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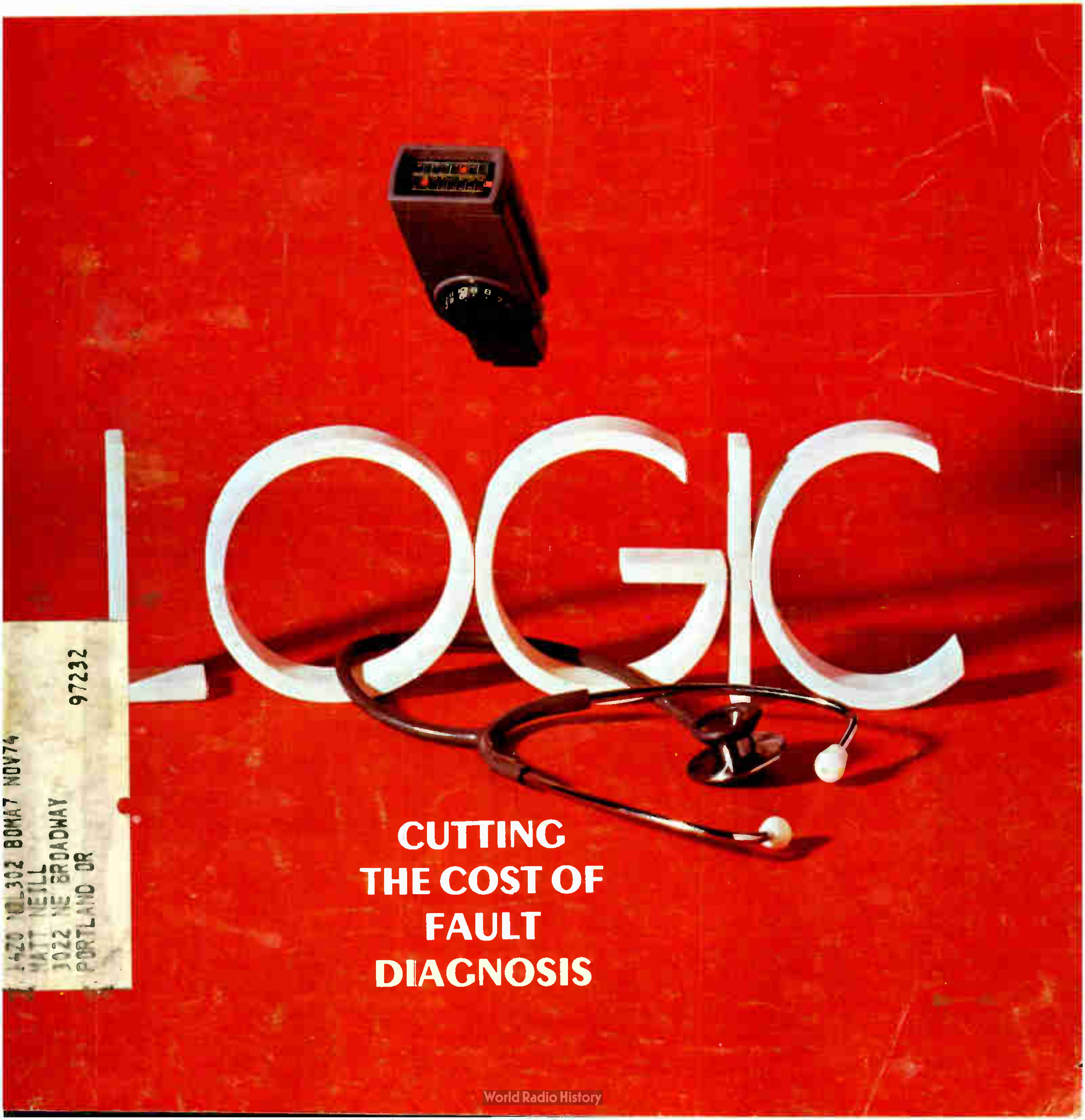

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10V-250A	1,200	1,400
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20V-125A	1,050	1,200
20V-250A	1,275	1,500
20V-500A	2,050	2,650
30V-100A	1,050	1,200
30V-200A	1,450	1,800
40V-60A	950	1,100

	Price	
Rating	EM	SCR
40V-125A	$1,300	$1,600
40V-250A	1,975	2,500
50V-200A	1,975	2,500
80V-30A	950	1,110
80V-60A	1,200	1,500
100V-100A	1,975	2,500
120V-20A	975	1,300
120V-40A	1,200	1,500

	Price	
Rating	EM	SCR
160V-15A	$ 950	$1,100
160V-30A	1,300	1,600
160V-60A	1,975	2,500
250V-10A	950	1,100
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250V-40A	1,975	2,500
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500V-10A	1,600	2,000

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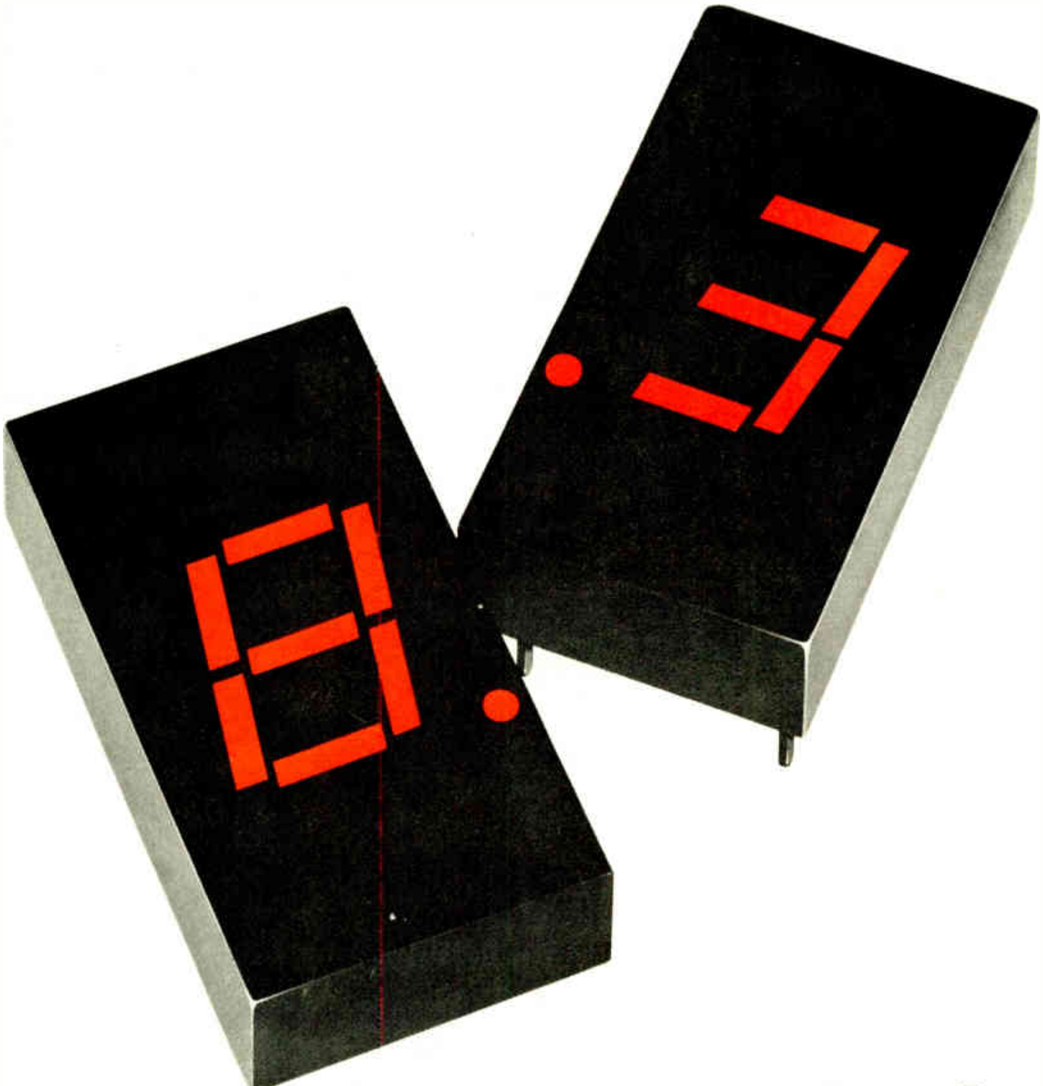

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Electronics
The International Magazine of Electronics Technology
Vol. 46, No. 23 • November 8, 1973

Highlights

The cover: Fast diagnosis of logic faults, 89
The user of a handheld logic tester need run through a troubleshooting procedure only once to uncover any faults in a digital-IC board. The instrument is a combination logic probe, logic clip, and IC comparator.

Declining R&D seen as threat to U.S. trade, 79
Expenditures for research and development in electronics and four other technology-intensive industries dropped 25% between 1964 and 1970, says a National Science Foundation report. This drop probably contributed to present trade imbalances, and the simultaneous decline in basic research also threatens electronics' long-term growth.

How to beat heat, 98
As active elements crowd closer on chips and IC packages crowd closer on boards, preventing electronic equipment from overheating becomes a major headache for designers. Part 1 of this new series on thermal design outlines the general problem, and Part 2 (p. 102) suggests specific solutions in the case of plastic-packaged power ICs.

A bigger memory for better addresses, 107
A 32-bit word length, double the minicomputer norm, gives a new minicomputer unusually easy access to its unusually large, million-word memory.

And in the next issue . . .
Annual report on the Japan market . . . IC modules for acquiring and transmitting industrial control data . . . computerized multipoint temperature measurement: Part 7 of the "Minicomputers in action" series.

Electronics

Publisher's letter

Heat is the inevitable result of pushing electrons through electronic circuitry. And thermal design, inevitably, is gaining more attention from electronics engineers. That's especially true with large-scale integration. As more and more devices are packed into a given area, more and more heat has to be pulled out.

On page 98, you'll find the first part of our new series on thermal-design considerations by Packaging and Production Editor Stephen E. Grossman. On page 102, we follow up with the second part, which covers thermal aspects in the design of plastic power ICs. And there's more to come in future issues.

As Grossman points out: "Poor thermal design at the least reduces lifetime, undermines reliability, and degrades system performance. At worst, it can cause catastrophic failure." We feel that our series will step up the flow of data in this increasingly critical design area—thermal management.

Electronics managers and engineers will find both good news and bad from Washington in this issue, most of it reported by Senior Editor Ray Connolly, our bureau manager there, following a day-long session with H. Guyford Stever, director of the National Science Foundation, his staff, and the 25 industry leaders he assembled in the capital. The subject was U.S. science and technology policy—particularly as it relates to research and development in such high-technology industries as electronics.

The good news was that NSF is showing greater interest in industry's needs and has put together the first comprehensive collection of data on the state of engineering and scientific R&D in the U.S., comparing it with the rest of the industrialized world.

The bad news is that NSF indicators show that U.S. electronics and other technologies have lost substantial ground in the world's R&D competition. Connolly not only looks at the numbers and trends and their meaning for electronics (p.79), but he explores another set of NSF data on the growth of domestic R&D markets, beginning on page 36.

He also offers some words of his own in the Washington Commentary on a related and somewhat more divisive industry issue—the consequences of increasing sales of U.S. technological know-how to potential competitors abroad (p. 50).

A fourth Connolly contribution to this issue—a look at the widening U.S. electronics trade deficit (p.31)—tends to support his saddened view that "stories about technology and stories about politics today in Washington seem increasingly to share a common feature: unfortunately most of the news is bad."

Copies of the special October 25 report—The Great Takeover—are available at $2 per copy. Write to Electronics Reprint Department, Box 669, Hightstown, N. J. 08520.

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Readers comment

Bias against blackness?

To the Editor: I found "Engineering schools court minorities" [*Electronics*, Aug. 30, p.67] quite interesting, but in the three years I have been reading your magazine, I have yet to see you take an editorial stand on any social issue. Too bad.

I am black and am writing my thesis for an MS in bioengineering (EE background) while working in a temporary non-engineering position for the Federal Government. I have also fulfilled the requirements for a degree as an educational specialist in engineering, qualifying me to teach basic engineering courses at the junior- or community-college level.

Although I have been applying for jobs since August 1971, my only interviews were with personnel people visiting while I was on campus. All my classmates—graduate, as well as undergraduate non-minority students—have received interview trips and job offers. I must have received more than 200 rejections, not counting companies that did not reply to my inquiries.

Perhaps it's my age (40), my being black, or some other unknown factor. However, the result has been and continues to be a very bitter experience.

I would suggest that schools encouraging minority students to become engineers also make them aware that they will be "showcase" personnel—if they get jobs—with very little chance of advancement into the upper echelons of management. They will also have to be better-than-average engineers.

William Anthony
Rockville, Md.

CATV casebook clarified

To the Editor: I would like to clarify a point or two about my Designer's Casebook, "CATV transistors function as low-distortion vhf preamplifiers," [*Electronics*, Oct. 11, p.105].

The two 10-microfarad electrolytic capacitors should be air-trimmer capacitors having a range of 2 to 10 picofarads. And the type BFR36 transistor, which is made by SGS-ATES for CATV applications, can operate over a frequency range of 40 to 860 megahertz.

The transistor can provide a power gain of 16 decibels at 200 MHz. Its collector-base breakdown voltage is 40 volts, its collector-emitter sustaining voltage is 30 V, and its dc collector current is 200 milliamperes. To date, no equivalent device made in the U.S. can be used as a direct substitute.

P. Antoniazzi
SGS-ATES Componenti Electtronici
Milan, Italy

Sonagram belongs to Kay

To the Editor: In "Doctors call for emphasis shift in design electronics for hospitals" [*Electronics*, Sept. 13, p.103], a picture has the description of a "M-mode sonagram."

The word Sonagram is a copyrighted trademark of Kay Elemetrics Corp. and should be used only to describe readouts printed on our Sona-Graph, also a trade name.

E. E. Crump
President
Kay Elemetrics Corp.
Pine Brook, N. J.

Counter inputs switched

To the Editor: There is a labeling error in the circuit diagram of my Designer's Casebook, "Digital clock/calendar offers dual-mode display," [*Electronics*, Sept. 13, p. 112]. The inputs noted as A_{IN} and BD_{IN} for the type 7490 decade counter should be reversed in both the clock and calendar sections of the circuit.

Gregory Baxes
BaKad Electronics
Mill Valley, Calif.

Pye owns Videophone

To the Editor: Pye Ltd., Cambridge, England, owns the Videophone trademark in the U. K. and in overseas territories; it is listed *inter alia* for use with television apparatus and parts thereof. In Electronics International [Aug. 30], this name was wrongly referred to in the generic sense without any indication that it is a trademark.

R. W. Walsby
Trade Mark Agent
London, England

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Circle 7 on reader service card

40 years ago

From the pages of Electronics, November, 1933

The new radio prosperity

The whole radio industry has been enjoying sudden prosperity. Set manufacturers have fallen far behind in their orders, and have been working their plants overtime.

Parts manufacturers in some cases have had to go on double and triple shifts. One plant has multiplied its payroll employees by six times, as compared with the number employed a year ago at this period.

Even for the radio engineer, the employment stringency has lightened somewhat, as manufacturers are building back their organizations, particularly on the production side.

There is no doubt about it, that for the present, at least, the whole radio production industry is bathed in the warm sunshine of prosperity and customer orders. Manufacturing activity is feverish, and once again the lights burn in radio plants long into the night.

But will it last? But is all this demand for radio sets and radio parts to be regarded as permanent? Will this unique revival of past prosperity last beyond the next month or two? Will manufacturing plants be speeded up and output multiplied, only to build up a tremendous overstock, which eventually will have to be liquidated, at tremendous losses, with "dumping" and destruction to retail businesses? Will January and February see a return of the disastrous practices of a few years ago?

There is plenty of evidence to be had that the radio industry is already accelerated to a pretty excessive pace. Surveys of retail dealers indicate that these front lines of radio selling have not felt the new sunshine and "new deal" in such poignant fullness as have the manufacturers who are shipping them the goods. The dealers' stocks have been sadly depleted this past year, and so they are just beginning to be replenished. These stocks are being built up, and customers are buying some sets and taking them away. But when equilibrium is established will depend upon external factors.

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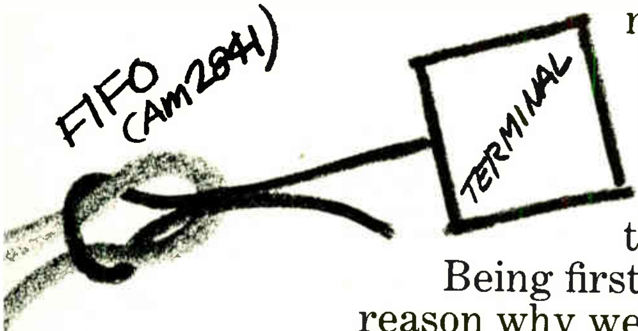

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While other systems are confined to either interactive or batch operation, DBOS-II offers a combination of both. Plus a comprehensive file management system, text editors, interactive debug routines, mathematical functions and commercial libraries. That explains our faster program implementation.

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GENERAL AUTOMATION

Circle 13 on reader service card

People

Strobe helped win medal for Edgerton

Medal winner. Harold Edgerton's creativity won him the National Medal of Science.

"Choose a new area; don't be impeded by others in a big area. Electronics is full of new things to do—the problem is to recognize what they are." This is the advice Dr. Harold E. Edgerton has given his students at the Massachusetts Institute of Technology. And likely it is this philosophy that last month won Edgerton, founder and honorary chairman of the board of EG&G Inc., the National Medal of Science.

The award commends him for "his vision and creativity in pioneering in the field of stroboscopic photography and for his many inventions of instruments for exploring the great depths of the ocean." But Edgerton, with characteristic modesty, says, "They must have gotten to the bottom of the barrel" in choosing him for the medal.

The 70-year-old engineer-scientist's studies of the transient oscillations of synchronous machines led him to develop the first stroboscope in 1931.

He and his students developed the circuitry, flash tubes, energy-storing capacitors, and other components that transformed stroboscopy from a scientific curiosity into an important tool. "I was lucky," Edgerton says, "to arrive when new technologies made strobe blossom." But he, more than anyone else, contributed to its bloom.

Among other things, Edgerton's recognition of the possibilities of the stroboscope led to the formation of EG&G Inc., formerly Edgerton, Germeshausen & Grier, to make strobes and related equipment. Although strobes continue in its product line, the company has diversified into a number of other technologies. Its sales are now more than $125 million a year.

Edgerton has worked in all phases of photography and cinematography, adapted strobes for night aerial photography, and designed electronic flashlamps and underwater cameras capable of operating at great ocean depths. He has developed instruments that depend on sound waves, rather than light, to explore the ocean floor.

Ostensibly retired now, Edgerton is using low-frequency sonar to look for the Monitor, the ironclad warship of Civil War fame. And he has visited Greece twice since 1960, helping archeologists look for two cities lost about 325 B.C. "These are good examples of things that are absolutely useless, but are difficult tasks—a challenge," he says.

As a teacher at MIT, Edgerton has stressed the importance of choosing small, new areas of study. "I like to teach by project," he says, "and I tell students to pick something useless; if it's useful, others will take over a project and put a lot of pressure on it."

Brougher is bullish on TI's calculators

When Texas Instruments Inc. decided to go into the consumer-calculator business, some industry insiders estimate that the company pumped 60% of its annual strategy funds into the effort. It has paid off so well that TI recently spun the activity out in a new division—the Calculator Products division. And its new head, TI vice president John Brougher, brings bullish projections to his new task.

Brougher pegs 1973 consumer-calculator sales for the U.S. alone at 7½ million units, with another 2 million projected for business and scientific calculators, including slide-rule types. "In 1974," he says, "we see the consumer calculator going above 10 million, and there will be

the New BUSS® SNAP-LOCK

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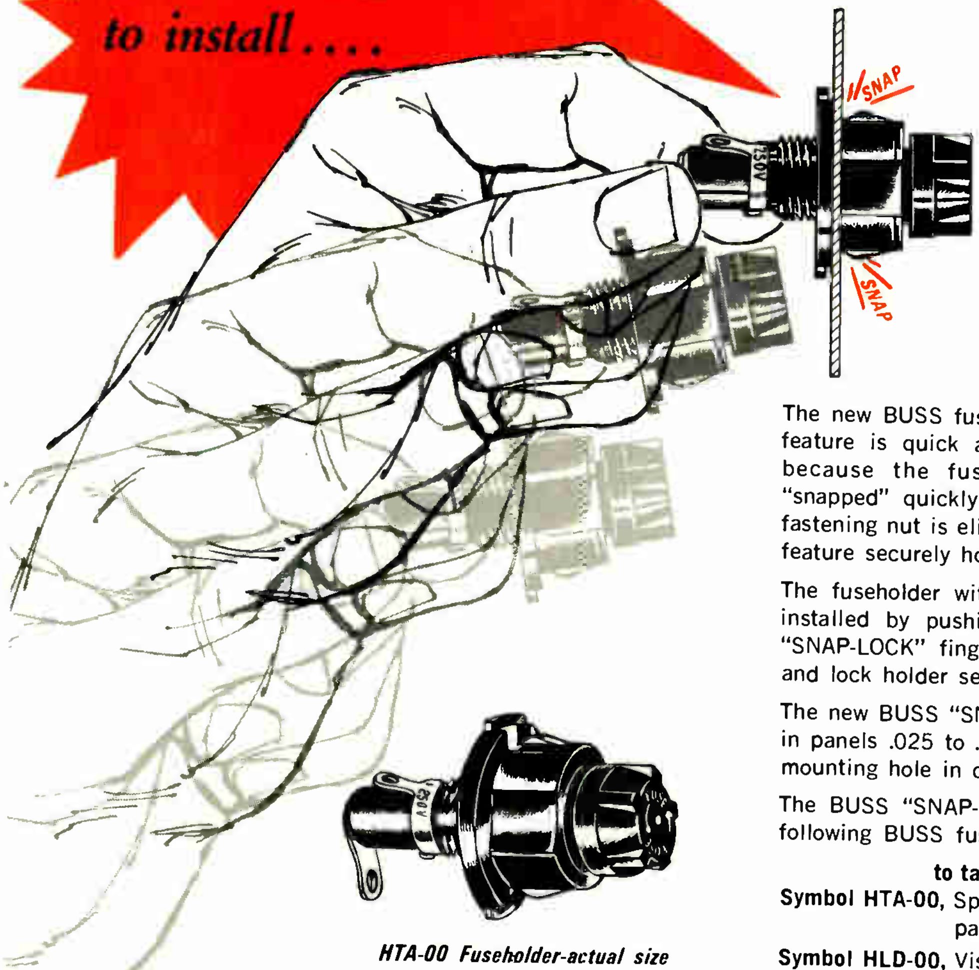


The new BUSS fuseholder with special "SNAP-LOCK" feature is quick and easy to install. It saves time because the fuseholder can be **pre-wired** and "snapped" quickly into place from rear of panel. A fastening nut is eliminated because the "SNAP-LOCK" feature securely holds the fuseholder in place.

The fuseholder with "SNAP-LOCK" feature is simply installed by pushing it into panel from rear side. "SNAP-LOCK" fingers engage edge of hole in panel and lock holder securely in place.

The new BUSS "SNAP-LOCK" fuseholder can be used in panels .025 to .085 inch thick. (See recommended mounting hole in dimensions below).

The BUSS "SNAP-LOCK" feature is available on the following BUSS fuseholders:

to take ¼x1¼ inch fuses:

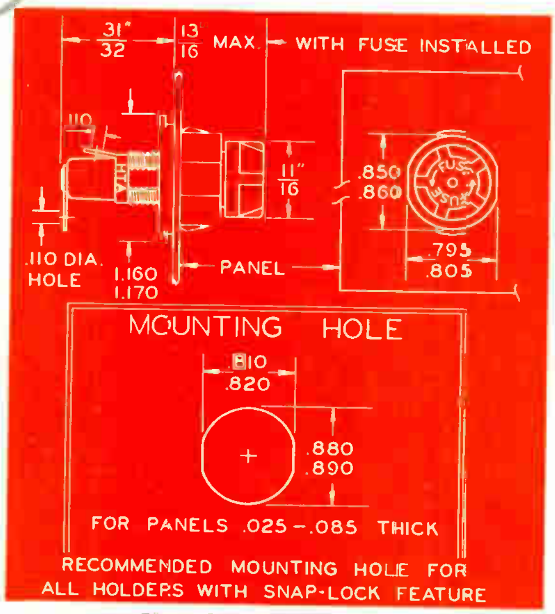
Symbol HTA-00, Space Saver, extends just 1 in. behind panel.
Symbol HLD-00, Visual Indicating Fuseholder.
Symbol HKP-00, Standard Fuseholder.

to take ¼x1 inch fuses:

Symbol HJM-00, Standard Fuseholder.

All are available with quick connect terminals, if so desired.

HTA-00 Fuseholder-actual size



Dimensions of HTA-00 holder
When tooling up for mounting get latest blueprint.

Also fits ½ in. knock-out in electrical boxes

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St. Louis, Mo. 63107
Makers of a full line of Electric Fuses

SUPPLIED THE ECONOMICAL WAY ...THRU DISTRIBUTORS
BUSS QUALITY FUSES

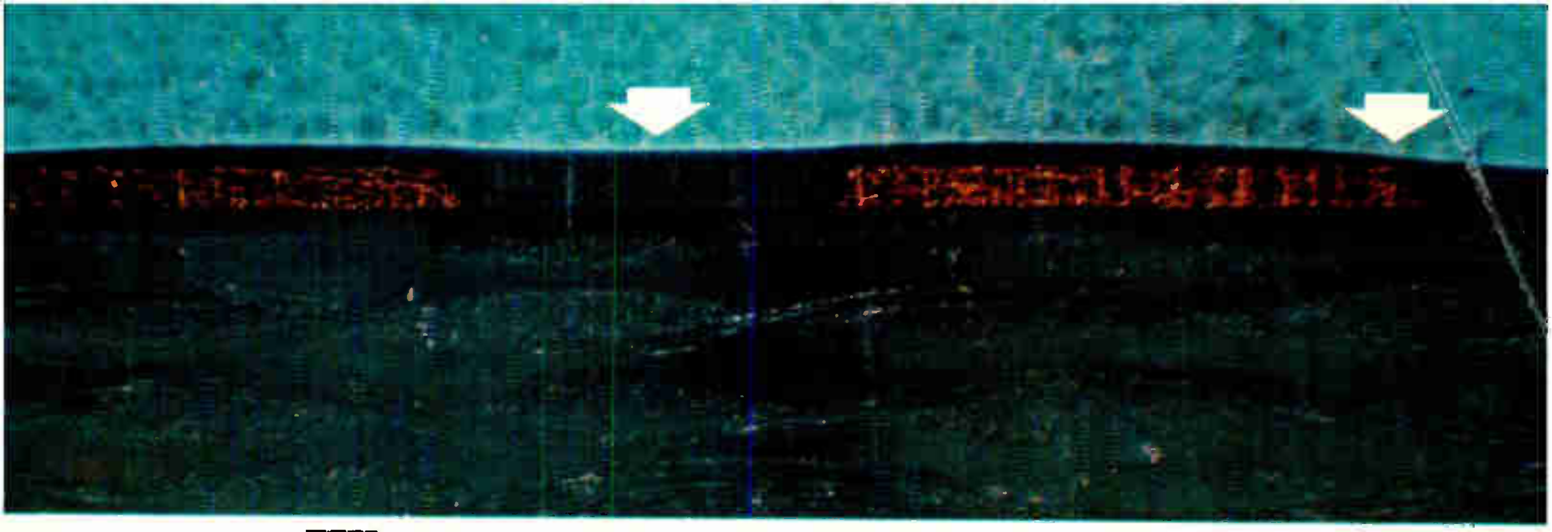
slightly less growth in the total business and scientific calculators combined." Brougher looks for quality consumer calculators selling for $20 or less by the end of next year.

Brougher has been with TI since 1955. He has been with the consumer-products effort from its inception as the Solid State Products division, serving as vice president and operations manager. He moved into his present post in late summer, when that division was split into the Calculator Products division and another activity, Business Development for Consumer Products.

Brougher sees no reason for the significant difference between the price of the low-power portable calculator and a transistor radio. He foresees several calculators per household, and he continues bullish when he says, "I think that there will be saturation in terms of the numbers, just as transistor radios have leveled off at about 26 or 27 million per year, but they continue to be sold."

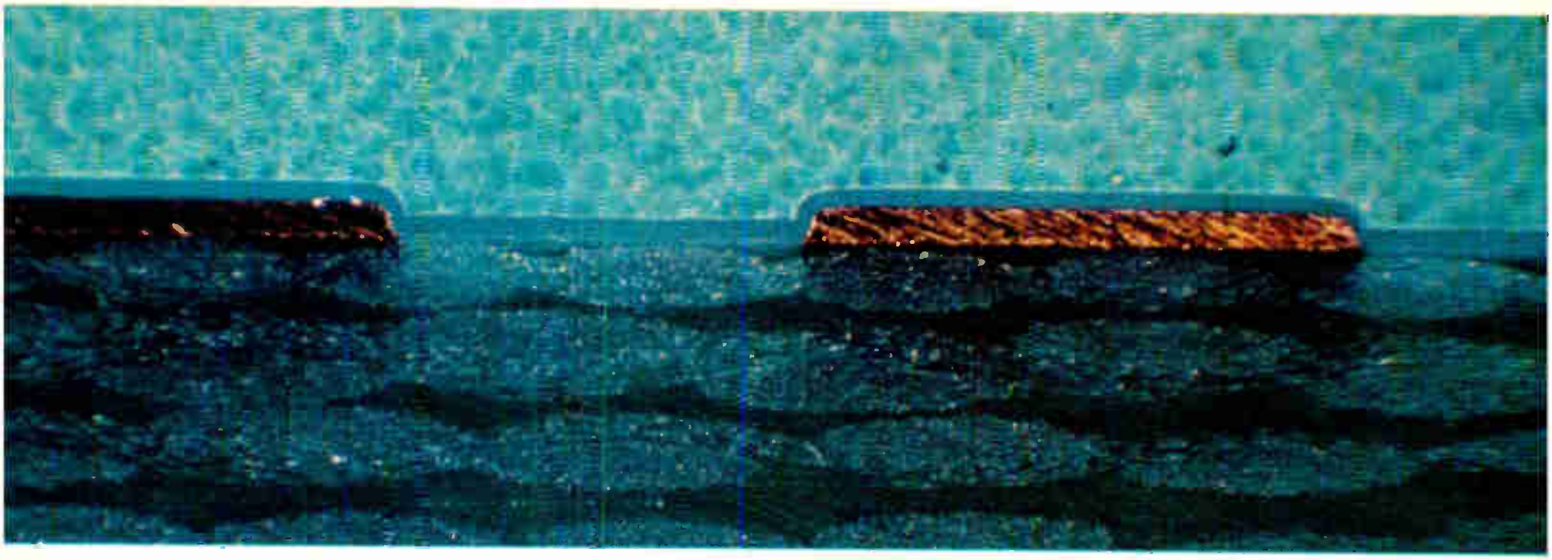
As for TI's plans, Brougher indicates that the pace set since 1972—introduction of one new machine every two or three months—will be maintained. "There will be several introductions between now and the end of the year," he adds. One of those will be a true office machine, a logical extension of a line begun by the TI-4000 desktop calculator with memory, he says, "and there will be additions to the line with increasing power, capability, and good, low prices."

Optimist? TI's John Brougher sees consumer calculator sales at 10 million in 1974.



When spray or dip coatings fail...

Parylene works.



You are looking at magnified cross-sectional views of copper conductors on a circuit board . . . and why parylene protection brings the highest reliability to electronic circuitry.

The spray-applied urethane coating (top photo) bridges the channel between conductors and offers scant protection at the edges. Urethane, silicone, epoxy . . . liquid coatings are uneven, and can produce potential failure points.

Parylene forms a thin and even coating, whatever the configuration, however complicated or delicate or densely populated. Without bridging. Without pinholes, voids, bubbles. We call it a conformal coating. From conformality comes reliability.

Parylene conformal coatings can be applied in precisely controlled thicknesses from 0.002 to 3 mils. *In one step.*

Parylene is applied at *room temperature.* No heat, no melting, no cure. No coating shrinkage. In other words, no discomfort for delicate components.

Parylene provides better barrier protection than urethanes, silicones or epoxies. It is extremely resistant to chemical attack, exceptionally low in trace metal contamination, and compatible with all electronic solvents. Dielectrics are excellent.

Parylene has qualified under the stringent requirements of MIL-I-46058C; it does so with a 0.6 mil coating—parylene excels in the micro-electronic virtue of thinness.

Parylene conformal coatings have shown excellent cost effectiveness in many applications. On delicate, sophisticated and complex circuitry, in hybrid circuits and components, they may be the most cost effective answer for long term reliability.

Union Carbide invented the parylene system. The method is gas phase deposition, which is the only route to the reliability of conformal protection. Various patents apply; commercial use of the patented technology is licensed.

You can get complete information on parylene by writing for our 16-page brochure: Union Carbide Corp., 270 Park Ave., Dept. RB36, New York, N.Y. 10017. Further investigation will no doubt indicate a trial run which we can perform at reasonable cost. If you would like to discuss that or any other related matters, please call Bill Loeb at (212) 551-6071.

UNION CARBIDE PARYLENE

Circle 17 on reader service card

TY-RAP® System Means Lower Harnessing Costs

Here's why this harness costs less than it did last year

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This new tool answers the problem of quick and uniform tying even in high-density wiring. The narrow nose and long slim body reaches into confined areas. A squeeze of the trigger cinches the self-locking tie to a preset tension, trims tie evenly. Eliminates rework! Tying uniformity is the responsibility of the tool rather than the installer.

GET A GRIP OF STEEL

One of the most important considerations in plastic ties is the reliability of the tying device. Now, only TY-RAP has a patented non-magnetic, stainless steel locking wedge embedded in the cable tie head. Your customers get a grip of steel every time with TY-RAP ties.

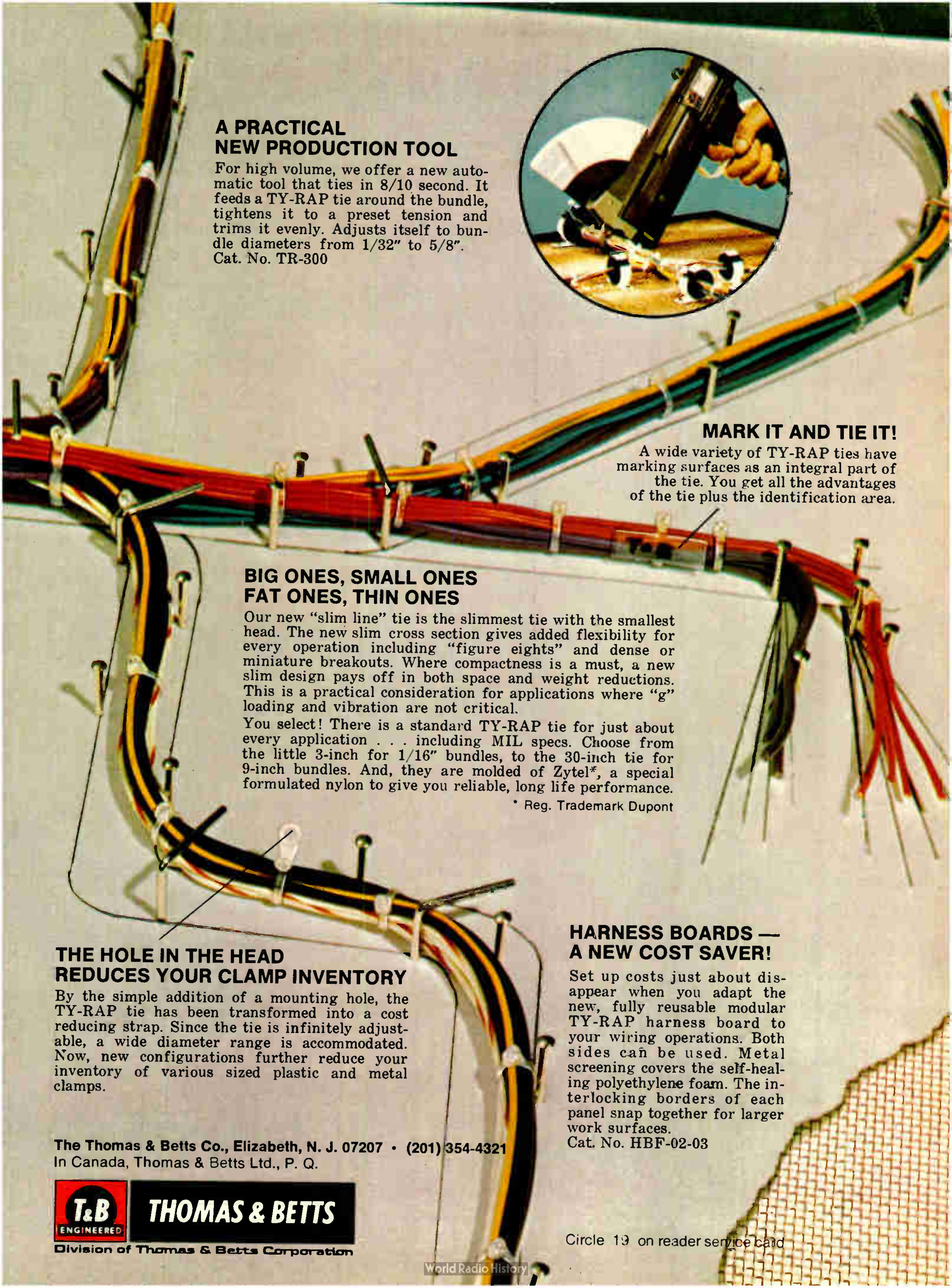
Hundreds of thousands of field-proven applications over 14 years are the credentials for TY-RAP tie reliability. This experience gives you a lower profile tie, a non-slip stippled back, a trademarked, curved tail, a low insertion force head, and the widest range of sizes and configurations. Your customer gets a higher quality job, at a lower installed cost to you.

Retainers that hold and shape the bundle during harness making are one of many aids available for board work.
Cat. Series TC-81

Harness installation and point-to-point wiring are further advanced through use of adhesive mounting bases and hundreds of other devices. Cat. No. TC-342A and TC-353A

How can the TY-RAP System lower your costs? Write for our new guide and catalog.

Sold Only Through T&B Distributors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For high volume, we offer a new automatic tool that ties in 8/10 second. It feeds a TY-RAP tie around the bundle, tightens it to a preset tension and trims it evenly. Adjusts itself to bundle diameters from 1/32" to 5/8". Cat. No. TR-300
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BIG ONES, SMALL ONES FAT ONES, THIN ONES
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Circle 19 on reader service card

Meetings

Conference on Magnetism and Magnetic Materials: AIP, IEEE, Statler-Hilton, Boston, Nov. 13–16.

Nuclear Science Symposium: IEEE, Sheraton Palace, San Francisco, Nov. 14–16.

National Telecommunications Conference: IEEE, Hyatt Regency Hotel, Atlanta, Nov. 26–28.

International Symposium on Computers: MMG, Fair Grounds, Munich, West Germany, Nov. 27–30.

International Electron Devices Meeting: IEEE, Washington Hilton, Washington, D.C., Dec. 3–5.

Fall Conference on Broadcast and TV Receivers: IEEE, O'Hare Inn, Chicago, Dec. 3–4.

Vehicular Technology Conference: IEEE, Sheraton Cleveland, Cleveland, Dec. 4–5.

Joint Conference on Sensing of Environmental Pollutants: ISA, IEEE *et al*, Sheraton Park, Washington, D.C., Dec. 10–12.

Reliability and Maintainability Symposium: IEEE, Biltmore, Los Angeles, Calif., Jan. 29–31.

International Solid State Circuits Conference: IEEE, University of Pennsylvania, Marriott Hotel, Philadelphia, Feb. 13–15.

Computer Conference (Compcon): IEEE, Jack Tarr Hotel, San Francisco, Feb. 26–28.

Aerospace and Electronic Systems Winter Convention (Wincon): IEEE, Marriott Hotel, Los Angeles, March 12–14.

Zurich Digital Communications International Seminar: IEEE, Swiss Federal Institute of Technology, Zurich, Switzerland, March 12–15.

International Convention (Intercon) IEEE, Coliseum and Statler Hilton Hotel, New York, N.Y. March 25–29.

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Circle 21 on reader service card

3 excellent reasons for you to investigate the new TEKTRONIX® 60MHz Oscilloscope

It's flexible

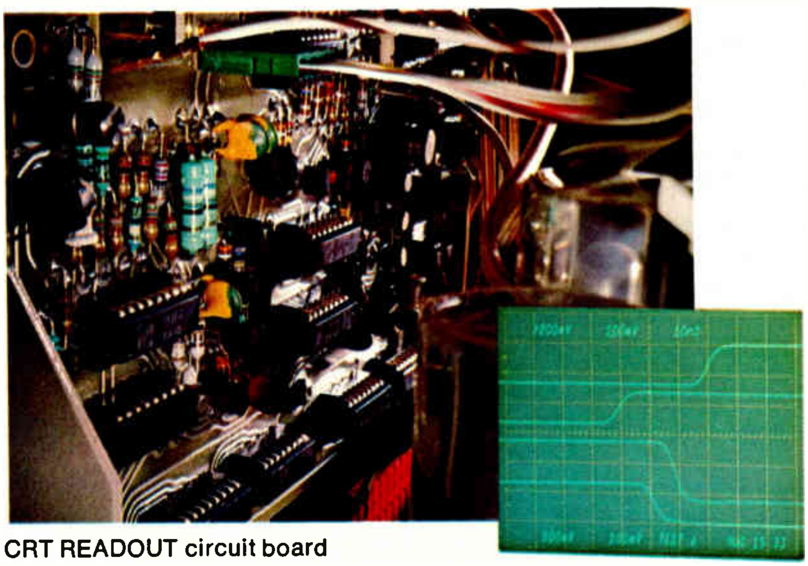
Basic units are the 5403 three-plug-in Mainframe, D40 Display Module, 5A48 Dual-Trace Amplifier and 5B42 Delayed Sweep Time Base. The 5403/D40/5A48/5B42 gives you 60 MHz bandwidth at 5mV/div sensitivity (1 mV/div at 25 MHz) and magnified sweeps to 10 ns/div. Two 60 MHz 5A48s may be paired for four-trace displays. The 5A48 has 5 display modes (Channel 1, Channel 2, Added, Alternate, and Chopped). This performance is offered in an easy to move or carry 29 lb. package. Fifteen other plug-ins (w/o CRT READOUT) give outstanding versatility, including: simple to use, dual-trace DC to 1 GHz bandwidth, delayed sweep sampler and sweeps to 1ns/div; high-gain differential amplifier with 10 μ V/div sensitivity and 100k:1 CMRR for low-amplitude, low-frequency applications; differential comparator amplifier (accuracy to 0.20%) and CMRR of 10k:1; four-trace 1 MHz amplifiers offering up to eight traces; curve tracer for displaying semi-conductor characteristic curves.

Easy to operate

The 5400 has it with a large (6½") bright CRT, pushbutton functions, beam finder, and color coded control panels making the operator's job straightforward. Optional CRT READOUT further enhances ease of operation. Added operator speed, perception and convenience advantages are realized with the CRT READOUT as it actively displays measurement parameters. Plus, a unique, programmable CRT READOUT offers the ability to identify tests and note conditions on the display. Easy determination of control display has been brought together in one highly visible area.

Low cost

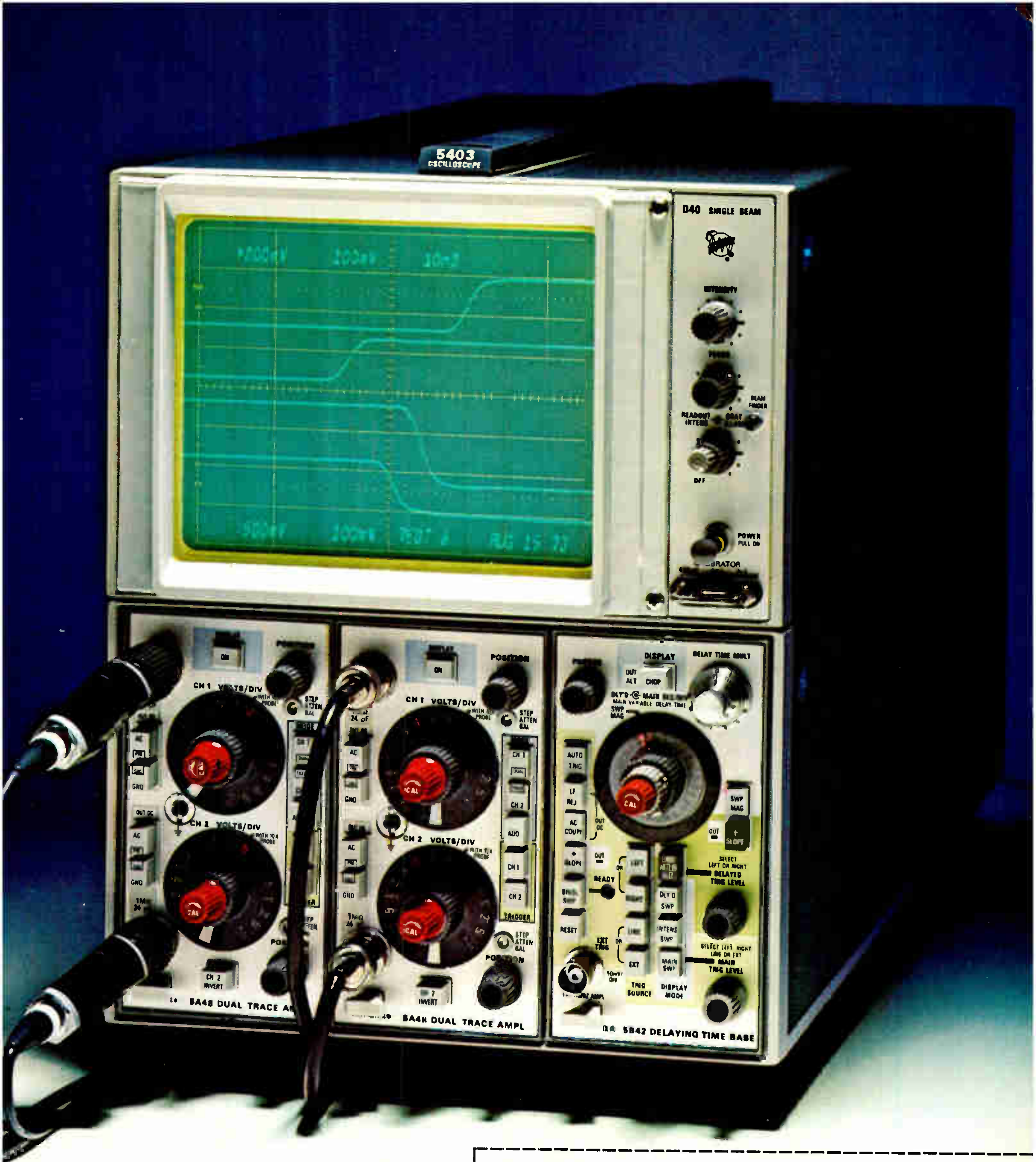
At $2200 ($1850 w/o CRT READOUT) the 5403/D40/5A48/5B42 is a very low priced 60 MHz, dual-trace, delayed sweep oscilloscope. Integrated circuits used wherever practical help keep reliability up and costs down. Maintenance costs are also low with Tektronix modular construction, fewer calibration points and ready access to circuits. CRT READOUT of plug-in parameters has never before been available at this price. The 5400 oscilloscope series provides versatility and excellent measurement value, with more on the way.



CRT READOUT circuit board

Quick, non-ambiguous measurement information at a glance.

Circle 22 on reader service card
For a demonstration circle 23 on reader service card



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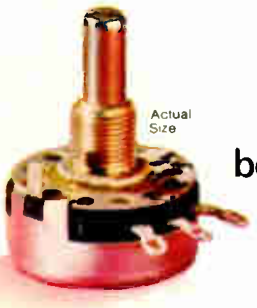


If you're really serious about cost, be serious about quality.

ALLEN-BRADLEY
Milwaukee, Wisconsin 53204

Circle 24 on reader service card

EC64

Signetics' IC for Japan Victor adapts stereos for quad

The development of a monolithic quadraphonic demodulator circuit has been nearly completed at Signetics, Sunnyvale, Calif. **The circuit is designed to allow both stereo and quadraphonic disks to be played on the same player without level adjustment.** Signetics is developing a circuit for Victor Co. of Japan (JVC), which will sell plug-in demodulators based on two ICs—one for the right and one for the left channel—to set manufacturers. Signetics and Asahi Glass, a Signetics agent, will also sell the ICs to JVC licensees next Spring.

The IC is a new version of the quadraphonic subsystems made by JVC in discrete-component form that makes possible recording-studio-quality hi fi. A phase-locked-loop locks onto the quadraphonic carrier signal, and a limiter amplifier in the IC enables the loop to maintain lock when the carrier level drops as low as 30 decibels.

The design is expected to make quadraphonic sound more popular because it lowers demodulator costs to the point where a quadraphonic subsystem can be added inexpensively to medium-priced sets. **Existing stereo systems can be upgraded to quadraphonic operation by installing a demodulator subsystem on a postcard-size printed-circuit board and two additional channel amplifiers.** Signetics expects to sell the IC in a 16-pin DIP for as little as $1.54 each in high volume.

H-P tries harder with minicomputer that's better

The Hewlett-Packard Co. late last month reinforced its beachhead in the commercial-computer market by reintroducing its HP-3000 computer, complete with hardware changes and a new Multiprograming Executive operating system. **The software, says H-P president William R. Hewlett, overcomes the "very embarrassing" speed and reliability problems** that had caused H-P to withdraw the computer from the market early this year after shipping only 23 systems.

H-P has also cut system prices 10% to 20%. Systems will be sold on lease-payout programs, rather than rented, as in the past. **An average system with peripherals now costs about $180,000.**

The HP-3000 is designed for concurrent processing in four computer languages, and a fifth is to be added this month.

GE, Solid State joint venture starts producing

First production shipments of integrated liquid-crystal watch modules went out last month from Integrated Display Systems Inc., the Montgomeryville, Pa., company formed jointly last April by Solid State Scientific and General Electric. **The new company assembles 3½-digit field-effect displays based on technology passed on from GE's Electronic Components division. It integrates them with complementary-metal-oxide semiconductors bought from Solid State.** Coming in the first quarter of 1974 is a six-digit-display module showing hours, minutes and the date, and a display for a woman's watch. Also in the works: LC displays for automotive-dashboard applications and for a broad range of instruments and GE-produced appliances.

Laser beam writes on film for big display

While many companies have discussed large-screen laser displays, Singer Co.'s Librascope division, Glendale, Calif., is delivering a number of these displays to various military agencies. In operation, **a laser beam writes on a 35-mm film, and the image is simultaneously projected**

on a screen. Two real-time laser cursors may also be projected, and as many as seven colors are available. The image plane can be a variable-persistence red or blue photochromic memory film, a permanent thin-metal film, or a conventional photographic heat-sensitive, dry-processing film. **Applications include air command and control, field tactical briefings, aircraft-cockpit moving displays, and training.**

Silver-alloy epoxy challenges gold

The major technical reason for using expensive gold-filled epoxy in die-bonding hybrid circuits will be challenged by a newly developed nonmigrating silver-filled epoxy. Silver epoxies, less than 1/10th the price of gold, are already used in 95% of conductive adhesive applications, but because of migration problems, certain military agencies have mandated gold. The new material, developed by Ablestik Laboratories, Gardena, Calif., a major epoxy-adhesive supplier, uses **a silver-palladium alloy that reduces migration by a factor of 10 or more. User cost will be about 1/20th that of gold** for the same volume of adhesive.

IBM competitors seek early relief from Justice Dept.

The Justice's Dept's antitrust suit against International Business Machines Corp. has taken on a new cast with a joint proposal by four of IBM's top competitors urging early interim relief for industry "to insure a possibility of the restoration of competition." **The position taken by the chief executives of Control Data, Honeywell, National Cash Register and Sperry Rand in their joint meeting Oct. 31 with Thomas Kauper, assistant attorney general for antitrust, stressed** "the importance of an early trial, coupled with injunctions to be sought prior to the formulation and implementation of final relief, **in order to prevent IBM from wrongfully entrenching its position while appeals are pending."**

The companies also stressed the need for "behavioral restrictions and the imposition of controls on IBM's attempt to gain additional market share" **in the period, and called for separation of the Government's trial on the merits of the case from the determination of penalties.** The companies called for deferral of the issue of ultimate relief for competitors—including the possible breakup of IBM—to a later date, questioning the feasibility of such a plan.

Capital spending in electronics to rise 16%

The outlook is bright for capital spending in the electronics industries next year, but those outlays will drop in 1975. That is the conclusion of a special survey by McGraw-Hill Publications Co.'s Economics department, which forecasts **a healthy 16% increase for 1974 over the 1973 level, but a drop of 6% the following year.** Electronics-industry sales, the survey predicts will rise 5% next year.

RCA, Siemens compete in PABXs

Banking on experience gained as a builder of electronic switching systems for the military, RCA's Communications Systems division, Camden, N.J., is readying an electronic private automatic branch exchange (PABX) system that could be commercially available in early 1975. **The system accommodates 300 or 600 lines and relies on LSI and C-MOS.** And Siemens Corp., Iselin, N.J., will also be marketing in the U.S. electronic PABXs and other switching systems developed by Siemens AG, its parent company in Munich.

Transport, health take growing share of civil R&D outlays

Some civil R&D areas grow but the big spender is still defense as space budget declines again

Civilian-oriented research and development is taking an increasing share of Federal R&D funds, even though national security and space programs continue to dominate total outlays. Civilian R&D in fiscal 1974 will account for $5.5 billion, roughly one-third of the $17.4 billion Federal outlay. In fiscal 1969, the amount was less than $3.6 billion, or less than one-fourth of the $19.6 billion total.

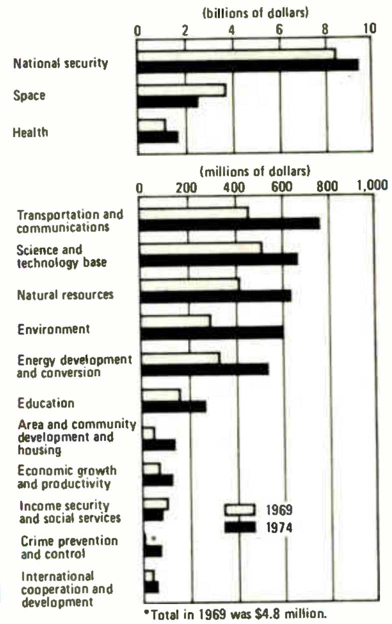
The big money is still in defense. It is, says the National Science Foundation in a new report (see p. 79), "the leading function by a wide margin, taking up more than 50% of the R&D total." This fiscal year's national-security R&D, estimated by the Electronic Industries Association, Washington, D.C. to have an electronics content of 35%, will peak at $9.4 billion—an increase of $478 million, an amount greater than the over-all net growth in all other categories. This will put national-security Federal R&D funds at 54.2%, its largest share in any of the last five fiscal years. The figures are contained in a forthcoming NSF report, titled "An Analysis of Federal R&D Funding by Function, Fiscal Years 1969–74."

Civilian. On the non-military side, says, NSF, the three chief dollar contributors to Federal R&D growth are transportation and communications, health care, and environment. However, the largest percentage growth rate in the five-year period was in R&D for crime prevention and control, which rose 62%. Space, on the other hand, continued to decline to a six-year low of $2.5 billion, even though it is still the second largest consumer of Government R&D money (see chart).

The NSF figures for this fiscal year show increases in all but three functional areas. Besides space, which industry estimated to have an electronics R&D content of 35% to 40% of total outlays, the other two R&D losers—natural resources, down 10%, and income security and social services, down 23%—have no meaningful electronics content.

Gains of 51% in R&D for crime

FEDERAL R&D OBLIGATIONS BY FUNCTION, FY 1969 AND 1974 (EST.)



*Total in 1969 was $4.8 million.

Source: National Science Foundation

NSF cites cutbacks in basic research

The positive note sounded in the National Science Foundation's R&D study—that civilian-oriented efforts are claiming an enlarging portion of Federal R&D funds—is somewhat muted by other indications from the NSF that there are negative trends in basic research emerging in this country.

This disturbing finding was contained in the NSF's 1973 National Science Board report. The principal pessimistic trends that were cited in the report are these:

- Research funds per scientist and engineer in Ph.D.-granting institutions dropped 15% in constant 1961 dollars between 1968 and 1972 as a result of decreased Federal spending and continued growth of faculties. Physics and engineering suffered two of the three largest declines of any disciplines, dropping 32% and 17%, respectively.
- Young university and college researchers—those holding a Ph.D. less than seven years—suffered a more severe cutback in Federal support than senior investigators. The proportion of young investigators supported fell from 65% to 50% between 1964 and 1970, as opposed to a 10% drop to 63% for senior researchers in the same period.
- Federal laboratories, another source of industrial research talent, cut back basic research outlays by 20% between 1970 and 1972 when measured in constant 1961 dollars, with the largest cuts taken by NASA—the largest single Federal sponsor of basic research and the one with heavy commitments in electronics and related sciences.

prevention and control and 3% each in health and education will affect industry, however, which estimates the electronics content of Federal law-enforcement R&D expenditures at 10% of its total, while health-care electronics outlays are growing slowly but steadily from the present level of 3%. These percentages would put electronics for crime prevention and control at roughly $5.5 million and electronics R&D for health-care at $50.3 million this fiscal year.

Transportation and communications, lumped together in one large category by NSF, is termed "a strong growth area," despite the observation that "a sharp drop in the communications subfunction placed R&D obligations only slightly above 1969." Overall, the transportation-and-communications category will be increased $52 million this year to $765 million, or 4.4% of Federal R&D funds. Air-transport R&D is the dominant function in the category, with industry estimates of electronics R&D through NASA and the Federal Aviation Administration taking 20% to 30% of the funds. The funding decline in civilian communications stems largely, NSF says, from "a phaseout of NASA's work on experimental communications satellites, now expected to be handled by private industry" [*Electronics*, Sept. 27, p. 80].

Environment, which industry estimates to have a 6% electronics R&D content, "is one of the more rapidly expanding functional areas," according to NSF data. Federal outlays this fiscal year are estimated to reach nearly $590 million, or about 3.4% of the R&D total, compared with 1.9% five years ago. With declines in funds for pollution control and abatement, as well as reduced emphasis on air-quality control, more R&D money is being channeled into programs to understand, describe, and predict environmental conditions—an area that calls for more electronic instrumentation and data-processing and similar equipment. NASA's environmental-satellite program, as well as the National Oceanic and Atmospheric Administration's efforts, are regarded as forerunners of growth potential in this category.

Defense gains this fiscal year will come in all categories except aircraft and related equipment as several programs near completion of the R&D stage with none to replace them. These include the Navy's F-14 interceptor and S-3A antisubmarine warfare plane as well as the Air Force F-15 air superiority fighter and F-5E international fighter programs. The biggest increases are planned for the military astronautics and missile categories. The astronautics increase covers a prototype Air Force satellite to demonstrate precise navigational capabilities, as well as more dollars for advanced satellite surveillance technologies. □

Packaging

Selective plating cuts gold usage

The sky-high price of gold is forcing package manufacturers to seek ways to cut their usage of the precious metal. The basic approach is to selectively plate ceramic IC packages to cut as much as 30% off the prices of some packages.

The first company to ship such packages in volume to semiconductor manufacturers appears to be Metalized Ceramics Corp., Providence, R. I. But Kyocera International, Sunnyvale, Calif., is offering customers sample ceramic packages with selective gold plating, and American Lava Corp., Chattanooga, Tenn., plans to introduce such packages early in 1974.

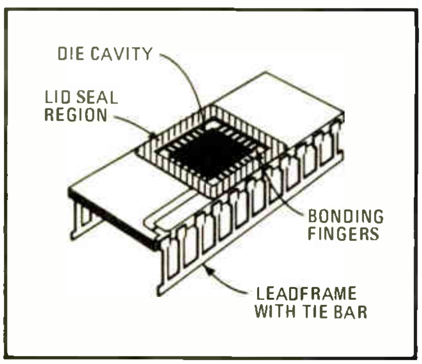
Instead of gold-plating the lead frame and die cavity, the MetCeram technique consists of applying gold only to the lid-seal region of a ceramic package, the die-attach cavity, and the bonding pads—the tiny fingers that enable the bond wires to connect the chip to the package. In addition to the 16-lead packages, MetCeram has tooled up to use the spot-plating technique on 22-lead ceramic packs and will soon add 24-, 40-, and 42-lead packages to its product line.

For the smaller packages, says Harold Ottobrini, MetCeram's executive vice president, the spot-plating technique will save the buyer about 10%, but the savings could go as high as 30% in the 40-lead units. Ottobrini points out that semiconductor-memory manufacturers seem more interested in using ceramic packages, even with the advent of improved reliablility in plastic packaging [*Electronics*, Oct. 11, p.80] because the higher unit value of the memory chip justifies the more expensive package.

The machine. A saving in the cost of ceramic packages by using less gold will further enhance their position in relation to plastics. Therefore, MetCeram has pumped more than $75,000 into developing its first gold-spot-plating machine and has it in production.

MetCeram developed its own machine, even though a number of spot-plating techniques are available for adding gold to metal pads,

Less gold. Spot-plating restricts gold to cavity and lid-seal regions. Metalized Ceramics' spot-plating machine (right) can process over 300,000 packages a week.



because "there were none that we felt could both spot-plate package cavities in high volume and offer the flexibility of handling different package types," Ottobrini notes. A second spot-plating machine will be in production when tooling for the first machine is completed.

The machine can process 300,000 packages a week, employing a gasket system to confine the gold to the three areas where it is desired. The customer can solder-dip or tin-plate the leads, as he chooses, Ottobrini says. Packages are inverted over gaskets and travel through the machine, while a system of jets applies the gold to the selected nickel-plated ceramic regions. The gaskets eliminate the need to mask the leads during plating.

MetCeram claims that the plating technique provides more uniformity from package to package than does a more conventional plating-tank approach. □

Trade

U. S. trade deficit widens in first half

Despite sharp increases in integrated-circuit and semiconductor exports, the United States has been unable to offset mounting imports of communications and consumer-electronic equipment in the first half of 1973. The result: a $459 million trade deficit for the period, 27.5% higher than it was in the first six months of 1972.

Soaring exports of components in the first half totaled $754 million, compared with $440 million the year before, according to new figures from the U.S. Department of Commerce. More than half of this gain was accounted for by $86 million in shipments of ICs and semiconductors. Nevertheless, the U.S. trade balance for components was held to $355 million, as components imports in the first half jumped more than 70% to $399 million to meet U.S. component shortages.

Components imports exhibiting the largest increases were capacitors and resistors, up $25 million, and semiconductors, up $130 million, of which $81 million was for ICs and $24 million for transistors and other semiconductor devices.

Asia flood. While the gains in components imports were high, import increases in consumer electronics were even higher. Consumer imports rose nearly 20% to top the $1 billion mark for the first time. Japan accounted for $667 million of this $1,055 million total, of which about half consisted of television and radio receivers and parts. The 50% increase in consumer-product exports to $150 million did little to stem the tide. The consumer-product trade deficit from January to June of $905 million proved much greater than last year's $781 million in red ink.

Taiwan increased its total electronics exports to the U.S also, but it still runs a poor second to Japan. A large proportion of Taiwan's $213 million in shipments—12.7% of America's electronics imports—stems from consumer products of U.S subsidiaries and joint ventures. The U.S. electronics-trade deficit with Taiwan now stands at $147 million, followed by Hong Kong, Singapore, and Mexico, which also have an increasing number of U.S. offshore operations (see table).

U.S. ELECTRONICS TRADE AT A GLANCE
(JANUARY – JUNE 1973 IN MILLIONS OF DOLLARS)

	Imports From		Exports To		Balance
Japan	$ 819	48.5 %	$ 99	8.0 %	– $ 720
Taiwan	213	12.7	66	5.4	– 147
Mexico	134	7.9	128	10.4	– 6
Singapore	99	5.9	64	5.2	– 35
Hong Kong	92	5.4	34	2.7	– 58
Canada	70	4.1	184	14.9	+ 114
Korea	60	3.5	43	3.5	– 17
U. K.	56	3.3	102	8.3	+ 46
W. Germany	36	2.1	96	7.8	+ 60
All others	112	6.6	416	33.8	+ 304
Total	$ 1,691	100.0 %	$ 1,232	100.0 %	– $ 459

Another contributor to the trade deficit that first began in 1968 is telephone and telegraph equipment. Imports of $57 million in the first half represent an increase of nearly 30% from last year and offset a $10 million increase in exports to $47 million. The resulting $10 million deficit is $3 million more than it was a year ago. Much of this increase in imports comes from Japan, too.

Commercial, military, and industrial electronics maintained a positive, but declining, trade balance. The $93 million difference between exports of $266 million and imports of $173 million was down sharply from the $218 million advantage the U.S. held in the first half last year. The Department of Commerce attributed most of the imports increase—from $109 million to $173 million—to gains of $54 million in non-consumer television apparatus and parts, plus nearly $6 million in radio and navigational-aids. □

Commercial electronics

Digits move fast in the teller's cage

When the First National City Bank, headquartered in New York City and nicknamed Citibank, reduced the prime interest rate twice last month, other major banks across the country quickly followed suit. But it will take them much longer to catch

Secret. Citibank won't disclose its ID-card encoding method. It is claimed to be tamper-proof and immune to duplication.

up on the latest example of Citibank's exploitation of electronics—its instant check-cashing service for customers.

So far, Citibank has invested $30 million in research and development to provide computer- and communications-based financial services for its customers. The newest, dubbed Superteller and employing a proprietary Magic Middle identification card, will shorten that irritating delay at the teller's cage when a personal check is being cashed. Now, in about eight seconds, any teller at any of Citibank's 230 branches can cash a Citibank check for any amount up to the balance of the account for any of the bank's nearly 800,000 customers.

The reason that Citibank may remain ahead for a while in this type of service is its early decision not to buy vendor-developed terminals and other equipment nor to seek outside help. Instead, the bank started from scratch, developing a patented identification card and a special terminal to go with it. The development was carried out by Los Angeles-based Transactions Technology Inc., a subsidiary of First National City Corp. Citibank officials won't disclose the card's encoding method, except to say it does not use magnetic, embossed, or laser technologies and that it is tamperproof and immune to fraudulent duplication.

To cash a check, the teller inserts the ID card and keys in the amount of the check. The information is transmitted over the communications system to a computer that scans the customer's account and returns a digital display to the teller to verify the amount of the check. The computer-communications network covers the five counties in New York City and two adjacent counties, and can handle about 20,000 terminals. At present, though, some 1,500 terminals are in operation for check-cashing service, and about 1,000 similar terminals are installed in merchant locations to service Master Charge purchases.

Teller terminals are connected to a central computer in the Wall Street area, while the merchant terminals go to a computer in Huntington, N.Y. Citibank charges merchants $20 a month to rent a Master Charge terminal.

Backing up the terminal installations is a hierarchy of unattended multiplexers and remote data concentrators, also designed, built, and installed by Transaction Technology. Each of 24 multiplexers can handle 210 75-bit-per-second terminals. The 24 multiplexers transmit at 1,200 b/s to eight concentrators that are connected to the data-base computers. Total hardware investment is $6 million. □

Solid state

Voltage-regulator squeezed into TO-3

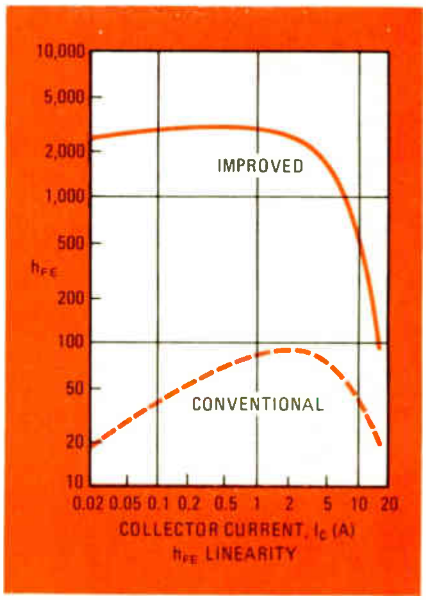
A hydrogen heat-treating process that raises transistor efficiency has helped a Japanese firm put a 100-watt voltage-regulator hybrid integrated circuit into a TO-3 transistor can. Sanken Electric Co. of Asaka, in suburban Tokyo, also makes discrete power transistors with the process, which multiplies the dc forward-current transfer ration(h_{FE}).

The pass transistor of the IC—a 5-volt voltage regulator for TTL systems—has an h_{FE} of more than 100 at the normal output current of 15 amperes, claimed Masao Tamura and Sei-Inchi Denda, of Sanken Electric, at the symposium of the International Society for Hybrid Microelectronics in San Francisco last month. That is five to 10 times higher than the h_{FE} of conventional power transistors. At lower currents, h_{FE} rises to around 3,000, or about 30 times that of conventional transistors.

Hydrogen heat-treating reduces the carrier losses at the surface of the transistor's base region by improving the interface between the silicon-dioxide layers, thus raising injection efficiency and minority-carrier transport factors. Secondary breakdown is not a problem because the customary way of raising a transistor's h_{FE}—shrinking the base width—need not be used.

Property exploited. The transistor's high h_{FE} is exploited in the regulator-circuit design to keep down internal power dissipation and heating. A single triple-diffused transistor serves as the output stage. The substrate collector of the 5.3-millimeter-square chip is soldered directly to the package's metal

Riding higher. Hydrogen-treating improves the h_{FE} characteristics (as shown above) by reducing the carrier losses at the surface of the transistor's base region.



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The 214 is the third miniscope from Tektronix. Like the non-storage 211 and dual trace 212, it has a bandwidth of 500 kHz and vertical deflection from 1 mV/div to 50 V/div. Sweep speeds range from 5 μs/div to 500 ms/div. All three are constructed of high-impact plastic to withstand rough treatment, and they are double-insulated for greater protection while making high-voltage measurements. Rechargeable internal batteries allow up to 5 hours continuous operation with non-storage and up to 3½ hours in the storage mode.

Costly equipment breakdown in the field requires that you get there with the right tools, find the problem and solve it. And you need to do it fast. In those times, oscilloscope storage is proving itself more and more valuable.

Many times, low or random repetition rate signals are difficult to view. The 214 combines storage with triggered single sweep to automatically wait for and capture an elusive event. It writes in the storage mode at up to 500 div/ms, and holds the display for up to an hour.

214 Dual-Trace Storage Oscilloscope $985

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Circle 32 on reader service card

For a demonstration circle 33 on reader service card header, which serves as the power input. Junction-case thermal resistance is only 1.25°C/W.

The rest of the regulator circuit is a thick-film, alumina-substrate hybrid IC mounted above the power chip on two pins and connected by wire bonds to the transistor base and emitter. On the substrate, a monolithic control-amplifier chip 1.2 millimeters square is bonded face-down to a ruthenium-oxide resistor network.

In the network, the current-sense resistor and a bypass resistor for the power transistor are located in the transistor's base circuit. The sense resistor sees a current of only $1/h_{FE}$ and dissipates only 0.1 W. If the sense resistor were in the power-output line, as in conventional regulators, it would dissipate 9 W and overheat the control chip. Also, moving the sense resistor allowed its value to be increased from 0.04 ohm to 3 ohms, which makes it easier to print and trim.

Tamura and Denda consider the design experimental because reliability tests have not been completed. However, they said it has operated almost a year without problems. At 25° C, the regulator can dissipate as much as 100 W. The output current is limited by the circuit design to 16 W at the normal operating temperature of 75°C. □

Government Electronics

Coast Guard tests solar-cell power

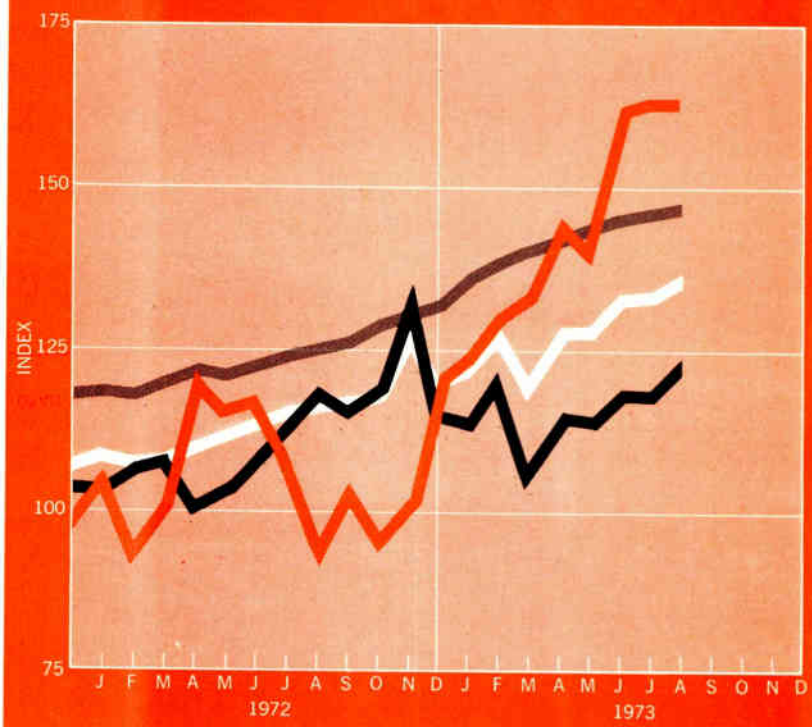
The U.S. Coast Guard is looking toward the sun to help cut its maintenance of untended buoys and shore aids. The service is deploying solar-cell-powered buoys in several harbors as part of a two- to three-year test program, and, if successful, it is likely to buy such units for at least part of its fleet of 14,000 untended buoys and shore aids, says David Price, chief of the service's Floating Platforms section.

The buoys will weather the different climates of Boston, Ketchikan, Alaska, and St. Petersburg, Fla. In all, the service is testing 73 arrays, Price says, counting 53 at the Research and Development Center, Groton, Conn., nine on a "small-buoy farm on Long Island Sound," six in Los Angeles at factories of the suppliers, Centralab and Heliotek, the leading U.S. solar-cell manufacturers, and one on oil rigs in the Gulf of Mexico.

Because they use big primary batteries of zinc-air cells, the present buoys are large and need big ships and crews to attend to them, usually once a year. Solar-powered buoys could be smaller because they would use salvageable lead-acid secondary batteries that could be maintained by smaller craft and crews, explains Lloyd R. Lomer, solar array project officer in the Environmental and Transportation Techniques branch. "We'd like to have a power supply that lasts six years," he says, adding that the system should pay off in a few years.

And what . . .? There are problems, though. "The critical thing is moisture," Lomer says. This de-

Electronics Index of Activity



Segment of Industry	Sept. '73	Aug. '73*	Sept. '72
Consumer electronics	146.6	145.9	104.3
Defense electronics	122.0	120.1	119.8
Industrial-commercial electronics	148.5	147.2	128.3
Total industry	134.0	132.5	119.8

For the third consecutive month, the index showed an increase, rising 1.1% in September, and 11.0% above a year ago. The defense sector was up 1.8% from a year ago, the industrial-commercial sector, rose 0.9%, which is 15.7% above the level of September 1972. Consumer electronics rose 0.5% from August's level, but it is 40.6% higher than last year.

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.

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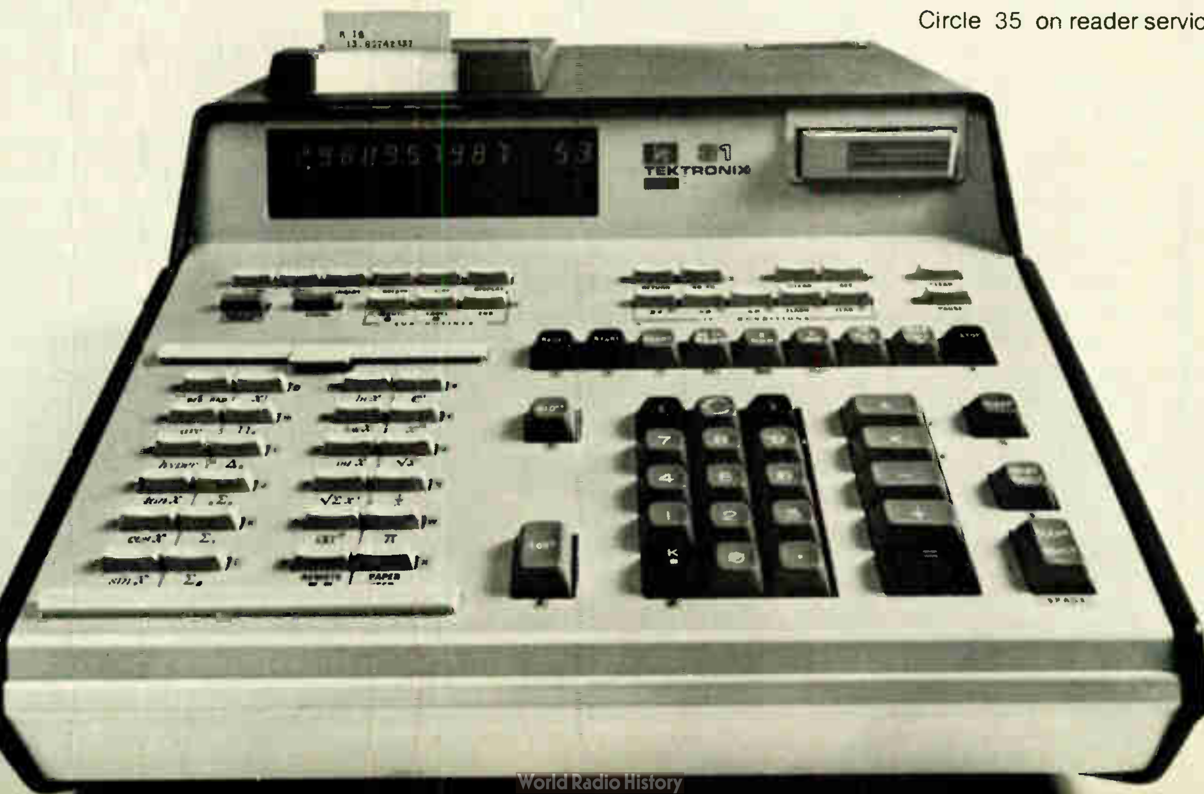
Circle 35 on reader service card



grades the silicon cells' performance. Other problems for the flat-mounted horizontal arrays, Price points out, are snow, rain, spray, "people bumping into them, and bird droppings." But, he says, the solution is only a matter of packaging: "The big part is reliability. A lot can be engineered in by the manufacturer."

After the testing period, the service will build a preprototype and then buy several hundred initially, Price says. There would be three basic sizes for inventory at $600 to $1,000 per array plus battery.

The idea should work. Japan already has deployed more than 200 lights by solar arrays, and England is trying the technology, too. Also involved in the U.S. are Exxon Corp., through Tidelands Signal Corp., and Automatic Power Inc., both in Houston, say Price and Lomer. Even if the idea doesn't work out, Price says he has a backup idea: generating the power by wave action. □

Memories

Memory makers urged to match new technology to user needs

Memory makers are developing technology too rapidly for the best interests of computer users. That was a major conclusion to emerge last month from the International Memory Conference in Paris. Computer-science experts underlined the need for greater coordination between memory designers and their clients. And combining memory technologies stood out as a major future benefit, especially to large-system users.

Conferees reflected a growing feeling that memory makers are rushing ahead with the development of faster, denser, and, theoretically, cheaper memory systems without enough thought as to how the technology can be matched to user needs. The president of the conference organizing committee, Marc Chappey, of the French government's Telecommunications research organization, explains that the memory builders are now working for much more sophisticated clients than they were a few years ago. "Since the semiconductor-memory explosion, memory designers are able to have a much more precise understanding of customer needs," he declares.

Christiaan J. Alewijnse, of Philips Electrologica, in The Netherlands, is more specific. He sets out several main criteria for evaluating new technologies:

- The memory has to play a prescribed role in a memory hierarchy.
- Cost and performance calculations must be based on the over-all structure of the memory hierarchy.
- Essential criteria, such as bit price and access time, can vary by as much as five orders of magnitude when calculated at different points in the same hierarchy.
- Total hierarchy performance varies with the application.

Model is prophetic. Using these principles, Alewijnse has developed a model that projects trends in hierarchy requirements over the next five years. Using an evaluation system based on bit price, cycle time, and access density, he figures that, by today's technological standards, a single-level main memory is best for small machines having capacities as high as 250,000 bytes.

A bigger machine needs a hierarchy made up of a fast buffer section, combined with a main memory slower than that of the smaller machine. Additional memory capacity in the form of the drums could be added to the biggest systems. But by 1978, Alewijnse says that hierarchy structure will need to be changed as performance goes up and prices come down.

For a main memory having a 600-nanosecond operating speed and a capacity of 64,000 bytes to 1 million bytes, for example, he calculates that the bit price will fall from 10 cents to only 1 cent, including control electronics. Speeds will be increased rapidly. According to the model, access times of buffer memories will drop from 150 ns to 50 ns; of drum memories, from 5 milliseconds to 1 ms; and of disk memories, from 35 ms to 15 ms.

The price and performance improvements will mean a new set of hierarchy combinations. For example, the development of higher-speed drums will enable them to be used with a main memory in a system having a capacity of 64,000 to 1 million bytes. By 1973 standards, drums are only feasible with capacities of 1 million to 8 million bytes. At the same time, the over-all cost of a hierarchy using a drum with a 1-million-byte system would drop from around $700,000 to $800,000 at 1973 levels to as low as $100,000 by 1978. □

Societies

IEEE members vote on separating groups

The results of an IEEE referendum that appeared with this month's presidential ballot could drastically alter the structure of the organization. If approved, the referendum would direct the board of directors to form a separate organization of the institute's groups and societies to oversee all technical and educational activities while the main body of IEEE concentrates on professional/economic action.

The result of this vote will be known later this month. The board has come out against the issue and is not legally required to abide by the referendum even if it is approved. So if it passes, the next step depends on how much the leadership is swayed by the vote of the members.

The board of directors is against the idea because, it says, dividing

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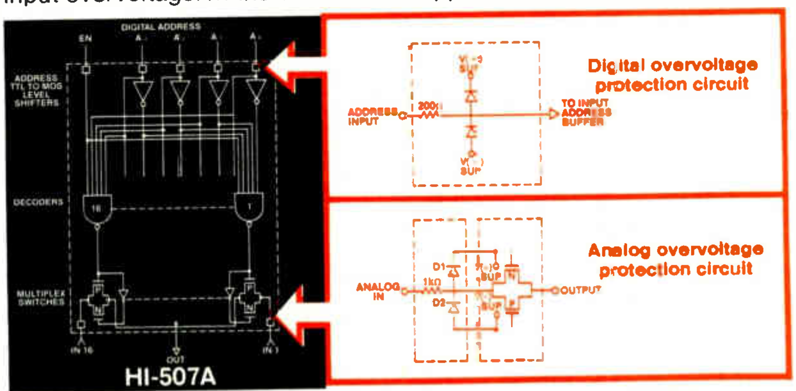

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Circle 38 on reader service card

the organization would either sap its financial strength of increase costs to members.

The Computer Society has provided most of the impetus for this referendum. In a sense, the Computer Society's objective is to insure that the pendulum has not swung too far toward career and lobbying plans at the expense of IEEE's technical information missions. □

Military electronics

ISHM proposes new hybrid-IC standard

The hassle over military specifications for hybrid integrated circuits may soon be resolved by a proposed new standard being readied by the International Society for Hybrid Microelectronics, Park Ridge, Ill.

The society hopes to complete the document early next year and submit it for approval by industry and military agencies. D. D. Zimmerman, chairman of ISHM's standards committee, claims that the proposed standard could save millions of dollars spent by producers to meet provisions of military standards, which were written originally for monolithic circuits.

The standard, which has been in preparation since last November, was to have applied to all hybrid ICs, but the spadework was done by members concerned with military and high-reliability circuits, and sections covering commercial and consumer circuits were not included. The proposed standard was introduced last month by W. Dean McKee, now a materials engineer at the Naval Electronics Laboratory Center, San Diego, Calif., at ISHM's annual International Microelectronics Symposium in San Francisco. At that time, McKee was employed by Rockwell International, Anaheim, Calif.

Three MILs attacked. Hundreds of major and minor revisions are being made to MIL-STD-883, MIL-STD-1331, and MIL-M-38510, the military documents that govern IC test methods, control parameters, and quality-assurance. The committee roundly criticized the specifications for ICs as being vague and incomplete in their references to hybrids. The three documents were characterized as replete with tests inappropriate to hybrids and lacking many of the specifications and tests necessary to check such characteristics as resistor trimming, adhesion of films to substrates, nondestructive checks of wire-bond strength, and toxicity of materials used in circuits for medical applications.

The committee plans to combine the revised versions into a general standard and subdocuments covering chip components, substrates, and other parts and materials of hybrid circuits.

A radical departure from the philosophy behind military specifications is being made in the revision to MIL-STD-883. The current standard requires circuits for different classes of service to meet an assigned group of tests. However, ISHM is planning a shopping list of optional tests from which producers and buyers would select tests to evaluate fitness for intended applications.

For example, Zimmerman says, a heart pacemaker might now be specified to meet 883's Class A test group. "It's crazy to specify −55 to +125°C temperature range when a pacemaker sees only a few degrees of temperature change," he argues. "It would be better to specify a Class A vibration test and a Class D, E, or F temperature test. Since hybrids are a custom business, we should allow for custom specifications." □

Semiconductors

D-MOS developer founds company

More than two years ago, Joseph Kocsis and his colleagues at Signetics Corp., Sunnyvale, Calif., predicted that nanosecond-speed MOS logic devices could be made by

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double-diffused MOS (D-MOS) technology. [*Electronics*, Feb. 15, 1971, p.99]. Because of his impatience to make that forecast come true, Kocsis has left Signetics and founded his own company, D-MOS Inc., to produce both logic circuits and transistors with the process.

Kocsis says that his company in Saratoga, Calif., has already made prototypes of logic circuits and discrete devices, but he doesn't plan to introduce them for several months. D-MOST Inc. intends to make off-the-shelf devices and custom large-scale ICs, the founder says.

A patent squabble is not expected with Signetics, Kocsis says. Because it was developed simultaneously by a number of people, Kocsis contends that D-MOS is virtually in the public domain. The process has been under development at Japan's government-sponsored International Technical Laboratory for about five years [*Electronics*, Oct. 13, 1969, p.207]. The Japanese are already making ICs with the process—Nippon Electric Co. reports development of first-stage radio-frequency amplifiers for 400-megahertz mobile radios. And Signetics is known to be developing D-MOS ICs, but the firm won't say what types are planned. Kocsis was co-developer of the process used at Signetics to produce microwave transistors [*Electronics*, March 29, p.34, and Aug. 2, p.35].

Small size, low power. A D-MOS inverter, the basic building block of MOS logic arrays, has an on resistance about one fifth that of a conventional MOS stage of the same size, Kocsis says. This will permit drive devices to be reduced in size, thereby providing higher packing density and lower power dissipation for D-MOS LSI than can be obtained with conventional MOS. In addition, Kocsis says that both high-voltage drivers, operating as high as 200 volts, and low-voltage logic and drivers compatible with TTL can be fabricated on the same chip. He estimates internal gate delays at 1 to 10 ns.

Kocsis plans to use the same dimensional layout rules employed for volume production of other types of ICs—that is, thin-film metal electrodes will have standard widths. However, the double-diffusion process reduces practical channel lengths to 1 micrometer, or about one fifth the length of conventional MOS-transistor channels, allowing the D-MOS transistor to switch in less than a nanosecond, Kocsis points out.

The firm's discrete devices under development include tetrode and triode linear amplifiers with gains as high as 10 decibels at 1.5 gigahertz, switching triodes with rise times as short as 1 ns for digital and analog switching (one is expected to have an on resistance of only 1 ohm), uhf power amplifiers with ratings as high as 3 W at 1 GHz, and high-voltage triodes with minimum breakdown voltages from 70 to more than 300 V.

Having fled Hungary during the 1956 uprising, Kocsis worked at Bell Telephone Laboratories and at the Shockley Laboratories before joining Signetics. Although his firm is still headquartered in his home, he says he has received financing and has arranged with a Japanese firm for wafer processing in Japan. □

Beam-lead survey shows market stable

Beam-lead chip producers got some good and some bad news last month at the International Society for Hybrid Microelectronics symposium in San Francisco.

First, the bad news. ISHM's survey of 102 hybrid-IC manufacturers showed that beam-lead chips are still in roughly the same market position they have been in for several years. Relatively few firms are using them. The good news is that beam leads continue to have a promising future [*Electronics,* April 26, p. 76].

Only 3% of the firms surveyed use beam-lead discrete devices and 4% use beam-lead IC chips, compared with 27% and 30%, respectively, for wire-bonded devices. Most of the users are military-system manufacturers. And beam-lead chips were ranked as the most expensive type.

But beam-lead devices came out on top as having the greatest potential if they become available in unlimited quantities. Some 44% of the manufacturers voted for beam leads, compared with 25% for flip chips, 19% for wire-bonded chips, and only 3% expressed a preference for carrier devices.

Beam-lead devices were highest in all potential cost categories: testing, assembly, rework, and automation. They also won the highest reliability score, 39%, and wire-bonded chips were second at 38%. One third of the firms listed beam-lead chips as the type they would like to see the semiconductor industry concentrate on, with solder-bump flip chips second at 23%. □

News briefs

Litton indicted for fraud

The Memory Products division of Litton Systems Inc. and four company officers have been indicted by a Federal Grand Jury in San Diego on charges of defrauding the government of $216,000 in customs revenue between November 1968 and August 1972. The alleged swindle applies to imports of memory-core planes from Litton-affiliated plants in Mexico and Singapore; Triad de Mexico at Tijuana is named as the Mexican assembler. The Justice Department says the 121-count indictment alleges conspiracy and the use of false customs entries and invoices that undervalued the memory core planes and willfully failed to declare "all the foreign components in the parts," including the foreign origin of wire provided by Duluth Scientific to the Singapore assembler.

A Litton spokesman in Washington would only say: "We know of the case. Since it is now before the court, we will have no further comment." Named in the indictment are Donald Krueger, Litton Systems' Components Group comptroller, and Memory Products division officers Robert Lurvey, president; John Ross, general manager; and Joseph Gaskin Jr., materials manager. Maximum penalty on the conspiracy charge is five years in prison and a $10,000 fine, plus a $5,000 maximum fine on each of the 120 counts of using false documents to import the memory planes.

Rockwell and Admiral to merge

Admiral Corp., which has had its share of the color-TV market slip recently, and Rockwell International Corp., have agreed in principle to merge. The merger will be based on an exchange of 56 cents a share of Rockwell common stock for each share of Admiral common stock. There are 5,900,000 shares of Admiral stock and 27,250,000 shares of Rockwell stock.

Admiral's share of the color-TV market in 1970 was pegged at about 3.5%, a figure that has been steadily declining. It had 5.6% of the black-and-white TV market for the same year. Rockwell, however, has not determined if it will retain the Admiral name.

One-chip watch from Intersil

Competing with the SOS single-chip approaches of Inselek, RCA, and Rockwell International, Intersil Inc., Cupertino, Calif., is putting all the logic, display multiplexing, and LED-drive circuitry of a digital wristwatch onto a single chip. One C-MOS design operates drivers at 3 volts, while the rest of the circuitry operates at 1.5 V, using a 32-kilohertz crystal. The company's goal is a single-chip high-frequency design that will work with a small, 2-MHz crystal, making it possible to build miniature ladies' watches with digital displays, but meanwhile the firm plans to start selling the single-chip wristwatches in 1974.

FAA splits radio channels

In a move that will require aircraft owners to obtain new airborne radio equipment, the Federal Aviation Administration will begin to double the number of channels for radio navigational aids after January 1976. Channel spacing will be reduced from 100 to 50 kHz on the very-high-frequency unidirectional radio range, instrument-landing-systems localizers, and simplified direction-finding gear; and from 300 to 150 kHz on instrument-landing system glide-slope indicators on an as-required basis. In May, the FAA doubled the number of uhf communications channels.

RCA okays three satellites

RCA Global Communications Inc. and RCA Alaska Communications Inc. have chosen the company's AstroElectronics division, Princeton, N.J., to make three 24-transponder satellites for the $25.5 million second phase of the Domestic Communications Satellite System [*Electronics*, June 21, p. 72]. The first three-axis-stabilized craft will be launched late in 1975. Lockheed Missiles and Space Co.'s Communications Satellite Corp. and a team from Fairchild Industries and TRW Inc. also bid for the job.

Hughes simplifies display

Used to control the direction in which a weapon or sensor system on an aircraft is pointing, Hughes is developing a helmet-mounted holographic display that the company claims could overcome problems with present helmets. The display is said to be lighter, less costly, and less complex than other displays. A small cathode-ray tube and holographic lens project a virtual image at infinity without interfering with pilot vision. The Hughes study is part of a larger effort on visually controlled systems.

FAA buys Wilcox ILS

The Federal Aviation Administration has awarded a $11,509,975 contract for 101 instrument-landing systems to Wilcox Electric Inc., Kansas City, Mo., its largest single purchase of ILS equipment to date. Eighty-four units will be complete, and 17 will be partial systems. Delivery is to begin in 16 months and end in three years. A full ILS unit includes a localizer, for horizontal guidance to the instrument runway, a glide-slope signal, giving angle of descent, and two marker beacons to indicate the distance to the runway.

What good is the Age of Computers if you can't afford to join?

Remember all the wonderful things computers were going to do for you? They were going to solve your day-to-day problems. Lighten your burden. Free your mind for important decisions.

Then you found out what they cost and that was the end of that.

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Centralab perspectives

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One million cycles make this potentiometer the right choice for any application requiring high rotational life.

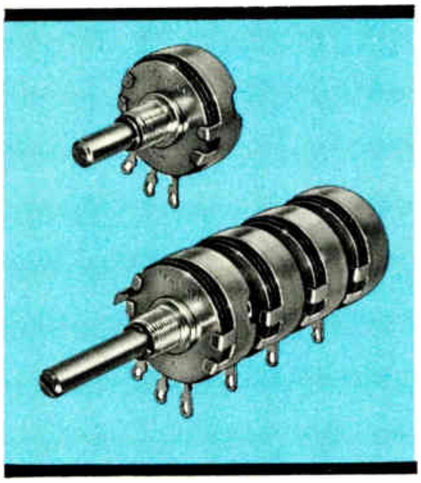
Meeting the demands of continuous motion or other extreme service, the Ultralife™ potentiometer finds use where extra life, reliability, smooth action and low noise are required.

Design and application engineers specifying potentiometers for high rotational life requirements, now have another choice with substantial savings in cost. From the extensive line of Centralab potentiometers comes the ULTRALIFE—a 2¼ watt hot molded carbon control.

The ULTRALIFE incorporates a specially developed Lifelon bearing that prevents the shaft from contacting the bushing. The bearing is self lubricating to guarantee rotational life exceeding one million cycles with smooth feel, uniform operating torque and an extremely low mechanical noise. Low contact resistance variation (CRV) throughout the long life of the potentiometer is assured by the use of a hot molded resistor track and contact brush. In addition, wear-resistant plating applied to the collector ring further maintains minimal CRV.

Today, ULTRALIFE potentiometers are being used in many industrial and commercial applications. Musical instruments like electronic organs and guitars. For servo-systems and motor drives. And in high temperature applications. With stainless steel cover and shaft, they meet salt-spray environmental requirements as well.

For full information on ULTRALIFE, write Centralab for Bulletin 1374P.



Available in up to four sections, Ultralife offers resistance values from 10 ohms to 5 megohms. Standard tolerances are ±20% to 499K ohms, ±30% to 5 megohms.

Unit No.	Initial Resistance	After 100,000 Cycles Resistance	% Ch.	After 250,000 Cycles Resistance	% Ch.	After 500,000 Cycles Resistance	% Ch.	After 1,000,000 Cycles Resistance	% Ch.
1	99.319 K ohm	97.998 K ohm	−1.33	98.079 K ohm	−1.25	96.839 K ohm	−2.50	94.979 K ohm	−4.37
2	105.350 K ohm	104.600 K ohm	−.712	105.190 K ohm	−.152	104.080 K ohm	−1.21	101.810 K ohm	−3.36
3	95.289 K ohm	94.629 K ohm	−.693	94.619 K ohm	−.703	94.089 K ohm	−1.26	91.849 K ohm	−3.61
4	108.360 K ohm	107.010 K ohm	−1.25	107.240 K ohm	−1.03	106.900 K ohm	−1.35	104.300 K ohm	−3.75
5	101.090 K ohm	101.060 K ohm	−.030	101.630 K ohm	+.534	101.660 K ohm	+.564	101.040 K ohm	−.049
6	99.059 K ohm	99.049 K ohm	−.010	100.020 K ohm	+.970	99.709 K ohm	+.656	97.839 K ohm	−1.23
			Av.−.670		Av.−.272		Av.−.850		Av.−2.73

Testing proves the reliability of Centralab's Ultralife potentiometer. After 1,000,000 cycles at 3,000 cycles per hour, resistance change averaged 2.73% for six tested units.

Circle 191 on reader service card

Centralab perspective:

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Circle 192 on reader service card

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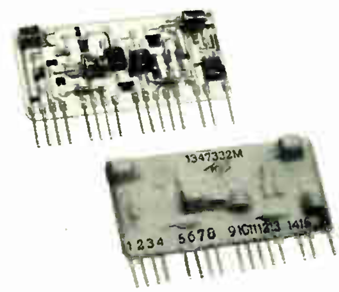
Need ceramic substrates for your hybrid circuits? For resistor networks? Capacitor networks? Centralab's got them in every shape and size. In aluminas of 99.5% and 96%. Plain or metallized. With holes, slots, notches, scorelines or plain. With accurate dimensions and a surface finish compatible with your particular needs.

The pay off with Centralab is high performance reliability right from the start. So start right and specify Substrate/ScoreStrate ceramics from Centralab. You'll end up with the same high reliability substrate found in Centralab thick-film circuits

For assistance on specifications, price and delivery, call Chuck Thompson, 414/228-2942 or write Centralab for Bulletin No. 1057TC.

Circle 193 on reader service card

Centralab perspective:



Two thick film hybrid systems. PEC and MEC.

Centralab offers the flexibility to design and fabricate thick film modules to fit virtually any application and cost parameter.

Low-cost silver/carbon or PEC systems for consumer applications:

- Resistor Range........10 ohms to 10 megohms
- Resistor Tolerance..±10% preferred minimum
- Ratio Matching...............±5% minimum
- Capacitor Types.........Ceramic and tantalum
- Active Devices.......Diodes, transistors & IC's
- Operating Temp. Range.... —55° C to +85° C

Noble metal/cermet or MEC systems for commercial and industrial uses:

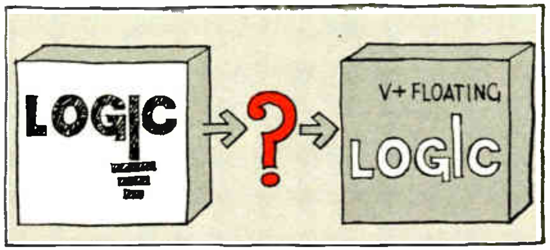
- Resistor Range..........3 ohms to 3 megohms
- Resistor Tolerance............±.5% minimum
- Ratio Matching...............±1% minimum
- Capacitor Types.........Ceramic and tantalum
- Active Devices.......Diodes, transistors & IC's
- Operating Temp. Range... —55° C to +150° C

For Bulletin 1429H write
A.R. Wartchow, Manager,
Electroceramic Marketing.
Outside U.S.A. contact
J.H. Meunier, Manager,
International Sales.

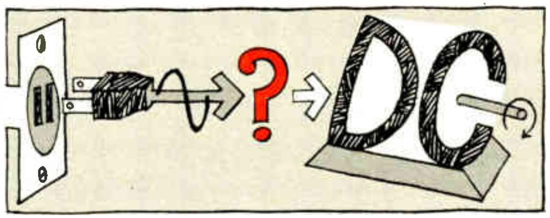
Circle 194 on reader service card

Find your control system interface problem here...

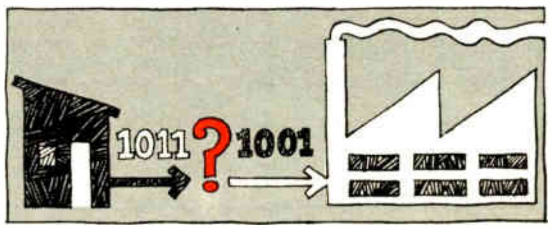
1. Incompatible Logic Families



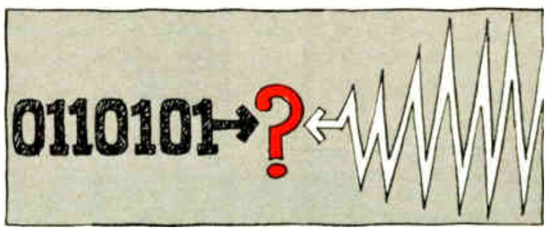
2. AC-to-DC Control



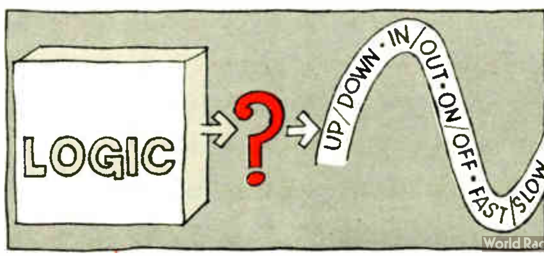
3. Controlling Remote Power Supplies



4. Voltage Transient Feedback

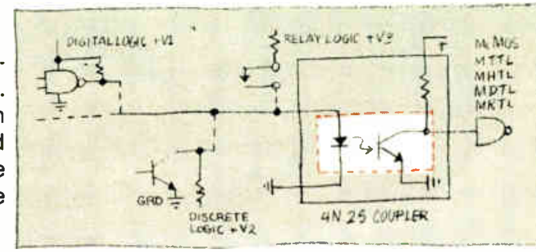


5. DC-to-AC Control

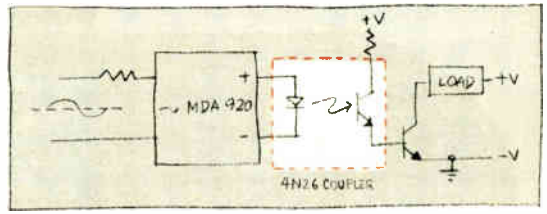


Then solve it with an optical coupler

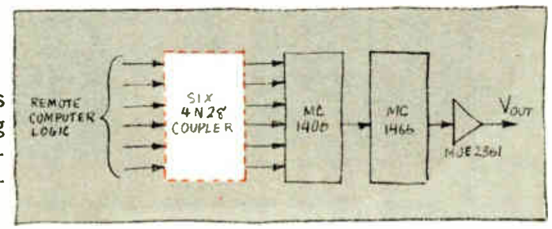
1. Logic-to-Logic Interfacing
Optical couplers afford total flexibility in logic family interfacing. Logic supplies can float with respect to each other, ground loops and intricate interface techniques involving voltage translators are eliminated.



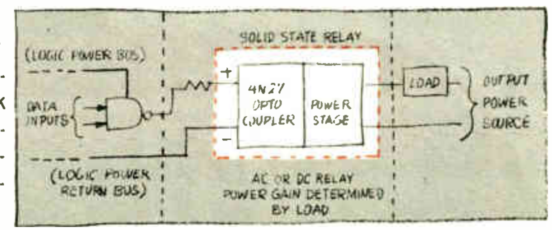
2. AC-to-DC Interfacing
AC signals actuate the optical coupler which controls the current through the DC load. Highly economical, the coupler replaces step-down transformers and obviates transient feedback.



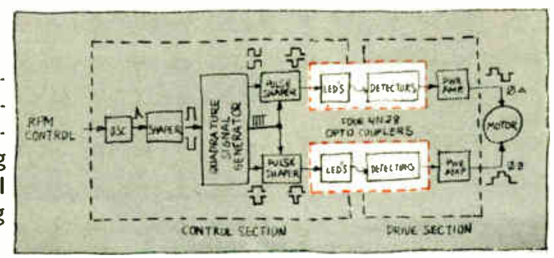
3. Remote Control Of Digitally-Programmed Power Supply
100-billion-ohm isolation affords control of a remote floating power source from the computer/peripheral without intricate biasing networks.



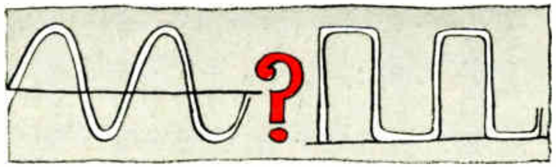
4. Logic-to-High Power Interfacing
One unidirectional optical coupler minimizes transient feedback from high power loads conventionally isolated through bidirectional transformers or RC coupling.



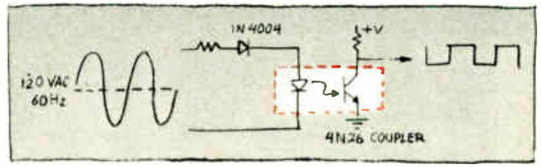
5. Logic-to-AC Control/Motor
Easy, economical control of high-level AC power without electromechanical relays and transformers is possible using low-level, 500-2500 V optical isolation. Miniature packaging and PCB plug-in are bonuses.



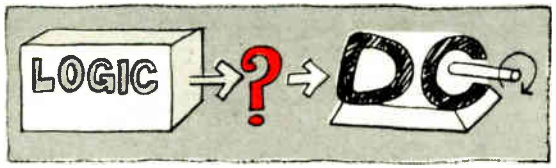
6. **Zero-Crossing Detection**



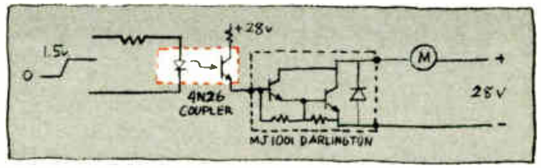
6. Zero-Crossing Detection
For applications requiring use of line voltage for synchronization purposes, an economical approach uses a coupler in place of a transformer.



7. **Logic Control Of DC Motors**

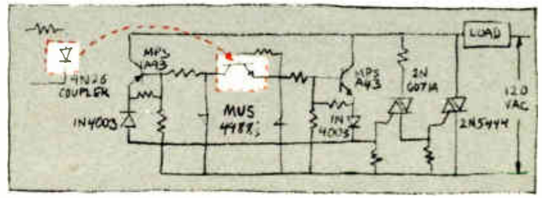


7. Logic-to-DC Motors
Traditional, long-term solid-state operation without arcing, bounce or wear-out is ensured with a no-moving-parts optical coupler and power Darlington transistor.



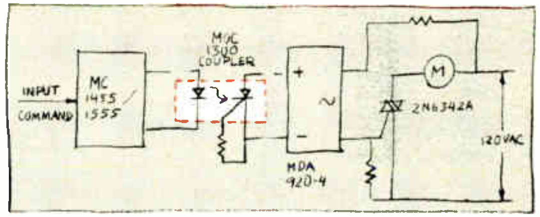
8. **Logic-to-AC Relays**

8. Logic-to-AC Relay
Control of AC loads from logic is easily implemented using optical isolation. Speed for zero-crossing actuation unavailable through E-M means, is provided by the total solid-state approach.

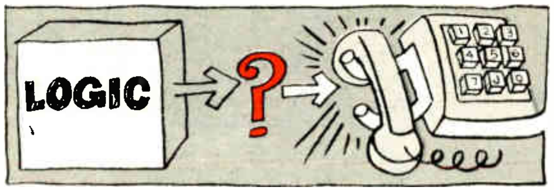


9. **Long Time Delay Relays**

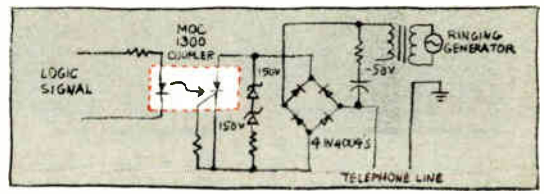
9. Long Time Delay Relays
Processing requirements needing precise mixing/metering through time delay can be met using the MC1555 timer and a coupler to isolate the logic/AC power source.



10. **Telephone Ringing Current Interrupt**



10. Telephone Bell Ringing Actuator
Limited contact life, high maintenance and EMI problems are eliminated with an optically-coupled bell actuator.



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problem solving

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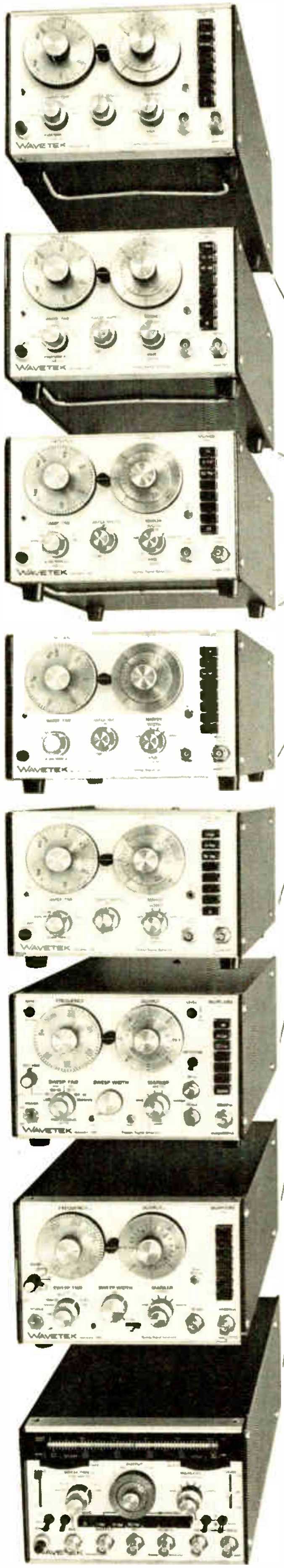
Circle 47 on reader service card



One thousand one...
one thousand two...
one thousand three...
one thousand four...
one thousand five...
one thousand eight hundred one...
two thousand...
two thousand one...

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*We also offer a complete line of attenuators and detectors covering the same frequency ranges.

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Washington newsletter

U.S. MNCs lead sale of technology know-how abroad

From the sale of American technological know-how abroad, **U.S. multinational corporations (MNCs) earned "four to five times" the $670 million to $680 million estimated for the U.S. for 1972,** say National Science Foundation officials. **But these dollars "are not counted" in published Government figures,** they say, because payments for technology transfers within the multinationals, involving patents, manufacturing rights and licenses, need not be reported.

U.S. receipts from such sales in five high-technology industries, including the manufacture of electrical and electronic equipment, aircraft and parts, and professional and scientific instruments, soared from a low of $244 million in 1961 to more than $621 million a decade later, according to the Commerce Department. **Japan, according to the NSF, has been a major buyer.**

FCC expected to assert its intrastate power

Though sources in the interconnect equipment industry confidently expect **the Federal Communications Commission within the next few weeks to assert jurisdiction over the states on interconnect devices,** following hearings Oct. 30 on North Carolina's counter-proposals, they are uneasy as to how far the commission will go. **North Carolina is claiming the right to stop interconnection equipment provided by other than a telephone company from being linked to intrastate phone circuits** [*Electronics*, Sept. 27, p. 74]. The commission could rule outright that North Carolina is out of bounds, but is believed to be more likely to issue a policy statement. Either way, in asserting jurisdiction, **the FCC will be setting the stage for a court test,** observers predict.

Engineers think again about split with NAS

After threatening to split with the National Academy of Sciences last spring [*Electronics*, April 12, p.36], the National Academy of Engineering is reconsidering and may stay within the NAS after all, if its members approve a plan now being thrashed out between the two bodies. **The present draft leaves the science academy in charge and limits NAE's autonomy.** The engineering academy would function as one of four assemblies under the National Research Council dominated by the science academy. And, although its executive committee would serve on the council and its president would remain as vice chairman of the council's governing board, **previously independent NAE projects would have to go through the council for approval.**

Addenda

The National Oceanic and Atmospheric Administration is exercising its option to **buy two more geostationary operational environmental satellites (GOES) from Philco-Ford** [*Electronics*, Aug. 2, p.64] **for an estimated total of $10 million to $15 million.** The company also may build similar satellites for Japan and Europe for their part in a global satellite weather watch which they, along with the U.S. and the Soviet Union, are due to start in 1976. . . . Noting a **"substantial growth in the number and size of criminal justice information systems,"** a Law Enforcement Assistance Administration commission proposes that **every state establish systems** for use by all its agencies and ensure the systems' privacy, and that **each police agency "have a well-defined information system"** of its own.

Detente with the National Science Foundation

If this is the dawning of the Aquarian Age when men come to accept their brotherhood, share their knowledge and live in peace, there are few signs of it this dark autumn in the national capital.

But one slight sign appeared not long ago in the conference room of the National Science Foundation, citadel of America's academics and lobby for its scholars. There, at October's end, some 25 of the country's top corporate research and development chiefs and industry trade association executives assembled for their first meeting with NSF director H. Guyford Stever and four principals of his staff to exchange views on U.S. science and technology policy. As with any detente, the day-long session was slow going, once the briefing documents had been set aside. Nevertheless, the industrialists had breached the foundation's walls.

Data versus policy

There was something of an Old Boy atmosphere to the session because many members of the industrial boarding party know Stever well through their backgrounds in R&D and strong ties to the academic community. Yet the mood was shattered periodically by some sharp questions for which Stever had no strong answers. When Stever stressed NSF's new and comprehensive effort to collect data on the state of U.S. science and technology and its relative position in the world, some in the audience sought to determine the impact of those efforts on U.S. policy. "They were shouting 'Policy! Policy!' and Stever was answering 'Data! Data!' " mused one NSF staffer later.

If Stever doesn't know yet how to apply the new data in the formulation of policy before the figures turn cold, it is probably because the functions of a Science Adviser to the President, which were also recently assigned to him, have diminished authority and responsibility under the Nixon Administration. Moreover, one longtime critic of Stever contends, "The man is not a policy-maker. He administers well, negotiates options well, and is good at most everything else. But he's just not tough enough to make strong policies and push them through" to Government adoption.

Nevertheless, Stever and his people can be justifiably proud of their newly published indicators, put together by the National Science Board. The 143 pages of analyses, with their 68 charts and tables, represent the best national effort yet to assess the strengths and weaknesses of Government, corporate and academic R&D and their relationship to the rest of the industrial nations of the world (see p. 79). Yet Stever's equanimity was somewhat rattled during the session when Electronic Industries Association president V. J. Adduci bluntly asked: "Now that we have got the information, what is going to be done with it?"

Do it yourself

Despite its indelicate phrasing, the question was a good one, and Stever proved an artful dodger at first. Yet he came back to the issue later when he noted that the assembled company and trade association representatives had disparate interests that probably precluded agreement on any single interpretation of the new indicators. In effect, Stever said, industries can employ the data any way they want. He suggested further that the time has come for industries to start making more decisions on their own, rather than waiting for Government to tell them what they must do.

For the high-technology aerospace and electronics industry men at the table, that was probably the most meaningful message of the day. Long dependent on Government funds and the precise guidance contained in mission-oriented requests for proposals, some corporations need weaning from the Federal breast if they are to compete successfully in the marketplaces of the world.

The National Science Foundation under Stever has opened its doors to industry and is listening to what it has to say. This change has resulted from no little amount of urging from Congress and the White House. They want NSF to turn more of its attention to science and engineering applications in society rather than contemplate the future of basic science. In this new accommodation with industry, there is still much to be done on both sides. For one, industry must not misread NSF's charter and expect more than the foundation is able to deliver.

Guy Stever and his colleagues are essentially thinkers who can perform useful services for industry by collecting and interpreting information on the state of U.S. and other national technology programs. They can also provide seed money and coordinate national pilot programs, as they are now doing under five experimental R&D-incentive programs. But they cannot and will not perform the functions of organizations such as Japan's Ministry of International Trade and Industry. And, as one NSF staffer told his audience, "Government in the civil sector is not going to repeat NASA by selecting national goals from monumental proposals" from industry.

—Ray Connolly

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Telecommunications market in France is up for grabs

Sides are being drawn in France for what promises to be a long and bitter fight over French telecommunications. The issue at stake is who is going to get what share of the country's fastest growing major industry.

The inadequate telephone system has been a major embarrassment to France for years. Now, for the first time, a massive effort is under way to beat the chronic overloading with an investment spree that will include a steady movement to electronic switching equipment.

Stakes. The rewards will be huge. Orders for public telephone hardware will be close on $1 billion this year. Total French telecommunications business will double between now and 1976 to top $2.3 billion. By 1980, the business will have grown to $4.6 billion—about the present size of the French auto industry.

The fight is essentially between the ITT group and the Compagnie Général d'Electricité. Both concentrate on switching equipment, which makes up roughly two thirds of the business. Reigning champion in the business right now is ITT with 43% of the public telephone switching-hardware orders last year. CGE subsidiary CIT-Alcatel came second with 32%.

But the Pompidou administration wants an all-French champion. Government planners propose that CIT-Alcatel work closely with Sweden's Ericsson to form a powerful contender in the electronic exchange business—which will take the major part, if not all, of the French market and challenge ITT and Siemens on export markets. In the French switching business as a whole, the planners want to push ITT's share down to at least 35%.

Places. But ITT has a head start over CIT-Alcatel. It has a semielectronic system, the space-division Metaconta, ready to install. In fact, a modified version is already installed as a private exchange at a new French airport. Another is in operation in Morocco, and others will go into service in Las Vegas, Nev., and Mexico early next year. What's more, the Metaconta can handle up to 30,000 lines, while the French all-electronic Platon, a time-division system, in its present experimental form can only handle up to 3,000 lines.

CIT-Alcatel is racing to catch up. A bigger experimental system is being installed right now in a French provincial city to handle 6,000 lines, but there are rumors that the upgrading has caused technical problems. For the really big exchanges with capacities of 50,000 lines and over, the ITT and CGE groups are neck and neck. Industry sources say that both companies now have pre-prototype models that work on C-MOS technology.

While the planners plug for the CGE group, the government department in charge of telecom-

Around the world

Device checks contact intermittency

When connectors have to be checked for what is technically called intermittency performance, the test is normally done by putting a constant current through the contacts. The current flow rises and falls as the contact pressure varies, and the parallel voltage variation appears on an oscilloscope. Because of the difficulty in isolating the scope from all the noise produced by the vibration-generation equipment, the true signal often gets lost. Now, Plessey Co.'s product-assessment laboratories, in Titchfield, Hampshire, has built an instrument to check connector intermittency performance against a spec. It was on show at the recent Internepcon Exhibition at Brighton, England.

The spec is entered into the instrument as two thresholds: the maximum change in contact resistance that is normally tolerable and the maximum time duration that an individual excursion over the limit can be permitted. Every excursion outside those two thresholds taken together is counted and the total displayed. Plessey's prototype has 10 identical channels and is isolated from the powerline and screened so that it will operate reliably in a noisy test environment. The minimum resistance change detectable is about 25 milliohms and the maximum 200 ohms. The minimum pulse duration over the resistance threshold that can be selected is 1 microsecond, the maximum 1 second.

Car-engine governor is all-electronic

An electronic engine-speed limiter from West Germany's Siemens AG, automatically shuts off a car's ignition when the rpm value exceeds the allowable limit for the car. The limiter works in conjunction with a transistorized ignition system that Siemens developed some time ago. Siemens experts figure that within two or three years, transistor ignition units will be mass-applied on some car models. This should then boost sales of the rpm limiters as well.

Essentially what the new Siemens device does is suppress as many ignition sparks as is necessary to keep the rpm value from becoming critical. In effect, it shuts off the ignition at the upper limit of the permissible rpm range and allows it to come on again when the engine revolutions have dropped back down to the preset permissible value. This switching action causes the engine to shake slightly, which signals the driver that he has reached the rpm limit for that gear.

munications, the Ministry of Posts and Telecommunications, (PTT), wants a system that is cheap, proven, and easy to install. And only ITT has anything to offer right now. What's more, the PTT is reluctant to start putting development money into an upgraded Platon system when it already has an enormous investment program.

The split between planners and PTT executives is now thought to be leading to an old-fashioned compromise that will give the big systems business (30,000–50,000 lines) to Metaconta and the smaller systems to the fledgling Platon. But what the exact share will be is anybody's guess.

In between. Meantime, the other big electronics group in France is not standing idly by. Thomson-Brandt is already making a firm bid for a big stake in the transmission business currently cornered by several smaller companies. Before year-end it will formally join an official transmission-systems builders' club—Socotel. As for the switching business, Thomson is not even ruling out an eventual crack at that market. "We have no intention of entering the switching business in the near future," hedges Edouard Guigonis, marketing vice-president at the Thomson subsidiary, Thomson-CSF, which handles the telecommunications business.

The haggling with CGE and the government to determine how much business Thomson will get is just starting now. Back in 1969, Thomson and CGE signed an extraordinary agreement giving Thomson the consumer product business in exchange for CGE's monopoly of the telephone business. But even the glow of the booming color-TV business looks dim beside telecommunications, and Thomson has hardly been able to wait for the end of 1973, when the pact must come up for review prior to its expiration at the end of next year.

The outcome is already taking shape. Thomson will get a foothold in telephones and may even join CGE in a joint export venture to sell French telephone systems— another idea dreamed up by government medium-term planners. But not warmly welcomed by anyone in industry. □

All aglow. AEG-Telefunken's gas-discharge display allows 27 special symbols in addition to 36 alphanumerics. Decimal point and position indicator are available, too.

West Germany

Gas discharge runs large-area display

A new breed of large-area alphanumeric display, which offers high character-generating speeds and low power consumption, is being prepared for a market debut by the middle of next year. The display, from AEG-Telefunken and called the Varisymbol, uses gas-discharge elements with segmented symbols as indicating devices.

These devices, which consume only 1 milliampere per segment, use less current than some other types of display elements. The total power required to produce a character on the Varisymbol display suitable for, say, airline arrival listings is about 1 watt. This means that relatively thin interconnecting wires can be used, something that cuts down the weight of the display board considerably, AEG-Telefunken says.

Speed. To light up an element takes only 50 microseconds. With such fast response time, information can be written at speeds of 20,000 characters per second. Element lifetime, the company says, is between 20,000 and 100,000 hours.

Electrically and mechanically the system is modular, offering a large degree of freedom in the choice of layout, size of display surface, and number of display elements. With the addressing scheme employed, an indicator board can have up to 2,048 characters arranged in 64 columns and 32 rows. A maximum of eight such boards can be hooked together to make for a display with more than 16,000 characters.

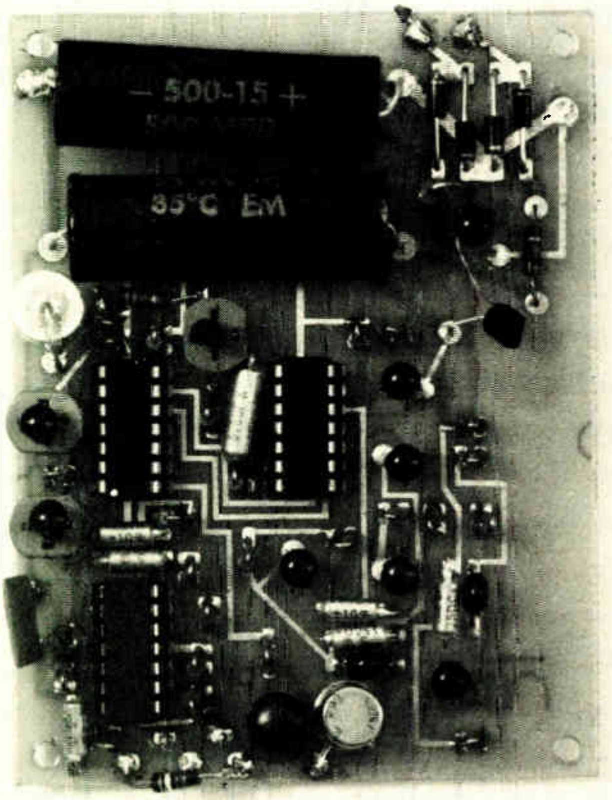
The elements for the display come in three versions: with characters 20, 40, and 60 millimeters high—sizes that allows viewing distances between 6 and 75 feet. With the 14-segment devices, a total of 63 different characters—36 alphanumerics and 27 special symbols—can be displayed. Besides the 14 segments, each element has two additional segments, one serving as a decimal point and the other as a position marker.

Operation. The indicating elements are about ¼-inch thick. Serving as the element's common anode is a thin transparent gold layer on the inner surface of the glass cover plate. The individual segments constitute the cathodes.

A dc ignition voltage of about 130 volts applied across the anode and a particular cathode causes a segment to give off bright orange-colored light. Its luminance intensity is about 850 candelas per square meter, corresponding to roughly 250 foot-lamberts. The element's conducting and erase voltage values are 135 and 125 volts, respectively.

For control, the system uses a 24-bit word, which an input register accepts either in parallel or serial form. The word contains the address for the rows and columns as well as the symbol information. If several boards are hooked together the word also contains the board address. □

The Kluge Vs. Monochip



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Commercial radio comes to Britain

Commercial radio broadcasting has started in Britain with the opening last month of two local services in London. **Five more major cities will have commercial radio services in the next year and another 11 by the fall of 1976.** The operating companies are independent but have to conform to standards laid down by the Independent Broadcasting Authority, the governmental agency that also supervises commercial television. IBA also provides the transmitters. Each service will have medium-wave and vhf broadcasts, and for the latter transmissions IBA is introducing circularly polarized transmission into Britain. So far, radio broadcasting in Britain has been horizontal or slant polarized, but circular polarization helps vhf car-radio reception.

Japan moves closer to its first practical satellite

Japan's first practical satellite is one step closer to being launched into orbit. Japan's National Space Development Agency awarded to Nippon Electric Co. a contract for basic design of a geostationary meteorological satellite. The contract calls for a complete basic design by next March 30. Nippon Electric is expected to land the follow-on contracts for completion a year later of a detailed design and for fabrication and test of two satellites, one each for mission and backup, by mid-1976. **The satellite will be launched by NASA into a stationary orbit above the equator at 140° east longitude by end of calendar 1976.** The mission includes gathering of cloud pictures, collection of meteorological data, distribution of data to users, and space measurements. Life will be about three years.

Nippon Electric has a technical tie-up with Hughes and will use Hughes technology for both bird and camera, but the contract is solely to Nippon Electric. The company beat out Mitsubishi Electric Corp., which would have used Philco-Ford technology for the satellite. Mitsubishi planned to use a camera being developed in France for a European satellite.

French giant makes moves abroad

Thomson-CSF is staking out some international claims in the world components market. Thwarted so far in its efforts to reach agreement on a joint venture with Germany's AEG-Telefunken, Thomson-CSF is reaching out to the Southeast Asian market through a new joint venture between its component packaging subsidiary and the Swiss Plating Corp., owned by the Hong Kong-based finance group, Jardine Matheson. **The new company, Hong Kong French Electronics, will manufacture and sell packaging products such as headers and lead frames for discrete and integrated semiconductors.** Target area will be Japan, Southeast Asia, and Australia. Using French technology, the first products will be launched onto local markets next spring.

This is the second big Thomson-CSF initiative recently. Last month, the company signed a technical agreement with Signetics Corp., Sunnyvale, Calif. Thomson-CSF's semiconductor division, Sescosem, wins access to some Signetics' know-how and will get help with design of advanced circuits, except in the area of wafer diffusion processes. Both agreements fit in well with French government planners' hopes of developing the French components business to a level where it can compete more effectively with its foreign rivals.

International newsletter

Camera system warns of changes in monitored scene

Engineers at Siemens AG have added still another piece of monitoring equipment to the company's growing arsenal of theft- and pollution-control systems. Basically a remotely controlled low-light-level TV camera coupled to a signal-storage unit, it gives an optical or acoustical alarm whenever the camera spots a movement or variation in the scene that it is picking up. In an unattended mode of operation, it first records and **stores the video signals of a particular object, then continuously compares them with the signals of subsequently taken pictures** and responds to any deviations from the originally recorded image by giving the alarm. The system, called Telemat A, has a picture resolution of 3,200 image points.

Besides jobs like guarding bank safes and other critical areas in a theft-control application, it can handle the detecting of **variations in the composition of sewage waters and the spotting of irregular and pollution-causing combustion processes.**

Plessey expands LED operation

Plessey Co. is building a production line for gallium phosphide green and yellow light-emitting-diode material and will have it running in volume by early next year. The company plans to produce about 1,000 square inches a week of vapor epitaxial slices for subsequent zinc diffusion and metalization by customers, and up to 200 square inches a week of fully diffused and metalized slices. Plessey men say several LED makers and users have shown interest in the material as a basis for bright yellow displays. **Plessey has, in fact, built a complete monolithic yellow seven-bar numeric module,** which it will announce soon, **but would rather concentrate on supplying base material to LED makers and building complete displays** only to custom order.

German firm markets compact receiver for satellite photos

West Germany's Rohde and Schwarz is putting the finishing touches on Europe's first commercially developed system for receiving very-high-resolution-radiometer pictures from U.S.-built metereological satellites. The satellites, orbiting the earth at a 1,400-kilometer altitude, provide a maximum resolution of 0.9 to 1 kilometer. The R&S receiving system, designated RW072, will be shown operating for the first time at the company's Munich facilities later this year. **It features automatic tracking and automatic processing of analog picture signals into finished photos, as well as storage of one day's worth of VHRR pictures.**

Of note is the system's high gain—31 dB—and relatively small antenna area—only 2 by 2 meters, or roughly 6 by 6 feet. Overall system weight is less than 970 pounds, which is light enough to eliminate the need for heavy pedestals. The first customer is the Institute for Meteorology and Geophysics in West Berlin. R&S plans call for an initial production run of 10 such systems.

Two more companies sign up for Telefunken's disk

Add two more names to the growing list of companies that have acquired rights to produce and sell the Telefunken/Decca-developed TED video disk system. They are Japan's Sanyo Electric Co., of Osaka, and the King Record Co., of Tokyo. While **Sanyo will concentrate on manufacturing and selling the TED playback unit, King Record will handle production and distribution of the TED video disk.** A Telefunken spokesman in Frankfurt says marketing the system will initially be restricted to Japan.

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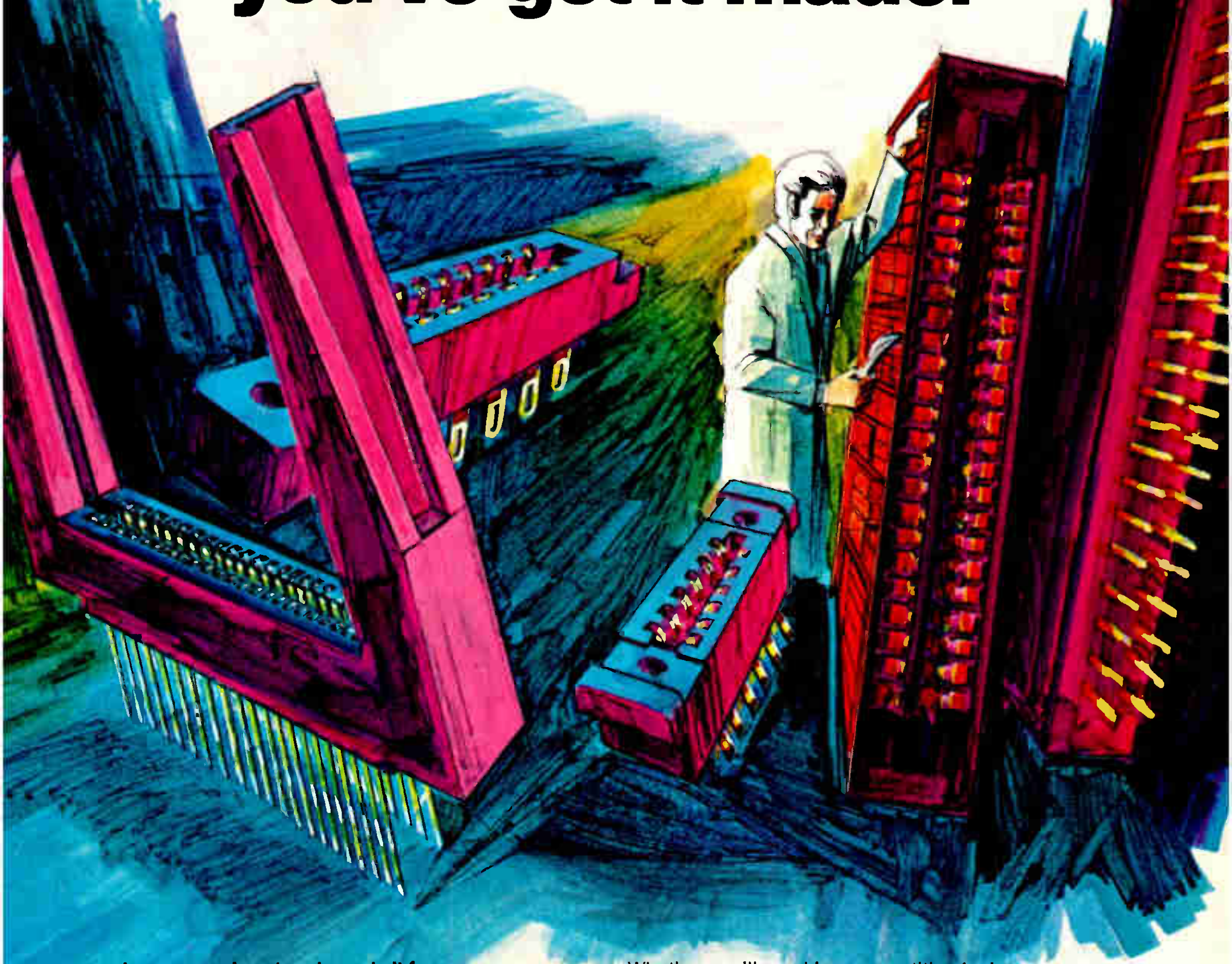

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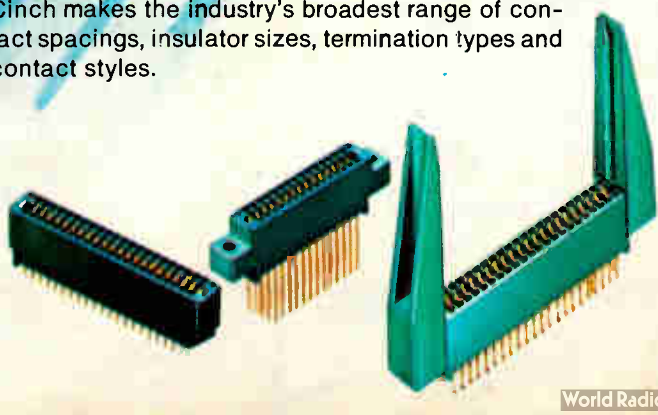

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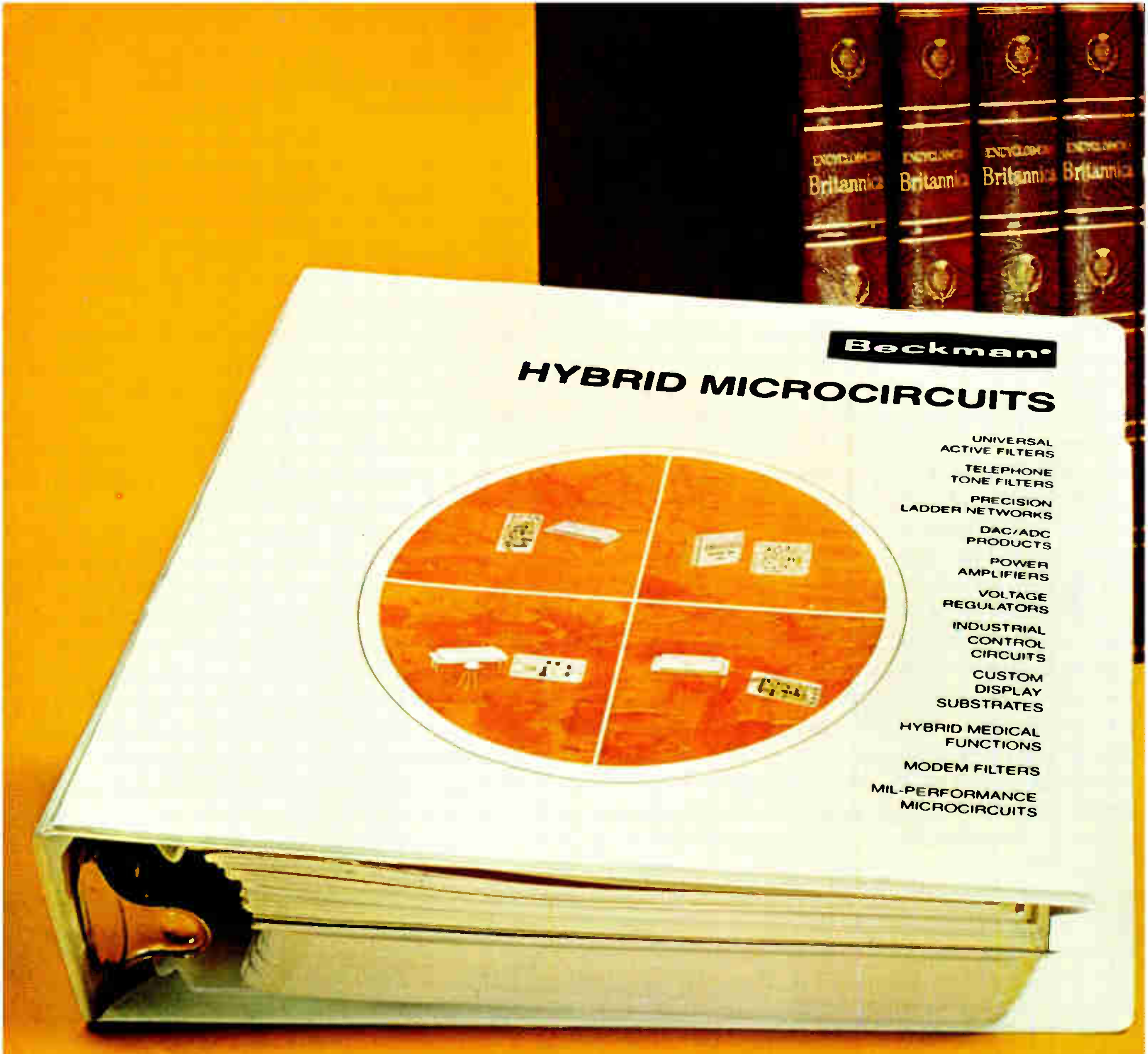

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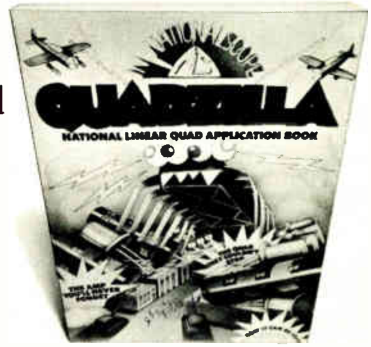

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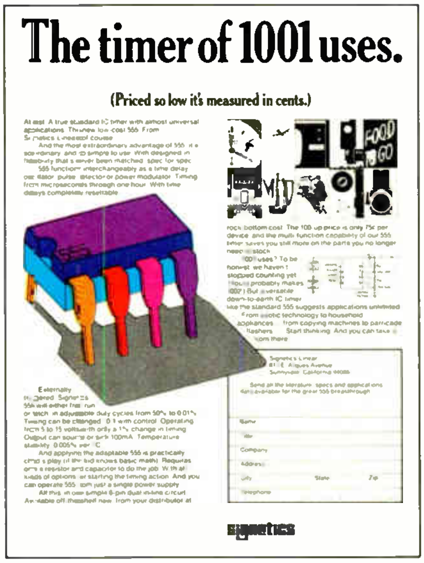
556: A real IC two-timer.



Man, did you inundate us with applications for the 555 single timer. You used it for every possible function from light switches to audio generators to RF outputs. And then, you often used a second 555 to control the function you'd generated with the first one.

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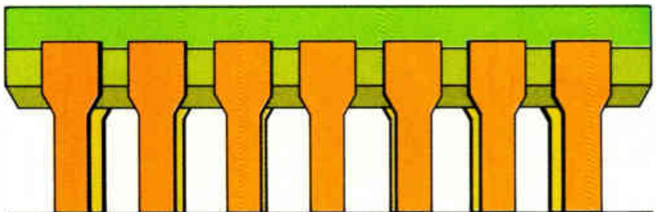

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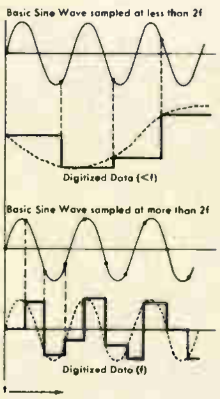
Patstone Writes.
Digitizing dynamic data.

Did you ever consider that *aperture time* and *sampling rate* may not, depending upon the application, be directly related? That they may be separate considerations to the designer converting dynamic analog data into a digital format? Well, they may not necessarily go together, but there is no doubt that they are the two most basic pieces of information required in data conversion system designs. Let me explain.

Know your frequency.

First, it is extremely important that the designer know the highest frequency component of the dynamic waveform to be digitized, since if you sample the data at less than twice the frequency of the highest signal component you build into the digitized data a non-recoverable low-frequency component; i.e. you will alias your data as shown. Thus, the frequency spectrum of the data to be sampled puts a lower limit on *sampling rate.*



Know your accuracy.

Next it is essential to know the accuracy required of the total conversion system, often specified in percentages of full scale or in numbers of bits. Tying accuracy with the idea of the dynamics of the wave form itself, it should be evident that you only have a limited period of time to convert the data. If during this *aperture time* the signal moves more than the allowable amount, you're in trouble. Since the slope of a sine wave is maximum when it passes through zero, a sampling window at this zero-crossing point produces the greatest sampling error and the formula shown below clearly indicates that the error voltage as a percentage of full scale is proportional to the product of the frequency and aperture time (Δt).

$$\text{Percentage Error} = \frac{\Delta V}{A} = 2\pi f \Delta t$$

Where ΔV = Aperture Time Error
A = Maximum Signal Amplitude
f = Maximum Signal Frequency
Δt = Aperture Time

So, given a certain percentage, the higher the signal frequency, the smaller the allowable time window to freeze the data.

Know your application.

In many applications the conversion time of general purpose ADC's will produce insignificant aperture time errors. However, in more demanding applications that require high speed data conversion, high signal frequencies force window times to nanosecond levels, where two distinctively different solutions to conversion problems are possible. You can use a very high-speed Analog-to-Digital Converter to freeze the data accurately just because of the very short conversion time of such devices. Unfortunately, they are damn expensive! Alternately, you can use a high-speed sample-hold amplifier with a low aperture time, holding the data long enough to permit a slower ADC to perform the conversion.

For many applications this combination of high-speed sample-hold and moderate-speed ADC represents the best price performance trade-off.

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Product Manager

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RCA Solid State bounces upward

1973 shipments to total $150 million, up from $100 million in 1972, in wake of reorganization and decisions to emphasize certain lines

by Alfred Rosenblatt, New York bureau manager

Once known as merely another vacuum-tube manufacturer that didn't quite make the transition to ICs, the RCA Solid State division may finally have some numbers that tell quite a different story. After 1972 sales of nearly $100 million, the division should do $150 million in '73, analysts say. And in 1974, the division's business will grow by about 30%, some three times the rate expected for discrete and integrated-circuit devices in general, says Bernard V. Vonderschmitt, vice president and general manager of the division [*Electronics*, Feb. 1, p. 14]. This growth has been accomplished through a reorganization, and, perhaps more important, by concentrating on some of the hottest semiconductor product lines—complementary metal oxide semiconductors and linear ICs.

Well over half of the standard complementary-MOS devices being sold today are probably RCA's. Estimates indicate worldwide C-MOS sales may reach anywhere from $36 million to $48 million by the end of 1973, and they could grow to $320 million by 1978. This latter figure would represent about 20% of the total sales of MOS and transistor-transistor-logic devices.

In addition, RCA claims to be the largest supplier, with more than 50% of all sales of linear ICs for consumer applications, a market it began to develop back in 1964. Sales of linear circuits for industrial applications are also climbing from $350 million worldwide in 1973 to a projected $800 million in 1978. The division is also a leading supplier of silicon power transistors, a $300 million market in 1973, which Vonderschmitt predicts will total $520 million in 1978. Other areas of Solid State involvement include thyristors, which had total worldwide sales of $155 million in 1973, and rf power transistors, a $60 million market.

The foundation for RCA's current surge in semiconductors was set back in April 1970 with the arrival in Somerville of William C. Hittinger as general manager. At Hittinger's behest, semiconductor operations were pulled out from under the control of the company's Electronic Components division, an operation charged with manufacturing and marketing such products as vacuum receiving and TV picture tubes, vidicons, and lasers, in addition to semiconductors.

By this move, semiconductor operations achieved greater visibility within the corporation, and Somerville could style its organization to meet its specific needs. "We were able to get more direct access to the top echelons of RCA," explains Vonderschmitt, "and it allowed us to establish our own separate sales force and distributors."

Division commander. Bernard V. Vonderschmitt runs RCA's Solid State division.

Organization streamlined. In the new structure, Hittinger created five profit-and-loss centers built around specific product lines, a practice prevalent in the electronics industry. Separate engineering, manufacturing, and marketing responsibilities now exist within each product line. Initially, the product lines consisted of C-MOS, which RCA's David Sarnoff Research Laboratories in Princeton, N.J., had developed back in 1963; linear ICs; power transistors; thyristor/rectifiers; and radio-frequency products. Since Vonderschmitt took over the division last January, two other profit-and-loss centers have been added—high-reliability ICs in September 1972, and liquid crystals.

The division also made some tough but salutory marketing decisions. Early in 1969, the development of saturated bipolar logic devices was discontinued, and C-MOS technology was pursued instead. Vonderschmitt acknowledges that "we were too late" in bipolar. Diode-transistor and transistor-transistor-logic devices were being marketed by some tough competitors, and prices were already being cut sharply. Instead, RCA decided to bank on its C-MOS-logic development in which it was a pioneer and had a head start. RCA was convinced that C-MOS, with its low power dissipation, high noise immunity, and low voltage-supply requirements, has a broad range of applications. And the advent of the plastic package in 1971 made the technology feasible for industrial and commercial, as well as aerospace, applications.

In 1971, RCA also decided to get out of the high-speed emitter-coupled-logic business, except for meeting requirements of its now-defunct computer operation, which consumed about 4% of the division's output. The market was large but not large enough, and the number of customers involved was small. In addition, other technologies—such as Schottky TTL—were sniping at it, says Vonderschmitt and, because it is "an intrinsically complex technology," ECL required a relatively heavy R&D investment. A similar decision was made to avoid the larger power transistors—above 100 amperes—and concentrate on medium-current (35 to 50 amperes) rectifiers for such applications as the automotive business. The division doesn't make thyristors with capacities of 1,000 A and higher.

It's interesting to compare the division's big sellers of 1970 and today. First at that time—and now—were power transistors. Second then—and now—were linear ICs for consumer applications. And third were thyristors, as they are now. But there is this major difference: C-MOS didn't appear on the 1970 list; today, it's challenging for the third spot with every indication that it could go even further. Also unchanged is the overseas sales figure: 25% of the total.

C-MOS pays off. RCA faith in C/MOS is being well-rewarded. RCA is already one of the major suppliers to the automobile industry for seat-belt interlock systems, and of C-MOS for digital clocks. But these two applications represent less than 15% of the division's total C-MOS output, asserts Harry Weisberg, manager of MOS ICs.

The applications are exceptionally diverse, he points out. Units are going into such equipment as point-of-sale and computer terminals, other computer peripherals, telephone-switching equipment, modems, and other communications gear. More than half of the sales are, incidentally, going through distributors, a factor that makes it difficult for RCA to know exactly where the C-MOS winds up.

Linear-IC sales are also growing fast. Vonderschmitt regards Solid State's engineering staff here as one of its strongest, having "as many patent disclosures as all of the rest of the divisions for the first half of the year." Consumer applications will continue strong, and industrial applications are beginning to find markets for controls and instrumentation, computer interfaces, and communications. "Our new design activity is very healthy," says linear marketing manager Julius Lempner. "We're going to see many new designs and equipment applications in 1974 and 1975."

New products ahead. Vonderschmitt predicts that RCA will make several important technology announcements in 1974. Among them, he expects to see more C-MOS circuits that are specially designed for linear operation. This follows disclosure earlier this year of C-MOS designs that have merely been characterized to operate linearly.

RCA also plans to turn over a "great deal of manufacturing" to ion-implantation technology, Vonderschmitt continues. Plans are also under way for getting people committed to designing products for semiconductor memories using charge-coupled devices. "We're very well structured in MOS, but we've totally neglected the semiconductor-memory market," says Vonderschmitt. "It's a different market, and it needs a group of people committed and thinking about it. We can't do it as an extension of the C-MOS business." Although it's early to say what roles CCDs will play in memory hierarchy, Vonderschmitt believes the technology should begin to display some market impact by 1977.

But one thing the division won't do is go into the calculator or watch end-equipment business. It intends to remain a component supplier, rather than compete with its customers.

The company is also investigating C-MOS circuitry fabricated on sapphire substrates, in which Vonderschmitt expects the "next most significant jump in technology" to occur [*Electronics*, Oct. 11, p. 82]. However, it isn't yet possible to define clearly the market relationship between C-MOS-on-sapphire and standard C-MOS.

"From a performance standpoint, the advantages are certain," Vonderschmitt says. "Speed will be increased by three to five times; power dissipation will be decreased by at least a factor of 10. But just how the cost of the new devices will fit in is yet to be determined.

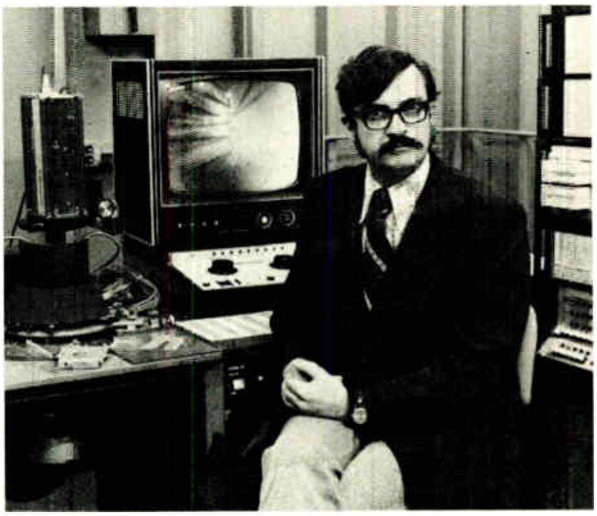
"If costs are increased by as little as 5% through the sapphire-substrate approach, you won't replace standard C-MOS," he continues. "It will be used only where the improvements are needed."

Building plans. As is not too surprising for an organization that should increase its sales by half this year, the Solid State division is finding it necessary to add capacity and employees around the world. While it now numbers 9,000 workers at its plant sites, it expects that number to be 11,000 by the end of 1974. At the same time, space will grow considerably from the 1.1 million square feet that the division calls its own in the U.S. and overseas.

The Mountaintop, Pa., plant, which does wafer preparation and assembly and test of transistors, rf devices, and thyristors, and the division headquarters site in Somerville, N.J., are both on the expansion list. These, in addition to the division's other facilities in Liege, Belgium; Findlay, Ohio; Sunbury-on-Thames, England; and Taiwan, are running at capacity.

Vonderschmitt says the plants are straining to meet their orders, and sizable increases in space and facilities are planned. Last month, RCA announced it was beginning construction of an $8 million manufacturing facility with 84,000 square feet of space in Malaysia. Production of ICs and power devices is scheduled to begin there in September 1974. Some 100,000 square feet have been added this year in Mountaintop, and more will be added in Somerville. Plants and facilities are expected to be expanded at a fast pace through 1974. One estimate places the total investment during 1973 and 1974 at more than $50 million. □

"We figured their W311 for a 15-month payback. We figured right."



John Thome
Manager, Microelectronic Engineering
Allen-Bradley Co.
Milwaukee, Wisconsin

Fast payback on high throughput. That's what Allen-Bradley demanded when the company went shopping for a laser trimmer a year ago.

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Now, 6,000 grueling hours later, John Thome can report that "our payback is right on schedule." Up to 15,000 resistors an hour go through the W311—24 hours a day, six days a week. Downtime is minimal. Remarkably, what few service problems have cropped up have usually been solved by a single phone call to Teradyne's service bureau.

What Allen-Bradley is trimming is thick-film resistor networks to be DIP-packaged. Typical trim accuracy required is 1 to 2%, with some 0.5%. If you know Allen-Bradley, you know each trim has to be every bit as clean as it is accurate and fast.

Would Allen-Bradley buy the W311 again?

"We not only would, we did," says Mr. Thome. "Our second system was delivered in April to increase capacity."

Fast payback is one good reason why more than 50 Teradyne laser trimming systems are now working overtime all over the world. To get the full story, write: Teradyne, 183 Essex Street, Boston, Massachusetts 02111. In Europe: Teradyne Europe S. A., 11 bis, rue Roquépine, 75 Paris 8ᵉ, France.

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PABX systems do battle in Europe

IBM to unveil its new 3750, but won't say if it is—or isn't—headed for U.S.; ITT, GTE, and Europeans also vie in growing $800 million PABX market

by Michael Johnson, McGraw-Hill World News

Europe is fast qualifying as a proving ground for new automatic private phone exchange (PABX) equipment. Advanced all-electronic or semi-electronic systems by the hundred are arriving in the marketplace from major U.S. manufacturers and some Europeans.

Even IBM, which has shied away from the U.S. telephone business for political and other reasons, has more than 100 of its model 2750 PABX operating in six European countries, and this fall will begin delivery in those countries of its new 3750 unit.

Battling IBM with their own hardware are ITT's omnipresent European subsidiaries. L.M. Ericsson's French subsidiary meanwhile is entering the market, Northern Electric of Canada is preparing to jump in from a new Irish plant, and General Telephone & Electronics is putting the finishing touches on a new unit. All are going after Europe-wide business, fighting each other as well as the firmly entrenched local manufacturers.

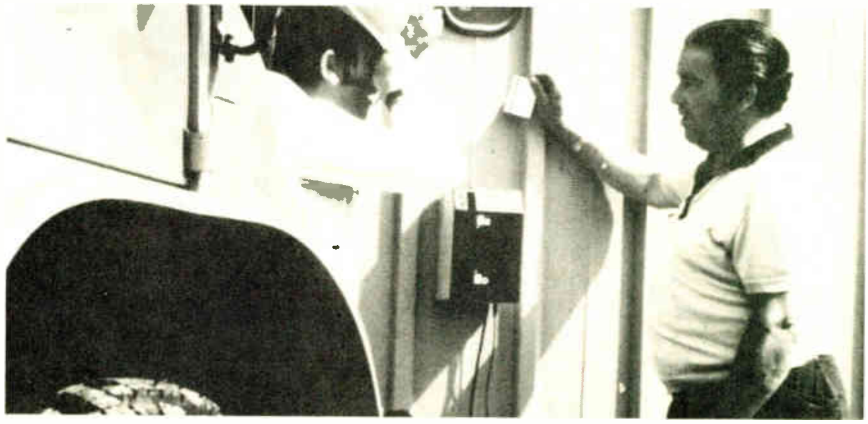
At stake is a market estimated by ITT at $800 million—and prospects of expansion as more and more firms start using the sophisticated data-transmission capability that many suppliers offer.

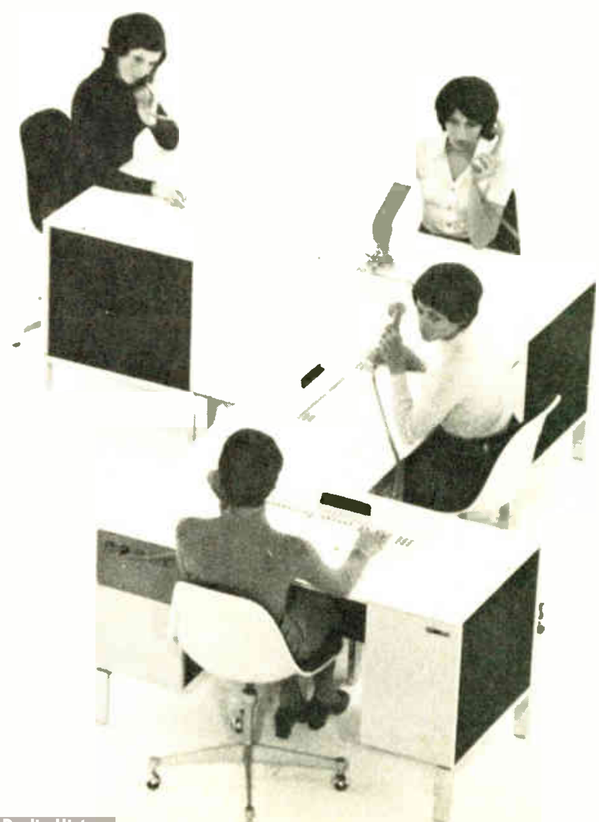
IBM, which in the model 2750 boasts the only all-electronic system on the market, is urging customers to integrate the PABX equipment with in-house IBM computers so that the pushbutton telephone doubles as a computer terminal for data collection and inquiry. Though the price is high— $240,000 to $1.6 million, depending on accessories—there are buyers for the systems.

"We are quite pleased with sales," allows Mark Evans, manager of marketing switching-system products at IBM's Paris-based World Trade Organization.

IBM in fact has been so successful in the Paris area, where about 50 of the model 2750 PABX units are installed, that it has won the admira-

Checking and calling. French trucker checks in via IBM's new model 3750 PABX, while bottom picture shows office arrangement of the system. The 3750 will be introduced by IBM in Europe, where the older 2750 already has more than 100 installations.





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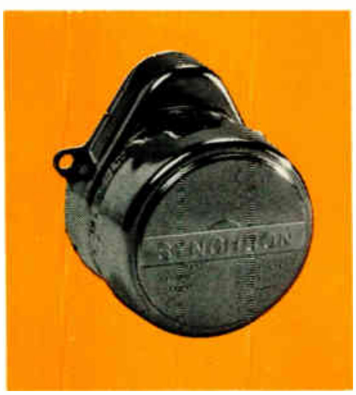

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tion of the competition. "They have put a formidable sales force on this product," says Henry Simon, general manager of ITT-Europe's business systems group, "and they certainly have managed to sell a large amount in a short time."

While IBM's Evans refuses to confirm that the 3750 is being test-marketed for later introduction into the AT&T-dominated U.S. market, he won't deny it either. Everything points to the company's European introduction of the product—the first major piece of hardware IBM has introduced abroad—as being in part a test run for eventual sale in the American market.

Evans says banks, hospitals, insurance companies, and industrial groups are the main customers for the equipment, which can do the work of an advanced PABX system, including conference calls, automatic-beeper paging systems when an extension does not answer, and automatic redialing of busy numbers. In addition, a variety of data-handling applications can be added on—such as monitoring electric devices to identify open or closed doors, trigger fire alarms, or read badges with magnetic strips. As a data-acquisition tool, it can interrogate a computer and elicit an audio response.

"We can offer a 128-word vocabulary, in any language," says IBM's Evans.

The IBM equipment is duplexed, and switches over automatically to standby every 24 hours. Data and voice messages are routed through 25,000 solid-state crosspoint switches on command from the programable control unit. The model 3750 offers semiconductor memory capacity of 32,768 to 65,536 16-bit words, plus disk capacity of 5 million words.

Geography is similar. The IBM lab on the French Riviera takes the credit for developing the PABX system. Similarly, the French subsidiary of ITT, La Compagnie Générale des Constructions Téléphoniques, claims credit for developing ITT's basic hardware, the Metaconta, which is also programable. But despite their related geographic origins, strategies for selling the two high-capacity telephone-exchange systems are vastly different.

ITT, which claims 25% of the PABX market across Europe, has been in the field far longer than IBM and can help old customers expand or step up capabilities by adding onto older models. On the other hand, ITT does

In and working. This is the IBM model 2750 all-electronic PABX. Some 50 of the private exchanges are being used in Paris area alone. Price starts at $240,000.

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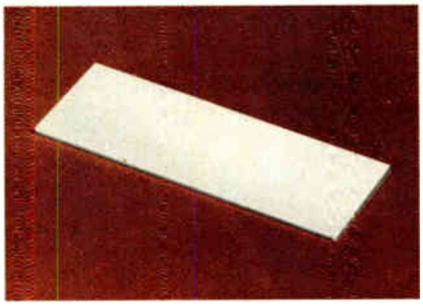

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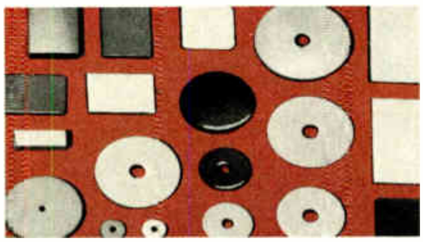

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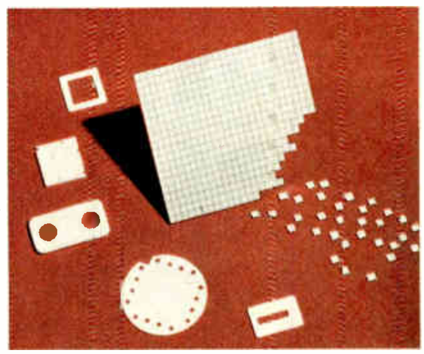

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not have IBM's big computer-customer base to build upon.

Moreover, contract obligations to some ITT users forbid introduction of incompatible ITT equipment for periods as long as 20 years. This orients ITT's investment heavily toward the standard electromechanical switching system, which also sells well to public telephone monopolies throughout Europe.

ITT claims it has had the technology to go all-electronic for several years, but that it will hold off until all factors make such equipment feasible.

"We don't have a fascination with electronics," says ITT's Simon. "We'll switch when it makes sense." Nevertheless, Simon predicts that the market will be dominated by all-electronic systems by the end of the 1970s.

But ITT's more basic difference from IBM is in the packaging of the product. IBM uses the "all-in-one-box" approach, with voice and data capability integrated. On the other hand, ITT sells the voice-only Metaconta equipment and offers an optional model 710 add-on preprocessor that builds the Metaconta into a voice-data combination. ITT claims the beauty of the 710 is that it can be linked easily to conventional ITT PABX systems other than the Metaconta.

This weighs heavily in West Europe, where more than half the PABX market is an extension of existing units and maintenance. "You simply can't sell a customer an expensive PABX, then turn around and tell him to tear out the system when he wants to add data," says Gilbert Gorissen, who is the division manager for private communications at ITT-Europe.

So far the ITT-IBM battleground has been in France, where both firms have major manufacturing facilities. Local influence is still a key factor to the success of a phone-exchange builder, however, and potential importers have an obstacle course of official approvals to negotiate before they can sell in France or elsewhere.

GTE task force. General Telephone & Electronics, for one, is not to be discouraged. GTE has detached a task force of engineers in Britain to develop a semi-electronic PABX for European markets.

"We are tooling up now to make them in Italy and Brazil," says Aldo Cardarelli, GTE's Rome-based manager of European telecommunications. "We will have a preproduction prototype operating in a couple of months. We have the desire to expand, and we've got the talent to do it," he adds. GTE will go for the small-capacity PABX of up to 100 lines at first, expanding later into the IBM-ITT league with equipment handling thousands of lines.

Another newcomer in the European market, Société Française des Téléphones Ericsson, is just launching the PE 1024, another programable PABX with functions similar to those IBM and ITT are offering. The Ericsson equipment, like IBM's, integrates data and voice capability. It is available only in France, but will be promoted throughout Europe as governmental authorization comes through in some of the other countries. □

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SINGER
INSTRUMENTATION

Commercial electronics

The toll highway faces automation

Automatic vehicle-identification systems, undergoing tests on both coasts, may replace human collectors

by William F. Arnold, Aerospace Editor

Picture toll roads without toll booths—with drivers receiving monthly bills instead. That might come to pass someday with automatic vehicle identification. Not only that, but strong interest by national groups and Federal agencies in using the computerized sensing systems for other applications also presages a growing electronics market. These applications include registration, determination of highway usage, highway-traffic control, vehicle location, and law enforcement.

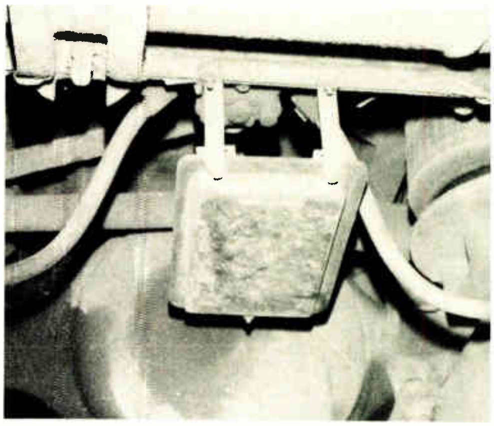
For toll-collecting, pilot tests on San Francisco's Golden Gate Bridge and in New York's Lincoln Tunnel show that the system works perfectly 99.5% of the time and markedly speeds up bus commuting, while easing congestion. "As far as the hardware is concerned, we know it will work," declares Glen Wallis, a senior project engineer for the Golden Gate Bridge, Highway, and Transportation District, which has been experimenting with automatic identification for three years. The district is pondering the procedural problems before deciding whether or not to equip all of its buses with systems.

For the second phase of its Lincoln Tunnel testing program, the Port Authority of New York and New Jersey expects to receive proposals Nov. 12 from four manufacturers: General Electric, Glenayre Electronics, North American Philips, and the Union Switch & Signal division of Westinghouse Air Brake Co. The authority will choose one manufacturer a few weeks later to supply 100 transponders aboard buses—the pilot test involved 40 buses—to be used with two interrogators at Lincoln Tunnel stations, reports Robert S. Foote, Research division manager in the Tunnels and Bridges department. The second phase will check out billing and other problems.

The Port Authority also hopes to cooperate in a year-long, $200,000 program being considered by the New Jersey Turnpike Authority to equip two interchanges with interrogators and place 250 transponders on vehicles of volunteers to test nonstop toll collection for drivers commuting to New York. New Jersey expects to receive prices from the same four manufacturers Nov. 10 and intends to select one to start the program early next year, says Robert G. Ott, director of systems and data processing.

The Turnpike Authority is thinking about a later second phase "to expand it on a broader base" and has seriously discussed equipping the entire turnpike, "as time goes by, but not in one move," he says. To equip the entire toll highway for 250,000 participating cars would cost about $3 million, including transponders, Ott figures. Foote estimates that the Port Authority, which also operates the George Washington Bridge, could equip 3,000 buses for about $150,000.

Induction preferred. Actually, there are three types of automatic identification systems: optical, adopted by the railroads (see "Working on the railroad"); microwave, somewhat impractical because it requires line-of-sight transmission; and the more popular rf system, which uses low-frequency



Taking tolls. Lincoln Tunnel toll booths would be a memory if automatic vehicle identification becomes universal. Transponder is shown mounted beneath bus.

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induction. In an induction system, a loop of wire buried in the pavement interrogates a vehicle-mounted LSI transponder to trigger a flow of digital data back to the interrogator antenna. The interrogator requires 100 to 350 watts of input power, and the loops radiate frequencies between 96 and 200 kilohertz to about 15 inches. For its first-phase test, which ended last June, the Port Authority installed GE, Glenayre, Philips, and Westinghouse Air Brake rf systems on 40 buses. Depending on volume production, typical costs run $25 to $100 per transponder and from $2,500 to $10,000 per interrogator, plus computer costs.

As for toll-collection, an automatic system has several advantages. William A. Rusch, executive director of the International Bridge, Tunnel, and Turnpike Association Inc., points out that it speeds traffic flow and cuts travel time, saves money by lowering the costs of toll-collecting personnel and money-handling, and improves the environment by eliminating stop-and-go movement by buses, cars, and—eventually—trucks. Diesel trucks and buses belch a lot of toxic black smoke when starting, Rusch notes.

In addition to toll-collection, various groups and agencies foresee other uses for regional or national systems:

■ A major prospect is parking lots—"actually compressed toll roads with time, rather than distance, the unit of measurement," says Norene Dann Martin, executive vice president of the National Parking Association. She says that automatic identification would greatly benefit parking facilities with monthly contract users. She pinpoints big parking-lot sales targets as airports, hospitals, shopping centers, and universities.

■ Dynamic electronic highway-traffic-control systems, based on automatic vehicle identification, could monitor and meter traffic flow on highways and indicate to drivers the best routes to take, says Asriel Taragin, deputy chief, Traffic Performance and Analysis division of the Transportation Department's Federal Highway Administration. "If all the interested people cooperate, we can get AVI going within five years," he says. Taragin also says it could give better traffic data and usage-planning for improved national, state, and local highway planning.

■ A vehicle-registration system based on automatic identification—assigning each vehicle its own coded 15-digit numbers—would aid highway departments, says Jack Leverentz, director of vehicle services, American Association of Motor Vehicle Administrators. His association, as well as the Society of Automotive Engineers and the American National Standards Institute, are working out a national standard vehicle-identification-number system toward that goal.

■ "If AVI systems could be coupled with locating techniques, the idea becomes quite attractive to the trucking industry," says William E. Elder of the Engineering section of American Trucking Associations Inc. The benefits would be better routing and prevention of truck hijacking, he says, where, for instance, an automatic identification system could be alerted for a stolen truck and warn police when the vehicle passes an induction loop.

■ And, while no one exactly touts the issue, an obvious use would be to enable state police to keep a constant electronic surveillance of major roads to nab fleeing cars, check registrations, and perhaps use such networks to trap speeders.

The privacy issue. But the contemplated use of automatic identification also brings out cries of police state and invasion of privacy. While proponents of the technique claim that an electronic number is actually no different from a license plate, they admit that opponents don't view it that way. The Port Authority's Foote says the problem can be avoided by making participation voluntary.

Another question is how should the system be built—on a local, state, regional, or national basis? Commonality of equipment also becomes a problem. Foote and Ott admit that they won't be able to cooperate if their two authorities choose different manufacturers. And Elder says that the truckers, who have a "wait-and-see attitude right now," don't like the possibility of having to carry four different transponders to drive from New York to Chicago. While no one seems to have figured out the cost of full-scale systems, the Federal Highway Administration's Taragin notes that the price tag will be high. However, it could be paid for out of user taxes and registration fees. □

Working on the railroad

Calling it automated car identification, the railroads have chosen an optical system that "reads" colored bar-coded plaques on the sides of cars. Although the system has run into some trouble because some railroads don't keep their cars clean enough [Electronics, Oct 25, p. 49], it is successful enough that:

■ The Grand Trunk Co. is building the first integrated operations and accounting system based on automated car identification. The $7.5 million system will tie together scanners along the Detroit-to-Chicago line.

■ Twenty-eight Chicago-area railroads are cooperating in a system linking more than 100 freight yards and 7,600 miles of line so they can keep accurate track of their traffic.

■ The Kansas City Southern Lines has retrofitted a $1.6 million automated identification terminal-management system in its Shreveport, La., yard.

■ The Duluth, Missabe Railway Co. uses a system coupled with automatic weighing scales for its trains of ore cars.

■ The Southern Pacific recently opened a $39 million computerized hump yard in Colton, Calif., that uses automatic-identification techniques.

"We're striving for computer-run yards," says Robert A. Petrash, executive director of the Data Systems division of the Association of American Railroads. "With what we've got, we have a chance to use ACI as part of the system." He hopes that within 20 years all yards will be automated. Equipment manufacturers include Serve Corp. of America, Hicksville, N.Y., and the ACI Systems division, South Holland, Ill., of Computer Identics, Westwood, Mass.

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Technology

New R&D indicators: picture is grim

NSF board reports continuing slippage in U.S. staffs and investment as competing nations expand; instrument industry a bright spot

by Ray Connolly, Washington bureau manager

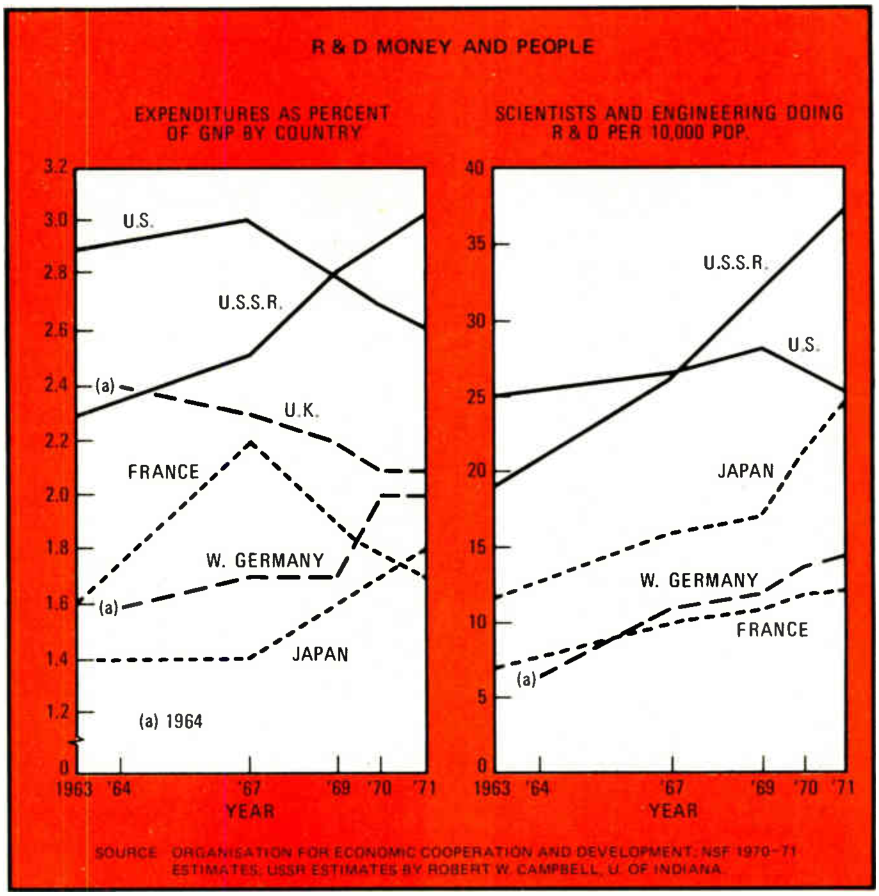
Electronics and other high-technology industries in the U.S. that compete in the global market are beginning to get a comprehensive picture of where their country stands relative to the rest of the world in research and development. The image isn't a bright one, with R&D "intensiveness" continuing to drop.

The picture presented in the 1973 report of the NSF's National Science Board, a 143-page document titled "Science Indicators—1973," contains some disturbing data for the U.S. and its electronics industries. Described by board chairman H.E. Carter as "the first results from a newly initiated effort to develop indicators of the state of the science enterprise in the U.S.," the report provides a new perspective on the decline of the U.S. investment of dollars and manpower in R&D in comparison with development efforts of other major powers during the past decade (see "R&D money and people").

The study documents a continuing downward slide in the R&D intensiveness of the five industries that account for 81% of the U.S. industrial investment in technological innovation—electrical equipment and communications, aircraft and missiles, professional and scientific instruments, machinery, and chemicals. R&D intensiveness—defined as "the proportion of the total human and financial resources" invested by an industry—is measured chiefly by the number of R&D scientists and engineers per 1,000 employees, as well as the percentage of net sales devoted to R&D. Aircraft and missile manufacturers, for example, topped the five most intensive industries in 1970 with a people ratio of 74 per 1,000 and an investment of 18.5% of net sales. For the second-place electronics industries—which the Government includes in electrical equipment—there were 39 people and 7.5%, with instruments accounting for 31 people and 5.9%.

The indicators show that R&D intensity in the five industries dropped 25% between 1964 and 1970, although an upturn is now in sight. The downturn is believed related to another negative—the declining U.S. trade balance that has already developed in such technology-intensive industries as electronics.

"Though the U.S. maintains a strong position as a net exporter in these industries overall," the report declares, "indicators suggest that position may deteriorate in the near future with an increasing rate of decline in electronics exports and a less favorable ratio" of exports to imports for aircraft. That ratio stood at 9-to-1 in 1971. Instruments of all types proved the single exception, maintaining a steadily increasing annual investment in constant dollars over the 1961–1970 decade with its own funds (see "Industry spend-



ing for R&D, 1961–70"). And instruments have continued to post small but steady gains in net exports year after year.

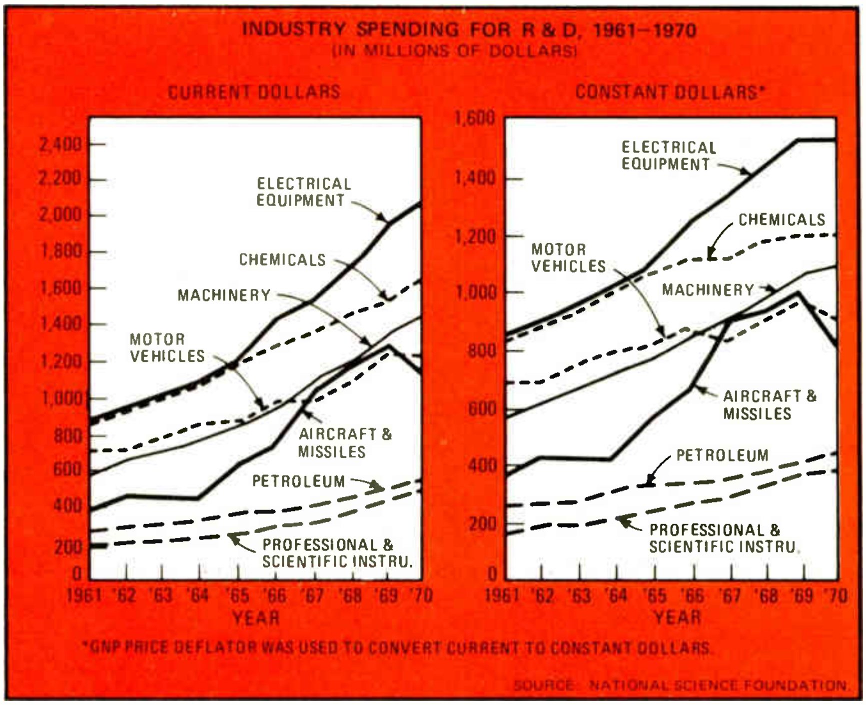
Upbeat. Although company expenditures for R&D in electronics and electrical equipment, which lead all other U.S. products, continue to rise, purchasing power was essentially unchanged between 1969 and 1970 after inflation was factored in. Nevertheless, an NSF survey of the 50 largest U.S. corporations, completed last year, shows electronics companies projecting increases in their own R&D investments between 1972 and 1975 in line with an all-industries forecast of 25%. Aerospace companies, on the other hand, "foresee future R&D growth at a pace somewhat below the rest of industry."

As for engineers and scientists employed in general industrial R&D, the number is projected to increase to 260,000 by 1975, up from a 1971 low of approximately 225,000. Again, electronics companies estimate they will absorb a proportionate share of this 16% increase. However, if the industrial R&D pattern set in the decade through 1972 continues as expected, the distribution of these jobs will change as emphasis on development increases.

The declining empahsis on basic research poses a long-term problem for the growth of electronics industries, especially in developing sources of engineering and scientific manpower. General Electric Co., for example, recently expressed concern to NSF's director H. Guyford Stever over what its R&D vice-president Arthur M. Bueche called "the indicators on our precious manpower resource." Those indicators show that total national outlays for basic research in universities and colleges declined between 1968 and 1972 when measured in constant purchasing power of 1961 dollars. Affected disciplines included engineering and physics—both critical to electronics and the resupply of manpower pools for industry.

"Despite the grim picture, we at least have better data," observes staff director Robert Brainard.

"One of the past criticisms of our indicators is that they were not interpretive enough," Stever recalls. With NSF's new and more detailed annual analyses, he notes, "conclusions are being drawn, and we expect broader interpretations in the report next time." If U.S. technology is to get the funds it requires, Stever points out, "we have to have better things to say to the Office of Management and Budget and the Congress." Clearly, NSF's director believes he now has them. □



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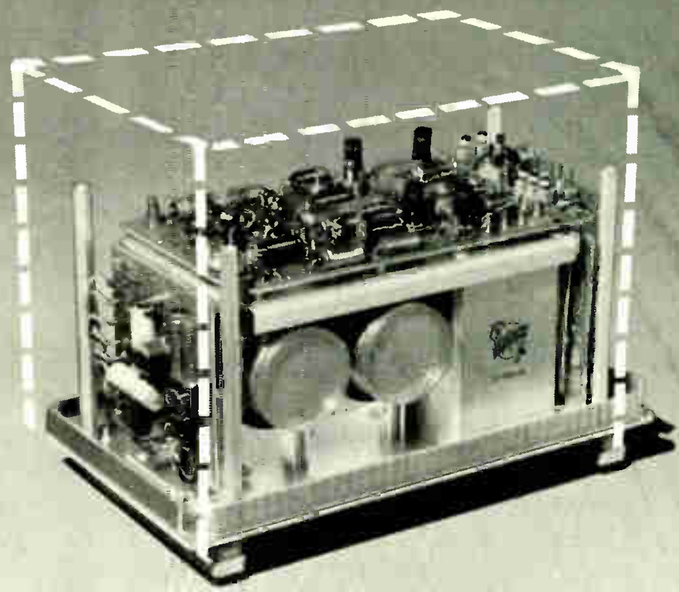

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Toroids of Ceramag 24 were used by Tektronix, Inc. for transformer cores. Again, this is a proven material, widely used by the computer industry for pulse transformer cores. It has a tightly controlled initial permeability, and tooling for a variety of sizes is also available.

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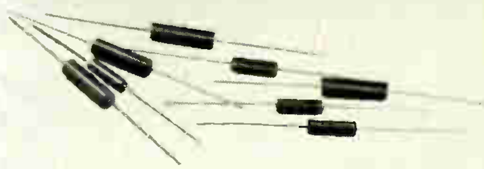

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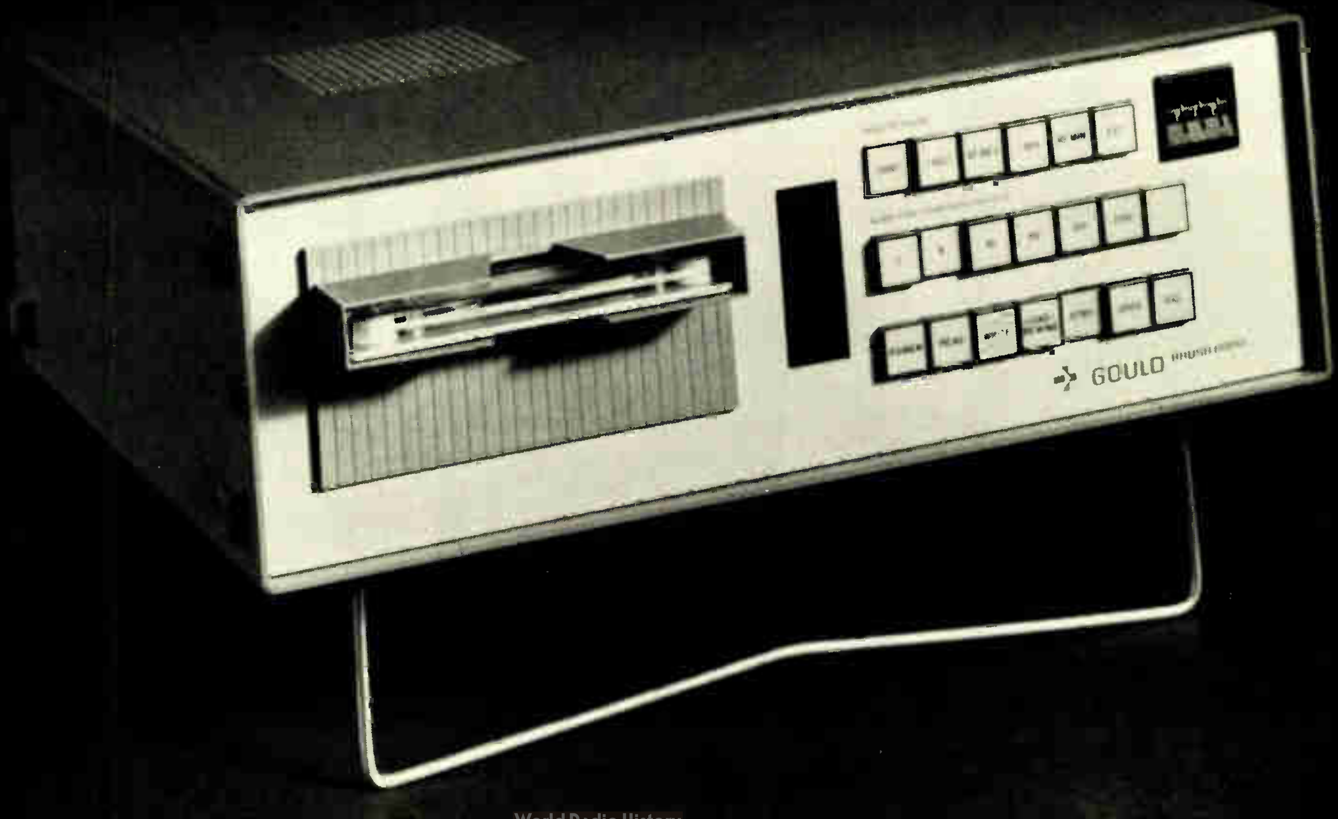

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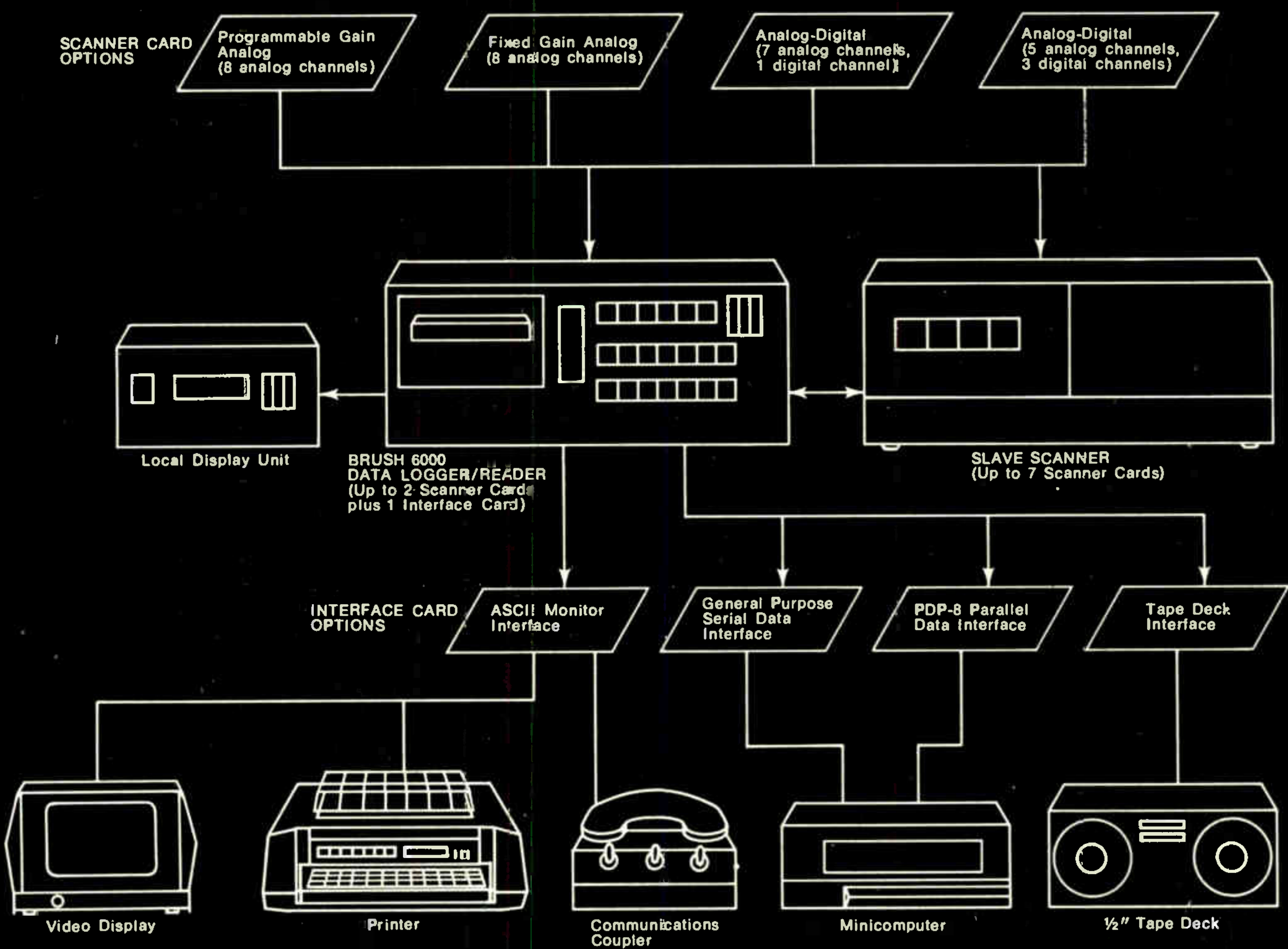

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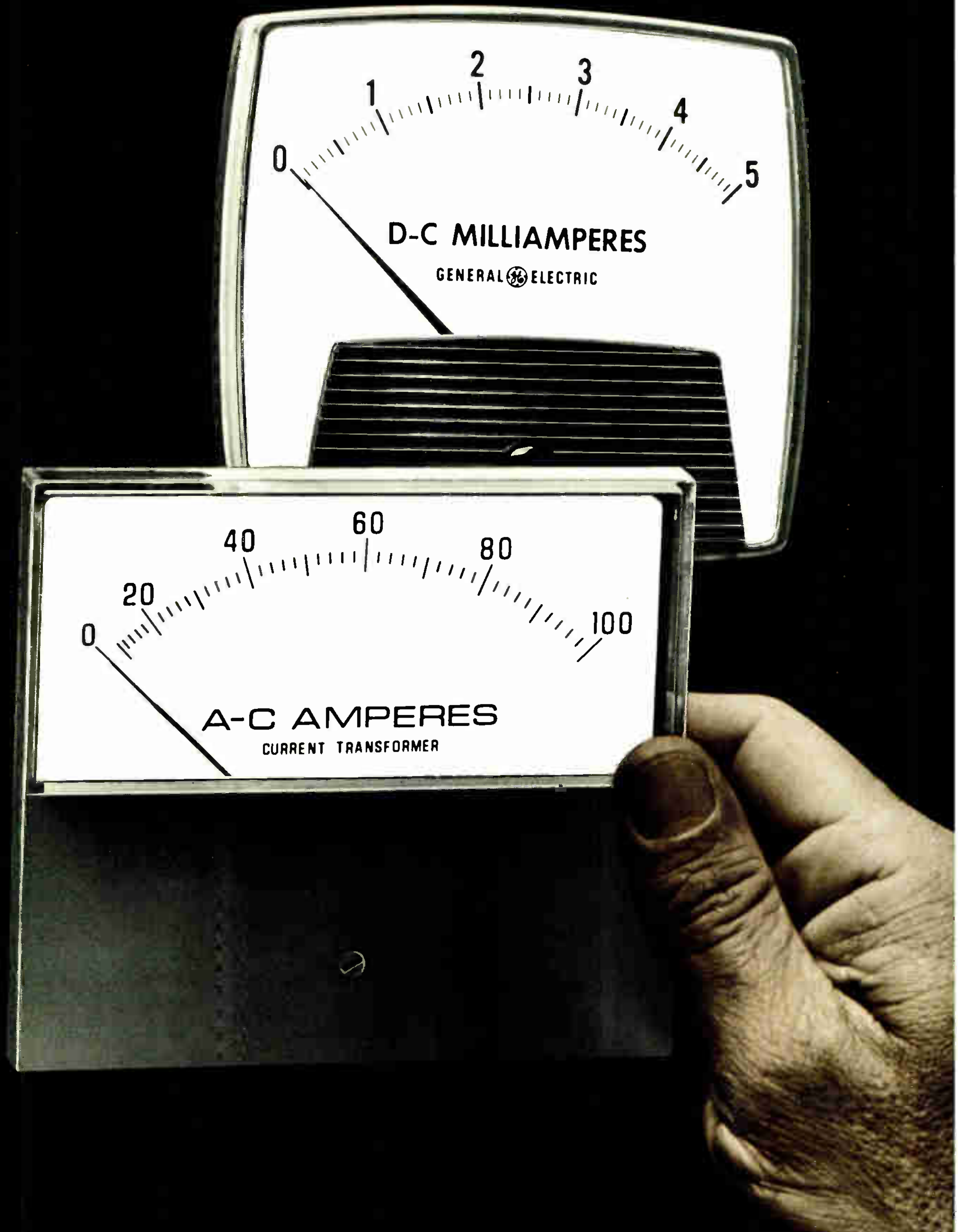
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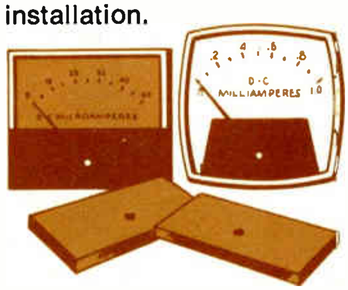

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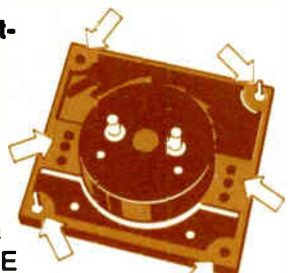

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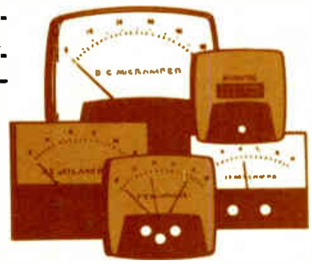

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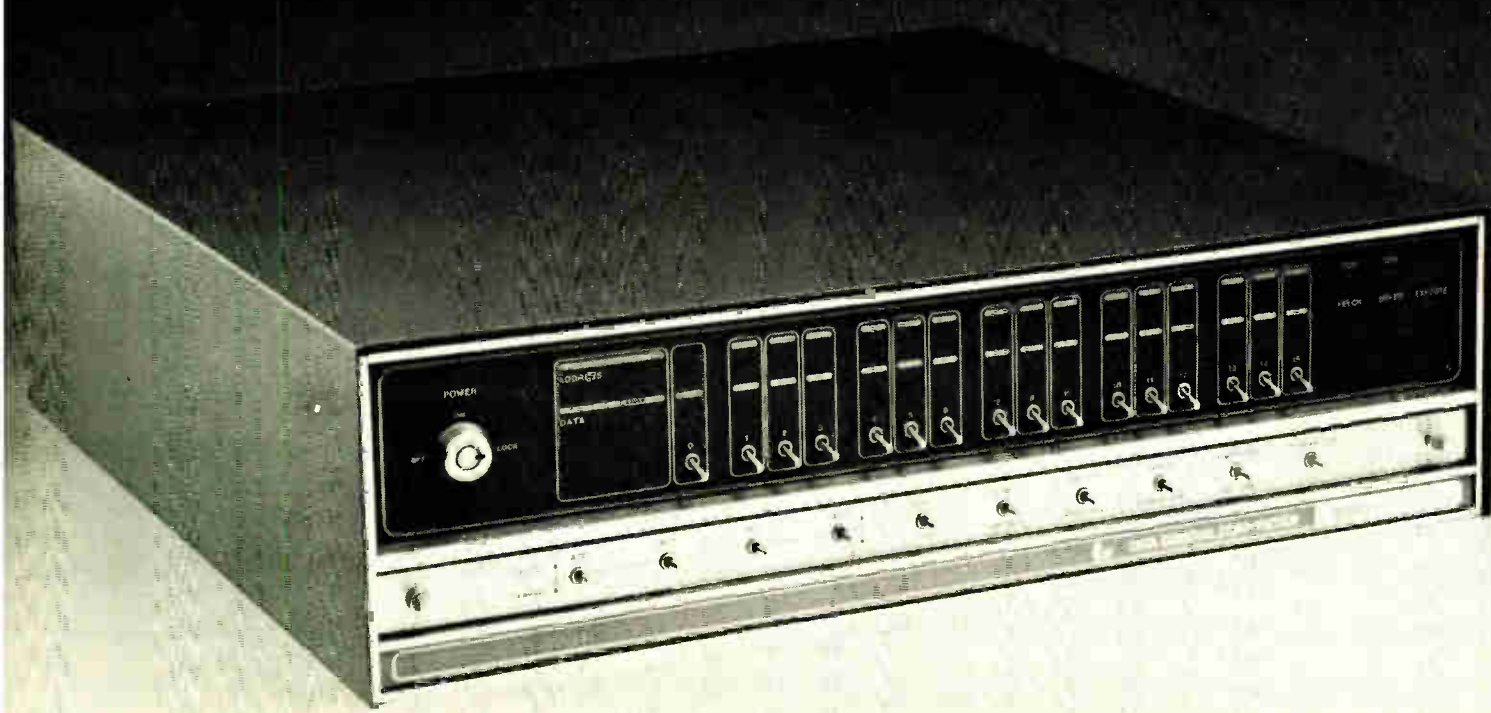

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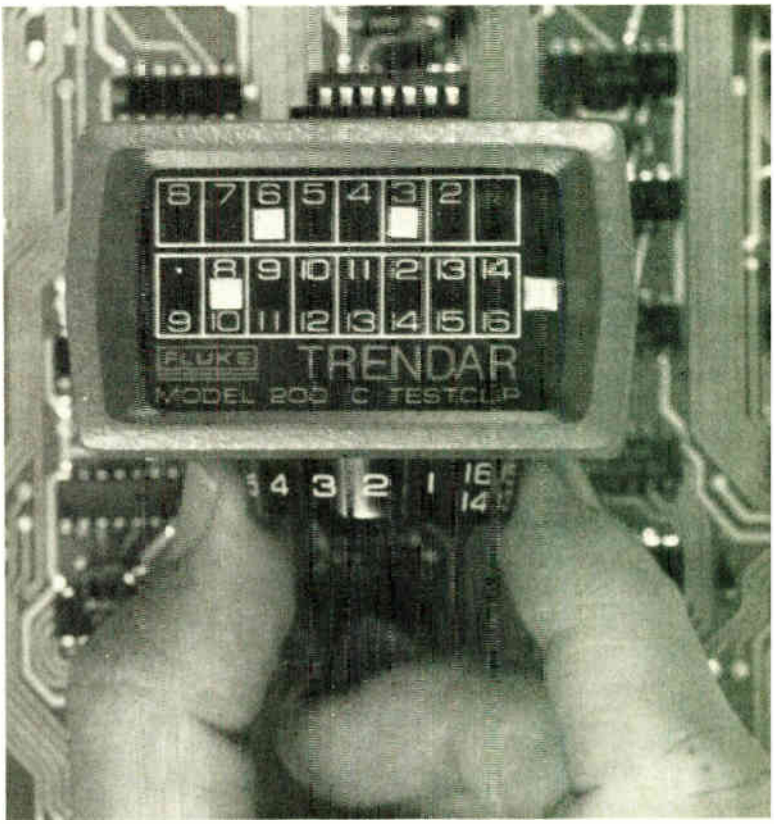
Logic tester uses single trial procedure to troubleshoot digital IC boards

Combining the properties of a logic probe, a logic clip, and an IC comparator, this hand-held instrument promises significant cost reductions, both in factory use and in checking actual systems operating in the field

Donald P. Allen, *Trendar Automation Corp., Mountain View, Calif.*



☐ About 10 million of the 500 million or so digital ICs produced this year will prove to be defective, and the process of wave-soldering devices to digital logic boards will probably produce about 90 million solder defects. For some companies, the cost of isolating these faults represents 20% to 25% of their total board-production cost. At $1 per defect, the industry as a whole could pay out $100 million.

For equipment in the field, solder defects show up only rarely, and component-defect rates drop with time—the current crop of ICs may be expected to produce about 2.5 million failures, and an equal number may be expected from all ICs previously installed. However, the service cost per defect may be 10 to 100 times that on the production line—an industry total of $50 to $500 million.

Looking for the trouble

These high troubleshooting costs have spurred the evolution of several faultfinding aids, the most complex of which (Teradyne's "Trace" and General Radio's "Caps") are highly sophisticated programs for specialized computer-based test systems. The Fluke Trendar Testclip, however, represents a simpler breed of tool.

The Testclip allows a single test procedure to troubleshoot a digital IC board, either operating in an actual system or being run by a pattern from a logic tester. A combination logic probe, logic clip, and IC comparator, the instrument promises to reduce costs significantly both in the factory and in the field.

All troubleshooting is an exercise in comparing what one finds with what one expected to find. In the case of logic-fault detection, the latest tools merely speed up the original diagnostic methods—operating-mode analysis and oscilloscope-waveform observation—and have led to the first generalized procedures for fault-isolation of any logic.

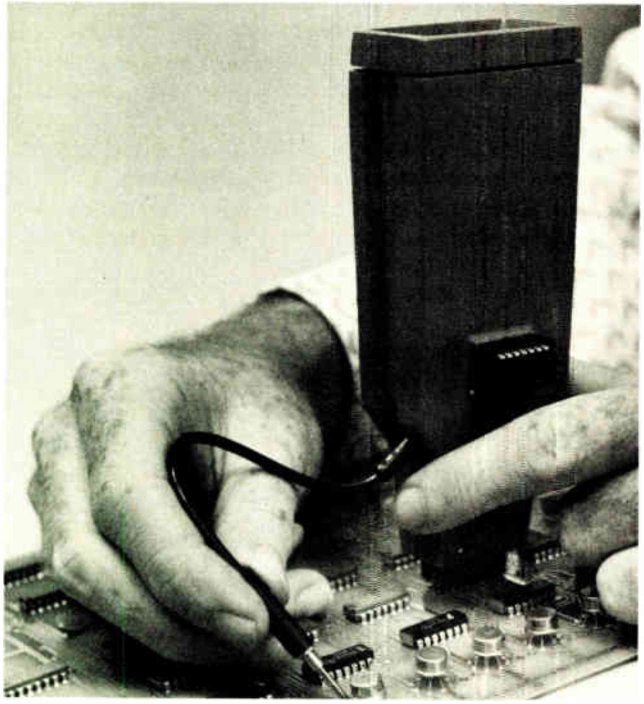
Operating-mode analysis applies when a system has enough operating modes and displays for faults to be diagnosed, at least down to the module level, by clever control sequencing and deductive reasoning on the part of the operator. It is occasionally possible to carry this method all the way to pinpointing the defective circuit stage itself—in fact, military maintenance technicians pride themselves on their ability to narrow the location of a fault down to two or three stages through display analysis only. More typically, however, the method is combined with scope waveform analysis and power-level checks.

The traditional troubleshooting technique is fast and costs little in the way of test equipment, especially if an experienced technician is at hand. But it has disadvantages.

It may be impractical to fully recreate the control combination or sequence that produces a fault that is not catastrophic. Or the human observer may miss a fault's fleeting appearance on a scope. The usefulness of logic-pattern analysis can be greatly extended by Hewlett-Packard's new 5000A logic analyzer [*Electronics*, April 26, pp. 139–140] which, however, is still like a scope in being unable to examine more than two circuit points at a time.

Since logic circuits operate between two nominal voltage levels, the continuous coverage provided by oscilloscopes is often unnecessary. Instead, logic probes have been introduced as a low-cost way to observe static levels and the presence or absence of toggling.

The dozen or more single-point probes now available can detect that large class of IC faults that manifest themselves as stuck pins and are caused by shorts to ground or collector-supply voltage or by open-circuit lead-bond failures. This single-point sleuthing works for perhaps 50% of IC faults—it will not pick up the defect in a counter that periodically miscounts or fails to reset, for example.



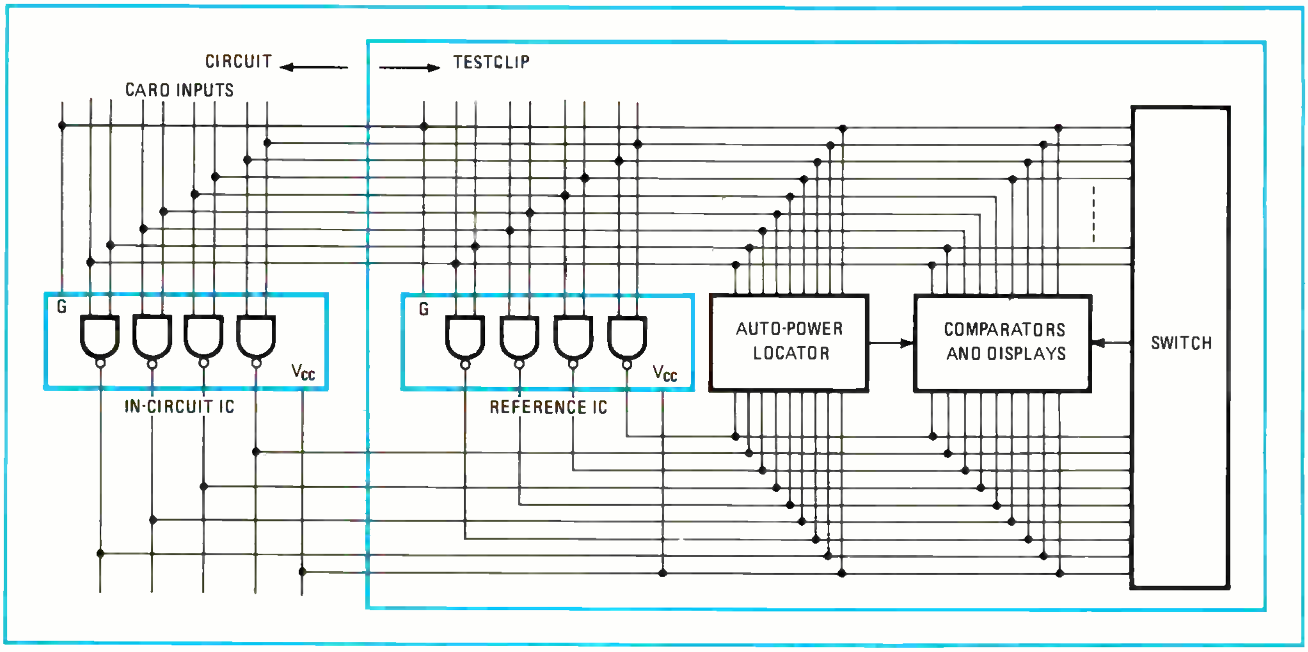
1. Three-in-one. Testclip clips onto board IC to be tested. There it can act as an IC comparator, a logic clip, or a dial-up logic probe. When used as a comparator, the Testclip has plugged into it a reference IC known to be good. The logic probe extension, shown in use here, is used to examine nearby circuit nodes.

The logic clip was a natural outgrowth of the probe. It contains an array of LED lamps and slips onto a working dual in-line package to display the logic states of all of its pins at the same time. Most such clips require the system clock to be slowed down if they are to be able to differentiate between a steady logic 1 state and toggling at a high duty cycle. The Fluke Trendar Testclip and the Rohde and Schwarz Logiscope, in addition, contain stretching and blinking circuits to catch and stretch narrow pulses.

A short circuit, whether caused by a solder sliver on the board or a fault internal to the IC, may lock the behavior of a number of ICs connected to a common trace. Hewlett-Packard and Testline make various forms of single-pin and multiple-pin pulsers for use with either a scope or a clip that generate narrow high-current pulses of either polarity. The current delivered by these pulsers is sufficient to drive the node to the opposite logic state, but narrow enough to prevent excessive heating. If the states of the other input pins allow it, the good ICs will respond, preventing false changeouts. But not all ICs are amenable to this treatment—an eight-input NOR is an example.

Component substitution is an age-old cut and try method of troubleshooting. Since digital ICs are generally soldered on the boards, an adaptation of this technique is to operate a duplicate IC that's known to be good by paralleling its inputs with the IC in the circuit. The functional behavior can be checked through an exclusive-OR comparison of corresponding IC outputs.

The comparator will detect failures in total IC func-



2. Making the comparison. The in-circuit IC and the reference unit are compared by having their inputs paralleled by long pins on the reference IC socket. Short pins on the output leads prevent shorting of the outputs which go only to the comparator and display circuitry.

tion if proper input toggling signals are present. Sequential logic must be initialized by circuit action. Otherwise, a false reading might occur. Also certain ICs cannot tolerate the circuit load presented by an unbuffered comparator.

One of the first IC comparators was the HP 10529A which used reference ICs on small circuit boards plugged into a small case cabled to an IC clip. For production testing, the Trendar 2000 Test Station has this capability built in, with the added protection of buffer isolation of the clip.

Three on one

While each of these new tools removed or ameliorated some difficulties in troubleshooting logic circuits, many problems remained. For example, many fault types require the simultaneous use of several tools, yet people have only two hands. The result has been a trend toward inferential troubleshooting methods and a consequent increase in the time needed to diagnose a given fault.

To help reverse this trend, Fluke Trendar set itself the task of developing an instrument that would meet the following objectives:

- In a small hand-held package, incorporate the capabilities of a logic probe, a logic clip, and an IC comparator. (These three were chosen because they are the minimum complement of tools that will provide a universal troubleshooting procedure.)
- Try for hands-off testing because of the need for frequent manipulation of system or unit controls to exercise the board.
- Place the reference IC in the closest possible proximity to the IC under test and use high-impedance circuitry. This would eliminate false readings caused by excessive loading of the board under test and would also minimize vulnerability to overvoltage.
- Eliminate the need for power inputs, connectors, clips, and cables. Enable the instrument to power itself automatically from the board, despite wide variations in supply voltage.
- Find the simplest possible means for programing the reference IC—that is, telling the Testclip the difference between an input and an output.
- Handle bipolar logic families automatically with no adjustments or switching.
- Catch and display single narrow pulses or pulse streams to a high frequency.

The instrument that resulted is shown in Fig. 1. The case slips over the IC to be tested, and the reference IC is plugged into a conventional socket, which, in turn, is plugged into the case. The reference IC is paralleled with the board IC, each seeing the same input signals (Fig. 2).

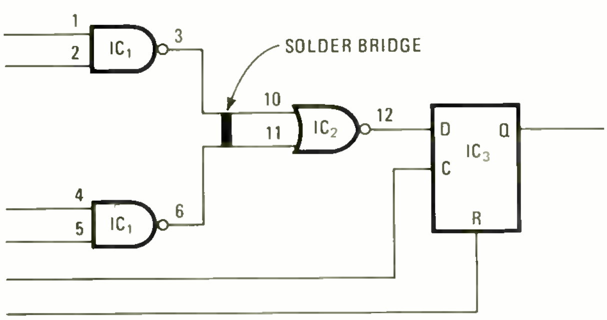
The outputs are compared by high-impedance comparators. Failures are displayed on an array of light-emitting diodes driven by the comparators. Logic states and toggling activity are displayed on a separate LED

Faultrack finds faults in both boards and ICs

The Faultrack procedure is a step-by-step backtracking of logic states that do not correspond with normal states. The non-correspondence is displayed in two ways to the operator: stuck states are observed by using the Testclip in its logic-probe mode, and truth-table faults are displayed in the IC-test mode. Both board faults and IC faults cause abnormal states that can be tracked by the Faultrack procedure. Here is an abbreviated version:

1. Verify that the active inputs of the failing IC stage are toggling by using the Testclip in its logic-probe mode. This is important with sequential logic to be sure initialization occurs. If some inputs are not toggling, the signal flow is probably being interrupted elsewhere. The instrument should be moved to the preceding IC or ICs. If all inputs that should be toggling are, move on to step 2.
2. Examine the failing output by using the logic-probe mode. If there is logic activity, go to step 3. If the output pin is stuck at a logic 1, go to step 4. If the output is stuck at a logic 0, go to step 5.
3. Check adjacent pins and parallel traces for a solder bridge. If there is none, replace the IC being tested.
4. Check for a short-circuit to V_{CC}. If there is no short-circuit, replace the IC being tested.
5. Check for a short-circuit to ground. If there is none, the failure could be in the IC being tested or in an input to an IC being driven by the IC under test. Depending upon the number of fan-out ICs, the fault usually can be located by trial changeout or by disconnecting the failing output of the IC being tested from its fanout and then retesting. A high-resolution ohmmeter can null a mechanical short without cutting traces or lifting pins.

The circuit shown in the figure, complete with failure, illustrates the application of the Faultrack procedure. Assume that the fault is a solder bridge across the inputs to the NOR gate, IC_2. Since the procedure can be started anywhere, assume the first check is of IC_3, the D flip-flop. All nodes (pins) are found to toggle when their logic states are checked. In-circuit IC comparison to a reference shows no faults in the state diagram. The next check is of IC_2. Its inputs and output toggle in spite of the input bridge. IC comparison would pass the IC. (Note that because of the short, the complete truth table of this IC is not being tested. For thoroughness, it must be done after the fault is found.) When IC_1 is checked, all nodes will be toggling, but failure indications will be obtained at pins 3 and 6. If the input rate is slowed and behavior of the pins' logic states examined, simultaneous transitions independent of input truth conditions will indicate the presence of the short. If the fault had been a stuck low condition at pin 11 of IC_2, then the logic-states check of IC_2 would have revealed the unchanging logic 0 state.



World Radio History

that can be connected to any pin by a rotary switch. The signals detected by an external probe can be displayed, as well.

How it works

To present high-resistance, low-capacitance inputs to the device under test, the Testclip was built with complementary-MOS logic. Its circuitry will load inputs of the device being tested with a 50-kilohm pull-up resistance plus one input load of the reference device. Outputs are loaded by a 100-kilohm pull-up resistance. The C-MOS circuits draw negligible current from the board being tested.

The instrument automatically locates the most positive and most negative pins of the IC under test and draws its power from them. The circuitry that does this is illustrated in Fig. 3.

An important item to consider regarding the automatic power-locating circuitry is the minimum value of the drain supply voltage, V_{DD}, that the circuit will provide to the C-MOS circuits. This voltage must be at least 3.0 V for the device to work properly. When 5-V logic is being tested, the collector supply voltage, V_{CC}, at the IC under test can be expected to be at least 4.5 V (5 V minus 10%). As Fig. 3 shows, the automatic power-locating circuit puts two forward-biased diodes in the supply-voltage path; thus the V_{DD} supplied to the C-MOS circuitry is equal to $V_{CC} - 2V_F$, where V_F is the forward voltage drop across each diode. With a maximum V_F of 0.7 V for the diodes, V_{DD} has a worst-case value of 3.1 V, so all is well.

At first sight, C-MOS logic circuitry operating at a V_{DD} of 3.1 V might seem unsuitable for the functional testing of transistor-transistor logic operating at a V_{CC} of 4.5 V. The brief analysis that follows, however, shows that there's nothing wrong with this combination.

Two criteria must be satisfied if C-MOS comparators are to be suitable for testing TTL circuitry. First, the maximum voltage that the C-MOS comparators will recognize as a logic 0 ($V_{IL(max)}$) must be greater than or equal to the maximum voltage of a TTL output in the logic 0 state ($V_{OL(max)}$). Second, the minimum voltage that the C-MOS comparators will recognize as a logic 1 ($V_{IH(min)}$) must be less than or equal to the minimum voltage of a TTL output in the logic 1 state ($V_{OH(min)}$).

$V_{IL(max)}$ is given by 0.3 V_{DD} for a C-MOS input, and therefore, remembering that the comparators are raised above ground by the drop across one forward-biased diode:

$V_{IL(max)} = 0.3(V_{CC} - 2V_F) + V_F$.

For V_{CC} = 5.0 V and V_F = 0.7 V, this works out to $V_{IL(max)} = 0.3(5.0 - 1.4) + 0.7 = 1.78$ V. Since $V_{OL(max)}$ = 0.4 V, the first criterion is satisfied with room to spare.

Turning to the second criterion, observe that the devices used for comparator inputs are selected to have a $V_{IH(min)}$ value of 0.47 V_{DD}. Plugging in the same values of V_{CC} and V_F, as were used before yields,

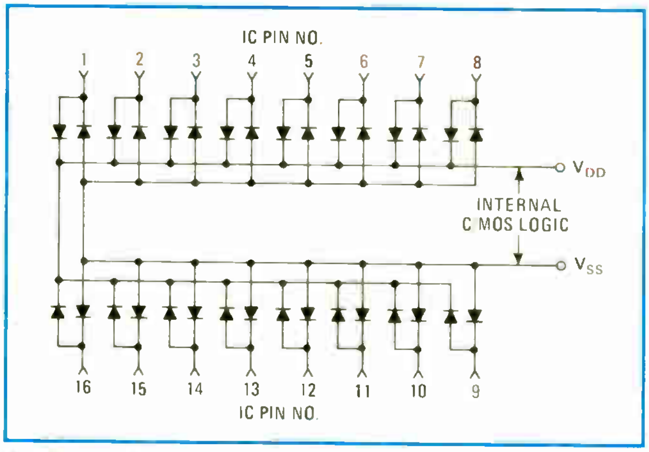
$V_{IH(min)} = 0.47(V_{CC} - 2V_F + V_F$
$= 0.47(5.0 - 1.4) + 0.7 = 2.392$ V.

Since $V_{OH(min)}$ is 2.4 V, the second criterion is met—just. Actually, the situation is not as critical as these numbers make it look because the 2.4-V figure is really a minimum, and a typical limit value for $V_{OH(min)}$ is usually listed as 3.2 to 3.4 V, depending upon the TTL device type.

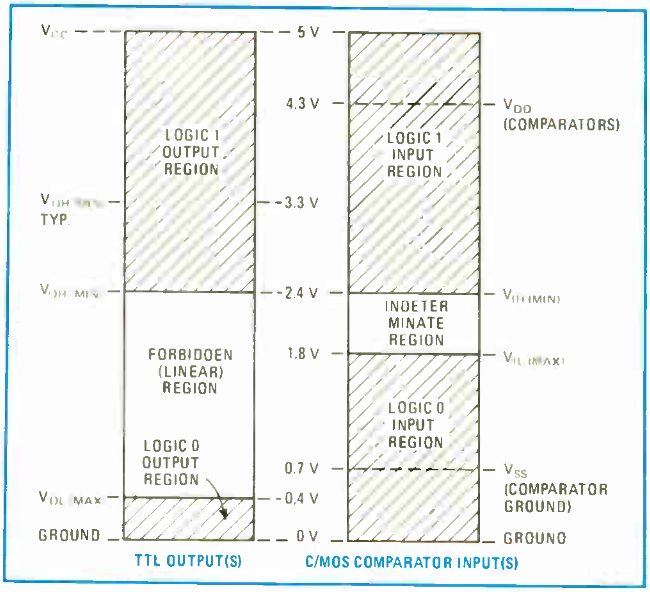
The relationships between TTL output levels and the C-MOS comparator-input levels are presented graphically in Fig. 4. If the output of a TTL device falls into the forbidden (linear) region because of a parametric defect, this may not be detected. Such defects are rare, however, and, in the author's experience, are almost always accompanied by logic failures.

It's all done with pins

When operating as an IC comparator, the instrument must be provided with some means for distinguishing IC outputs from IC inputs. Corresponding input and power-supply pins on the reference IC and the IC under test must be connected in parallel so that both ICs receive the same excitation. Output pins, on the other hand, must be kept separate so comparators can see if the board IC behaves the way the reference IC does.



3. Finding the power. Simple diode circuit performs the twofold function of automatically locating the most positive and most negative pins of the board IC and drawing power from them.



4. Compatibility. Though C-MOS comparators may operate at a V_{DD} of only 3.1 volts, their inputs are compatible with the outputs of TTL circuits operating at a V_{CC} of 4.5 volts.

What about testing C-MOS?

Can the Testclip, which uses C-MOS circuitry, also be used to test C-MOS devices in circuits? The answer is that it depends upon the individual circuit and device.

Obviously, the input characteristics of the Testclip are C-MOS-compatible. However, C-MOS output characteristics must be examined also. Unlike TTL, C-MOS logic is inherently subject to wide variations in transition time because of capacitive loading, as well as power-supply voltage. Also, as a family, current C-MOS products vary widely in transition time from one manufacturer to the next; differences as great as 4 to 1 have been measured for simple gate circuits under identical load conditions. Furthermore, since C-MOS manufacturers specify up to 50 C-MOS input loads for some devices, significant stray capacitance may exist on the printed-circuit board.

The outputs of a reference IC plugged into the Testclip drive one C-MOS input load with a 100-kilohm pull-up resistance. The outputs of the unit under test, however, may have to drive:

- One C-MOS load and 100 kilohms from the Testclip,
- An additional C-MOS input in parallel with 150 kilohms to V_{CC}, if the logic probe is dialed to that output,
- Plus up to 50 C-MOS input loads and an unknown amount of capacitance on the pc board.

This means there will be significant variations in transition time between the unit under test and the reference IC, which will be seen as noncomparable outputs by the comparison circuits in the Testclip.

Now, even with TTL circuits, some variation in transition time is to be expected, and the Testclip incorporates failure-blanking to ignore errors that persist for only a short time. For typical C-MOS circuits tested to date 200-nanosecond failure-blanking has proven adequate over power-supply levels from 5 V to 10 V. Thus, failure-blanking allows the Testclip to detect logic errors in TTL circuits operating up to a 2.5-MHz square-wave frequency, while compensating for typical C-MOS timing variations.

Sufficient failure-blanking is provided for the faster transition times of the most recent C-MOS devices. As C-MOS manufacturers continue to improve transition times and approach a common standard, C-MOS testing will become universally practical.

In earlier comparators, this identification of input and output pins has been done by means of a small, programing printed-circuit card for each IC. A special tool is used to break those board wires that would have resulted in shorted output pins. The Testclip uses a replaceable-pin IC socket in which the reference IC is mounted. The standard pins in the socket are long enough to short together the corresponding pins on the reference IC and the IC under test. To program the socket, the pins carrying IC outputs are replaced with short pins, which automatically break the connections with the unit under test and allow the Testclip to compare the output behavior of the board IC and the reference device.

When used as a logic probe, the Testclip has a pulse-stretching feature that can capture and display pulses as short as 100 nanoseconds. In this mode, the operator can observe the states of the various IC pins, one at a time, by dialing them up with the rotary switch on the body of the instrument and observing the logic-state LEDS.

When the reference IC is omitted, the instrument becomes a logic clip, indicating the logic states of each pin. However, in this mode, as with most logic clips, its principal use is for checking quasi-static states because the pulse-stretching feature does not operate on any pin except the one dialed up by the rotary switch. Nevertheless, an operator can use this mode to check out a counter or note the action of a gate. (A pulser can be used with the clip in this mode).

Toggling rates of greater than 1 megahertz cause continuous blinking at approximately five blinks per second; consequently single events can be observed and stuck pins distinguished from toggling pins. The plug-in probe extender enables the operator to examine the toggling behavior of any nearby pin while observing the failure indications on the board IC. Failure coincidence with another board event can thus be noted.

A failure is a noncorrespondence in logic states between corresponding output pins and is sensed any time it occurs. Failure-sensing is asynchronous. Once a fault is sensed, it is latched for 0.1 second so the human eye can detect it, and then it is automatically reset. If another failure occurs during the latch period, it extends the time of reset 0.1 seconds longer. Thus, a stuck fault will cause a continuous failure display, but a single fault is reset, opening the comparator to catch the next one.

The single test procedure

Improved diagnostic tools are all well and good, but to realize their full potential, they should be combined with improved troubleshooting procedures. One such new procedure, called Faultrack, is based on the fact that logic faults will leave a track of abnormal logic states in the system in which they occur (see "Faultrack finds fault with both boards ICs," p. 91). These improper states can be detected and traced back to their causes.

For this procedure to be valid, two conditions must be met: the logic board must be operating (on an extender in its normal unit or in a logic exerciser/tester), and all sequential logic must be either initialized automatically or of such a nature that initialization can be forced. The procedure itself is based upon the checking of two criteria: (1) are all the actively used nodes toggling? and (2) do the ICs behave the same as known-good ICs under the same inputs? If the answers are yes, the confidence level is extremely high that the ICs and the board are free of defects. If the answer is no, the fault can be tracked to a node where one of three causes will be found: a solder or trace defect, a defective IC driving the node, or a defective IC being driven by the node.

The Faultrack procedure applies to both simple and more complex circuits. In particular, it combines the ability to track stuck nodes with the ability to confirm the operating integrity of an IC and the board, even within logic feedback or in the presence of multiple faults. Technicians find the ability to confirm stage integrity quite valuable in zeroing in on faulty nodes. □

Digital demodulator for phase-shift-keyed data

by C.A. Herbst
Technology Resources, Paris

Exclusive-OR gates and a repeat-modulation scheme can be combined to produce a digital phase-shift-keyed (PSK) demodulator that allows accurate recovery of the reference-carrier pulse train. The demodulation of binary PSK data usually involves two major problems: recovering the reference carrier, and differentiating between the logic 0 and the logic 1 data pulses. This latter problem is resolved easily with differential coding, assigning a logic 1 when the change in carrier phase is 180° and a logic 0 when there is no change.

The first problem, however, cannot be resolved as simply. Usually, the input PSK-modulated carrier frequency is multiplied by 2 to cancel out the phase changes. But this technique, unfortunately, generally results in a degradation of demodulator performance.

A better method is to remodulate the demodulator's local oscillator with the received data so that the phase changes due to input modulation are cancelled out. This produces a virtually unmodulated reference carrier that is equal in phase to one of the two possible input PSK phase states. The ambiguity between the two phase conditions can be resolved by differential encoding.

The circuit shown employs this improved demodulation technique. A quad exclusive-OR IC is used to perform both the demodulation and remodulation functions. Here the exclusive-OR gates are operated as controlled inverters. In the phase-detector portion of the circuit, the PSK input carrier and the remodulated voltage-controlled-oscillator (VCO) signal are normally at quadrature with each other when the system is in lock. This results in a pulse train having a 50% duty cycle at the output of gate G_1. The pulse train is then integrated by the low-pass filter into a dc error signal.

As the phase difference between the input PSK signal and the input VCO signal deviates from its normal 90° shift, the pulse train at gate G_1's output becomes width-modulated. The average dc error voltage then changes, correcting VCO phase and frequency in the direction that reduces demodulation error.

In the circuit's data-demodulator section, the input signal and the VCO output are either mostly in phase or mostly out of phase with each other, depending on the modulation status of the input PSK signal. Therefore, the output of gate G_2 is either logic 0 or logic 1, according to the status of the PSK data.

A second low-pass filter then integrates G_2's gate output signal, which is subsequently squared by the comparator to produce the demodulated output data. This final output signal is also used to modulate the VCO by means of gates G_1 and G_3. □

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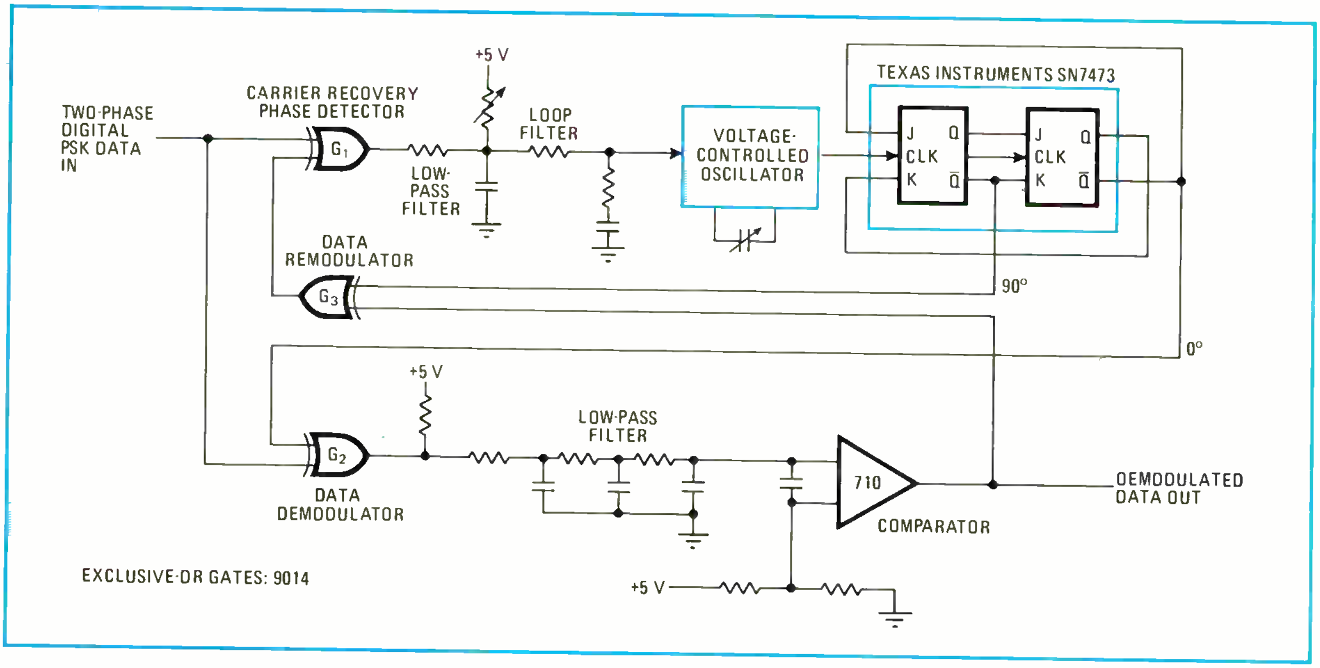
C.A. Herbst, "Digital Phase-Locked-Loop with Loss-of-Lock Monitor," EDN/EEE, October 15, 1971.

Unscrambling a binary line. Demodulator for phase-shift-keyed inputs operates exclusive-OR gates as controlled inverters to decode the input data and recover the reference carrier. Input data is remodulated with an error-corrected output from the voltage-controlled oscillator, cancelling out any phase changes from the input modulation. This permits a nearly unmodulated reference carrier to be recovered.



Combined op amps improve over-all amplifier response

by William Ott
Burr-Brown Research Corp., Tucson, Ariz.

By interconnecting a low-drift op amp with a wideband op amp, the best characteristics of both amplifiers can be preserved in a composite amplifier that offers the added benefit of increased open-loop gain. Typically, wideband op amps tend to produce significant errors because they exhibit a large offset voltage drift with time and temperature. But in the composite amplifier, the low-drift op amp can continuously compensate for the input offset voltage of the wideband op amp.

The composite amplifier of (a) is an inverting-only configuration. Low-drift amplifier A_1 senses the offset voltage between ground and the summing junction of wideband amplifier A_2. Any offset that is present will be integrated by A_1 to develop an offset-compensating voltage at the noninverting input of A_2.

This integration continues until the summing junction voltage is offset from ground by only the input offset voltage of low-drift A_1 (including the effects of A_1's input bias currents on resistors R_1 and R_2). The offset voltage of the composite amplifier, therefore, is essentially that of the low-drift op amp.

For the differential-input composite amplifier of (b), A_1 amplifies the offset voltage at the inputs of A_2. Low-drift amplifier A_1, then, supplies an offset-compensating voltage for the offset-nulling input of A_2.

In this way, the output of amplifier A_1 reduces A_2's offset voltage to that of the low-drift op amp, plus the offset from the bias current in resistors R_1 and R_2. As with circuit (a), the offset voltage and the offset voltage drift of the wideband op amp are essentially replaced by those of the low-drift op amp.

The open-loop gain of both composite amplifiers is $A_{O2}(1+\alpha A_{O1})$, where α is defined as $E_x/A_{O1}E_i$, and A_{O1} and A_{O2} are the dc open-loop gains of amplifiers A_1 and A_2, respectively. For the inverting-only configuration of (a), the quantity, αA_{O1}, is the response of the integrator formed by amplifier A_1, resistor R_1, and capacitor C_1. For the differential-input configuration of (b), α is essentially a constant and is independent of frequency; it is the change in the offset voltage of amplifier A_2 due to a change in A_1's output voltage, E_x.

If the inverting-only composite amplifier is to have a single pole in its open-loop gain response to insure gain stability, then:

$$R_1C_1 = A_{O2}/2\pi f_{c2}$$

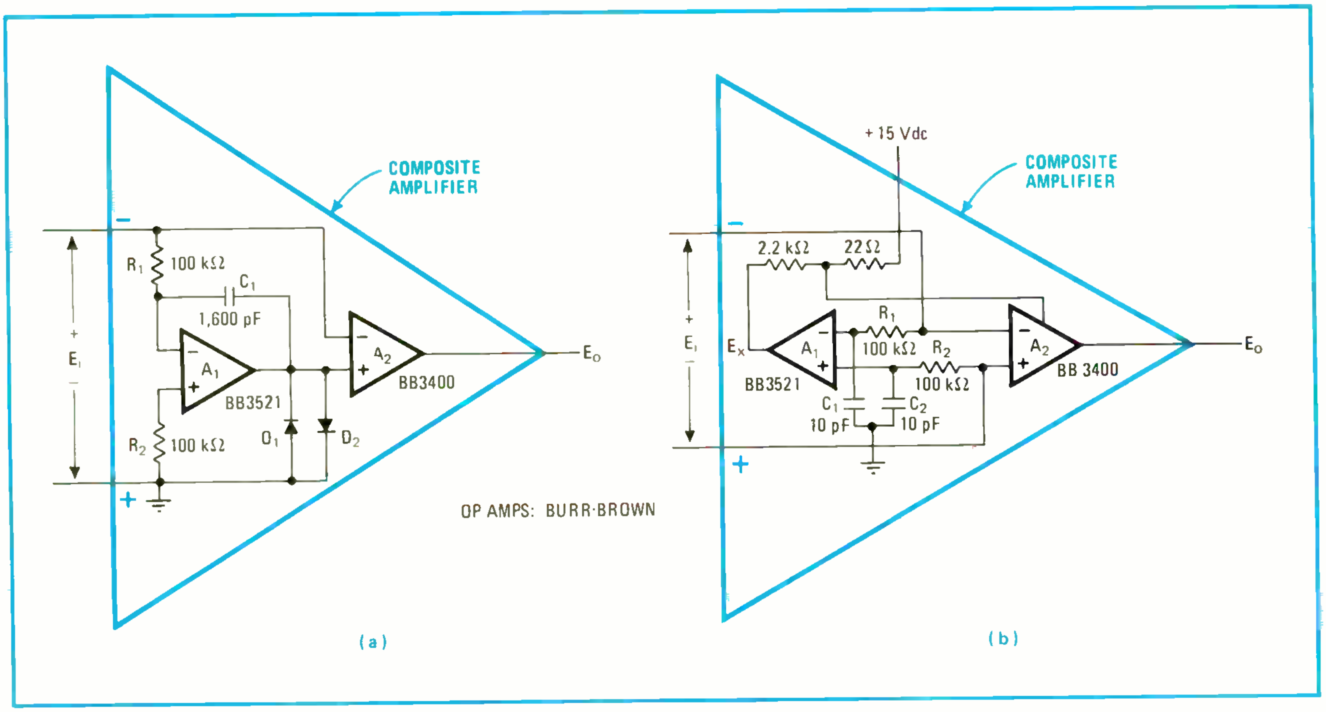
where f_{c2} is the unity-gain bandwidth of amplifier A_2. The bandwidth of the composite amplifier is essentially equal to f_{c2}, about 100 megahertz. The over-all offset voltage is about 200 microvolts, with a drift of 1 μV/°C. The over-all open-loop gain is around 200 decibels.

For the differential-input composite amplifier to have a single pole in its open-loop gain response:

$$\alpha = -f_{c2}/A_{O2}f_{c1}$$

where f_{c1} is the unity-gain bandwidth of amplifier A_1. Like the inverting-only amplifier, the differential-input amplifier has an over-all bandwidth of 100 MHz, an offset voltage of 200 μV, and an offset voltage drift of

A good combination. Two op amps—a low-drift one (A_1) and a wideband one (A_2)—can be wired to produce a composite amplifier that is both fast and stable. Circuit (a) is an inverting amplifier, while circuit (b) is a differential amplifier. Both amplifiers provide an over-all bandwidth of 100 megahertz, an over-all offset voltage of 200 microvolts, and a total offset voltage drift of 1 μV/°C.



1 μv/°C. The circuit's over-all open-loop gain, however, is somewhat smaller—140 dB.

Besides less offset voltage drift and more open-loop gain, the differential-input amplifier offers the additional advantage of improved common-mode rejection at low frequencies. For low-frequency operation, the common-mode rejection of the wideband op amp is essentially replaced by that of the low-drift op amp, which typically provides much better common-mode rejection.

In circuit (a), diodes D_1 and D_2 at the output of the low-drift op amp prevent a latch-up condition from occurring. Latch-up is possible in the composite amplifier when the low-drift op amp's output saturation voltage exceeds the wideband op amp's common-mode range.

And in circuit (b), there are two low-pass filters (formed by resistors R_1 and R_2 and capacitors C_1 and C_2) at the inputs of the low-drift op amp. They prevent high-frequency common-mode voltage swings from unbalancing the input stage of the low-drift op amp and changing its input offset voltage. □

Inexpensive power supply produces zero-ripple output

by Rod Spencer
Chlorescope Systems, Linden, N.J.

Here is an easy way to build a low-cost power supply in which ripple voltage can be brought virtually to zero. Through a feedback arrangement, the ripple voltage is inverted and summed to cancel the normal ripple.

As indicated in the figure, an operational amplifier and a series-pass transistor are connected in the standard manner. However, a portion of the unregulated ripple voltage is fed into the op amp's inverting input.

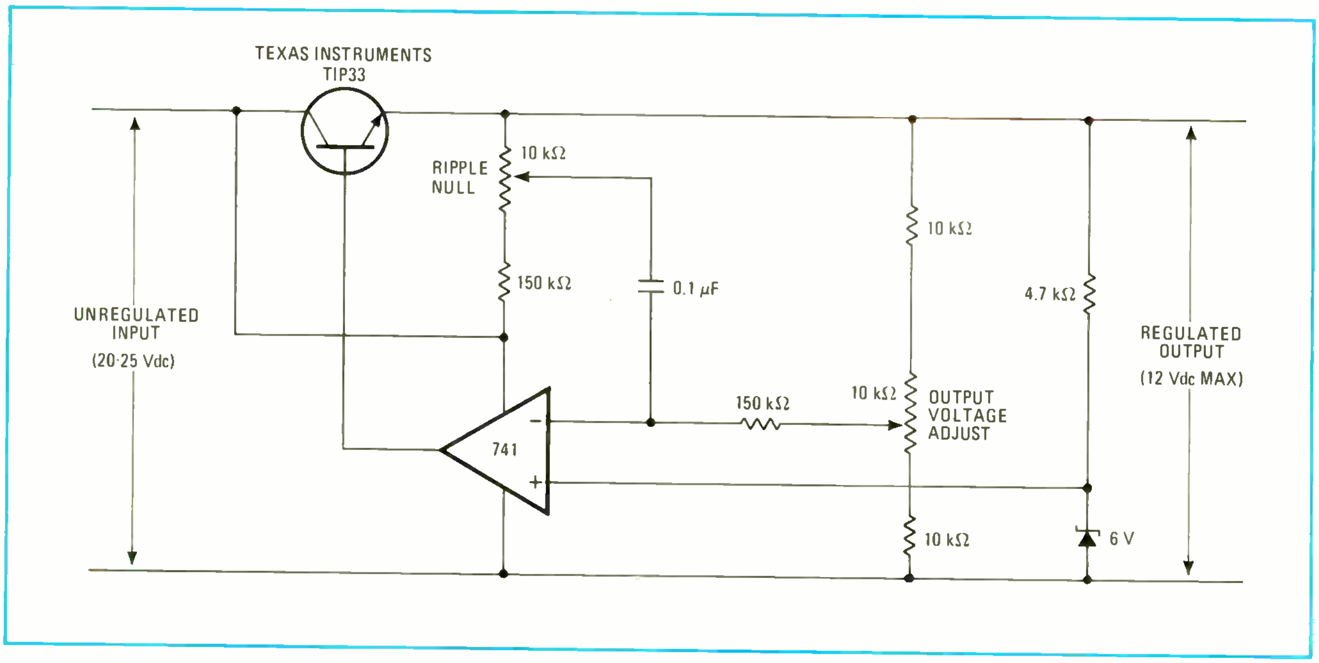
When the wiper of the RIPPLE NULL potentiometer is set up toward the output voltage bus, the supply's ripple is normal. But when the pot wiper is set down toward its unregulated-input end, a phase shift of 180° is introduced, and the ripple is reversed. If this RIPPLE NULL is adjusted properly, the supply's ripple voltage can be completely eliminated.

To adjust the circuit, first set the regulated output voltage to the desired level and then subject the output to the maximum load condition. Next, use an oscilloscope to monitor load voltage, and trim the output ripple voltage to zero. This supply's ripple will remain essentially zero for any load condition less than the maximum.

Representative component values are shown in the figure, and parts should be chosen to satisfy a particular application. The series-pass transistor, of course, is selected to meet load requirements. And, if an op amp cannot supply a sufficient base drive for the transistor chosen, a Darlington pair can be used instead. □

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.

Canceling ripple. Low-cost power supply employs inverting feedback loop to eliminate output ripple voltage almost entirely. Some of the circuit's unregulated ripple is applied to the op amp's inverting input, where it is reversed. This "negative" ripple cancels the supply's normal "positive" ripple. The technique can be made to satisfy a variety of application requirements by adjusting the component values.



The thermal demands of electronic design

The dense packaging, fast switching of ICs today create so much heat that designers must bone up on old remedies, find out about new ones

by Stephen E. Grossman, *Packaging & Production Editor*

☐ Heat—the inescapable byproduct of every device and circuit—is looming larger and larger as an electronic design problem. With large-scale integration packing ever more active devices on chips, and with circuit boards carrying IC packages in the hundreds, the pressure is on circuit designers to mind their thermal manners as never before. Still another dimension to the problem is added by each advance in device performance: higher switching speeds in digital ICs, for example, or higher output powers in analog circuits.

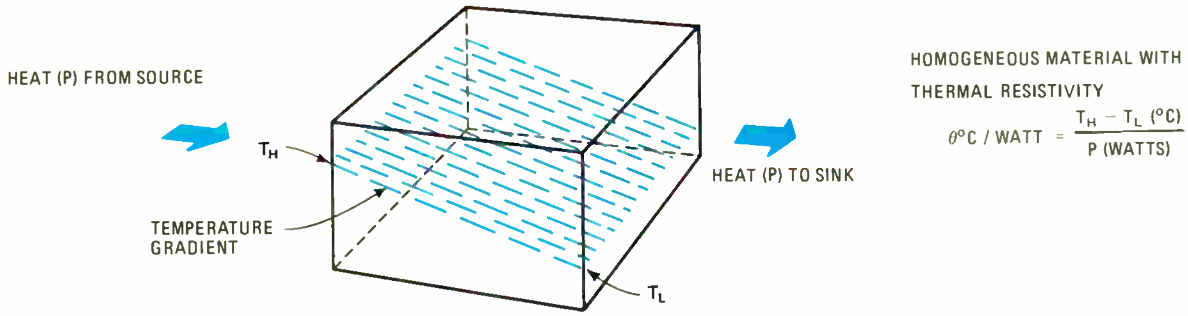
The prudent designer will regard heat as his implacable enemy. Poor thermal design at the least reduces lifetime, undermines reliability, and degrades system performance. At worst, it can cause catastrophic failure, unsafe products, and costly, even fatal damage.

Thermal management, then, is too important to be left only to specialists. It should be the concern of all electronic engineers right from the circuit concept stage, through the selection of components, materials, into layout and final packaging. In the end, a heat specialist may be required, but his services may be costly if preliminary attention hasn't been paid to heat fundamentals.

David Hegarty is well acquainted with their importance, for as chief applications engineer at Wakefield Engineering Inc., Wakefield, Mass., a company which specializes in thermal management, he often receives pleas for help which arrive too late. Says Hegarty: "Frequently, the circuit designer lays out the whole board—then he comes to us for help in coping with the heat. Too often it is just too late for an efficient and economical design. So the thermal solution may end up being a kluge."

At the other end of the scale are firms like IBM, which, recognizing the critical nature of thermal management to its business, involves teams of heat transfer specialists and thermal designers in the development process. Richard Chu, who manages IBM's thermal development

1. Taking the heat off. Liquid cooling is an increasingly popular way to remove heat from semiconductor devices with high dissipation levels. This cold plate, made by Wakefield Engineering, can dissipate over 600 watts. Note that the coolant lines pass directly under the devices.



2. Thermal Ohm's law. Components with arbitrary geometries can be assigned a thermal resistance (θ) by determining the heat flow and the temperature drop parallel to the heat flow path and calculating the quotient of temperature to power in degrees centigrade per watt. Thermal resistance plays an important role in solving many thermal problems in electronics.

group at the Poughkeepsie, N.Y., development laboratories, describes his company's attitude: "Here at IBM we look at heat transfer from the very beginning of a design. We also make a point of considering the impact of thermal design on both product performance and reliability. It is not simply a matter of saying 'the lower the temperature, the better.' "

So it behooves the electronic designer to get some feel for the terminology and the units of measurement of this important domain, and to keep up to date with its emerging techniques (Fig. 1). Such knowledge will enable him to include more thermal management in his

How heat hits semiconductors

Because the electrical and mechanical properties of electronic devices are temperature-dependent, it comes as no surprise that both excessive heat and erratic, uncontrolled temperature excursions accelerate semiconductor device failure.

There are two prominent failure mechanisms: thermal mismatch, and hot spots.

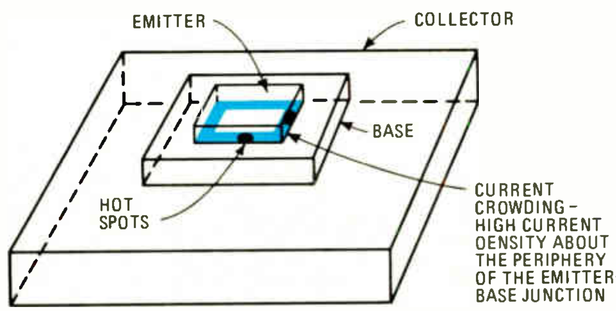
Thermal mismatch causes a stress known as shear to develop along a bonded interface between two dissimilar materials when the junction is subjected to temperature variation. It occurs as the result of unequal coefficients of thermal expansion in the two mated materials. As an example, if silicon is bonded to a ceramic substrate at a high temperature, the silicon will shrink less than the ceramic when they cool, and the shear stress that develops may rupture the bond. This accounts for the popularity of epoxy adhesive to bond large silicon dice to substrates because bonding temperatures are low—typically 200°C. (Eutectic die-attach temperatures rise at least twice that high.)

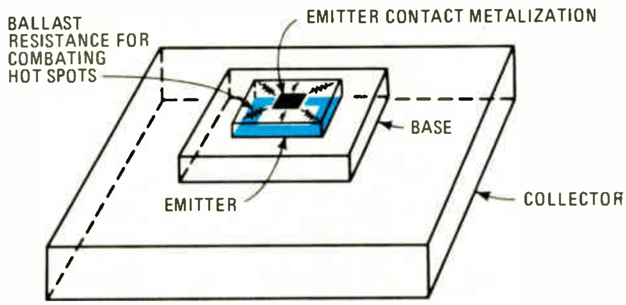
Current crowding is a phenomenon that develops in bipolar devices causing localized device heating. It leads to hot spots that raise temperatures to destructive levels and cause premature device failure. Such crowding across the emitter-base junction occurs because an unavoidable voltage gradient develops across the base, adjacent to the emitter.

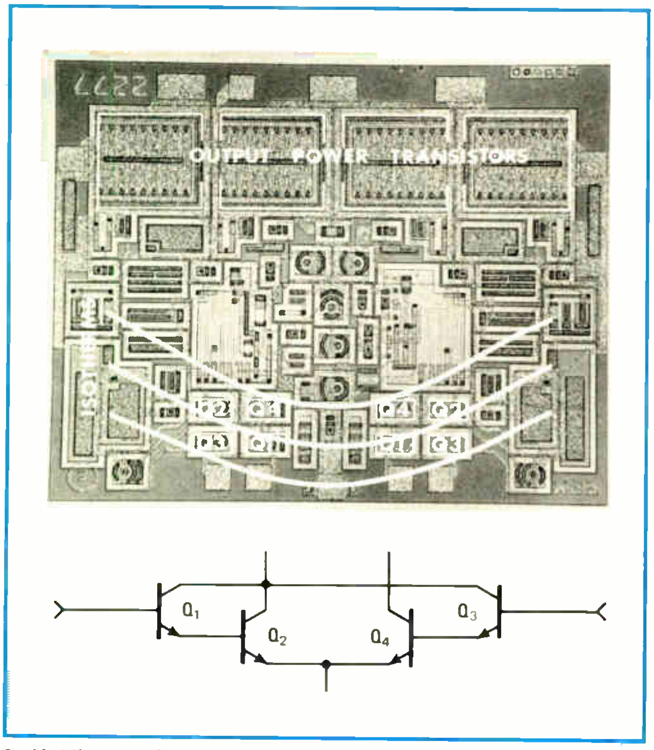
One technique that device designers have employed to combat this effect is to configure the base-to-emitter geometry as interdigitated fingers. This maximizes the parameter-to-surface area ratio and counteracts the crowding effect.

A second technique is to ballast the emitter by increasing the resistivity of the paths between the emitter contact metalization and the emitter-base junction as shown. It is accomplished by raising the bulk resistivity of the emitter region. A self-regulating effect results because the bulk resistance response to rising current is to develop a reverse bias which prevents hot spots from developing.

Yet another technique is to enlarge the silicon pellet so that the interface area is larger and provides a broader path over which the heat can flow to the sink. But enlarging the interface of the pellet with the heat sink increases the likelihood of a bond failure because of the thermal match problem. Copper is a good sink material because it has a low thermal resistance, but it is a poor thermal match to silicon. Its coefficient of thermal expansion is about 17.5×10^{-6} in./in./°C, much larger than that of silicon at 2.3×10^{-6} in./in./°C. Some manufacturers turn to molybdenum, because its coefficient matches silicon's well (3×10^{-6} in./in./°C. Then they clad it with copper to reduce the thermal resistivity of the interface with silicon.







3. Hot lines and cold. Isotherms, shown on this dual power IC chip, are lines that connect points having the same temperature. By judicious placement of the driver devices (Q1-Q4) relative to the isotherms, power gain remains virtually independent of temperature.

future design plans, and will also provide him with the vernacular to communicate with heat transfer specialists should the need arise.

Heat always follows a thermal path that is downhill, so to speak, traveling from the relatively high temperature of the source to the cooler temperature of the sink.

For simplicity, it can be assumed that this thermal path is homogeneous with a uniform cross section (Fig. 2). Under these conditions, the thermal path can be thought of as a thermal resistor, which has the dimensions of degrees per watt instead of ohms. One degree per watt also represents a thermal gradient through which 1 watt of heat may be transferred through the material, and thus also connotes a potential gradient which serves the same role as a circuit voltage. That is, temperature gradient is a potential that determines the power flow, in watts, through a given component.

The concept of thermal resistance then conveniently reduces the analysis of thermal problems to a simple relationship resembling Ohm's law. Thus, in order to raise the heat transfer capability from one point to another, without changing the temperatures of the source and sink, it's only necessary to lower the thermal resistance between the two points as far as possible.

The problem can become complicated, however, when the thermal resistance path is not homogeneous. Then the over-all gradient becomes a function of the composite thermal paths.

The levels

It is commonplace in packaging to speak of separate packaging levels: the device, the surface which supports the device—the printed-circuit board or the backplane—and the enclosure. This division also lends itself to analysis of the thermal aspects of packaging.

IC devices come into consideration because device designers are packaging more and more active circuits into the device package. Though power levels for the commonly-used families of logic gates are in the 10- to 100-milliwatt range, the problem is simply that putting thousands of these gates into a small IC package translates into extraordinarily high power densities never before encountered in electronic packaging. Since silicon cannot withstand operating temperatures much above 150°C, the device designer cannot allow the junction temperatures to rise above the device limit. So he must lower the thermal resistance of the path out of the package. This means either altering the geometry, or selecting packaging materials with lower thermal resistances, or doing both.

Geometry is also the key to assuring stable power-IC performance independent of temperature, for it enables device designers to take into account the fact that gain is dependent on temperature. Figure 3 illustrates the device geometry of a Sprague parallel power amplifier chip. The output power transistors are identified near the top of the chip. Isotherms, which are lines connecting points having the same temperature, have been drawn through the region at the bottom of the chip, where the Darlington-connected driver pairs are located. Note that transistor Q_4 lies on the isotherm nearest to the power transistors. This transistor is the hottest. Transistor Q_3 is a degree or so cooler, while paired-transistors Q_1 and Q_2 are at about the same temperature. However, in both cases the transistor pairs are equidistant from the center isotherm. Consequently, the gain of the Q_1-Q_2 pair is about equal to the gain of the Q_3-Q_4 pair, and over-all gain of each amplifier section remains essentially independent of temperature variation.

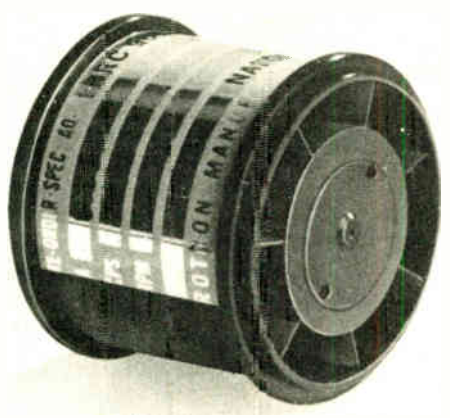
The next level of thermal concern is the printed-circuit boards and the mechanically wired backplanes. Here the predominant mode of cooling is convective air.

In free convection the boards are positioned in a vertical attitude so that warm air rises along the board surfaces carrying the heat away. Free convection is economical, because no air-moving equipment is required, and it is also reliable, which explains its popularity where low maintenance costs are crucial—in telephone companies, for example.

But the higher density of modern electronics needs a faster rate of air flow than 0.5 linear feet per second—which is about the highest that can be expected in free convection. Consequently, forced air cooling has become commonplace, and today fans and blowers are performing two principal functions: cooling localized hot spots such as high-power transistors, and flushing hot air from an equipment enclosure, so that the ambient temperature is held below a specified design limit.

But even forced air cooling is reaching its limit for localized cooling as digital designers drive devices at higher switching speeds and raise the power they dissipate. As a result, liquid cooling is being used more and more.

Bill Allen, a manager of large computer circuit design, at Burroughs Corp., Paoli, Pa., points out some of the arguments in its favor: "Temperature variation



4. Breezes to order. This fan weighs only an ounce, fits in a 1-inch cube, and is well suited for microelectronic applications. Rotron, the manufacturer, rates life expectancy in excess of 20,000 hours. Device delivers up to 8 cubic feet per minute.

within a mainframe enclosure plays havoc with both noise margin and propagation delay. But by switching to liquid cooling such variations are easily minimized. Liquid also enables the size of the power supplies, a major source of heat in most large systems, to be reduced. Also, air-moving systems often create a lot of acoustic noise, and liquid cooling rids the enclosure of blowers and fans."

Cold plates are heat-exchanging devices which transfer heat from an electronic device to a moving liquid. The unit shown in Fig. 1 dissipates a lot of power—600 w developed by 21 TO-3 devices and two TO-66 devices. Thermal resistivity from device case to coolant is about 0.3°C/w per transistor, and the coolant flow rate is 1½ gallons per minute.

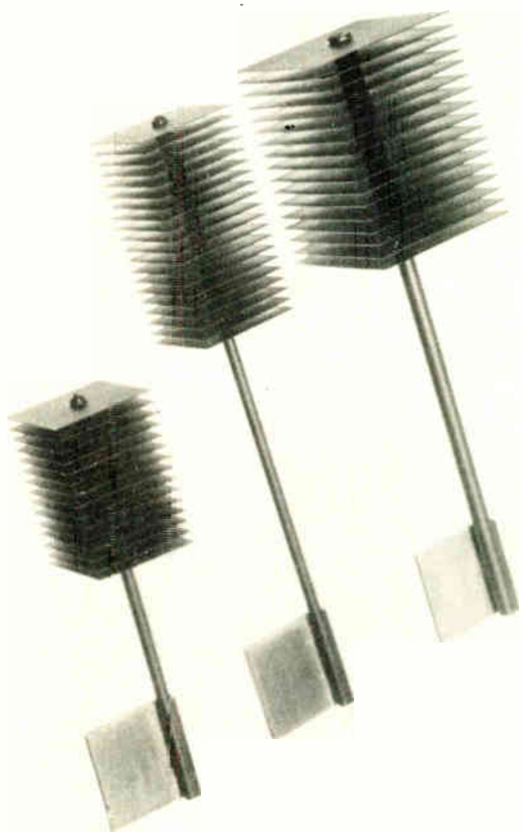
Cold plates can be operated as either an open-loop system, which would be a simple tap-to-drain arrangement with flow provided by the local water supply, or a closed-loop system. The closed-loop system, though more costly, enables the coolant to remain free of contamination. Frequently, a deionization system is employed which removes impurities from the coolant and also prevents foreign materials from blocking the coolant lines.

Closed-loop systems normally employ a heat exchanger to cool the fluid. The heat exchanger is a device which functions very like an automobile coolant system. A pump maintains the coolant flow. The hot coolant from the cold plate is passed through a radiator which is cooled by a forced air flow. The coolant is then returned to the cold plate.

Tom Coe, president of Wakefield Engineering points out: "Computer designers are rediscovering the heat exchanger, a familiar friend to engineers who have worked in induction heating and high power rf."

Heat pipes

Still waiting in the wings is the heat pipe, which has yet to take hold as a major participant in commercial heat transfer applications even though the technique dates back to a 1942 patent. Heat at one end of a sealed pipe causes liquid inside that end of the pipe to vaporize and travel to the opposite, cooler end, where it condenses. The liquid makes the return trip to the hot end by being drawn by capillary action along a wick lining the pipe [*see* "Heat Pipes—A Cool Way to Cool Circuitry," *Electronics*, Feb. 16, 1970, p. 94].



5. Heat pipes. These units are designed to cool discrete devices which mount on the tabs at bottom and transport heat to the finned radiator at top. Manufactured by Jermyn, they are among the first off-the-shelf products to employ the heat-pipe principle. The advantage of heat pipes is that they provide thermal resistivities several orders of magnitude lower than the best thermal conductors.

Thermal experts are enthusiastic about heat pipes because these devices function with a very small temperature drop—several hundred times less than the best thermal conductors. Negligible temperature drop permits a designer to position a sink in a remote location and then use the heat pipe to transport the heat from a pad to a finned radiator (Fig. 5). The pads on these assemblies are drilled by the user and the semiconductor devices are secured in place.

First of a series

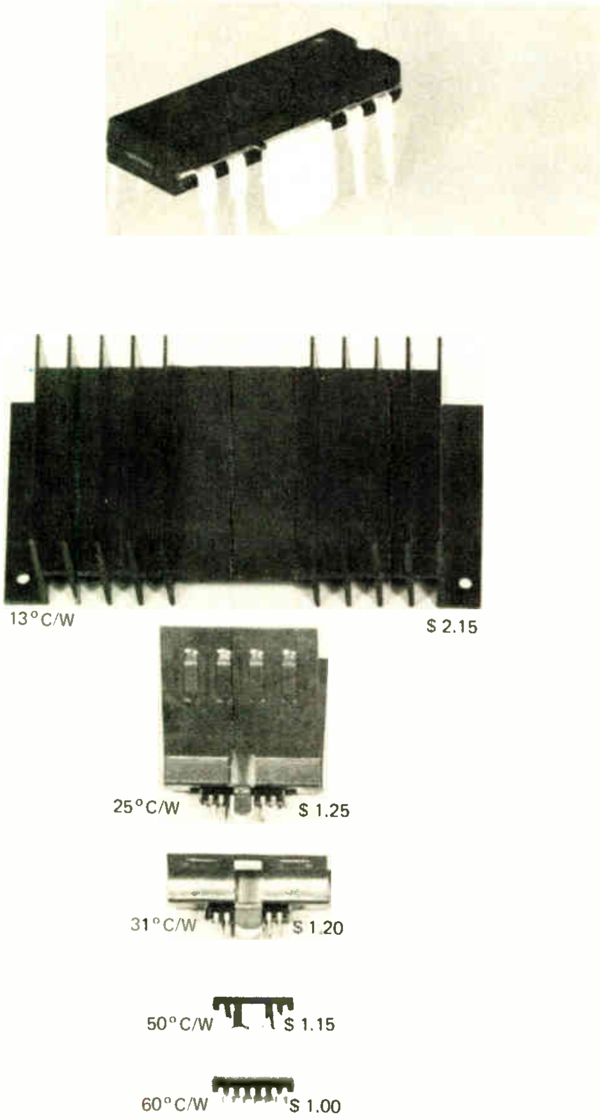
The article which begins on page 102 is the first in a series on thermal design. It discusses techniques for raising the power capability of plastic-packaged power ICs.

In the next article in the series, Forest Golden of General Electric will discuss the thermal problems encountered by engineers who design and use discrete power semiconductor devices. Subsequent articles will explore thermal topics of concern to device, circuit and package designers. ☐

Plastic power ICs need skillful thermal design

Minimizing power dissipation and lowering thermal resistance with batwing lead frames and heat sinks enables 5- to 10-watt linear ICs to operate reliably

by Sumner B. Marshall and Raymond F. Dewey, *Sprague Electric Co., Mass.*



1. Sink the heat. Batwing power IC (top) lets heat sink be directly attached to lead-frame tabs, greatly increasing thermal dissipation capability. Larger sink geometries (middle) lower the thermal resistivity and thus increase the power capability. Such arrangements contrast sharply with the high thermal resistance (60° C/W) of the conventional 14-lead device with no heat sink (bottom).

☐ Linear power ICs in plastic packages can now deliver 5 to 10 watts of continuous power and are beginning to supplant the more expensive metal-cased transistor. However, their thermal requirements are much trickier to handle than those of the discrete power device, for there is no simple way to heat-sink them and assure them of a path of low thermal resistance. ICs are soldered to a printed wiring board or, what's worse from a thermal viewpoint, plugged into plastic sockets.

Thermal design can be an important contributor to performance. Merely adding a heat sink costing less than half a dollar to a plastic-packaged IC can raise the rated power output by a factor of eight. But from the reliability standpoint, thermal design is really crucial because failure to heed its requirements will assure the onset of a whole raft of thermally-induced ailments—increased leakage currents, material decomposition, drift, and premature device failure. It falls to the designer, then, first to select a device that satisfies not only the electrical and mechanical requirements but the thermal criteria as well, and then to protect the device from damaging temperatures.

To perform these tasks, he must understand the thermal paths within the plastic-packaged device, and familiarize himself with the roles of heat sinks (Fig. 1) and forced air cooling. With this background he is well equipped to optimize the thermal operating environment of the plastic-packaged power IC.

Start of the trouble

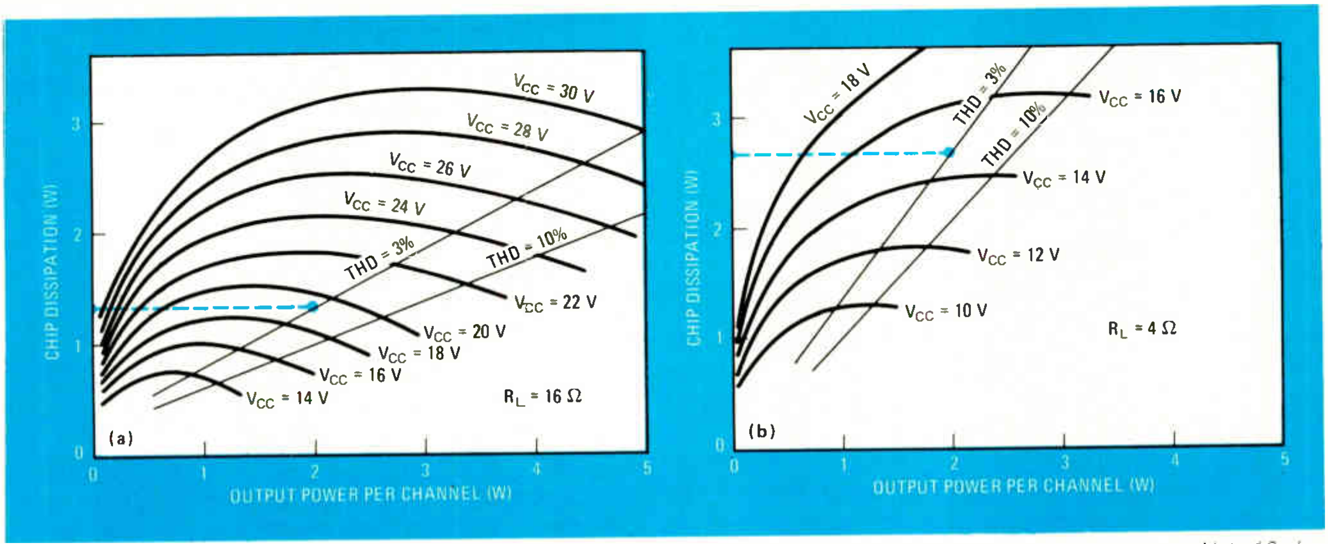
The power IC must be held below its maximum safe operating temperature. This is typically 150°C for silicon.

A second constraint is the temperature of the operating environment of the packaged device, usually termed the ambient. If the plastic package were the only consideration, the ambient could be allowed to rise to perhaps 70° or 85°C. But usually the maximum operating temperatures of nearby components will restrict the ambient to an upper limit of 50°C.

Another constraint is that a minimum temperature differential must be maintained between the ambient and the chip, to ensure that the required power can be dissipated. These relationships are apparent in the thermal equation:

$$P\theta_{J\text{-}A} = T_J - T_A$$

where P is the rate of heat flow in watts



2. Minimize dissipation. The curves shown here apply to a Sprague type ULN-2277 dual power IC. If the amplifier is operated into 16-ohm loads (a), rather than 4-ohm loads (b), chip dissipation is minimized. This also minimizes device temperature and enhances reliability. Dissipation values indicated are for 2 watts of delivered power and 3% total harmonic distortion (THD).

θ_{J-A} is thermal resistance from junction to ambient in °C per watt

T_J is the junction temperature in °C

T_A is the ambient temperature in °C

The design task then is to first minimize the dissipated power and the thermal resistances from the junction of the chip to the ambient, and then to take whatever additional steps are required to lower the ambient.

A good place to begin is to select both the circuit components and the dc supply voltage for minimal power dissipation. The chip power dissipation for various load impedances and supply voltages can be obtained from manufacturers' specifications.

A typical example is the Sprague Type ULN-2277 dual 2-watt audio amplifier IC. As shown in Fig. 2, the power dissipation is determined by the output power required, the maximum acceptable total harmonic distortion (THD), and the dc supply voltage, V_{CC}. If a power output of 2 W is required with a 3% maximum total harmonic distortion, then chip power dissipation is about 2.7 W at a V_{CC} of 15 V with a load impedance of 4 ohms. However, power dissipation is only 1.4 W at V_{CC} = 19 V with a 16-ohm load. In general, the highest load impedance for a given output power is the most desirable, within the output voltage capability of the device.

Once the circuit has been optimized for minimal power dissipation, attention can be turned to the matter of thermal resistance.

The path out

Heat removal from plastic-packaged ICs is difficult. Unlike discrete components, which often have studs and thus fairly low junction-to-ambient thermal resistances, ICs are usually soldered into printed-circuit boards or plugged into plastic sockets, and chip-to-ambient thermal resistance without a heat sink are relatively high.

There are two paths from the chip to the ambient. One is the path from the junction through the plastic case (denoted by the upward pointing arrow in Fig. 3) and has a thermal resistance of between 50°C/W and 100°C/W. The second path (indicated by the downward pointing arrow in Fig. 3) is the sum of the thermal resistances of the silicon chip, the die bond, and the lead frame, and has a much lower thermal resistance. So the designer's best course is to make sure that the thermal resistance of this path is as low as possible.

Device manufacturers frequently employ Kovar, an iron-nickel-cobalt alloy, for lead frames because it has a coefficient of thermal expansion which is quite close to silicon. In this way they minimize the mechanical stress that develops between the lead frame and the chip when the device is subjected to temperature variations. However, Kovar's thermal resistance is about 30 times that of copper, so in high-power circuits a copper or copper-alloy lead frame is preferable.

Batwings help

Manufacturers are further enhancing the thermal path by altering the conventional 14- and 16-lead designs. One such design is the "batwing" IC package (shown with and without heat sinks attached in Fig. 1). It is becoming an industry standard. Size is the same as a conventional 14-lead IC package, but the central lead-frame sections are formed as tabs that measure ¼ inch square. These tabs may be soldered, welded or bolted to a heat sink or inserted directly into some sockets. This geometry achieves a worst-case thermal resistance of about 11°C/W, junction to case, whereas an IC with a conventional 14-pin copper lead frame exhibits a thermal resistance of 19°C/W.

Sometimes even a package that boasts as good a thermal design as the batwing configuration will require a heat sink. The manufacturer's data on a given device will enable the designer to make this decision. The data, which sometimes is presented in the form of curves, takes into account the maximum chip temperature that can be tolerated and the thermal resistance of the IC package.

Actual thermal performance in any design, however, also depends on many other factors, like interference in the air flow by nearby components, heat radiated or convected by other components, atmospheric pressures, and humidity. So, in selecting the thermal resistance of a heat sink, it is wise to allow a generous safety factor.

Heat sinks for plastic ICs can be procured from a number of vendors in a variety of styles. A few are shown in Fig. 1.

As an alternative, sinks can be fabricated from copper sheet. This material is quite effective in reducing thermal resistance from the case to ambient, and dimensions for a range of thermal resistances are given in Fig. 4. These values are for square sinks, 0.015 in. thick, with a dull or painted finish. They are intended to be mounted vertically on either side of the lead frame as shown in the figure. They should be soldered directly to the lead frame. Soldering adds on an interface thermal resistance of the order of 0.3°C/w.

Although unfinished copper is an effective heat sink, it lacks the eye appeal of finished metal. For this reason, and also to prevent corrosion of the raw metal part, heat sinks are often painted or anodized.

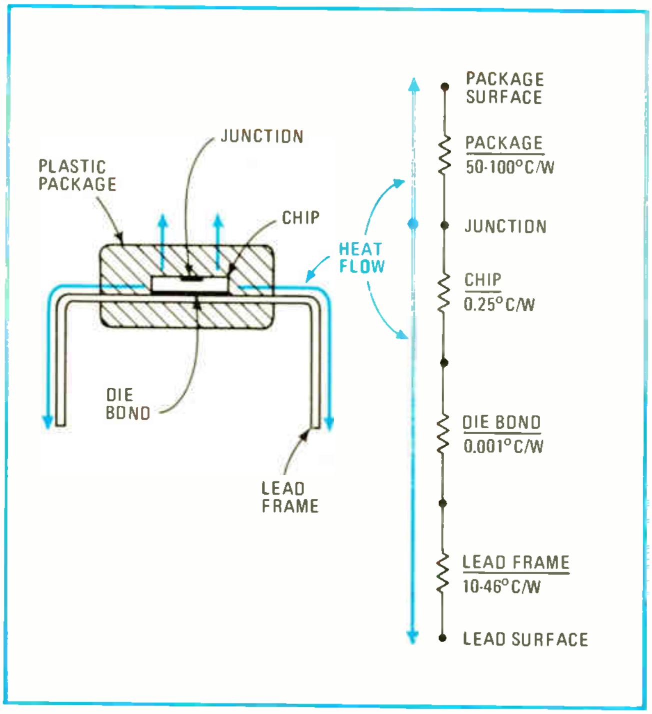
The most common finish is black anodizing. Besides being economical and attractive to look at, it enhances thermal performance by as much as 25% because the dull black is the most efficient surface for thermal radiation. On the other hand, an anodized surface is a poor thermal conductor, so those surfaces which mate with the IC must be free of anodization to ensure optimum thermal conductivity.

Iridite and chromic acid are other popular metal finishes because they offer low electrical and thermal resistivities. But like anodization, they also result in poor thermal radiators.

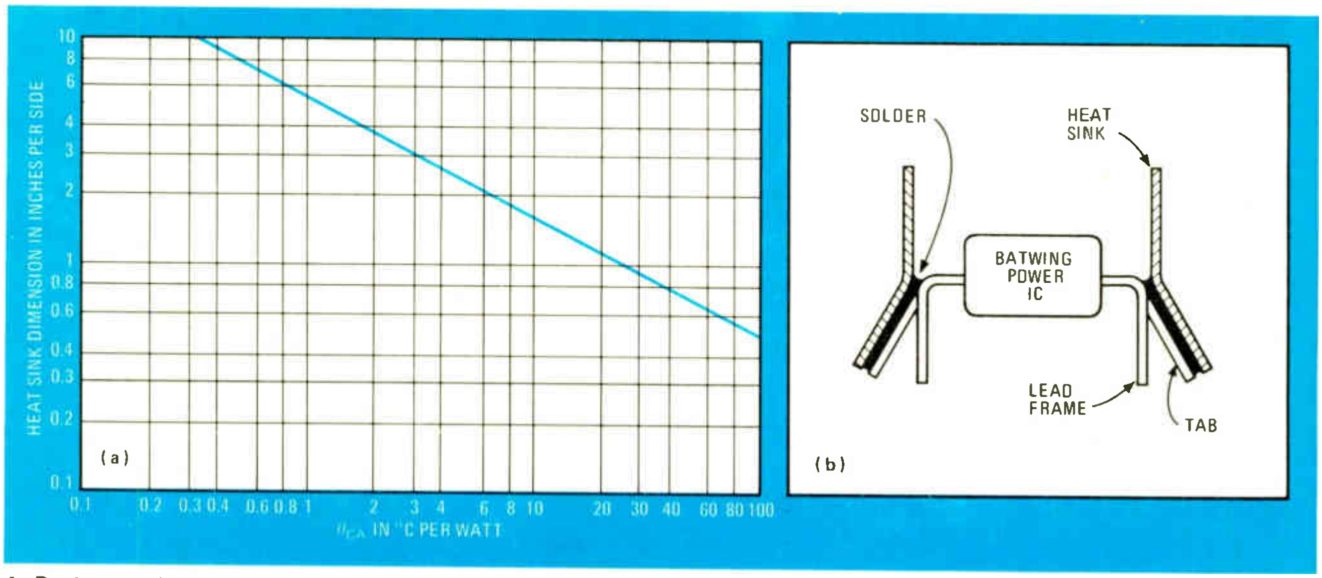
Convective cooling

Convection as well as radiation is at work removing heat from the sink. If the power dissipated is low, then the air is essentially stagnant, and the effective thermal resistance of the sink-to-air interface will be quite high. However, as the power dissipation rises, the air adjacent to the sink heats up and begins to rise. This induced air flow is known as a natural convection, and it sweeps the heated air clear of the heat sink, effectively lowering the sink-to-air thermal resistance.

Forced air cooling can improve heat sink performance by as much as 100%. A rule of thumb is that semiconductor failure rate is halved for each 10°C reduction in junction operating temperature. Even where space is at a premium, the cost of a small, compact fan or blowers can often be justified. Often an air-moving device, intended primarily to flush air from an enclosure, can be so located that it will force a high air flow directly across a plastic power IC. □



3. Two paths. Thermal resistivity is lower—on the order of 10° -46° C/W—through the lead frame than through the package—over 50° C/W. Device designers can optimize the thermal resistance through the leads by selecting a material with low thermal resistivity.



4. Design a sink. Once the required case-to-ambient thermal resistance is determined, the dimensions for pairs of square, 0.015-inch-thick copper plates can be selected (a). Plates are mounted to lead-frame tabs (b). Soldering holds interface thermal resistance to about 0.3° C/W. A dull black finish will enhance the radiating properties of the sinks.

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Addressing technique unlocks minicomputer's extended memory

New 32-bit architecture expands the power of small machines and breaks the barrier of conventional addressing schemes, which have proven inadequate for many applications that require high performance and complex software

by William B. Sweet, *Interdata Inc., Oceanport, N.J.*

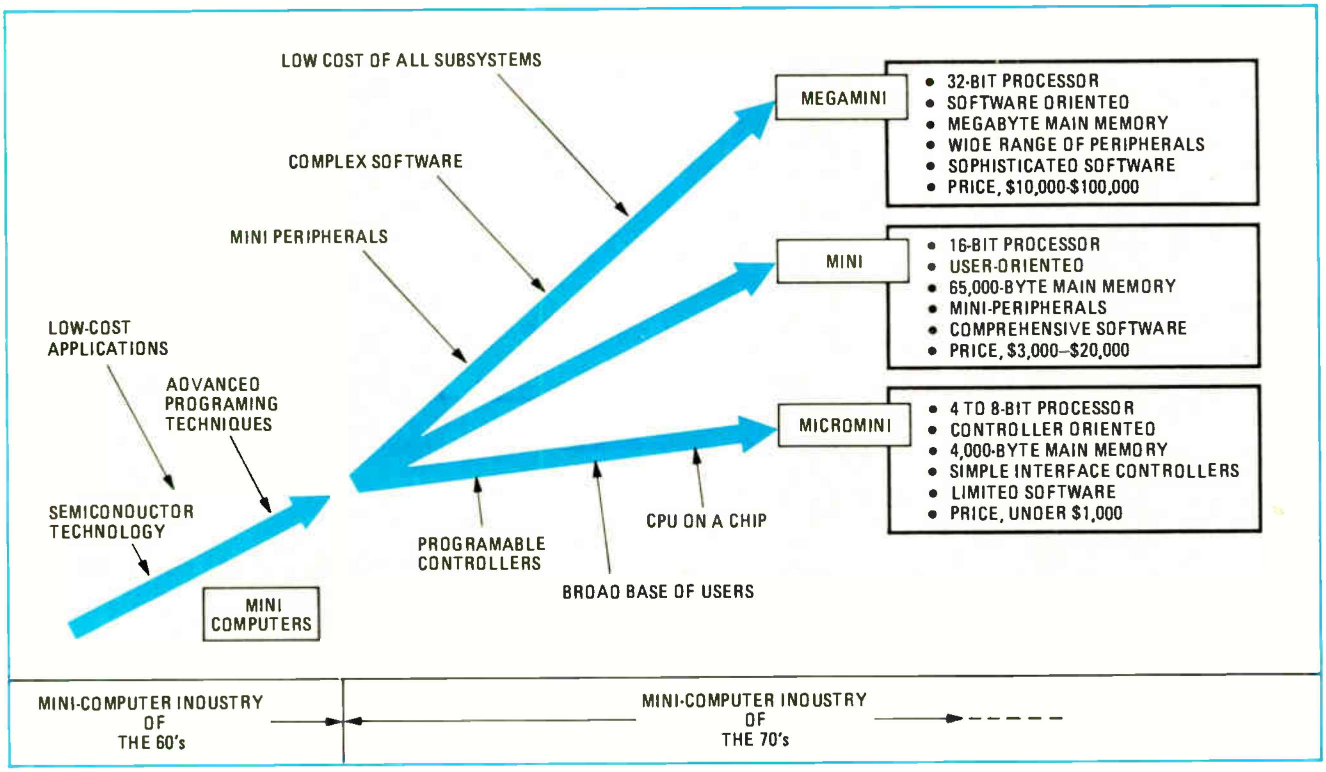
☐ The major architectural shortcoming of most minicomputers is their limited amount of memory that can be directly addressed. Various approaches to overcoming this limitation have appeared in recent years, but the newest is a machine that, like many medium-scale and larger systems, has a 32-bit word length and straightforward access to more than a million words of memory. Its classification as a minicomputer is justified by a price of less than $10,000 and a processor that occupies only about 14 inches of a standard rack.

The new machine, Interdata Inc.'s 7/32, represents one of three distinct branches of the minicomputer market that have appeared in the last couple of years (Fig. 1). These branches are represented by the traditional minicomputer, the new microminis, and the megamini.

The megamini is a high-performance machine that has the extended memory required for such applications as power generation, the petrochemical industry, scientific laboratories, communications, and many others—yet it costs much less than a medium-scale computer, the only alternative to an extended memory. Traditional minicomputers have been blocked from these applications by such barriers as a limited amount of directly addressable memory, logic and arithmetic operations of limited precision, primitive instruction sets, a small number of internal registers, and lack of sophisticated high-level programing languages and operating systems. Some of these constraints have been relaxed somewhat by particular features of some machines.

Do users need extended memory?

Probably the most severe of these constraints, from the user's point of view, has been the limited amount of addressable memory. Once upon a time, a memory capacity of 65,536 locations in a minicomputer was considered enormous, but not today—for four reasons:



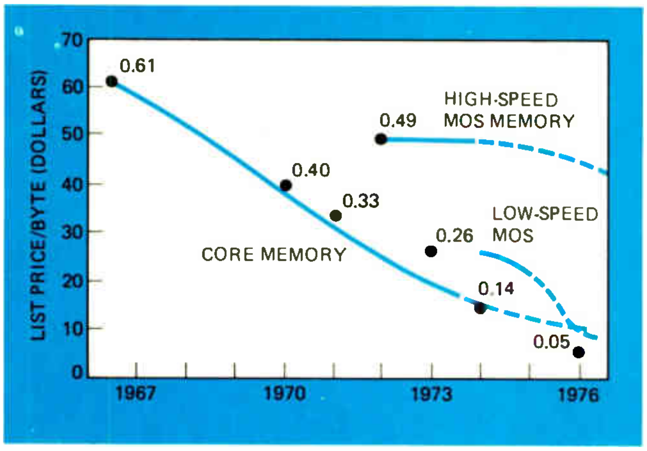
1. Trifurcation. Minicomputers once were merely minis, but now there are microminis and megaminis too. Megamini users have sophisticated applications that are nevertheless dedicated and therefore not well suited to the classic minicomputer.

■ Many current applications require large programs and large numbers of locations to store data—more than 65,536. These applications include on-line analyses of power-distribution networks and complex petrochemical plants, as well as array-processing typical of weather research, seismic-data analysis, and mathematical modeling of industrial processes.
■ Although some of these applications can be handled slowly enough that the excess programs and data can be kept on bulk-storage devices, such as magnetic drums or disks, many processes can't tolerate the long access times necessary to retrieve data from peripheral storage, nor the somewhat limited reliability of these units.
■ As memory size increases, programing complexity and costs both tend to decrease. Programers' salaries have been rising for some time, but memory prices are plummeting (Fig. 2), leading to a demand for plenty of memory for purely economic reasons.
■ Multiple minicomputers are being studied for such large, complex processes as control of nuclear-power plants. These minicomputer networks could be interconnected through a large shared memory, accessible to each individual minicomputer (Fig. 3), requiring each minicomputer to be able to address many more than 65,536 locations.

Thus large memories are necessary, and their size implies longer words than are commonly available. Typically minicomputers have 16-bit word lengths, although a few have 18 bits, and some have a length of only 12. At the very least, a computer instruction must include an operation code and the address of the data upon which that operation is to be performed. If both of these are squeezed into one 16-bit word, neither the instruction set nor the directly addressable memory can amount to much because there are not enough combinations of the 16 bits to permit it. Refinements, such as the use of internal registers, indexing, indirect addressing, and so on, offer a partial solution, but are still limited to a maximum of 65,536 locations.

Therefore large programs must be broken up into segments, which are overlaid, one after the other, in the limited memory space that is addressable. As long as instructions are executed in a single sequence, this isn't too bad, but difficulties abound when a routine in a previously overlaid segment of the program must be repeated in any of a vast number of iterative processes.

Memory capability can be expanded considerably by putting the operation code, plus necessary refinements, into one word and inserting the operand address into the immediately succeeding word, allowing up to a full 16 bits for each. With this 16-bit address, a maximum of 2^{16}, or 65,536, locations in the memory can be directly addressed.



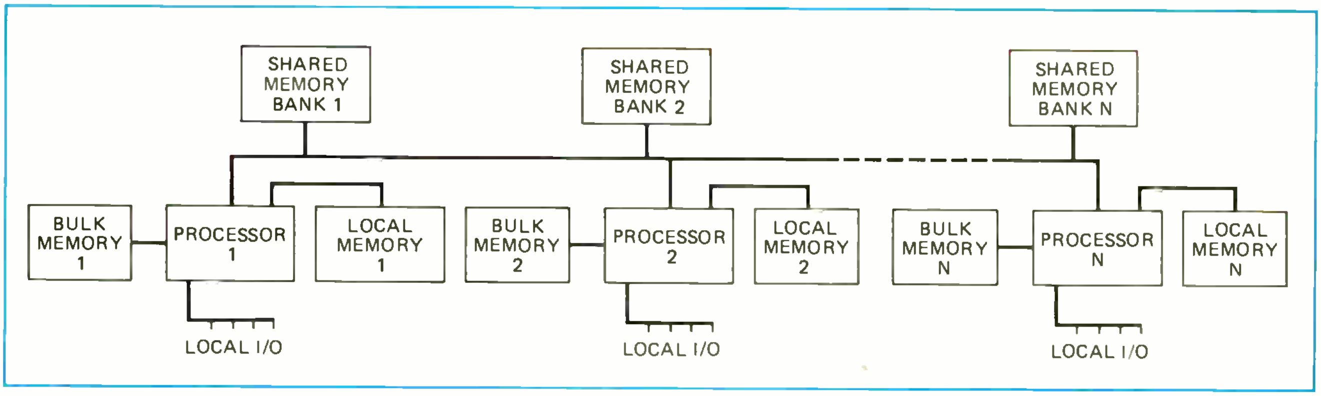
2. Price evolution. Main memory gets cheaper, while programers' salaries keep increasing. Since bigger memories permit simpler programing, part of the demand for memory is purely economic.

Extended-memory consequences

Since users have a legitimate need for large memories, and therefore for addresses of more than 16 bits, this leads directly to a need for performing arithmetic and logical operations on operands of more than 16 bits. When a user gets the big memory and the capability to address it, he must be able to alter the addresses—when indexing or changing an indirect address, for example. Either of these steps permits a single instruction to operate on data stored in any one of several different places in memory.

In addition, the size and complexity of applications that require big memories and long addresses also call for sophisticated software—including high-level languages such as Basic and Fortran, as well as extensive operating systems that can support large files, many simultaneous users, on-line editing, compiling, assembling, and debugging.

This heavy software orientation and the capital investment it requires call for architecture that can be depended on to remain in use for several years. Such an



3. Network demand. Minicomputer power may be boosted by interconnecting several machines through a large shared memory. The total memory can contain several million bytes, and each minicomputer in the net must have access to all the memory.

architectural design can enable hierarchies of computers to be compatibly expanded upward as a user's requirements grow.

The need for extended memory is behind a number of other important characteristics required of a modern computer system. But this need isn't new. It has been getting more and more desperate for several years, and it has inspired the development of several alternative ways to extend memory.

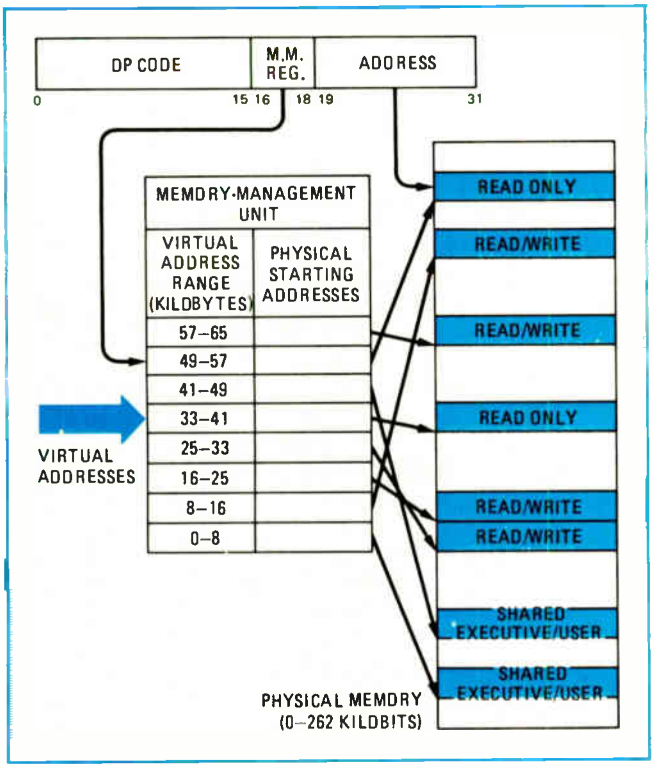
The first alternative, mentioned previously, is to segment the program into a root portion with a series of overlays and to divide the stored data similarly. Those portions of program and data not in current use are kept in bulk storage. To implement this alternative is a tedious, time-consuming, and sometimes impossible task. When not impossible, the task causes frustrating difficulties with software debugging and maintenance.

A second alternative was introduced in the fall of 1971 by Digital Equipment Corp. in its PDP-11/45, which employs the principle of memory segmentation and relocation, previously used in several large-scale computers. The 11/45 is available with up to 262,144 bytes (131,072 words) of which only 65,536 are accessible at any one time. However, these accessible locations can be scattered in blocks of various sizes anywhere throughout the physical memory, in any order, as shown in Fig. 4.

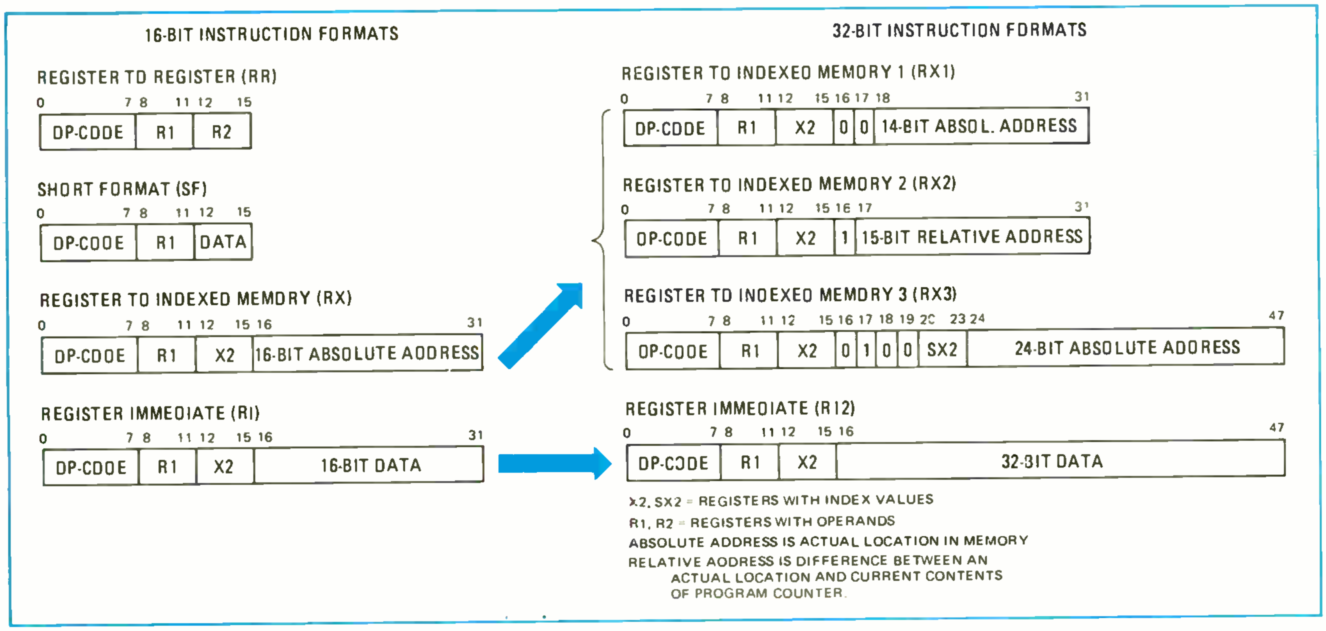
Their actual locations are recorded by a memory-management unit, consisting of a set of eight hardware registers, called segmentation and relocation registers. These registers identify eight contiguous areas in the physical memory. Three bits in the instruction identify one of the segmentation and relocation registers, while the remaining bits identify a specific location within an area. The segmentation and relocation registers are loaded by separate instructions in the software.

This technique has two major advantages in addition to the extension of memory capacity: First, it offers a means of protection, through the operating system, for all programs and data in any part of the memory. The user cannot write in protected areas, so that their contents cannot be disturbed.

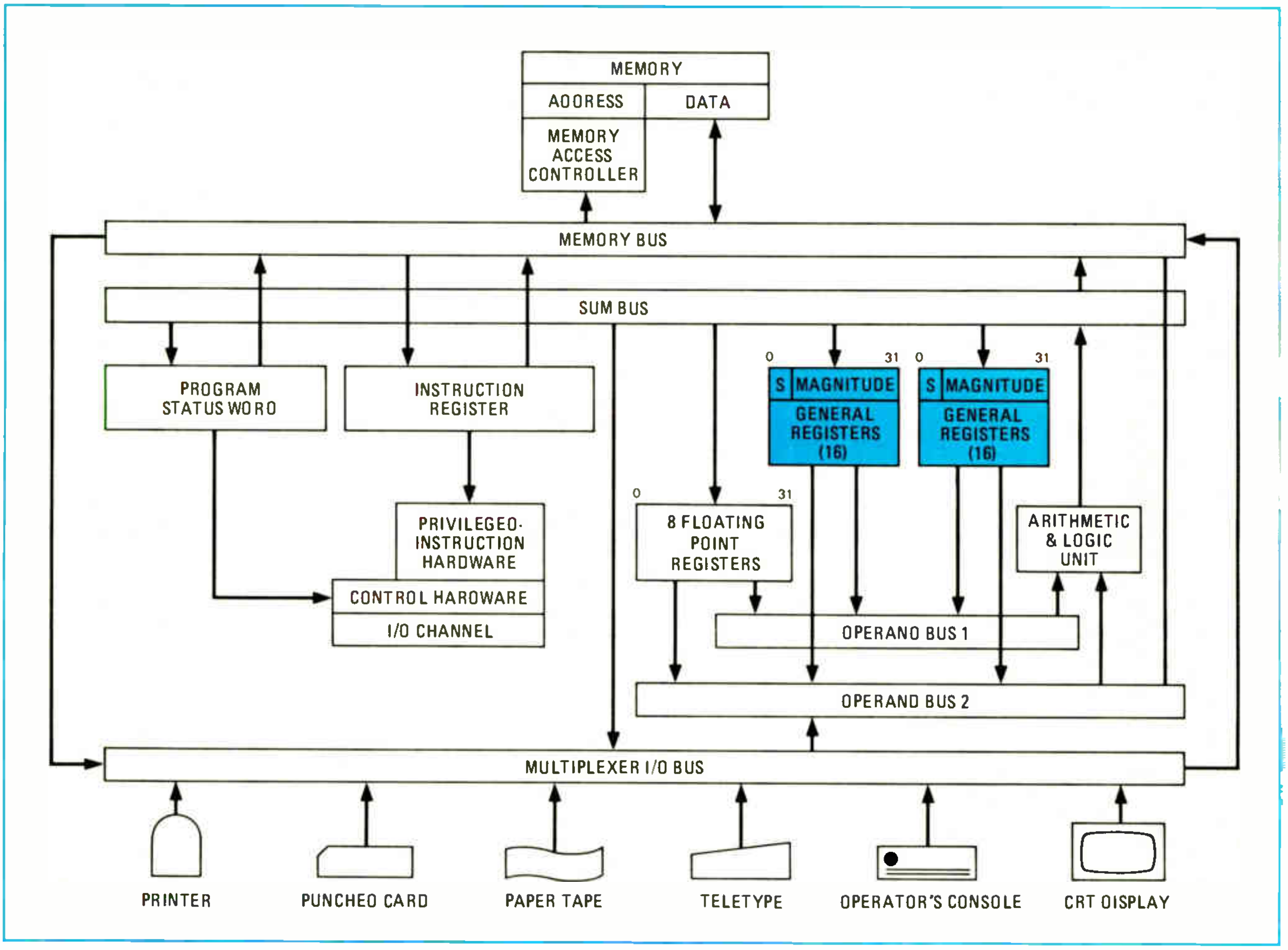
The second advantage is that the operating system can dynamically relocate portions of programs as the user requires them. This means that the user can write his program in terms of a single continuous stream of



4. Segmentation and relocation. In one approach to extended memory, a 16-bit address is translated by a memory-management unit to refer to a 262,000-byte array, most of which is inaccessible without reloading the management unit. Each 8-kilobyte virtual-address range is actually bounded by multiples of 8,192.



5. Instruction formats. Former 16-bit formats (left) are still usable in the new Interdata 7/32, which retain compatibility with its predecessors, while expanded formats (right) extend direct access to more than a million bytes now, and architecturally make 16 million possible.



6. Megamini architecture. Thirty-two registers of 32 bits each (color) establish the full capability of Interdata's new 7/32 computer. Of these 32 registers, 16 are available to the user, while the other 16 are reserved for the operating system and for interrupts.

TYPICAL INSTRUCTION TIMES, INTERDATA 7/32		
Instruction	Execution time (μs)	
	RX1 or RX2	RX3
Load register (32 bits)	1.0	NA
Load half word (16 bits)	2.75	3.25
Store (32 bits)	3.0	3.75
Store half word (16 bits)	2.5	3.0
Add	3.25	3.75
Add to memory	4.0	4.25
Compare	5.75	6.25
Compare to register	3.5	NA
Compare logical	3.25	3.75
Multiply	16.0	16.5
Multiply register	15.0	NA
Divide	100.0	100.0
Exclusive OR	3.25	3.75
Floating-point add	19 average	NA
Floating-point multiply	33 average	NA
Conditional branch	2.0	2.5

instructions and remain completely oblivious of how they are scattered around in the physical memory—or even in bulk storage.

Whether his program consists of 8,000 instructions or 800,000, only one instruction can be executed at a time, and over a short period of time, the instructions that are successively executed are usually close together in the program. This bunching of instructions permits the operating system to maintain only the currently active portion of the program in the physical memory, to bring in new portions from bulk storage as they are needed, to place them anywhere it pleases in the physical memory, and to set the segmentation and relocation registers accordingly.

Other manufacturers have imitated this approach in one way or another. One, in particular, offers a multiplicity of general registers and a 32-bit arithmetic and logic unit, giving the appearance of a megamini system. However, in that system, extended memory is conspicuous by its absence.

Although the use of segmentation and relocation registers helps relieve some of the inherent limitations of traditional minicomputer architecture, it leaves other constraints untouched and introduces some new constraints of its own. For example, if a user's program and on-line data together occupy more than 65,536 bytes of memory, they must be broken into smaller pieces, and all but the currently active segments must be kept either outside the directly addressable part of the main memory, or on a secondary storage unit—a magnetic disk, for example.

This introduces the task of keeping track of all the little pieces, knowing which one is currently active, where to get the next one when it's needed, and where to put it when it is brought in. The extra record-keeping adds to the size of the software package, which was too big to begin with, and it slows the machine's performance, both while doing the record-keeping and while transmitting the pieces of program and data base back and forth. Worse yet, the procedure doesn't contribute anything to the user's data-processing capability; it's all pure overhead.

Furthermore, that overhead is the result of the excessive size of the user's program and data. In the PDP-11/45, the operating-system software alone—without either a user program or data—occupies a minimum of 80,000 bytes, and thus won't fit in any directly addressable part of the physical memory.

Perhaps the greatest limitation of segmentation and relocation is that address calculations and memory-access techniques add to an already overcomplicated software environment instead of reducing it. And although the 262,144-byte upper limit can conceivably be increased by special engineering work or by evolution of the system as time passes, the architecture permits access to it only through the 65,536-byte windows.

The third choice

Interdata's new 7/32 represents a third alternative that overcomes the disadvantages of both the old overlay technique and the segmentation-and-relocation registers. Its characterization begins with the solution to the problem of addressing the large memory.

If 65,536 bytes of memory are available and considered sufficient, a 16-bit address is necessary. Since in a 16-bit computer this amounts to one whole word, the basic instruction in such a machine must occupy 32 bits, or two words—one for the address and one to specify the operation code, registers, and operands.

But if every instruction were to take up two words, the available amount of memory would be prodigally used, and the execution of any program would be rather slow. Therefore, memory is conserved and performance substantially improved—both in Interdata machines and those of other manufacturers—by the use of one-word instructions that operate on data that had been previously loaded in registers, perhaps by a preceding instruction, or on data included in the instruction itself, such as one that adds a constant to a previously calculated variable. These various instruction formats are illustrated on the left side of Fig. 5.

But when an extended memory—substantially more than 65,536 bytes—is necessary, a longer address than 16 bits is needed to get into it. The new Interdata architecture provides a maximum address length of 24 bits, allowing as many as 16,777,216 bytes to be directly addressed. In the 7/32 design, 20 of these 24 bits are actually implemented, giving an upper limit of 1,048,576—well above the old 65,536-byte limit.

To permit the use of a 24-bit instruction, the basic instruction length is three words, or 48 bits. There is enough room in this format for two index registers to be specified, along with another register containing an operand. The double indexing substantially improves programing flexibility in a way achieved in other machines by indirect addressing, but is much faster.

Needless to say, this technique is also prodigal with memory, so two two-word instruction formats are available. One of these, corresponding to the basic two-word format of the 16-bit machine, is executed in much the same way, except that it directly addresses only 16,384 bytes with a 14-bit address, which is adequate for many instructions. It's necessary because two bits are lost to identify the particular format in use at the moment, and its disadvantage is outweighed by the availability of the three-word format and by the other two-word format.

The latter specifies, instead of a particular location, an address relative to the present contents of the program counter. In effect, it says, "Fetch the data from the yellow house four blocks up the street," instead of "from 123 Elm Street." It has a relative excursion of 16,384 bytes, but it can go either forward or backward, for a total range of 32,768. Furthermore, that is its unindexed range; the format also specifies an index register, which can stretch the total range to the machine's architectural limit.

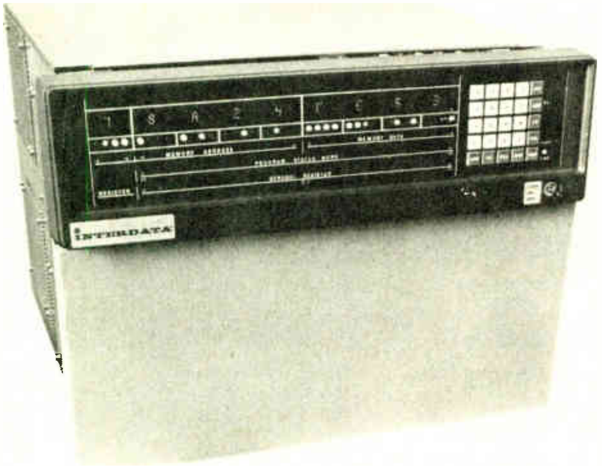
Another three-word format has a single level of indexing in which a 32-bit data word is included in the instruction in place of the 24-bit address and the second index-register specification. All of these long formats are shown on the right side of Fig. 5. The 7/32 also works with all four 16-bit formats.

Hardware in the 7/32

Two sets of internal registers are used in the 7/32. Each set contains 16 registers, and each register holds 32 bits. One set is available to the programer for use as accumulators, index registers, and other miscellaneous functions. The other set is reserved for use by the operating system and for interrupts from external events and from exceptional conditions arising during computation. They are shown in color in Fig. 6.

The main memory has a 750-nanosecond cycle and is 16 bits wide. Its basic size is 32,768 bytes, but it can be expanded to a maximum of 1,048,576 bytes. An automatic character input/output feature is included in the processor to convert character codes to and from internal machine format and to recognize special incoming characters, and which, like interrupts, cause a forced branch to special routines. Typical instruction-execution times are shown in the table.

An optional memory-access controller facilitates dynamic relocation and memory protection under control of the operating system. There are several modes of memory protection, based on the three actions the processor can take with regard to the memory—fetching data, fetching instructions, or writing. These modes are: no access; unlimited access; branch-protect, which prevents the inadvertent loading of data into the instruction register, and thus prevents the interpretation of data as instructions if the program mistakenly branches into a data table; write-protect, which prevents the loading of new data into the memory (and thus the wip-



7. **Hex panel.** Hexadecimal keyboard, at right of console, simplifies operator intervention in a process, while optional hexadecimal display, in parallel with binary indicators, eases interpretation of status.

ing out of old data), but permits fetching either data or instructions; data-fetch only; unlimited access with an interrupt to the operating system after the first write operation, a mode useful in time-sharing; and an indication that the program sought is not in the memory, a mode useful in virtual-memory systems.

The same memory modules and the same peripheral equipment and interfaces are used with the 7/32 as with its predecessors.

A hexadecimal display panel, visible in the photo (Fig. 7) is available as an optional feature on the 7/32 processor. It is part of the operator's console, which includes as standard a 16-character hexadecimal keyboard, nine function keys, and four light-emitting-diode indicators that show such conditions as power on and the wait state (on, but not running). The memory address, memory-output data, program-status word, and contents of an addressed general register are displayed by a row of 36 binary LED indicators. This display is duplicated by the hexadecimal display when installed—one hexadecimal character for each four LEDs in the binary display.

Invisible hardware

The Interdata 7/32, in spite of its substantial capabilities, is classed as a minicomputer because of its low price. The price, in turn, is made possible by its microprogramed architecture and the inexpensive medium-scale bipolar integrated circuits from which it is built.

The microprogram is of the type sometimes called "vertical," meaning that its microinstructions are relatively short (24 bits) and that most machine functions are encoded with relatively few bits in the microinstruction. With this approach, a microprogram is easier to write, can be stored in less memory, and costs less, than with the alternative "horizontal" approach. With the latter, each bit in the microinstruction would control a specific function in the machine, permitting faster operation.

The microprogram is stored in a read-only memory made from 42 integrated circuits, each holding 256 4-bit words, accessible in 60 nanoseconds. These are arranged in seven "pages" of six ICs each, and each page holds 256 microinstructions of 24 bits. Had the horizontal approach been chosen, the equivalent capability would have required more than twice as many chips and microinstructions 96 bits long.

The 32 general registers, each with 32 bits, are put together from 16 chips, each holding 16 4-bit words, with an access time of 40 ns. These registers can store four times as many bits as can the registers in the 7/32's predecessor, the Interdata model 70, but they are packaged in the same number of IC chips. Furthermore, despite their quadrupled capacity, these chips cost only twice as much as those in the model 70 and dissipate only half as much power.

The components of both the general register and the read-only memory, plus nearly all the internal logic of the processor, consist of transistor-transistor logic. All these components are available from more than one manufacturer, assuring low cost and high reliability.

All logic in the 7/32 is mounted on three single-layer two-sided printed-circuit boards 15 inches square, and the basic 32,768-byte memory module comes on a fourth similar board. These boards are plugged into a 16-socket rack-mountable chassis. The 12 extra sockets can hold additional memory, peripheral controllers, or processor options. The large boards permit moderately high packaging density and minimize interconnections on the back panel, thus enhancing reliability. Their horizontal arrangement enables uniform heat dissipation and prevents the boards from falling partly out of the sockets when subjected to vibration, as vertically mounted boards sometimes do.

What's in the future?

The model 7/32 is the forerunner of a new line of 32-bit-oriented hardware and software products to be offered in the megamini marketplace. During the next 12 months, Interdata plans to introduce a faster version of the 7/32 that uses Schottky TTL and MOS memory. It will offer such additional features as double-precision floating-point arithmetic, a reloadable control store, and peripheral devices powerful enough to accommodate a megamini.

Although the current maximum memory size is now one million bytes, its expansion will be fairly simple when memory modules become available in smaller packages and customers demand it; as noted previously, the architecture can support a capacity of 16 million bytes. Alternatively, the machine's addressing capability is sufficiently flexible to allow implementing such powerful concepts as virtual memory.

The 32-bit word length offers a strong improvement over the segmentation-relocation approach in the price/performance ratios. Unquestionably the megamini will make economically attractive many new applications that only a short time ago were economically ridiculous.

For example, the machine facilitates the distributed-minicomputer approach to large problems and enhances the general trend toward making minicomputers commonplace, yet essential, components of the environment. □

Analyzing ladder-type networks by a quick arithmetic procedure

Many ladder networks can be analyzed virtually by inspection through the generation of an impedance matrix that can be rapidly checked to find network voltage transfer characteristic and input impedance

by Einar C. Johnson, *Naval Air Development Center, Warminster, Pa.*

☐ Since most filter, equalization, and phase-shift networks can be reduced to ladder form, a simple analysis procedure for ladder-type networks can be a significant time-saver. One technique that involves only simple division and determinant evaluation allows many networks to be analyzed quickly by inspection for input-to-output voltage transfer ratio, as well as input impedance.

The procedure is easy to follow. As shown in Fig. 1 for an n-mesh ladder network, an impedance matrix can be generated. A large square is drawn and then divided into n smaller squares, which are filled with impedance values taken from the ladder network. The large outer square is called the impedance matrix ($\dot{Z}$). For an n-mesh network, the impedance matrix has an nth-order determinant that is designated as D_n.

The inner squares along the main diagonal are filled with the impedance sums accumulated by going around each mesh. The squares adjacent to and parallel with the main diagonal contain the shunt impedances of the network. (These shunt impedances are negative because of the direction chosen for positive mesh-current flow.) All the other squares are left blank, indicating an entry of zero.

Network voltage and impedance analysis

To find the voltage transfer ratio, e_1/e_2, only the nth mesh current, i_n, must be computed, since:

$$e_2 = i_n Z_{2n}$$

The matrix form of Ohm's law is:

$$\dot{i} = (\dot{Z})^{-1}\dot{e}$$

In this case, only the last mesh current, i_n, in current matrix $\dot{i}$ is needed. And the only non-zero entry in voltage matrix $\dot{e}$ is e_1. Additionally, the only pertinent element of inverted impedance matrix $(\dot{Z})^{-1}$ is $(Z_2Z_4Z_6 \dots Z_{2n-2})/D_n$. Rewriting the last equation yields:

$$i_n = e_1(Z_2Z_4Z_6 \dots Z_{2n-2})/D_n$$

since:

$$e_2 = i_n Z_{2n} = e_1(Z_2Z_4Z_6 \dots Z_{2n})/D_n$$

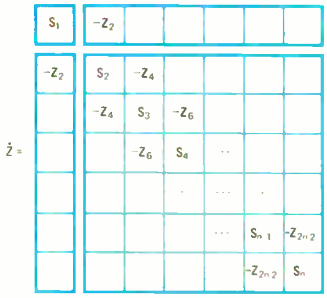
then:

$$e_1/e_2 = D_n/(Z_2Z_4Z_6 \dots Z_{2n}) \qquad (1a)$$

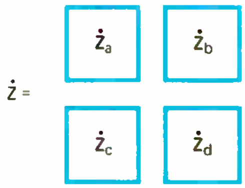
or:

$$\frac{e_1}{e_2} = \frac{\text{determinant of impedance matrix}}{\text{product of all shunt impedances}} \qquad (1b)$$

To show how the input impedance of an n-mesh network can be evaluated, the impedance matrix is cut into four submatrixes so that the S_1 sum is isolated:



For simplicity, the four submatrixes of $\dot{Z}$ are labeled as $\dot{Z}_a$, $\dot{Z}_b$, $\dot{Z}_c$, and $\dot{Z}_d$:



In terms of these submatrixes, the network's input impedance can be expressed as:

$$Z_{in} = \dot{Z}_a - \dot{Z}_b(\dot{Z}_d)^{-1}\dot{Z}_c$$

Since $\dot{Z}_a = S_1$, this equation can be rewritten as:

$$Z_{in} = S_1 - \dot{Z}_b(\dot{Z}_d)^{-1}\dot{Z}_c \qquad (2)$$

Because submatrixes $\dot{Z}_b$ and $\dot{Z}_c$ contain a single common entry, $-Z_2$, only the element in the first row and column of inverted matrix $(\dot{Z}_d)^{-1}$ is needed. This element is D_{n-2}/D_{n-1}, where D_{n-1} is the determinant remaining after the first row and column are eliminated from determinant D_n. Likewise, D_{n-2} is the determinant remaining after the first two rows and columns are eliminated from D_n. Substituting impedance values for the submatrixes in Eq. 2 yields:

$$Z_{in} = S_1 - (-Z_2)(D_{n-2}/D_{n-1})(-Z_2)$$
$$= S_1 - Z_2^2 D_{n-2}/D_{n-1}$$

or:

$$Z_{in} = (S_1 D_{n-1} - Z_2^2 D_{n-2})/D_{n-1}$$

Since the numerator of this equation is simply a mathe-

Fast ladder analysis

With this shortcut approach, many ladder networks can be analyzed almost by inspection for both their voltage transfer characteristic and their input impedance (including phase angle).

The key to the analysis is the network's easily generated impedance determinant. An n-mesh ladder requires an nth-order determinant, D_n, as shown. Elements S_1, S_2, S_3, ... , and S_n are the sums of the impedances in each mesh of the ladder:

$$S_i = Z_{2i-2} + Z_{2i-1} + Z_{2i}$$

where i is the number of the mesh. The network's shunt impedances are inserted in the spaces that are adjacent to the main diagonal of D_n. Since all the other spaces of D_n remain blank (contain zeros), the impedance determinant is easy to evaluate.

The voltage transfer ratio of the network can be found by simply dividing determinant D_n by the product of the shunt impedances:

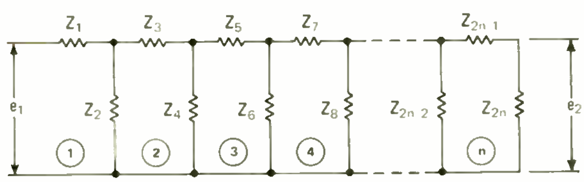
$$e_1/e_2 = D_n/Z_2Z_4Z_6 \ldots Z_{2n}$$

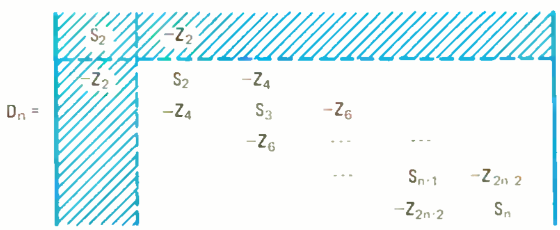
Crossing out the first row and first column of determinant D_n reduces it by one order, producing determinant $D^n{}_{-1}$, which is shown as the unshaded portion of D_n. The network's input impedance can now be written as:

$$Z_{in} = D_n/D_{n-1}$$

If the impedance level of the entire ladder is multiplied by a factor K, the voltage transfer ratio does not change, but the input impedance becomes:

$$Z_{in} = KD_n/D_{n-1}$$





matical statement of determinant D_n, the expression for Z_{in} can be reduced to:

$$Z_{in} = D_n/D_{n-1} \qquad (3)$$

Analyzing a network

To visualize how to use the equation for voltage transfer ratio (Eq. 1) and the equation for input impedance (Eq. 3), consider the four-mesh network of Fig. 2 and its impedance matrix. The determinant of this matrix is:

$$D_n = D_4 = S_1[S_2(S_3S_4 - Z_6^2) - Z_4^2S_4] - Z_2^2(S_3S_4 - Z_6^2) \qquad (4)$$

where:

$$S_1 = Z_1 + Z_2$$
$$S_2 = Z_2 + Z_3 + Z_4$$
$$S_3 = Z_4 + Z_5 + Z_6$$
$$S_4 = Z_6 + Z_7 + Z_8$$

The network's input-to-output voltage ratio can be found from Eq. 1:

$$\frac{e_1}{e_2} = \frac{S_1[S_2(S_3S_4 - Z_6^2) - Z_4^2S_4] - Z_2^2(S_3S_4 - Z_6^2)}{Z_2Z_4Z_6Z_8}$$

And the network's input impedance can be computed after evaluating D_{n-1}, the reduced-by-one-order determinant of the impedance matrix:

$$D_{n-1} = D_3 = S_2(S_3S_4 - Z_6^2) - Z_4^2S_4 \qquad (5)$$

From Eq. 3, the input impedance is:

$$Z_{in} = D_4/D_3$$

Substituting Eqs. 4 and 5 in this last expression and simplifying yields:

$$Z_{in} = S_1 - \frac{Z_2^2(S_3S_4 - Z_6^2)}{S_2(S_3S_4 - Z_6^2) - Z_4^2S_4}$$

Analyzing an RC oscillator

A more practical application of the shortcut ladder network analysis is provided by the RC oscillator of Fig. 3a. The technique can be used to solve for the frequency of oscillation, the gain that must be supplied by the amplifier, and the input impedance that the oscillator circuit presents to the signal source.

The input phase-shift network is a three-mesh ladder, which can be drawn as shown in Fig. 3b. In practice, the three capacitors in the ladder are usually made equal to each other:

$$C_1 = C_2 = C_3 = C$$

And the resistors are made equal to the parallel combination of resistors R_3 and R_L:

$$R_1 = R_2 = R_3R_L/(R_3+R_L) = R$$

The determinant of the network's impedance matrix (Fig. 3c) is:

$$D_n = D_3 = S_1(S_2^2 - R^2) - R^2S_2$$

where:

$$S_1 = R - j/\omega C$$
$$S_2 = 2R - j/\omega C$$
$$S_3 = 2R - j/\omega C$$

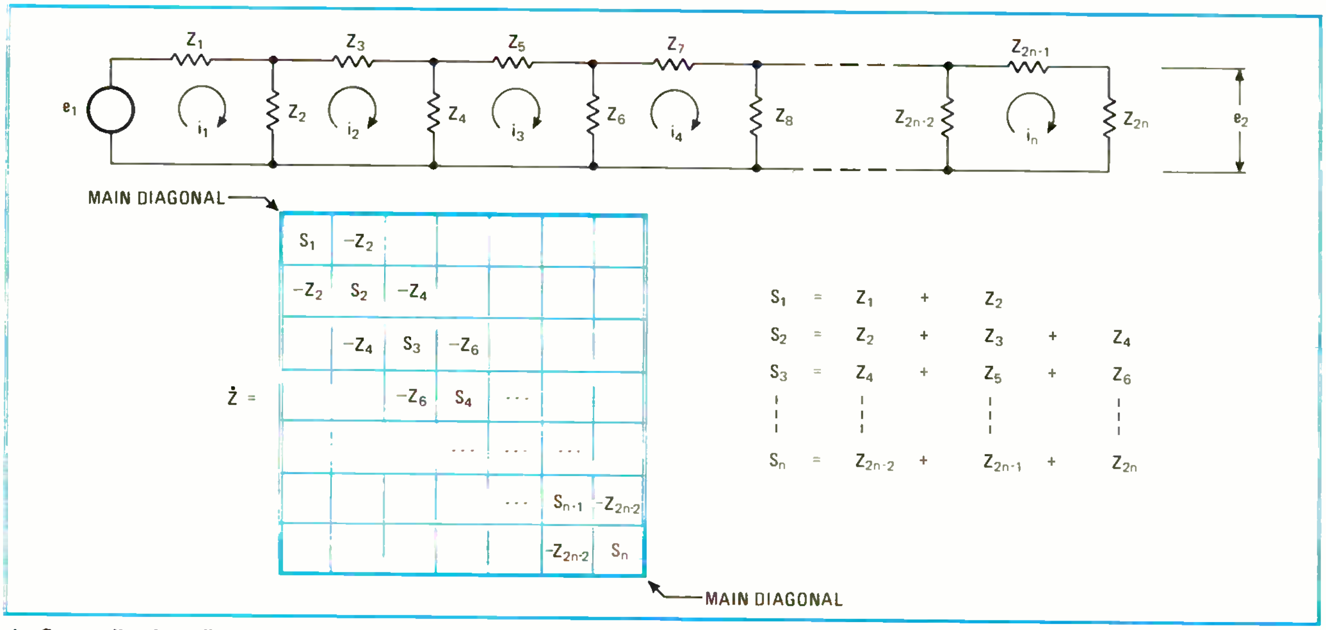
where ω is the operating frequency expressed in radians per second. Substituting these impedance sums into the network's determinant, and separating the real and imaginary terms gives:

$$D_3 = [R^3 - 5R/(\omega C)^2] + j[(1/\omega C^3 - 6R^2/\omega C]$$

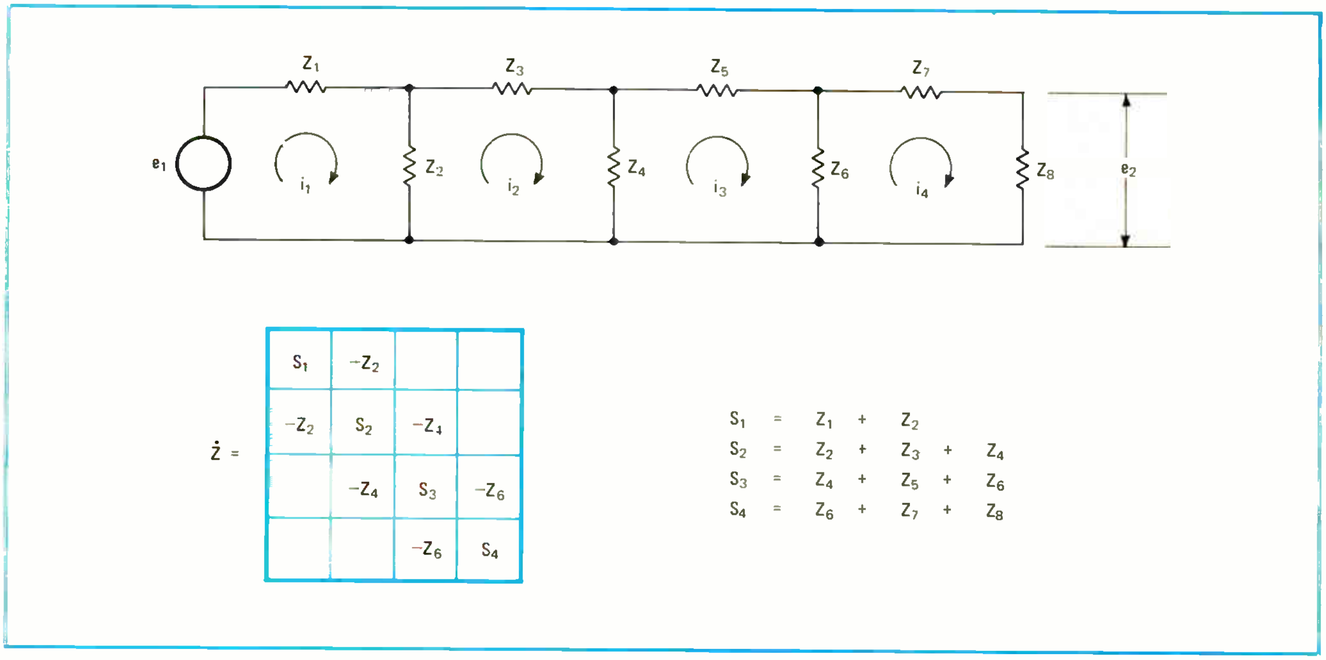
Since the phase shift between input e_1 and output e_2 must be 180°, the output can be expressed as:

$$e_2 = -(1/G)e_1$$

where 1/G represents the attenuation of the network, and G represents amplifier gain. With Eq. 1, the oscillator's input-to-output voltage ratio can be evaluated:



1. Generalized configuration. Ladder network, consisting of n meshes, can be represented by an impedance matrix, $\dot{Z}$. Since this matrix is a square array, it can be handled as an nth-order determinant, where n is the number of meshes. The impedance sums for each mesh are placed along the matrix's main diagonal, while the shunt impedances are alongside of these; the other spaces remain blank.



2. Four-mesh ladder. Here, impedance matrix $\dot{Z}$ is only a fourth-order determinant. But, no matter how large the ladder network is, the impedance matrix can be evaluated quickly because there are always many zeroes (blank spaces). Once the impedance-matrix determinant is evaluated, the network's voltage transfer ratio can be found by simply dividing the determinant by the product of the shunt impedances.

$$\frac{e_1}{e_2} = -G = \frac{[R^3 - 5R/(\omega C)^2] + j[(1/\omega C)^3 - 6R^2/\omega C]}{R^3}$$

or:

$$GR^3 = [5R/(\omega C)^2 - R^3] + j[6R^2/\omega C - 1/(\omega C)^3] \quad (6)$$

The left side of this equation is a pure real number, allowing the imaginary term on the right side to be equated to zero:

$$j[6R^2/\omega C - 1/(\omega C)^3] = 0$$
$$6R^2 = 1/(\omega C)^2$$

which can be solved for the frequency of oscillation:

$$\omega = 1/\sqrt{6}\,RC \text{ radians/second}$$

or:

$$f = 1/(2\pi\sqrt{6}\,RC) \text{ hertz}$$

By substituting the quantity $6R^2$ for $1/(\omega C)^2$ in the real part of Eq. 6, amplifier gain can be found:

$$GR^3 = 5R(6R^2) - R^3$$
$$G = 29 \text{ or } 29.5 \text{ decibels}$$

This is the amplifier voltage gain required to sustain oscillation. To find input impedance, the network's D_{n-1} determinant must be evaluated:

$$D_{n-1} = D_2 = S_2^2 - R^2 = [3R^2 - 1/(\omega C)^2] - j[4R/\omega C]$$

But since:

$$6R^2 = 1/(\omega C)^2$$

then:

$$D_2 = -R^2(3 + j\,4\sqrt{6})$$

Applying Eq. 3 gives:

$$Z_{in} = D_3/D_2 = 29R/(3 + j\,4\sqrt{6}) = R(0.829 - j\,2.706)$$

Changing network impedance level

Additionally, this analysis technique permits the impedance level of the ladder network to be changed readily. If each impedance element in an n-mesh ladder is multiplied by a factor of K, then each element in the impedance-matrix determinant is multiplied by K. When every element of an nth-order determinant is multiplied by the same factor, the entire determinant is effectively multiplied by a factor of K^n. The network's voltage transfer ratio becomes:

$$e_1/e_2 = K^n D_n/(KZ_2)(KZ_4)(KZ_6)\ldots(KZ_{2n})$$

or:

$$e_1/e_2 = D_n/Z_2Z_4Z_6\ldots Z_{2n}$$

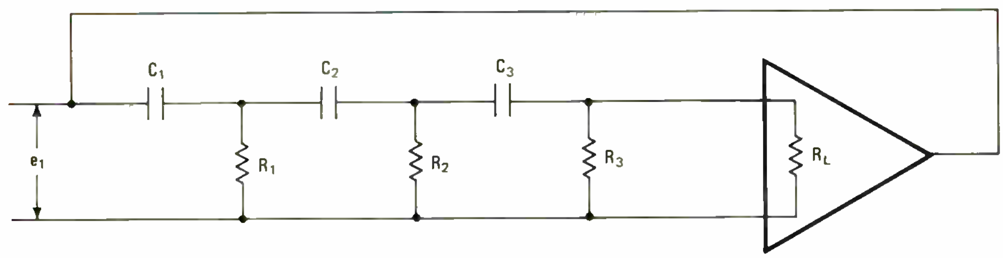
which is identical to Eq. 1. Therefore, changing a network's impedance level has no effect on the voltage transfer ratio.

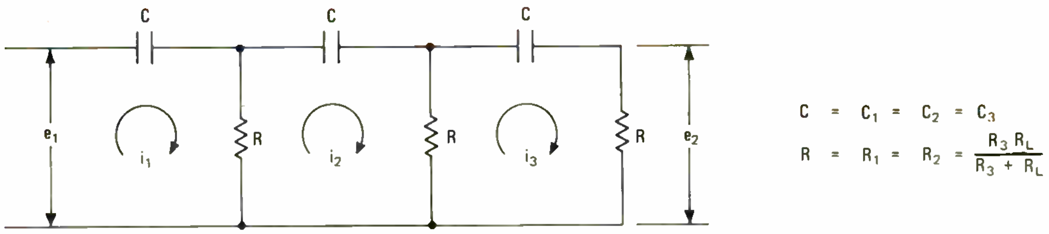
Network input impedance, however, does change. Since multiplying all the elements of the impedance-matrix determinant by K multiplies the entire determinant by K^n, then the D_{n-1} determinant is multiplied by K^{n-1}. From Eq. 3:

$$Z_{in} = K^n D_n/K^{n-1}D_{n-1} = KD_n/D_{n-1}$$

The input impedance of the ladder network, therefore, is multiplied, by the same factor as the individual network impedances. □

3. Oscillator circuit. Three-mesh ladder of RC oscillator (a) can be reduced to network drawn in (b) for analysis. Impedance matrix of (c) simplifies computation of oscillator's operating frequency, input impedance, phase shift, and the gain of the amplifier.





$\dot{Z} =$

S_1	$-R$	
$-R$	S_2	$-R$
	$-R$	S_3

$S_1 = R - j/\omega C$

$S_2 = 2R - j/\omega C$

$S_3 = 2R - j/\omega C$

(c)

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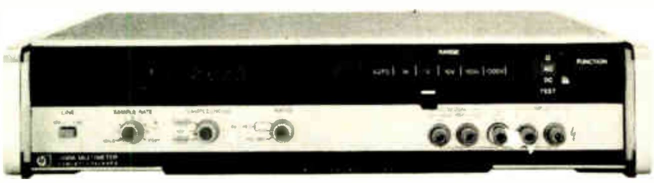
Self-Test 3490 makes double use of its internal ICs to bring you HP's extensive "Self-Test" capability without extra cost. The basic 5-digit 3490, ready to measure AC, DC and Ohms sells for only $1,650* (and at low added cost you can have isolated BCD output and isolated remote control, or the highly-useful remote control with ASCII bus). Compare the 3490 with any other multimeter in its class and you'll find an unusual blend of features and performance for the money.



Snap-On 3470 provides you with an economical 4-digit LED display unit that you can equip to meet your exact measurement needs. Get DC only for $475* total, AC/DC/Ohms for $600* total, or DCV/DCA/Ohms for $875* total (5-digit versions are $700*, $825* and $1,100*). Add on a battery pack center for $200*, BCD output center for $175* or an H-P

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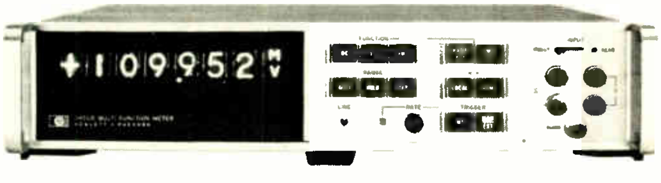

Speed Star 3480 is systems oriented, but fine for the bench as well. This 4-digit, ±0.01% unit delivers a fast 1,000 readings/sec. Get the exact capability you need by selecting plug-ins. For example, you can have DC, Ohms and true-rms AC for $3,090* (isolated BCD output and isolated remote control for plug-ins are low-cost options). You can even turn the 3480 into an inexpensive A-to-D converter with a sample and hold option that also lets you take peak readings or do transient analysis. Or, add data storage that stores up to 50 readings at the 1000/sec. rate and employ a low-cost printer to output the data.

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Electronic slide rules

Many engineers are forsaking their traditional slide rules for handheld electronic calculators like Hewlett-Packard's HP-35. This calculator, which currently sells for less than $300, is specifically intended for engineering applications. But like many other calculators, the HP-35 can do more than its operating manual indicates. Here are some suggestions submitted by HP-35 owners.

Lucinda Mattera, Circuit Design Editor

Evaluating polynomials and finding their roots

by Philip R. Geffe
Westinghouse Electric Corp., Baltimore, Md.

The HP-35 calculator has enough storage capacity to allow the user to evaluate any polynomial in a single continuous chain operation without writing down any intermediate calculations. Furthermore, this chain operation can be used to find the real roots of the polynomial with Newton's method. Again, no calculations need be written down, and the polynomial's roots can be obtained to 10 significant figures.

To evaluate the polynomial, P(x), first write it (or think of it) in the form:

$$P(x) = a_n x^n + a_{n-1}x^{n-1} + \dots + a_1 x + a_0$$
$$= [(\dots (a_n x + a_{n-1})x + a_{n-2})x + \dots + a_1]x + a_0$$

And a simple program allows P(x) to be evaluated for a given argument, x_o:

- Write x_o—Press STO and CLX
- Write a_n—Press ENTER, RCL, and ×
- Write a_{n-1}—Press +, RCL, and ×
- Write a_{n-2}—Press +, RCL, and ×
- Continue chain operation
- Write a_1—Press +, RCL, and ×
- Write a_0—Press +
- $P(x_o)$ is now displayed

Of course, if some of the coefficients are negative, you can write them as positive numbers, and then depress the − key instead of the + key.

A polynomial's real roots can be found by using the above program as a subroutine within an iterative procedure having a quadratic error function. The error in an iteration, then, is approximately the square of the error in the previous iteration.

Since the algorithm will not converge unless the first trial root is approximately correct, polynomial P(x) must first be evaluated for a few arguments until two are found that yield opposite signs. For example, suppose that P(a) is positive and P(b) is negative. A real root will then lie on the x-axis between a and b. Accordingly, this interval can be bisected to find the mean argument, c:

$$c = \tfrac{1}{2}(a+b)$$

P(c) will then be either positive or negative (if c is not a root). If P(c) is positive, then a root lies between b and c; if it is negative, the root is between a and c.

Proceed in this way until you have about two significant figures for the root. Now, switching to Newton's method will usually produce a solution that converges very rapidly because of the quadratic behavior of the error function—an error of, say, 10^{-4} is reduced to 10^{-8} in only one iteration.

Let P′(x) be the derivative of P(x), and let x_1 be the first approximation to the root. With this estimate held in the calculator's side storage register, the following program can be used:

- Calculate $P(x_1)$ [in x register]
- Press ENTER [$P(x_1)$ is now in y register]
- Calculate $P'(x_1)$ [in x register]
- Press ÷, CHS, RCL, and +

These steps complete one iteration. The calculator display now contains x_2, which is the improved approximation of the root.

The program continues:

- Press ENTER, ENTER, RCL, and ÷

The display now shows the ratio of x_k/x_{k-1}, where k is the index of the current approximation. Program iterations should be continued until this ratio is equal to unity. Whenever it is not unity, the next program step is:

- Press R, STO, and CLX

The calculator's side register now contains root approximation x_2, and the next iteration is started by looping back to the first step of the "root" program. When the ratio of x_k/x_{k-1} is unity, then the side register contains the root to 10 significant figures.

As can be seen, both programs are chain computations, allowing the calculator's display to replace pen and paper completely. □

Storing two constants instead of just one

by J. Snaper
U.S. Navy, Fleet Post Office, New York

Another capability of the HP-35 calculator is its ability to store and utilize two constants—a handy computational aid for performing calculations like dual conversions of long strings of numbers.

The calculator's operating manual describes how to make use of only a single constant in the store/recall register. As an example, the manual gives this method:

- Key-in conversion factor
- Push STORE
- Key-in numbers for conversion
- Recall conversion factor
- Operate arithmetic key for answer

For each additional number to be converted, the conversion factor must be recalled, making the operation a little unwieldy for large strings of numbers.

A simpler and more convenient method is to fill the calculator's memory stack with the conversion factor by pushing the ENTER key three times. This causes the factor to recirculate in the memory and become a constant, allowing the store/recall register in effect to store a second conversion factor.

The improved two-constant technique becomes:

- Key-in conversion factor
- Push ENTER key three times
- Enter number for conversion
- Operate arithmetic key for answer, push CLx key

The calculator is now programed with the conversion constant and additional conversions can be carried out indefinitely in a simple two-step operation:

- Key-in number for conversion
- Operate arithmetic key for answer

If desired, a second conversion factor can be entered in the STORE register and recalled after the first conversion is complete. In this way, the double conversion of a long string of numbers can be done very simply and efficiently:

- Key-in number for conversion
- Operate arithmetic key
- Recall second conversion factor
- Operate arithmetic key for answer

Of course, the HP-35 calculator greatly simplifies root computations, as many users probably already realize. The square-root function is a direct push-button operation, but there is no key for finding cube or nth roots directly. A short program does the job:

- Key-in root desired
- Operate 1/x key
- Key-in number for which root is desired
- Operate x^y key for answer □

Electronic slide rules

Doing statistical analysis with a single data entry

by Walter V. Manka
American Precision Industries Inc., Delevan Div., East Aurora, N.Y.

Engineers frequently find it necessary to determine the mean, variance, and standard deviation of experimental data. Classically, this statistical information is computed separately so that the data must be entered more than once. With the HP-35 calculator, however, the mean, variance, and standard deviation can be found with a single entry of the data.

The table outlines a method for solving a convenient form of the equation for the standard deviation:

$$S.D. = [[\Sigma(D_i)^2/N] - [\Sigma D_i/N]^2]^{1/2}$$

where D represents the data value, N represents the number of data values, and i varies from 1 to N. With this equation, data values must be entered only once, and the mean, variance, and standard deviation can be read directly from the calculator's display. Furthermore, the need for writing down calculations is minimal. □

MEAN, VARIANCE, AND STANDARD DEVIATION			
Enter each data value with this key sequence		After the last data value is entered execute this key sequence	
KEY	DISPLAY	KEY	DISPLAY
$(DATA)_i$	D_i	N	N
ENTER ↑	D_i	÷	$\Sigma (D_i)^2/N$
ENTER ↑	D_i	RCL	ΣD_i
RCL	ΣD_{i-1}	N	N
+	ΣD_i	÷	MEAN
STO	ΣD_i	ENTER ↑	MEAN
R ↓	D_i	x	$(\Sigma D_i/N)^2$
ENTER ↑	D_i	−	VARIANCE
x	$(D_i)^2$	$\sqrt{\ }$	STANDARD DEVIATION
+	$\Sigma (D_i)^2$		

Compact rf wattmeter measures up to 50 watts

by Fred C. Gabriel
Perkin-Elmer Corp., Norwalk, Conn.

A direct-reading rf wattmeter that is accurate to within ±1% of full scale for power levels of up to 50 watts can be built around a single integrated balanced-mixer circuit. The design multiplies instantaneous voltage by instantaneous current and then averages the two to get a true power reading. It can be assembled either as a separate test instrument (with battery power, if desired) or as part of a larger instrument, such as a transmitter.

Unlike reflectometer-type instruments, which are generally used for in-line rf measurements, this wattmeter does not require the user to subtract two meter readings to find the power transferred to mismatched loads. Rf load power is read directly on a linear wattage scale. Rf line current and rf line voltage are sensed by a current transformer and a voltage divider, respectively, in a simple assembly that may be remotely located from the rest of the circuitry.

Signal voltages representing the load current and the load voltage appear across the 51-ohm terminating resistors at the far ends of each of the equal lengths of miniature coaxial cable. These signal voltages drive the inputs of the IC balanced mixer, which functions as a four-quadrant analog multiplier operating at rf.

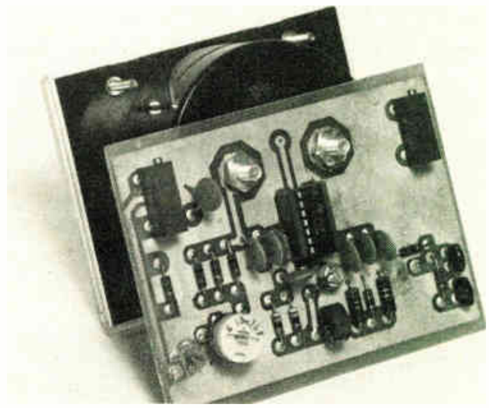
The averaged product of the voltage and the current appears as a dc reading on the microammeter. The meter can be read directly in watts. It can be set to full scale (50 microamperes) when the circuit is driving a 50-ohm dummy load at an rf power level of 50 w (as read on a calorimetric wattmeter).

The other components of the input circuitry to the balanced mixer are included to trim the residual phase and amplitude errors of the current and voltage sensors. The variable capacitors are adjusted to produce a reading of zero when a short circuit, open circuit, or purely capacitive load is placed on the output.

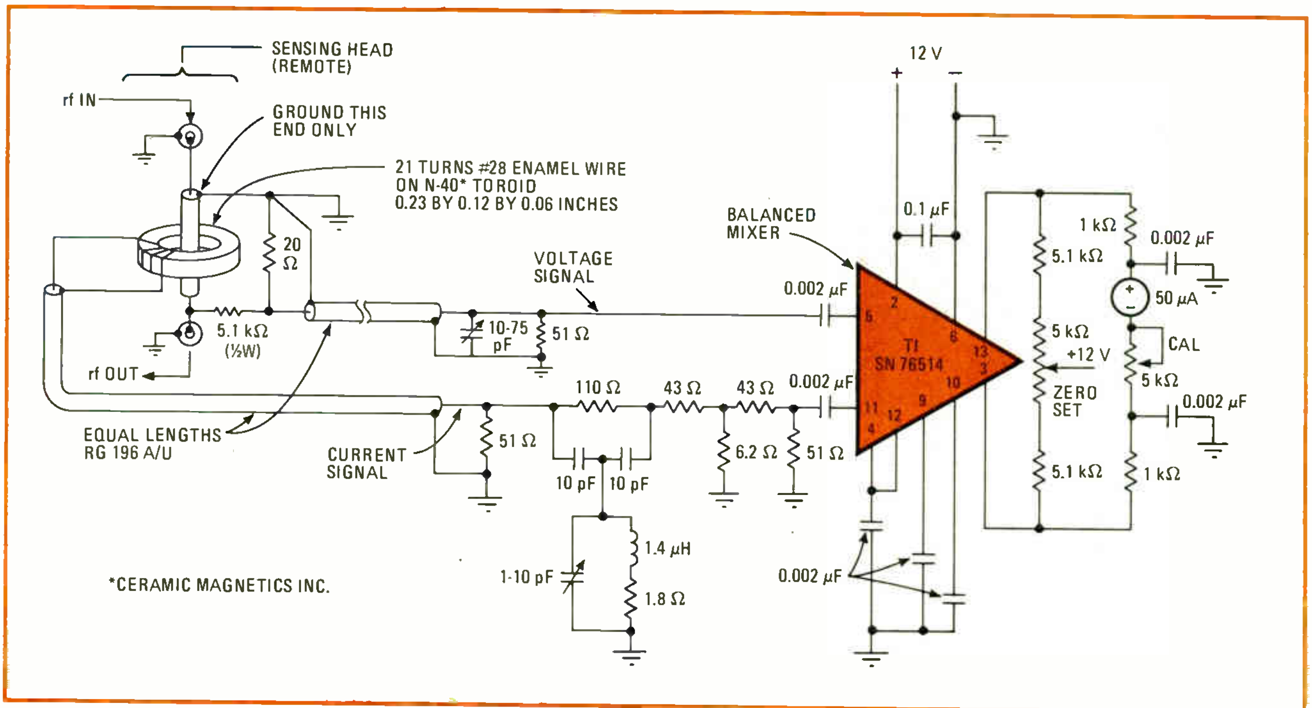
The full-scale accuracy of the instrument is on the order of ±1%. Although the design shown is for operation at 27.12 megahertz, the basic circuit can probably be adapted for any frequency up to about 100 MHz.

As shown by the photograph, the entire circuit, except for its sensing components, can be built on a small circuit card and mounted directly on the back of the wattage-reading microammeter. □

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



Snug fit. Excluding sensing components, rf wattmeter circuit can be mounted on single pc card and attached to its own microammeter.



Small and accurate. For this rf wattmeter, an IC balanced mixer functions as an analog multiplier, generating a signal that represents the true average power. The meter can be read directly in watts. Rf power inputs as high as 50 watts can be measured within ±1% of full scale.

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Prices for the 3N211 and 3N312 are 70¢ in 1,000-piece quantities. And 75¢ for the 3N213.

For data sheets, indicate by type number and write: Texas Instruments Incorporated, P. O. Box 5012, M/S 308, Dallas, Texas 75222.

Noise Figure and Gain Parameters

Type	Application	NF (Max) dB	@ Freq MHz	Gps (Min) dB	@ Freq MHz
3N201	FM, VHF RF amp	4.5	200	15	200
3N202	VHF mixers	—	—	15	200
3N203	Intermediate freq amp	6.0	45	29	45
3N204	VHF, UHF, RF amps	3.5	200	14	450
3N205	VHF mixers	—	—	17	200
3N206	Intermediate freq amp	4.0	45	25	45
3N211	VHF RF amp	3.5	200	24	200
3N212	VHF mixers	—	—	21	200
3N213	Intermediate freq amp	4.0	45	27	45

Turn those resistor leads into inductors

Here's an effective and cheap way of getting that odd resonant or tuning inductance in signal-processing or high-speed-logic applications. **Instead of using the usual small coil or ferrite bead in series with a resistor** to form the low-Q bias or isolation network, **you can often get the right inductance directly from the resistor leads themselves.**

Of course, the average resistor gives you only fairly small inductance values—a couple of microhenrys for most high frequency circuits—but you do have two leads to play with. Also, one resistor company, Micro Electronics in Phoenix, Ariz., recognizing the great demand from customers, has invested in a special machine that tools the leads on its resistors into a more usable form.

Chip applies itself to appliances

For designers of appliance control circuits, who often require zeners, transistors, and thyristors arranged in various configurations to perform a given circuit function, there's now a member of the growing family of monolithic array circuits aimed directly at their needs. Available in samples from RCA, the chip is called the industrial designer's array. **On it are five uncommitted devices—three transistors, a 7-volt zener, and an SCR**—which can be connected to form, say, the standard phase-control circuit needed to switch an appliance's typical resistive loads. **The 16-pin part can just as easily perform time delays, or be an oscillator, a one-shot,** or the like.

New board saves bench wire time

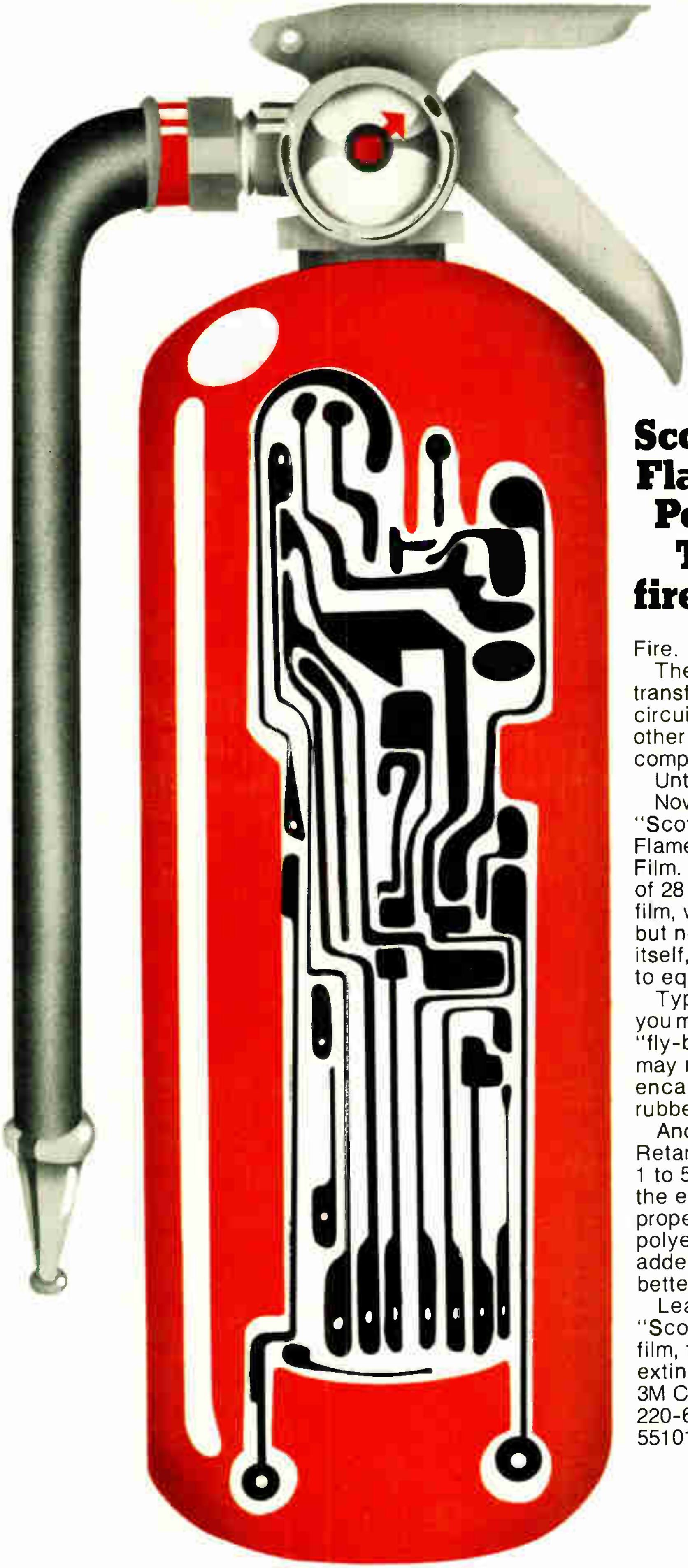
A new line of copper-etched breadboards makes converting paper schematics into live circuits a lead-pipe cinch. **You simply solder your components to the board, which has copper-foil patterns** suitable for analog, digital, or mixed circuits and can take almost any package type—can or DIP. No drilling or cutting is necessary, points out manufacturer Instant Instruments Inc., 306 River St., Haverhill, Mass. 01830.

Capacitors keep inductance low

Users of electrolytic capacitors should get with the new low-inductance aluminum electrolytic technology, available from a number of components manufacturers. Sprague, for example, uses a unique stack-foil construction, where fingers of aluminum electrolytic foil take the place of the usual single tubular, cylindrical, coil construction to keep the unwanted series resistance and inductance very low. Indeed, typical throughout this industry are **100,000-microfarad aluminum electrolytic capacitors with only 1-nanohenry inductance and 0.001-ohm series resistance**—and that's pretty good.

How to stay in the know about minicomputers

An information service on minicomputers is being started by the Datapro Research Corp., Morristown, N.J., and consists of a reference volume, monthly and quarterly supplements, and a telephone and mail consulting service. The service provides detailed evaluations of minicomputers and peripherals, **case studies of minicomputer applications, design tradeoffs and technological trends,** and a vendor directory. Annual subscriptions are $250, but a charter rate of $190 is available for a short time.



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And, "Scotchpar" Flame Retardant Film, available in 1 to 5 mil thicknesses, has the electrical and physical properties of standard polyester films, with the added benefit of a much better winding surface.

Learn more about "Scotchpar" Type 7300 film, the built-in fire extinguisher by, writing 3M Company, 3M Center, 220-6E, St. Paul, Minnesota 55101.

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Planar panel provides complex display

Ac-coupled gas-discharge unit combines alphanumeric and fixed messages; high uniformity of illumination achieved through capacitive current distribution

by Joel DuBow, Components Editor

Complex displays are finding increased application in interactive graphics, instruments, and consumer products. Most of these displays are mixtures of dc cold-cathode, light-emitting-diode, and incandescent elements. Now, however, a capacitively coupled neon-gas-discharge panel developed by National Electronics Inc., Geneva, Ill., can combine numeric, alphanumeric, and fixed messages in a single panel.

The ac technique allows a wide range of character sizes in a flexible format, dissipates about one-half the power of a similar dc display, and provides higher uniformity than its dc counterpart.

The new panels currently operate over a range of −20°C to +85°C, although a −60°C version, aimed at aircraft-cockpit applications, is expected soon. Segmented characters from 0.4 to 5.0 inches high, as well as special symbols and fixed messages may be included readily, since panel construction, which employs thick-film screening on glass substrates, is limited only by masking facilities. Currently available panel sizes range from 1 by 3 to 8 by 15 in.

Ions contact glass. The equivalent circuit of the device is three series capacitors—the anode glass dielectric, the gas, and the cathode glass dielectric. There are no metallic conductors in contact with the gas, thus eliminating the cathode secondary emission and its attendant heating associated with dc displays that have dc electrodes inside the panel in contact with the gas. In the ac-coupled display, the ions contact the glass dielectric. In addition, the parallel-capacitor combination of each display element shares the current distribution so as to uniformly illuminate the lighted area. Because the cold-cathode dc display has a resistive equivalent circuit, it tends to be more sensitive to parameter variations and provides less uniform illumination.

Fast update. Displays may either be black characters against a neon-orange background or orange characters against a black background. A planar panel with 10 digits and 40 fixed messages will dissipate 6 watts and provide brightness of 50 foot-lamberts. The update or switching time is in microseconds. Mean time between failure is estimated at 50,000 hours. The price of a display such as the one shown below is $80 to $100 each in small lots.

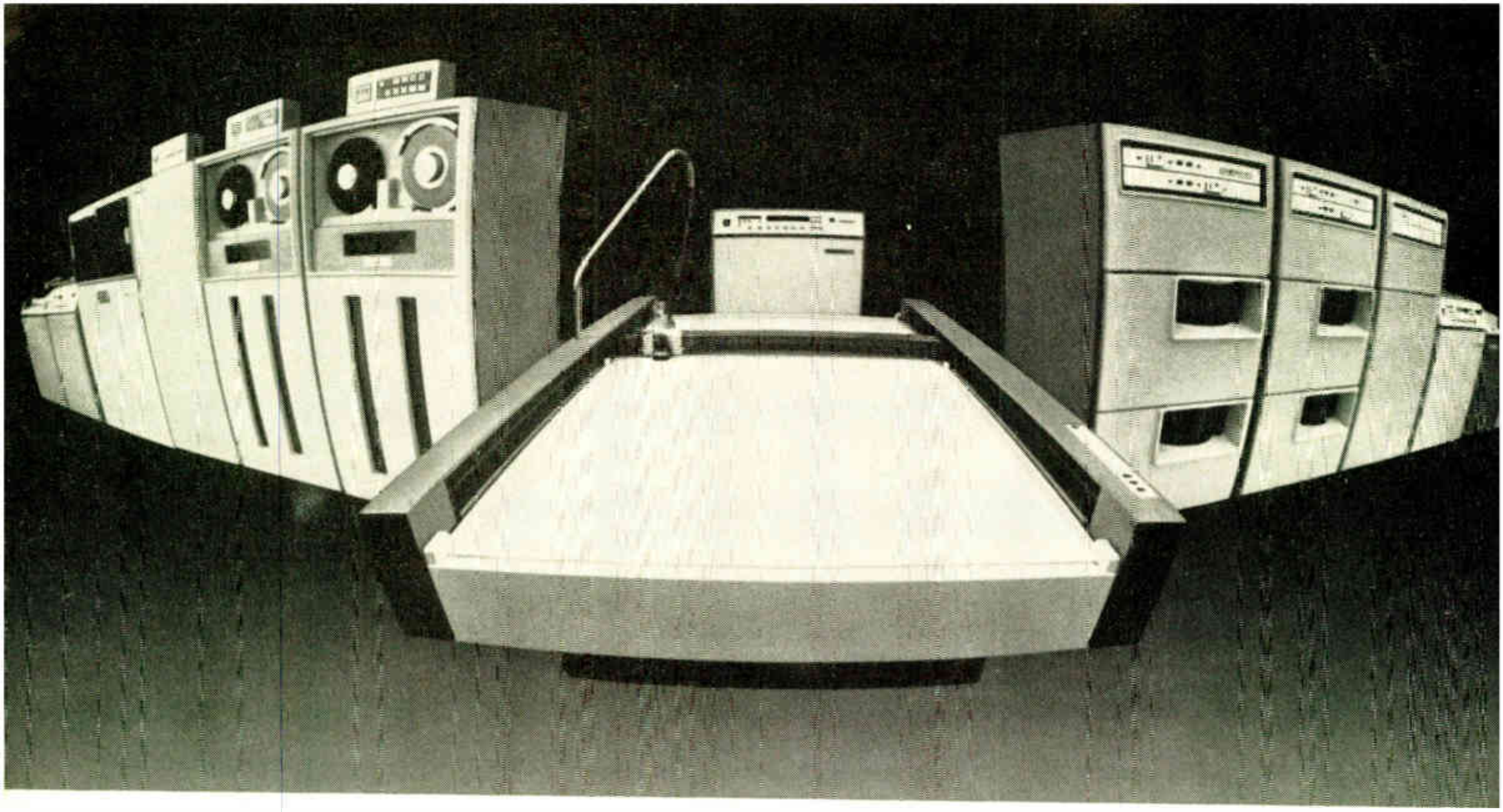
Jim Teppo, product manager, predicts that the largest impact of the panels will be in the custom-display area, in point-of-sale terminals, for example. "They don't directly fall into the LED or cold-cathode dc-discharge marketplace. Their main application will be in integrating a number of display functions, thereby realizing a cost savings, and in achieving previously unrealizable displays," he says.

For example, a planar panel could replace a three-technology dc panel with incandescent message areas and alphanumerics of LEDs or tubes. Teppo does not believe that liquid-crystal displays, which might be expected to compete with these panels, will be able to match the optical and electrical parameters exhibited by the National Electronics display.

Delivery time is 90 days. Since the display is essentially a big capacitor, many drive schemes are possible to obtain the 180 v ac.

National Electronics Inc., a Varian Subsidiary, Geneva, Ill. 60134 [338]

Information panel. Capacitively coupled gas-discharge display can combine alphanumerics and fixed messages. Characters may be orange against a black background or vice versa.



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Disk memory equipment. This was our second area of concentration. In a remarkably short time, we have become the leading independent supplier.

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The point is we have not grown by accident. Thirteen years after our beginning, we have become a leader in computer peripherals.

For information on peripheral products, call your local CalComp office, or contact California Computer Products, Inc., EM-11-73, 2411 West La Palma Avenue, Anaheim, California 92801. (714) 821-2011.

CALCOMP

LED package includes IC regulator

Solid-state lamp glows with constant brightness without help of driver, anode resistor, or regulated supply

by George Sideris, San Francisco bureau manager

Connect a power supply of anything between 4.5 volts and 16 V to a new solid-state lamp from Litronix Inc., and it will glow at a constant brightness without the aid of a driver, an anode resistor, or a regulated power supply. Yet the unit costs no more than the price of a conventional LED-resistor assembly.

Inside the lamp package are a light-emitting diode and a tiny monolithic current regulator that drives the LED with either a 10-milliampere or 20-mA forward current throughout the supply range. Since current and brightness depend on neither supply voltage nor anode-resistor value, the lamps can be taken from stock, plugged into systems, and look the same, regardless of what the voltages are at the plug-in points.

As shown in the schematic, the regulator contains a control transistor Q_1 and a driver transistor Q_2. Q_1 looks at the voltage drop across Q_2 and regulates its base current to keep the diode's forward current constant. The regulator chip is mounted on the lamp's anode pin and is wire-bonded to the light-emitting-diode chip, which is on the cathode pin.

Litronix doesn't plan to make a resistor-LED because the regulator IC is as cheap as a resistor. It adds only about 12 cents to the basic LED cost (plain LEDs cost about 28 cents in 1,000-up lots, and the new lamp costs 50 cents). If a design equivalent to a resistor-LED is desired, the lamps can be ordered with the driver portion of the IC chip shorted out.

In a pinch, the lamps may be used as small constant-current sources in low-power designs that do not need precision current regulators. Custom versions will be supplied, Litronix adds, for such applications as battery-discharge indicators requiring a specific turn-on threshold. One such design will have the IC resistors sized so that the lamp sees a turn-on current when battery voltage is about 3.2 V. If the lamp doesn't light when a battery-test button is pushed, the equipment user will know, without using a meter, that it is time to change the battery.

In contrast to the rapid rise with voltage of forward current in other devices, such as discrete light-emitting diodes and LED/resistor assemblies, the Litronix lamp's current rises through a turn-on region between 2.5 and 4.5 V and then almost stabilizes.

The current of the LED-with-regulator package does increase a few milliamperes above 4.5 V, but that has no apparent effect on brightness—the extra current increases the LED's temperature, which reduces the light output and also compensates for the rise in current.

Another advantage is that dissipation over the operating voltage range rises almost linearly with supply voltage, while in conventional designs, the dissipation rises in proportion as the square of the voltage increases.

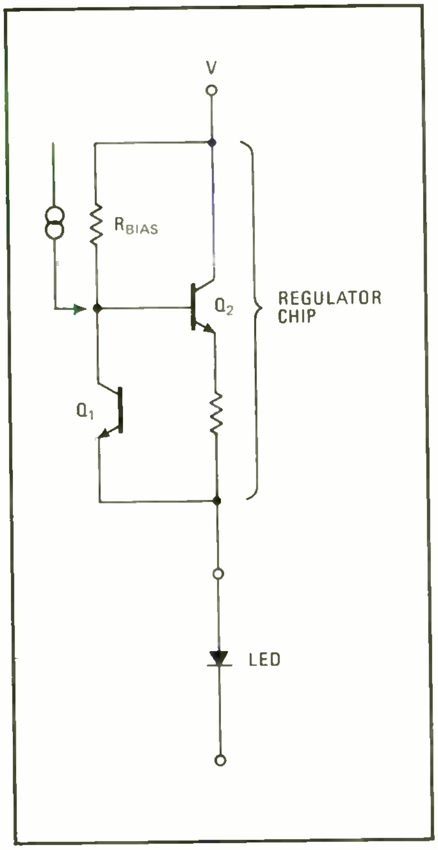
The assembly is made in three red-lamp versions:

- RLC-200 in a T-1 ¾ standard lamp package. It is specified to operate at 4.5 to 12.5 V with 0.8 millicandela minimum brightness and 20-mA forward current.
- RLC-201 in a T-1 ¾ package, operating at 4.5 to 16 V with 0.4 mcd minimum brightness and 10-mA forward current.
- RLC-210 in a T-1 miniature package, operating at 4.5 to 11 V with 0.6 mcd typical brightness and 10-mA forward current.

The RLC-200 and RLC-201 cost 90 cents in one to 99 quantities, 60 cents in 100 to 999 quantities, and 50 cents in lots over 1,000. RLC-210 prices are $1, 75 cents, and 60 cents.

All versions of the new assembly will be available from stock this month.

Litronix Inc., 19000 Homestead Road, Cupertino, Calif. 95014 [339]



All in one. Solid-state lamp assembly includes an integrated-circuit regulator that is wire-bonded to the light-emitting diode.

Components

Capacitors use new impregnant

Ester replaces PCB compounds in devices from Sprague and GE

The environmental furor over polychlorinated biphenyls (see p. 29) has led to the introduction of substitute impregnants for paper capacitors used in critical applications. Sprague Electric Co., North Adams, Mass., and General Electric Co. have recently been granted patents on capacitors with ester impregnants. Sprague is introducing a full line of 1- to 25-microfarad, 330- to 600-volt capacitors. GE is introducing a similar series with ratings of 1 to 50 microfarads.

It is expected that these devices, called the Eccol series by Sprague and Econol series by GE, will find widest applications in computers and in equipment for international markets, where regulations on polychlorinated biphenyls vary and are in a state of flux. The Eccol capacitors are slightly larger—because their dielectric constant is smaller—and hence they are currently 10% to 20% more expensive than their PCB equivalents.

However, the material has certain electrical advantages over PCB, which could lead to additional applications. The new Eccol and Econol capacitors have a flatter frequency-dependence of the loss-angle tangent, or parasitic series resistance, with frequency and with temperature, than PCB capacitors do. The new devices have a lower freeze point (-65°C versus -30°C) and improved thermal properties, which eliminate the thermal runaway that can occur with a PCB-impregnated capacitor at about 85°C. Thermal runaway occurs when the material starts absorbing more energy than is thermally removed from it.

Although the ester impregnant, having a flame point of 500°F and a flash point of 425°F, is more reactive than PCB, which has a flash point of 800°F, and although ester has higher moisture-retaining properties, the material has proven quite stable in field trials over the past few years, Sprague engineers claim. The components are made by impregnating a dielectric paper (dielectric constant about 5.9) with an ester solution and rolling the paper into cylinders for packaging.

General Electric Co. is tooling up at its Hudson Falls, N.Y., plant to produce material for its stabilized-ester capacitor lines.

Sprague, which is developing capacity to meet OEM orders, is turning out thousands of Eccol capacitors per week. Donald Rowe, product manager for large paper, large film, and energy-storage capacitors, says that materials development in polypropylene, polyethlyene and polysulfoam films could lead to replacement of Eccol capacitors. They have higher dielectric strength than paper's 4,000 volts/mil and can be made thinner. Production quantities of uniform, single sheets of one of these films is considered three to five years away.

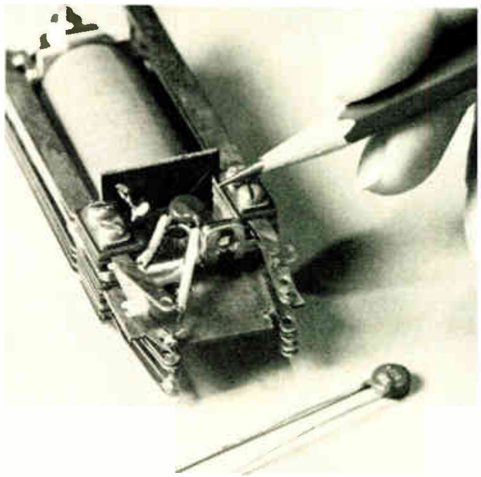
R.H. Kimball, manager of marketing and planning at GE, feels that the corona-breakdown problem caused by small air bubbles will require that even film capacitors such as polypropylene will require an impregnant for high-voltage applications.

Sprague Electric Co., 125 Marshall St., N. Adams, Mass. 02147 [341]

General Electric Co., Hudson Falls, N.Y. 12839 [405]

Line of varistors are rated to 40 volts

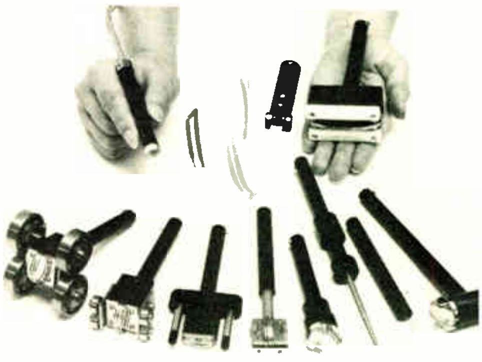
A line of voltage-transient suppressors includes six aspirin-sized MiniMov varistors. They are designed to cover 40 to 80 volts rms of applied voltage, and maximum applied dc voltages include 53 v, 80 v, and 110 v. The varistors are based on polycrystalline technology; the metal-oxide devices are voltage-dependent and symmetrical, and function rather like back-to-back zener diodes in circuit-protective functions. Price is as low as 57 cents in 1,000-lots.



General Electric Co., Semiconductor Products Dept., Electronics Park, Building 7, Mail Drop 49, Syracuse, N.Y. 13201 [401]

Surface-temperature probe measures up to 900°F

A selection of surface temperature probes is designed for almost any measurement up to 900°F. These thermocouples use a sensor ribbon that is accurate to within ±½°F. A variety of configurations is available, including probes that measure the surface temperature of cylinders and other odd shapes, probes that slide or roll over moving surfaces, and probes small enough to measure the temperature of a transistor. A pyrometer is also offered with the range of probes, reading out in

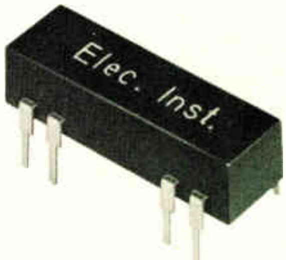


seven ranges. All of the probes are available from stock.

Omega Engineering Inc., Box 4047, Stamford, Conn. 06907 [402]

DIP reed relay offers coil voltage of 5 V

A Form A dual in-line reed relay is designed to provide a coil voltage of 5 V and a coil resistance of 500 ohms. Contact rating is ½ ampere maximum for dc and 100 V maximum for dc. Power limitation is 10 watts maximum. In addition, the package is only 0.200 inch high. Price for 1,000-lots is $1.54 each.



Electronic Instrument & Specialty Corp., 42 Pleasant St., Stoneham, Mass. 02180 [403]

Two inverter SCRs permit high-frequency operation

Two high-current inverter SCRs are designed to operate at unusually high frequencies. One is designated the C609 and it is rated at 1,000 amperes, with voltages up to 1,200 volts and a switching capability up to 5 kilohertz. Further, it has a one-cycle surge capability of 10,000 A. The other device is the C509, rated at 775 A with voltages up to 1,200 V

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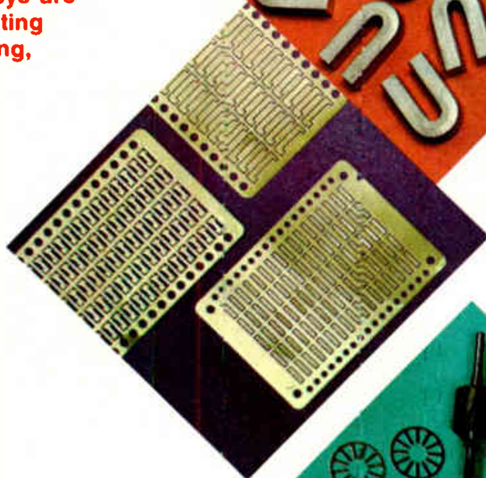

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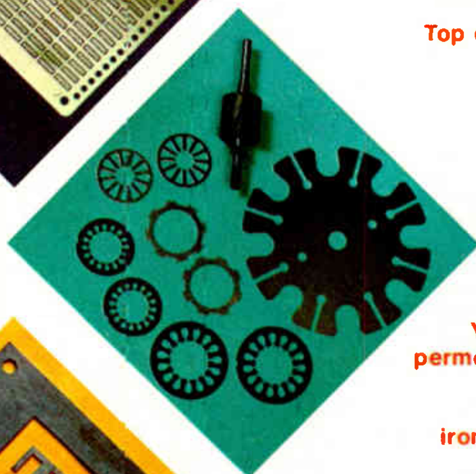

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and a switching capability of 5 kHz. It has a one-cycle surge capability of 7,500 A. These specifications result from the use of an involute interdigitated gate turn-on pellet configuration developed by the company. Price for 10 to 99 is $134.50 each for the 509 and $162 for the 609.

General Electric Co., Building 7, Mail Drop 49, Electronics Park, Syracuse, N.Y. 13201 [343]

Switch modules are easily changed

The model 49 lighted display pushbutton and switch modules can be removed from front panels for servicing without disturbing wiring behind the panel and can be replaced in one minute or less. The switches are available in double-pole double-throw or quadruple-pole double-throw configurations and have contacts rated at 2 amperes resistive at 28 volts dc/115 v ac. A choice of solder or wrap-type wiring terminations is offered. Price of the switch assembly in 100-lots starts at $13.65, and the display push button sells for $3.40 in the same quantity.

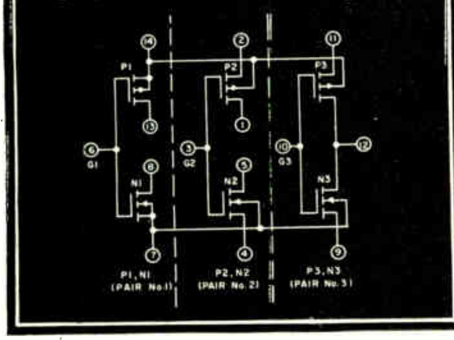
Stacoswitch Inc., 1139 Baker St., Costa Mesa, Calif. 92626 [345]

Filter-oscillator aimed at communications channels

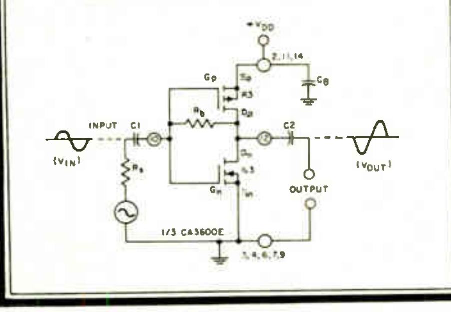
Intended for applications in data communications, telemetering, dial pulse systems, and speech-plus-tone signaling, the model 22 RC active filter is combined with an oscillator

Linear COS/MOS... RCA's CA3600E premieres

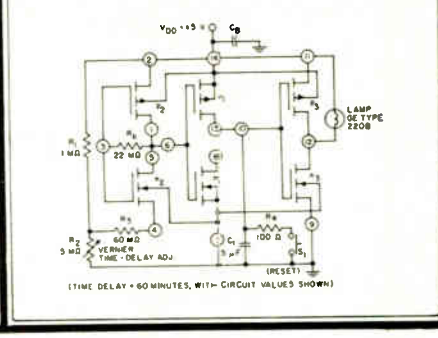
CA3600E schematic diagram



CA3600E transistor pair biased for linear-mode operation



Analog timer using CA3600E



Meet the linear IC with the advantages of COS/MOS. The new RCA CA3600E Transistor Array... three pairs of complementary enhancement-type MOS (p-channel/n-channel) transistors on a single chip.

The CA3600E is designed for a great variety of applications requiring virtually infinite input impedance, wide bandwidth, matched characteristics, lower power consumption and general purpose circuitry.

And that's not all. With the new CA3600E you get performance advantages that include square-law characteristics, superior cross-modulation performance, and a greater dynamic range than bipolar transistors.

Whether you're working in timing, sensing and measuring or any other applications, or if you're tired of fighting beta variation in your bipolar circuit, let your "linear" imagination run wild. The features offered in the new CA3600E COS/MOS Linear IC are too good to pass up.

☐ Virtually infinite input resistance/ 100 gigohms
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☐ Low gate-terminal current/ 10 picoamps
☐ No "popcorn" (burst) noise
☐ Matched p-channel pair/gate-voltage differential ($I_D = -100uA$) ... ±20mV (max)
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☐ High voltage gain/up to 53dB per COS/MOS pair.

Supplied in the 14-lead dual-in-line plastic package, the CA3600E is available in production quantities from your local distributor or direct from RCA.

For complete data sheet/ application note write: RCA Solid State, Section 70K-8, Box 3200, Somerville, N.J. 08876. Or phone: (201) 722-3200.

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International: RCA, Sunbury on Thames, U.K., or Fuji Building, 7 4 Kasumigaseki, 3-Chome, Chiyoda-Ku, Tokyo, Japan. In Canada: RCA Limited, Ste. Anne de Bellevue 810, Canada.

Circle 135 on reader service card

New products

working at the same frequency. Since variations in tuned circuit and feedback are magnified by Q, metal oxide resistors and mica capacitors are used for stability. Price is $87; quantity prices are also offered.

Controlec Inc., Box 48132, Niles, Ill. 60648 [346]

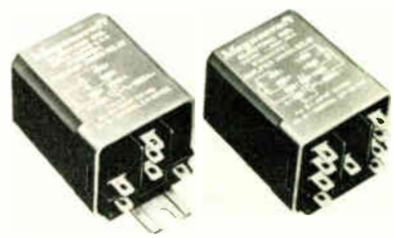
Vhf switch attenuator operates from dc to 120 MHz

A line of vhf switch attenuators is precision devices operating over the range from dc to 120 megahertz in 1-decibel steps to 101 dB. The units offer a low VSWR and low error, making them suitable for i-f applications. A variety of female connectors is offered with the devices. Prices start at $100 each in small quantities.

RLC Electronics Inc., 83 Radio Circle, Mt. Kisco, N.Y. 10549 [344]

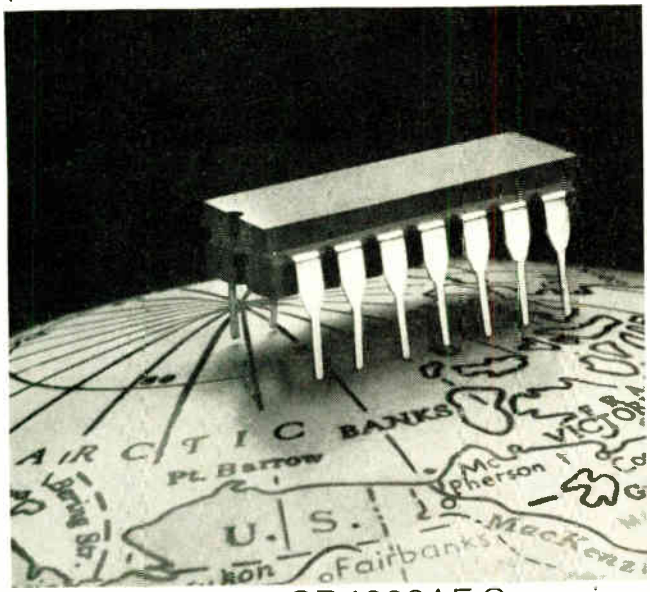
Relay provides 10-A switching

A Class 388 amplifier-driven general-purpose relay is a solid-state hybrid device that allows 10-ampere switching with low-power control. The amplifier circuit in the device provides high impedance to the control circuit, thus making it suitable for the low-power signal levels asso-



RCA COS/MOS in low cost ceramic.

RCA now offers COS/MOS in a new low cost ceramic package. So you can select, from our complete line of COS/MOS circuits, an IC package to meet your exact needs for performance and price.



Our new CD4000AF Ceramic IC's feature electrical characteristics identical to the present AD and AK series weld seal ceramic COS/MOS circuits. You get a completely hermetic package designed to operate over the full military temperature range of −55°C to +125°C...at a commercial price.

Compare the prices of our new ceramic IC's. If you've needed the temperature range and hermetic features of ceramic, but couldn't afford

TYPE NO	FUNCTION	AF PRICE (1000+)
CD4001AF	Quad 2-input NOR gate	$ .98
CD4011AF	Quad 2-input NAND gate	.98
CD4013AF	Dual "D" master-slave Flip-Flop	2.03
CD4020AF	14-stage binary/ripple counter	5.90
CD4027AF	Dual J-K master-slave Flip-Flop	3.14
CD4029AF	Presettable up/down counter	7.94
CD4042AF	Quad clocked "D" latch	4.23
CD4046AF	Micropower phase-locked loop	5.63
CD4047AF	Monostable/Astable multivibrator	3.75

the price, now you can discover the digital world of COS/MOS in RCA's new low cost ceramic package.

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For complete pricing and data sheet write: RCA Solid State, Section 70K-8, Box 3200, Somerville, N.J. 08876. Or phone: (201) 722-3200.

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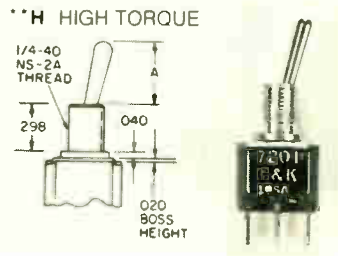
International: RCA, Sunbury on-Thames, U.K., or Fuji Building, 7 4 Kasumigaseki, 3 Chome, Chiyoda Ku, Tokyo, Japan. In Canada: RCA Limited Ste. Anne de Bellevue 810, Canada.

ciated with integrated circuits. A control voltage as small as 2.4 v dc will signal the amplifier to energize the relay, provided the 24 v dc driver supply voltage is maintained.
Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago, Ill. 60630 [347]

Toggle switches feature high-torque bushing

High-torque bushing is being offered free as an option on all of C&K Components' toggle switches. This feature provides the switches with resistance to greater twisting forces imposed on the switch case from the rear of the panel, which



may occur during equipment assembly or during maintenance. In addition, the shoulder on the bushing absorbs axial forces that are created by tightening the switch nut.
C&K Components Inc., 103 Morse St., Watertown, Mass. 02172 [348]

Crystal oscillators can be modulated up to 200 kHz

A voltage-controlled crystal oscillator, geared to applications such as high-frequency-response telemetry channels and fast-settling phase-locked loops, is designated the model 6725WXA-1. The 70-megahertz device can be modulated at rates up to 200 kilohertz with fm distortion no greater than 5%. Frequency deviation is ±14 kHz. Other models are available with deviation and modulation specifications varying in proportion to center frequency.
Damon/Electronics Division, 80 Wilson Way, Westwood, Mass. 02090 [349]

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The big one, EA4800, stores 16K bits in a 2048 x 8 or 4096 x 4 format in a 24-pin package. It's a favorite for microprocessors. Has a maximum access time of 1.2 μsecs. Uses .032 mW/bit power. Requires +5v and −12v supplies. No clocks needed – it's static. No address decoding required – it's on the chip. No input pull-up resistors needed – they're on the chip. Price is $28 in quantities of 100.

The fast one, EA4000, has a 725-nanosecond guaranteed worst-case access time. Stores 512 10-bit words in a 24-pin package. Uses .04 mW per bit power. Requires +12v and −12v supplies. Price is $13 in quantities of 100.

The low-power one, EA3800, uses only .02 mW per bit. Stores 1024 12-bit words in a 28-pin package. Has a maximum access time of 3.3 μsecs. Requires +12v and −12v supplies. Price is $22.50 in quantities of 100.

The big one, 16K bits

The fast one, 725 ns

The low-power one, .02 mW/bit

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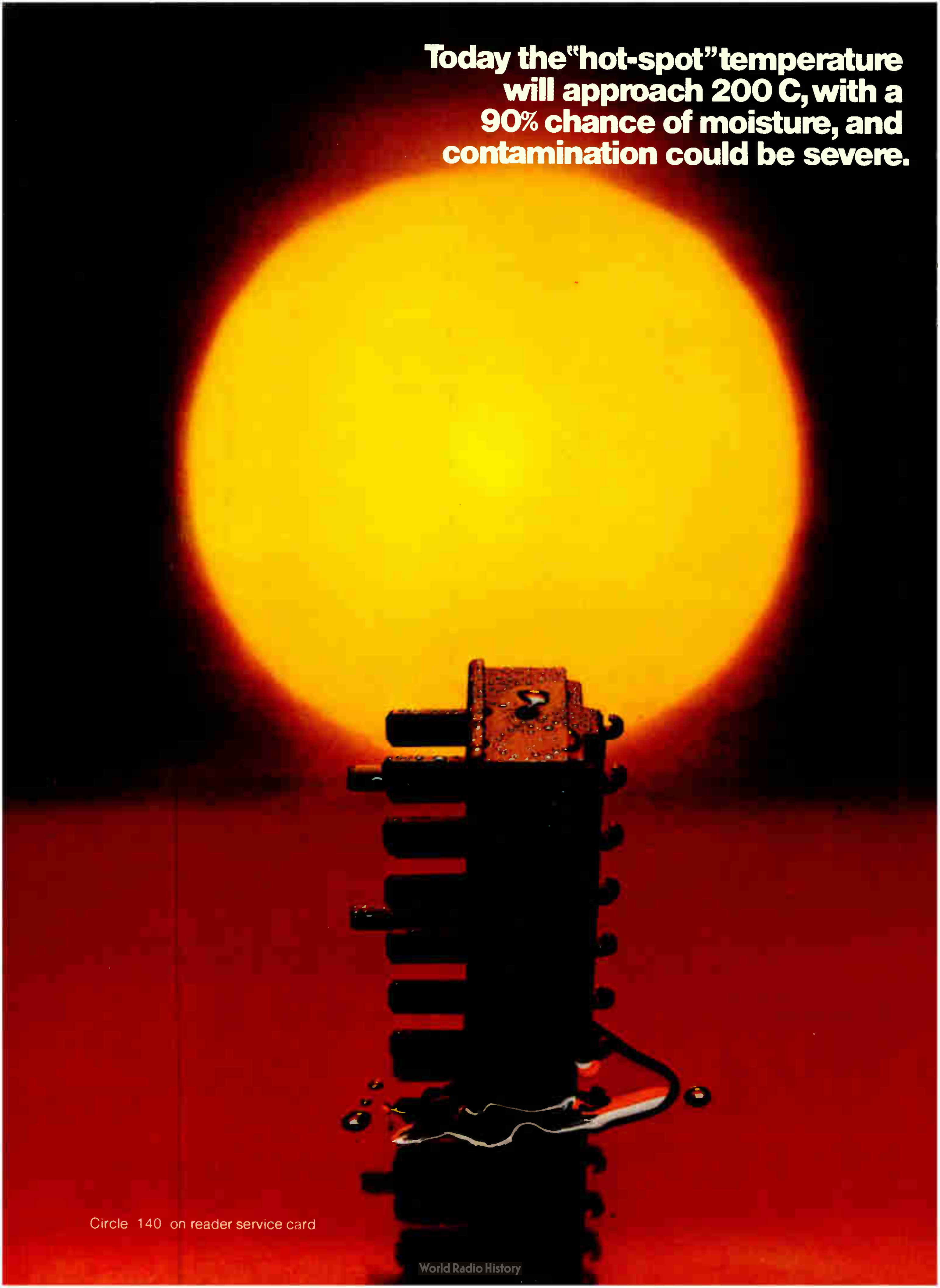

Today the "hot-spot" temperature
will approach 200 C, with a
90% chance of moisture, and
contamination could be severe.
Circle 140 on reader service card

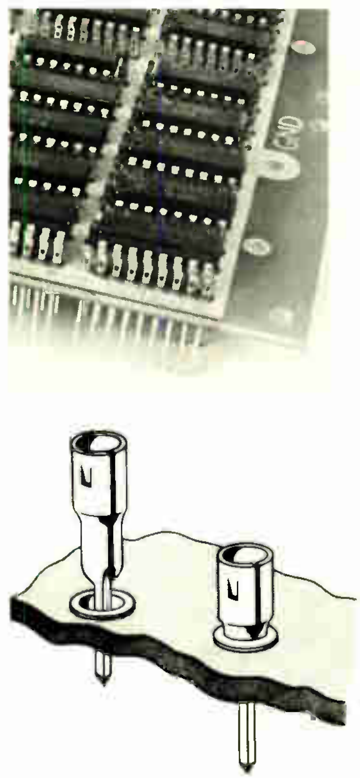
Packaging & production

Circuit panels go solderless

Mechanically wired units have socket pins that are wedged in place

The mechanically wired circuit panel, a fast-growing means of mounting and interconnecting integrated circuits, is going solderless. Panel fabrication has usually entailed soldering the socket pins to the panel. Now Winchester Electronics, a division of Litton Industries, has developed a panel having socket pins that are wedged, rather than soldered, in place.

The Winchester panel eases the problems of replacing damaged socket pins—a procedure which usually requires soldering and unsoldering damaged pins and can render unserviceable a panel worth thousands of dollars. But a solderless pin can be removed and replaced with little risk to the panel. Withdrawal force is approximately 20 pounds, and contact resistance between the socket pin and the plated-through hole in the panel is less than 5 milliohms. The socket pin employs a curled metal barrel that the manufacturer calls Wedgrol. The socket-pin barrel fits snugly in a plated-through hole in the panel and contacts about 320° of the 360° circumferential area.



Fast fix. Winchester's mechanically wired panel uses a wedging action—rather than solder—to secure socket pins in place. The photo at top is a section of a panel that mounts 120 16-pin DIPs.

Mechanically wired panels are muscling in on the hard-wired printed-circuit-panel market in computer mainframes and communications terminals—applications where a large number of interconnections are required. The reason is that printed-circuit wiring offers the designer virtually no hope for circuit changes after a panel is fabricated. However, changing a wire in-house on a mechanically wired panel is a fairly simple procedure that seldom creates much of an engineering or a manufacturing-cost impact. The cost of modifications in the field is also negligible.

Such versatility and economy explains why mechanically wired panel usage is growing. George T. Howard, vice president for sales at Winchester, estimates that there has been a 25% jump in mechanically wired panel sales in the past year, and total sales volume for the industry is approximately $50 million annually.

Winchester Electronics, Oakville, Conn. 06779 [391]

Wafer washer-dryer handles parts in their carriers

Called the model SKG-1/W, a semiconductor wafer washer-dryer handles wafers while they are in their carriers. The loaded carriers are inserted into nests on the rotor and are spun at selected speeds while being washed and dried. The standard rotor can process up to 150 wafers per load. Price of the unit varies between $2,000 and $3,000, depending on options.

I.I. Industries Inc., 450 Clyde Ave., Mountain View, Calif. 94040 [394]

Thermal stripping system removes wire insulation

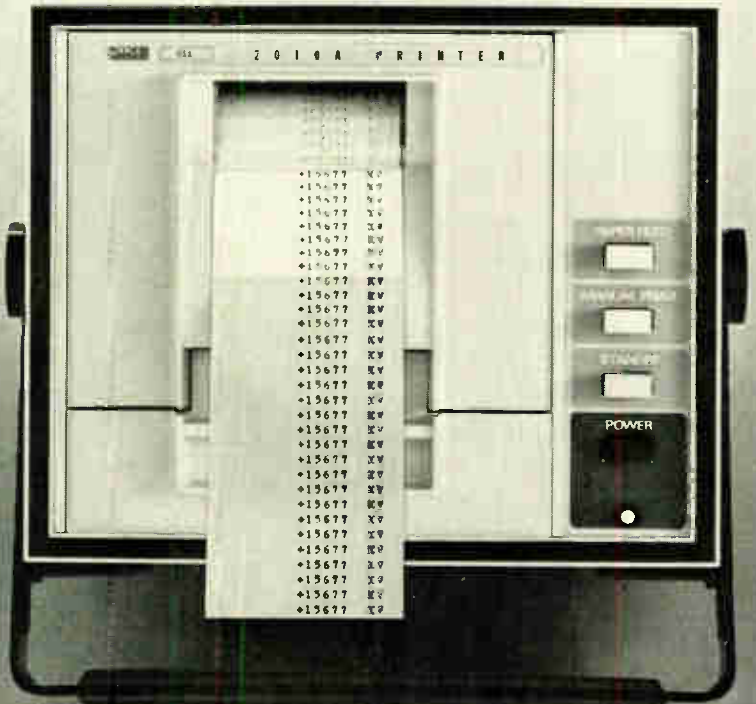
StripTweez is a thermal stripping system that removes wire insulation without nicks or scrapes. The model TSP-20 removes almost any type of insulation from #43 wire size, up to ¾-inch-diameter cables, and its working end can reach into wells as deep as 2 inches. The unit comes with power supply. Price is $129.

Pace Inc., 9329 Fraser St., Silver Spring, Md. 20910 [404]

Recorder monitors pc-board temperatures

The temperatures of printed-circuit boards during preheating and flow soldering are indicated by the model 110 temperature recorder. The unit contains six calibrated heat-sensitive increments, which are silver-colored windows that turn black at their rated values. Incremental values range from 100° to 350°F in 10°F steps. Response time is less than 1 second, and accuracy is within ±1%. The model 110 is applied to the surface of a pc board af-

It isn't just another new printer, this one's from Fluke



Fluke's new Model 2010A Digital Printer is the perfect match for Fluke digital instruments and most comparable instruments by other manufacturers.

It's easy to interface. Range and function data can be on either coded or discrete lines. You don't need special decoding and encoding circuitry. When you use it with a Fluke multimeter or counter, simply select one of our standard interconnecting cables.

An abundant array of print characters provides you with a well defined data format. Chances are your application conforms readily to the standard capabilities of this versatile performer.

For recording data from most digital multimeters and counters, the basic 10 column model fills the bill. An 18 column version is available for those data sources with a large number of outputs.

Unique data storage capability and busy flag are standard—an especially helpful feature in systems with sampling rates faster than printer output. The printing rate of the 2010A is at least 2.5 lines per second in either black or red.

The 2010A uses fan fold paper that neatly self-stacks in the convenient front panel drawer. Standard 2¼ inch adding machine roll paper can also be used.

For further versatility, a standby control lets you record data when you want it. In this mode, the memory continues to update with new data but the 2010A prints only on a manual print command.

Price of the 10 column unit is $795. The 18 column unit sells for $875.

In the continental U.S., dial our toll free number 800-426-0361 for the name and address of your nearest local source. Abroad and in Canada, call or write the office nearest you listed below, John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, Washington 98133. Phone (206) 774-2211. TWX: 910-449-2850. In Europe, address Fluke Nederland (B.V.), P.O. Box 5053, Tilburg, The Netherlands. Phone 013-67-3973. Telex: 844-52237. In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2 4TT. Phone, Watford, 33066. Telex: 934583. In Canada, address ACA, Ltd., 6427 Northam Drive, Mississauga, Ontario. Phone 416-678-1500. TWX: 610-492-2119.

FLUKE®

Circle 143 on reader service card

ter removal of the protective backing. Price is 90 cents each in lots of 100.

Telatemp Corp., Box 5160, Fullerton, Calif. 92632 [393]

Coaxial connectors operate through 50 kV

Designed for a variety of applications, a single-contact coaxial connector is intended for use in the military as well as commercial fields. The MS-24 and MS-22 shell-size

connectors operate through 50 kilovolts, and the MS-18 connector operates though 40 kv. All have corona-free operation in excess of 6 kv rms, and they function over the range from −50° to 200°C.

Rowe Industries, 6225 Benore Rd., Toledo, Ohio 43612 [395]

Jack mounts directly on printed-circuit boards

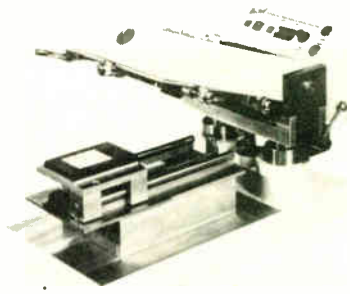
A BNC female receptacle for direct mounting on a printed-circuit board is constructed of nontarnishing silver-plated brass and is 0.5 inch high when installed. The device, designated the model 58-051-0000-67, mounts in the same board-hole layout as subminiature connectors hav-

ing four grounding lugs on a 0.2000-inch grid.

Sealectro Corp., Mamaroneck, N.Y. 10543 [396]

Screen printer requires no substrate leveling

The model 44 semiautomatic screen printer for thick-film applications requires no leveling to maintain screen-substrate alignment. The unit also provides a squeegee that an electric motor drives at a con-



stant speed throughout the full stroke. A print-repeatability to 0.0005 inch is also offered. A tilting head allows the lower side of the screen to be cleaned without being removed. Price is $7,500.

Wells Electronics Inc., 1701 S. Main St., South Bend, Ind. 46623 [397]

Precision shear has optical control

The model VON ARX KS-820 precision shear is equipped with an illuminated optical control with magnification, which allows the operator to cut sheets precisely along previously marked lines. A backstop can be adjusted with a front-mounted hand wheel calibrated in

P&B low-profile R50 Relays let you tee off on critical printed circuit board spacing problems.

New low profile R50 relays with 0.1" grid spacing are designed for switching currents where larger relays are usually required. Up to 2 amps @ 26 VDC or 1 amp @ 115 VAC, resistive.

While retaining a small package size—0.415" height—some R50 operating parameters exceed those of reeds. Special 1 Form C contacts, for example, will switch capacitive or lamp loads that normally would weld reed relay contacts.

Additional features include contact resistance of less than 50 milliohms, sensitivity to 125 mw, and standard coil voltages from 6 to 115 VDC with operate and release times of less than 6 ms.

Enclosures are ultrasonically welded to their base making them ideal for use with production techniques requiring flow soldering and spray cleaning.

R50 relays can be used in most applications demanding high density packaging such as 0.6" center to center spacing of printed circuit cards. Other applications include: Annunciator circuits that only require a single contact and limited mounting space for switching device . . . communication systems such as intercoms, modems, auxiliary tape devices, interfacing systems and read out devices . . . machine tool control circuits.

For complete information, contact your local P&B representative or call Potter & Brumfield Division of AMF Incorporated, Princeton, Indiana 47670. Telephone: 812 385 5251.

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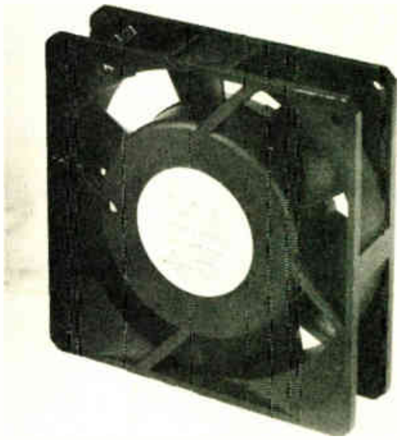
increments of 0.005 inch, providing an alternate method of alignment. Optional equipment includes a micrometer front stop with fingers for printed circuits and an electric heating table to prevent brittle material from breaking.

The Marindus Co. Inc., Box 663, Englewood, N.J. 07631 [398]

Tubeaxial fan built for high-density packaging

A 3⅝-inch-square tubeaxial fan measures 1 inch thick and is suitable for high-density packaging applications. The unit delivers air flow up to 40 cubic feet per minute at zero static pressure, and water pressure at zero air flow is 0.35 inch. The fan is called the model 99 and is part of the 760 series. Optional accessories

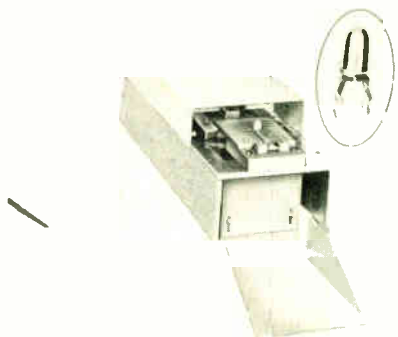


include filters, finger guards, and plug and cord assemblies. Delivery is from stock.

Amphenol, 2875 S. 25th Ave, Broadview, Ill. 60153 [399]

Component-preforming die processes LED leads

A component-preforming die is designed to process light-emitting-diode leads. All die sets feature clamping action to provide lead restriction during cutting and forming



processes, eliminating the possibility of component damage. When the square LED leads are processed, they can be formed in simple bends or stand-off and snap-in configurations.

Henry Mann. Inc., Box 65, Feasterville, Pa. 19047 [400]

Buying a function generator isn't a big deal.

Using one every day is!

Because there's not much difference in function generator prices, there is often a tendency to specify the "name" brand. But **handle-ability** can be an essential factor. When a basic signal-source goes into your lab, consider first the **day-to-day efficiency** of the instrument and **its effect on the real cost of ownership.**

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This, and many other human engineering and price/performance differences that exist between the two function generators reflect INTERSTATE's continuing concern for the user, and are factually catalogued in our FREE specifier guide. Check the number below to receive it, or for more direct information, call John Norburg, (714) 772-2811.

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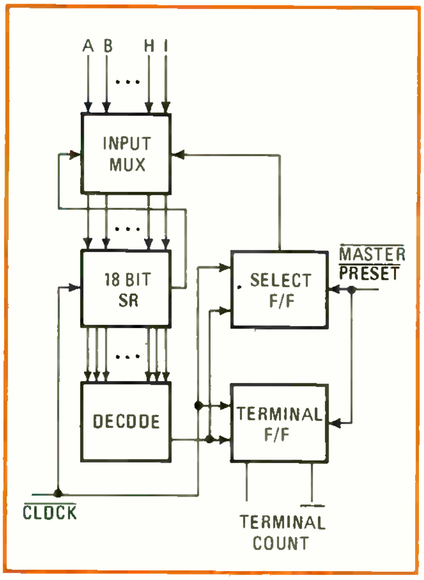
Braintree, MA.

Semiconductors

18-stage divider put on a chip

Programable MOS device in DIP reduces cost of accurate timing

Accurate timing is one of the more expensive circuit functions that engineers have to deal with, and it usually requires a series of four-stage dividers. Now, however, Fairchild Semiconductor has put a fully programable 18-stage divider in a standard 16-pin dual in-line package, which apparently turns precision delays, clock-rate divisions, and



digital rate-generation into inexpensive functions. With only nine programing pins, the model 3816 can be set to any countdown modulus from three to 262,145 ($2^{18}+1$).

Moreover, the 3816 is a silicon-gate, p-channel MOS device that is compatible with transistor-transistor logic. This means it can be controlled by logic or by MOS memories if the countdown needs to be changed often in a machine-control or a pseudorandom-sequencing application.

Input clock rates may range up to 1.5 megahertz. Consequently, output pulse rates from several hundred kilohertz down to a few hertz may be generated selectively.

As shown in the block diagram, the clock is counted down by an 18-bit linear-feedback shift register, the outputs of which are decoded on the chip to produce complementary terminal-count output pulses the same width as the input clock pulses. The output pulses are spaced in accordance with the programed divisor. Nine pins serve as programing inputs. The combined programing value of these pins depends on whether they are connected to ground, terminal count, or complementary terminal count. Each pin consecutively presents two of the register's flip-flops—one when the terminal count is high and one when its count is low.

Because of this mode, the pins cannot be programed in a straight binary format. Fairchild will supply the programing codes and has also prepared a short Fortran program to calculate the codes.

To simulate an 18-bit counter programed in straight binary, the codes may be stored in an MOS read-only memory at locations accessed by binary addresses. The terminal count is fed back to the ROM's least-significant-address input to get the two nine-bit sequences necessary to preset all 18 register stages. A standard 256-by-10-bit ROM will allow up to 128 countdown ratios to be selected under address control.

Half a dual TTL flip-flop and a single gate convert the 3816 to a precision digital one-shot. A start command is fed to the flip-flop J input and the terminal count to the K input. The flip-flop Q output is then a delay corresponding to the divider setting N, divided by the clock frequency.

As a delay, the circuit is more precise than conventional one-shots timed with resistor-capacitor networks, according to Ann Fairchild, the applications engineer responsible for the 3816. She recommends the circuit for applications such as TTL breadboards of MOS LSI designs, where highly accurate delays must be incorporated in the breadboard to simulate MOS path delays. LSI designers have resorted to special TTL counter assemblies to get a precision delay from a clock train, Miss Fairchild points out. Such assemblies are difficult to design and often require many TTL packages, she adds.

Inputs and outputs of the 3816 are completely compatible with TTL. It operates on standard MOS supplies. The device increments on the positive-going transition of the clock input and has a maximum propagation delay from clock input to terminal count output of 300 nanoseconds. Maximum clock frequency is 1.5 MHz; minimum preset pulse width, 1 microsecond; and temperature range, 0° to 70°C.

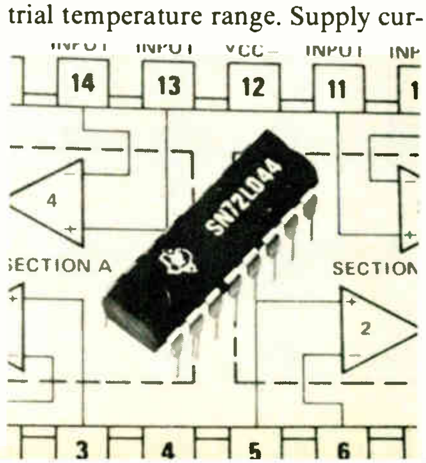
The price of the 3816 is $15 each for up to 24 units, $10.50 for 25 to 99, and $8.80 for 100 to 999.

Fairchild Semiconductor Components Group, 464 Ellis St., Mountain View, Calif. 94040. [411]

Quad op amp consumes 340 microwatts at ±2 volts

A low-power quad monolithic operational amplifier from Texas Instruments promises to extend the range of application of monolithic devices into fields previously occupied by high-performance hybrids or single-channel units. The device, designated the SN72L044, dissipates only 340 microwatts at ±2 volts. Major applications are expected to be in active filters and portable instrumentation where multiple op amps are now commonly used and where the low power dissipation and space saving will be advantageous. Portable audio equipment for industrial and consumer use are among other possible applications.

Total power dissipation of the quad op amp is a maximum of 15 milliwatts over the 0° to 70°C industrial temperature range. Supply cur-



New products

rent is only 250 microamperes typical at 25°C and ±15-V amplifier bias. Input bias current is typically 100 nanoamperes, and input offset current is 15 nA. Equivalent input noise voltage is 50 nanovolts per root hertz, and unity-gain bandwidth is 0.8 megahertz.

The L044 is designed so that power can be applied to one section of two amplifiers to allow for different output-voltage swings, and to perform some voltage translations. It also features internal frequency compensation, absence of latch-up, a slew rate of 0.5 V per microsecond, and output short-circuit protection.

The LO44 is available in 16-pin plastic dual in-line packages. Price is $4.15 in 100-piece quantities.

Texas Instruments Incorporated, Inquiry Answering Service, P.O. Box 5012, M/S 308, Dallas, Texas 75222 [419]

ECL-to-MOS translator holds delay to 20 ns

"The new n-channel MOS is getting so fast that it has to be used with fast emitter-coupled logic to take full advantage of its capability," says Ed Tynan, MECL product planner at Motorola Semiconductor Products in Mesa, Ariz. That's why his company, which makes both of these increasingly popular computer components, has introduced a dual ECL-to-MOS translator, the MC10127, for its MECL 10K line of devices.

Motorola is also developing a triple MECL-to-MOS translator specifically for n-channel applications, to be introduced in the first quarter of 1974. Tynan says the main effort in n-MOS memories now is in add-on memories, peripherals, minicomputers, and specialized circuits rather than large-mainframe memories, but he expects that the mainframe-memory market will open in the future.

The MC10127 device is very fast, with a typical propagation delay of 20 nanoseconds. It converts ECL input signals to a low-level output, (V_{OL}) of 0.5 volt maximum and a high-level output (V_{OH}) of 10 to 20

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Circle 153 on reader service card

v. depending on the power-supply level.

Jerry Prioste, applications engineer at Motorola, says that the device can be used to drive address, data, and clock lines on popular p-channel memories such as the 1103 and 6002. The newer, fast n-channel memories, like the 7001 static 1,024-bit RAM and MCM6605/6 4,096-bit dynamic RAM, require only one high-voltage signal.

The MC10127 will drive a 15-v signal into a 500-picofarad load with a rise time of 15 ns and a fall time of 20 ns. It uses an external current-limiting resistor to reduce package dissipation by about 35% from what it would be with an internal resistor for each translator. As it is, the power rating of the package limits operating frequency at higher voltages. Supply voltage can be 10 to 20 V.

Differential inputs to the two parts of the MC10127 provide high noise immunity and high speed through the use of twisted-pair cables.

The ECL-to-MOS translator is supplied in a 16-pin ceramic dual in-line package, and for 100 to 999 pieces, the price is $7.97 each.

Motorola Inc., Semiconductor Products Division, Box 20924, Phoenix, Ariz., 85036 [412]

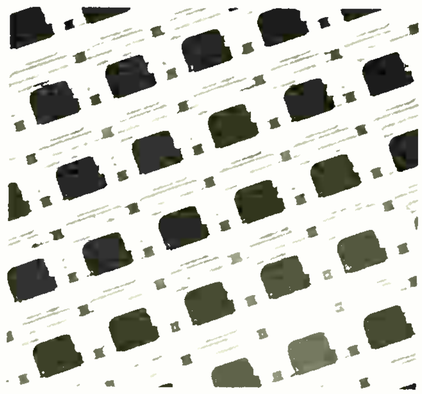
MOS circuit offers low threshold voltage

A COS/MOS dual complementary pair plus inverter is capable of operating down to 1.1 volts and up to 6 volts. Designated the model TA 6178W, the device is recommended for breadboard designs of battery-powered watches, clocks, fuse timers, timing circuits, and oscillators. The device is available in sample lots in a 14-lead ceramic DIP, priced at $4.94.

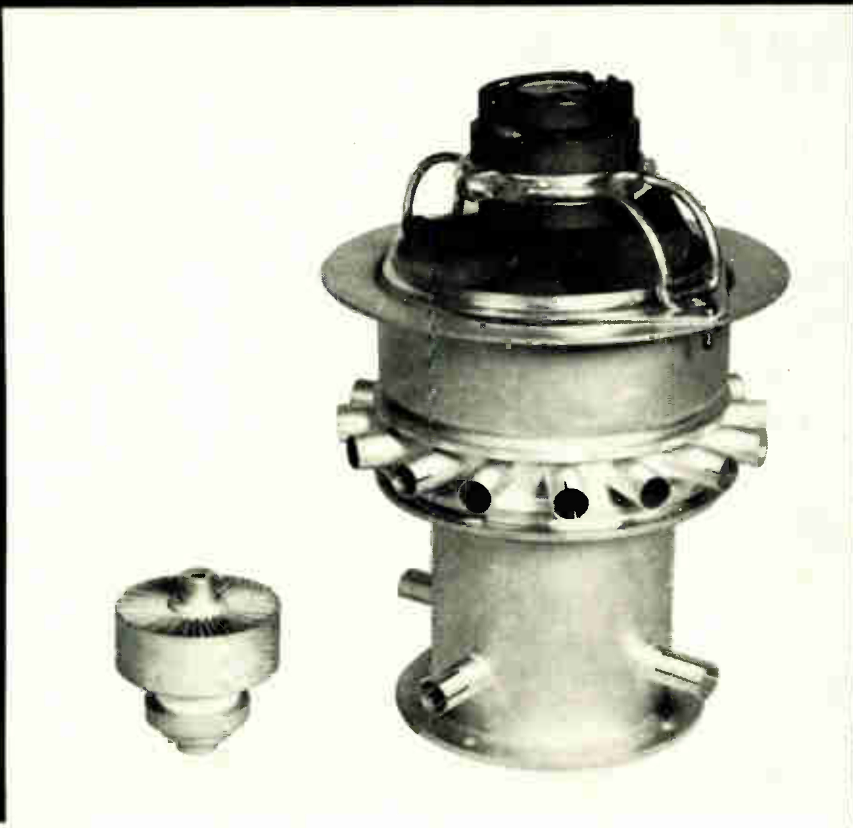
RCA Corp., Solid State Division, Rte. 202, Somerville, N.J. 08876 [415]

MOS photodiode matrix put on quarter-inch chip

A matrix scan array is designed for optical measurement and detection in a variety of applications, includ-



Here's all it takes to make it at 900 MHz.



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You save because the RCA A2965A UHF power amplifier tube is specifically designed for base station transmitters. It delivers power in excess of 150 watts from 806 to 960 MHz. And its sturdy, coaxial input construction assures optimum performance at UHF with minimal tube inductances and feed-thru capacitances.

For more information on RCA tubes, cavities and know-how for 900 MHz equipment, contact your RCA Representative. Or write Manager, Power Tube Marketing, RCA, Section ZR15, Lancaster, Pa. 17604.

RCA Power Devices

INTERNATIONAL SALES OFFICES: ARGENTINA—Casilla de Correo 4400 Buenos Aires/BRAZIL—Caixa Postal 8460, São Paulo/CANADA—21001 No. Service Rd., Ste. Anne de Bellevue, 810 Quebec/ENGLAND—Sunbury-on-Thames, Middlesex/HONG KONG—P.O. Box 112/MEXICO—Apartado 17-570, Mexico 17 D.F./SWITZERLAND—118 rue du Rhone CH1204, Geneva ing pattern-recognition, OCR systems, and flaw-detection. The MOS array provides 4,096 planar silicon diodes, spaced on 0.003-inch centers in a 64-by-64 matrix on a 0.245-by 0.247-inch chip. The MOS dynamic shift registers and accessing devices required to interrogate the diodes are on the same chip, so that the array is equipped internally to provide serial video-output signals. The chip is encapsulated in a 24-lead ceramic dual in-line package with a glass window. The photomatrix is said to provide high resolution and sensitivity.

Integrated Photomatrix Inc., 1101 Bristol Rd., Mountainside, N.J. 07092 [416]

Four-PROM package aimed at microprocessor functions

A four-PROM floating-point package is designed for the Intel 8008 and 8008-1 microprocessors. Included are four arithmetic operations, square root, and floating point-to-positional BCD output for display applications. Floating-point numbers are represented by three 8008 words, a two-word mantissa, and a third word that carries the mantissa sign and the characteristic. Price is $495.

Recognition Systems Inc., 15531 Cabrito Rd., Van Nuys, Calif. [417]

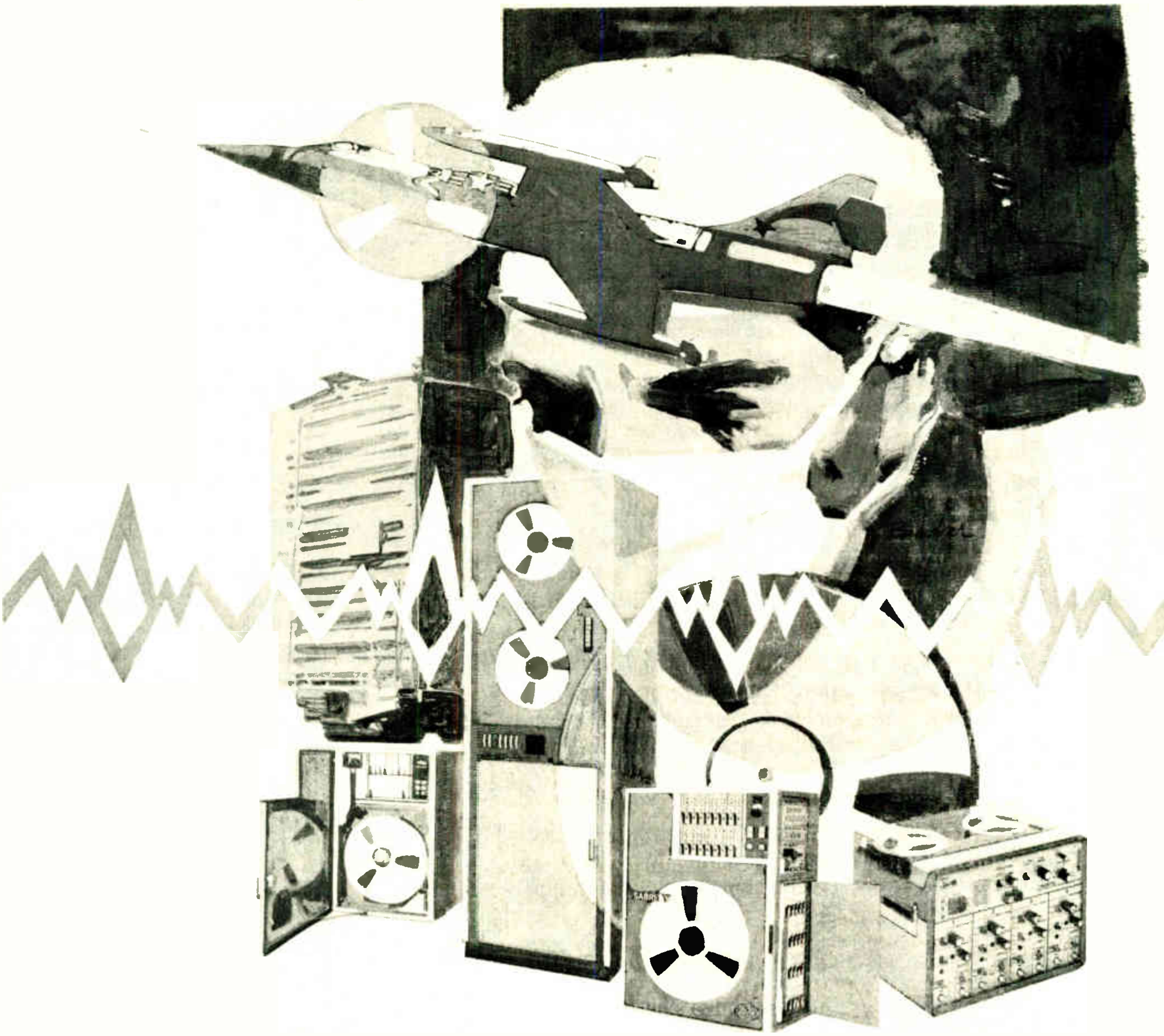
2,048-bit RAM is fast, fully decoded

A fully decoded 2,048-bit dynamic random-access memory, called the model MM5262, is designed for use in bus-organized systems as high-speed mainframe memories or for mass memory storage. Organized as 2,048 bits by one word, the device does not need a memory-address register to hold the address on its inputs during a cycle. Bipolar compatibility is offered on all input lines except clock. Access time is 365 ns, and cycle time is 475 ns for short/read and 635 ns for write or for read/write. Other specifications include a 2-millisecond refresh cycle; operation from −15 volts, +5 V, and +8.5 V; 400 milliwatts maximum operating power; and 2.5 mW maximum standby power. The unit is available in both commercial and military temperature ranges and is housed in a 22-pin dual in-line package. Price is $16.80 in 100-lots.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051

N-channel shift register operates from dc to 5 MHz

An n-channel metal-gate MOS shift register is designated the MC6565L. The 5-megahertz quad 80-bit device



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Sabre III gives you lab quality and total bandwidth convertibility in a compact all-band portable.

Sabre IV is our laboratory model that's setting new standards of accuracy in recording and reproduction.

Both Sabre III and IV let you process data up to 2.0 MHz in the direct mode, 500 KHz in the FM mode, and with full serial and parallel PCM capability. They feature total bandwidth convertibility, too.

The Sangamo-Tandberg TIR 100 does almost everything you'd expect a $16,000 recorder to do but costs under $4,500. It features four channels including one for voice or data recording, a built in CRT monitor and a portable size smaller than a cubic foot.

That's four Sangamo recorders in all. One of them is bound to do the best possible job on your data recording job—whatever it is.

For more information, write:

Sangamo Electric Company, Data Systems,
P.O. Box 3347, Springfield, Illinois 62714
Or call (217) 544 6411/Telex 406-421.

SANGAMO RECORDERS
THE INNOVATORS IN TAPE INSTRUMENTATION

370

Circle 157 on reader service card

is actually four monolithic shift registers on a single chip. It is directly compatible with TTL levels and uses a single TTL-level clock input. Recirculate logic is also provided on the chip. Applications are varied and include use as a refresh store for Motorola's n-channel 8,192-bit ROM character generator. Price is from $10 to $15, depending on quantity.

Motorola Inc., Semiconductor Products Division, Box 20924, Phoenix, Ariz. 85036 [413]

Static 1,024-bit RAM accesses in 450 ns

By combining its silicon-gate n-channel and ion-implantation depletion-load technologies, Mostek Corp. has developed a static 1,024-bit random-access memory with a worst-case access time of 450 nanoseconds. Designated the MK 4102-1P, the MOS LSI RAM is a pin-for-pin replacement for the Intel 2102-1, the Signetics 2602-1, and the Intersil 7552-1.

Other features include direct TTL compatibility, a three-state output buffer, and single +5-volt-supply operation. The high-impedance off state and chip-select input allow a minimum of additional components for large memory arrays, and the fully static operation cuts system overhead for small and medium-size memory applications.

Cycle time is also 450 ns maximum, and chip-select and -deselect require a maximum of 200 ns. Input capacitance is 5 picofarads maximum; output is 10 pF.

The 4102 is available from stock in standard 16-pin ceramic DIPs at $24 in 100-unit quantities.

Mostek Corp., 1215 West Crosby Rd., Carrollton, Texas 75006 [418]

Maximum switching performance comes in two sizes: small and smaller.

MICRO SWITCH SM and 1SX subminiatures offer electrical capacity normally found only in much larger switches. The result is big switch performance in a smaller package.

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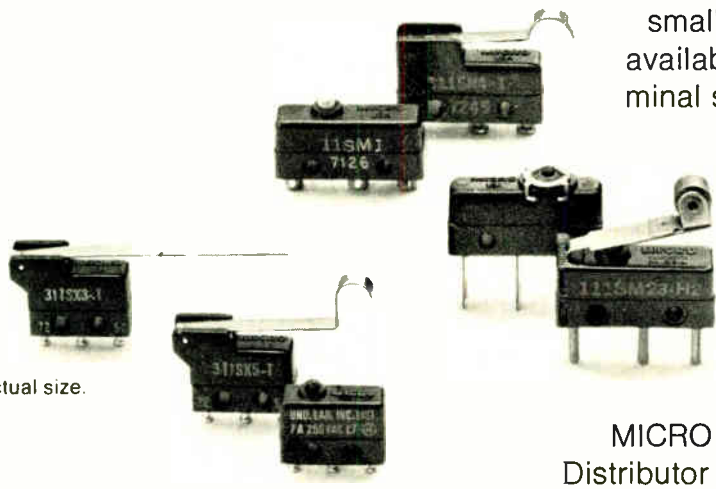
Choose from hundreds of versions, including some that meet MIL-S-8805. Our small SM (up to 11 amp capacity) and the smaller 1SX (up to 7 amp capacity) are both available with a variety of actuator and terminal styles. There's even a screw-terminal SM as well as a sealed-plunger version for wet or dirty applications. UL and CSA listings are standard. Low operating force, bifurcated gold contact and low differential travel types are available for your application.



Shown actual size.

For more information, contact your MICRO SWITCH Branch Office or Authorized Distributor (Yellow Pages, "Switches, Electric"). No request is too small for them to handle.

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Subassemblies

Sample-hold provides gain

High-speed, accurate, low-priced device offers variable gain

Generally, a sample-and-hold circuit merely holds a sample of a signal for an analog-to-digital converter; whatever comes in goes out. The trouble is, incoming signal levels are often too small to drive most

a-d converters directly, so the sample-and-hold circuit must be supplemented by amplifiers to increase the signal level. And, if high-speed signals are to be processed, these amplifiers can not only be expensive, but they can slow down the processing procedure.

In developing an economical, compact unit for 12-bit, high-speed measurement applications, Hybrid Systems Corp. has hit upon a way to "program" the unit's gain, thus eliminating the need for amplifiers. All the sample-and-hold circuit requires is one feedback resistor having a value in direct proportion to gain. The circuit's output signal can be as high as 10 volts. Gain, which can range between 1 and 100, is normally set for 1.000.

Designated the SH730, the sample-and-hold device measures 1.5 by 2 by 0.4 inches and is priced at $89 for one to nine units, which the company says is considerably lower than comparable devices.

The SH730 can acquire a full ±10-V signal, accurate to 0.01%, in less than 1 microsecond, and small-signal settling time is even faster at 500 nanoseconds. Small-signal bandwidth of the new circuit is 5 megahertz.

Input impedance is 100 megohms. Aperture time is 50 ns, with ±5 ns uncertainty, and slew rate is 20 V per μs. Sample-to-hold offset is 5 mv, and offset drift is 25 μv/°C. The SH730 comes complete with input and output operational amplifiers, so the holding-capacitor charge current does not have to be supplied by the input signals.

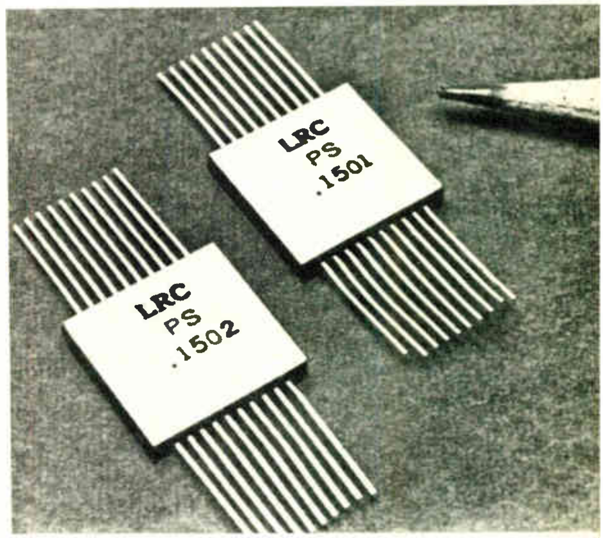
Hybrid says that the accuracy and economy of the SH730 makes possible a new range of applications not practical and higher-priced units of equal accuracy that need external amplifiers. For example, fast a-d converters with an accuracy to 0.01% are expensive enough so that users will often switch them from signal-to-signal, instead of buying a converter for each signal. This means that each input signal must go through a sample and hold circuit having the same accuracy. But the more expensive and sample-and-hold, the less economical it is to use several of them, and the user may only decide to buy extra converters. Now Hybrid claims that the SH730 can provide the desired accuracy relatively inexpensively, obviating the need for extra converters.

Delivery time is from stock to two weeks.

Hybrid Systems Corp., 87 Second Ave., Burlington, Mass. 01803 [381]

Miniature power supplies provide high output voltages

Two power supplies are offered in a flatpack, designed for use in strip-line circuits and with printed-circuit boards. The models PS-1501 and PS-1502 operate from ±5 to ±25 v and ±10 to ±25v supplies to provide output voltages from +45 to -70 v and output currents of ±30 milliamperes and ±50 mA, depending on model. The units are 0.650-inch square by 0.150 inch high. Both miniature power supplies operate



with high efficiency, up to 80%, the company says.

LRC Inc., 11 Hazelwood Rd., Hudson, N.H. 03051 [386]

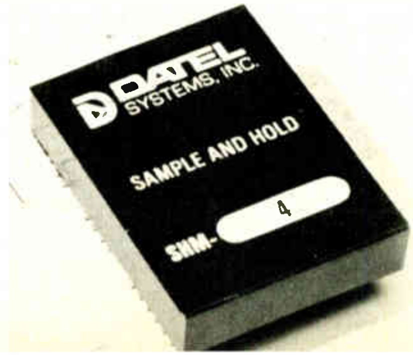
Active filter has separate low, high, bandpass outputs

Featuring separate low-pass, high-pass, and bandpass outputs, the model 1881 active filter is a thick-film hybrid module with a dual in-line lead configuration with 0.600-inch row spacing. Corner or center frequency can be adjusted by external resistors in the range of from 100 hertz to 20 kilohertz. Q is adjustable up to a maximum of 500. Input impedance is said to be high, and output impedance is 100 ohms. For additional buffering, a separate amplifier is included.

Epitek Electronics Ltd., 19 Grenfell Crescent, Ottawa, Ont., Canada [382]

Sample-and-hold amplifier has 2-ns aperture time

A sample-and-hold amplifier, called the model SHM-4 simultaneously samples several high-speed analog



inputs and freezes them for subsequent processing by, for example, an analog-to-digital converter. Aperture-time variation between units is 2 nanoseconds, and acquisition time is 6 ns to within 0.005% of full scale. Other specifications include a 20-microvolt-per-millisecond output-decay rate, allowing the outputs of several units to be sequentially processed through an analog multiplexer, and a 100-megohm input impedance. Price is $49.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021 [383]

Unregulated dc power supplies offer up to 200 W

A series of unregulated dc power supplies provides a low-cost alternative for applications where power

regulation is not necessary. Four types are available, providing power ratings from 15 up to 200 watts at a variety of voltage outputs. All models feature floating output and may be referenced to another low voltage, common ground, or placed in series with another dc source. Price ranges from $20 to $59. Quantity discounts are available.

Standard Power Inc., 1400 S. Village Way, Santa Ana, Calif. 92705 [385]

Divider has ¼% error, wide dynamic range

The model 434B modular one-quadrant Y(Z/X) divider guarantees an accuracy to within ¼% and is

Caught in the old cassette vs. ½″-drive, price vs. performance crunch?

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It's a unique approach to digital tape storage that's priced like a cassette but performs like a ½″-compatible drive.

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It uses ¼″ tape and records at up to 3200 frpi, so it stores up to 5.5 million bits of data per track on 1 to 4 tracks.

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Because the "Scotch" Data Cartridge functions as its own transport, tape handling is fast, accurate and precise at all times. It's ideal for: Word processors and terminals. Point-of-sale data capture and computer data entry. Minicomputer I/O and paper tape replacement.

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Just contact any of the major peripheral manufacturers or Data Products, 3M Company, 300 South Lewis Road, Camarillo, Calif. 93010. Telephone: (805) 482-1911. TWX: 910-336-1676.

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New products

also available in a ½% version, the 434A. Both offer a 100:1 input signal range of from 100 millivolts to 10 volts. In addition, error decreases with output level, resulting in an error performance of 1 mv ±0.15% of reading. This means that for inputs of 100 mv/10v, the theoretical output of 100 mv will be accurate to within about 1 mv or 0.01% of full scale. Unit price is $75 for the 434A and $87 for the 434B. Delivery is from stock.

Analog Devices Inc., Rte. 1 Industrial Park, Box 280, Norwood, Mass. 02062 [384]

D-a converters offer 200-mA output current

The models 7581 and 7582 are six- and eight-bit digital-to-analog converters respectively. Both models offer a 200-milliampere output capa-

bility and unipolar or bipolar operation. They are designed to drive coaxial cables, deflection coils, and other types of high-current loads. Features include a dc-to-3-megahertz word rate. Price is $151 to $206, depending on model and quantity.

Optical Electronics Inc., Box 11140, Tucson, Ariz. 85706 [387]

Solid-state system simulates test loads

A solid-state load bank is designed for simulating loads in testing electronic equipment, and can replace large resistors and rheostats, as well as larger load banks. Useful for manual or automatic on-off switching, the unit can simulate dynamic loads up to 50 kilohertz. The heart

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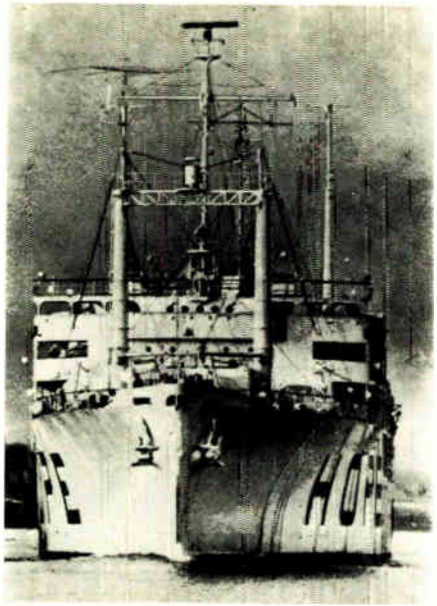
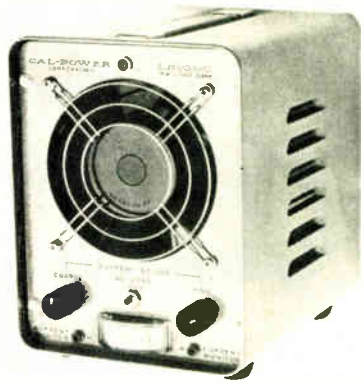


New products

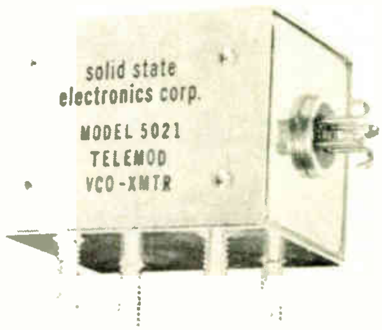


of the bank is an adjustable current regulator, which can also be used as a constant-current source in connection with an external dc voltage source. Price is $425.

Cal Power Corp., 140 Kansas St., El Segundo, Calif. 90245 [388]

Voltage-controlled oscillator, fm transmitter combined

Designated the model 5021 Telemod, a module contains a voltage-controlled oscillator and an fm transmitter in a miniature package to offer a complete fm-fm telemeter system. The Telemod can be used with the model 5004 receiver and



the model 430KF frequency meter, which is used as an fm discriminator. The output of the discriminator can be used to drive a suitable pen recorder, oscillograph or dc voltmeter. The receiver output can also be fed directly to an electronic counter or tape recorder.

Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343 [389]

Caelus disk drives

If Caelus can't match your mini-computer disk drive needs, chances are no one can. That's a strong statement, but we think you'll find the facts bear it out. Because we have a complete family of mini disk drives to offer. Front loading models and top loading models. (Even a sealed, fixed-disk model.) 24, 48, and 96 megabits storage capacity. And you can combine them to get up to 384 megabits system storage. Like any good family, they're model interchangeable, can be daisy chain intermixed, and utilize common spare parts. All accept standard media. Each is a self-contained system, with its own power supply and the largest air filtration system of any mini drives on the market.

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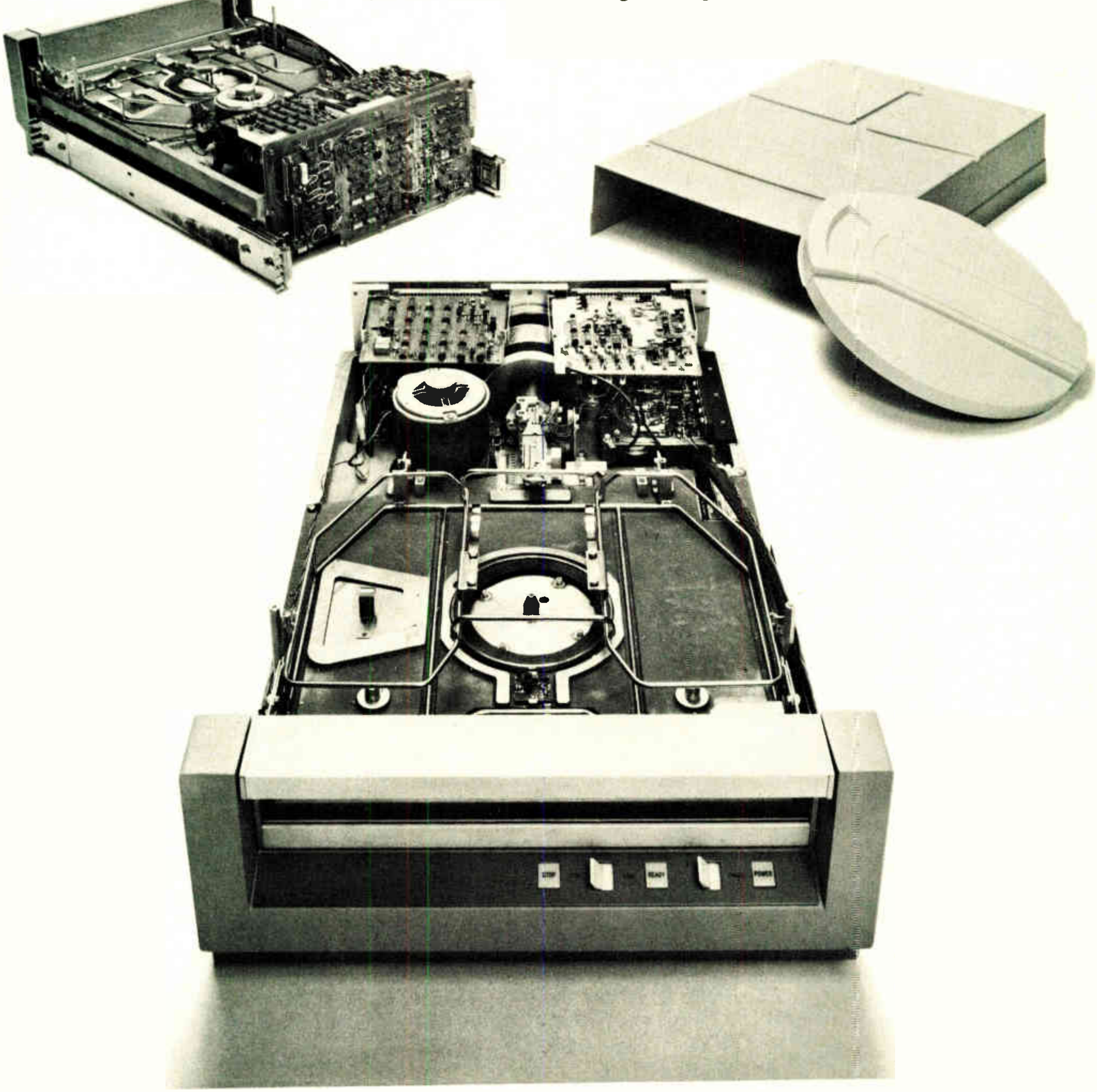
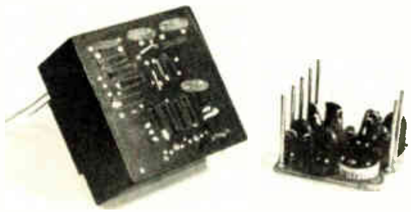


Circle 167 on reader service card

New products/materials



A low viscosity of 2,000 to 3,000 cps gives a ceramic resin good handling characteristics for potting densely packaged circuitry. Called material 305, the resin eliminates the need for preheating and evacuating the compound in many cases. Thermal conductivity is comparable to that of conventional casting resins of high viscosity, and heat-distortion temperature is 130°C. Price is about $18 per gallon.
Castall Inc., Weymouth Industrial Park, E. Weymouth, Mass. 02189 [476]

A rosin foam flux, number 5381, offers a nonconductive residue that is easily removed and is said to be harmless to electronic assemblies. The material can be used on most metallic surfaces associated with electronic soldering, if they are clean and free of excessive oxide. Although primarily designed as a foam flux, the material can also be applied by dipping, waving, roller-coating, spraying, or brushing. Delivery is from stock.
Multicore Solders, Westbury, N.Y. 10022 [477]

For use in infrared detectors, detector arrays, and infrared vidicons, single crystals of triglycine sulfate, l-alanine doped triglycine sulfate and triglycine fluorberylate are said to be of high purity. The crystals can be supplied as blanks, or as plates cut and polished to specifications. Unsupported polished windows as thin as 30 micrometers are also available.
Interactive Radiation Inc., 406 Paulding Ave., Northvale, N.J. 07647 [478]

A one-part, nonsetting silver resin system, numbered 72-00018, has the consistency of putty and can be applied with a caulking gun, syringe, spatula, or putty knife for shielding from electromagnetic interference

and sealing. The conductive system is copper- and carbon-free and operates over the range of from −80 to +400°F. Further, it is moisture-resistant and exhibits less than 1% shrinkage after application. Price for a one-pound container, is $25, and evaluation kits of 2 ounces are available for $15.

Technical Wire Products Inc., 129 Dermody St., Cranford, N.J. 07016 [479]

Resistor inks that are laser-trimmable are designated the 5500 series. Temperature coefficient of resistance is ±50 ppm/°C from −55 to +125°C for resistance values between 100 ohms and 100 kilohms. This specification is linear and relatively flat over that temperature range. The inks also exhibit a low voltage-coefficient of resistance with constant temperature. Firing temperatures from 750 to 1,000 °C cause little, if any, resistivity variation. Price is $50 per ounce.

Electro Materials Corp. of America, 605 Center Ave., Mamaroneck, N.Y. [480]

Instant release of clean pieces with good surface finish is said to be the result when using the non-silicone release agent designated the Contour 1. The quick-drying release agent is effective with polyurethane elastomers, polystyrene, rubber, epoxy, and other materials. It is specially effective for filament winding, can be used on any substrate, and does not interfere with post-finishing operations.

Contour Chemical Co., 3 Draper St., Woburn, Mass. 01801 [371]

A one-part solution for cleaning aged or tarnished solder was developed primarily to eliminate blowholes in solder-plated printed-circuit boards. Designated SnPb, the material has an unlimited shelf life, does not fume, and can be used at room temperature. It may be applied by spraying or dipping. When used to clean solder prior to reflow in infrared equipment, SnPb imparts a bright finish to the reflowed solder. It is available from stock in packages of 5, 15, and 55 gallons.

Coppertech Inc., 9th and Greenland St., Allentown, Pa. 18102 [372]

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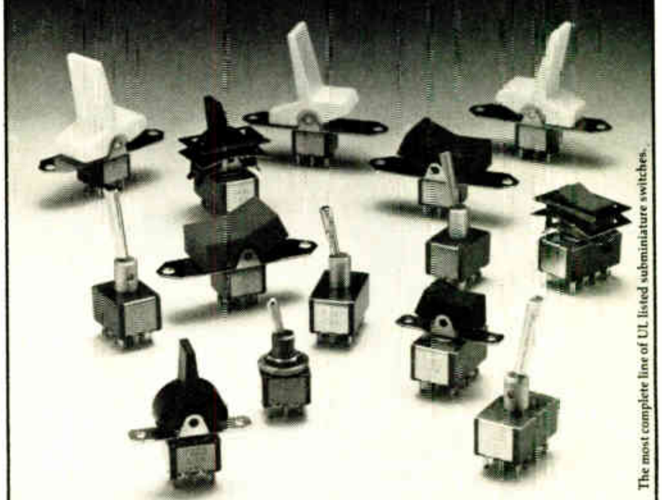

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Max. current	= (8.5 amps.)
Nom. Voltage	= (3.5 VDC)
Th	= (50°C)
Qc Max. at ΔT Zero	= (19 Watts)
Max. Op. temp.	= 100°C

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Circle 224 on reader service card

New literature

Spectrum analyzer. The 7L13 spectrum analyzer, which provides 30-MHz resolution from 0 to 1,800 megahertz, is described in a brochure from Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97005. Applications, waveforms, and characteristics are discussed. Circle 421 on reader service card.

Semiconductors. A 44-page interchangeability and cross-reference guide from General Electric Co., Semiconductor Products department, Electronics Park, Building 7, Mail Drop 49, Syracuse, N.Y. 13201, lists more than 6,000 semiconductor types. [422]

Relays. An eight-page catalog describes the line of relays, stepping switches, and accessories available from Schrack Electrical Sales Corp., 1140 Broadway, N.Y. 10001. [423]

Thick-film materials. Bala Electronics Corp., Cermet Division, 14 Fayette St., Conshohocken, Pa. 19428, is offering a thick-film materials literature package, which provides information on screen-printable thick-film cermet pastes. Processing tips and applications information is included. [424]

Delay lines. An eight-page bulletin from Bel Fuse Inc., 198 Van Vorst St., Jersey City, N.J. 07302, gives technical information on delay lines used in all kinds of electronic equipment. Included are fixed and variable delay lines housed in dual in-line packages, as well as fatpack and tapped versions. [425]

Infrared microsampling. Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn. 06902. A 14-page booklet on infrared microsampling provides several charts showing the spectra produced by using this technique. [426]

Miniature switches. A pocket-size product selection guide describes 22 miniature-switch families. The brochure, available from Alco Electronic Products Inc., 1551 Osgood St., N. Andover, Mass. 01845, gives information on configurations such

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Electronic Parts/Components

Engineers with experience in electrical and/or electronic parts test evaluation, specifications, selection and technical parts control are needed. Emphasis is on semiconductor component—transistors, hybrids, LSI arrays, diodes and microwave devices. A knowledge of military and/or NASA specifications would be helpful. Capability to interface effectively with circuit designers and device suppliers is required. The function provides support to major Boeing DOD, NASA and commercial programs. Experience in planning, estimating and implementing support to such programs would be useful.

Computer Software

Real Time operational computing systems requirements analysis and design. Includes definition of computer software requirements, developing plans and specifications, performance of trade and design studies of hardware / software systems.

Real Time operational systems computational analysis and algorithm development. Develop and evaluate numerical algorithms to satisfy specific requirements for aerospace systems.

Real Time operational systems computer program development and implementation. Development and implementation of computer programs for operational systems, simulators and other Real Time applications and for programs to assist in debugging and testing of operational software systems.

Communications

Radio and telecommunications, both narrow and wide-band transmissions.

Definition and evaluation of communications performance, interface, integration, modulation techniques, modem, multiplexers, encryption, teletype or high-quality audio distribution systems.

Computer/Displays

Real Time operational systems requirements, analysis, design and checkout. Includes definition of computer and display hardware requirements, developing plans and specifications, performance of design, and trade studies of hardware/software systems.

Design, development and integration of computer systems, subsystems and components for both general purposes and special purpose applications.

Definition of functional and physical interfaces between the computer systems and all interacting display, sensor and communication systems.

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New literature

as solder-lug, wire-wrap and printed-circuit terminals, and also discusses actuator options. [427]

Keyboards. Datanetics Corp., 18065 Euclid St., Fountain Valley, Calif. 92708. A series of product brochures covers the line of discrete key switches and keyboards for communications and data entry applications. [428]

Power supplies. Power One, 6324 Variel Blvd., Woodland Hills, Calif. 91364, has issued a four-page catalog covering the company's line of IC-regulated modular dc power supplies. [429]

Mercury relays. The Adams and Westlake Co., 1025 N. Michigan St., Elkhart, Ind. 46514. A booklet offering data and technical information on mercury relay spin-out describes the cause of this phenomenon and how to overcome it. [430]

Decoders. Palomar Engineers, P.O. Box 455, Escondido, Calif. 92025, has issued a data sheet describing the model T-2 series of plug-in decoders for Touch Tone signals. Specifications, dimensional drawings, and applications information are given. [431]

Instruments. General Resistance Inc., 500 Nuber Ave., Mt. Vernon, N.Y. 10550. Bulletin 440-3 is a 12-page catalog of the company's line of instruments, which includes voltage current sources, voltage references, voltage dividers, and universal resistance decades.[432]

Power supplies. Acopian Corp., Easton, Pa. 18042 has published catalog 73-74, which features a selection of rack-mounted dual-output unregulated, miniaturized power supplies. Plug-in and general purpose types are also included. [433]

Filter connectors. A line of electrical connectors with protection against electromagnetic interference for sensitive circuits is described in a 24-page catalog from Bendix Corp., Electrical Components division, Sidney, N.Y. 13838. Installation data in

New literature

both metric and English systems, basic filtering theory, and information on connector and contact types are included. [434]

Klystrons. A range of reflex klystrons is described in a 12-page catalog from EMI-Varian Ltd., Hayes, Middlesex, England. Included are klystrons for microwave links, pump oscillators, and plug-in and tunable millimeter applications. Performance curves are given, along with notes on operational circuits. [435]

Ceramic chip capacitors. A four-page brochure from Bell Industries, Electronic Components division, 150 W. Cypress Ave., Burbank, Calif. 91502, provides information on the models K1200 and NPO ceramic chip capacitors. [436]

Product catalog. Tek-wave Inc., 71 Old Champlain Rd., Somerville, N.J. 08876. A 48-page catalog contains technical descriptions, engineering drawings, specifications and other information on the company's full line of products. These include connectors, metalized substrates, chip attenuators, circuit frames, and resistors. [437]

Plotting systems. A six-page brochure from Time Share Peripherals, Rte. 6, Bethel, Conn. 06801, describes computer data plotting systems, plotter control and accessory devices and other time share equipment for converting digital data into graphic form. [438]

Chip capacitors. Johanson, Monolithic Dielectric division, Box 6456, Burbank, Calif. 91505. A six-page catalog describes and provides specifications for a variety of chip capacitors including hermetically sealed axial lead types and an extended range series. [439]

Attenuators. McGraw-Edison Co., Edison Electronics division, Grenier Field Municipal Airport, Manchester, N.H. 03103. A catalog covers the company's line of rotary and vertical slide attenuators, pads and attenuation networks. [440]

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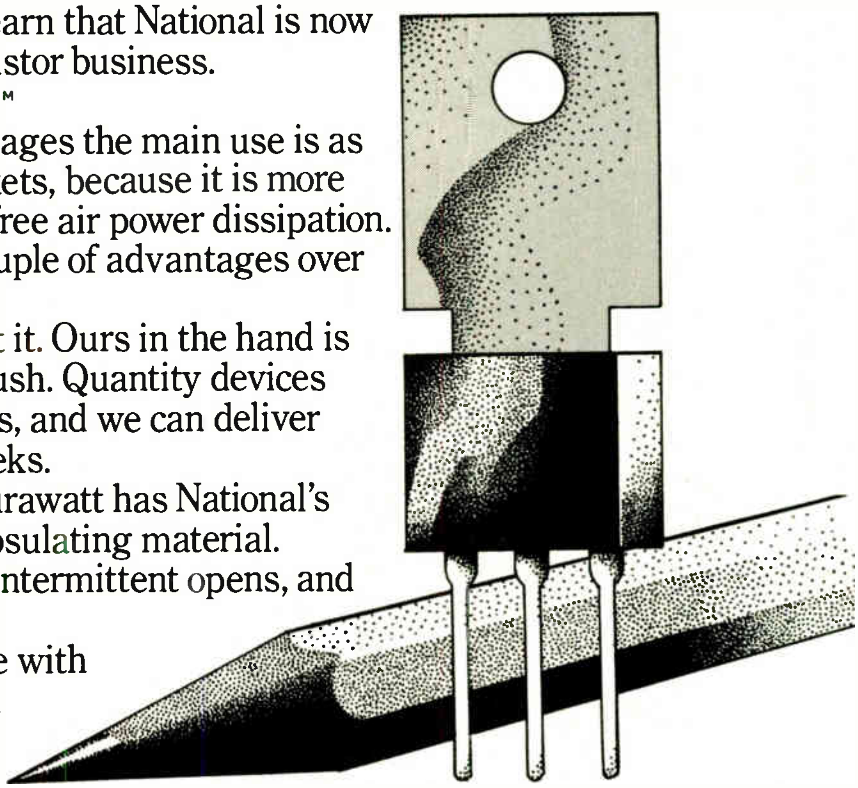

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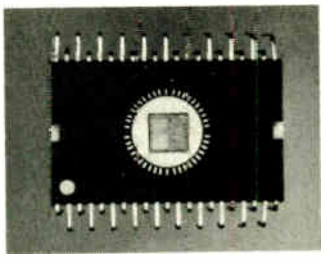

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Petroleum and You (A History of the Former)

Chapter Six: Technology on the March

In the period between the World Wars new refinery processes moved to the forefront, forcing old refinery processes to move to the aftback. Thermal cracking was developed in an attempt to obtain a greater yield of gasoline from petroleum. In this process the heavier hydrocarbon molecules found in crude oil were broken down to form the lighter molecules which go to make up gasoline. And as an unexpected boon it was found that the process also created a gasoline with superior burning characteristics, which in turn allowed an increase in the compression ratio of auto engines, thus paving the way for such modern-day breakthroughs as the fur-covered rearview mirror and styrofoam dice.

Two modern-day automotive breakthroughs.

Thermal cracking was, however, soon supplanted, thanks to the experiments of a French-born engineer named Eugene Jules Houdry. In 1935 Houdry, or Eugene Jules Houdry as he was called by his associates, discovered that the addition of a catalyst to the process—usually an oxide or silicates of aluminum and magnesium—greatly increased the rate of cracking and also produced a far superior product. But much to the shame of the industry his discovery was not implemented for more than a year because someone had misplaced his phone number.

Telephone, circa 1935.

Luckily it was later found behind a chiffionier and his work made possible the high-octane aviation fuel used in World War II.

Also in the 1930s polymerization began to loom large, and ultimately, as a result of popular outcry, it became an established practice. This process dealt with those hydrocarbon molecules in crude oil which were even lighter than the molecules making up gasoline and which had received for years the kind of mild contempt usually meted out to a snappy dresser.

Opal cufflink found along with phone number behind chiffionier of acknowledged snappy dresser.

But with polymerization these lighter molecules can be linked together, making yet another way to obtain a higher gasoline yield from petroleum. By 1942 it was an open secret that World War II had begun, and the petroleum industry met the challenge with characteristic pluck. Aside from the high octane fuels demanded by the air war, the industry supplied untold amounts of lubricants and fuel oils vital to the war effort. In addition the petroleum industry developed the primary ingredient in fire-fighting foam, plus Amprol 8, a special substance to protect machinery from dampness, corrosion, and the heartbreak of psoriasis.

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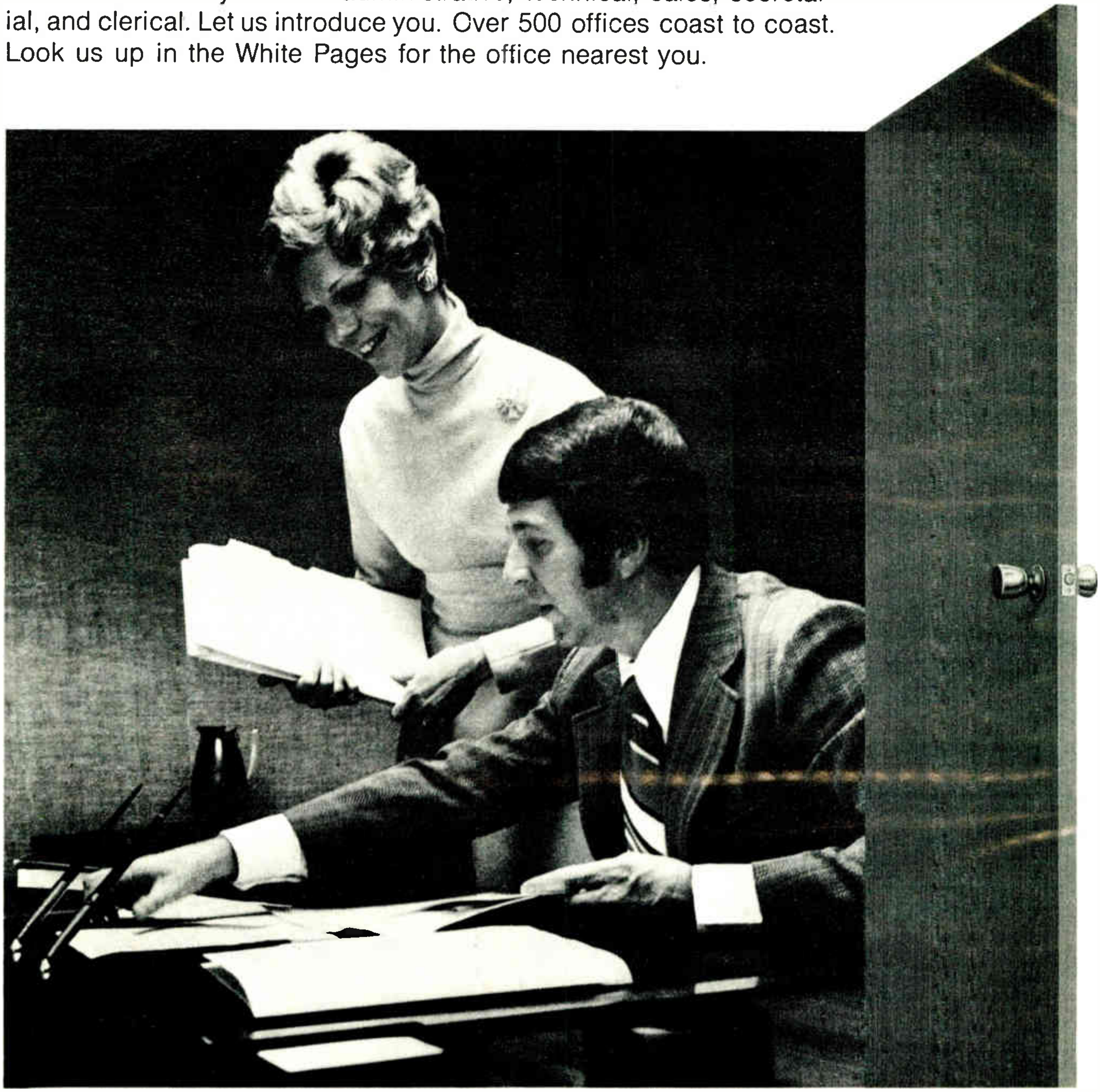

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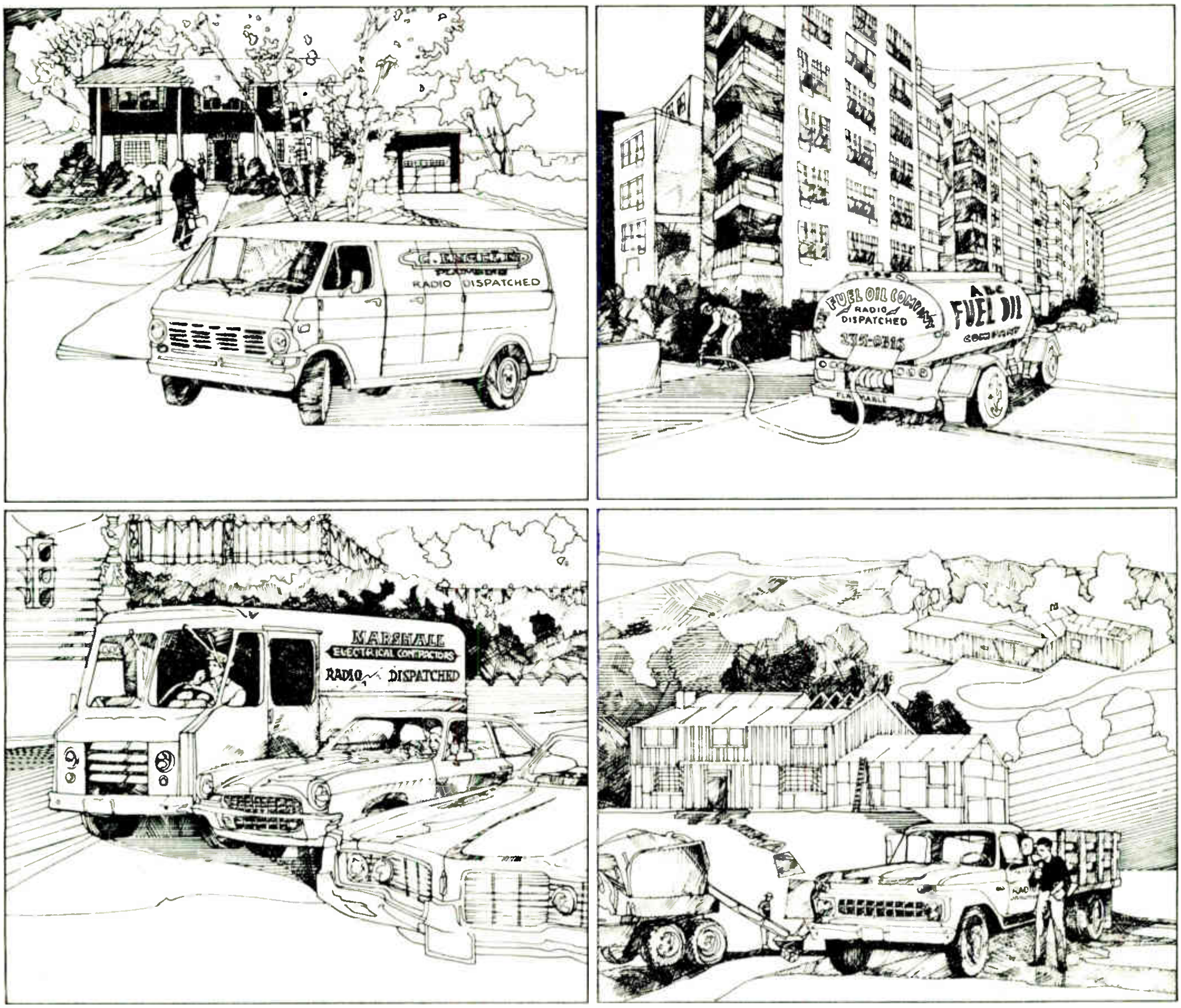

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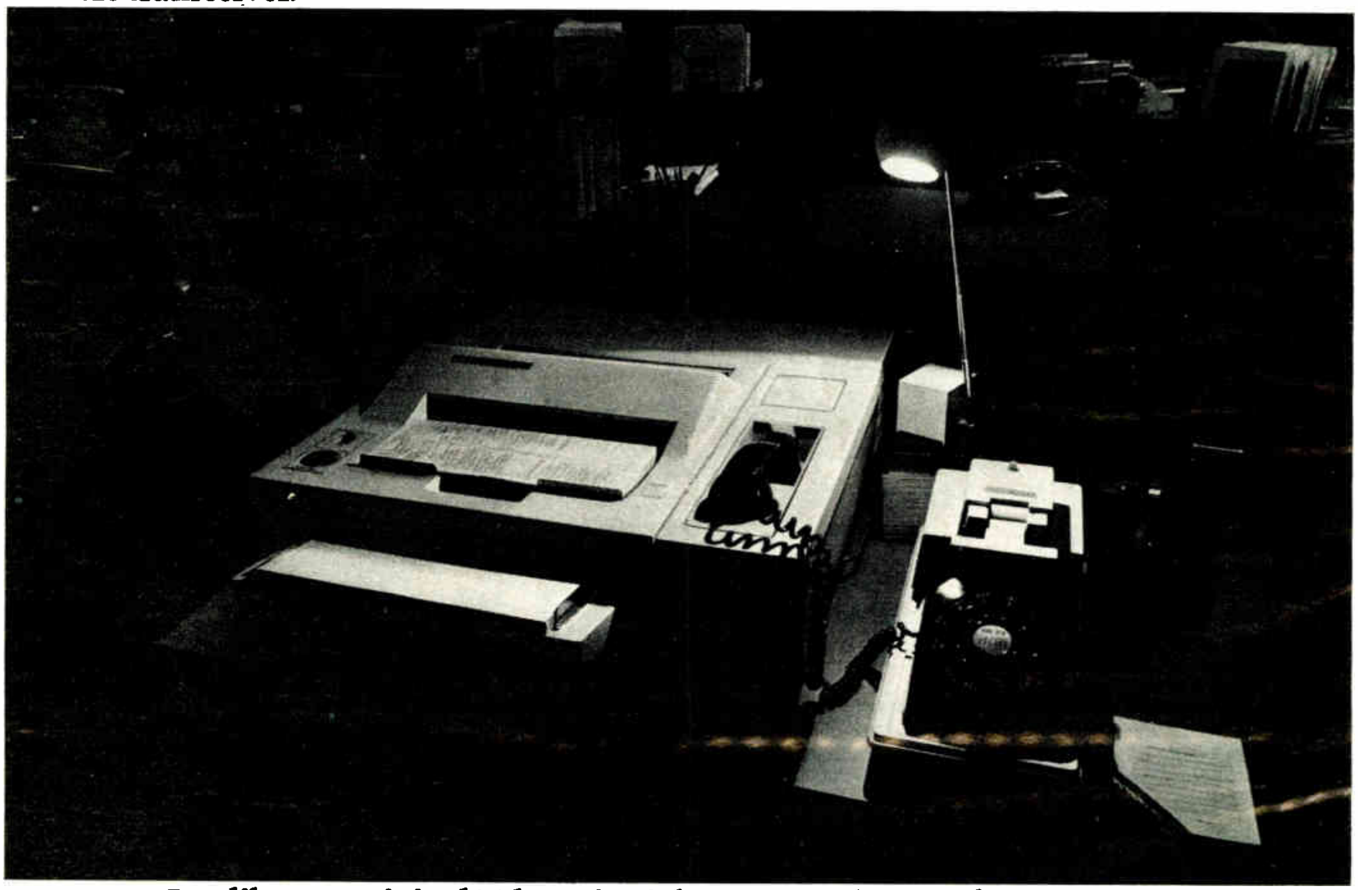

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3Q3	500 μh to 1 h	
3Q4	1 mh to 4 h	
4Q0	150 μh to 20 mh	±1%>2 mh ±2%<2 mh
4Q3	1 mh to 2 h	
4Q4	2 mh to 7.5 h	
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