkout and maintenance that it will eventually take over in all firmware-controlled equipment. "It helps locate flaws quickly," says Rakoczi, "and that's important in system test, the largest single item in manufacturing cost." Add to this its ability to make engineering changes, particularly in large systems, without extensive rewiring, and his feeling for its inevitability is easily understandable. He points to its use in IBM's System 360 models 85 and 195, in the System 370 models 135 and 145, in the giant 3330 disk drive's controller and in the integrated adapters for IBM's smaller 2319 disk drive and communication system.

Rakoczi points out that the reloadable control store will also give System 370 a much longer life than even the 360 had. One of IBM's objectives in introducing the 360 in 1964 was to stop having to introduce new systems for new applications every year or two. It figures that it would be easier to design new models within the basic 360 framework than from the ground up, and that the approach would be good for at least 10 years. In the event, System 360 lasted little more than six years, and has been almost completely supplanted by the 370, even though the step from 360 to 370, taken in June, 1970, is much less of a venture than the step from pre-360 to 360 in April, 1964. No 360s are in new production now except the model 195 (the recently announced model 22 is built with a collection of parts cannibalized from other systems returned by purchasers of 370s).

By 1976, the 370 will be as old as the 360 was when the 370 was announced. Should IBM then choose to make an advance that earlier on might have necessitated a new line, it will need only to issue new control routines and maybe a bigger control memory, and it will be in business.

Software in the '70s

So many loose strands are left dangling round the edges of the typical software project that programing really needs to be transformed into a full blown discipline like engineering.

"Every person today who develops any expertise in programing has built it up from ground zero," says Thomas Kurtz, director of the Kiewit Computation Center at Dartmouth College. "There's no correlation between techniques used by programers in different places; what it amounts to is that all software work is done by trainees." The answer, Kurtz thinks, is to establish software as an engineering discipline derived from a set of basic principles. Then, when a new software system is required, it can be built up without running into the major difficulties that IBM, for example, encountered when it tried to generate software for System 360.

Douglas T. Ross, president of Softech Inc., has been plugging the software engineering concept for some years, from a slightly different point of view. He uses engineering techniques to develop hundreds of computer languages for special applications, so that the computer user who programs for his application in one of these languages need not be a computer expert. The engineering reduces the problem to its essentials, subjects it to an orderly set of bounds, and eventually replaces the specific with the general.

Ross claims that the enormous advances in hardware over the past years are due, not to miniaturization in itself, but the fact that miniaturization has permitted a graduation from basic principles to larger functions along with the changeover from diodes and transistors to flip-flops to registers. But though this functionality has improved the economy and reliability of hardware, the basic principles always must be borne in mind.

Software is subject to similar constraints. It can be made to accomplish great things if it is reduced to its essentials and then functionalized. But at the same time, its fine points must be understood and kept in mind for use when they become important. Too many of the essentials and fine points in software are not well enough understood, Ross thinks.

Need to systematize. Just as engineers thrash around in mathematics, the language that represents the underlying physical reality, so programers need a language that represents the basic components of software. A software engineering language would implement both the multiple-use components and their specific uses, just as in mathematics the operation represented by the plus sign can be used at various levels.

However, Ross feels that an important element is still

missing, the technology to make software engineering real. The engineer can translate his design into wires and transistors that he can pick up and handle; but in software he needs something that he can use naturally to aid his thinking, and can also be loaded directly into the computer and compiled into a working program.

Once this has been achieved, the next thing is a way to make these tools portable between different machines. If the engineering approach is applied in enough depth, an understanding will be obtained of what is machine-limited and what is problem-limited.

Unlike industry, universities can afford research efforts that are not product-oriented, and can work legitimately on the problem of establishing a software discipline parallel to existing hardware disciplines.

Sad end of Sofix. In fact, a start was made in a program called Sofix that was under way at the NASA Electronics Research Center, in Cambridge, Mass. Sofix was set up as a result of the Apollo project, the software for which took 6,000 man-years to write, and was an attempt to make the corresponding task for future missions easier by investigating the fundamental theory of software. It was going into its second year when it was terminated as part of the general closing of ERC. Frank Sullivan of NASA couldn't say how much more work there was in Sofix had the project survived, but he does feel that at least 10 years of work would be required substantially to reduce software costs.

One distinct possibility that appears for the 1970s is the large-scale incorporation of software functions in hardware. This now appears possible because hardware, unlike software, has been dropping fantastically in cost and is now less than half the cost of a computer system.

Gerhard Hollander, the Fullerton, Calif., consultant, points out a number of ways of carrying out the substitution. The most direct, and the least appealing, is just to build special-purpose computers. Another possibility is to pile on the microprograming, to the point where the computer is nearly special-purpose. But this is unlikely to be cost-effective and also exacts a time penalty.

A third alternative is to build a computer around a series of very large macro-instructions, and give the computer the capability to decide which macro is best able to achieve the results requested by the programer. Using macros is a labor-saving trick well known to programers. In hardware, it has a lot of potential, but would work economically only on very large machines, and could only be developed by a very large company.

Related to the idea of hardware macros is the idea of small special-purpose boxes, each of which would contain a specific complete routine, and which could be connected into a network. One box, for example, could contain a sine routine, another a sort routine, and so on. The basic computer then would only supervise the operation of these boxes, and would itself need only a very small memory for a supervisory program. But this is a notion of which John Pinkerton of ICL is very wary. "The bulk of effort in any problem is in the logical thinking through of it," he says, "and when this is imperfectly done you run into difficulties—whether you try to solve it in hardware or in software."

There have been several major efforts to date to put software functions into hardware. At the last two Spring Joint Computer Conferences, Harut Barsamian of the National Cash Register Co. described the design of a hardware-firmware sort processor and the evaluation of tradeoffs in such a design. This week, too, a paper is being presented by Anthony Hassitt, J.W. Lageschulte, and L.E. Lyon, of IBM's Palo Alto Scientific Center, at

Two views from the top company

As the company with the largest percentage of the computer business—in fact, according to some yardsticks, the company with the largest percentage in its line in any industry—IBM necessarily must be careful about its public statements. Any predictions it makes about the computer industry are likely to happen almost automatically, because of a bandwagon effect.

Nevertheless, two IBM executives were able to confirm the trends that other observers see in the industry, and to add a few comments of their own.

For example, when asked how many circuits could ultimately crowd into a semiconductor chip, Emanuel R. Piore, vice president and chief scientist, says, "Any prophecy is self-serving; it depends on resources, not on first principles. Density has been increasing by a factor of two every 18 months for some time, and that rate will probably continue for the time being. But the industry will be up against first principles by some time in the '80s, when there'll be circuits that work with a few quanta of energy, and it will be hard to push density further."

"At the same time," adds John E. Bertram, director of engineering, programing, and technology, "these electronic circuits will be getting less and less expensive, to the point that by the end of the decade rotating machines—such as fixed-head disks and drums—may have been completely replaced."

The executives agree that networks and distributed data bases will appear in increasing numbers over the next few years, and that the machines at the nodes of the network can be of any size. "Computer networks appear to offer many advantages," says Piore. "If your own machine is saturated, you may want to have access to another computer through a network—or may need access to other data bases. In any event the network depends on the uses to be made of it. It could interconnect primarily large machines or a mixture of different-sized machines." Thus, he discounts the prospects of minicomputer networks as such.

Bertram says semiconductor memories have hurdled their worst technological barriers. "Reliability was a problem until recently, but it's been solved," he says. "And cost isn't a problem either. IBM leases 2-microsecond core memories at $12 a month per kilobyte in the 370/155 and 165. Compare this with the semiconductor memory in the 370/145, which is more than four times as fast, contains some logic in the first module along with the storage cells, and leases at about $19 a month per kilobyte. Conceivably a machine at the performance level of a model 155 or 165 with an all-semiconductor main memory could be available in three to five years."

"Improvements in programer productivity during the next ten years will be influenced by two trends in software," Piore believes. "These are the increasing cost in programing, and the increasing complexity of applications. There are a great many possibilities for improving programer productivity; getting hardware to pick up more of the traditional software functions is one of them but not the only one, by any means."

the joint IEEE-ACM Workshop on Microprograming in Santa Cruz, Calif., describing how a new microcode for the IBM System 360 model 25 was written to make the machine run directly on the APL programing language.

Another attempt, which came a cropper when the company encountered financial difficulties, was Astrodata's sorter [*Electronics*, July 19, p. 30]. This machine was designed to accept up to 2.5 million bytes of data from a processor, sort it, and return it to the processor in about a minute. By so doing, it could reduce the execution time of many programs by as much as a half.

But the most ambitious effort thus far is the center of an on-going research program, and will surely have a strong impact on design by 1980. It's the Symbol computer, built at Fairchild Camera and Instrument Corp.'s Systems Technology division by Rex Rice, and purchased by Iowa State University with National Science Foundation money.

Starting afresh. Symbol has a high-level programing language built right into it, and can compile up to 70,000 statements per minute, as compared to the 5,000 or so statements per minute of conventional software compilers. It also contains a time-shared operating system in hardware. It's such a new machine that Iowa State's first task, under the guidance of Robert M. Stewart, chairman of the department of computer science, and Roy J. Zingg, associate professor of electrical engineering and computer science, is to find out just what it can do, and in what ways it's better or worse than a conventional computer. "I feel like a little boy in a candy store with a $10 bill," says Stewart.

The new language for the Symbol computer, also called Symbol, is described as "artifact-free." In this context, an artifact is a statement defining the location and amount of storage needed for some aspect of a program or its data; the artifact itself contributes nothing to the statement of the problem or to its solution. As a result, when Symbol's user refers to data, he won't previously have had to define where that data is. The address of the data is fixed only at the time of execution—not at the time of compilation, as with most languages.

Stewart doesn't know what this will mean to the user—that's one of the things his research project will have to find out. But it might, for example, reduce the number of rules one must know to write a program for the machine, and so make the computer easier to use.

A program written to be executed on the Symbol computer is translated from its source code into what is commonly known as "Polish notation." This is the designation most computer people give to a method of writing algebraic statements originated by a Polish logician, J. Lukasiewicz. This notation arranges the variables and mathematical symbols in such a way as to eliminate parentheses, by the simple expedient of having each mathematical operation refer, not to the two numbers that it stands between, but to the two numbers preceding it—or in the case of some operations, such as sign changing, to only the last preceding number. Thus the same statement can be expressed three ways:

- In English: X is the sum of two numbers; the first of these is the quotient of A divided by the sum of B and C, and the second is the product of D multiplied by the difference of E and F.
- In conventional Fortran notation:
  X = A/(B+C) + D*(E-F)
- In Polish notation:
  BC + A/DEF - + * + X =

Polish notation is much easier for a computer to handle, because during the reading of an expression, it can perform every mathematical operation as it encounters the sign for it, without backing up to see what went before or waiting to see what comes next.

In the Symbol computer, however, the time saved in this way has to be traded off against the fact that the variables are undefined, and have to be defined as they are located. This takes time, and some critics have said it takes too much time, because occasionally the translation has to take place over and over—all data is kept in source-language form and translated only when it is needed. Just how much time it takes, and whether that time would justify storing frequently used data in binary form rather than in source-language form, is one of the questions Stewart's research program will try to answer.

System supervision also takes hardware form in the Symbol computer, being implemented in one of six separate processing modules. The supervisor starts up the other processors when the program load requires it, handles queues of instructions waiting for various machine resources, and generally performs all the functions usually assigned to software supervisors. Because it's all in hardware, it requires only 8,000 bytes in the computer's memory, as compared to about 30 times that much in a typical IBM system 360 model 65 installation. This feature relieves the user of the expense of maintaining a software operating system, but the magnitude of this expense remains to be more precisely determined, along with how well the hardware supervisor works and what modifications should be made.

Terminal-oriented. The Symbol computer is time-sharing and terminal-oriented. Initially, Stewart plans to have three terminals connected to it, and the capacity of 32 may be used eventually. Important research can be carried out here, because those terminals can be of different kinds, with different levels of local processing capability.

Even interactive graphics may be carried out with Symbol. Iowa State has several graphic terminals in the University's computation center (from which the Symbol is carefully kept disconnected), and these could be experimentally switched over to Symbol.

Like many computers of recent design, Symbol is built around a bus. This means that expansion of the system would be very simple—new boards carrying extra functions could just be plugged into the bus.

One of the basic design objectives in Symbol was to minimize software. To this end its design is unconstrained by any conventional approaches, by compatibility or hardware constraints. Compilation, memory management, and peripheral equipment management are all handled in hardware.

This machine's impact on computers in the '70s is foreshadowed by the acceptance today of a number of components developed directly as part of the Symbol project. Notable examples are the familiar dual-in-line package, and Fairchild's Complementary Transistor

Micrologic (CTμL) circuit family. Also developed for Symbol, but then not used in it, were a 256-bit bipolar random-access memory chip and a memory system built around it, which wound up in the Illiac 4 supercomputer, and is being offered by Fairchild as a commercial product. Meanwhile, Symbol had to settle for a core memory, for reasons related to Fairchild's decision not to enter the computer market as such.

There's widespread interest outside Iowa State University in the Symbol computer. Utah's Barton, for example, says, "Rex Rice has done a rather heroic thing. I very much admire him for it." But the outlook isn't all sweetness and light. Even when Stewart and his colleagues have learned how to make the best use of the concept, further research into applications is necessary, and that will take money.

Doubts. Besides, the project may be a few years too late, suggests Intel's Gordon Moore. Moore, who was Rice's superior at Fairchild before he left for Intel, says, "The idea would have been a lot more important if it had come along before so many people had invested so much in software." He's got a point—replacing software-based computer systems, if it happens, will be a long and difficult job. And Barton, in spite of his admiration, realizes that "many potential users [of a machine like Symbol] would object to the freezing of a particular language into hardware."

What else is likely to happen in software? Ruth Davis of the National Bureau of Standards predicts the availability of what she calls "procurable software." For a price fixed in advance, the customer gets not only the conventional software package plus all documentation, but also all maintenance and updating of the package for a period of years. Eventually this could lead to a package of software that, more or less incidentally, includes the hardware—you buy the software and the service, and you get the means to execute the software as part of the package.

The tendency to substitute hardware for software will retard this trend, Davis believes. But the fact remains that the trend toward procurable software is underway now, while hardware substitution, as in the Symbol computer, is just getting started. Procurable software is aided by the coming growth in the use of minicomputers and of data communication, the combination of which will take over the great bulk of conventional computing activity by 1975.

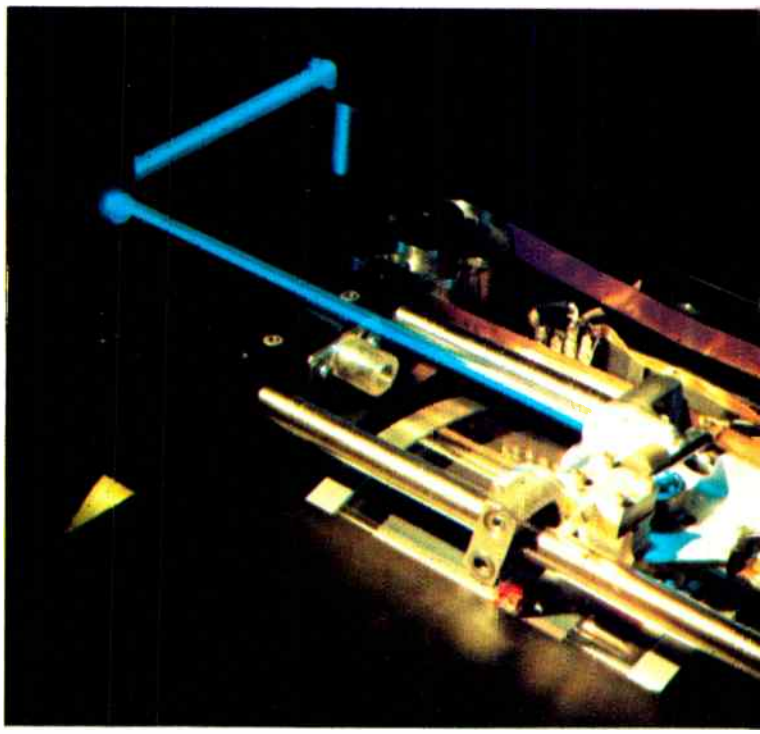
In programing languages, there's a need for a new high-level language, asserts Nick Mazzarese, vice-president for small computers at Digital Equipment Corp. "Just in the past few years, the cost of hardware is down by a factor of about four to one," he says, "but the cost of programing is going up—we're not getting the necessary improvement in our tools." These improvements have been forthcoming for large commercial machines in the shape of Cobol compilers, report program generators, and the like. But small machines haven't benefited from such advances, and their growing popularity will compel the development of such a language.

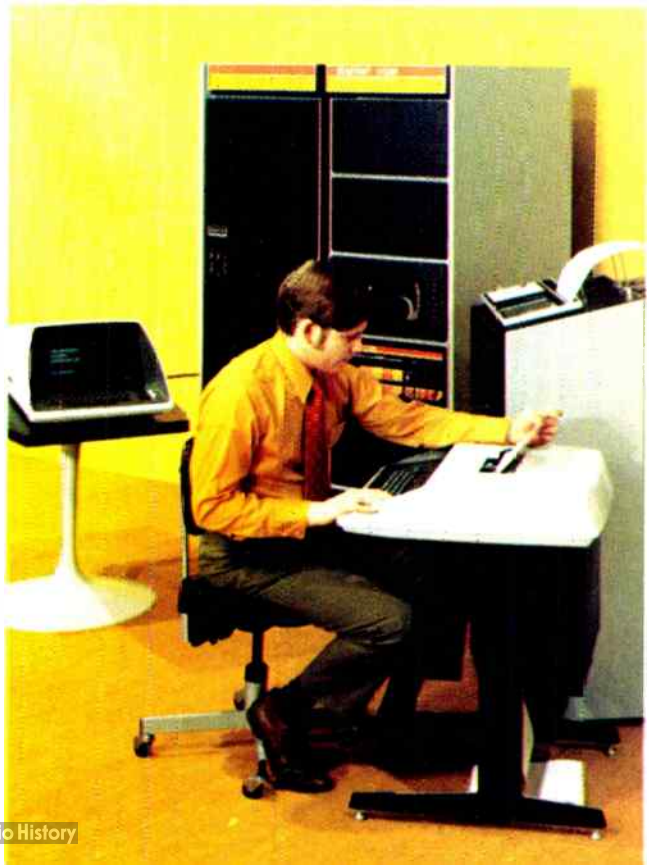
12. Teaching aide. Educators are finding more uses for computers, a trend that minicomputers will encourage. Here a student does his homework on a Digital Equipment Corp. minicomputer.

High-level languages tend to be inefficient in their use of hardware, Mazzarese admits, but with the cost of hardware coming down, the user can afford to trade it off for lower programing costs. "Sooner or later the cost of hardware will be almost trivial," says Mazzarese, unknowingly agreeing with Davis.

But any new language is automatically constrained by the requirement that it be compatible with its prede-

11. Laser recording. In Unicon trillion-bit memory, laser beam is directed at recording medium by mirror mounted on carriage that slides back and forth across the medium. Fine control is obtained by tilting the mirror with a galvanometer mechanism.





cessors. This is part of the push behind software engineering—starting from a core of basic principles, it would permit the development of a language with the desired features without having to retain compatibility. The Symbol language, of course, has done this very thing in a different way: since it was developed for a specific new machine that differs from all others in significant ways, it was not constrained by compatibility, and therefore achieves capabilities not previously available.

Fernando Corbato, of MIT's Computation Center, feels strongly that technical laymen, who would, of course, include the readers of *Electronics*, should all learn some kind of programing language for two reasons: first, because English and other spoken languages for the most part tend to be imprecise, a programing language serves as a conceptual framework in which to express an action, or a means for achieving action—an algorithm; and second, to serve as a lingua franca in which to communicate technical information to other people. (Imagine a future issue of *Electronics* written in PL-1). These two reasons themselves will lead to the development of more permissive languages, with fewer rigid rules. In these languages a programer can make a statement and the machine can assume what he means, or in tough cases in which it can't make an assumption, it will ask him what he means. Corbato won't hazard a guess as to when this might happen, but he points out that languages today are evolving from a series of simple imperatives toward a series of more complex declaratives. When the computer can tolerate ambiguities, such as minor misspellings, in a program made up of a series of declaratives, a great deal of additional power will be available to the computer user.

"Integrated emulation." A prominent characteristic of the IBM System 370 is its ability to run programs written for older IBM systems, and even to mix these programs with others in 360 and 370 code in a multiprograming environment. IBM calls this "integrated emulation," to distinguish it from ordinary emulation, a characteristic added to the 360 shortly after its introduction to enable it to run older programs. Because effectively integrated emulation offers a way to make a machine look like a different machine, this development at IBM and related developments at other companies have great significance for the 1970s.

So far IBM's integrated emulation applies only to its own second-generation computers. But there's no reason, other than IBM's own rather hoity-toity attitude towards competition, why the concept couldn't apply across the board—so that, for example, an IBM 370 model 165 could be made to emulate a Burroughs 6500 or a Univac 1110.

An equivalent design is already offered by Standard Computer Corp. in its IC-7000. This is a microprogramed machine in which the microprogram, rather than being entombed in a read-only memory or even ensconced in a reloadable control store, is implemented in what Laszlo Rakoczi, vice president, calls an "inner computer" through which the computer as a whole can be given any desired instruction set, and with which therefore the computer can be made to act like any other computer. Standard Computer has designed a freestanding version of this inner computer, and Rakoczi has described it in a paper scheduled to be presented later this month at the Advanced Summer Institute on Microprograming, St. Raphael, on the French Riviera. Standard may later offer the computer commercially, together with its services in beefing up existing computer systems.

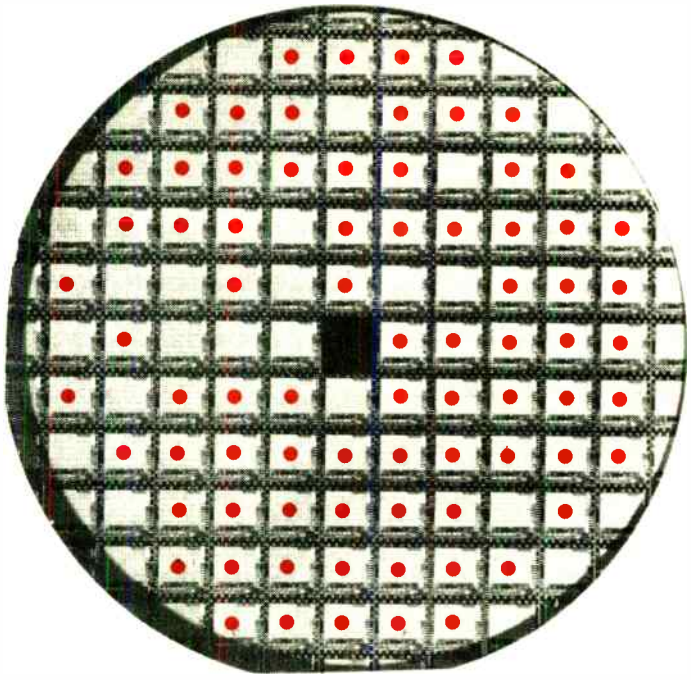
Cars and computers

Unquestionably the computer will become a more and more important part of every individual's daily life and every company's ordinary routine. It may even attain the level of importance that the automobile has reached since World War 2. Today the automobile is a necessary attribute of living. People put up with automobile-generated smog, traffic jams, and communities dichotomized by superhighways, because they are unwilling to part with the mobility and the convenience.

The computer hasn't reached that point—although the characteristics of some software are quite analogous to those of smog. But if present trends continue, by 1980 we'll depend on computers in much the same way we depend on cars today. In some areas, such as banking, we already do. "Banks couldn't begin to handle the volume that they do nowadays if it weren't for computers," says an official of a large New York bank. "And this volume is in the form of many new and different kinds of services that would simply be impossible if we didn't have computers to handle all the figures."

Not everyone views the pervasiveness of computer use as a healthy situation—"I regard the prospect of dependency on computers as a terrible probability," says MIT's Licklider. "If we don't take steps to protect ourselves, and soon, we'll find ourselves dependent on computers; we'll find we don't want the dependency, but we won't be able to go back, any more than we know today how to get rid of the unpleasant aspects of an automobile-based society."

13. Means of exit. Getting the answer out of the computer requires a continuously growing proportion of the investment that goes into computer hardware. These devices, for use on Data General Corp.'s Nova line, include a printer, a paper-tape reader, and a card reader.



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Designer's casebook

Fast-discharge sawtooth simplifies capacitance meter

by R.W. Johnson
R W Johnson Co., Huntington Beach, Calif.

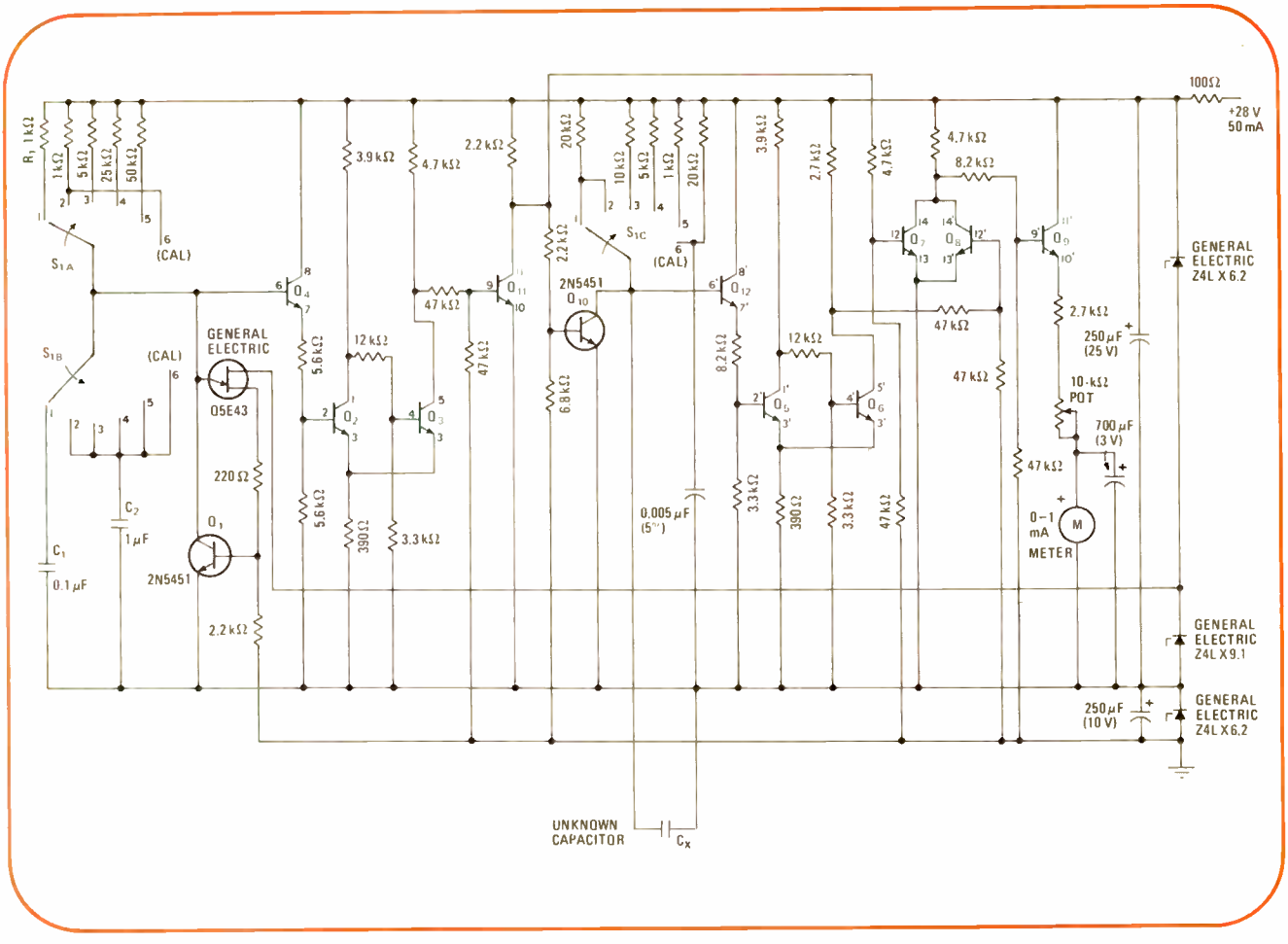
A direct-reading capacitance meter, accurate to 2%, employs a low-cost unijunction transistor to obtain a reference sawtooth voltage. The circuit measures a pulse duration proportional to the capacitance value to be determined. An average-reading meter is used to indicate capacitance directly on a linear scale. Measurement accuracy depends on meter movement and circuit calibration.

The relaxation oscillator portion of the circuit does not require a high-quality, expensive transistor to supply a reference voltage. A low-cost unijunction can be used, because high-current transistor Q_1 quickly discharges the oscillator's timing capacitor, dropping emitter voltage below its valley voltage and permitting a low-value timing resistor to be used. Since the second base (base 2) of the transistor is returned to a zener-regulated voltage that is lower than the charging voltage, the effects of leakage currents are minimized. Timing components are selected with the range switch, S_1.

The relaxation oscillator generates a sawtooth control voltage that discharges the unknown capacitor, C_x, once each cycle. To establish a reference voltage, the oscillator's output is applied to a Schmitt trigger formed by Q_2 and Q_3 through emitter-follower Q_1.

Capacitor C_x charges as the oscillator's timing capacitor charges from the regulated supply. When the voltage across C_x reaches the firing point of a second Schmitt trigger formed by Q_5 and Q_6, the trigger turns on, enabling the NAND gate formed by Q_7 and Q_8. The

Meter measures capacitance to 2%. Reference sawtooth generated by unijunction transistor relaxation oscillator and Q_2-Q_3 Schmitt trigger controls voltage across unknown capacitance C_x. Another Schmitt trigger (Q_5-Q_6) fires when voltage across C_x reaches its threshold, enabling Q_7-Q_8 NAND gate. Pulse duration of gate output is linearly proportional to C_x. Average-reading linear-scale meter shows capacitance.



gate output pulse, taken from the common collectors of Q_7 and Q_8, has a duration linearly proportional to the unknown capacitance.

Applying this pulse to an averaging meter through emitter-follower Q_9 allows the unknown capacitance to be read from a linear scale. Capacitor C_x discharges the instant the unijunction transistor fires, because high-current transistor Q_{10} conducts and remains saturated until the reference Schmitt trigger turns on again.

Even the true capacitance of leaky capacitors can be measured. The only condition under which the meter will give a false reading is when capacitor leakage resistance is less than 10 times the charging resistance. Since all the charging resistors have low values, most capacitors, including electrolytics, can be measured accurately.

Transistor Q_{11} performs as a pulse shaper and inverter so that Q_{10} can properly discharge C_x. Emitter follower Q_{12} drives the Q_5-Q_6 Schmitt trigger and prevents overloading C_x. Ten of the 13 transistors required for the circuit are housed in two integrated circuit packages—RCA's type CA3046 five-transistor arrays (shown in white with package pin numbers).

The capacitance meter has five full-scale decade settings, from 0.001 microfarad through 10μF. The smallest capacitance that can be accurately measured is about 100 picofarads because of stray capacitance as well as sawtooth rise and retrace times. Only precision resistors should be used for range switching. Resistor R_1 is trimmed to $C_2/10\ C_1$ kilohms so that capacitors with a tolerance of 10% or 20% can be used.

The circuit is calibrated by using a known capacitance within the overall measurement range. Position 6 of the range switch places a 5% 0.005-μF polystyrene capacitor in the measurement loop. The 10-kilohm potentiometer then can be adjusted until the meter shows an exact half-scale (0.5-milliampere) reading.

Resistance switching cuts tone oscillator jitter

by Barry M. Kaufman
Compath Co., Redwood City, Calif.

If the bit rate is high enough for the bit period to approach or even become less than the tone signal period, 20% to 40% jitter distortion can be encountered when asynchronous digital data is transmitted with frequency-shift-keyed modems. A frequency-shift tone oscillator that delivers a phase-continuous, constant-amplitude signal significantly reduces this error.

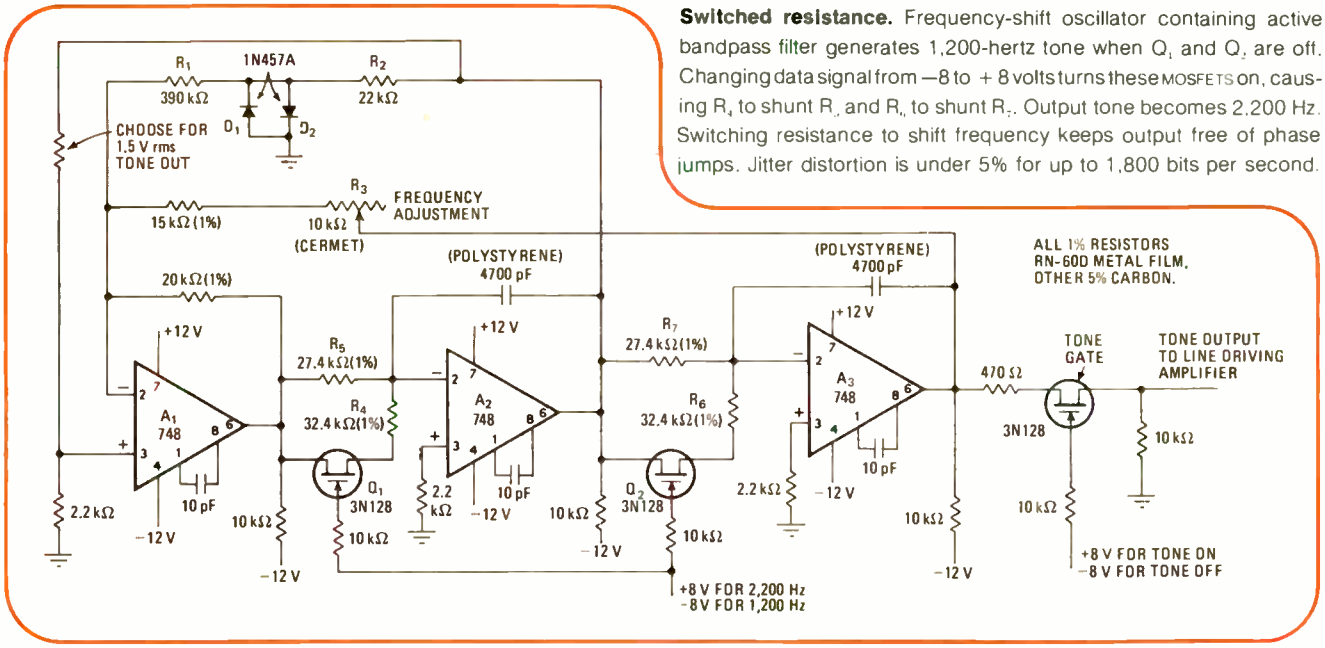
The tone oscillator holds jitter distortion to less than 5% at a data rate of 1,800 bits per second. The circuit employs a state-variable active bandpass filter that changes its frequency when resistance is switched.

Since switching resistance does not cause phase jumps, phase changes occur only at the incoming data signal transitions. The oscillator resonates at the filter frequency, generating a sine wave whose amplitude is limited by an anti-parallel diode pair.

Many conventional tone oscillators use an LC tank circuit as the resonating element so that a reactance must be switched to change the oscillator frequency. Jitter distortion can become significant because switching stored reactance energy not only generates phase jumps but also modulates signal amplitude. Furthermore, other oscillators frequently contain a square-wave multivibrator whose zero crossings seldom coincide with the zero crossings of the incoming asynchronous data.

The state-variable active bandpass filter in the low-jitter tone oscillator is formed by inverting amplifier A_1 and integrators A_2 and A_3. With positive feedback through resistors R_1 and R_2, the circuit oscillates at the filter frequency, which can be fine-tuned with R_3.

Because of its high Q, the active filter generates a



Switched resistance. Frequency-shift oscillator containing active bandpass filter generates 1,200-hertz tone when Q_1 and Q_2 are off. Changing data signal from −8 to +8 volts turns these MOSFETS on, causing R_4 to shunt R_5 and R_6 to shunt R_7. Output tone becomes 2,200 Hz. Switching resistance to shift frequency keeps output free of phase jumps. Jitter distortion is under 5% for up to 1,800 bits per second.

stable sine wave with less than 1% harmonic distortion. Signal amplitude is limited by diodes D_1 and D_2. The output MOSFET is a tone gate that can be controlled by an associated modem's request-to-send circuit.

The oscillator supplies two tones, 1,200 and 2,200 hertz, which are compatible with the popular Bell type 202 modem. When the data voltage is −8 volts, MOSFETs Q_1 and Q_2 are cut off and the 1,200-Hz tone is generated. If the voltage is changed to +8 V, Q_1 and Q_2 conduct, shunting resistor R_1 across R_3 and resistor R_6 across R_7; the output is the 2,200-Hz tone.

Tone amplitude remains constant because the time constants of both integrators are changed equally. The rate at which the phase shifts is the only tone signal parameter affected by the incoming digital binary data.

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

Doubling the divisor yields odd-order counter

by Charles Gordon and Thomas Chau
General Dynamics, Electric Boat division, Groton, Conn.

A simple concept makes it possible to achieve an often-difficult result—an odd-order counter that will deliver an output pulse train with a symmetrical duty cycle, as long as the input is a symmetric square wave. Usually, digital logic frequency dividers that have an odd divisor produce an unsymmetrical square wave.

The frequency divider shown first doubles input signal frequency (f_i) and then divides the resulting pulse train by twice the desired divisor (D). The output frequency (f_o) becomes:

$$f_o = 2f_i/2D = f_i/D$$

If a divide-by-seven counter must be built, the only components required are two-thirds of a hex inverter package, a dual NAND gate, and an eight-bit parallel-in/serial-out shift register. The register and one of the inverters divide the doubled input pulse train by a factor of 14.

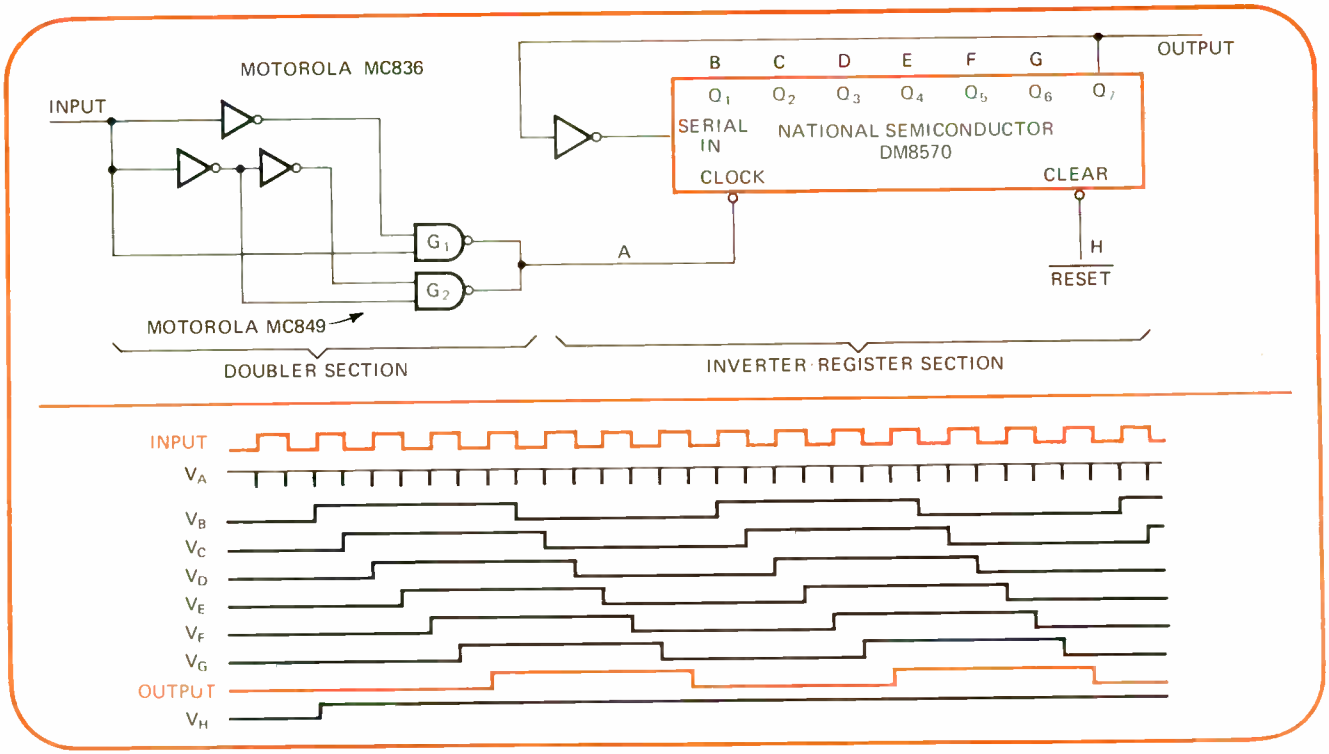
Three inverters and two NAND gates form the frequency doubler. The propagation delay of the logic elements themselves enables G_1 to contribute a pulse at each positive transition of the input, while G_2 contributes one at each negative transition. Since the outputs of the two gates are wire-ORed, the frequency of the input is doubled.

This $2f_i$ pulse train becomes the clock input for the shift register; it produces a single pulse for every eight clock pulses or one pulse for every seven of the input. The shift register must be reset initially.

If a divide-by-five counter is desired, the doubler section remains the same, but the output of the inverter-register section must be taken from the register's Q_3 terminal to divide the clock pulse by 10. To extend the divider scheme, additional shift registers must be used.

The propagation delays associated with the logic packages are not shown in the timing diagram.

Frequency divider. Odd-order symmetric counter can be implemented by doubling input frequency and then dividing by twice the desired divisor. Because of inverter propagation delays, G_1 is enabled at every positive input transition, G_2 at every negative transition, thus doubling input frequency. Inverter and register then divide doubled pulse train by 14 to realize divide-by-seven counter shown.



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You can depend on today's rf power transistors

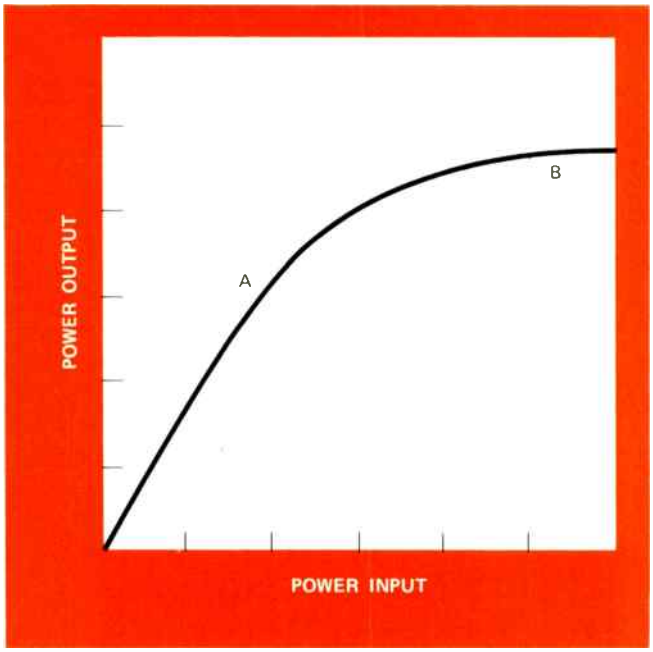
Designers no longer face unrealistic power claims, unrealiable multichips, and stringent circuit parameters; present devices give up to 150 W of dependable rf power and they're steadily getting better

by Joseph H. Johnson and Michael J. Mallinger, *Communications Transistor Corp., San Carlos, Calif.*

☐ After a decade of hard work, semiconductor manufacturers finally are producing dependable rf power transistors. Now an rf circuit designer can obtain 50 watts of continuous power at 400 megahertz without having to accept compromises in other device parameters—ruggedness, efficiency, power gain and power slump—that finally make the overall design unacceptable.

A look back to 1968 shows just what this improvement means to the engineer. In 1968 the best choice to achieve 50 W at 400 Mhz was the 2N5178 transistor, a multichip device costing $230, which could deliver the power, but only in a very carefully tuned circuit. If the transistor was mistuned or mismatched slightly, failure was rapid and the loss total. Today, single-chip devices at one-fourth the price can provide the power and withstand the mismatch.

There are many more comparisons that show the rapid strides made in recent years. Among them:



1. Games specmen play. Two points on the power curve are possible when specifying power output. A transistor specified at point B, although showing very high power levels, is operating at saturation and will be unreliable. Power at point A, linear portion of power curve, will offer useful, reliable operation.

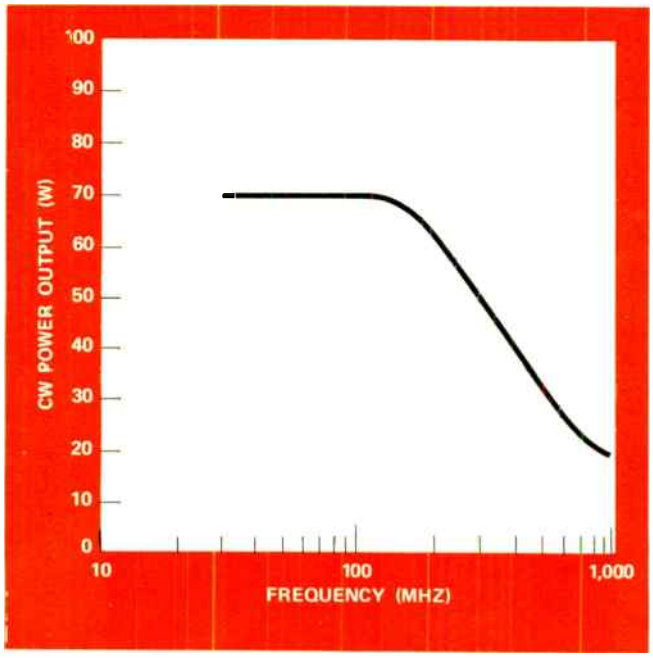
- Rf power transistors were vulnerable to large voltage standing wave ratios; today's transistors can withstand infinite VSWR.
- Outputs of several watts at microwave frequencies had been obtainable only with unrealiable multichip transistor designs; now single-chip transistors can supply tens of watts of stable, reliable microwave power.
- It was once fairly common for parameters (power gain, efficiency, power slump) to vary by as much as 30%; with present transistors, tolerances can be held within much narrower borders.
- Unsuitable packages having high lead inductance and subject to rapid degradation have been replaced with low-lead-inductance, hermetic rf power packages.

One of the most important factors contributing to the improvement is a growing sense of realism on the part of semiconductor manufacturers. With greater experience with their products, suppliers can offer more accurate specifications; the designer no longer is confronted with advertisements claiming 100 W of continuous rf power—with a 75-W power dissipation rating written in fine print.

What can the rf circuit designer realistically expect from his transistor supplier? A review of the state of the art in electrical performance, chip design, and packaging will clarify what is available and where design compromises may be necessary.

Electrical performance. The most poorly defined parameter in rf power transistors is power output capability. Clearly, output should be specified at a level that is useful for reliable circuit design. Useful rf power available from a circuit is limited by a device's dissipation capability and its ruggedness. A circuit should never be designed using the transistor at the absolute maximum saturated power output, as it had been so often.

The power specmanship game shows up in the simple curve of Fig. 1, depicting the power-out vs power-in for a typical device. Two general points labeled A and B on the curve are available in defining power output. A device specified in region A, the unsaturated portion of the curve, can be expected to provide steady, reliable operation because it's operating at low power dissipation and low temperature. A device specified in region B, although boasting higher power, is in hard saturation and will have excessive power slump (20% to 30%) over the operating temperature range.



2. Available. Commercially available transistors have power-times-frequency characteristics that range from 70 W to about 20 W cw in the rf range. Shown is typical useful power available

The relation between rf power output and power dissipation can be quantified: at no time should an rf power transistor be specified with a cw power output exceeding 50% of the dissipation rating. Indeed, with continuous operation at high heat-sink temperatures and an occasional mismatched load, a dissipation greater than two times the power rating may be required to keep junction temperature below a safe 200°C.

The VSWR rating is another factor in specifying power levels. A device must be able to withstand an infinite VSWR at the rated output power and supply voltage. Load mismatch and related component degradation over long periods of time can introduce VSWR that's sufficiently high to destroy a marginal product.

The output range of commercially available transistors specified at power rating consistent with reliable operation and infinite VSWR is shown in Fig. 2. At collector voltages (V_{cc}) of from 12.5 to 28 volts, the power output curve remains constant at 70 W cw up to a frequency of 175 MHz, where the transistor's power gain declines gradually to about 20 W at 1 GHz.

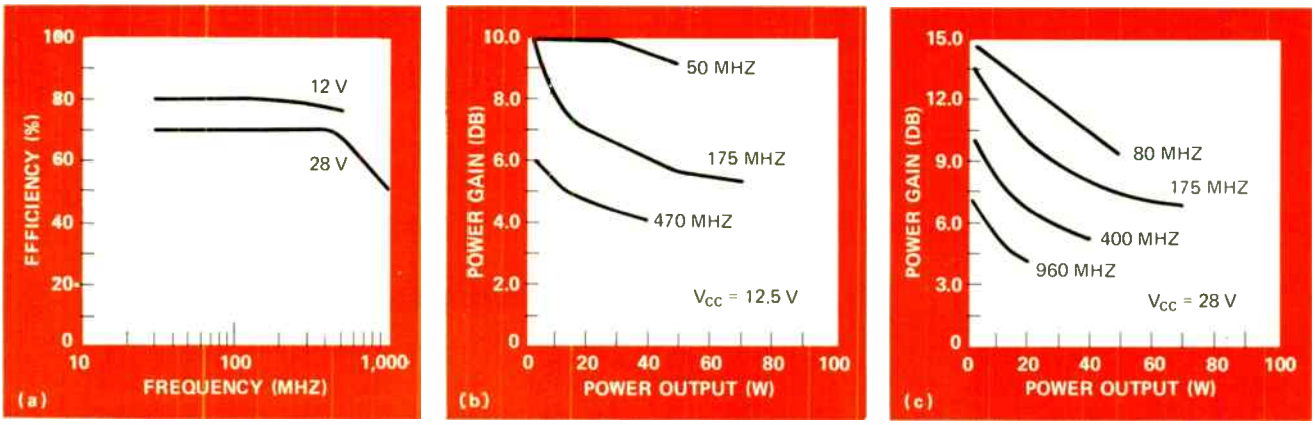
The state-of-the-art transistor featuring high power output and ruggedness also can run at high efficiency, as can be seen from Fig. 3(a), which displays collector efficiency as a function of frequency for typical devices. Efficiency is more closely related to circuit design than transistor design. First a transistor is chosen with sufficient gain, then the necessary gain/efficiency tradeoffs are made in the circuit. Key device parameter requirements are: high gain-bandwidth product f_T, low collector capacitance C_c, low dc β, high power gain, and low rf saturation voltage. With these parameters optimized, Fig. 3(b) shows typical power-gain vs power-output from available devices.

Chip design and processing. For a long time, a consensus settled on a chip size of 50 x 100 mils as the limit for a fine-geometry rf power transistor. This limit no longer applies, as illustrated by the two transistors shown in Fig. 4(a) and 4(b). Die sizes are 65 x 190 mils and 135 x 266 mils, and the emitter (stripe) widths are only 4 microns and 7.5 microns, respectively.

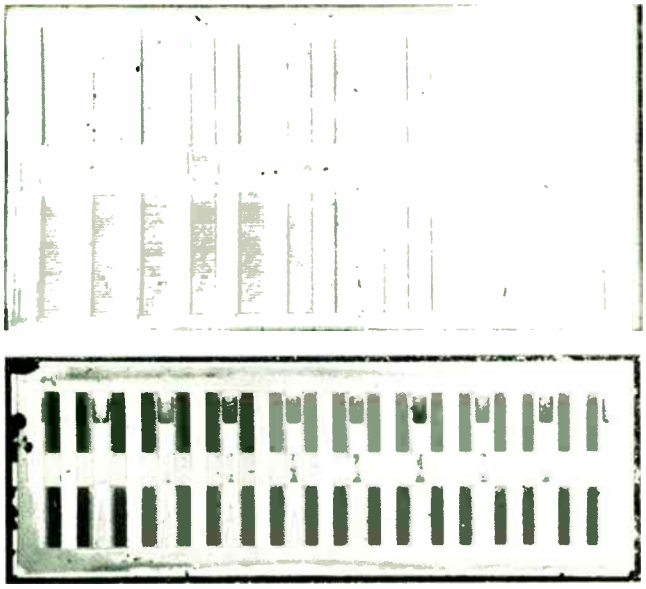
The transistor chip in Fig. 4(a) is large (12,450 mil^2 die size) than any rf power transistor available prior to 1971. The emitter edge is 10,000 mils, giving the device a current-handling capability of 20 A at 12 V or 10 A at 28 V. Moreover, a power dissipation rating of 180 W is achieved without straining the device, indicating that extremely rugged transistors with power outputs in excess of 70 W are possible. Emitter width, at 4 microns, is the same as that commonly used on 1-GHz transistors; with proper diffusions, an f_T in excess of 2 GHz can readily be obtained.

Impressive as this device is, the chip shown in Fig. 4(b), the largest rf power transistor chip ever manufactured, is bigger by about three times. With an emitter periphery of 21,000 mils, the device has a current-carrying capacity of 60 A peak collector current. The 36,000 mil^2 area permits power dissipation exceeding 350 W. And because of the fine geometry used, the device can yield powers of over 150 W in the 2-to-200-MHz range.

As recently as 1969, only multichip designs could have achieved this level of performance; today, the yield on these single chips is better than a respectable 35%. The single-chip route is certainly the most reliable way to achieve power levels as high as 70 W. In fact, single-chip transistors are available today to meet all



3. Efficient. High efficiency is no stranger to today's rf power transistors, as seen from this curve. Over the rf band efficiencies high as 70% to 80% are available from transistors that can withstand infinite VSWR. Key parameters are low C_c, low dc β, and low rf saturation voltage.



4. Giant. The largest transistor chip of pre-1971 vintage (top) has a die size of 12,450 mil². Bigger still, the chip shown in bottom is three times the size of the largest and represents best processing to date. The 36,000 mil² area permits 60-A peak current, giving 150 W of useful power in the 2-to-200-MHz range.

the power levels shown in Figs. 2-3.

The key to making rugged, high-power, single-chip devices is elimination of hot spot formations that create metal-silicon dissolution and degrade reliability. The best method of eliminating hot spots is to use some form of emitter ballasting. Several emitter-ballasting techniques are available. Figure 5(a) shows an external silicon bar resistor approach; external small discrete silicon bar resistors are strapped in series with the emitter. This technique somewhat relieves hot spot formation by limiting power output, but the effect of this approach is small because each resistor is tied to a large number of emitter sites.

Another approach replaces the silicon bar resistor with long, narrow, meandering aluminum stripes, shown in 5(b), directly on the chip. This method eliminates the external chip resistor, but causes other disasters. When the resistors are large enough to do any good, the current density in the aluminum becomes so high that the aluminum migrates. Few manufacturers are still using this technique.

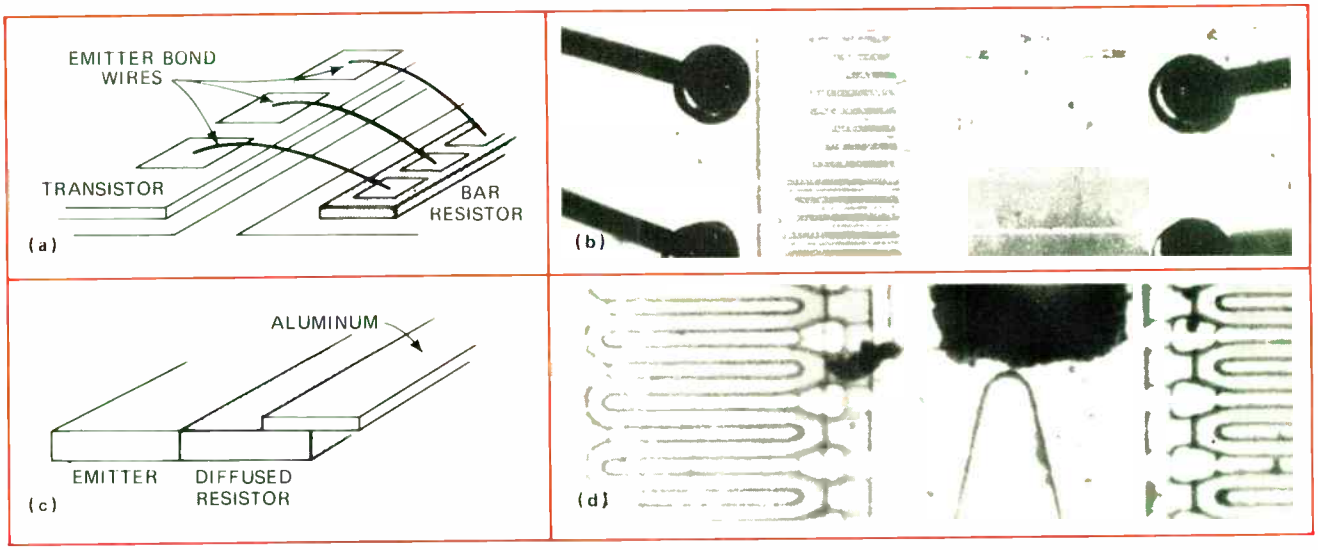
Migration of the meandering aluminum-stripe resistor can be stopped by using diffused silicon emitter resistors as shown in Fig. 5(c). But these do not completely solve the problem because the diffused resistors, with a negative temperature coefficient similar to that of the silicon chip itself, function poorly at high temperatures. The result is devices with very meager thermal stability, marginal ruggedness, and many hot spots.

The solution to emitter ballasting is to place a thin film nichrome resistor in series with each individual emitter site, as shown in Fig. 5(d).

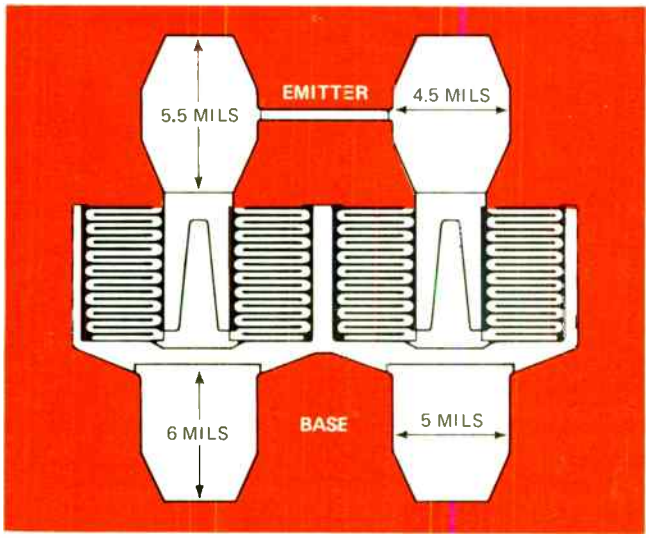
The nichrome resistor can provide the correct emitter ballasting value in series with each emitter site. It's stable over wide thermal and VSWR excursions, and offers an additional bonus of power distribution over very large areas, resulting in uniform temperatures across the chip. Although requiring more stringent process control than the other methods, proper design will provide a temperature gradient of less than 10 C across very large chips.

Reliability. The biggest problem in the rf power transistor business has always been how to produce devices that look alike from week to week, month to month, lot to lot. Now, thanks to improved equipment and process control, products can be manufactured with variations typically less than 10% in the important parameters—power gain, h_{FE}, f_T, and collector-to-base feedback capacitance, c_{ob}.

High frequency, power, and power gain demand extremely narrow emitter widths. To define the very narrow emitters, it was necessary to eliminate any oxide cut for the metal contact over the emitter and wash the oxide away from the emitter area (commonly referred



5. Heavy ballast. External silicon-bar resistor ballasting (a) put in series with emitters somewhat relieves hot spot formation but has only a small effect because each resistor is tied to several emitters. In (b), meandering aluminum stripes are laid down directly on the chip. Another method (c) uses silicon emitter resistors in place of the aluminum; but both of these are largely unsatisfactory. Placing a thin film nichrome resistor in series with each individual emitter site (d) appears to be the best available solution to the knotty ballasting problem.



6. Washed up. Old method of washing away oxide on emitters was difficult to control in fine-geometry devices and led to unreliable transistors. New technology has been developed that gives clean emitters—shown in this typical device, a 400-MHz, 3-W, 28-V transistor.

to as the "washed emitter" process). This process was extremely difficult to control and reproduce, and resulted in unreliable products due to a high percentage of emitter/base shorts.

Recently developed masking technology now enables the semiconductor manufacturer to very accurately cut open the oxide for the emitter metal contact. This provides a well-controlled and reproducible product that is free of emitter-base short failures. Figure 6 shows an emitter arrangement of a typical device—a 400-MHz, 3-W, 28-V transistor.

The package. RF power transistor packages have been unsatisfactory for many reasons: the molded-plastic package was unable to pass thermal cycling and long-term high-humidity tests; soft copper studs would deform prior to reaching an acceptable torque level; packages such as TO-60, TO-39, and narrow-lead striplines had extremely high common-lead inductances; the early ceramic sealed stripline packages were hermetic when manufactured, but leaked when the leads were flexed.

To overcome these deficiencies, packages have been developed that utilize total ceramic/metal high-temperature braze or ceramic/ceramic sealing. These have good electrical characteristics, are mechanically rugged, and have leak rates below 10^{-7} atmosphere per cubic centimeter per second. Stud torque capability has been doubled with special alloys.

An important package design consideration is overall thermal resistance of the transistor when mounted on a heat sink at normal operating power levels. Usually, thermal resistance specified in manufacturers' data sheets is only from junction to case, not junction to heat sink. That's why many circuit designers assume thermal resistance from case to heat sink is negligible.

This, of course, is untrue; it can be seen from Fig. 7, which gives typical values of case-to-heat sink thermal resistance for various packages. These values must be added to the manufacturer's stated thermal resistance in order to calculate overall thermal resistance. Furthermore, thermal resistance of the flange package varies with surface flatness, often changing during the life of the device because of a mismatch in the expansion coefficients of the stock package and the heat sink. Besides, the thermal resistance typically provided by the manufacturer is measured at low dc power levels, often leading to gross inaccuracies under rf conditions where hot spots are present. The only way to make an accurate measurement is via the infrared scanning technique. This method makes it possible to directly read the actual junction temperature and heat sink temperature during an operation by making a map of the thermal resistance.

INDUCTANCE OF AVAILABLE STRIPLINE PACKAGES

	TO-39	TO-60	HF-19	1/4" STUD	3/8" STUD	1/2" STUD
L_B (nH)	3	3	1.0	1.1	1.3	1.4
L_E (nH)	3	3	.6	.35	.4	.7

What's ahead for rf power transistors? During the next few years, great progress will be made in rf devices. For example, large stripline packages that provide extremely low lead inductances, as shown in the table, will make high gains possible. Power frequency products are continually increasing due to improved materials and manufacturing techniques. Reliability and long-term life tests indicate 500,000 hours (mean time between failure) of useful life can now be expected. □

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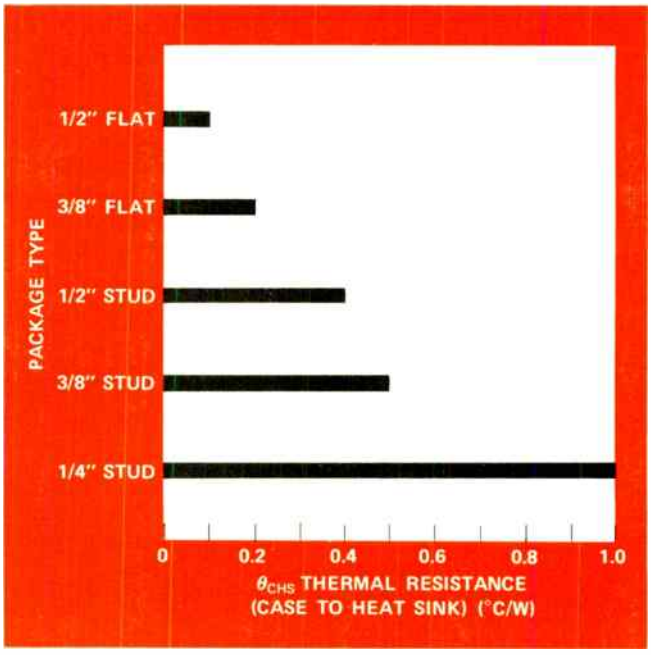

7. Getting hot. Since thermal resistance is specified by most manufacturers from junction to case and not from junction to heat sink, these values must be added to get overall thermal resistance.

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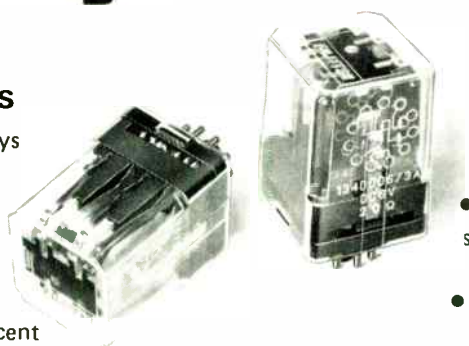
Type 134 Power relays



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- Lift-off spring drive for more positive action in transfer or twin-contact relay operation.
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- High breakdown voltage --- AC 1500 volts.
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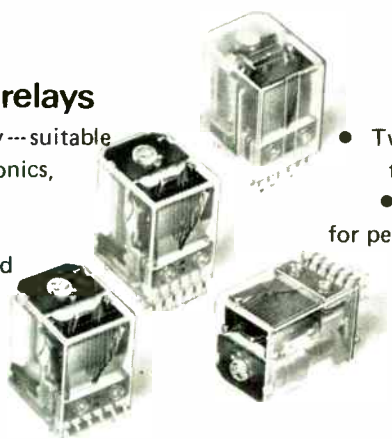
- Contact material --- silver, with gold overlay for twin contact.

Type 491-series Control relays



- High sensitivity and high reliability --- suitable for high-repetition duties in electronics, communications and control apparatus.
- Silver-palladium contacts, with gold overlay for movable contact.
- Compact --- only 34 mm tall when mounted, weighing 55 grams (relay) and 7 grams (socket).
- Two basic choices --- current holding type and bistable self-latching type.
- Many contact-form combinations for permitting selection to precisely meet each relay need.
- Flexible mounting --- available with plug-in, PCB mounting or solder-connection terminals.

Product	Contact form	Contact rating	Nominal coil voltage	Pick-up current	Operate time	Release time	Initial contact resistance	Break-down voltage	Shock	Life
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Type 134-A relays for AC applications		AC 115V, 5A (twin contact)	AC 6 ~ 200V							
RELAYS Type 491-series										
No.493D relays No.494D relays for current holding applications	6C (E8M) (standard); 6C (BM); or 4C (E8M) + 2D (EMB)	DC 48V, 0.5A	DC6 ~ 100V	3.4 ~ 19.5 mA	20 ~ 5 ms	5 ms	250 MΩ max.	AC 500V or DC 750V for 1 minute	10G for 11 ms	7 ~ 40 million
No.493L relays No.494L relays for bistable, latching applications	6C (E8M)									

- Figures given refer to ranges of values for respective relay series.
- Size: 51mm (enclosure length) x 35.6mm x 35.6mm --- Type 134 relays
  34mm (enclosure length) x 29mm x 22.5mm --- Type 491-series relays

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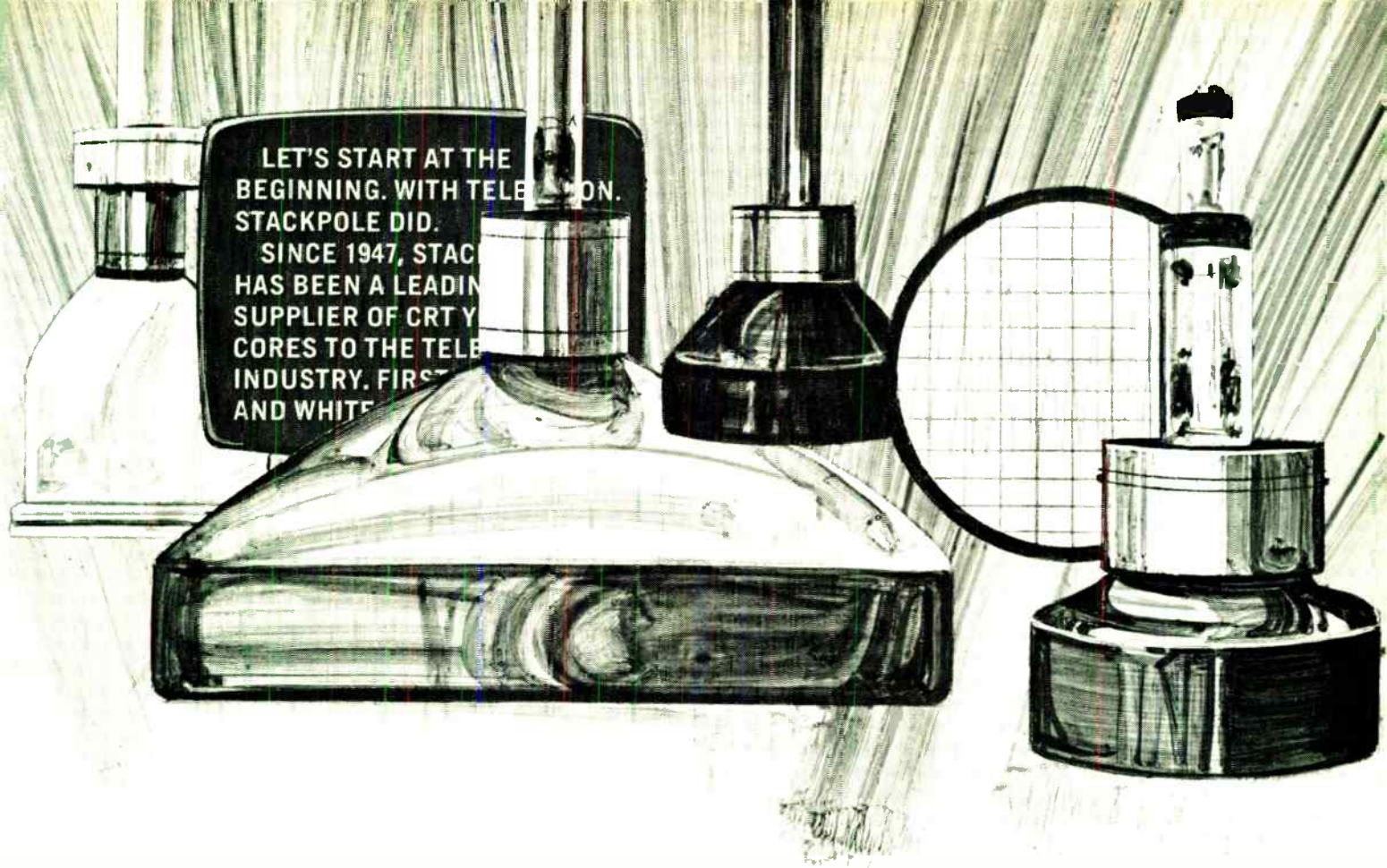

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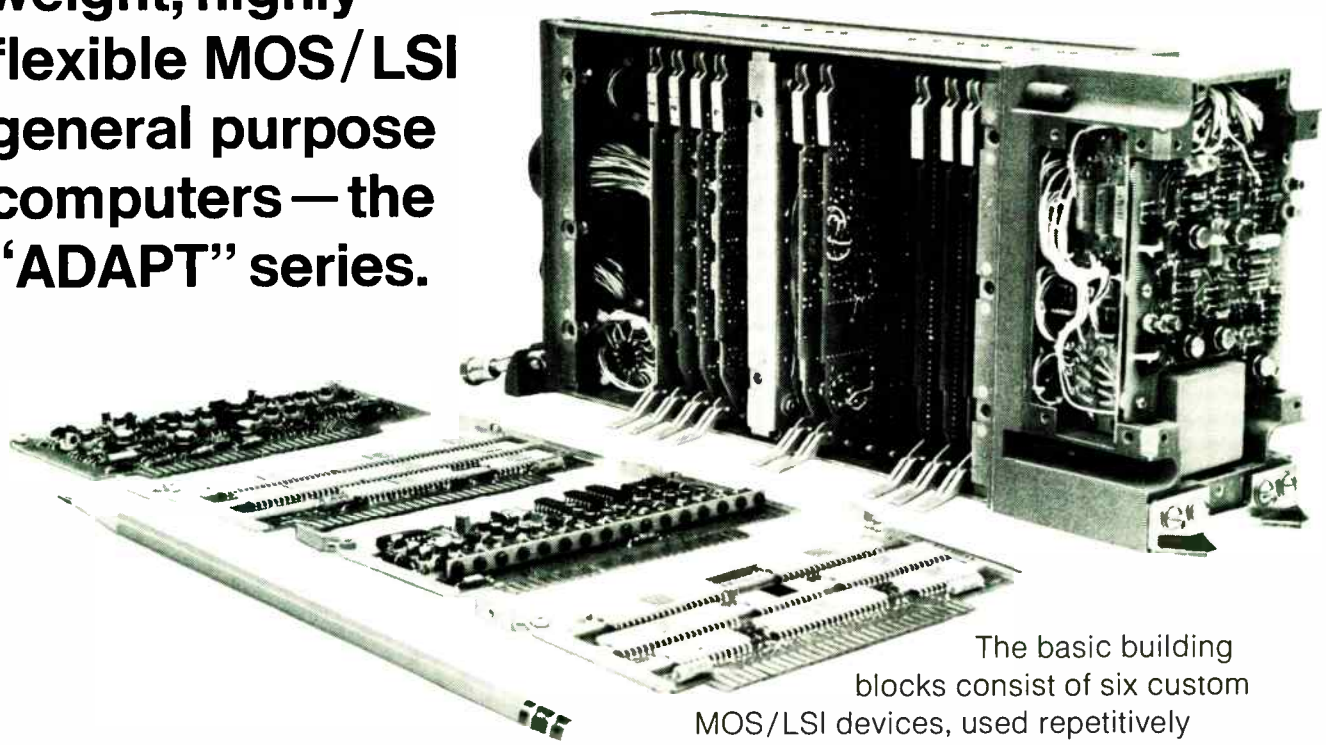

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CH03V	800–1,300	400	8,000	115	Fast turn off type 50–30 μs

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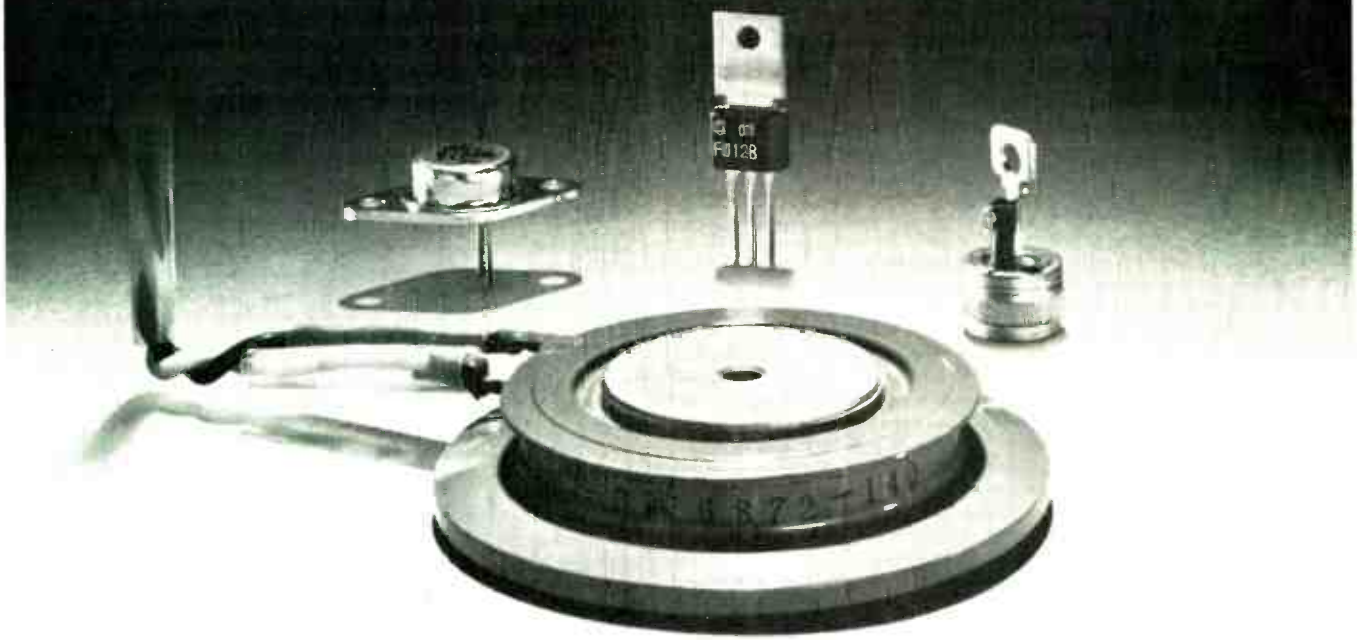
FS06							TO-66 (Metal)
FR01	200-400	16	5	3	50	100	Stud base
FR02							Flat base (Metal)
FQ01	200-400	20	5	3	50	100	Stud base
FQ02							Flat base (Metal)



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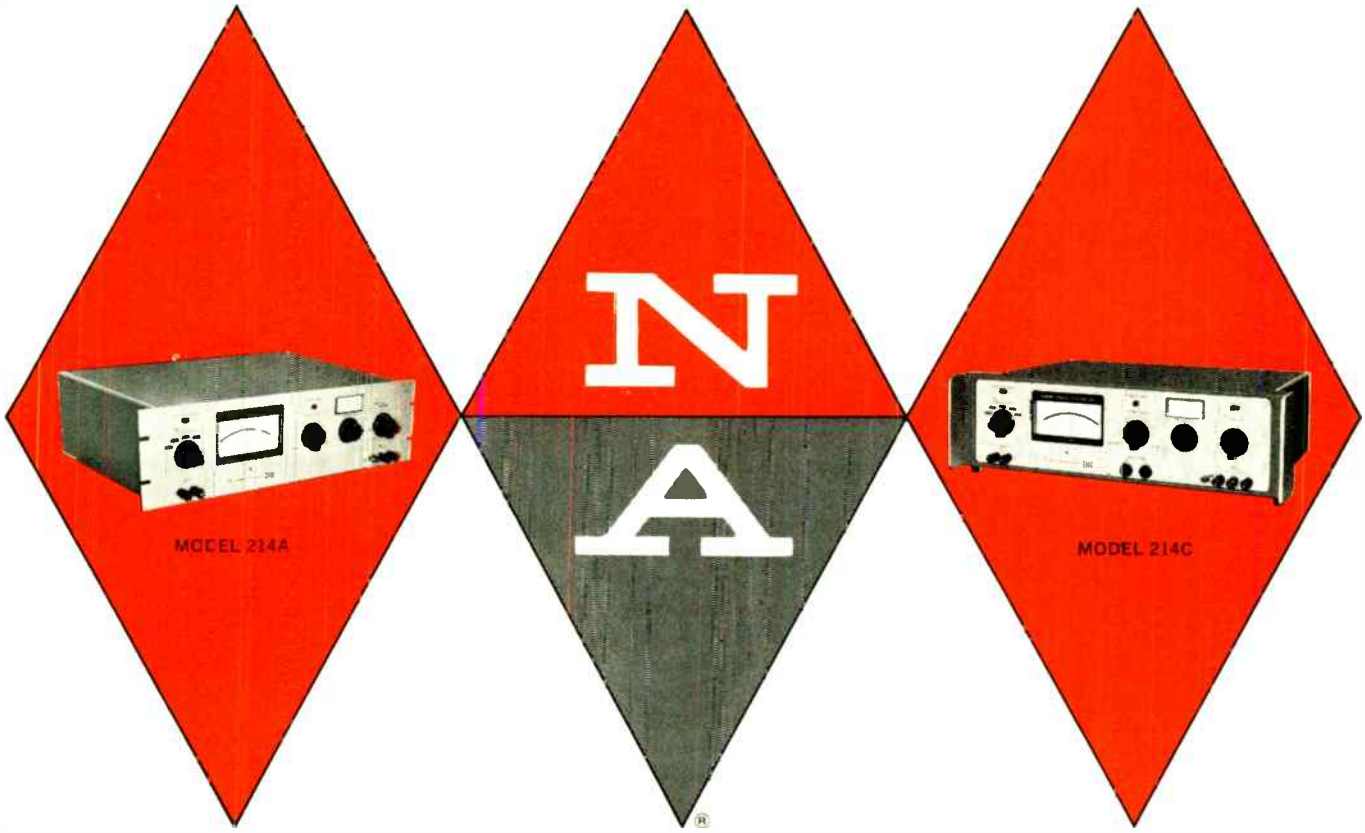

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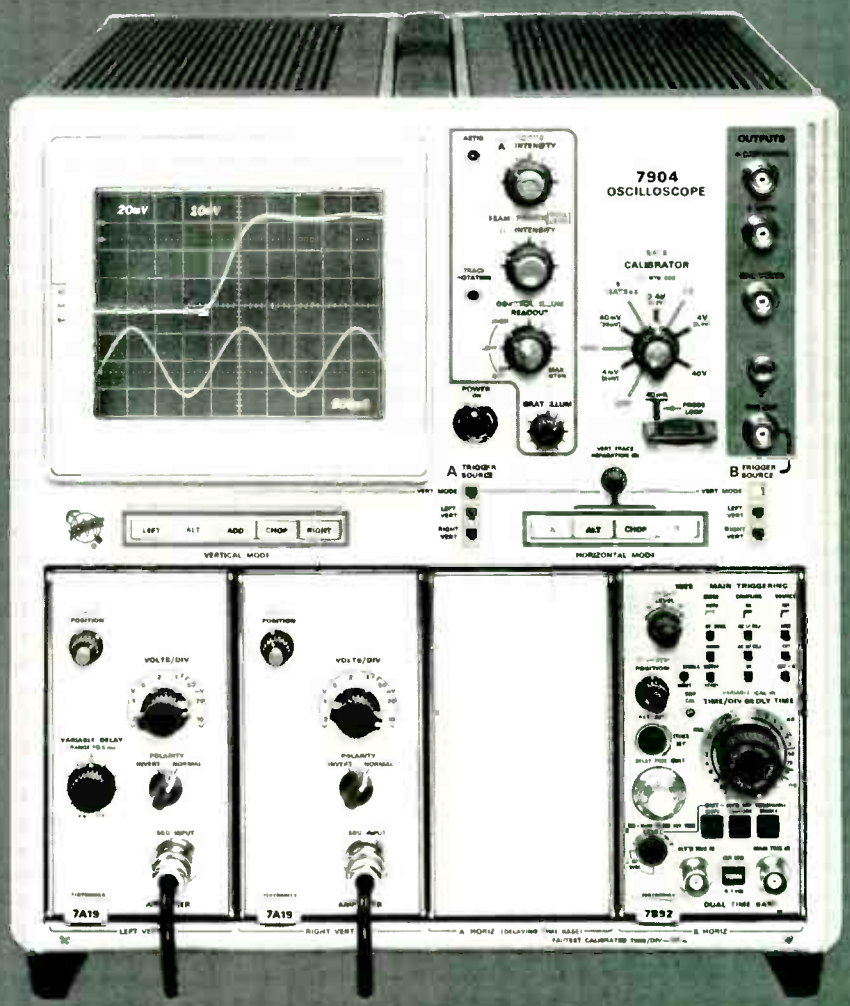

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Coal miners dig electronics

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by Larry Armstrong, Washington bureau

Most people picture the coal miner as covered with dust, working long hours with noisy equipment, suffering from the dreaded "black lung" disease, and menaced by the roof falls and explosions that still take many lives each year. But a growing number of electronics firms foresee him as a technician sitting behind a computer-like console and operating machinery that utilizes advanced electronics techniques.

In fact, the portrait of tomorrow's miner is anything but grim. With strong help from electronics, the miner will orchestrate cutting and loading equipment far from the mining area—the first 25 or 30 feet from the mine's working face where roof, face, and rib falls account for more than 60% of all fatalities. He will watch operations with a low-light-level TV camera. With sophisticated electronic sensors he will monitor the buildup of methane, which, at 5% concentrations, combines with oxygen to spark and fuel mine explosions; he will watch for the 1- to 5-micron respirable coal dust particles that cause black lung disease in as many as 40% of all coal miners; and he will listen for telltale patterns in rock stress noises to predict rockfalls.

Though companies aren't speculating about the potential size of the coal-mining market for electronics, they've two strong reasons for being optimistic. The first is passage of the Federal Coal Mine Health and Safety Act of 1969, which provides for the development and enforcement of tough Government standards, requiring extensive monitoring and also communications equipment, and allocates research funds at the Federal level for that purpose. The other is the boom in coal mining to meet the nation's steadily increasing power needs. Coal output this year is expected to rise to 620 million tons, close to the peak 670 million tons in 1947, and may hit 1 billion tons by 1980.

Until recently coal mine operators hadn't spent money on researching new techniques for health and safety measures. Hence the Government action. But the companies have been spending a lot on automating mines to increase productivity. Take for example Continental Oil Co., Ponca City, Okla., which ranks as the country's largest coal producer through its subsidiary, Consolidation Coal Co. "New mining systems are the number-one concern among management-level people at Consol right now," says Gordon R. Haworth, mining research supervisor. Consol's research efforts are directed toward a system that it would like to have operational in five to 10 years.

Byproduct. "Originally, our goal was strictly increased productivity with safety as a byproduct," Haworth admits. "But as we got into it, the new system turned out to be inherently more safe. The haulage method was safer, and the coal-cutting technique reduced respirable dust generation." But it's increased productivity that will make these new, expensive mining systems feasible. "With increasing underground productivity, and because of the cost of rehabilitating strip mine areas," Haworth says, "we'll soon be able to compete with strip mines."

Danger signal. Electronic devices like this infrared detector are improving safety in mines by helping spot hazardous conditions.

Rescue and survival. Westinghouse electromagnetic communications surface equipment helps locate trapped miners who contact it through a belt-worn low-frequency transmitter.

Consol started its work in early 1968, but the big impetus for coal industry research into new, automated, remote mining techniques was provided when public outrage over incidents like the November 1968 mine explosion that killed 78 miners in Farmington, W.Va., culminated in unanimous congressional passage of the Federal Coal Mine Health and Safety Act of 1969. To accompany those stringent regulations, Congress dramatically stepped up funding research—it jumped from almost nothing in fiscal 1969 to nearly $30 million this year. Robert L. Marovelli, mining research health and safety chief at the U.S. Bureau of Mines, expects health and safety research funds to level off at that $30 million for coal mining but estimates that such expenditures for metal and nonmetal mining will grow to nearly $10 million from the current $2.9 million; another official says they may reach $30 million.

Investment. The new regulations insure that the "mining industry is going to have to spend dollars," concedes James J. Scott, the bureau's assistant director for mining research. But there's growing evidence that the industry may spend more than the legislated minimum. Electronic monitoring of rock stress noise in an Idaho silver mine recently protected workers from an imminent rockburst—a violent outburst of flying rock fragments. Now operators of seven or eight mines in Idaho's Coeur d'Alene district have indicated they would be willing to install the bureau-developed, $35,000 system. It consists of an array of seven geophones feeding an underground desk-top computer, a Hewlett-Packard 9100. The operators also want to accumulate the information at a surface station to monitor all area mines and predict regional tectonic conditions.

Besides sensors, automation, and remote control, Bureau of Mines officials foresee miner-to-miner communications as another prime target for improvement. "Communications sophisticated enough that an individual would be in constant contact with fellow miners and his supervisor would have a dramatic impact on health and safety problems," Scott says.

The first tentative steps toward this were taken by Westinghouse Georesearch Laboratory, Boulder, Colo., as part of a $3.4 million Bureau of Mines contract for a coal mine rescue and survival system. Demonstrated to depths of 800 feet in a two-week simulated mine disaster near Gary, W. Va., earlier this year, the Westinghouse system relies on belt-worn receivers powered by the miner's lamp battery. Although Westinghouse hasn't decided whether it will make the $30-$35 unit commercially, the bureau optimistically has ordered a second set of the surface emergency communications equipment for further testing in deeper mines.

Lowdown. Westinghouse overcomes severe through-the-earth attenuation problems by using signals in the very-low-frequency range of 200 to 3,000 hertz for surface-to-miner voice communications. The miners can get in touch directly with the surface communications van via a beacon transmitter stored in a portable underground survival shelter. If trapped miners cannot get to the underground shelter and its transmitter, they can pound on roof timbers or rock walls—and an array of implanted geophones connected to the communications van will determine their position.

The second step in the bureau's communications plan—continuous, nonemergency voice communications between any two surface stations and 10 underground units—has been contracted to Mine Safety Applicances Co., Pittsburgh, Pa. To be installed in the bureau's research mine at Bruceton, Pa., the surveillance and communications system will include state-of-the-art sensors in each station to monitor methane, carbon monoxide, smoke, temperature, hydrogen, and ventilation, and to display those parameters in the surface center.

"We'll use electronics to make mining inherently safe by removing the miner from the hazards," Scott says. His deputy, Joseph J. Yancik, adds, "We'll take state of the art and make it state of the practice."

Charged to develop and test an inherently safe mining system under a new $5.9 million award is FMC Corp's. Advanced Products division, San Jose, Calif. The FMC proposal includes several alternatives that could be developed for such a system, including shielding the mine worker with protective enclosures or self-advancing roof supports, providing remote control or long-reach equipment, and using warning devices and instrumentation to alert miners of imminent danger.

In a related award of almost $1 million, Bendix Research Laboratories, Southfield, Mich., will develop remote-control devices and sensors to keep continuous mining machines correctly aligned in the coal seam. "We're looking at possibilities such as lasers to provide a known reference line," says Louis C. Paine, manager of remote-control mining work. Bendix is using electrical and acoustical techniques to characterize the differences between coal and the host rock—to measure the thickness of coal left on the floor and roof while the machine is operating. However, admits Paine, "We have quite a long route to go to duplicate the complex interplay of senses" used by a coal miner.

Bendix also is developing a guid-

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ance system and obstacle detectors for shuttle cars, which miners have to operate almost blindly in low-ceiling areas. "This is the first step toward remote operation of shuttles," Paine says. "We'll probably use optical ranging techniques detecting either painted lines on the ceiling or on the mine's own vertical surfaces." The bureau expects to award within two months an estimated $120,000 for developing low-light-level TV techniques, for a demonstration of a TV guidance system for shuttle cars in the bureau's Bruceton mine.

Other Bureau of Mines contracts, to be awarded later this year, will be scattered to a wide range of companies in an attempt to broaden the base of company involvement in coal mine health and safety, says a bureau official. These contracts include money for:

- Pulsed and continuous wave acoustic holography to obtain optical images of fracture zones, openings in rock, density contracts, and rock inclusions up to 10 feet beyond the mining face.
- A monitor to instantaneously detect, measure, and warn of injurious concentrations of carbon monoxide, carbon dioxide and nitrogen oxides, as well as low oxygen levels.
- Improved gas-pressure gradient instrumentation in fractured material such as coal.
- A rapid, inexpensive gamma-ray spectrometry method to determine trace elements in respirable mine dust.
- A study of pulsed laser photography to locate bad rock, such as faulty roofs, in mines. The bureau also is preparing RFPs for developing infrared and sonic techniques for detecting and monitoring bad rock.

Annual source. In addition, the Defense Department's Advanced Research Projects Agency provides the bureau with some $3 million a year for work in rapid tunneling and new excavation methods. Typical of the awards is a $240,000 contract to Westinghouse missile launching and handling department, Sunnyvale, Calif., for a 36-kilowatt electron-beam gun for cutting rock. The bureau also is looking for laser and sonic rock-cutting methods, according to Scott. □

Probing the news

Packaging & Production

Edge-mounts get big user's blessing

Calculator maker finds package provides better servicing, less damage than DIPs; organ firm is switching over, too

by Stephen E. Scrupski, Packaging & Production Editor

Praised by some as one of the few innovations in semiconductor packaging last year, the edge-mount LSI pack also was strongly criticized by others at the same time. The scoffers felt that wires could short to the chip during bonding, and they were reluctant to use a package that introduced yet another connector interface [*Electronics*, Oct. 12, 1970, p. 48]. They also predicted that the gold plating on the edge pads and connector contacts would wear off if the package were plugged in and unplugged several times.

But these skeptics might want to take another look. None of these drawbacks has materialized at SCM-Marchant Group, Oakland, Calif., first large-scale user of the package. The firm includes two or three of the packages in each Marchant 1 portable calculator, and although it still hasn't swung over completely to the edge-mount—somewhat less than half of its 15 calculator models use it—Marchant has glowing reports about reduced package damage and faster service time. Meanwhile, another large potential user, Hammond Organ Co., Chicago, Ill., is about to introduce an electronic organ that will contain six edge-mounts.

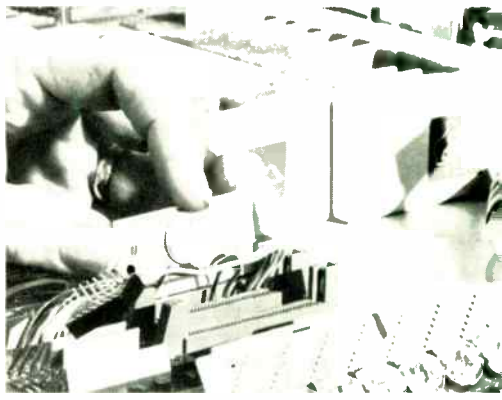
Other companies haven't committed themselves, though they are looking hard at edge-mounts. Semiconductor manufacturers may not provide much impetus because offering edge-mounts would split their production runs, thus reducing the savings possible with volume purchases of a single package type. And plenty of users remain committed to soldering ICs onto printed circuit boards to avoid any extra contact interface.

The edge-mount consists of a ceramic substrate with metalized conductor patterns connecting the chip bonding area to gold-plated pads along the edge. These are inserted in a mating connector mounted on a printed circuit board.

On the Marchant 1, which sells for $495, either two or three edge-mount-packaged devices are used, depending on which of the two circuit suppliers, American Micro-systems Inc., Santa Clara, Calif., or Texas Instruments Inc., Dallas, is providing the devices for that particular production run.

Changeover. Little redesign of the calculator circuitry was required in the changeover from dual in-line to edge-mount. The biggest difference in the packaging was the greater height required by the edge-mounts compared with the low-profile mounting of DIPs. In Marchant's case the height could be tolerated, but for close spacing of printed circuit boards, the edge-mount user would have to use a right-angle connector that projects the edge-mount out parallel to the board surface to

Final touch. LSI devices in edge-mounts are inserted in mating edge connector.



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reduce the total profile of the circuitry.

"In our experience, damage to a certain percentage of 40-pin dual in-line packages is inevitable," says a Marchant spokesman, and it's this damage that's turning in one of the biggest arguments for edge-mounts. Marchant reports that with edge-mounts, the money that was represented by damage was reduced from 30% of the device cost to a negligible amount. Thus, if a device costs, say, $13, a whopping $4.50 more would have to be spent to account for losses caused when someone inadvertently ruined the circuit with static electricity by touching a lead or because the leads were not attached strongly enough. With the edge-mount, these extra costs would drop to about six cents a device.

Pluggable. As for the extra contact interface objection, a Marchant spokesman says, "We can't imagine anything but pluggable packages for expensive large-scale devices in our type of product, especially since our experience shows edge-mount circuits stay in their connectors as securely as if they had been soldered." Marchant reports that the easy pluggability of the edge-mounts has cut field service time by about two-thirds and adds that rugged handling of the calculator in the field hasn't caused any problems with the contacts. In any event, Marchant had already made the switch to pluggable DIPs in earlier calculators because they facilitated servicing. Unsoldering a 40-pin dual in-line package almost always destroyed the circuit, the Marchant spokesman says.

However, there still is strong industry sentiment against any plug-in package. Typical of engineers committed to soldering LSI devices in the boards is Dino Sirakides, vice president of engineering for the Monroe division of Litton Industries, Orange, N.J., who says: "We just don't like mechanical connections." Sirakides adds that Monroe instead is looking to plastic-packaged LSI devices for cost savings.

The value of pluggable vs soldered-in packages, says Agelor F. Petrie, manager of standardization, components engineering, at Hammond Organ, "depends on whether you want to replace boards or individual ICs." After the company's new electronic organ is out in the field, he says, he will wait for service reports on how the edge-mounts have affected service operations before he makes a decision on future use of the package. "We do think the edge-mounts will be a little better than soldered ICs," he notes.

Short stop. Accidental shorting problems with edge-mounts have been solved, says James Barnett, AMI's packaging development manager. In edge-mount packages the plane of the chip is higher than that of the wiring pads. With ultrasonic bonding, the wire usually exits the back of the bonding head at a shallow angle, so that the wire could accidentally touch the chip, shorting it out (the chip edge is unavoidably exposed because the scribing operation breaks the coating and exposes bare silicon). Barnett says AMI has modified an ultrasonic bonder so that the wire rises vertically off the chip, forming a loop of consistent height as taken over to make contact to the bonding pad. Barnett also points out that thermocompression bonding can be used.

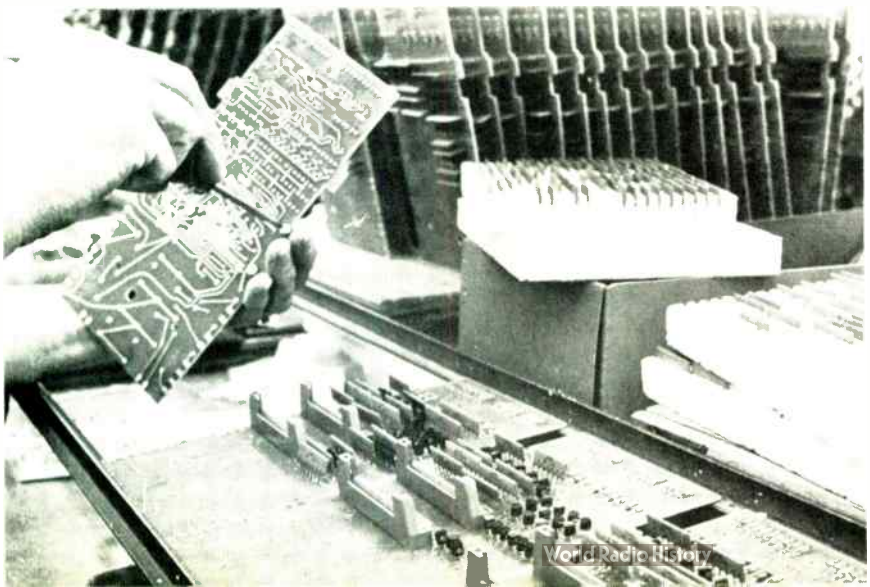
As for the criticism that edge-mounts won't wear well, one connector manufacturer—Texas Instruments Metallurgical Materials division, Attleboro, Mass.—is making a connector that has a gold stripe clad to the contact spring. This configuration, says Ray Larsen, TI project manager, raises contact life from the 30 or so insertion cycles of earlier connectors to well over 100 cycles.

Incoming inspection and assembly operations have benefited from the relative ease with which the edge-mounts can be handled compared with the DIPs, according to Marchant. Although MOS devices now are well protected against inadvertent static electricity blowouts caused by a person touching one of the leads, it still is a danger—and it's difficult to pick up a DIP without touching the leads. The edge-mount, however, has exposed conductors along one edge and offers plenty of area for handling. Lead breakage also has always been a problem with DIPs, but of course, the edge-mounts have no leads.

Quotes. Cost is another factor working in favor of edge-mount/connector combinations. Coors Porcelain Co., Golden, Colo., supplies the packages to device producers and is quoting prices of 55 cents each in volume, while one edge connector manufacturer, TI, is quoting 45 cents each. Amp Inc., Harrisburg, Pa. and Winchester Electronics division of Litton Industries, Oakville, Conn., are other connector suppliers. Forty-lead ceramic pluggable DIPs are selling for about 9 cents and the sockets for about 60 cents.

Coors says that with about a 50% yield during circuit production, the ceramic package cost thus is doubled before workable-packaged devices leave the semiconductor plant, resulting in $1.80 for the dual in-lines against $1.10 for the edge-mounts. The connectors aren't yielded, of course, so the total for each approach is about $2.40 for the DIP/socket combination and $1.55 for the edge-mount/connector combination. □

Turn of the screw. SCM-Marchant assembler bolts edge-mount connector to pc board for greater rigidity. The boards shown use two edge-mounts; other versions use three.



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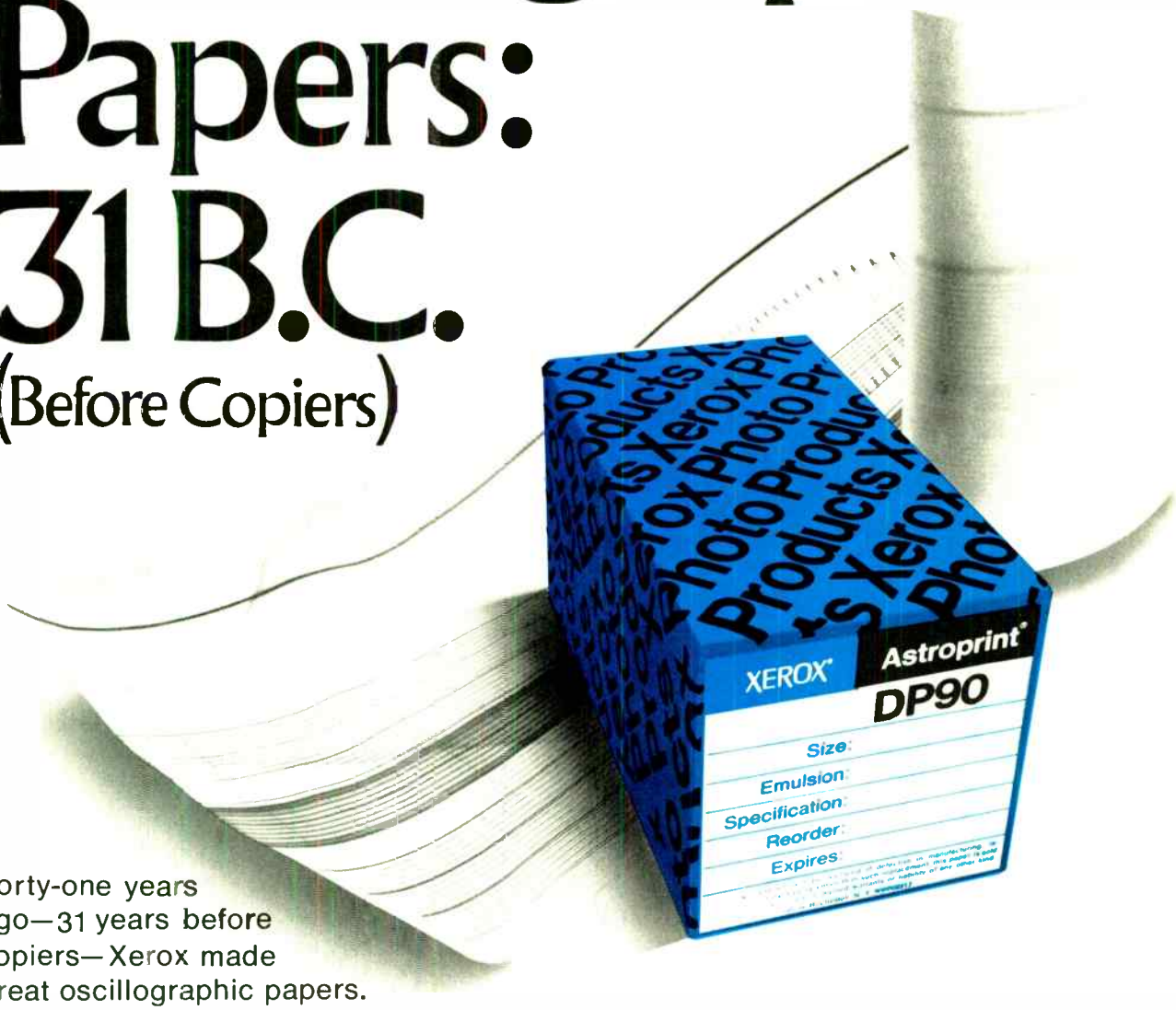

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Consumer electronics

Engineering, meet consumerism

High-powered consumer affairs groups at TV firms are opening a link between buyer and engineer by processing reliability, safety, and service data

by Gerald M. Walker, Consumer Editor

Swimming with the tide of consumerism, television manufacturers have been busily reorganizing their customer-relations departments, frequently at the highest corporate levels. But while these consumer affairs departments ostensibly provide a sympathetic ear for irate buyers and help in bridging the often wide gap with service operations, they are starting to perform a more valuable but less publicized function: opening a pipeline between the consumer and the engineer.

Officials at such consumer-sector giants as Philco-Ford, RCA, Motorola, and General Electric are convinced that involvement with consumerism is good business, and are providing top management support. "Consumerism has a certain amount of fadism connected with it, but it will certainly not go away," says Herbert T. Brunn, vice president of consumer affairs for RCA Corp., New York, and a 30-year veteran with the firm.

But the companies' embrace of consumerism has another side, too. Plagued by the increased costs of warranty work [*Electronics,* June 7, p. 105], the companies are using their consumer-affairs departments as advisers to engineering operations. Though they do not yet initiate engineering changes themselves, the consumer units, thanks to their increasing influence at corporate headquarters, now have a good deal of power behind their bats when they pass on data regarding reliability, serviceability, and safety. And although it's too early to credit the consumer affairs men with actual changes, engineers at some firms already are beginning to sing their praises.

For example, at RCA Consumer Products division, Indianapolis, Ind., chief engineer Marvin H. Glauberman is highly pleased with at least one concrete plan instituted by the consumer affairs department. The program is a formal, statistical reliability analysis of components instituted to head off failures that might crop up in the production stage before the chassis bench model is built. This approach is common at aerospace and computer companies.

"Engineers were inclined to complain that the producton run was over before they could make changes, but once we started this analytical approach and began catching just 50% of the problem components, it was worth the effort," says Glauberman. A former plant-level consumer affairs manager before moving to head engineering, he quips, "Now I'm in a position to practice what I preached."

Ombudsman. VPs like RCA's Brunn help consumers get message to engineering.

At Motorola Inc.'s Consumer Products division, Chicago, the backbone in Motorola's consumer affairs organization is provided by Garth J. Heisig, who has spent 20 of his 25 years with the firm in engineering. Heisig has spearheaded a plan to telephone set owners soon after purchase to find out about buyer satisfaction rather than sit back and await complaints. With these early warnings, Heisig uses his engineering familiarity to communicate design and maintenance suggestions to manufacturing based on what he has discovered in the field. "Consumerism is a new tool for engineering," he contends. "If an engineer can spend $1 to save $2 in repairs during the warranty period, he's made a contribution.

Philco-Ford Corp., Philadelphia, was the first to set up a formal consumer affairs organization and chose to make it a line operation headed by vice president Armin E. Allen, a 35-year Philco man with both engineering and management experience. To put clout into Allen's efforts, Philco-Ford took a leaf from the auto industry's book by putting him on the high-powered warranty and quality-control committee. Through this committee the operating vice president, executive vice president, and president review all complaints from customers and the action that was taken by the company's service organization.

Relations between consumer af-

a. PROGRAMMABLE POWER SUPPLIES

The programmable power supply module is composed of up to nine precision programmable power supply units. These units supply the power and functional references for the device under test during functional and parametric testing.

Table 3 is the detailed limits of the individual supplies.

	V_{HC}, V_{HL}*	V_{LC}, V_{LL}†	V_{HR}, V_{LR}	V_{cc}, V_{cc_2}	V_{BB}
Range Volts	30	30	30	50	+25
D.C. Current Amps	−1.20, +.10	+1.2, −.10	±.050	+.300	+.300
Slew Rate into 60 μf		5V/ms	+200μ sec./V.	200μ sec./V.	200μ sec./V.
Resolution		10mV	10mV	20mV	20mV
Accuracy		10mv+.1%	10mv+.1%	20mV+.1%	20mV+.1%

*These supplies are adjusted to compensate for Driver Offsets.
†Optional current measurement on V_{cc} and V_{BB} available.

b. PROGRAMMABLE CLOCK GENERATOR

The digitally programmable clock module is composed of six independent strobe sources and a delay function. All six strobes are derived from a common oscillator and therefore have the same basic rate. Each strobe, however, can have its leading and trailing edge independently programmed from one another and from other strobe edges.

Number of clocks 6	**Basic rate resolution 10ns**
Basic rate (maximum) 6.7 megahertz	**Pulse position resolution 1ns**

c. MD-183 DC FUNCTIONAL TESTER/DC PARAMETER TESTER

The DC tester is composed of a data memory, a logic section, a control panel, a cassette tape unit, automatic parameter tester and programmable power supplies.

The data memory holds all data necessary for a complete device test. This data is composed of setup data groups for each system module.

Zero Overhead Testing—Sequential testing, binning and logging are automatic once they have been set up. The data may cause a logging counter to be incremented on either a pass or fail criterion. Any one of several counters may be used with a particular test. The sequencing of tests on a particular device is continuous and stops only on a bin command. Each test may have a bin command associated with it whereupon a device may be binned on either a pass, fail or unconditional criterion. Binning classifies the device and makes the tester ready for the next device to be tested.

Test Sequences 64	**Logging Counters 64**	**Binning Counters 16**

*APT and PPS specs.

d. MD-100 STANDARD PRODUCT TESTER (ROMS, RAMS, SR).

Purpose of the MD-100

The power of the MD-100 comes from the fact that it does not use fixed test routines as the last generation of memory exercisers did for core memories, nor does it use burst mode testing from a buffer memory as do some of the more recent general purpose test systems. The MD-100 test routines are programmable, and they run at real time speeds. The system is a special purpose multiprocessor which is microprogrammed. It has an instruction set designed for efficient testing of memories. It is fast, with instruction fetch and execute times of 200ns allowing up to 5MHz test rates.

e. AUTOMATIC PARAMETER TESTER

The automatic parameter tester is a self contained unit that is capable of running a full complement of parameter tests. Typical tests such as stress, leakage, continuity, threshold, etc. can be set up in a microprogrammed form for either a single pin or a multiple pin test. Measurements are made to an accuracy of .2% full scale.

DRIVER

A. Voltage Scales:

Scale	100V	10V
Nom. Maximum	+102.35	+10.235
Nom. Minimum	−102.40	−10.240
Resolution	.05% of full scale	

B. Current Scales:

Scale	100ma	10ma	1ma	100μa	10μa	1μa
Nom. Maximum(1)	103.2ma	10.32ma	1.032ma	102.4μa	10.24μa	1.024μa
Nom. Minimum(1)	800μa	80μa	8μa	1μa	.1μa	10na
Resolution	.05% of full scale					

RECEIVER

A. Voltage Scales:

Scale	100V	10V	1V
Nom. Maximum	+102.4V	+10.24V	+1.024V
Nom. Minimum	−102.35V	−10.235V	−1.0235V
Tolerance	—	—	±1% of F.S.
Resolution	.05% of full scale		
Input Impedance	Greater than 100 megohms		
Overload Protection	±150V on any scale		

B. Current Scales:

Scale	100ma	10ma	1ma	100μa	10μa	1μa
Nom. Maximum	+102.4ma	+10.24ma	+1.024ma	+102.4μa	+10.24μa	+1.024μa
Nom. Minimum	−102.35ma	−10.235ma	−1.0235ma	−102.35μa	−10.235μa	−1.0235μa
Tolerance	—	—	—	—	—	—
Resolution	.05% of full scale					
Input Impedance	less than 2 ohms					
Overload Protection	±400ma on any scale continuous, ±1.2 A. short term					

(1) Absolute Values

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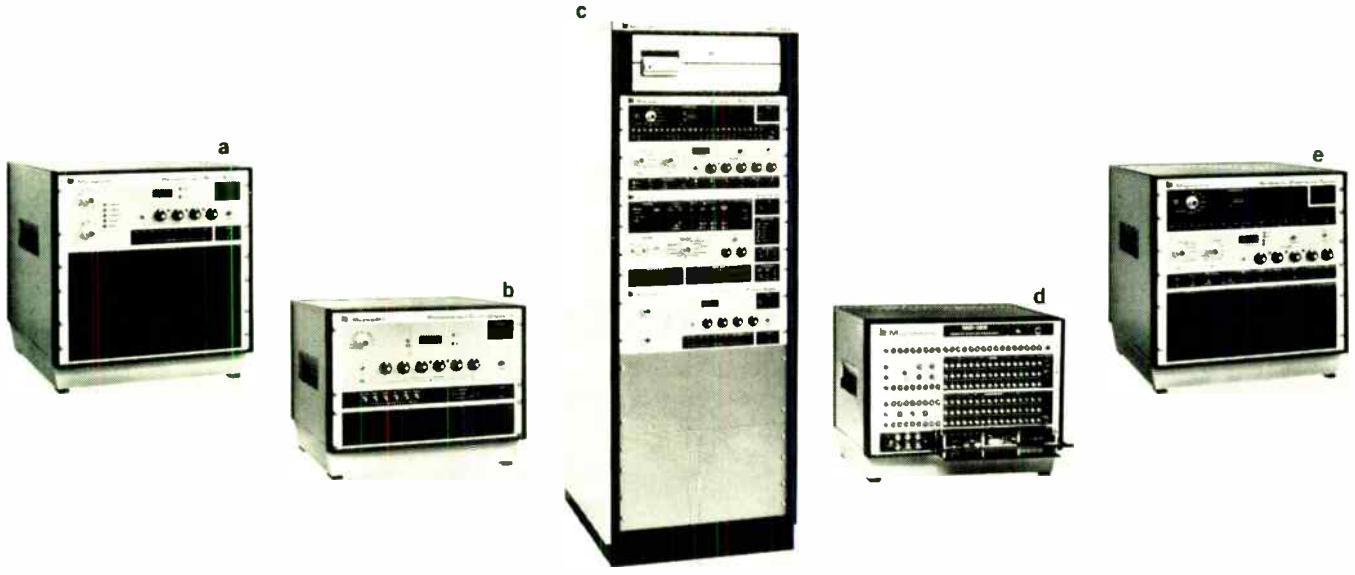


MACRODATA SLASHES DC TESTING COSTS with "The Stand-Alones"

fairs and engineering are less formal at Philco-Ford, however. "Consumer affairs," says Byron L. Garafoulis, chief engineer-video engineering for the Audio-Video division, "is a bridge between engineering, the Government, and the consumer. It fills the gap better than at any other time."

Part of this gap-filling is to guide engineering on safety regulations by wading through Government specifications and translating them into engineering terms. Consumer affairs also helps engineering by preparing radiation safety reports required by the Government.

As for specific engineering impact, Garafoulis points out that consumer affairs reviewed the design of a new chassis being readied for the next model year with an eye toward making service easier. It was designed more as a second check than to suggest changes, he notes.

"Our product is the most complicated in the consumer's house. And to make a TV set perform satisfactorily takes a lot more effort than in the past. A color set is by nature difficult to service and operate, so to simplify both is in the realm of consumer affairs," he says.

Second look. General Electric Co. also agrees that another look at designs is a good idea, even if the contribution made by consumer affairs is hard to pinpoint. Consequently, last spring engineer Eugene A. Anthony, GE's head of product service, began sitting in on design-stage planning to review the serviceability of sets before production in an effort to curb repair costs.

Though consumer affairs managers are bullish on the worth of their efforts, not every TV manager is convinced. GTE Sylvania, Batavia, N. Y., for example, looked at the idea and rejected a consumer affairs department on the ground that it does not do anything that wasn't already being handled in the service organization.

The vice president of engineering for another major TV producer scoffs, "These guys are riding the consumerism wave, but aside from helping with Government red tape, they're not doing anything for the industry that a good engineering department hasn't been doing all along." □

Probing the news

People

Pierce: what's ahead in communications

Before 'retiring' to Caltech, Bell Labs' executive director of research/communications takes a look ahead

by William Bucci, Associate Editor

Like other professions, electronics engineering has its prophets and its elder statemen, but few are as articulate, informed, and qualified to assess the future of technology as John R. Pierce. From a green Ph.D., who joined Bell Telephone Laboratories 35 years ago to work on vacuum tubes, Pierce has become an acknowledged spokesman for the communications industry, and has helped shape such vital developments as communications satellites and digital systems. This month, the 61-year-old executive director of the Labs' Research-Communications Sciences division retires to start a new career as professor of engineering at his alma mater, the California Institute of Technology. But clearly he is still concerned with the critical issues now facing communications technology.

Interviewed late last month in his modest Murray Hill, N.J., office before his return West, Pierce spoke of the developments he believes will have a significant impact on electronic communications in the coming years. He foresees the widespread use of domestic satellites for broadband transmission; both short- and long-distance laser communications over glass fibers; and the exploitation of the country's communications networks to bring new services to homes and offices.

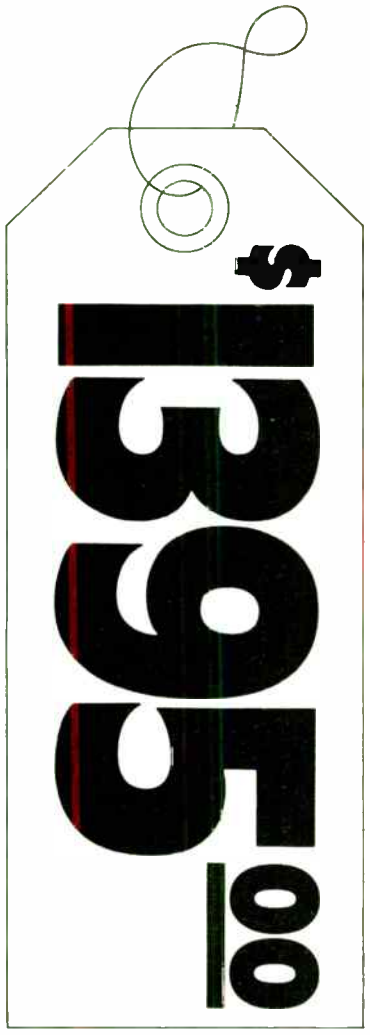
What makes his forecasts important is that Pierce is no blue-sky dreamer but has a reputation for hard-headed practicality. "It's got to be useful, it's got to work, and it's got to work right," he maintains. "That was perhaps the hardest lesson I had to learn in engineering."

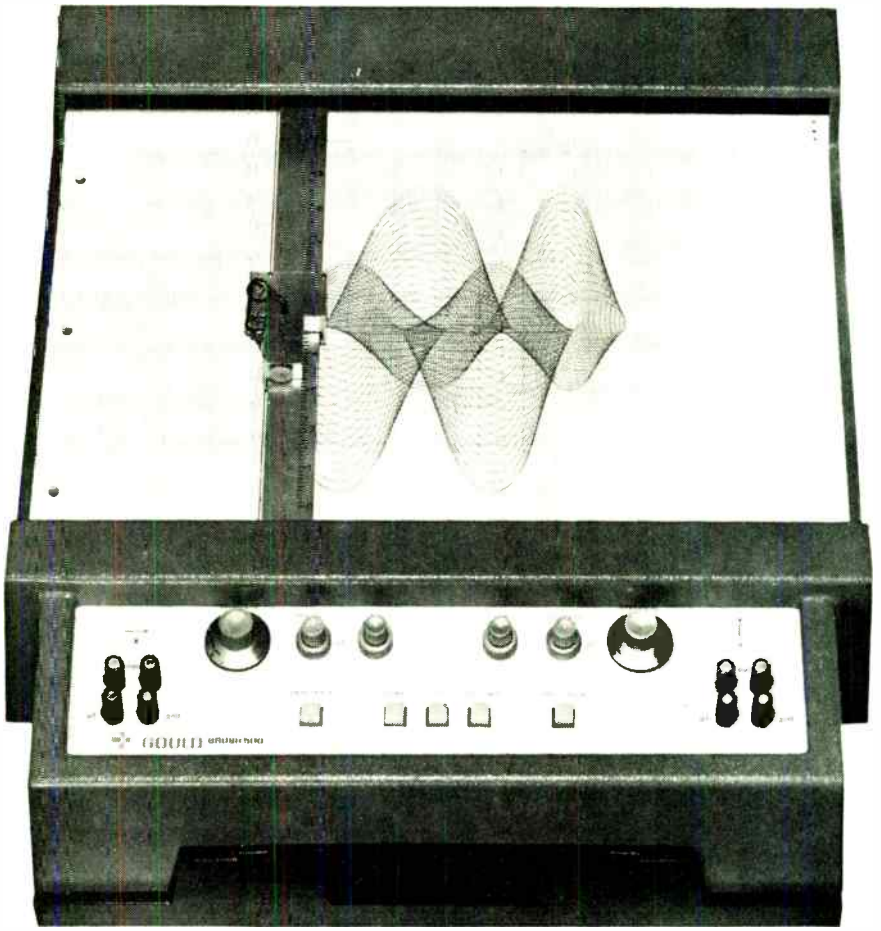
He talks unusually fluently, with the same precision he demands in engineering. Yet his rigorous approach to both language and engineering hasn't hampered his imagination and prevented him from seeing possibilities that others have frequently overlooked. A science fiction writer from his undergraduate days, Pierce was one of the first to explore the possibility of satellite communications in a 1952 science fiction magazine. But it was the practical engineer who three years later published a definitive, technical analysis of satellite communications in the American Rocket Society's journal, Jet Propulsion.

Vision. It was Pierce, too, who realized that the traveling-wave tube invented by Rudolph Kompfner, now at Bell Laboratories, might have far broader applications than as just a sensitive amplifier in radar detection. He saw the TWT as a potential broadband amplifier of microwave frequencies, and spent years working closely with Kompfner to develop the present, highly reliable device so essential to communications satellites. "I look on the golden age when Rudi Kompfner and I were working on traveling wave tubes . . . oh gosh . . . I suppose it's 20 years ago. Things were unfolding, and we were completely immersed," Pierce reminisces with a characteristic enthusiasm.

And it was Pierce who helped make successful the early experiments with Echo, the world's first practical, passive communications satellite, and Telstar, the first active satellite.

Domestic satellites, he thinks, will eventually become a major factor in communications because "they could give an unprecedented





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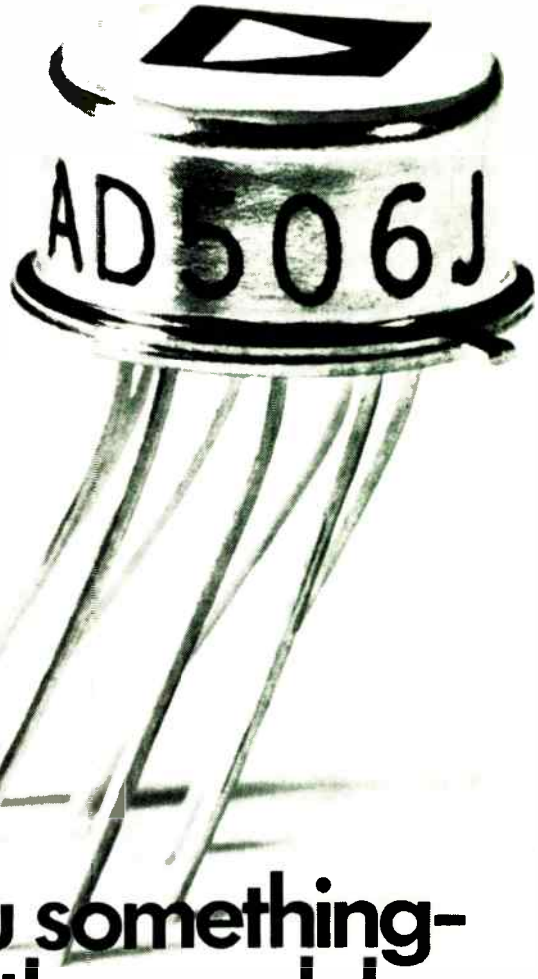

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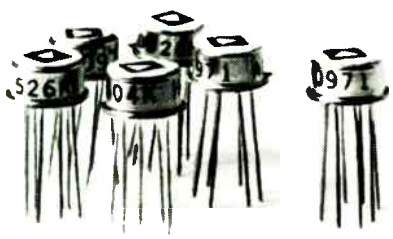

Circle 114 on reader service card

amount of broadband transmission, and the cost would be independent of distance. And the way things are going, I believe it will be cheap," he notes. "If you could resolve all the regulatory and managerial problems and get something launched, you could have broadband domestic satellite communications within five years. But the problems won't be resolved that fast and also, when large amounts of money in large enterprises are involved, commitments aren't made that way."

Digital. Pierce advocates using a broadband system, such as pulse code modulation, which is resistant to interference. "Then you can have lots of satellites maybe only 1 apart. You can use the frequencies many more times, and more than make up for the broader bandwidth."

Looking back on Bell's earlier championship of low-altitude satellites, he admits, "I underestimated the rate of progress in the space art. I didn't realize it would be possible to make large, complicated, and reliable things so soon. On the other hand, communications satellites in the early days did suffer from overambition," he recalls, citing such programs as the Advent communications satellite, which was cancelled. "Advent never got built, and if it had, it couldn't have been launched. My original thought in pushing for low-altitude satellites like Echo and Telstar was that we could do it as an experiment that would demonstrate capability."

For Pierce, then as now, the only valid approach was to go "step by step." But meanwhile Hughes Aircraft Co. came up with a synchronous satellite. "I have the greatest respect for Harold Rosen of Hughes," comments Pierce. "He devised an extremely ingenious, light, small, cut-to-the-bone satellite, which could be launched into synchronous orbit by existing vehicles. And that was a big breakthrough. But he, too, went step by step—he just thought of a good step."

Turning to another important step, Corning Glass Works' development of glass fibers with less than 20 decibels attenuation per kilometer, [*Electronics*, July 5, p. 46], Pierce comments, "This means you can send signals over such fibers for distances of up to a mile or two before repeating. The fibers are one of the biggest breakthroughs in communications over short distance—not that they aren't adaptable to long distances, but right now so many of our communications problems are in the cities where you need cheap, short-haul systems." He is quick to point out the problems yet to be solved. "We've got to get the life longer on semiconductor lasers. There are problems of making the fibers reproducibly and of finding ways of handling them and splicing them, for instance. But if we solve some of these and really get those 20-dB losses per kilometer, we'll get useful communications even with an incoherent source. And just think how many of those fibers you can pull through a cable duct."

Spokesman. John Pierce looks ahead to significant communications developments.

Pierce is solidly behind the plan to use pulse code modulation as the form of transmission in such laser systems. In fact, he is strongly partisan about using pcm switching systems in addition to tranmission systems. "Some years ago we did an experiment in my division on a digital switching system called Essex. Essex didn't win out as the first electronic switching system, and I was disappointed at the time. But it may have been a case of the right idea too soon—maybe it should have waited for the advent of large-scale integration."

Now that LSI has come along, Pierce states, "I believe digital

switching is right for the analog type [voice] signals, as well as for primarily digital signals, because ICs handle binary signals most reliably and effectively. And as the control portions of electronic switching systems get cheaper because of LSI, if you stick with analog switching, the cost of the switching network will get proportionately larger. The only way out I personally see is to get the signals into some form in which they can be effectively switched either by IC-type crosspoints or by time-division methods."

Just as he sees the need for digital switching systems for effective handling of telephone and other communications, Pierce cites the need for "some means of display that is a lot cheaper, more reliable and attractive than the teletypewriter, if use of communications facilities is going to extend into the home." He believes that offering such services as the electronic transfer of funds and credit card verification in the home depends more on terminal equipment than on rearranging the internal structure of the existing Bell System network.

Out of Sight? Commenting on another type of extended communication, Bell's Picturephone, Pierce states, "Whether this is the day when Picturephone will succeed in a big way or not, I don't know. It may been have tried too soon for success. Its coming depends both on the terminals and on transmission and switching being cheap enough, and that's a very tricky thing—to tell when the user has enough money and the technology has made things cheap enough so something is really going to go."

Pierce's ability to combine vision with practicality will be invaluable to him as an educator. With typical clarity, he has already defined his goal as a teacher. "Engineering students are learning an awful lot more than they used to learn, and they do have a strong sense of doing something worthwhile and relevant," he says, "but an important job facing us right now is to help them link things that are powerful, as indeed science and technology are, with real problems." □

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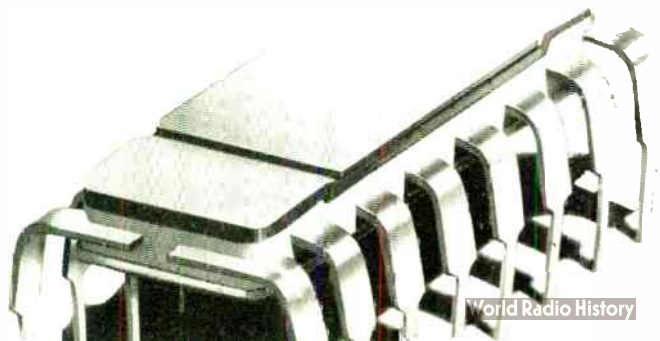

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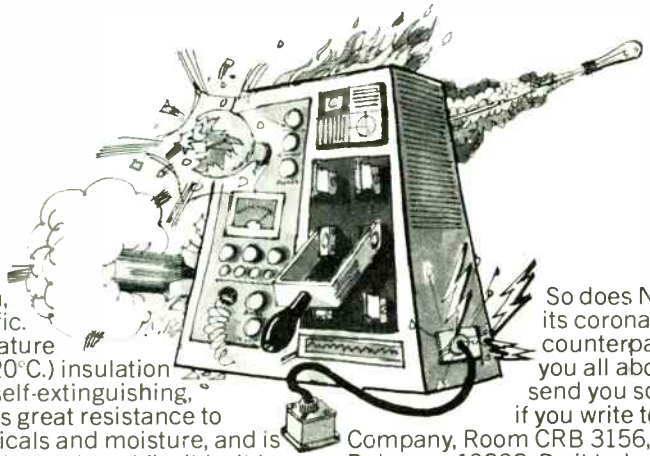

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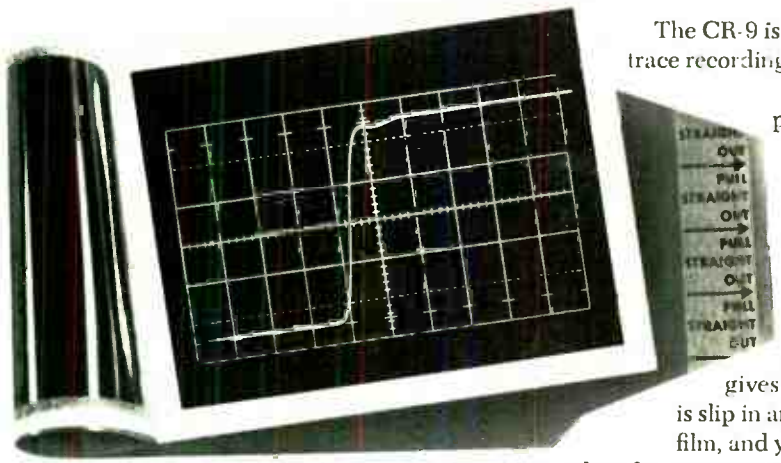

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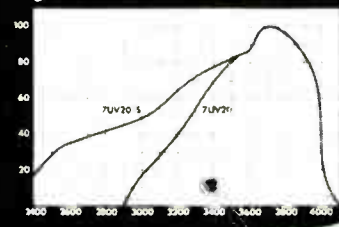

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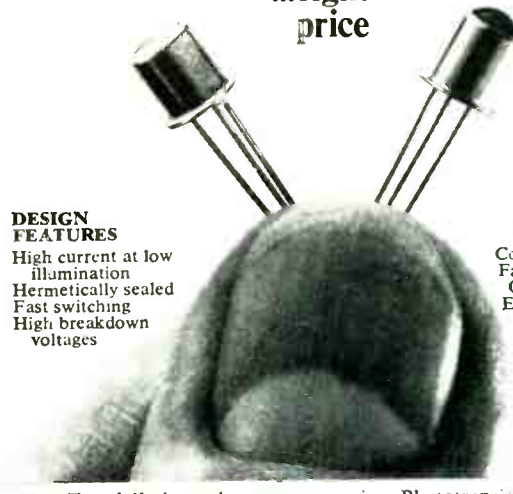

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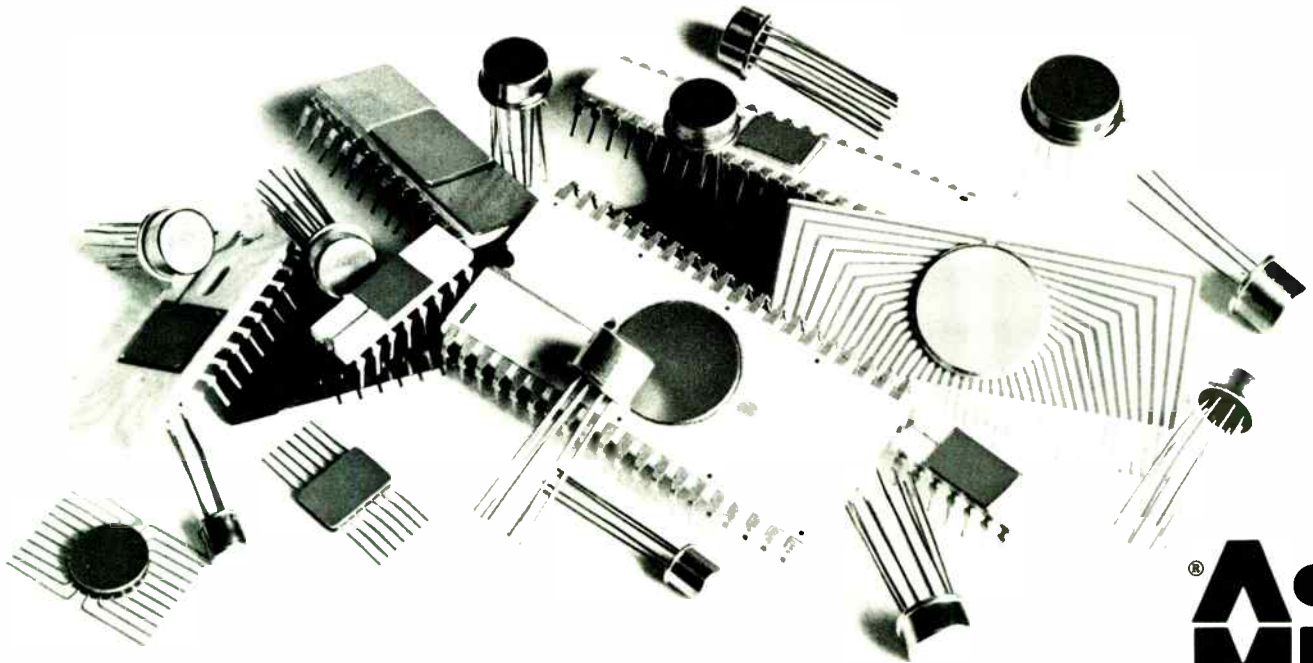

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Multiplier circuit is monolithic

by Stephen Wm. Fields, San Francisco bureau manager

TTL/MSI 2-by-4 device allows direct multiplication in minicomputers, simplifies Fourier transform analyzers

When a semiconductor company that's known as a second-source house starts to get into proprietary products, these items usually are improved models of earlier versions—faster memories or lower-noise op amps, for example. But at Advanced Micro Devices Inc., Sunnyvale, Calif., they do things a little differently. As one of its first proprietary products, the company has developed the first commercially available monolithic digital multiplier circuit.

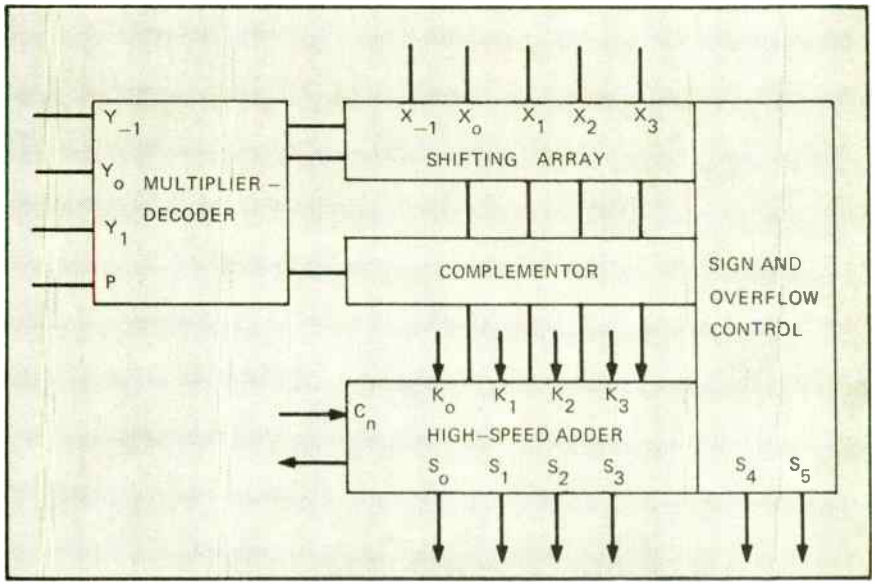
The new circuit, called the Am2505, is a TTL/MSI 2-by-4 multiplier that can be employed as an element in an iterative array to perform 2's-complement multiplication at relatively high speeds compared to other methods but without using large amounts of hardware. An eight-bit number multiplied by an eight-bit number employing eight devices requires only 135 nanoseconds. Clive Ghest, product manager for the Am2505, says the new circuit allows direct hardware multiplication in minicomputers, and also simplifies design of special-purpose processors such as fast-Fourier transform analyzers.

"Multiplication of a multibit number is nothing more than a set of single-bit multiplications and a series of parallel additions," says Ghest. But it's often a time-consuming process. For example, during multiplication the various additions take considerable time because of the carry-bit propagating through the system. "This carry time can be reduced," Ghest points out, "by not allowing the carriers to propagate at the same level but rather to add them at the next level. This is fast, but it takes a lot of additional hardware." Semiconductor read-only memories also have been employed in high-speed multiplication circuits, but these require custom masks and an iterative type of structure is not possible.

The Am2505 uses an algorithm for 2's-complement multiplication that's a modification of Booth's algorithm. That procedure requires an account of the previous operation; the last multiplier bit of the previous operation is used for this purpose. The equation of the multiplier is $S = XY + K$ where S is the result, X is a four-bit number, Y is a two-bit number, and K is the partial product of the calculation up to that point. In order to be able to multiply larger numbers, say an eight-bit by an eight-bit, "You have to be able to add partial products," says Ghest, "so that the devices can be connected together in a chain." This is the K function.

Inputs. Actually there are 5 X inputs and 3 Y inputs for each 4-by-2 chip; one of each is for the result of the previous operation. There are also the four K inputs, a carry-in and a carry-out, a polarity input, and the six output lines (the result

All on a chip. Digital multiplier circuit can be used as an element in an iterative array to perform 2's-complement multiplication wherever high-speed operation is required.



of multiplying a four-bit number by a two-bit number is a six-bit number). The polarity input is not for the sign of the answer, but rather for selecting the type of logic that is to be used. If the polarity pin is left unconnected, the chip is set for active low or negative logic; if it is grounded, the chip is set for active high or positive logic.

The Am2505 multiplier can be connected in an iterative array in a number of ways, either by itself or in conjunction with other MSI elements. The most straightforward (but not the one which gives the smallest delay) is to stack multipliers in rows, each row being the same length as the multiplicand and staggered from the previous row by two-bit positions. The least-significant two sum bits of each of the rows gives the least significant part of the result, and the remainder of the last row the most significant part of the product. Since multiplication is no more than a series of conditional additions, it makes no difference to the answer where in the array each addition takes place.

This means that multipliers can be moved in the array as long as the relative weight is not altered. Says Ghest, "The only things to be careful of are that the carry-in at the first multiplier in each row must be conditional on the appropriate multiplier digit, that these carries must be kept with the appropriate multiplier, and that the most-significant part of the array at each row carries the sign information and S_3 must be inserted into the appropriate K_3 input so as to effectively repeat the sign digit across the complete product length."

Ghest says that minicomputers and calculators are not the only places the 2505 can be used. Another application is in sonar or radar analysis employing Fourier analysis.

The Am2505 is priced at $26 each in quantities of 100 for the commercial-grade device in a 24-pin silicone dual in-line package. Delivery of the multipliers will begin toward the end of this month.

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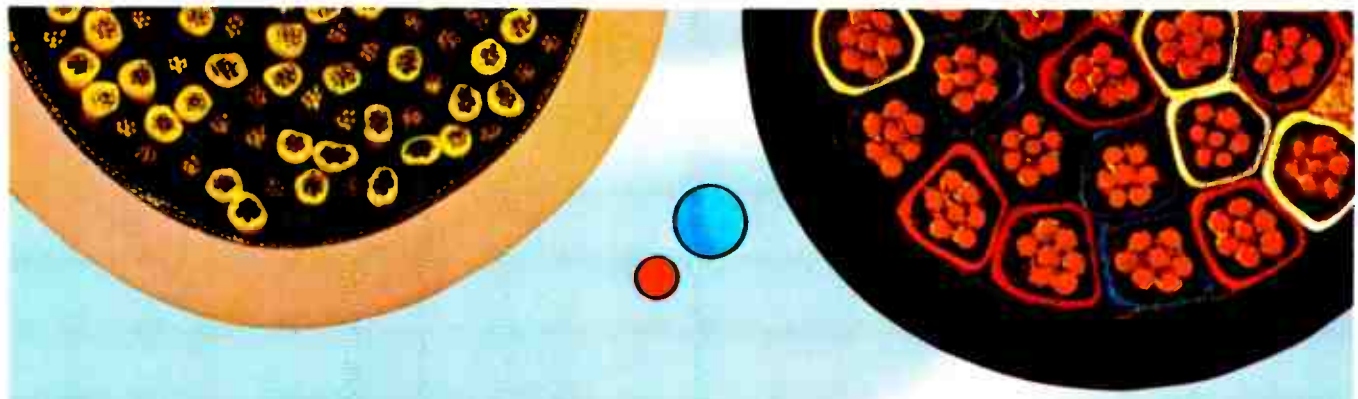

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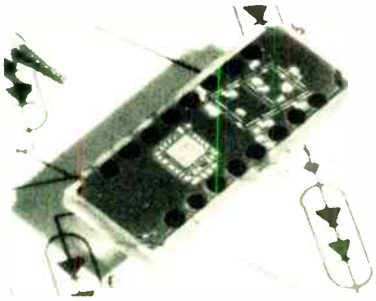
Chip decodes, drives LEDs

TTL monolithic unit is mounted on same substrate as seven-segment display

In industrial test equipment, space limitations often are severe. That is one of the applications that design engineers at Texas Instruments Inc. had in mind when they combined the widely used MAN-1 light-emitting diode display with a monolithic decade counter-latch-driver. The unified display takes up little more space than a single dual in-line package. Available in two versions, the TIXL 306 (left-hand decimal) and TIXL 307 (right decimal), the display is the first of its type on the market (Hewlett-Packard introduced a hybrid latch-decoder-driver with an LED display last year).



The TIXL 306/7 uses a ceramic substrate to mount the hybrid, 0.27-inch-high, seven-segment display. Also on the substrate is a TTL monolithic chip, which TI sells separately as the SN74143. The substrate is molded with clear plastic. The 16-pin package is in the DIP configuration, though it's 0.40 in. wide instead of 0.30 in.

With all the interface connections accommodated, the user doesn't have to provide the constant-current source, required in many schemes using LEDs. Dave Davies, product marketing engineer, points out that aside from a few specs on brightness, the data sheet is much like any TTL/MSI part.

The TIXL 306/7 includes blanking, BCD output from the latch, and a decimal point independent of everything in the package except blanking. Its made for the commercial temperature range, 0 to 70 C. and requires 175 milliamperes at 5 volts for maximum brilliance. Typical brightness at full illumination is 450 foot-lamberts.

Texas Instruments Inc., P.O. Box 5012, Dallas, Texas 75222 [411]

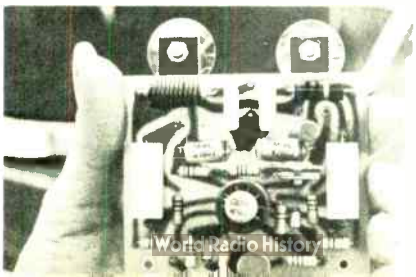
Semiconductor briefs

Photochips. PA arrays, in a line of cadmium sulfide and cadmium sulfo-selenide photodetectors, feature multicell configurations for multichannel monitoring applications. They are available with as few as two detectors or as configurations of up to 20 cells. Price is $3.50 in quantities of 500. Allen-Bradley Co., 1201 S. Second St., Milwaukee, Wis. 53204 [413]

Plastic packages. A pin-type with either tin- or gold-plated pins has standard 14- or 16-lead configuration for either substrates or pc board mounting. Price is 16 cents each in large quantities. Another is a DIP

with standard IC-type lead frame and can be handled by automatic staking equipment. It is priced at 13 cents. U.S. Electronic Services Corp., Holgar Industrial Park, Clifton Heights, Pa. 19018 [414]

Linear IC. Model 540 circuit can drive complementary output transistors in audio power amplifiers, positive and negative voltage-regulator solenoids, relays, controlled current sources, and ultrasonic equipment. It has a standby current of typically 13 mA, and provides

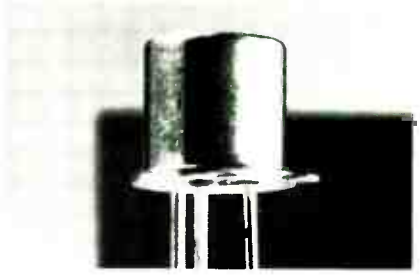


New products

high output drive current of more than 120 mA. The IC drives any type of load including resistive, inductive, capacitive or a combination. Price ranges from $2 to $3.40 for quantities of 100 to 999. Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086 [415]

Silicon-controlled rectifiers. Series IR140 and IR141 are designed for use in radar pulse modulators, ultrasonic cleaning equipment, and high-frequency inverters and converters. They operate up to 20 kHz, and are available with dc forward blocking voltage ratings of 50 to 400 V. Forward current ratings are 35 A rms and 22 A average. Price for the IR140F (50 V) is $6.70 in 100 to 999 lots; and for the IR140D (400 V), $19.15 in the same quantities. International Rectifier Corp., El Segundo, Calif. 90245 [416]

Transistors. Three series of programmable unijunction transistors, the 2N6119-2N6120 and U13T3-U13T4 for low-cost industrial applications,



and the 2N6137-2N6138 for military requirements are hermetically sealed in TO-18 packages. Applications include timing, pulse and sensing circuits, SCR triggers, and relaxation oscillators. Price for the U13T3 is as low as 53 cents in 1,000 lots. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172 [417]

Dual power driver. Type MCH 2890 translates DTL or TTL logic voltage levels to high power outputs, and loads can be either resistive or inductive. Applications include hammer drivers, paper tape punches, relay drivers, stepping motors, and lamp drivers requiring digitally controlled high-current pulses. The interface is provided in a single package, replacing an IC and two

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The versatile 935 is available from 6 through 50 volts, and from .0047 to 56 mfd. It is designed to operate from −55°C to +85°C at full rating, and up to +125°C with ⅓ derating.

For complete information and technical data, contact TRW Capacitor Division, Box 1000, Ogallala, Nebraska. Phone: (308) 284-3611. TWX: 910-620-0321.

TRW®

New products

Darlington transistors. Price is $7.95 for 100 lots. Motorola Semiconductor Products Inc., P.O. Box 20924, Phoenix, Arizona [418]

Monolithic voltage regulators. Type UL-2723 consists of a temperature-compensated reference amplifier, an error amplifier, power transistor, and current-limiting circuitry on one chip. Units feature low standby current drain, high ripple rejection, high current capability, and low temperature drift. Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247 [419]

FET follower. Model FA501 permits high-accuracy buffering of fast pulse, video, and rf signals without distortion. Output current, which is 100 mA, allows a 50-ohm coax to be

driven directly from it. Rise time is 5 ns, and the FET input provides for a minimum of loading of the signal source. Price is $175. Intronics Inc., Chapel St., Newton, Mass. [412]

Rf transistor. The 400-MHz, 28-volt model XB-50-28 offers 50-W power out, 12-dB gain and an input Q of less than 2. The unit is single-chip, hermetically sealed in a microstrip package, and a 1-kW system can be built with 34 of the devices. Price is $90. Communications Transistor Corp., 301 Industrial Way, San Carlos, Calif. 94070 [420]

DIP

DUAL-INLINE-PACKAGED REED RELAYS

Magnecraft is proud to announce its new DIP (dual-inline-package) line of 8-pin reed relays. These new relays are designed not only to be compatible with the standard packaging developed for integrated circuits, but to offer Magnecraft quality at a low cost. This unique design gives further savings by offering the user the optimum in automated insertion and other economical installation techniques associated with printed circuit applications.

These fantastic new epoxy molded reed relays are ideal for use in circuits where high density packaging is essential. The 5VDC IC compatible versions of these relays will operate directly from TTL or DTL circuits.

Other standard coil voltages are available from stock in 6, 12, and 24VDC as well as contact configurations in 1 form A, 2 form A, 1 form B, and 1 form C. Most versions are also offered with a choice of an internal clamping diode.

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Circle 133 on reader service card

What's all this noise about noise?

Philips' 30-series high noise-immunity logic modules solve noise problems instantly, right on the circuit design.

How to eliminate the effects of self-induced and externally generated a.c. and d.c. noise in logic circuits... there's a subject to keep earnest circuit designers debating into the night.
But it's time to call time, gentlemen. All this noise about noise is just valuable energy going to waste.
Philips' new 30-series high noise-immunity logic modules provide an instant solution, not only to problems caused by so-called d.c. noise, but to the more troublesome spurious a.c. pulses that can cause a logic system to go all illogical.
The trick is in matching up the relationship between noise-immunity and speed-of-system response. With a 30-series module you simply add, where necessary, a slow-down capacitor in the circuit... selected, of course, to fit the situation... and there's no more noise problem left to talk about!
Don't leave yet. The 30-series includes not only logic elements, but timers, power amplifiers, lamp/relay drivers, interface modules, p.c. boards, connectors, mounting racks... everything you need to build a complete system.
Modules come in 16 and 20 pin dual-in-line packages ready to insert. Philips provides full application support... we'll even design a prototype for you.
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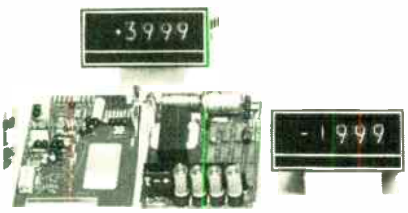
Instruments

Panel meters keep cool

Digital units for small equipment cabinets rise only 8°C during operation

Now that their prices have dropped to around $100 to $125, digital panel meters have been getting into more and more pieces of equipment. But most users still have one problem—heat. Most meters have a



heat rise of from 15° to 20°C in the first five minutes of operation, creating drift and reliability problems when installed in a small cabinet. But a new series of DPMs has only a cool 8°C temperature rise.

Called the 300 series, the new units are the entry of Electro-Numerics Corp., Santa Clara, Calif., into the small DPM market. According to Don Willett, marketing manager at Electro-Numerics, about two-thirds of all DPMs go into scientific analytical instruments where the manufacturers don't want to spend time designing their own display systems or in cooling the units that they have, "so there is a definite need for a cool DPM."

The 300 series meters are the same size as previously available units. Included are the 301, a 2½-digit unit employing Nixie tubes; the 371, a 2½-digit meter using Numitrons; the 300, 3½-digits with Nixies; the 370, 3½ digits with Numitrons, and the 302 which reads up to 3,999 and employs Nixies. Prices range from $118 to $235 in quantities of 10.

All of the meters use a passive-integration, dual-slope, analog-to-digital conversion technique that, says Willett, "provides long-term stability and noise rejection. The ambient temperature would have to increase by more than 20° C before you would see one digit change," Willett asserts, "and the full-scale temperature coefficient is 30 parts per million." An efficient power-supply design is the key factor in cool operation, Willett says.

All of the units have TTL-level BCD outputs. The Nixie meters require 4.5 watts, the Numitron units need 7 W. The meters are available from stock.

Electro-Numerics Corp., 2961 Corvin Drive, Santa Clara, Calif. 95051 [351]

Low-priced multimeter resolves 4½ digits

Big sales orders started rolling in almost immediately after Weston Instruments Inc. introduced a 3½-digit multimeter in the fall of 1969. Banking on similar success, the Newark-based firm is challenging the high-resolution companies such as John Fluke Manufacturing Co. with a 4½-digit multimeter, the model 1242.

The high-impact, shock-resistant case remains the same size as its 3½-digit predecessor, and the 1242 can be bench- or rack-mounted to be useful in the lab as well as in the field. All input circuits are overload-protected by resistor-diode networks, fuses, or both. Fuses are replaceable from outside the case, and a fuse-removal tool is provided at the end of each locking knob.

The bipolar instrument features 25 ranges for measuring dc and ac voltage and current, and resistance. It has a single-range selector, light-touch function switches, and recessed controls that can be operated with one hand. The 1242 sells for $595, with an optional leather case and battery pack available for field applications.

Another version, the model 1243, offers the same features as the 1242 but also has an isolated 8421 BCD output in parallel form, compatible with transistor-transistor logic. In addition to input data, polarity,

New products

overrange, and decimal-point information, the functions and ranges set up for the range switch also are available as a binary code. Price of the 1243 is $695.

Weston Instruments Inc., 614 Frelinghuysen Ave., Newark, N.J. 07114 [352]

Instrument briefs

Curve tracers. Model 5CT1N plug-in unit is used in the company's 5100 series oscilloscope systems for displaying characteristic curves of small-signal semiconductor devices to power levels up to 0.5 watt. A variable collector/drain sweep pro-

duces a maximum peak voltage of at least 250 volts, and a base/gate step-generator produces up to 10 calibrated current or voltage steps. Price is $350. Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97005 [353]

Ratiometer. Model 854 displays ratios of 19.99 for two dc inputs which may be derived from sources such as pressure, temperature, optical, or other transducers providing from

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New products

0.1 to 3.0 volts. The ratio is furnished six times per second, with each calculation independent of the previous one. Price is $875. MSI Electronics Inc., 34-32 57th St., Woodside, N.Y. 11377 [354]

Counter/timers. Universal units, model 1420 with 100-MHz frequency counting capability and model 1460 with 500-MHz capability, offer computer interface, remote programing, and BCD outputs. Other features include input signal conditioning of both A and B input channels with

50-mV rms automatic sensitivity for zero crossing measurements, and 10-mV rms sensitivity by manual or remote control. Price is $1,095 for the 1420 and $1,595 for the 1460. Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, Calif. 94520 [355]

Thermometer. Model DigiTec series 590 thermocouple device features LED displays, guarded input, and isolated system functions. Models

are available for standard temperature coefficients in either farenheit or centigrade. High conformities are attained by using 32 segments of digital linearization programed by read-only memories. Other features include self-check ice-point calibration. Price is $825. United Systems Corp., 918 Woodley Rd., Dayton, Ohio 45403 [357]

Nuclear instrument module. Three-wide unit model 715 has simultaneous preset time and count capa-

The one you've talked about and waited for just came onstage. The Eye modestly presents the new EPI Cassette Transport. Totally unique. Extremely low-priced.

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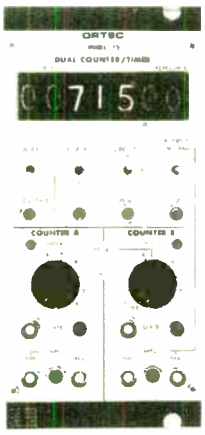
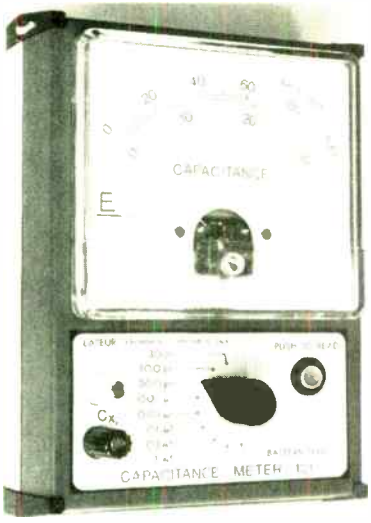
bility, and separate preset selection in both counters. Counter A can be used as a 20-MHz scaler while counter B can be used as either a 20-MHz scaler or timer. Discriminator



levels are front-panel adjustable, and gating and reset functions are independent. Ortec Inc., 7224 Midland Rd., Oak Ridge, Tenn. 37830 [356]

Capacitance meter. Model 101 covers the range of 2 picofarads to 0.1 microfarad, and uses IC op amps, FET circuits, and printed circuit switches. Accuracy is limited only by the meter movement. It can be switched through eight scale ranges until a direct reading is obtained,



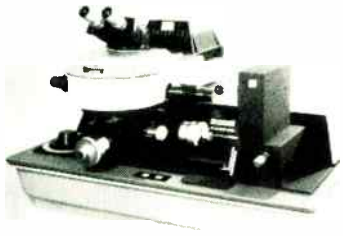
and the low-voltage operation is desirable for measurements on monolithic chips. Price is $94.50 Lateur Engineering Co., 950 Terminal Way, San Carlos, Calif. 94070 [358]

Packaging and production

1-micron IC lines resolved

Mask alignment-printing equipment offers projection ratios of 2:1, 4:1, and 10:1

Projection printing of integrated circuits is an attractive alternative to contact printing because it avoids damage to the mask masters [*Electronics*, Aug. 31, 1970, p. 90], but resolution of the optics has limited



line widths to about 3 microns—not good enough for makers of microwave and large-scale integrated circuits.

New projection aligners from Kasper Instruments Inc. reduce the image still further in the projection process and can achieve line widths of 1 micron. Machines are available with projection ratios of 1:1, 2:1, 4:1, or 10:1, with resolution ranging from 3 microns (1:1) to 1 micron (10:1). This lets the circuit designer employ larger geometries on the mask, say 10 microns, which can be reduced to 1 micron. To print the mask across the whole wafer (when it is reduced, it no longer fills the wafer), it is stepped and repeated. The recommended number of steps is one for the 2:1 unit, nine for the 4:1, and 25 for the 10:1 system.

Another advantage of the new projection aligners is that even masks with minor "printable" defects, such as pinholes, can be used. The smaller projected images virtually eliminate the mask defects, due to the 2× or 4× or 10× reduction provided by the system. Each of the four systems uses standard mask sizes, and since they print out of contact, there is no damage to the masks in the aligning or printing operation.

The systems feature prealignment accuracies of 1/10,000 inch. Alignment accuracies up to 2.5×10^{-6} in. are easy to achieve, because the device geometry is magnified by the ratio of the projection lens for easier and much more accurate visual alignment. During alignment, the mask and wafer image are in the same plane, and the operator can get an ultrafine focus of the image on the wafer surface before printing. An automatic focusing system on the wafer compensates for wafer thickness and taper variations. The system handles all types of substrate materials of any thickness, shape, or size up to 3 inches, and will even handle chips.

The fully integrated design includes special matched optics corrected for the two wavelengths used in semiconductor manufacturing: 5,460 angstroms (the green light needed for viewing and focusing) and 4,358 angstroms (ultraviolet for the exposure light). There is even a lamp alignment system that allows the operator to align the light path through the system before beginning the printing operation. An ultraviolet light integrator that senses photon flow from the light source to the surface for very precise exposure is standard in the systems and insures repeatable exposures from batch to batch. An operational television alignment attachment is also available.

The cost of the systems ranges from $45,000 for the 1:1 system to $60,000 for the 2:1, 4:1, or 10:1 unit. Delivery time is 60 days after receipt of order.

Kasper Instruments Inc., 500 Ellis St., Mountain View, Calif. 94040 [391]

Production briefs

Wave soldering system. Model BB-8 is designed for pallet/palletless operation, and offers oil intermix capability. Wave height is variable to ½ in. The system also features externally mounted pot heaters, a

Circle 143 on reader service card→

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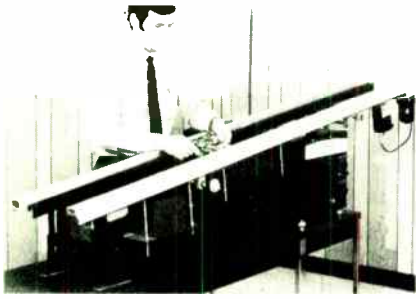
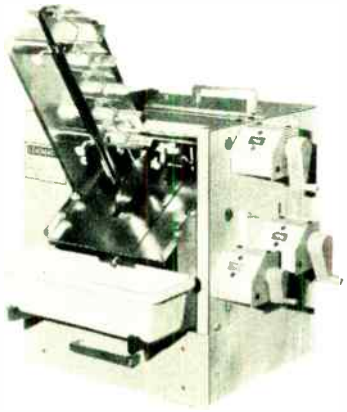
solder drain valve, and a PVC foam fluxer that withstands corrosive fluxes. The solder pump is located below the wave top, permitting



unobstructed access to the wave from any direction. Price ranges from $2,150 to $3,495. Gale Systems Inc., Dale St., Andover, Mass. [393]

Lead-forming machine. Leadmaster model H107 processes leads of all axial components from those with measurements of 0.010 in. lead diameter, 0.060 in. body diameter, and 0.125 in. body length, to those measuring 0.048 in. lead diameter,



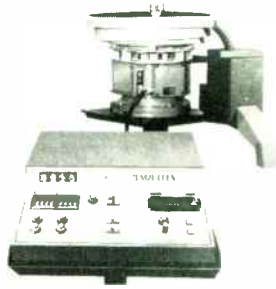
0.500 in. body diameter, and body lengths of over 2 in. It can form leads into a wide variety of shapes, and speeds range up to 14,000 parts per hour. Heller Industries Inc., 18 Microlab Rd., Livingston, N.J. 07038 [394]

Lead bending and cutting unit. Semi-automatic machine, model 4000, permits IC users to customize standard components for pc board applications. It takes any flatpack, DIP, TO, transistor, or axial component and bends and cuts it so that each lead configuration is identical and burr-free. Operating speed is 1,000 components per hour. Price is

New products

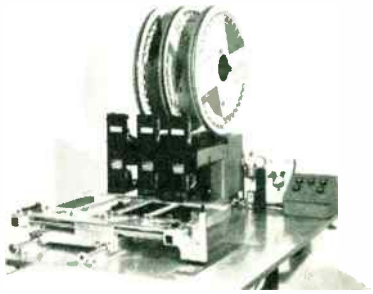
$700. Dies range from $225 to $350 for standard models. Fancort Industries Inc., 150 Broadway, Suite 915, New York, N.Y. 10038 [395]

Counter/feeder. Control console counts up to 100 lots of small parts per minute and, using a silicon photovoltaic sensor, can register up to 2,000 impulses per second. Called the Computron, it permits adjustment of vertical bounce and horizontal stroke of the vibratory bowl

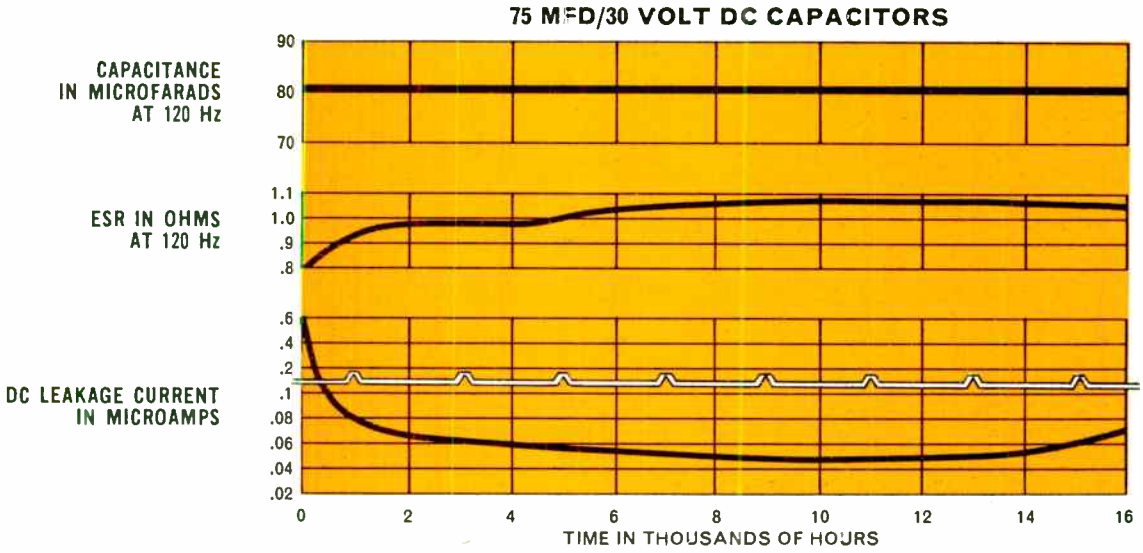


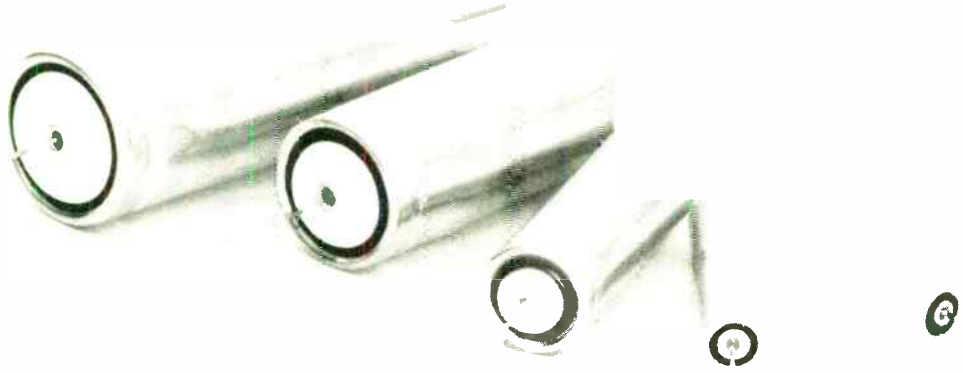
feeder for infinitely variable speed rates, or adaptation to special problems such as untangling parts. It also controls cycle rotation through fast, slow, full, and dump. Computron Div., Tessler Industries Inc., 4815 Lexington Ave., Cleveland, Ohio 44103 [398]

Color coder. Models KTE-6 and KWE-7 mark wire and tubing with numbers, letters, words, or combinations at any desired intervals, providing both functional and nu-



merical identification. The model 6 is hand operated, and the 7 automatically accomplishes 11,000 markings per hour. Only one color wire is needed for all circuits, reducing the cost. Quick, accurate assembly into the wire harness and connection to correct terminals are provided. Kingsley Wire-Marking Machines, 850 Cahuenga Blvd., Hollywood, Calif. 90038 [399]





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Circle 149 on reader service card

New products

Data handling

Sintered heads increase speed

Hot-pressing process also promises higher density for disk, drum, tape storage

With IBM's 3330 high-speed, 800-megabyte disk memory going operational, and with IBM already promising a tenfold improvement in the 3330's specifications [*Electronics*, Aug. 16, p. 38], the pressure is mounting both on computer mainframe and independent peripheral makers to meet or beat this competition.

One of the keys to their success will be the record-reproduce heads available for disk, drum, and tape memories. And the accent is going to be on frequency response, high initial permeability, and smoothness. The year-old Labtek Inc. expects the hot-sintered ferrite head to be the answer. Labtek claims to be one of the few firms making the cores for such items in the United States; hot-sintered cores have been a Japanese near-monopoly. Now Labtek has samples of its new materials at upwards of 50 firms, and some of the heads that result could operate at 20 to 30 megahertz with ease, according to Leo A. Brissette, president. And he promises better performance to come. Brissette says that Labtek's process, using pressures of 10,000 lb/in.^{2} and temperatures of 2,200 to 2,400° F, results in head core material that's about as homogeneous as single crystals, and perhaps denser than some. The material takes a very fine polish—typical smoothness of 0.01 micron is relatively easy to obtain—without chipping near the head gap as crystals do.

This chipping can make frequency response an uncertain factor, especially when dealing with gap widths on the order of 100 microns. And variability in gap width caused by jagged edges can lower yield of assembled heads. When nine such cores are needed in a single head, as in some IBM-compatible systems, the advantage of smooth gaps becomes important.

And because the glass-filled gaps in Labtek's cores are more finely defined, claims Brissette, he can specify their performance more tightly.

The same smoothness that makes for a finer gap also extends the life of these cores relative to other types. At the same magnification, Labtek's heads appear a dull grey, while ordinary sintered ferrites appear pock-marked. In one potential application—a point-of-sale machine recording transactions on magnetic tape—the user specified heads good for at least 3 million passes, and wanted 6 million. Conventional metal-laminated heads gave up at the 50,000-pass mark; conventional sintered heads got to 500,000. When last seen, Labtek's heads were past the million mark and still going.

Permeability is high, but varies with the ferrite material the user desires. Brissette indicates that the hot-press technique tends to increase initial permeability almost regardless of the type of ferrite powder poured into the press, and so claims lower residual noise in his cores than for cores of the same material made using standard sintering. This will mean less-ambiguous pulses coming from the head, and could be traded off against a playback amplifier design for reduced cost or, perhaps with standard playback and record amplifiers, designers could go for added speed instead.

Brissette says cores could sell for about $1 each in quantities of 100,000 or so; in 10,000-unit lots, the price would be about $1.50. Sample quantities are being delivered approximately at cost.

Labtek Inc., P.O. Box 103, Middleton, Mass. 01949 [361]

Data handling briefs

Core memory expansion. MOD 40+ add-on is for IBM 360/40 systems and will expand the processors from 32,000 to 512,000 bytes. The memories may be leased or purchased, and maintenance is available.

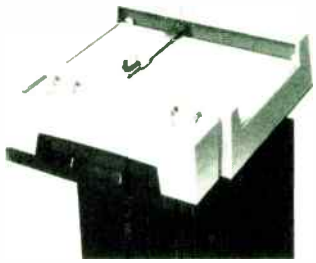
New products

Fabri-Tek Inc., 5901 South Country Rd., 18, Minneapolis, Minn. 55436 [363]

Digital data logger. Digitrend 210 scans, conditions, measures, displays, and digitally records multiple low-level dc signals from thermocouples, transmitters, and other millivolt transducers. Reference junc-

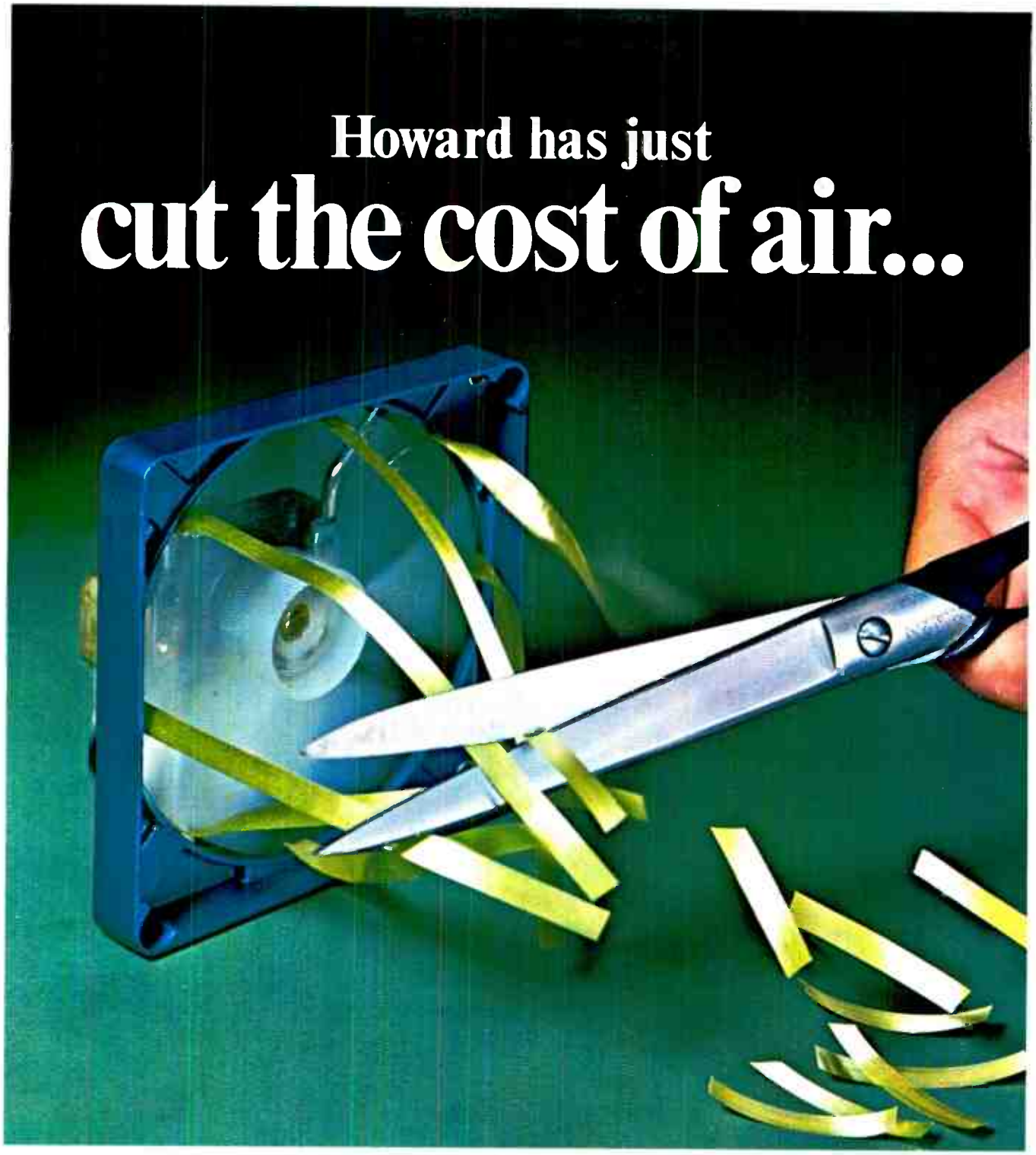
tions, solid state FET scanning, automatic zero drift correction, and digital linearization are built in. Accuracy is ±0.01%. Price is $2,000. Doric Scientific Corp., 7601 Convoy Ct., San Diego, Calif. 92111 [364]

Graphic plotter. Model 511 system is especially suited for time-share plotting of computer generated data for scientific and business applications. Production rate of hard-copy plots is at 2½ strokes per second and strokes can be as long as three inches, consisting of a continuous straight line or an interval be-



tween two plotted points. Other features include servo controlled X,Y axes, eight-level ASCII input codes selectable at rates of 10 or 30 characters per second, and compatibility with DTL/TTL voltage levels. Gould Inc., Brush Div., 3631 Perkins Ave., Cleveland, Ohio 44114 [365]

Display terminal. Aimed at the Teletype replacement market, the TelTerm 33 handles up to 80 characters



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Circle 151 on reader service card

New products

on a line and 27 lines of data. It can blink information on a screen and has a numeric pad in addition to the standard keyboard. Baud rate is

standard at 600 with optional transmission rates of up to 9,600 baud. Price is $2,750 and leasing cost is $110 a month. Delta Data Systems Corp., Woodhaven Industrial Park, Corwells Heights, Pa. 19020 [366]

Data recorders. A 96-column data entry unit designated the model 9601 is compatible with IBM System/3. Features are automatic blank card feeding during verification, plus and minus right justification, individual column backspacing, and fast card feed and punch times. The model 9610 offers all of the same features as the 9601 and, in addition, the ability to print on the card during keypunching and verification. Price of the 9601 is $5,500, and $120 a month for one-year and $110 per month for two-year rental. Price of the 9610 is $7,400 and $150 and $135 per month for one- and two-year rental respectively. Decision Data Corp., 300 Jacksonville Rd., Warminster, Pa. 18974 [367]

Data collection system. Model 7-70 is designed to receive information from the company's computers via phone lines or hard wire, and to record the received information on ½ in. tape on 9 tracks at 800 characters per inch. There are provisions for variable record lengths, all in

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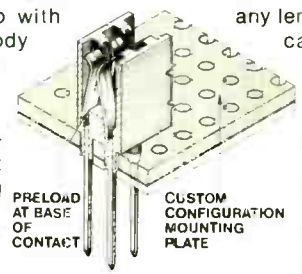


CANNON ITT

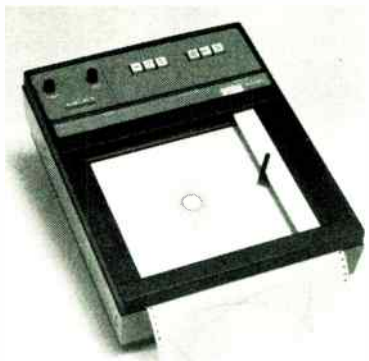
Circle 153 on reader service card

New products

IBM format. A minicomputer is at the heart of the system, and the unit will send accumulated data out on command to another 7-70 or a computer. Tapes may also be taken to data processing centers for direct readout. Single-reel capacity is about 1,728,000 characters. Price is $9,990 and rental is $315 per month. Novar Corp., 2370 Charleston Rd., Mountain View, Calif. 94040 [372]

ROM programers. Fusible-link units are for field programable semiconductor memories manufactured by Motorola, Signetics, and Monolithic Memories. All units operate in manual and automatic modes, and verification circuitry is included. Price is from $1,390 to $1,470 depending on the type of ROM to be programed. Spectrum Dynamics Inc., 2300 E. Oakland Park Blvd., Ft. Lauderdale, Fla. 33306 [370]

Graphic terminal. A self-contained interface to the company's series 2000 digital plotters allows plug-in compatible operation from TTY or CRT terminals to produce hard-copy graphic plots. A data protocol hardwired into the plotter allows it to bring its own software into the terminal. Price ranges from $2,650 to $8,500. Valtec Corp., 17751 Sky Park Circle, Irvine, Calif. [369]



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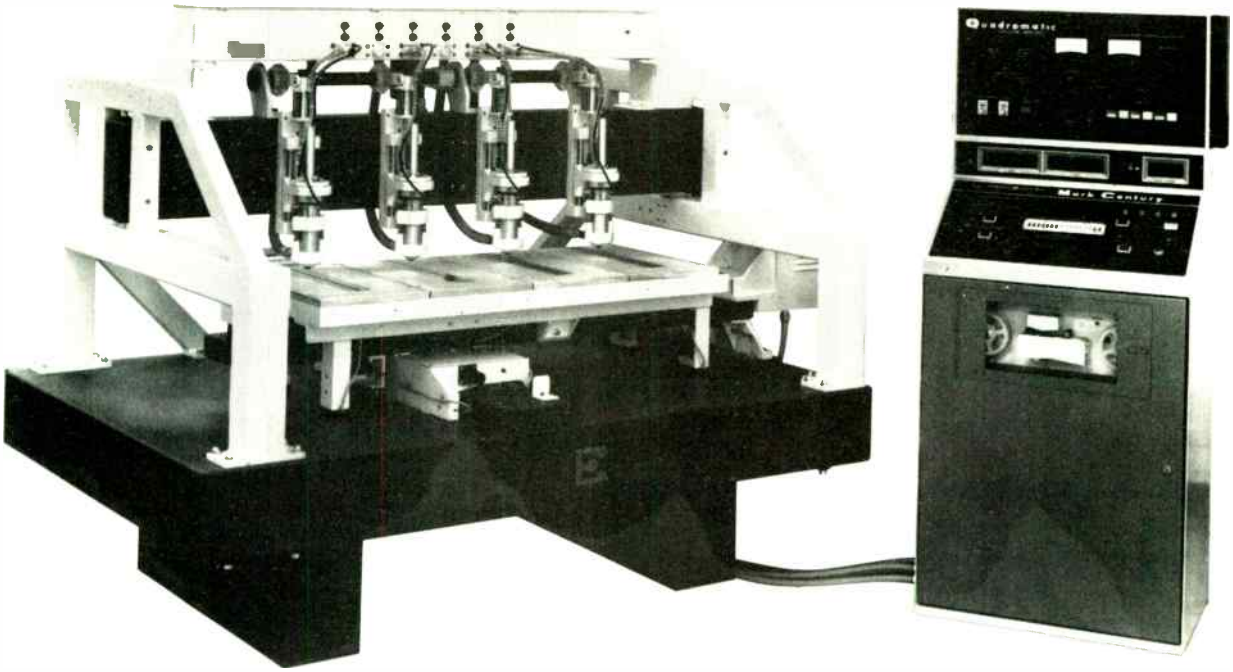

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Components

MOS memory driver is fast

Monolithic circuit for RAMs swings 20 V into 1,000 pF in less than 25 nanoseconds

Fast MOS random access memories and long shift registers are causing some problems for systems designers—no fast clock drivers and TTL-to-MOS converters are suited to them, so the designers can't take full advantage of their speed. Under the high capacitive loading, (500 to 1,200 picofarads) and the over-20-volt swing that memories such as the 1103 operate with, the drivers have been limited to 50 to 75 nanoseconds. But National Semiconductor Corp. has developed a monolithic circuit that is fast enough for the application. Called the MH0026 clock driver, the device can swing 20 V into 1,000 pF over the complete temperature range in under 25 nanoseconds maximum. And this 25 nanoseconds is guaranteed even with a 10-V supply.

According to Mike Scott, product marketing manager at National, "to swing 20 V into 1,000 pF is not easy. Monolithic ICs that have been built to do this have had two faults—either they are slow or if they try to operate at high speed they burn up." This is even true with discrete circuits, he says, because "after all, they have to put out 1.5 amperes in only a few nanoseconds." This belts the aluminum interconnect, and the devices cease to exist.

Scott says that with present driver circuits the speed is limited because of the size of the output transistor. As it becomes larger to handle more power for the high capacitive load, its collector-to-base capacitance also gets larger and this slows the device down.

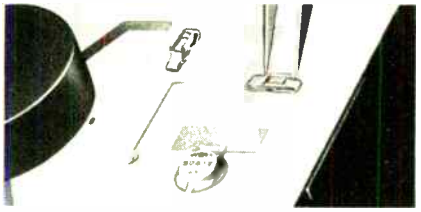
National solved the speed-power problem by designing the circuit so that rise time is controlled by a smaller-geometry transistor and not the power device. "This way," says Scott, "we get both speed and power." He says that the MH0026 was designed to drive the fastest MOS RAMs and shift registers; and it drives the precharge line as well as the clocks and address lines. Scott says that "it's for anyone who wants to go faster than 1 megahertz, or an access time of under 500 nanoseconds."

Each MH0026 contains two driver circuits and is available in a TO-5, TO-8, or an 8-pin silicone miniDIP package. In the miniDIP, the MH0026 sells for $5.95 in quantities of 100. Delivery is from stock.

National Semiconductor Corp., 2900 Semiconductor Drive., Santa Clara, Calif., 95051 [341]

Shuttle-tuned capacitor uses Teflon dielectric

Teflon has been getting increasing attention from components manufacturers because it has good insulating properties and gives very low friction in such applications as trimmer capacitors [*Electronics*, June 7, p. 113]. The latest component to use Teflon as a dielectric is a subminiature variable capacitor made by Voltronics Corp.; it's intended for microelectronic microwave applications. The Teflon is fused to a movable, stainless-steel shuttle that slides into or out of a contact clasp to change capacitance. Adjustment is performed with an insulated vernier compass or tweezers. Positive stops assure stable operation during either vibration or shock of over 40 g.



The solder-mounted unit, which measures 0.2 by 0.08 by 0.04 in., offers a capcitance range of less than 0.1 picofarad to more than 2.5 pF. Contact resistance is only 0.005 ohm, while dc voltage rating is 100

New products

volts. Q factor is over 1,000 at 250 megahertz and exceeds 100 at 2 gigahertz. Operating temperature can range from −55 to +125 C; temperature coefficient is 100 ±100 ppm/ C.

The model CP2 trimmer is aimed at applications through the 5-GHz range. Primary uses for the variable capacitor include microstrip circuits, oscillators, receiver phase arrays, X-band transmitters, and microwave power amplifiers.

Voltronics Corp., West Street, Hanover, N.J. 07936 [342]

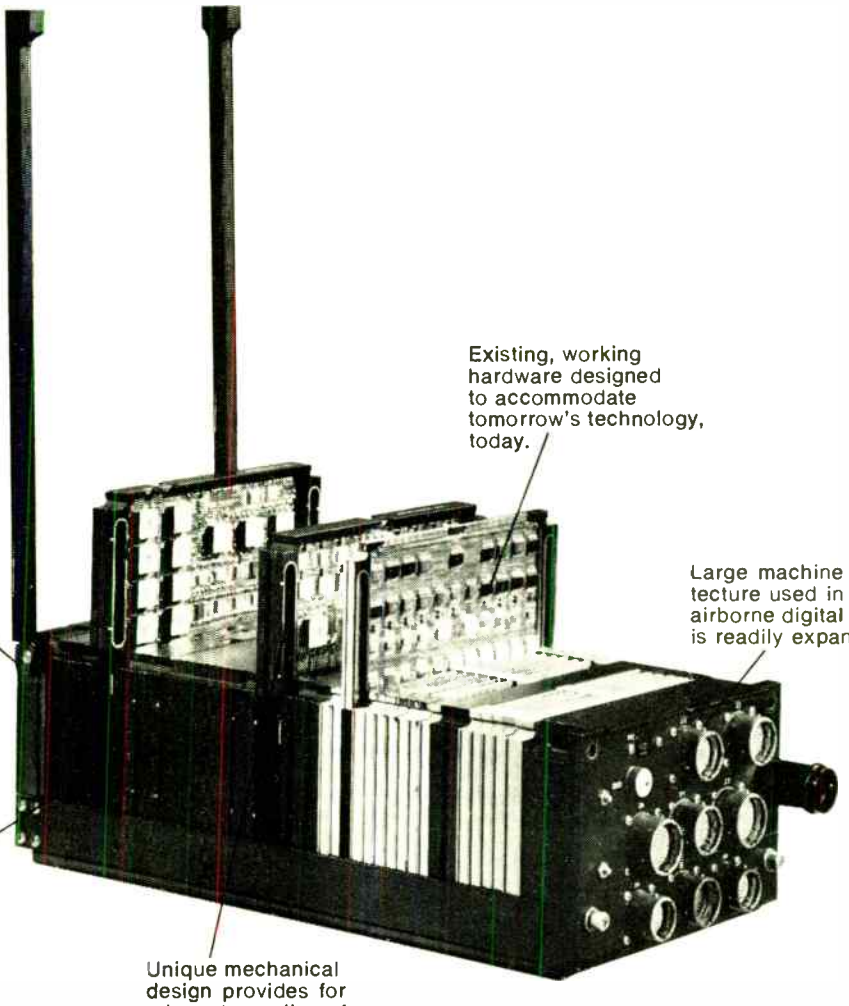
Component briefs

Preset switch. Johnson-coded ½-in.-diameter rotary device is for use with C/MOS divide-by-N integrated circuit counters. Applications are in frequency synthesizer communication systems and program counter controls. Switch is available in a one-pole or two-pole version; the

latter eliminates the need for isolation or pull-up resistors between the voltage supply and counter. The series 50 switch comes with either solder-lug or pc terminals. Price is as low as $4.92 in 100-piece quantities. Grayhill Inc., 561 Hillgrove Ave., La Grange, Ill. 60525 [343]

Capacitors. Type 7271 offers low-loss ceramic dielectrics and is suited for fine tuning of miniature crystal oscillators from kHz to GHz fre-

The mini-maxi machine. Kearfott SKC-2000 Airborne Digital Computer.



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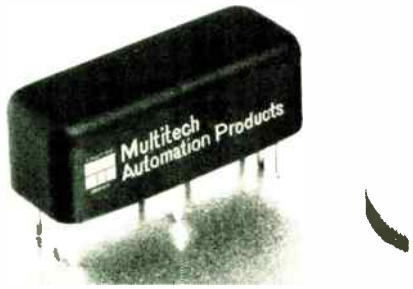
Data words, Fixed Point	32 bits including sign
Instruction Words	16 bits short, 32 bits long
Instructions	99 total long & short
Address Modes	Direct, indirect, relative, immediate
Average Execution Times For 1.9μ sec memory (LSI)	Add-2.125μ sec, multiply-5.875μ sec Divide -5.875μ sec
Memory words directly addressable	131,072

Circle 159 on reader service card

New products

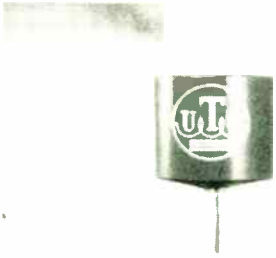
quencies. The variable device is designed for printed circuit mounting or welding to strip-lines, and has a solderless assembly. Price is from $1.50 to $7 each. Johanson Manufacturing Corp., 400 Rockaway Valley Rd., Boonton, N.J. 07005 [344]

Thermal relay. Miniature device, model 180, features fully guarded contacts, less than one microvolt thermal offset voltage, and under 0.01 picofarad direct capacitance from contacts to coil, for microvolt level switching. Integral magnetic



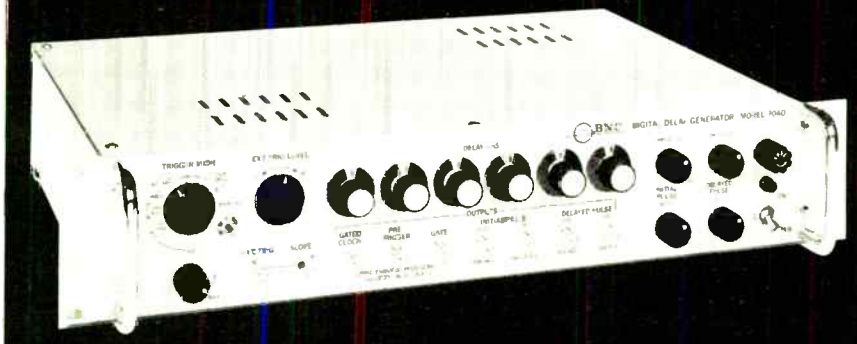
shielding provides close packing, and one billion operations in dry circuits are possible. Price is $8.50 in 1 to 9 quantities. Multitech Automation Products, 583 Monterey Pass Rd., Monterey Park, Calif., 91754 [345]

Transformers. Eighty types of industrial devices are included in a series called I-DI-T and I-DI-T. Power ratings go to 0.05 W and typical frequency responses are ± dB, 300 Hz to 20 kHz (I-DO-T) and ±3 dB, 400 Hz to 20 kHz (I-DI-T). Maximum op-



erating temperature is 85°C. Rugged mechanical design makes them suited to all assembly methods. Applications include isolation matching, and push-pull driving in modem and instrument circuits. United Transformer Company Div., TRW Inc., 150 Varick St., New York, N.Y. 10013 [348]

Programmable 1-ns Digital Delay Generator



The Berkeley Nucleonics' Model 7040 is a new breed of time delay generator:

- **It is programmable.**
- **It may be triggered internally or externally up to a 5-MHz rep rate.**
- **It is adjustable in delay from 1 ns - 999.999 μs in 1 ns increments.**
- **It is accurate to 100 ps.**
- **And its price is $2950.**

Whenever highly precise time delays are required, the Model 7040 will do the job. It is ideally suited for the following applications: calibration of time interval counters, time-to-amplitude converters and oscilloscope sweeps; radar range simulation, cable fault location and delay line testing. The Model 7040's programmable feature gives you an important new building block for automatic test systems and production testing of IC's.

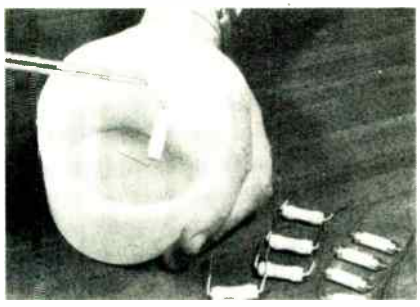
Berkeley Nucleonics has been developing and manufacturing precision pulse generators for eight years. These instruments have become standards in the nuclear research industry for testing linearity, stability and resolution of amplifiers and analog-digital converters. The Model 7040 is a product of the company's continuing interest in the development of pulse generators with precision parameters. For additional information about the Model 7040 as well as the rest of the product line, write or phone:

BNC

Berkeley Nucleonics Corporation

1198 Tenth Street • Berkeley, California 94710 • Phone: (415) 527-1121

New Products/Materials



Adhesive coating has single-component, alumina-ceramic base, and is for use in insulation of components at temperatures of up to 3,200 F. Called Cerama-Dip 538, it is available in paste form with a liquid thinner to produce thixotropic consistency for brushing on or dipping. After air drying for one hour, and a bakeout at 180 F for 3 to 4 hours, the coating hardens into a dense ceramic surface. Price is $40 for a one-quart kit each of paste and thinner and $140 for a kit with a gallon of each. Aremco Products Inc., P.O. Box 145, Briarcliff Manor, N.Y. 10510 [481]

Heat-resistant epoxy casting system, Tra-Cast 3354, pots and encapsulates transformers, integrated circuits, and other components for high-temperature applications. It has low viscosity, long pot life at room temperatures, and moderate exotherm. Tra-Con Inc., Resin Systems Div., 55 North St., Medford, Mass. 02155 [482]

Epoxy silver solder, type 326, in soft paste form, cures at room temperature and can be used with a hypodermic needle, squeeze tube, spatula, or automatic dispensing machine. The two-component material has a pot life of 3 to 4 hours. Price for a 2-oz evaluation kit is $15. Dynaloy Inc., 7 Great Meadow Lane, Hanover, N.J. 07936 [483]

Spray coating Cramolin PC Spray, acts as a protective coating for printed circuits, and prevents oxidation during storage periods. Not a permanent coating, the material is suited for short runs and also acts as a neutral soldering flux agent. Caig Laboratories Inc., 455A Union Ave., P.O. Box 788, Westbury, N.Y. [484]

NEW! INTERFERENCE-FREE, 3-PHASE MOTOR STARTERS.

Use them anywhere—even on drive motors of peripheral computer equipment. That's what the new Control Pak, solid-state starters were designed for—with EMI and RFI levels so low they can't affect low level logic circuits. And you get a lot more—hundreds of millions of operations; arcless, bounceless switching; resistance to shock, vibration, moisture. For fhp and 2, 5, and 10 hp motors, 208/240 or 440 V, 3-phase. Control voltages: 5, 12, 24 or 48 V-DC; 24 V-AC or line voltage. Write Hamlin Electronics, Inc., Lake Mills, Wis. 53551. Or call (414) 648-2361.

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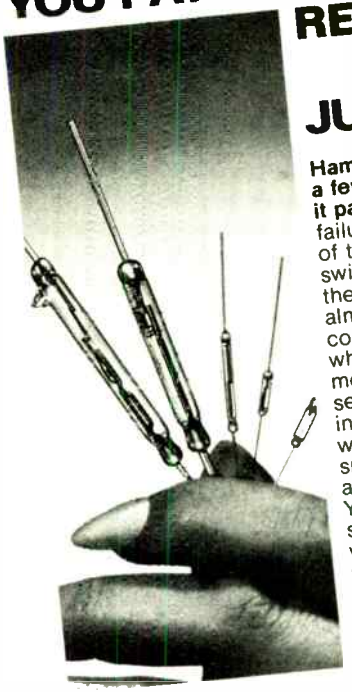

Hamlin reed switches cost a few pennies more. But it pays off. A reed switch failure can cost hundreds of times the price of the switch. Hamlin reduces the chance of failure to almost zero with rhodium contacts, assembly in white rooms, the industry's most effective hermetic seal, 100% electrical inspection—features that will make you glad you specified Hamlin even after millions of closures. You can choose from 2,000 switches—3/10 to 660 watt—and get Hamlin reliability in every one. And you pay for it only once. Write Hamlin, Inc., Lake Mills, Wis. 53551. Or call 414/648-2361.

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New books

The Successful Engineer-Manager, A Practical Guide to Management Skills for Engineers and Scientists, edited by Robert C. Haavind and Richard L. Turmail, Hayden Book Co., 166 pp., $8.95
This collection of articles covers six phases of managing: career, decisions, people, projects, finances, and communications. The articles are filled with practical advice, offering in one-two-three, how-to-do-it fashion information that can sometimes be more important than individual or even corporate performance. For example, the tips on politics and attitudes suggest that knowing "the rules of the game" is vital to "getting to the top." The sections on evaluating people and projects, and managing finances are aids to untangling administrative problems.

Recently Published

Electronics in Industry, George M. Chute & Robert D. Chute, McGraw-Hill Book Co., 619 pp., $13.95

Russian-English Dictionary of Electrotechnology and Applied Sciences, compiled by Paul Macura, Wiley-Interscience, 707 pp., $32.50

Analytical Techniques in the Theory of Guided Waves, R. Mittra and S. W. Lee, Macmillan, 302 pp., $10.95

Managing the EDP Function, Arnold E. Ditri, John C. Shaw, and William Atkins, McGraw-Hill Book Co., 228 pp., $14.95

Computer Analysis of Circuits, David J. Comer, International Textbook Co., 356 pp., $12.95

Fundamentals of Statistical Quality Control, Samson, Hart, Rubin, Addison Wesley Publishing Co., 144 pp., $5.95

Essentials of Electronics, Gershon J. Wheeler and Arley L. Tripp, Prentice-Hall, 436 pp., $17.35

Power Diode and Thyristor Circuits, Rex M. Davis, Cambridge University Press, 265 pp., $12.50

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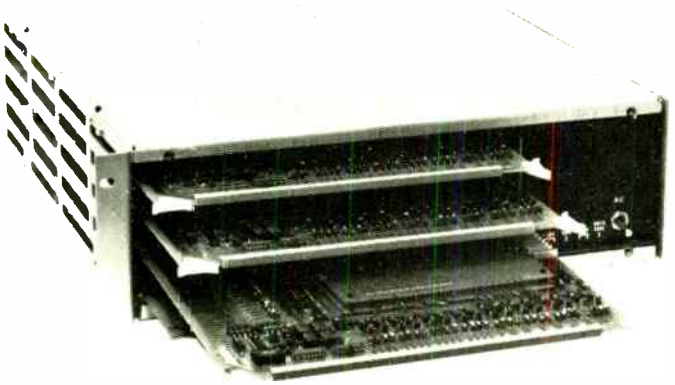

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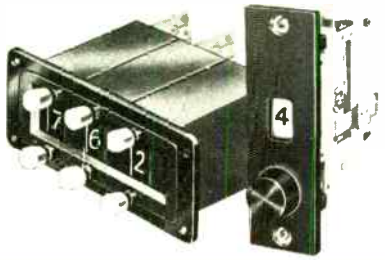
Miniature add/subtract units (left below) retrofit most minithumbwheel switch panel openings. Decades mount on ½-in. centers. Standard 10-position, 8- & 12-position on special order. Decimal, binary, and binary with complement outputs. Series PSB (at right in cut) binary and decimal rotary pushbutton switches are 10 & 12-position units; require but one inch panel space per module. All CDI pushbutton switches are fully sealed against hostile environments impervious to dust and liquids

THUMBWHEEL SWITCHES

CDI turns off hostile environment, turns on total protection—sealing both switching area and panel. Positive, long, trouble-free service operation is characteristic. PS Series (center in cut above) is available in digital and binary, meets MIL-S-22710. E.E. style bezels have no screws visible when mounted.

New Series TSM (at extreme right in cut above) mounts on ½-inch centers and retrofits most panel openings for miniature thumbwheel switches. It can be furnished with decimal, binary, and binary with complement outputs, or specified code readout characters; is available with extended PC boards for additional component mountings; also features easily-read characters, positive detent, 10- & 12-position capability.

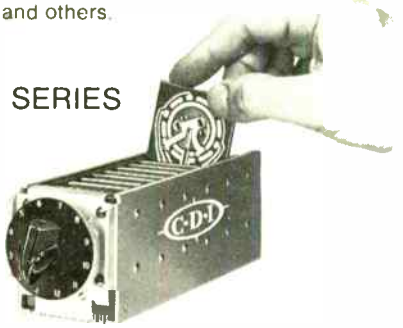


ROTARY SWITCHES

Cut maintenance requirements to seconds—where it might otherwise take days. No unsoldering, no disassembly, no wire removal! RS series in lengths up to 36 wafers; manual, solenoid, or motor operation; up to 32-positions; sizes 2", 3", or 4" square. Change programs, configurations, circuits quickly. These units meet MIL-S-22710. Tabet Pat. 2,841,-660 and others.

Snap-in, snap-out modules in seconds.

RS SERIES



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Precision Products Division
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Circle 165 on reader service card

New literature

Distortion analyzer. Communications Technology Inc., a division of Computest Corp., 1900 York Rd., Timonium, Md. 21093. A six-page brochure describes types of distortion in high-speed data transmission and how it is displayed on the screen of the company's model DTS-531. Circle 421 on reader service card.

Microprograming. Microdata Corp., 644 E. Young St., Santa Ana, Calif. 92705, has published a 352-page handbook detailing how to microprogram, why it is effective, and when it is most appropriate.

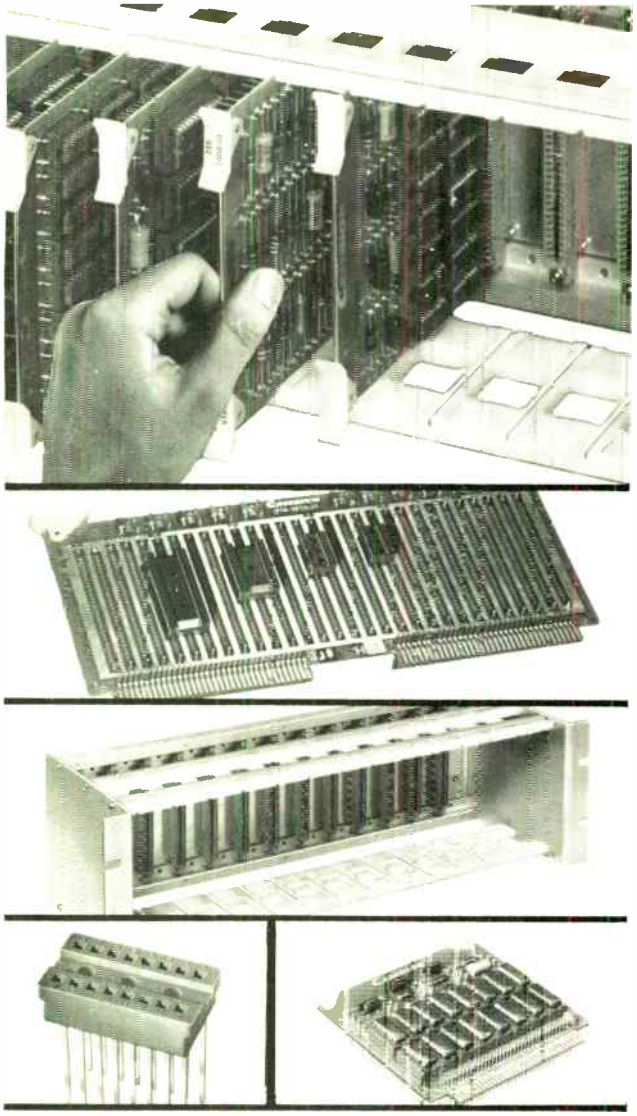
Circuit protection devices. Airpax Electronics, P.O. Box 8488, Fort Lauderdale, Fla. 33310. A 20-page journal for engineers who select circuit protection devices gives design parameters for a variety of applications. [422]

Terminal blocks. Curtis Development & Manufacturing Co., 3250 N. 33rd St., Milwaukee, Wis. 53216, has available a 24-page terminal block selector guide, designated Catalog 571. Included are illustrations, specifications, dimensional drawings, and prices. [423]

Semiconductors. General Instrument Corp., 600 W. John St., Hicksville, N.Y. 11802. Silicon rectifiers, silicon bridge assemblies, MOS/FETs, silicon diodes, high-voltage assemblies, germanium diodes and transistors are described in a 24-page brochure. [424]

Spectrum analyzers. Federal Scientific Corp., a subsidiary of Elgin National Industries Inc., 615 W. 131st St., New York, N.Y. 10027, has published a six-page bulletin discussing the company's line of spectrum analyzers and the options available with each instrument. [425]

Multiplex package. Lynch Communications Systems, 695 Bryant St., San Francisco, Calif. 94107. The model B910B portable microwave multiplex package for emergency and temporary communications is described in a bulletin. [426]



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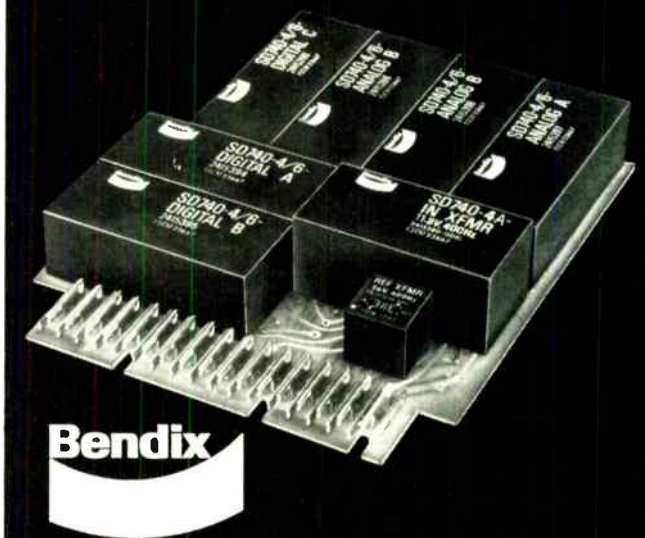
More information? Quotations on quantity sales? Contact: The Bendix Corporation, Environmental Science Division, Dept. 81, 1400 Taylor Ave., Baltimore, Maryland 21204.



Bendix

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Doric Scientific

An armadillo among the sheep.

International Newsletter

September 13, 1971

Display can function as a memory, too

Researchers at the University of St. Andrews in Scotland who developed zinc selenide light-emitting diodes [*Electronics*, Electronics International, June 7] now say that the devices also can function as memories. Two-terminal memory devices can be made from the Schottky barrier diodes by adding an insulating layer between the ZnSe and the gold layers. The devices have two distinctly separate conductivity states in forward bias, typically either 7 milliamperes or 70 microamperes at 1.5 volts. Raising the high-current state to, say, 10 mA switches the device to the low state; a reverse-bias pulse of about 10 V puts it back to the high state. **Switching time is about 100 nanoseconds.** While there's no visible light at low conductivity, there is a noticeable yellow-orange emission in high conductivity from about 7 mA up. Thus, the store can be read visibly as well as electrically, **but more important, the researchers believe, is the prospect of building a working display element with a reliable built-in memory.**

Liquid crystals may find new applications

Engineers at the Electrotechnical Laboratory of Japan's Ministry of International Trade and Industry have uncovered an effect that could make liquid crystals potentially low-cost sources of photodetectors and computer input devices. **The researchers have found that nematic liquid crystals used for displays generate a photovoltaic voltage when illuminated that's independent of the cell size and materials used.** Open-circuit output voltage is proportional to illumination to at least 500 lux, and typically runs to about 500 millivolts at that illumination level.

The researchers have applied to have their work included as part of the Japanese government's large-scale project for developing an information-processing system for the '80s (see Electronics International). There, alphanumeric or graphic information for effecting man-to-machine communications could be written into a liquid crystal matrix with a light pen—**in effect, it would be a low-cost version of Nippon Electric's Holotablet** [*Electronics,* Electronics International, July 19].

Laser communications experiment dropped by French group

Experimenters at France's Centre National d'Etudes de Telecommunications have dropped work on laser transmissions conducted at the Lanion facility in Brittany. The reason: **the results would have been of little use in urban areas,** where the soot, dust and noxious gas conditions aren't at all like the salt-air ambience in Brittany. Also, **officials of the French telephone network feel they can cover the nation's transmission needs through 1980 by adding high-capacity millimeter waveguides to the current cable and microwave links.** The Lanion people now are shifting to fiber optics for short transmissions and possibly for intracomputer links.

Japanese firms pick Germany as target for European drive

To offset potentially heavy losses in U.S. consumer markets in the wake of the 10% import surcharge, Japanese electronics companies are sharply stepping up their sales drives in Europe, and have apparently picked West Germany as the prime target. **Evidence surfaced at the recent Berlin radio and television exhibition, where Japanese consumer elec-**

tronics makers showed up in unprecedented numbers.

Spearheading the drive is Sony, which will introduce a new video cassette system in Europe late next year. Designed for playback of programs on either color or black-and-white sets, the system is intended primarily as an educational aid; initial price will be about $1,300. The ¾-inch cassettes with 60 minutes worth of programs will sell for $30. Another product Sony is banking on is a 12-inch portable TV set using a Trinitron tube. Already being marketed in limited quantities in England, France, and Switzerland, the set is likely to hit the German market early next year. No prices have been set yet, but industry observers believe it will sell for less than $400 in Germany. **Sony started activities in West Germany less than a year ago and expects 1971 sales in that country to reach $7 million.**

Japanese set to lay world's biggest submarine cable...

Nippon Telegraph and Telephone Public Corp. this month expects to lay a submarine cable whose 2,700-telephone-channel capacity reportedly is the highest in the world. It is expected to be put into operation by the end of the year. Transmission bandwidth is 36 megahertz and repeaters are spaced approximately 2.6 kilometers apart. Total length is 31 kilometers across the inland sea between the islands of Honshu and Shikoku. It parallels a 4-gigahertz microwave route that has four systems of 960 of channels each. **In addition to meeting new capacity demands, NT&T is laying the cable to obtain increased reliability by having parallel wire and wireless routes, so that communications would not be cut off in case of a disaster.**

...as Sweden plans highest-capacity telephone cables

Meanwhile, what's said to be the world's highest-capacity cable-based telephone transmission system soon will be put into operation in Sweden. The system, jointly conceived by West Germany's Siemens AG and Swedish telecommunications authorities, **has a capacity of 10,800 voice channels per coaxial pair and uses Siemens-made 60-megahertz broadband amplifiers along the link.** These amplifiers, installed underground at intervals of about one mile, are remotely controlled via the cables' inner conductors.

Calculator prices set to drop again in Japan

The stage is set for another round of price cuts in electronic calculators, starting with Casio Computer Co. Ltd., **which started production of an eight-digit, no-memory calculator that industry sources estimate could sell in Japan for as little as $120.** The calculator is built around a single-package IC array developed by Hitachi Ltd. Functionally, this array is very similar to the single-chip calculator IC built by Texas Instruments, but two chips are used in Hitachi's single package rather than the one chip in TI's. Hitachi engineers say that the two-chip design gives them much higher yield and also enables them to build circuits on a smaller total area of silicon. They use multilayer wiring to interconnect the two chips in the ceramic package.

Meanwhile, Hitachi and TI are said to be talking with almost every calculator company in the business to sell such arrays for eight-digit no-memory calculators. Price quoted for TI arrays is $12 to $15 in Japan, depending on quantity. Hitachi will not reveal its prices but says they are competitive.

Japanese launch $97 million study for '80s computers

8-year project focuses on pattern information, parallel data processing, associative memories, adaptive approach

The Japanese government plans to invest more than $97 million in an eight-year project that it hopes will prepare its computer manufacturers for the information processing systems of the 1980s. That's the word from the Electrotechnical Laboratory of the Ministry of International Trade and Industry, which will coordinate basic research of its own and industry R&D to develop a system capable of rapidly processing large amounts of pattern information. Parallel processing functions and associative memories, together with adaptive capabilities, will be extensively used in the system.

This new project differs fundamentally in several ways from the large-scale computer project rapidly nearing completion [*Electronics*, May 24, p. 42]. The earlier project's goals were defined in terms of machine capability in handling numbers—primarily cycle time in nanoseconds and mainframe memory capacity in bytes. The new project, however, is specified mainly in functional capability of input devices to handle pattern information.

There are several reasons for the new project. Officials believe it makes little sense to keep building bigger and faster computers while still requiring key-punching of information to get it into the computers. An equally important reason is that IBM has completed development of its 3.5 series and is developing pattern recognition information processing systems for the '80s.

The basic goals of the new project include direct acceptance of pattern information inputs, including written characters, graphical information, shapes of objects, and voice information. New data techniques, including parallel processing and association, will be used to the greatest extent possible.

Concrete goals include the recognition of 2,000 separate printed characters, including Chinese symbols, as well as about 100 hand-written characters. For graphical processing, the computer must be able to distinguish shade of darkness, color, grain, or texture, and should also be able to process abstract patterns. Object recognition includes the ability to distinguish a multifaceted object placed in a somewhat complex background, and to recognize simple curved objects. For voice recognition, the goal is the ability to distinguish 200 different spoken sounds when separated from adjacent phrases by a pause. Another goal is to recognize the configuration and meaning of simple sentences.

Basic studies. The first phase of the project, from fiscal 1971 through 1974, includes most of the basic research. It involves development of information-processing methods for the new functions, including recognition of characters, graphics, objects, and speech, as well as generating new processing methods for parallel processing and associative processing. Other tasks include development of methods of processing natural speech and of basic common software. Some system simulation also will be performed. Estimated budget for this phase is $14 million.

The second phase, extending from fiscal 1973 through 1976, will include simulation, design, and fabrication of individual recognition devices for characters, graphics, objects, and speech. Also, the entire system will be simulated and a hardware model built. Budget for this phase is about $28 million.

The final phase of the project will extend from 1974 through 1978. It includes design, fabrication, and testing of the overall prototype system, and evaluation in detail. Estimated budget is $56 million.

For development of pattern-information processing, a large-scale system, to be called Epics-1, will be assembled around a commercial-type computer. For the first year of the project, preliminary research contracts have been given to 10 Japanese manufacturers.

Japan

Digiplex stuffs more data into submarine cables

Because of the high cost of international communications circuits, work on increasing their information-carrying capacity and channel efficiency goes on unceasingly at the research and development laboratory of Kokusai Denshin Denwa Co., Japan's overseas cable and

communications system.

About five years ago, the laboratory completed development of a system it calls "rectiplex," which can transmit up to 108 50-baud teletype signals on a single voice-grade, submarine-cable telephone channel [*Electronics*, Dec. 12, 1966, pp. 51 and 154]. This rate is almost five times the transmission capacity of 22 Teletype signals usually transmitted by frequency-division multiplex on the same voice-grade channel.

Two systems of this type were built by Fujitsu Ltd. and went into service in 1968 between Tokyo and San Francisco. But high rectiplex terminal costs meant further R&D was necessary. Even before the commercial rectiplex systems were installed, work had started at KDD on a newer system, "digiplex," which has less expensive and smaller terminal equipment but can transmit almost twice as many Teletype signals as rectiplex.

Transpacific field tests of the digiplex communications system are scheduled for 1973.

Both rectiplex and digiplex use multiple phase modulation of multiple carriers in the voice band, with amplitude modulation imposed in digiplex to give added capacity. In rectiplex, analog circuits used for modulation and demodulation of each of its 18 carriers make for both high cost and bulky equipment. Each carrier requires one modulator and four demodulator circuits.

The digiplex system uses time-shared digital circuits to achieve a twofold improvement in the cost-performance ratio. The digiplex digital circuits also fit into two equipment bays rather than the nine bays needed for the rectiplex equipment.

What's more, standard digital integrated circuits can be used, and fabrication can be done almost completely by production personnel with almost no adjustment by engineers.

Where rectiplex uses a separate modulator for each tone and four demodulators for each tone, Digiplex uses a single common time-shared modulator and a single common time-shared demodulator for all 26 tones.

Rectiplex modulates incoming information onto 18 carrier frequencies transmitted in the 3-kilohertz bandwidth of the submarine-cable voice circuit. Two separate forms of multiplexing modulate each of 18 carriers with six independent Teletype signals to transmit a total of 108 teletype signals.

First the signals are brought together in pairs by a time-division multiplex circuit that also synchronizes the signals. The incoming signals arrive on 50-baud lines and the multiplexer interweaves two alternately into one 96-baud signal. It is able to squeeze them in by discarding a rather unimportant part of the information. The original signal requires 7.5 time units. It has a start element and five information elements of one-unit time length and a stop element of 1½ units. In the 90-baud signal, the final ½ unit of the stop element is discarded by the system.

Three 96-baud signals are phase modulated onto a single carrier. Since three independent binary signals can have eight different combinations of values, eight-phase modulation is used. Differential phase modulation—in which phase reference is the phase of the preceding element transmitted, rather than an absolute phase—is used to ensure rapid system recovery in case of disturbance.

By contrast, in digiplex, the two incoming 50-baud data signals are squeezed into one signal of 82 2/7 baud after multiplexing by completely eliminating the stop elements from the transmitted signal. This, and tighter carrier spacing, permits 26 carriers within the 3-kHz band, rather than the 18 used in rectiplex.

To transmit even more information, a fourth signal is amplitude modulated onto each carrier. This compound modulation scheme is superior to the more obvious method of using 16-phase modulation, because the same error rate can be obtained with a signal-to-noise ratio that is lower by 2.7 decibels.

International

Networking dominates data processing congress

There's a growing awareness on the part of international computer experts that the key to more efficient use of computer resources lies in nationwide data communications networks. That trend was strongly in evidence at the fourth International Federation for Information Processing Congress held in Ljubljana, Yugoslavia, last month. Although the consensus was that such systems aren't just around the corner, there was widespread agreement that the concept is inevitable.

The conference provided a forum for information about new approaches to systems applications and new concepts in terminal development and hardware designs. The West Germans told of a highly reliable computer-based data-switching network; the British described a simple data entry device that promises to broaden computer use considerably, and an American team revealed new ideas on voice input facilities.

As part of West Germany's national effort in computer-controlled data transmission networks, Siemens AG developed its electronic data switching system, which was described at the meeting. A prototype system, recently tested on an experimental link connected to equipment at post office research labs at Darmstadt, will be hooked into the public network by 1972 or 1973 for further trials. A second prototype is set for delivery to the post office by the end of this year.

The key components in the EDS are memories and problem-oriented processing units specifically designed for switching functions. Consisting of up to 16 memory banks, each with a capacity of 64 kilobytes, the memory units store data and programs, handle requests from processing units, and keep tabs on them. Trunk and subscriber lines are connected to the system via terminal equipment that uses asynch-

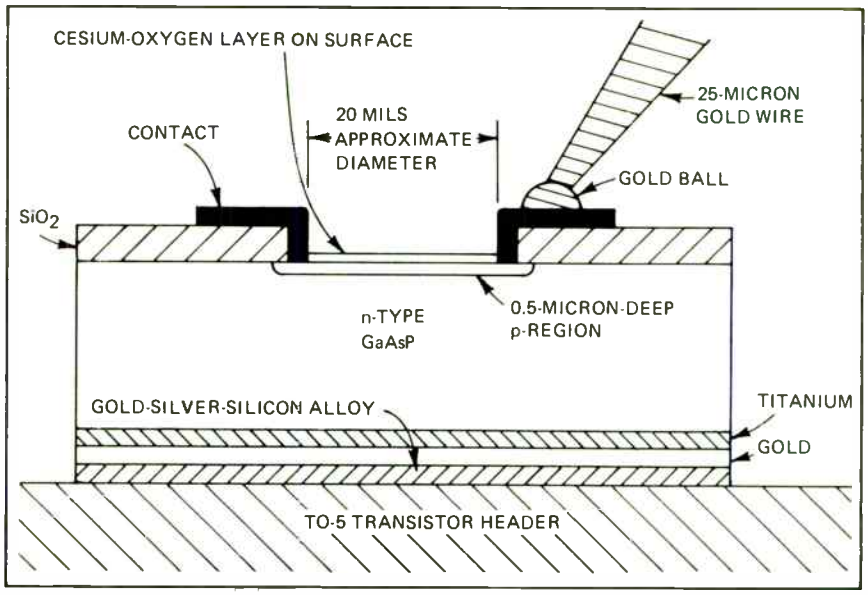
ronous time-division multiplex techniques for low and medium bit rates, and space-division multiplex for high bit rates.

Also discussed at the Ljubljana meeting were advances in computer terminal design. In their quest for a simple, low-cost data input system usable by the general public, researchers at Britain's National Physical Laboratory have developed a graphical input table for entering data into a computer. Called CHIT—for cheap input tablet—the device can be used with any writing stylus that doesn't need mechanical or electrical connections.

Basically, the CHIT system consists of a flexible membrane installed above a solid surface. Both membrane and surface have a uniform resistivity so that the potential alternately applied across opposite edges of either produces a linear voltage gradient. Under stylus pressure the membrane is deformed so that contact is made at a specific point with the lower surface. If the polarization of this surface is from right to left across its length, the membrane takes on a potential corresponding to the horizontal position of the stylus. Likewise, when the membrane is polarized from bottom to top across its length, the surface potential indicates vertical stylus position.

From the U.S., progress with voice input systems was detailed in a paper by specialists from IBM's T.J. Watson Research Center. IBM is working on a voice input system for digital computers that uses only a modest amount of special-purpose hardware. It's a variation on the filter bank approach, which calls for substantial amounts of special speech-processing hardware, and the microphone converter scheme which needs a significant amount of computer resources.

Designed for computer graphs applications, the IBM system uses a discrete word recognizer with a 33-word vocabulary. The immediate goal is to investigate the possibility of replacing the program function keyboard of the IBM 2250 display unit with such a voice-control facility.



Emitter profile. Cathode provides a narrow and uniform electron energy spread.

Great Britain

GaAsP emitter helps to cut tube beam-discharge lag

The lag problem that afflicts all low-light-level camera tubes is usually attacked from the target end, on the assumption that the cathode is a fixture. But two Britons have made some progress towards a cathode they believe will lessen beam-discharge lag.

The fundamental drawback of the conventional thermonic cathode is the exponential distribution of energy in its beam: the high end of its energy spread contains very few electrons. At low light levels, the charge on the target is so small that only the highest-energy electrons can get through the retarding field to discharge it, and because there are so few of them, often the discharge is not completed, and lag occurs. Peter Deasley of English Electric Valve Co. Ltd. and Ken Faulkner of General Electric Co.'s Hirst Research Center argue that if the energy spread is narrower and more uniform—thus with a sharp cutoff at the top end—more electrons of the right energy level will be available to discharge any target charge level—lag will be reduced. Supported by the Ministry of Defense (Navy), they've built a gallium-arsenide-phosphide emitter that partly meets this requirement, though its energy spread doesn't yet have the factor-of-two improvement over thermionic cathodes that they are looking for.

The new cathode was described this week by Deasley at a symposium on photoelectronic imaging devices at London's Imperial College. The electrons are injected across a forward biased p-n junction near the surface of the device. A p region not more than 1 micron deep is formed in the surface on n-type GaAsP. If the p region is deeper than that, the electrons crossing the junction will recombine before they reach the surface, and there will be no emissions. In the p region the electrons quickly come into equilibrium close to the bottom of the conduction band. They have a normal thermal electron energy distribution that is very narrow, not more than a few tens of milli-electron volts.

By putting a very thin layer of cesium-oxygen on the region's surface, the researchers bring the energy level at the surface below the bottom of the conduction band so that the electrons reaching the surface have enough energy to escape. Hence electron emission is over a narrow energy spread.

Deasley says he preferred GaAsp

to silicon because he needed a band gap wide enough to make uniform, stable emission possible, even though he also needed to fabricate a high-quality, shallow junction which would have been easier with silicon. In fact, Faulkner found that 120 minutes of zinc diffusion at 700°C by the closed tube process produced a good junction about a half-micron deep. The cathode is about 20 mils in diameter and is electroluminescent. Light distribution is uniform, indicating that injection across the junction is also uniform, and suggesting that electron emission at the surface is uniform as well.

Deasley reports that the 20-mil-diameter device gives an emission current density equal to about 1 milliampere per square centimeter, with an efficiency of about 0.01%, and that emission falls off sharply for about 10 minutes, after which some devices have been stable for more than 100 hours. He believes these figures can be improved by at least an order of magnitude. Energy spread is reduced by about 30% less than that of a thermionic cathode, which he regards as encouraging.

Simple dc technique checks MOS unit's impurity profile

Users of semiconductors ordinarily think only in terms of p and n regions, but makers of the devices have to go a step further and determine how the p and n dopants are distributed—what the impurity profiles look like. At least two instruments—one American, one British—have been produced for gauging the uniformity of the profile in bulk material. But Mullard's Research Laboratories has devised a nondestructive method of gauging it in the device. It measures in absolute terms the profile in the substrate region under an MOS transistor gate.

The Mullard researcher, John Shannon, says his method of MOS profiling is a simple dc technique that will be useful for checking the performance of any transistor in a completed IC chip without harming it, and for design research. He was scheduled to describe the method this week at the Solid State Devices Conference at Lancaster University.

Like other methods, the technique depends on producing a capacitance-voltage curve for the space-charge region under the gate. The impurity profile is calculated from this curve with the aid of equations similar to those used in defining an abrupt, asymmetrical p-n junction. To obtain the capacitance-voltage curve, a small potential—about 10 millivolts—is applied at room temperature between source and drain so that a small current flows. Then the substrate bias is changed by a small amount, and the change in gate voltage necessary to keep the source-drain current constant is measured.

When this constant change level has been reached for a given substrate bias, the ratio of the change in gate voltage to the change in substrate voltage multiplied by the oxide capacitance gives the space-charge capacitance, which is inversely proportional to the depth of the space-charge region. The oxide capacitance is a constant that is dependent on the oxide thickness.

The reciprocal of the square of the space-charge capacitance, plotted against voltage, provides one point on the capacitance voltage curve. A full curve needs at least a dozen points. At any given depth, indicated by the capacitance value, the doping concentration will be proportional to the slope of the curve.

France

GaAs diode matrix handles graphics like radar display

The cathode ray tube, though presently the favorite device for displaying waveforms or showing images remotely, has its drawbacks: it's relatively fragile, it needs high operating voltages, and it's bulky. None of these drawbacks is characteristic of matrix screen displays; but they have their own shortcomings, notably low light levels, relatively poor definition and —if you want to show changing waveforms—complicated and costly drive circuits. The last shortcoming shouldn't exist for too long. A trio of French researchers has developed a matrix display that can handle waveforms and other changing graphics like radar presentations.

At the moment, the technique is limited to matrices with relatively few elements. "We're working with Sintra on a 32-by-32 radar display," says Marcel Vogelsberger, who's in charge of the research laboratories of L'Equipement et la Construction Electrique. Assisting Vogelsberger on the display are Grilles Batailler, the director of the luminescence laboratory at the University of Poitiers, and Rene Tran of ECE.

The three have checked out their theory on a seven-row-by-15-column gallium arsenide array. The trick, of course, is to switch on the right element at the right time. In other words, each element in the matrix has a time associated with it because of the scan, so the amplitude of the waveform being displayed must be converted into an equivalent time. To do this, Vogelsberger and his co-workers use a seven-step voltage ramp—actually, a digital-to-analog converter—that converts the output of a clock-controlled binary counter into discrete voltage levels, stepping up a level each time the counter pulses.

The input signal and ramp voltage are compared in an amplifier. When they match, there's an output to a monostable multivibrator. This switches on a constant-current generator that powers the matrix for the duration of one step of the ramp.

Along with the d-a converter, the binary counter controls the switching of the scan along the rows through a decoder and an interface. The scan for the columns, too, is tied to the same binary counter. Every eighth pulse for the row decoder pulses a second binary counter that controls the switching from column to column. Since all three signals—amplitude ramp, row switch, and column switch—are synchronized, the right matrix elements go on at the right times.

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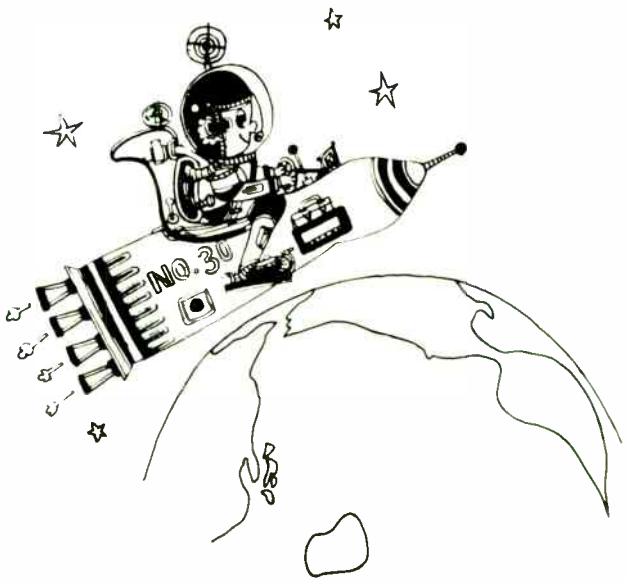

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YCM-8E (ALNICO-8)	7,500- 8,500	2,000-2,150	5.5- 7.0
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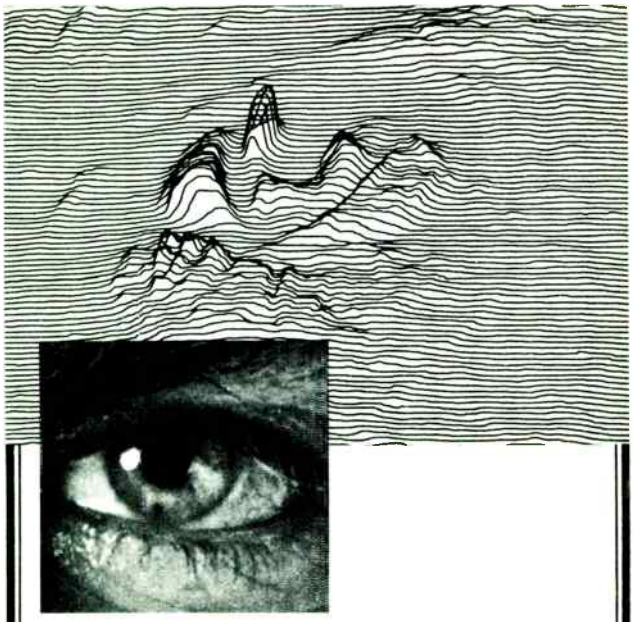

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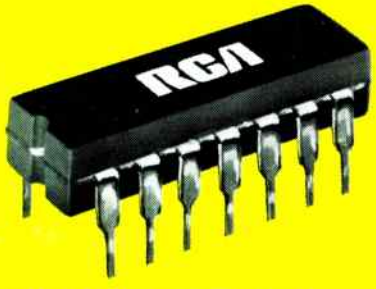

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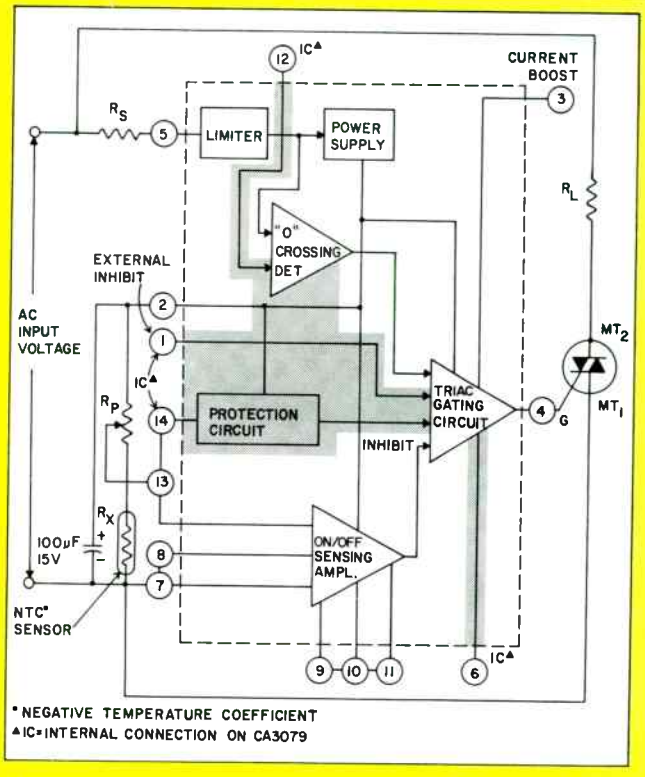

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