NOVEMBER 11, 1976

ELECTRONICA PREVIEW: A CAUTIOUS MOOD PREVAILS/73

The case for distributed-processor systems/105

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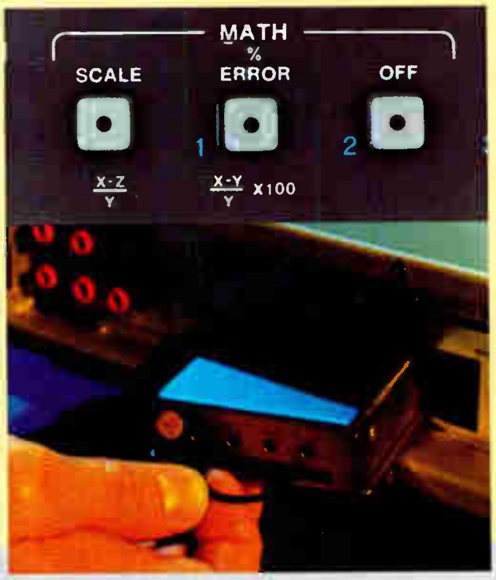

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Highlights

Cover: Solar-energy technology grows, 86
Photovoltaic power systems already answer some specialized needs, and companies worldwide are trying to boost solar-cell capabilities to rival those of conventional power sources. Part 1 of this special report examines the work on lower-cost, more efficient solar cells, while Part 2 reports on efforts to develop volume production of the cells.

Cover construction by Ann Dalton uses a solar-cell array supplied by Exxon subsidiary Solar Power Corp.

European markets recover slowly, 73
As electronics firms on the Continent prepare for the end-of-the-month Electronica show, they look back on a year that hasn't shown the expected full recovery from the 1975 slump.

Sharing the work lightens the load, 105
Adding satellite processors turns a computer-controlled system into a distributed control system that runs faster than a computer-only setup. Another plus is simpler software.

Low-cost filters can perform well, 111
By designing active-filter circuits for minimum sensitivity to component values, it's possible to use loose-tolerance resistors and capacitors and still achieve high performance.

And in the next issue . . .
A family of one-chip microcomputers unveiled . . . tips on memory-system design . . . digital trouble-shooting through current tracing.

Publisher's letter

"Distributed-system architecture goes all the way back to the Illiac 4 concept of about 10 years ago," according to David Fisher, co-author of the article on page 105. "However this concept didn't really take hold until minicomputer prices dropped in the early 1970s. Now, low-cost microprocessors have changed the whole dimension of the problem."

Fisher, an associate professor at Michigan State University's Department of Electrical Engineering and System Science, first became involved with distributed systems through work with environmental monitoring. Since then, he has consulted on many large-scale distributed systems including ones to monitor and control water pollution and to manage farming pests for his university and the state of Michigan. In his eighth year at MSU, Fisher has written a number of technical articles, including one in *Electronics* on calculator-based systems.

One of Fisher's most successful systems is a monitoring and control setup for agricultural pest management on a statewide basis. Weather information was "stripped" off 27 stations in an existing country-wide aviation weather network and stored in a minicomputer, which calculated temperature, dew point, and visibility, before passing on the data to a large central computer. Data loggers in the field collected other variables, such as soil temperatures, which were also fed into the computer. The central computer, working with a built-in management model, could then tell when to collect biological samples, spray insecticides, or plant crops. This system is now being applied to farming-crop management in Michigan.

Gary Krause, Fisher's co-author, is an engineer specializing in designing microprocessors for Motorola's Communications division in Chicago. Earlier, though, he did his thesis on Fisher's water-pollution project. Discussions of this thesis triggered the idea for their article.

Solar energy is an up and coming discipline, although there seem to be a number of obstacles that cast shadows over the quick harnessing of the sun's outpouring of energy. In this issue, you'll find a detailed report on the status of research and development into one of the most potentially useful of solar-energy collectors, the photovoltaic cell.

On page 86, the first part of the report homes in on the efforts being made to raise the efficiency and lower the cost of these solar cells, which can convert the sun's rays directly into electricity. It was written by Joel duBow, assistant professor of electrical engineering at Colorado State University, Fort Collins, Colo., where he is in charge of the school's solar-cell projects. Before moving to Colorado, incidentally, he was components editor on the New York staff of *Electronics*. The second part, by our Boston bureau manager, Larry Curran, starts on page 91 and examines the problems of turning out solar cells in large volume.

October 28, 1976 Volume 49, Number 23
95,472 copies of this issue printed

Published every other Thursday by McGraw-Hill, Inc. Founder: James H. McGraw 1860-1948. Publication office 1221 Avenue of the Americas, N.Y., N.Y. 10020; second class postage paid at New York, N.Y. and additional mailing offices.

Executive, editorial, circulation and advertising addresses: Electronics, McGraw-Hill Building, 1221 Avenue of the Americas, New York, N.Y. 10020. Telephone (212) 997-1221. Teletype 12-7960 TWX 710-581-4879. Cable address: M C G R A W H I L L N E W Y O R K.

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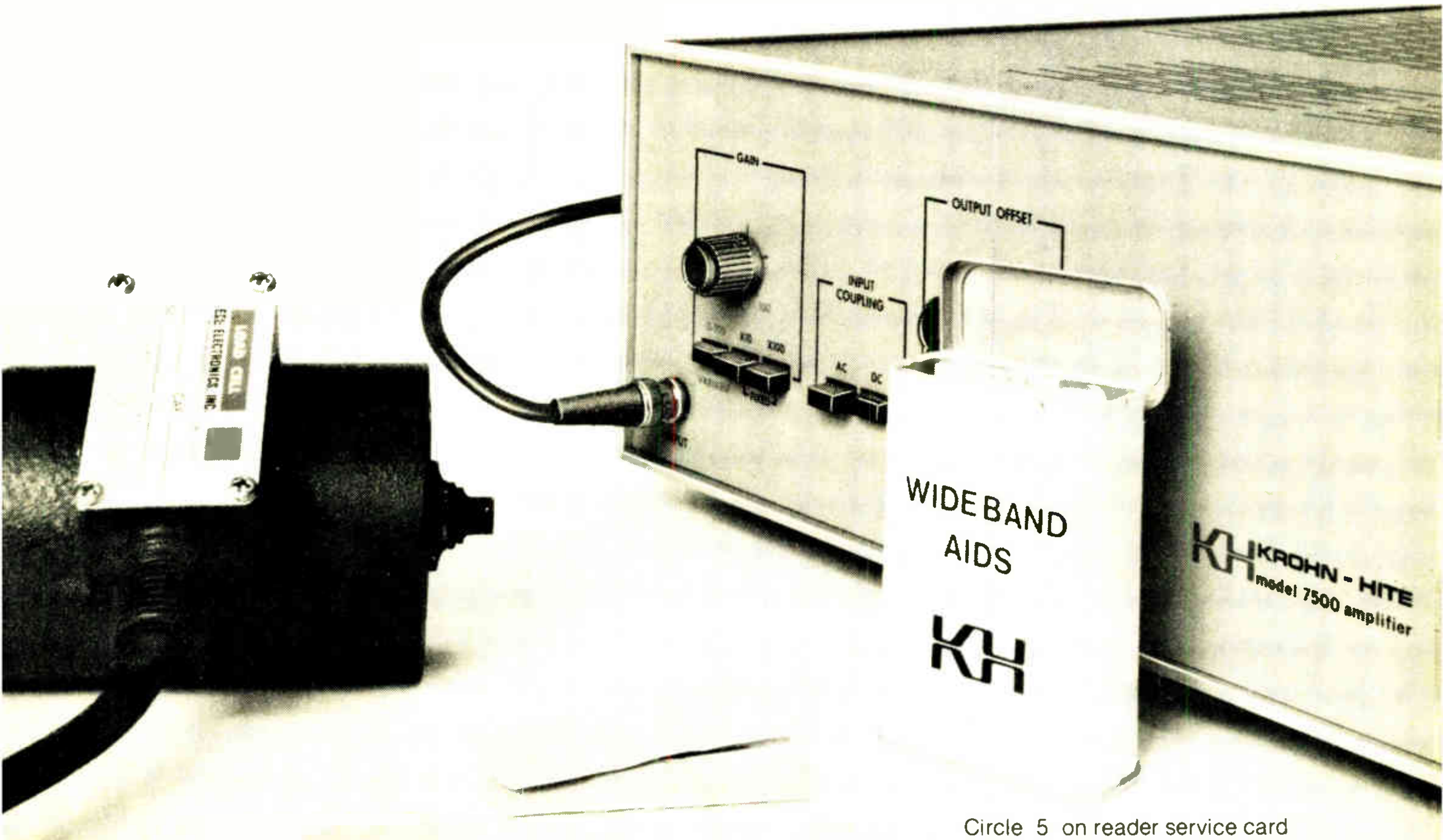

Circle 5 on reader service card

Readers' comments

Force funds aren't transferable

To the Editor: I am writing in hopes of correcting a misunderstanding that is implicit in your editorial, "Computer security: a case of priorities" [Sept. 30, p. 10].

I do see the obvious implication of the juxtaposed facts, but, as usual, the matter is more complex than is stated. Each year, Congress funds the Department of Defense within an overall ceiling, but DOD is not free to use these funds as it wishes.

The money is directed into various categories, called major force programs, and may not be transferred between the programs. One such category contains tactical jet fighters, such as the F-15. Security research falls into a separate program.

The Congress and the people they represent have an enormously difficult job in sorting out a balanced military program from increasingly scarce resources; therefore, it is easy to find any number of apparent incongruences within any given program.

Please consider that we, both the military and the Congress, are simply trying our best to cover the needs with available wherewithal. After all, the number of F-15s is also drastically reduced from the number required for the envisioned threat.

Robert J. Kunkle
Capt. USAF
Bedford, Mass.

Surveys no help to engineers

To the Editor: The Oct. 14 issue of *Electronics* reported that the Engineering Manpower Commission had overwhelmingly decided not to modify its policies of issuing its inaccurate supply and demand forecasts p. 36].

These "forecasts," which are distributed to high school and college guidance personnel, are used to seduce gullible students into the engineering profession. Thus, EMC serves its academic and corporate masters, rather than the working engineer.

Irwin Feerst
Massapequa Park, N.Y.

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SSD12-15	12	9.5	13.0	15.0	13.5	11.2	7.5	295
SSD15-12	15	13.0	17.0	12.0	10.8	9.0	6.0	295
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News update

■ The first major telecommunications product from National Semiconductor Corp. is winning a good reception. The device is an active-filter receiver system for a push-button telephone [*Electronics*, Oct. 30, 1975, p. 26]. So far, says Mike Hamper, telecommunications marketing manager, National has received 5,000 orders. Encouraged by its success, National plans to offer several other telecommunications products. This month, the Santa Clara, Calif., firm will start selling sample quantities of a dial-pulse generator for less than $20 each.

The unit will enable phone manufacturers to offer pushbutton dialing on a dial-pulse line. Then, by Dec. 1, National will introduce an under-$10 tone-generator chip that puts out a signal when a phone is dialed.

The earliest product, the receiver system for the push-button phone, consists of two printed-circuit boards containing thick-film hybrid integrated circuits for eight-tone filters, a band-splitting filter, a dial-tone rejection filter, decode circuitry, and digital outputs.

■ When Tektronix Inc. told the world about its 4051 graphic computing system [*Electronics*, Oct. 30, 1975, p. 120], a 65-pound model that could be programed easily in Basic, industry sages said that Tek was headed for a market battle with IBM's 5100, a portable computer that was unveiled about six weeks before the 4051. But, says Tektronix, the opposite has been the case. IBM's endorsement of a personal computer easily programable in Basic has actually benefited Tek's 4051. In fact, say officials at the Beaverton, Ore., headquarters of Tektronix, they have had to revise sales forecasts for the 4051 three times in the past 10 months because sales increased so sharply.

The heart of the Tektronix terminal is an M-6800 n-channel microprocessor from Motorola's Semiconductor division, and up to 32-k bytes of random-access memory can be accessed by the central processing unit (though 8-k bytes is standard). □

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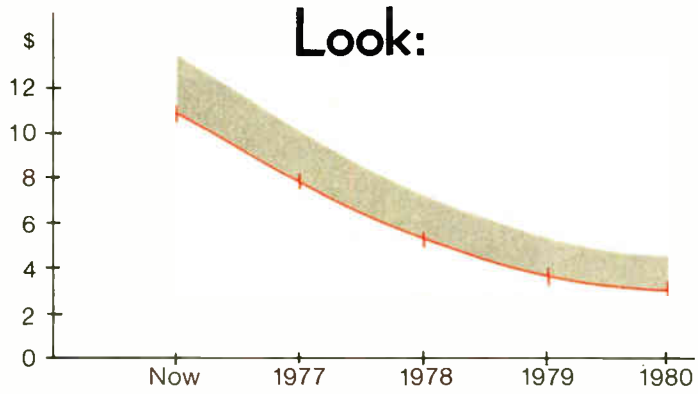

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INPUT & OUTPUT LEVELS	Fully TTL Compatible (400 mV —Noise immunity)
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TEMPERATURE RANGE Military	− 55°C to + 125°C
100% MIL-STD-883 PROCESSING	YES

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Solar energy: the pace quickens

It is heartening to see that the pace of solar-cell research is picking up. After all, photovoltaic cells offer the prospect of direct conversion of the sun's radiation into electricity.

The Energy Research and Development Administration has given a sizeable boost to the funds allocated to solar cells, although other energy programs still receive the lion's share of its R&D dollars. But even with a higher level of funding, which is necessary for the rapid development of solar-cell technology, ERDA must exercise caution in how it allocates its funds.

One of Erda's goals, certainly, should be to stimulate competition in an infant industry so that the price of photovoltaic energy can be cut by a factor of as much as 50 to make it competitive with fossil fuels. However, it must find ways to utilize the experience, knowledge, and expertise of the small group of companies that early on invested their risk capital in solar energy. This is just as important now as it ever was, even though they are finally being joined by bigger firms.

The agency's chief tool is its procurement power—it can buy both finished cells and R&D studies. ERDA is purchasing photovoltaic cells for terrestial applications from the pioneering solar-cell makers, the companies that years ago identified this small but profitable commercial market. They refined their materials-processing technology, built production lines, and were selling photovoltaic arrays in the open market even before ERDA was established. And they were logically the first suppliers that ERDA tapped, when it made two purchases of 176 kilowatts worth of solar cells for testing and eventual use at several Government installations, because they were among the handful of companies that could deliver them.

Now the agency is implementing an ambitious program that calls for technology advancements in tasks ranging from more automated manufacturing processes for silicon and other materials to more efficient ways to slice the ingots that are now produced. Some of the study contracts for assessments of manufacturing processes went to major semiconductor manufacturers, including Motorola, RCA, and Texas Instruments.

The entry of such companies is certainly welcome because of their long experience in processing silicon and other materials used for photovoltaic cells, such as gallium arsenide. They should be able to contribute to ERDA's long-term goals of making solar cells less expensive and expanding the industry.

Yet, ERDA should realize that there is the feeling among some of the pioneers that their own considerable technology is being overlooked. They feel they can do more than just produce cells; they can point the way to more efficient production themselves. One official at a solar-cell company puts it this way: "The solar-energy companies have a lot of technology that should be used more fully. We were disappointed that a solar-energy company didn't get some of that money to assess manufacturing processes." Another says flatly that "it's rankling to see people paid Government money to write reports about things we already know." No wonder some of them are worried that ERDA is funding the latecomers, who could nudge the early birds aside after getting up to speed with ERDA money and very little risk of their own.

It's clear, then, that ERDA should have yet another goal. It should do everything possible to take advantage of the technology that has already been developed and of the expertise that has already been gained.

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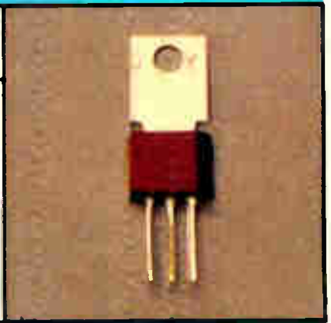
GE TYPE	P_T T_C = 25°C Max. (W)	V_{CEO} Min. (V)	h_{FE} @5V, 200 mA MIN.	h_{FE} @5V, 200 mA MAX.
D40C1	6.25	30	10,000	60,000
D40C2	6.25	30	40,000	–
D40C3	6.25	30	90,000	–
D40C4	6.25	40	10,000	60,000
D40C5	6.25	40	40,000	–
D40C7	6.25	50	10,000	60,000
D40C8	6.25	50	40,000	–

COMMENTS

- Very High Gain – 60k typical; High input impedance – 50k ohm typ; 1.2 watts P_T @ 25°C ambient.
- Applications: IC Interface audio output, touch switch, oscillator, buffer, high power transistor driver, relay replacement.

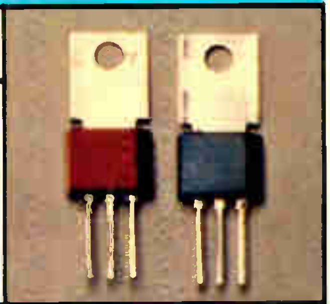


COMPLEMENTARY — 2 AMPERES

GE TYPE NPN	GE TYPE PNP	P_T T_C = 25°C Max. (W)	V_{CEO} Min. (V)	h_{FE} @5V, 200 mA MIN.
D40K1	–	10	30	10,000
–	D41K1	10	–30	10,000
D40K2	–	10	50	10,000
–	D41K2	10	–50	10,000
–	D41K3	10	–30	10,000
–	D41K4	10	–50	10,000

COMMENTS

Typical Applications:
- IC Interface
- Driver
- Regulator
- Touch Switch
- Lamp Driver
- Audio Output
- Relay Substitute
- Servo-Amplifier
- TO-202 Package

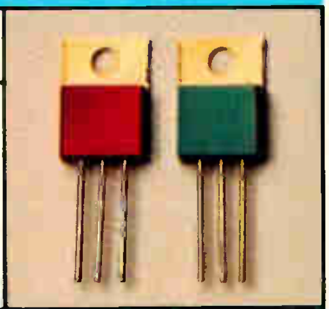


COMPLEMENTARY — 10 AMPERES

GE TYPE NPN	GE TYPE PNP	P_T T_C = 25°C Max. (W)	V_{CEO} Min. (V)	h_{FE} @5V, 5 Amps MIN.
D44E1	–	50	40	1000
–	D45E1	50	–40	1000
D44E2	–	50	60	1000
–	D45E2	50	–60	1000
D44E3	–	50	80	1000
–	D45E3	50	–80	1000

COMMENTS

Typical Applications:
- IC Interface
- Relay and Solenoid Driver
- Regulator
- Inverter Power Supply Switch
- Audio Output
- Relay Substitute
- Oscillator
- Servo-Amplifier
- TO-220AB Package



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GENERAL ELECTRIC

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People

Norden's Ergott confers military rank on PDP-11

"Do we need another company in the computer business?" asks Harold L. Ergott, the vice president for computer products at United Technologies Corp.'s Norden division in Norwalk, Conn. Not unexpectedly, his answer is yes, "because no one except us offers the military data-processing systems with software that's available in the commercial market. And we'll have a full set of militarized peripherals to go along with it too." Ergott is directing Norden's thrust into the military computer market.

The 45-year-old former manager of avionics and command control programs at IBM Corp.'s Federal Systems division, like an expectant father, is awaiting the birth later this month of his first product—a militarized, medium-performance version of Digital Equipment Corp.'s PDP-11 minicomputer.

This product is coming nine months after DEC licensed Norden to militarize, manufacture, and market its PDP-11 family. "By and large, computer companies have been serving the Federal Government's needs with boxes—that is, processor and memory systems," asserts Ergott.

Software costs. It's expensive for the military to develop and maintain the software, he points out, and he hopes to see Norden make its mark largely by eliminating that expense. "In time, we'll be offering all of the performance features and software that's available with the PDP-11 family," he says. That will be for the full PDP-11 range—even down to a militarized version of the LSI-11 single-board microcomputer.

The payoff for Norden could be handsome indeed. The Army and Navy have agreed to base their new family of software-compatible military computers for the 1980s with PDP-11 architecture [*Electronics*, Oct. 14, p. 77].

Three PDP-11 systems are under development now, and Norden, heretofore a builder of special-purpose computers for its traditional radar

Computer plus. The military will get more than just boxes from Harold Ergott.

and display-systems businesses, will start a fourth after the first model completes qualification tests around mid-1977. The company is relying on a one-for-one translation from commercial to military design. Components and interconnections are being changed to meet military specifications, says Ergott. But basic features won't be.

Identical. "We'll have more than compatibility with the commercial machines," says Ergott. "We'll have identicality." The Norden machines will not just be able to run on the PDP-11 software. Rather, "we'll be bit-for-bit, and function-for-function identical," he says.

And he continues, "It's gratifying to see people in the military so high on the PDP-11 software. The fantastic software base of the PDP-11 will indeed be a tremendous asset."

Field service, says Presta, needs decision-making

"The main difference between a laboratory and a field-service instrument is that the laboratory variety makes measurements, while field-service units must make decisions." The speaker is Eugene A. Presta, president of year-old Presta Digital Corp., North Bellmore, N.Y. He formed his company to develop instruments specifically suited to field service.

Several weeks ago, he introduced his first product—a logic probe that can also measure time intervals [*Electronics*, Sept. 30, p. 108]. Such

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a probe is probably the simplest type of decision-making instrument — the one or zero is equivalent to a yes or no. But Presta has his eye on other decision makers as well.

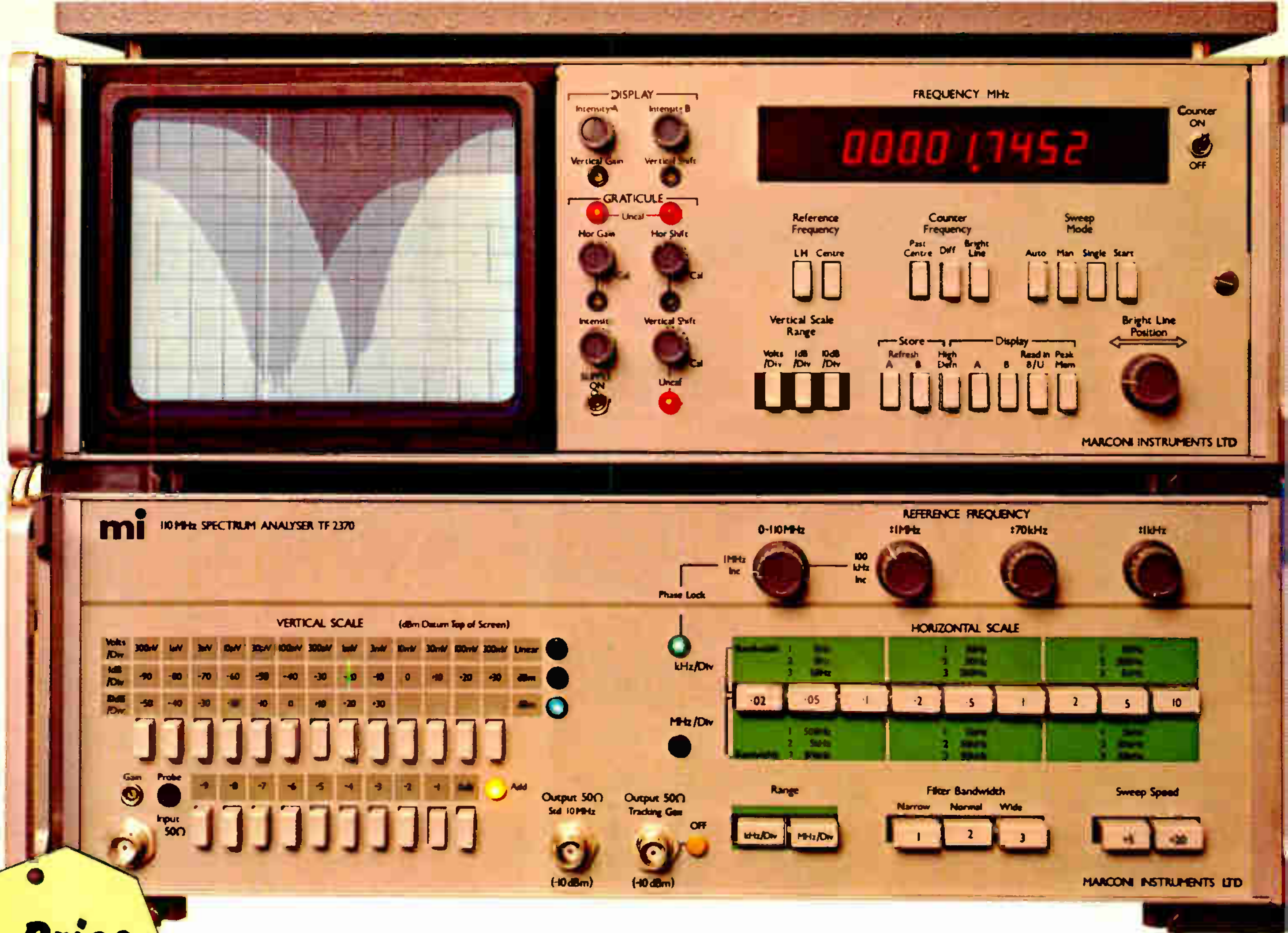
Very few. According to Presta's definition, only a very few true field-service instruments exist today. Lacking them, most companies wind up swapping boards instead of replacing bad components. The cost of this practice, he points out, is enormous. He estimates that the typical float of digital logic boards between customers and the repair shop is about 20% of a manufacturer's production. And at an average price of $500 per loaded, tested board, that float requires a lot of money to be tied up because of inefficient test instrumentation.

Having been a designer of electronic control systems for 15 years, the Brooklyn-born, 40-year-old Presta is well qualified to know the needs of field-service organizations. For about two years before founding his company, he worked for the Electronics division of Kurz-Kasch Inc., Dayton, whose main product was logic probes, one of the few instruments that meets his definition of a true field-service instrument.

In aiming exclusively at the field-service application, Presta believes he avoids head-on competition with the giants of electronic instrumentation. He hopes to sell mainly to training departments and service departments, rather than to engineering groups. His main business and selling strategy is to "attack the float." He points out, "No one wants to swap a $1,500 board for the sake of a 20-cent chip."

Wait and see. As for the future, he is waiting for customer feedback on his first product before making his next move.

Meantime, he has not only built his probe with lots of optional plugs-ins — for the timer function and for different time bases, as well as for the different logic families field-service technicians may have to deal with — but expects to develop new plug-ins as well. "Tektronix," he observes with a smile, "had a good idea there."



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Meetings

Electronica 76—7th International Trade Fair for Components and Production Facilities, Munich Fair Authority, Munich, West Germany, Nov. 25 – Dec. 1.

Eighth Annual Precise Time and Time Interval Applications and Planning Meeting, Naval Electronic Systems Command, NASA Goddard Space Flight Center *et al.*, Naval Research Laboratory, Washington, D. C., Nov. 30 – Dec. 2.

Forum on Computer Technology, American Society of Mechanical Engineers, Statler Hilton Hotel, New York, Dec. 5 – 10.

Chicago Fall Conference on Consumer Electronics, IEEE, Ramada Inn-O'Hare, Des Plaines, Ill., Dec. 6 – 7.

1976 International Electron Devices Meeting, IEEE, Washington Hilton Hotel, Washington, D. C., Dec. 6 – 8.

Bicentennial Winter Simulation Conference, IEEE, NBS., *et al.*, National Bureau of Standards, Gaithersburg, Md., Dec. 6 – 8.

1976 National Plastics Exposition and Conference, Society of the Plastics Industry, Inc. (New York), McCormick Place, Chicago, Dec. 6 – 10.

Distributed Data Processing Conference, American Institute of Industrial Engineers (Santa Monica, Calif.), Ramada Inn-O'Hare, Des Plaines, Ill., Dec. 7 – 10.

Solar Cooling and Heating: A National Forum, Energy Research and Development Administration, Fontainebleau Hotel, Miami Beach, Fla., Dec. 13 – 15.

1977 Winter Consumer Electronics Show, EIA, Conrad Hilton Hotel, Chicago, Jan. 13 – 16, 1977.

Reliability and Maintainability Conference, IEEE, Marriott Hotel, Philadelphia, Jan. 18 – 20, 1977.

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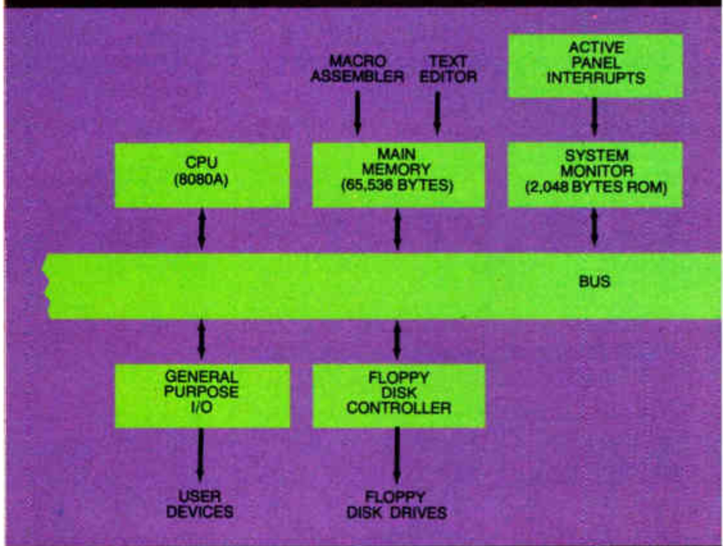

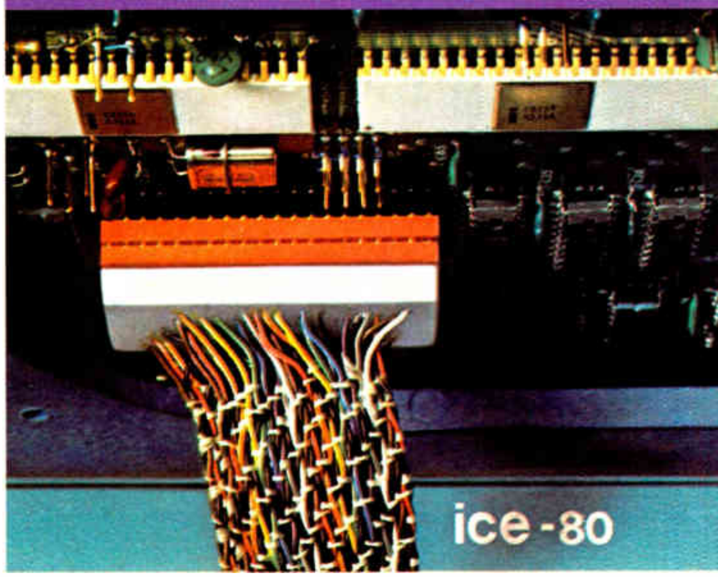

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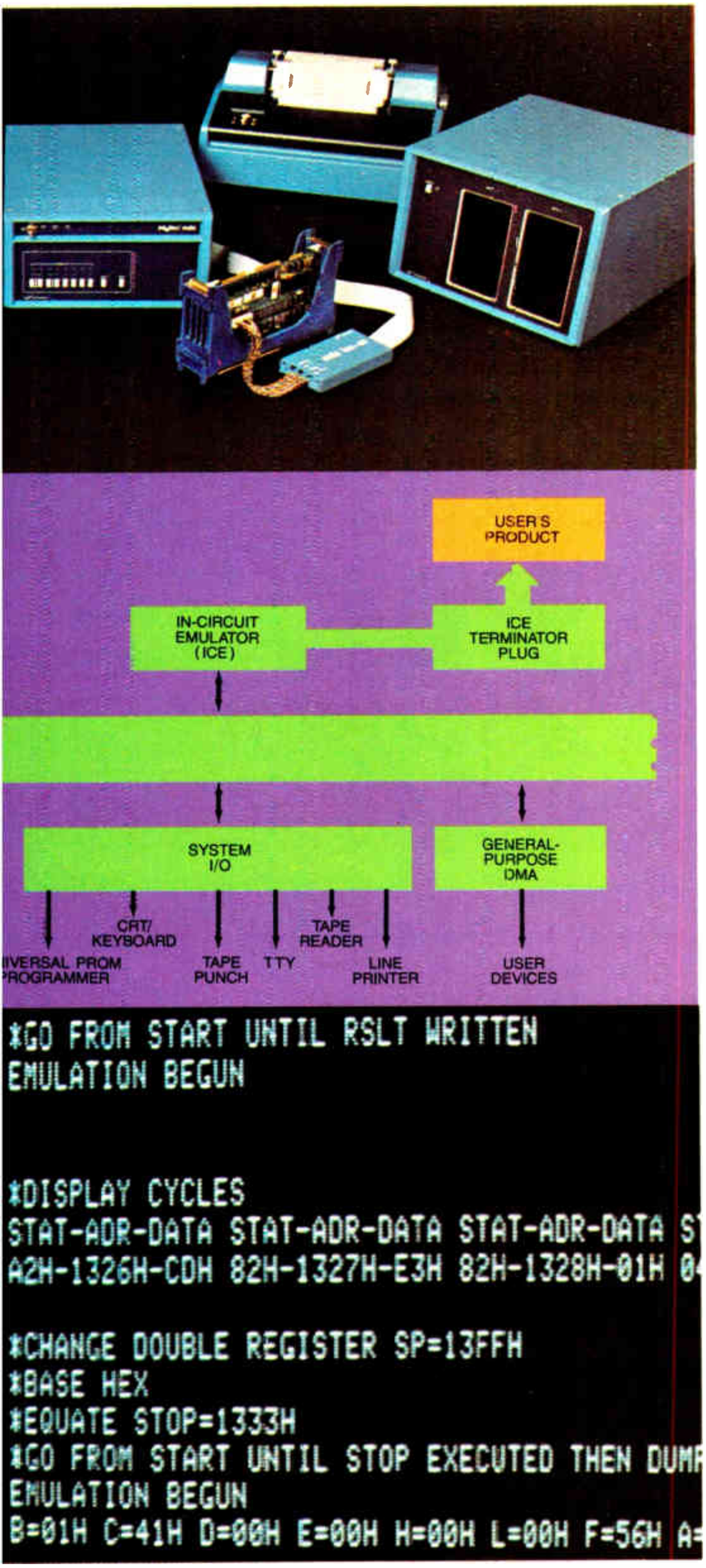

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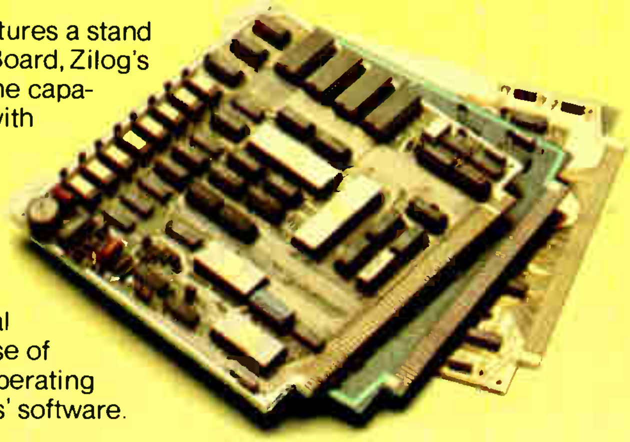

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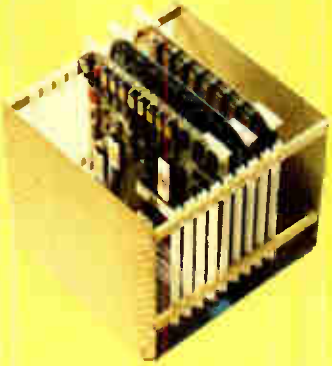
- 4K bytes dynamic RAM.
- Capacity for 4K bytes on non-volatile memory.
- Programmable serial I/O port with RS-232 or current loop interface.
- Universal parallel I/O with two independent 8 bit ports.
- Z80-CTC for programmable baud rate generation or other user functions such as real time clock.
- Bus drivers are provided for memory and I/O expansion to other boards.
- One-half K-byte monitor software has terminal handler, load and punch routines as well as set and display memory commands. A GoTo command begins execution of user programs. The 1K-byte version adds more debug aids such as set and display registers and breakpoints. The 2K and 4K-byte versions include a floppy disk controller and even more debug capability.

A second board gives you the advantage.

A second board gives you a 4-drive floppy disk controller and additional RAM backed up by a full disk operating system. Plus, you get the applications software you need: file, edit, assemble, debug, and high level languages such as BASIC, and more will be announced soon. This second board contains 12K of dynamic memory and additional 8 bit programmable parallel I/O ports.



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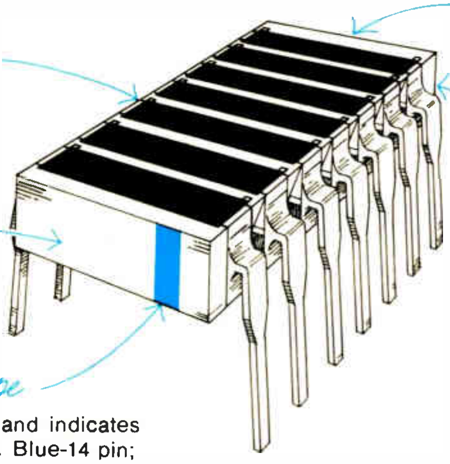

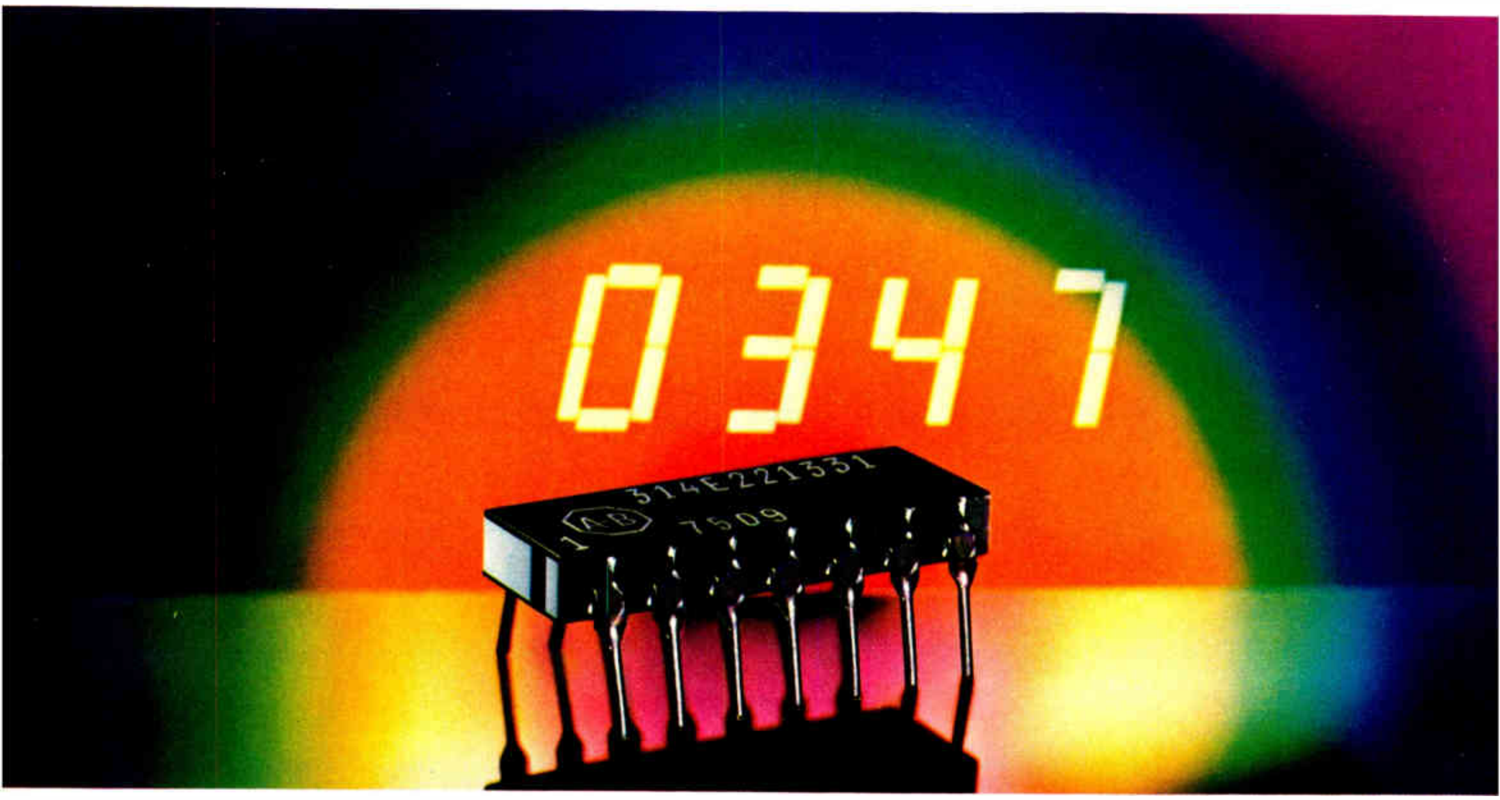

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TI, Motorola join Intel in battle for 2708 market

Intel is about to face formidable competition in a $30 million market that it practically owns: the 8,192-bit ultraviolet-erasable programable ROM. **The Intel device is one of the hottest items in the industry** because it is a key prototyping element in microcomputer systems, as well as a program ROM on a single-chip controller.

The competition will be coming from Texas Instruments, Motorola, and Advanced Micro Devices, which will introduce this part in the first quarter. Among others working on the difficult Famos process needed to build the device are National Semiconductor, Mostek, Electronic Arrays, Signetics, and American Microsystems Inc.

National prepares fast 18-pin 4-k memories

While the rest of the industry is adopting Mostek Corp.'s 16-pin 4027 for the market in high-speed (better than 200 nanoseconds) 4,096-bit dynamic memories (see p. 30), National Semiconductor Corp. is staying with fast versions of its 18- and 22-pin devices. Scheduled for the second quarter are parts that will have access times **in the 100-to-125-ns range,** with cycle times of only 220 ns, according to Jeff Kalb, National's director of memory development. Kalb sees the market growing for high-speed 4-k devices as the 16,384-bit memories begin to appear in volume for the slower applications. He says that this high-speed process is potentially capable of 80-ns operation as well as considerable reduction in die size.

Visually activated switch tested by Air Force

The Air Force Systems Command's Aerospace Medical division is testing a visually activated switch system as a way of simplifying control-system switching for fighter pilots in single-seat aircraft such as the F-16. Developed for Wright-Patterson Air Force Base by United Technologies Corp.'s Norden division in Norwalk, Conn., the system permits the pilot to activate cockpit panel switches **by directing a head-mounted infrared-light source onto cockpit-mounted switch sensors.**

Capacitor push mapped by TI

Watch for Texas Instruments to get into the capacitor business with a line of axial-lead devices, aimed at high-volume sales and rated at 10 to 1,000 picofarads with tolerances ranging from 1% to 20%. The Dallas firm has been quietly shipping the nitride-passivated MOS chip capacitors for four months, but it's now putting them in its standard diode package, a hermetically sealed glass cylinder with copper-clad iron leads **that lends itself to automatic insertion.** Nickel-iron plugs at the ends of the leads make a pressure contact with both sides of the capacitor chip.

TI is using three chip sizes, from 14 to 45 mils on a side, to cover the capacitance range. Prices will be from 5 cents to 15 cents each in production lots of devices with 5% tolerances.

Motorola to market add-on memory

Departing from a tradition of avoiding systems business competition with its customers, Motorola Semiconductor Products Group plans to compete in the memory-systems market. The first product, a 32-kilobyte RAM board made up of Motorola's 6605A-2 4-k RAMs, plus peripherals and connectors, **is a direct plug-in add-on to Digital Equipment Corp.'s PDP-11** intended to extend the system to 48 kilobytes. The board costs $1,200 in quantities of five to 24. Although Motorola plans other memory systems for the microcomputer and minicomputer market, it has no immediate plans to compete head on with Intel, National, and Advanced Memory Systems in the main IBM add-on market.

M7 loses $223,000 contracts for solar arrays

The Jet Propulsion Laboratory has terminated two solar-panel contracts worth $223,000 awarded to M7 International Inc. in its program to develop low-cost silicon solar arrays (see p. 91). JPL sources in Pasadena, Calif., calling the move "obviously a touchy and sensitive issue," confirm that the contract was terminated, although yield problems appeared to be on the way to solution. **Enough uncertainty remained** that project officials judged it "risky and expensive to proceed."

M7 admits to early yield problems on its $84,000 contract for 3-kilowatt arrays, awarded in January, "but I thought they had been solved," says Ronald W. Ignatius, president of the Arlington Heights, Ill., firm. "We were told that the cost-plus-fixed-fee R&D contract would be terminated because it would raise the per-watt cost above JPL's program goals." The firm's second award—$139,000 for 5-kW arrays—was also terminated " 'for the convenience of the laboratory' and before we were allowed to perform on it," he says.

Thick-film hybrids used in Army's Stinger missile

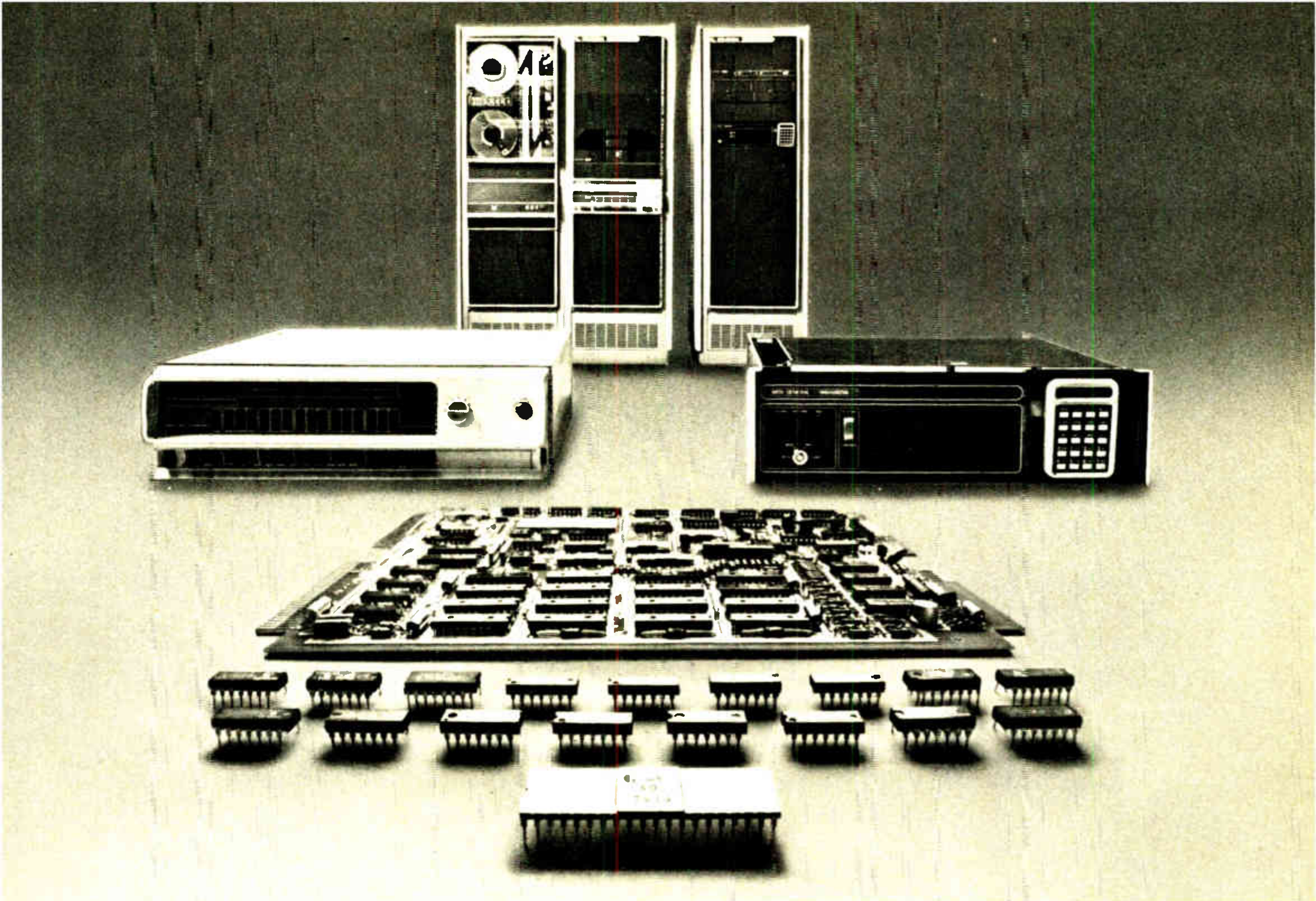
The Army's Picatinny Arsenal in Dover, N.J., is making extensive use of thick-film hybrid technology in developing the warhead for the Stinger, a new portable, forward-area air-defense missile. Now in its final development stages, the missile features a new propulsion system, a new guidance system with infrared counter-countermeasures, a new fuze, and an identification-friend-or-foe interrogator.

TI readies new bipolar LSI logic

After two years of intense development, Texas Instruments Inc. is about to spring afresh into the digital market with a new bipolar large-scale integrated family—a market it now dominates with its small-scale and medium-scale integrated 54/74 series. This new family of microcomputer components has at its heart **two versions of a 4-bit microcomputer slice.** They are the SN54/74S481, which has a microinstruction cycle time of 100 nanoseconds for the maximum program throughput, including implementation of macroinstructions, and an upgraded SBP 0400 4-bit integrated-injection-logic slice that has a wide range of speed/power tradeoff and full military-temperature performance. Both 4-bit slices are in prototype production. Other Schottky members of the family, including program memory, control elements, and microcontrol memories, either are in production or soon will be.

Addenda

Superior Electric Co. of Bristol, Conn., is dropping its line of numerical-control equipment for the machine-tool industry. NC accounted for 21% of Superior's $25 million in sales for 1975, **and 16% so far this year.** The company says it's dropping the line because of competitive price pressure and a changing market. . . . The Air Force Electronic Systems division has requested proposals for the design-verification portion of its Joint Surveillance System. Two parallel 15-month contracts will be awarded next summer. The system will link radars operated by the Air Force, the FAA, and Canada to assure air sovereignty of the two nations. **The entire program is expected to cost $250 million.**



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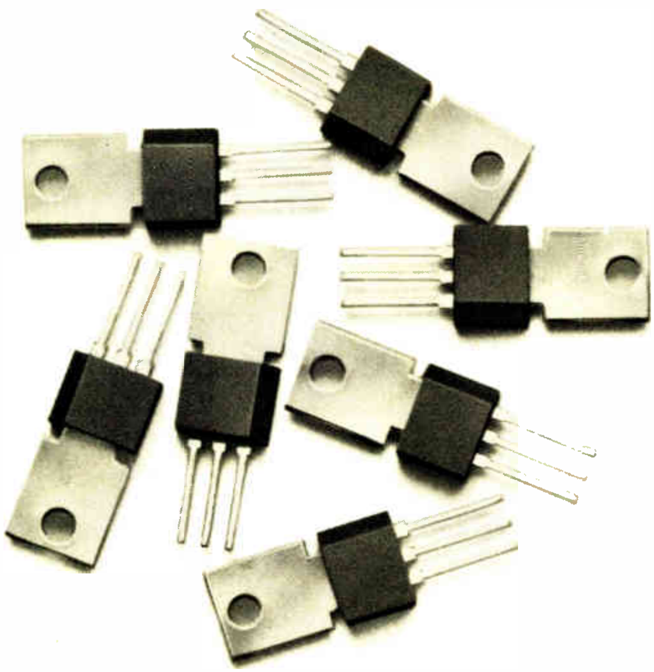

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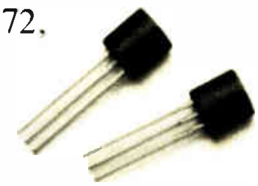


UNITRODE

Hand-held terminal to give field troops access to data nets

Litton unit transmits, over military voice links, data keyed in via see-through overlay on LED display

Clear view. Message keyed into interactive display terminal via transparent switch over light-emitting diodes (left) is reviewed for accuracy before being transmitted.

Headed for military evaluation is a hand-held data terminal that will give forward outposts "punch-up" access to command-network computers. While the 4-pound terminal from Litton Industries Inc. represents an innovation for the soldier in the field, it also uses innovative electronics.

It does its work, for example, without a conventional keyboard. Instead, it relies on a transparent switch plate that overlays a light-emitting-diode display. And the display, a good-sized area of 3 by $4\frac{1}{2}$ inches, allows the operator to compose messages simply by touching displayed letters and numbers through the transparent plate. Programed function "keys" can also be called up through the display, their titles touched in a "menu" list. And, the diodes will display graphics such as maps, as well as information transmitted to the terminal from command centers.

Basic module. "Seven years of homework and bits and pieces of lots of things" led to the interactive display terminal, says Tom O'Donnell, marketing manager at Litton's Data Systems division in Van Nuys, Calif. The display portion is built from a basic building block of a LED module with a display measuring $1\frac{1}{2}$ by 3 inches. Three of the LED modules go to make up the terminal, which is 8.6 by 6.1 inches in area and 1.6 in. thick.

Under a $350,000 contract, Litton is building three evaluation units to be delivered in March to the U.S. Marine Corps and, separately, two others for the West German Army. O'Donnell looks forward to a big market for the device. The Army, for instance, is interested in a portable terminal for its Tacfire battlefield tactical data system for which Litton is the prime contractor.

The display surface of the Litton device has a resolution of 33 lines per inch, according to Ron Harris, the engineering project manager. Each module has 4,698 diodes, on a basic 5-by-7 matrix, with the three together permitting a total of 288 characters.

While the transparent "membrane" switch is not new, it has not been employed over a display before, say Litton developers of the terminal. The switch is a three-layer sandwich with almost invisible copper wires 3 to 5 mils thick attached to outer plastic layers. Contact, from slight pressure, causes the wires to touch through holes in a plastic insulating layer. With 54 separate switch positions controlled by a microprocessor in a time-shared mode, the terminal allows any number of functions to be keyed in, Litton explains.

C-MOS processor. Inside the terminal are the microprocessor, a random-access memory, a digital-data modem, a power supply, and three D-size military lithium batteries. There is also a backup "keep-alive" battery that keeps data in memory if the main batteries fail. Litton had to build a C-MOS processor because nothing with the low-power requirements was commercially available when design began. However, Harris says the RCA Corp. 1802 Cosmac microprocessor may be used in production.

The terminal has 20,000 bytes of RAM in five 4,096-by-8-bit hybrid packages of 1,024-bit chips. The model supplies a modulated signal that is frequency-shift-keyed onto the carrier of standard voice radio transmitters. Data rate is 600 to 1,200 bits per second.

So far, a single set of three batteries has run up to 44 hours, handling more than 1,000 messages, Harris notes.

While Litton put its own research and development funds into the LED modules, the big impetus came from an award to build a 4-foot-square interactive computer presentation panel for the Army. Litton has a $2.5 million award for this three-color panel, which is made up of 392 edge-stackable, plug-in LED modules. It is in a run-off competition with Control Data Corp.'s plasma display approach [*Electronics*, June 10, p. 25].

Litton claims anyone can operate its terminal with only a few minutes training. "What the terminal does is allow the operator to think about communications, and not the device," says one developer. □

Solid state

Motorola, Fairchild technology exchange strengthens Intel's microprocessor rivals

As the dust settles from the double-barreled blast of second-sourcing and technology exchange between Motorola and Fairchild, it seems clear the cooperation of these industry giants will have great impact on the semiconductor industry.

The agreement, announced in two phases a week apart late last month, calls for Fairchild Camera and Instrument Corp., Mountain View, Calif., to build Motorola's 6800 microprocessor family, as well as the MC10800 emitter-coupled-logic 4-bit slice and the 8,192-bit erasable read-only memory. In exchange, Motorola Semiconductor Products Group, Phoenix, gets manufacturing rights to Fairchild's family of low-power Schottky TTL logic, the F-8 single-chip microprocessor, and the new 16,384-bit and 65,536-bit charge-coupled-device memories.

What appears to be happening is a double- and triple-teaming effort against Intel Corp., the microprocessor sales leader. Zilog Inc., and second-source Mostek Corp., are going after the high end of the 8-bit market with the Z-80, while American Microsystems Inc., Motorola, and Fairchild take on Intel in the middle. At the low end, Mostek, Fairchild and Motorola have the F-8 in the $7-to-$12 one-chip range, while AMI, Fairchild and Motorola will offer the 6802 two-chip device at the $15 level.

Intel's Microcomputer division general manager and vice president, William Davidow, declines to comment about how the Santa Clara, Calif., firm will react in the future.

Different. The top man at Motorola Semiconductor, group executive John R. Welty, calls the cooperation a "new kind of second-source agreement. We will provide masks and process information to Fairchild and assure compatibility. I am aware of no 8080 second-source [agreement] where Intel makes sure of compatibility."

He says the announcement will "help with customers sitting on the fence," looking at both the 6800 and 8080 but worried about dependable 6800 backup. He regards the exchange as even, since "there are three products involved on both sides."

Welty says that Fairchild's TTL is the "key element" in the technology Motorola will get. "It's no secret that for the past five years, Motorola has not been a vigorous competitor in bipolar ICs. This means we'll step up our efforts in that marketplace," he says. And he notes his company will not keep working on anything that duplicates products already introduced by Fairchild.

Fairchild's choice. On the Fairchild side, Van Lewing, microprocessor-marketing manager, says the agreement also includes the two-chip 6802 microcomputer still under development at Motorola. Before choosing the 6800 for entry into the general-purpose microcomputer market, Fairchild considered alternatives that included Intel's 8080, Zilog's high-performance Z-80 and Signetics Corp.'s 2650.

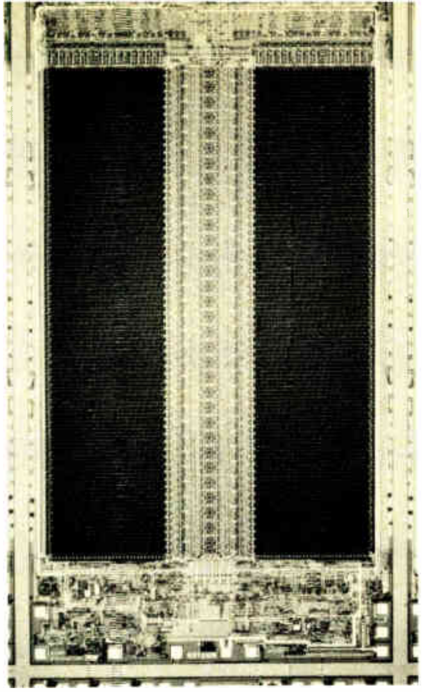
"But if we had gone that [8080] route, we would have been just another company, another almost identical second source," Lewing explains. "If we are going to be in the same marketplace, we thought we'd better be there with something as good or better."

Industry insiders speculate the 6800 now has about 20% to 25% of the 8-bit market, up from 10% to 15% a year ago. If the new alignment goes according to plan, they say, within a year, the 8080 and 6800 will each have 45% of the market, the Z-80 will have 5%, and all other machines 5%.

The sole previous second source for the 6800, AMI, welcomes Fairchild's entry, says John Richardson, vice president of sales. "We'll have to hustle to remain competitive, but that is offset by the number of new markets that will be opened up for an 8-bit machine truly second-sourced by three companies." □

Industry moves to Mostek RAMs

To the surprise of the semiconductor industry, Mostek Corp. has suddenly become the technology leader in dynamic metal-oxide-semiconductor random-access memories. Although Intel Corp. and Texas Instruments Inc. entered the market first with



Speed leader. Mostek's 16-k MOS RAM, with access time of 150 ns, looks good to the users who've seen and tested it.

samples of their 16,384-bit RAM [*Electronics*, Jan. 8, p. 27], the recently introduced Mostek 16-k MK 4116-2 part, which has an access time of 150 nanoseconds, has impressed memory users and manufacturers alike. The RAM is much faster than Intel and TI production devices.

What's more, Mostek has caught the industry off guard in the 4,096-bit RAM market as well. The Carrollton, Texas, firm's 150-ns MK 4027, now in volume production, has found such strong acceptance that every major 4-k memory supplier but one is rushing into production with high-speed 16-pin 4-k parts of its own. The exception is National Semiconductor Corp., which will introduce 100-to-150-ns versions of its 18-pin devices [see p. 25].

Remarkable. Dick Foss, president of memory-consultant Mosaid Inc., Ottawa, Ont., points out: "The 4027 is a remarkable part—the first 4-k RAM ever to be exactly copied throughout the industry. With the 16-k device, it has squarely catapulted Mostek into a leadership position in the RAM business." Mosaid is helping several manufacturers copy the part.

Typical of user enthusiasm for Mostek's new RAMs is the comment by James Sheehan, manager of technology engineering at Prime Computer Inc., Framingham, Mass.: "While Intel is the strongest 16-k supplier in terms of volume, the 150-ns speed of the Mostek part is just plain super." Robert Frankenberg, product manager of 21MX and 2100 minicomputer lines at Hewlett Packard Co.'s Data System's division, Palo Alto, Calif., says that preliminary lab tests show "the parts are all that Mostek says they are. But whether they'll stand up under rigorous testing is another matter."

At Digital Equipment Corp.'s facility in Maynard, Mass., Michael Gutman, product and engineering manager for MOS and core memories, says that, although the big minicomputer maker has not yet asked for the 150-ns Mostek part, the 200-ns MK 4116 is "clearly the fastest and lowest-powered part we've seen among 16-k units. I wouldn't be surprised to see the semiconductor industry model itself on the Mostek part."

Clearly, the 150-ns, 4-k and 16-k Mostek parts are already stimulating serious rethinking of speed specifications. TI, for example, is continuing to supply its single-level TMS 4070, which has a best-case access time of 250 ns, but is designing two-level parts, aimed at 200-ns speeds and faster. The parts will conform to the Mostek timing, which has no restrictions on the overlap timing for row- and column-address selection.

Moreover, in a surprise move, TI decided to enter the fast 4-k market with a copy of the 16-pin Mostek 4027. Ed Huber, MOS marketing manager, says TI's 4027, to be offered as samples in next year's second quarter, will match Mostek's speed. Huber predicts that the market for fast 4-k dynamic RAMS (200 ns and under) will quickly reach about 30% of the 4-k total, with a third of them 150-ns devices. TI will supply a range of 4027s rated from 150 to 250 ns, and it has no plans to redesign its 18-pin or 22-pin parts.

Iterations. At Intel, David House, memory-applications manager, stresses that, although design iterations are always underway, "We are not in a major redesign of our 16-k RAM." The company, which leads in 16-k shipments, is committed to latched parts with 64/128-cycle refresh. Intel, TI, and Mostek will ship about 50,000 16-k devices this year, and the total should reach 2 million next year.

Perhaps in response to Mostek's higher speeds in its unlatched 16-k part, Intel is specifying its latched part over a wider speed range—to a distribution of 200, 250, or 300-ns. "And, obviously we are looking at ways to tweak down to 150 ns," House says. In 4-k, Intel is in production with a 200-ns 16-pin part and is considering a 150-ns device. □

Military

RCA charge-coupled-device recon camera send to pictures to ground in real time

The Air Force is moving closer to reconnaissance cameras that beam their pictures back to the ground for instantaneous development. And it looks as if the cameras will be built around charge-coupled devices.

The need for real-time tactical photo-reconnaissance became apparent during combat in Southeast Asia, and the Avionics Laboratory at Wright-Patterson Air Force Base, Ohio, took steps to fulfill the need. The lab's latest move is a recent $1.1 million contract to RCA Corp.'s Automated Systems division, Burlington, Mass., for a solid-state wide-angle camera system that produces a photograph on the ground almost immediately after a scene has been captured by CCD arrays in the airborne sensor.

Flight test. James Rachal, project engineer for the program at the Avionics Laboratory, says RCA is to deliver hardware for flight testing in January 1978—about a year after the CAI division of Bourns Inc. is to deliver an electronic wide-angle camera system it, too, is developing with CCD arrays. CAI received its contract in 1973. RCA's camera will use a stationary "push-broom" technique to gather image strips along the aircraft's flight path, while the CAI approach pans perpendicularly to the plane's track, delivering a "bow-tie" swath [*Electronics*, Aug. 22, 1974, p. 30].

Five lenses. According to Gardner T. Burton, manager of electro-optical system design engineering in the RCA division, a chief objective is to make the airborne package as simple as possible. It contains five lenses roughly equivalent to 35-millimeter gear, each focusing images onto its own 1,728-element linear CCD array, a CCD-121 from Fairchild Camera and Instrument Corp., Mountain View, Calif. The sensor-head electronics also includes a drive and synchronization mechanism for scanning the sensors about 1,000 times per second, plus minimal video-processing hardware.

The sensor head will measure 11 by 15 by 8 inches and weigh no more than 35 pounds. A magnetic-tape recorder will be added to it for non-real-time transmission, and the Air Force will furnish a data link to send the analog video signals to the ground. There, a laser-beam recorder and dry, thermal processing on a silver-halide film will put a film strip into a photo-interpreter's hands less than 15 seconds after the CCDs capture the image.

The sensor head is designed to cover a 140° field of view. This corresponds to a 5,500-foot-wide path on the ground when the aircraft is flying at 1,000 ft. Because only one of the five lenses is aimed straight down, the geometrical distortion introduced by the oblique angles of the other four must be removed during ground processing.

Burton says this will be done in a digital time-base processor and digital buffer that follow the data-link receiver and analog-to-digital converter. The five sensor heads are scanned at a rate of 10.5 megasamples per second, which requires a minimum video bandwidth of 5.25 megahertz. "After the a-d conversion, the data goes into the first-in, first-out buffer," he says. "It goes in at a uniform rate, and we're taking it out at a variable rate controlled by the digital time-base processor."

That processor is built of transistor-transistor and emitter-coupled logic. The ECL speed is required to handle the readout rate of the buffer, which can be as fast as one sample per 50 nanoseconds and ranges from 4 to 22 megasamples per second. These samples are then converted back to an analog signal used to drive the optical modulator of the helium-neon laser-beam recorder. □

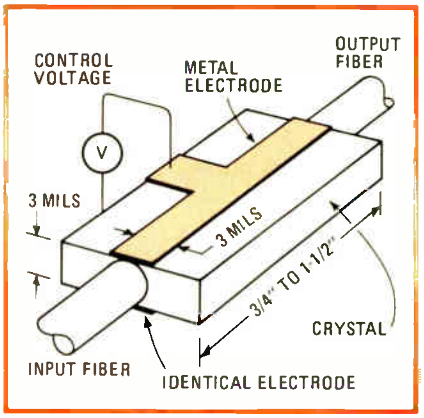
Fiber optics

Voltage-responsive crystal allows direct modulation of light beam

Loading information onto the light beam in a fiber-optic communications system is usually done indirectly, by modulating the injection current of the light source itself. But now Sperry Rand Corp.'s Sperry Research Center in Sudbury, Mass., has developed an electro-optic device that modulates the light beam after it is already in the fiber light pipe.

This approach not only eliminates an electronic-to-optical interface but could prove to be useful at very high frequencies where the response of the light source might be inadequate. In addition, the basic modulator design can be used to switch data along different paths, a requirement of multiplexers and data buses.

Crystal. The Sperry modulator, as shown in the figure above, is based on a thin wafer of an electro-optical crystal, such as lithium niobate or lithium tantalate, having a refractive index that changes when a voltage is applied. But first, identical metal electrodes must be evaporated on both sides of the wafer, which is 3 mils thick, to match the diameter of a single multimode optical fiber. The fiber's end is polished and butted to the crystal.



Mod crystal. Voltage applied across the surfaces of the electro-optic crystal modulates light in Sperry device. The longer the crystal, the deeper the modulation.

Output nil. When no voltage is applied, only a small percentage of light entering the crystal will reach the output fiber. That is because the light coming from the multimode fiber is not collimated. Instead, it enters the crystal in a cone containing many different angles and is dispersed instead of impinging solely on the output fiber.

When a voltage is applied to the electrodes, the index of refraction in that part of the crystal varies, changing the angle at which the light enters. The incoming light tends to be guided along the metal-electrode path to the output. But the amount of light at the output depends on the applied voltage so that the output is intensity-modulated.

In its development, the Sperry researchers found that a 50% modulation depth could be obtained by applying 14 volts rms, and the throughput loss was 18 decibels. The bandwidth was larger than 600 megahertz. A 25% modulation was achieved with 5 v, but it took 900 volts to approach modulation depths of 100%.

At an angle. Throughput loss is considerably improved, Sperry found, by butting the fiber up against the crystal so that the axis of

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the fiber is not perpendicular to it. This angle helps to increase the amount of light that can be captured, with voltage on the electrodes, from the input's wide cone.

For example, for 50% modulation, throughput loss was reduced to 10 dB when the applied voltage was increased a small amount—to 23 V. The voltage required for capturing the entire cone of light—100% modulation—was 225 V with the fiber cut at a 67° angle. This is roughly a quarter the voltage required when a fiber is coupled with its axis perpendicular to the crystal. Sperry says it can reduce the voltage required for 100% modulation even more.

Working with the support of the U.S. Army Electronics Command, Fort Monmouth, N.J., Sperry has already built a time-division multiplexer/demultiplexer that interleaves the optical bit streams of four separate multimode fibers onto a single output fiber. Such a unit could be applied in a switchboard that the Army would like to have when fiber optics replaces the standard 26-pair copper cable it at present uses in tactical environments [*Electronics*, Jan. 9, 1975, p. 29].

Elsewhere in the laboratory, Sperry has developed some other electro-optic goodies, including a 12-port-to-three-port multiplexer as well as a low-crosstalk, four-port crosspoint switch. □

Solid state

Devices meeting shows trends again

The annual Electron Devices meeting held in Washington in December usually previews the new process and device technology being readied for new-product designs. This year is no exception. A wide range of new technologies will be aired at the meeting Dec. 6 to 8, including new bipolar and metal-oxide-semiconductor structures to boost the performance of both discrete and large-scale-integrated devices, as well as materials and designs to make feasible optical and solar-cell devices for communications and energy applications. Microwave technology, both solid-state and vacuum, will be described that sets higher limits in frequencies and low noise.

CCD logic. Perhaps the most interesting developments to emerge will be TRW's ongoing work with logic structures built with charge-coupled devices [*Electronics*, June 10, p. 41]. Although CCD techniques are widely used in memory, imaging, and signal processing, the TRW Defense and Space Systems Group is alone in applying them to logic configurations, and with resounding success. The TRW CCD logic, for example, operates on only 10% as much power as complementary-MOS logic in 1% of the area. Moreover, the process is completely compatible with the CCD analog process. So far, a wide range of complex digital CCD functions have been implemented including half and full adders and multipliers.

A more conventional MOS-logic approach is a low-power LSI configuration using back-gated, or B-MOS structures, work that's underway at Hitachi Central Research Laboratory in Japan. Using a back-gated input terminal, which forms a p-type well in an n-type substrate, Hitachi researchers have built test inverters that operate with gain at voltage levels as low as 0.13 volt, or only a fraction of standard MOS voltages. Moreover, these test vehicles showed typical delay times of only 100 ns and power delay products of only 10 femtojoules, or 1,000th that of other logic systems.

A development of immediate application is the clocked C-MOS logic, or C^2L, which RCA has built into its 1802 microprocessor chip. It provides triple the packing densities of standard silicon-gate C-MOS while increasing speed approximately 4 to 6 times. This makes its performance comparable to n-channel circuits, but power dissipation is much lower.

Linear too. Developments in mixed-process linear integrated circuits will also be described. With no additional processing steps, vertical-junction field-effect transistors are being mixed on the same chip with bipolar transistors by Hewlett-Packard Laboratories, Palo Alto, Calif. The advantages are high operating frequency and impressive power-handling capability.

High-stability voltage references, which have been the province of bipolar technology, are now being implemented with MOS processing by General Electric Co., Schenectady, N.Y., for use in monolithic linears such as interface circuits and data converters. Also, process improvements in MOS technology are enabling the optimization of chip real estate.

IBM, Stanford. For example, both smaller polysilicon-gate MOSFETs are being made by IBM's T. J. Watson Research Center, Yorktown Heights, N.Y., and V-groove and double-diffused MOS transistors are being fabricated by Stanford University's Integrated Circuits Laboratory, Stanford, Calif.

Advances in microwave semiconductors will also be reported, among them low-noise bipolar transistors developed by Bell Laboratories with electron beams and Trapatt oscillators from Sandia Laboratories, Albuquerque, N.M., that utilize optically-generated carriers to lower frequency drift and speed up switching frequency. In opto-electronics, the news will include a position-sensitive photo-detector that exhibits high linearity and a whole rash of improved-performance photodiodes, as well as light-emitting diodes, for easing the characteristics of optical fibers for data transmission. □

Industrial

Capacitance yields yarn's denier

Capacitance measurements and the textile industry are not commonly associated. However, they are related in a piece of electronic gear when it comes to gauging the denier—or mass per unit length—of synthetic fibers coming off produc-

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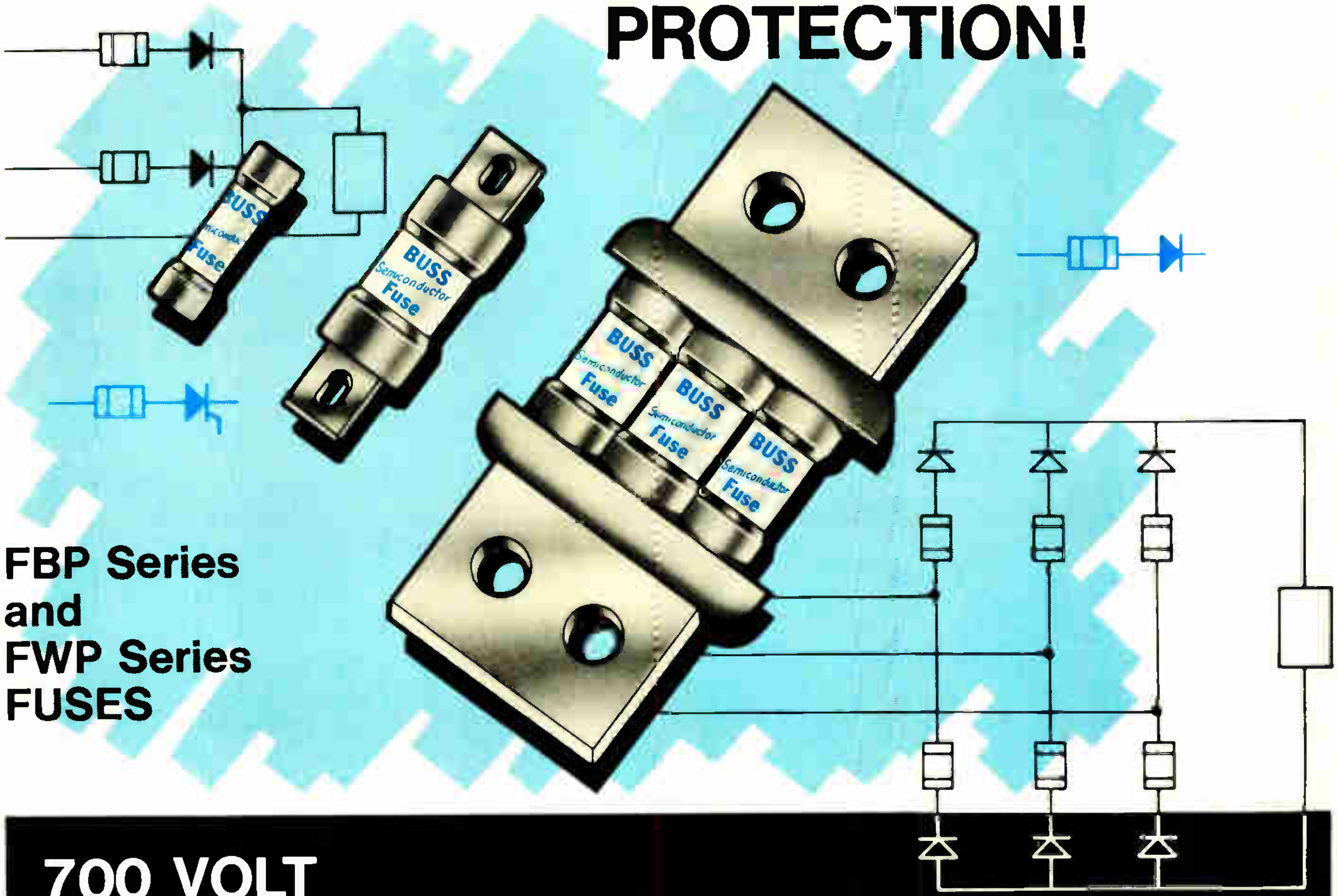

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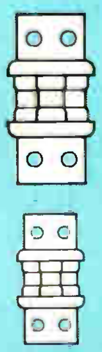

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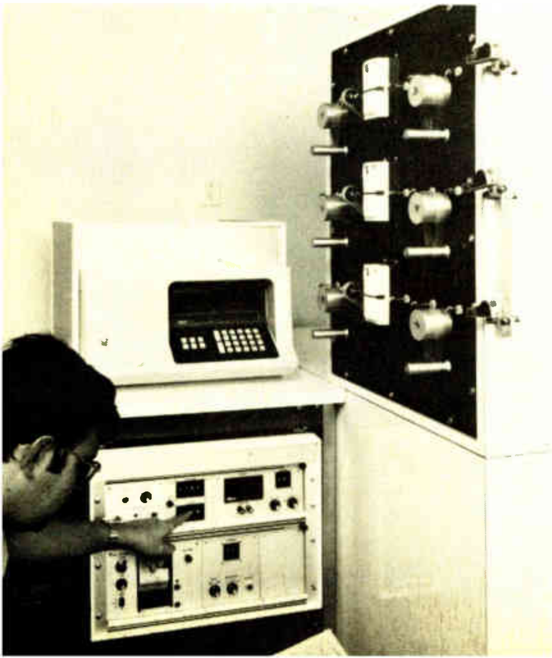
The right denier is a critical measure of fiber quality—so much so that a small analytical-instrument company thinks $50,000 is not too much to pay for a system it has developed to measure denier right in the dirty environment of the mill rather than a laboratory. Micro Sensors Inc. of Holliston, Mass., says its M/8000 quality-control system will cut appreciably the lag between the time the fiber is spun, drawn, or texturized and the time it is sampled and measured.

Accuracy. Moreover, the system delivers much greater accuracy—±1%—measuring denier than the ±10% of other measuring machines, says the company. Micro Sensors, 81% owned by Analog Devices Inc., displayed the system for the first time late last month at the American Textile Machinery Exhibition in Greenville, S.C.

Robert W. Smith, product marketing manager at Micro Systems, says the company's previous products have been either analytical instruments or in-process on-line monitoring systems. The analytical instruments, priced from $10,000 to $20,000, are intended for quality control in the laboratory and manufacturing-process development. The on-line equipment can cost as much as $100,000 to gauge fibers for

Dialing denier. Technician sets desired denier for which fiber will be tested. Yarn-handling portion of system is at right.



News briefs

Westinghouse to end TV-tube production

A sign of the competitive times in the U.S. television-set industry is Westinghouse Electric Corp.'s announcement that it will cease production of color-TV tubes in December. The last of the independent picture-tube makers in this country, Westinghouse cited rising costs, low selling prices, foreign imports of receivers, and lack of profits as the reasons for abandoning its Horseheads, N. Y., facility and idling 1,200 people. The company had previously ceased making its own TV receivers, but sold picture tubes to other U.S. setmakers and Europe. Still making the tubes in the U.S. are RCA, Zenith Radio, GTE-Sylvania, and General Electric.

IBM adds processor to its 370/158

Just two weeks after San Francisco-based Itel Corp.'s introduction of its AS/5, a computer system that duplicates the functions of IBM's 370/158 [*Electronics*, Oct. 14, p. 29], IBM announced an attached processor system for the 158, that improves performance by 1.5 to 1.8 times. The attached processor shares the main memory with the existing host processor and shares the load of processing instructions. This improves the system without adding main memory, disk storage, or input/output equipment. IBM introduced the concept of an attached processor earlier this year with a unit for the model 370/168.

Huge combat system awarded to RCA

RCA Corp.'s Missile and Surface Radar operation in Moorestown, N.J., has been awarded a $159.2 million U.S. Navy contract to develop a shipboard combat system using the Aegis fleet air-defense system as its nucleus. It will incorporate a number of sensors and weapons in addition to the RCA-developed Aegis system, which uses the Standard missile (Type II) built by General Dynamics Corp.'s Pomona division. Components of the combat system include Mark 26 guided missile launchers, Harpoon surface-to-surface missiles, and 5-inch guns.

Control Data sales to China, USSR finally approved

It took a year longer than expected, but Control Data Corp. finally got Federal approval for its long-standing proposal to sell two Cyber 172 models to the People's Republic of China for approximately $6 million [*Electronics*, Nov. 27, 1975, p. 59]. At the same time, CDC said it won approval to ship one Cyber 173 system worth $5 million to the Soviet Union. The equipment for Machimpax—the China Machinery Import and Export Corp.—will be installed in a seismic institute outside Peking to monitor earthquakes and aid the search for new oil reserves. The Soviet Cyber 173 will be used in similar applications. The Chinese and Soviet 60-bit-word, medium-scale, general-purpose systems will each have 65,000 words of central core memory plus another 250,000 words of extended core storage. For peripherals, the Soviets will get three CDC 841 disk drives of 432 million bits each, while the Chinese system will have four 844 disk drives with capacities of 870 million bits each.

U.S. consumer-electronics trade deficit for first half tops $1 billion

America's deficit in consumer-electronics trade during the first half of 1976 more than doubled the 1975 figure, soaring to a record $1,333.5 million. Japan accounted for 80% of the total, more than $1,075 million, according to new Commerce Department figures.

Imports of phonographs and tape recorders and players, the largest category, climbed 60% to $471.8 million. The largest percentage of imports gain—313%—came in radio transceivers and receivers, which totaled $413.3 million. Sales of citizens' band radios rose sevenfold to $262.4 million. Imports of TV receivers jumped 80% in the half to $333.5 million, with color sets accounting for $183.8 million, more than double the 1975 level. Commerce reported "a major shift in product mix" as sets with 19-inch and larger screens now account for more than half the import total.

One button dialing.

The busy person is constantly dialing telephone numbers. Locally. Throughout the country. Even internationally.

But let's face it. Dialing is one of the biggest time wasters in a busy day.

Think of the number of digits you dial. And have to remember. If you forget a telephone number and your secretary is unavailable, you lose valuable time looking it up. If the line's busy, you have to re-dial.

But General Instrument Microelectronics is changing all that. Our MOS/LSI circuits are making the telephone easier to use and a whole lot more human. They're making possible today's third generation solid-state phone. And tomorrow's "super phone."

With one-button dialing, the sky is the limit. You program your phone's memory with the numbers you call most frequently. Then, instead of dialing, you simply push a button. The phone dials for you. Instantly. Automatically.

You can set up your own identification system, too. If you like surnames, list your telephone numbers by surnames. Or by locations. Or by digits in sequential order. It's up to you.

That's not all. If you get a busy signal, the phone will re-dial until you hang up. You can see the number you're dialing with a digital read-out display. And you can even convert your phone into a data transmission center.

GI circuits are opening the way to advanced phone technology. You can select our AY-5-9200 that stores telephone numbers in multiples of ten. Or our AY-5-9100 that converts push button input to rotary dial pulses. Or our AY-3-9400 and AY-3-9410 that generate MF/tone telephone frequencies. Or our AY-5-9800 that decodes them.

Making engineering more human is our real job at GI Microelectronics. One-button dialing is a good example. Another is TV games. And hand-held calculators that print. And microwave ovens that practically nudge you when the food is cooked. And lots more.

True, GI makes standard and custom circuits. By the millions. Whole families of them. In depth. But we're really in business to help you make products that do things people want them to do. If you'd like to make your products more human, write or call General Instrument Microelectronics, 600 West John Street, Hicksville, New York 11802, Tel. (516) 733-3107.

We help you compete.

GENERAL INSTRUMENT CORPORATION
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denier and other specifications.

The M/8000 fits in between these two classes of equipment. It's an off-line station that quickly tests each package or bobbin of fiber just after it comes off the machines. Smith says this hasn't been possible before, especially with the accuracy the M/8000 offers. Heretofore, fiber makers usually had to gauge samples away from the production area. Because of the time lag between production and testing, large batches of fibers could wind up as expensive scrap before the out-of-tolerance machinery could be adjusted.

Six transducers. A standard M/8000 station consists of an automatic yarn-handling system, which controls the speed and tension of six parallel thread lines, six transducers, and a processor-based central measurement and control system. A digital panel meter and printed readouts present test results.

The transducers are the key to the station's performance. "We're measuring capacitance to 10^{-5} picofarads," notes Smith, pointing out that other fiber-measurement approaches are designed to measure deviation in capacitance. "They can measure changes, but we measure absolute and how far off the fiber is."

Fiber is fed through a slot in the transducer head, where its average absolute denier is measured. The system can also compute the fiber's coefficient of variation, which takes into account the amplitude and durations of deviations from average denier. The coefficient is the ratio of standard deviation to average denier for a given length of yarn.

No comment. All Smith will say of his system, which does not contact the yarn, is that MSI's transducers use the relationship between the dielectric constant of a fiber and fiber mass to measure the yarn's absolute denier as it moves through the sensing element at high speed. Circuitry translates a continuous dielectric measurement into a signal proportional to the absolute denier.

Four-year-old MSI was acquired by Analog Devices in 1973 to gain new markets for its own measurement and control capabilities. MSI itself was formed originally in a diversification move by Northrop Corp., the aerospace concern. Sales of MSI could reach "several million dollars in several years," predicts John Corsi, vice president of the Analog Devices Instruments and Systems group. □

Computers

Low-cost analog unit simulates digital ICs

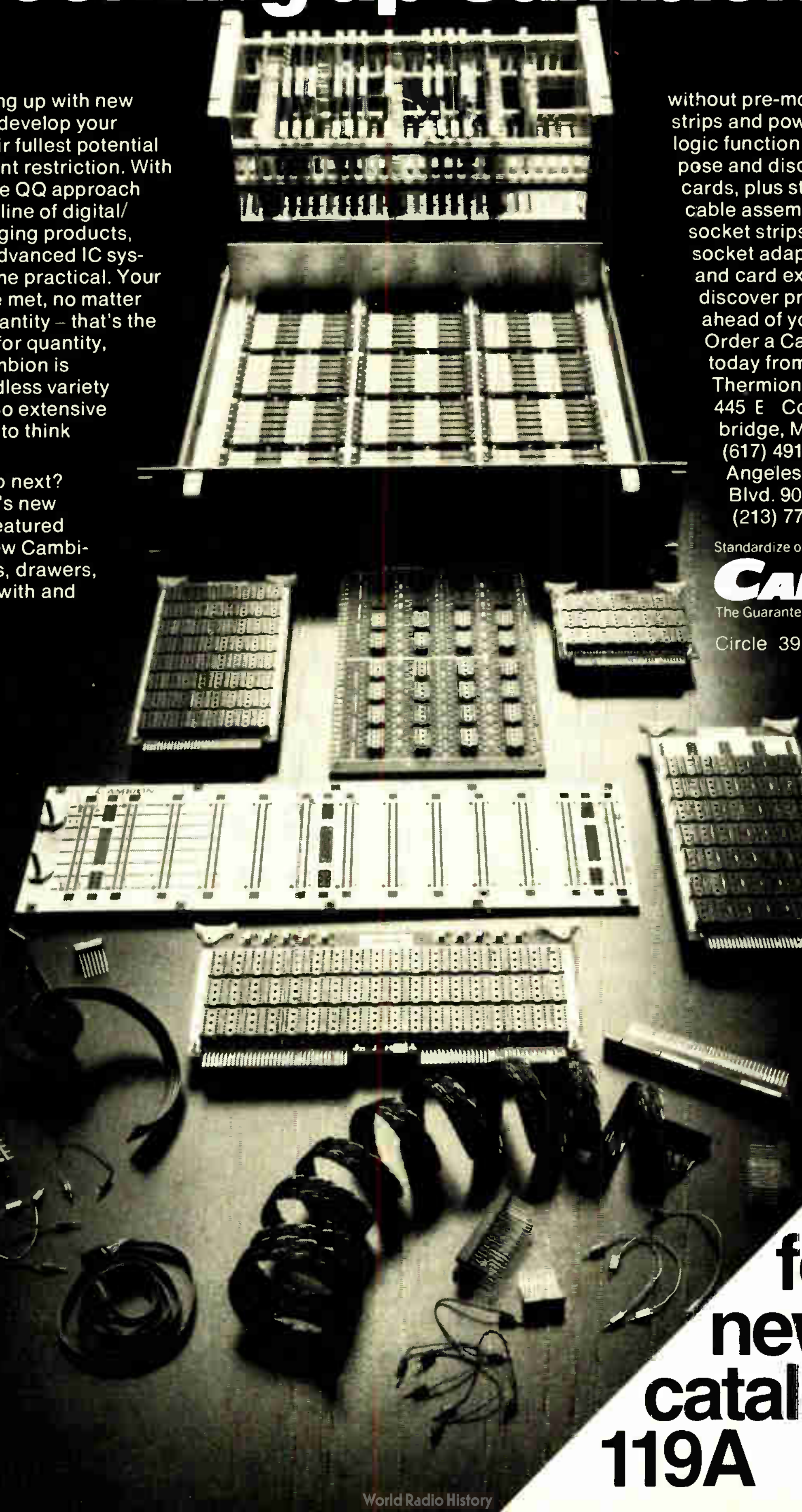
An analog computer for simulating the fastest kinds of monolithic digital circuit chips can be put together from hardware costing only about $3,600, say two West Germans.

Built by Hans-Martin Rein, a professor of electrical engineering, and Roland Ranfft, a research assistant, both at Ruhr University's Institute of Electronics in Bochum, the computer is being used to analyze nonsaturated-logic families. These include emitter-coupled, diode-transistor, and Schottky transistor-transistor logic. The two researchers, applying their computer to developing experimental low-power subnanosecond devices, are checking out the limits of the bipolar silicon-planar techniques with respect to such characteristics as power dissipation and delay times.

Plug-ins. The computer consists of two (possibly three) "mainframes," plus their power supplies. Each "mainframe" consists of 12 plug-in modules, 10 of which model transistors and two of which model diodes.

The transistor models are based on the so-called transport model, which is similar to the well-known Ebers-Moll model. This model allows variation of the following parameters: base transit time, collector-and base-spreading resistances, four junction capacitances, and the collector-base capacitance, which is divided into extrinsic and intrinsic parts. Current gain and the emitter-base forward voltage can also be adjusted. If necessary, the equivalent circuit can easily be expanded to

Everything's coming up Cambion



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take into account additional spreading resistances in series with the junction capacitance.

The diode models are analogs of 10 Schottky diodes, five in each of the two plug-in modules allotted to them.

The basic two-mainframe computer can simulate logic gates with as many as 20 transistors and 20 Schottky diodes. These numbers are usually the upper limit on what needs be simulated in the design of a circuit chip. However, if necessary, a third mainframe can be added.

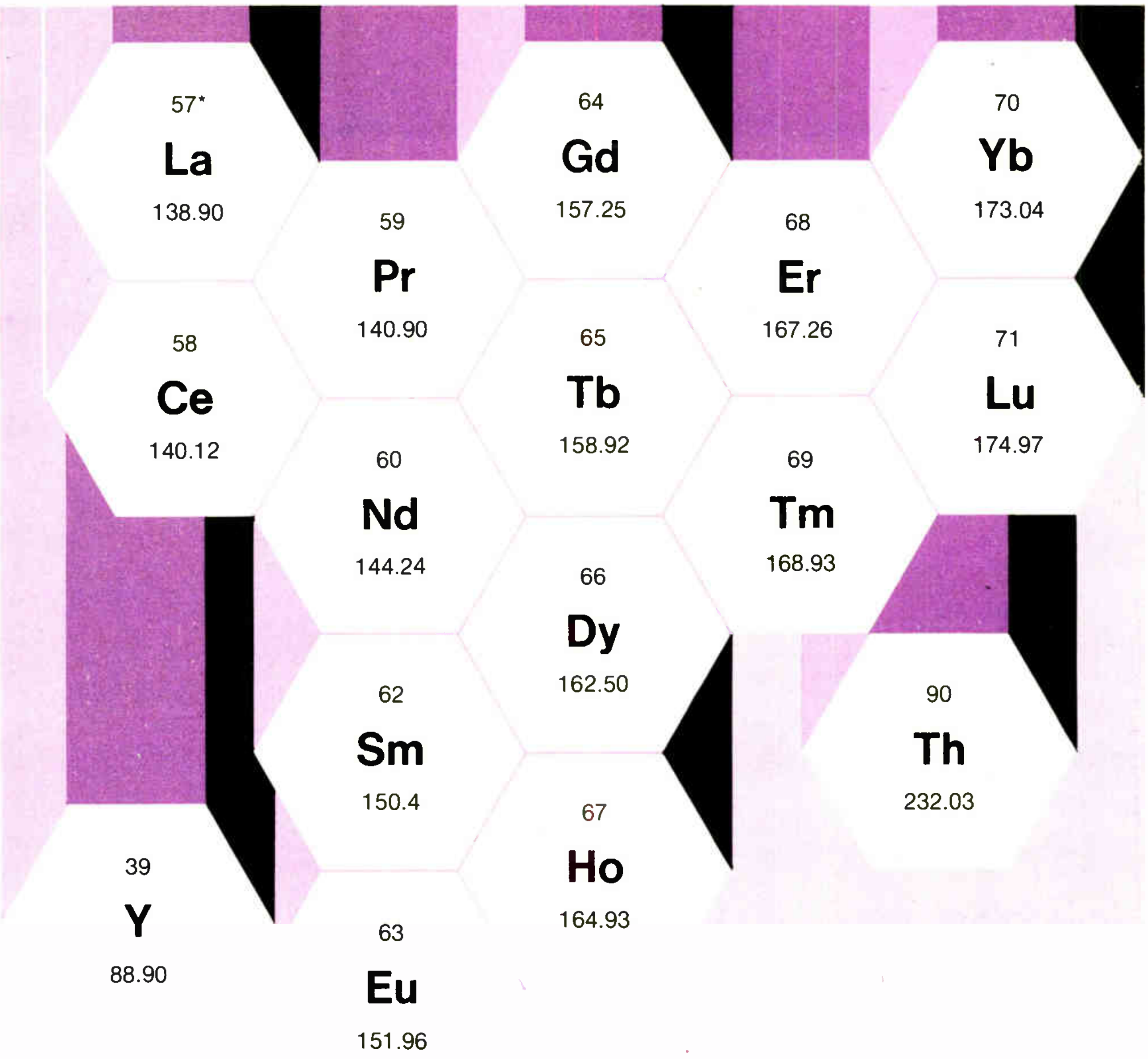
Device parameters can be set by potentiometer knobs on the computer's front panel. As with other analog computers, no special programing knowledge is needed.

The $3,600 cost of the computer is for a pair of 12-module mainframes and associated hardware, according to Ranfft. It does the same job as an expensive large-scale digital computer using elaborate and time-consuming network-analysis programs: a multitude of computer runs is required as parameters are changed to optimize the circuit.

Time scale. In typical analog fashion, the computer works with a time-scale factor that slows the speed at which the circuits operate. A factor of one million, for example, translates an actual transistor switching time of 1 nanosecond into 1 millisecond, slow enough for the gate elements to be interconnected by simple wiring.

Even at gate-delay times of 0.4 nanosecond, there has been good agreement between the transient response of the real circuit and the simulation, Rein says. This holds even though the transistor equivalents are less flexible, the two point out, than those available in modern network-analysis programs used on high-speed digital computers.

The low millisecond speeds of their computer allows switching behavior to be displayed as parameters are varied on an inexpensive low-frequency dual-trace oscilloscope. Dc characteristics can also be displayed. Any standard pulse generator with a variable pulse rise time can drive the computer system. □



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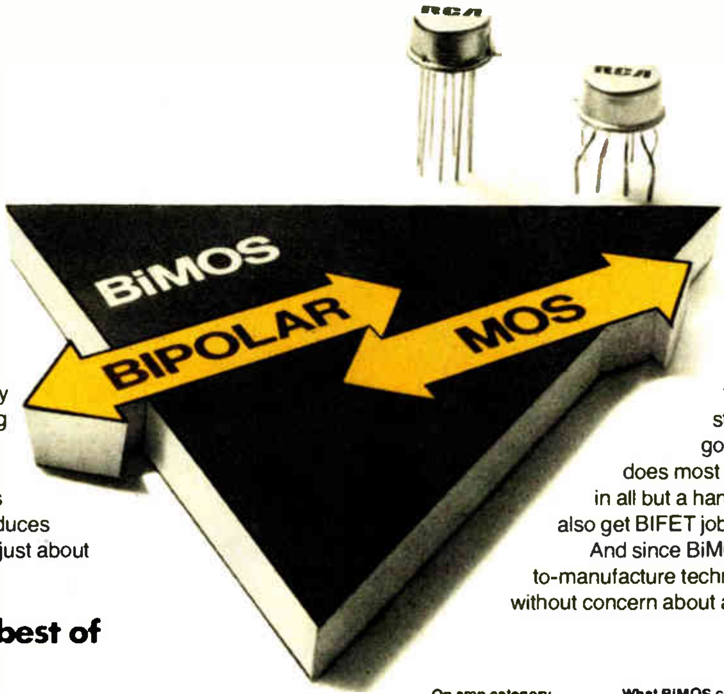
THE BiMOS OP AMP



The BiMOS concept we announced just three years ago has already changed the thinking of many system designers. And has sweeping implications for both engineer and manager.

BiMOS is easy to use. Improves product performance values. And reduces costs over just about any op amp. In just about any socket that calls for one.

With just a few types, BiMOS affords the opportunity to establish new low-cost standards in all op amp categories. For example, the 3140 does most things better than the 741. Yet, in all but a handful of critical situations it will also get BIFET jobs done. At a fraction of the cost. And since BiMOS is a high-volume, simple-to-manufacture technology, you can use it freely without concern about availability.

BiMOS combines the best of Bipolar and MOS.

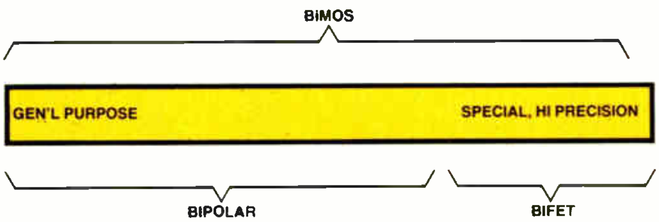
The BiMOS technology was born with the CA3100. Without miracles of any kind. We simply put our experience in two technologies together on the same chip, using standard commodity manufacturing processes.

BiMOS proved that two technologies could be better than one. More stable. More rugged electrically than either unprotected Bipolar or BIFET. And lower priced by far than BIFET op amps.

By varying the mix of Bipolar and MOS we have made BiMOS op amps which match a wide variety of circuit requirements.

BiMOS fills today's need for a more universal approach.

The chart below represents a new guide to op amp performance and application for the design engineer.



Op amp category	What BiMOS contributes	RCA device
General Purpose	Wide applicability Low cost	CA3140 CA3130
FET Input	Lower device cost Reduced circuit cost	CA3140 CA3130
Wideband 4.5 to 70 MHz	High slew rate with low ringing	CA3140 CA3130 CA3100
Micropower down to 1.5 mW	Strobability	CA3130
High Current up to 22mA	Eliminates driver stage Low device cost Rail-to-rail output swing	CA3130

Simple manufacture means high yield with high uniformity.

From one manufacturing step to the next, the BiMOS op amp doesn't know whether it's a 3140 or a 741. It takes the same kind and number of processes to make both.

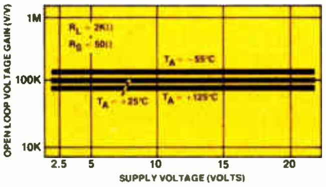
In sharp contrast to the simplicity of BiMOS, the BIFET process is longer and relies on ion implantation, used to define a channel in a doped epitaxial layer.

Since the electrical characteristics of this epi layer vary, the junction formed varies. That affects the FET pinch-off voltage, making device parameters harder to hold to BiMOS tolerances. This is illustrated by the gain vs. voltage and temperatures curves.

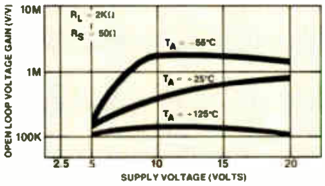
A management report on a technology whose time has come.

Since the BiMOS process is easy to control, high yields are the order of every manufacturing day. This has been our consistent experience in three plants producing BiMOS in three different parts of the world. So we are confident we can fill your high-volume needs without interruption.

BiMOS



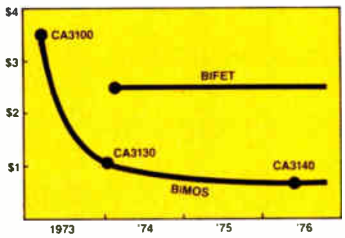
BIFET



BiMOS puts a new slant on the learning curve.

The fast build-up of BiMOS production, already in the millions, brought a correspondingly sharp decline in the price-learning curve.

One year after our first announcement, the 3130 was introduced at the one-dollar level. And this year, we made the 3140 available at the same price as a 741.



Curves show lowest published price for each technology

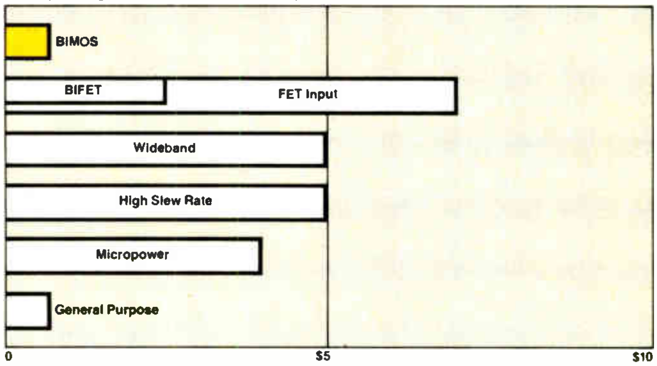
Once again the BiMOS experience is in sharp contrast to that of BIFET op amps which, although announced in 1974, are still relatively high in price and low in volume.

BiMOS encourages engineering and manufacturing economies.

Savings from BiMOS go beyond low purchase price. For one thing, the all-embracing performance of BiMOS simplifies and speeds up the design process for engineers.

Whether they're redesigning a circuit or tackling a new problem, they can confidently use BiMOS to do a wide spectrum of jobs – where previously, each of these jobs may have required careful, time-consuming selection from an array of specialized op amps. What's more, BiMOS op amps can often do jobs that used to require additional parts. This opens up further savings in design, manufacturing and parts costs.

TYPICAL PUBLISHED OP AMP PRICES



Standardizing on BiMOS offers other important cost benefits, too. Such as consolidated purchasing, simplified incoming inspection, and fewer types in inventory. You can treat BiMOS as a second source for all the op amps it replaces.

BiMOS answers consumer demands for improved values.

To sum up, BiMOS is an advance in step with the times. It provides many performance and reliability advantages over the old way of doing things – at no extra cost. It's in keeping with the trend toward standardizing on fewer components that can do more jobs. At a time of squeezed profits, it can help reduce costs all along the line – costs of design, manufacture, purchasing, inventory control, incoming inspection. The end result is that you can offer consumers more value at competitive prices.

A BiMOS offer from RCA management to yours.

If you want to know more about how to use BiMOS circuits in your new designs or redesigns, or if you'd like to discuss how you can fit BiMOS into your present inventory program, call us. Ask for the BiMOS Product Director at 201-685-6116. That's our specially dedicated BiMOS phone. Or write him at RCA Solid State, Box 3200, Somerville, New Jersey 08876.

RCA

DELCO'S NEW 25-AMPERE HIGH VOLTAGE DARLINGTONS WITH THE SPEED AND ENERGY CAPABILITY YOU ASKED FOR.

Good news for motor speed control designers who have expressed a need to upgrade horsepower ratings. The 25-ampere gain of these new Darlingtons permits increased horsepower ratings of existing AC motor speed control systems and a reduction in paralleling in new designs. However, grouping of t_{off} is available for current sharing in designs with parallel Darlingtons. A speed-up diode is built into the DTS-4074 and DTS-4075 permitting data sheet t_f typicals of 1.0 μs. Drive circuit techniques involving $I_{B2} \geqq 2$ A and a Baker clamp produce t_f typicals in the 0.4-0.6 μs range for the DTS-4066, DTS-4067, DTS-4074, and DTS-4075.

Our experience with tolerances, faults, transients, and start-stall conditions in most systems convinces us that these Darlingtons have the right trade-off between speed and peak power handling capability. Note the greater than 10 kVA region of the reverse bias safe operating graph. All this, and you still get Delco's traditional solid copper TO-3 hermetic package that has a conservative 0.75°C/W thermal resistance.

These Darlingtons are already in high volume production and are available on distributor shelves. Prices, applications literature, and data sheets from your nearest Delco sales office or Delco distributor can complete the story on these new Darlingtons.

MAJOR PARAMETER LIMITS

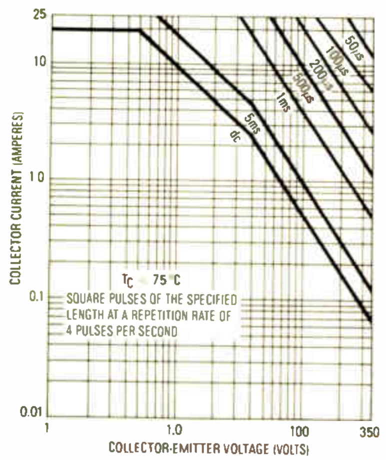
Type	h_{FE} @25A	h_{FE} @10A	V_{CEO} (sus)	V_{CE} (sat) @20A	I_{CEO} @600V
DTS-4066	5	75	350V	3.5V	0.25mA
DTS-4067	10	150	350V	2.0V	0.25mA
DTS-4074	5	75	350V	3.5V	0.25mA
DTS-4075	10	150	350V	2.0V	0.25mA

TYPICAL SWITCHING

	DTS-4066 DTS-4067	DTS-4074 DTS-4075
t_r	0.5μs	0.5μs
t_s	5.0μs	3.2μs
t_f	4.5μs	1.0μs

NPN triple diffused silicon Darlingtons are packaged in solid copper cases conforming to JEDEC TO-3 outline dimensions.

SAFE OPERATING CURVES



Features of Delco's new DTS-4066, 4067, 4074, 4075 Darlingtons.

- ☐ **Upgrade existing motor speed control horsepower ratings.**
- ☐ **Reduce need for paralleling in new systems.**
- ☐ **Offer switching speed improvements over our earlier types.**
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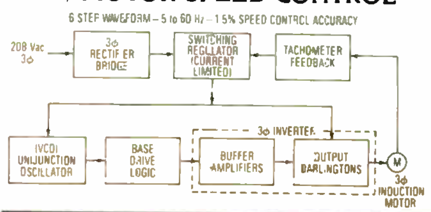

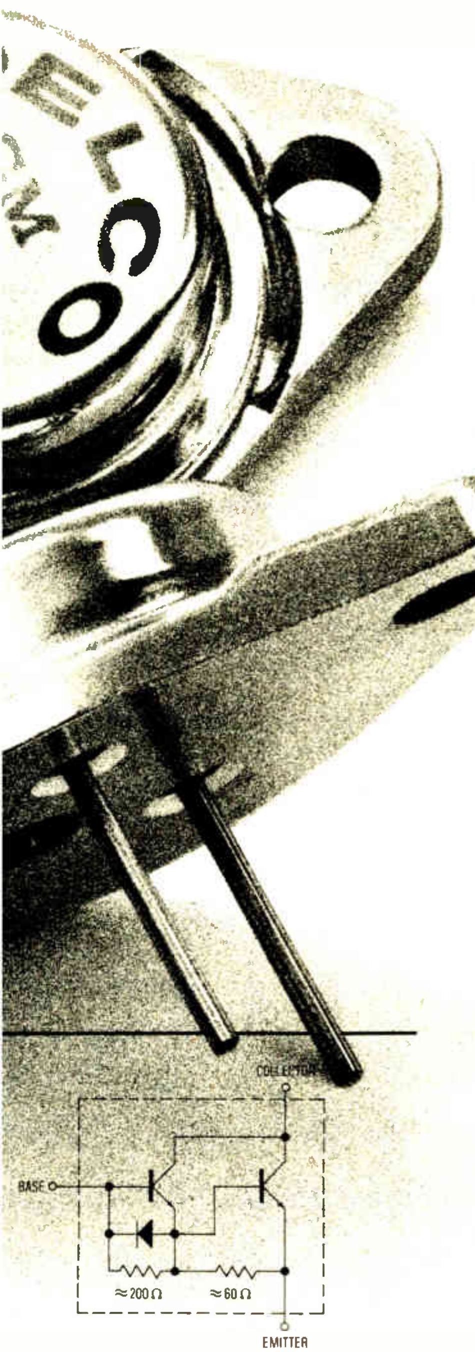

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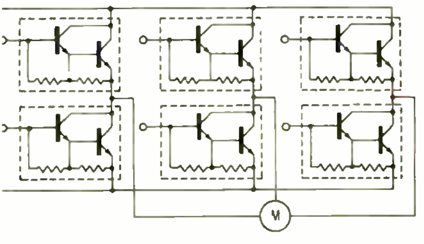
DTS-4066-4067



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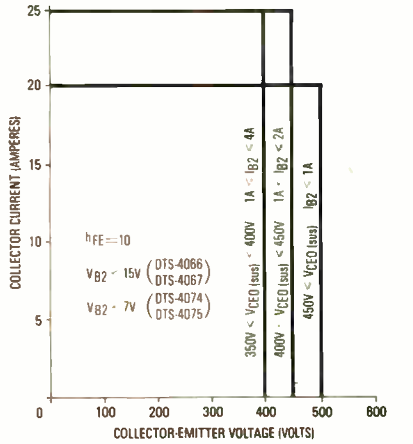

Delco Electronics
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Circle 44 on reader service card

Under New

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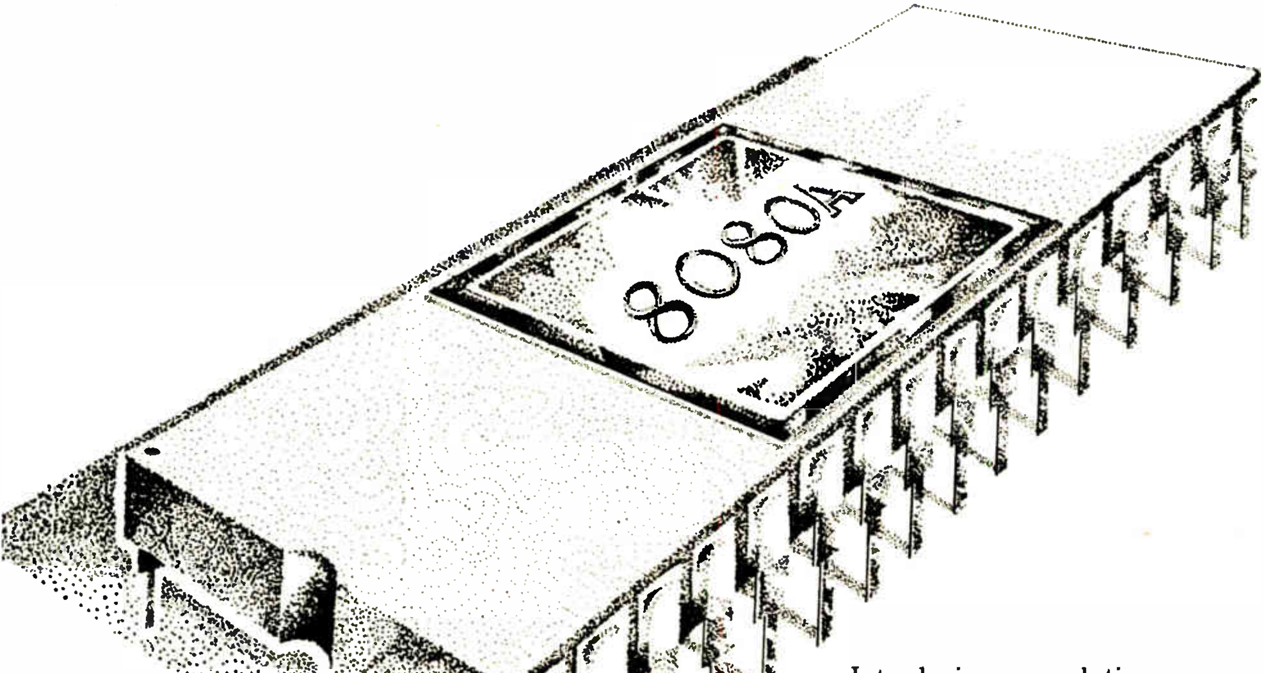

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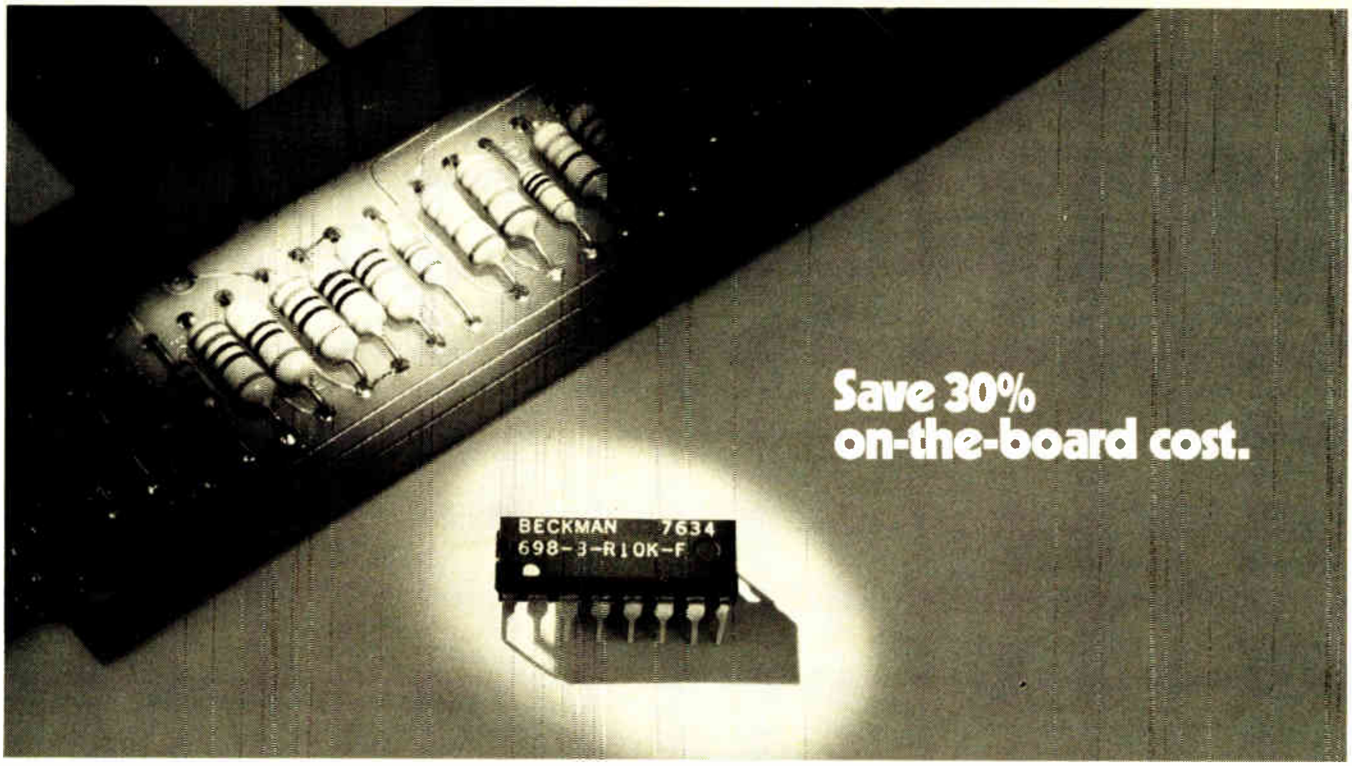

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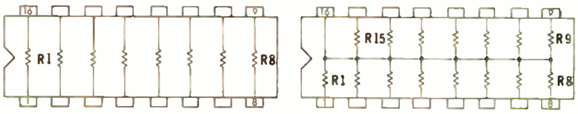

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Independents dispute AT&T's $1 million lobbying costs

American Telephone & Telegraph Co.'s disclosure that it spent $1.04 million in three months lobbying for passage of the Consumer Communications Reform Act of 1976 **is being questioned by an "outraged" North American Telephone Association,** independent makers of telephone equipment. Citing AT&T's "massive" congressional lobbying effort, NATA asked "if this is the total quarterly expenditure incurred by Bell" in the April-June period covered by the company's report to the Federal Communications Commission.

The report is the first to the FCC since the Common Carrier Bureau ordered AT&T and its subsidiaries to separately report lobbying expenses on the company-sponsored bill to limit telecommunications competition. It will be reintroduced next year. AT&T expects to report lobbying outlays for 1975 and the first 1976 quarter soon. Apart from NATA's criticisms, the report received little notice in Washington because it came in the final week of the Presidential election campaign.

Trade balance drop seen steeper in second half . . .

The 40% decline in America's favorable electronics trade balance to $818 million just posted for the first half of 1976 **is expected to be even larger in the second.** Commerce Department trade specialists privately estimate that consumer electronic imports, mostly from Japan, continue to rise sharply (see p. 36). "They are more than offsetting our exports gains in computers, components, and military hardware," says a Federal analyst. First-half imports rose 58% to $3.12 billion from 1975, while exports of $3.94 billion reflected an increase of only 18%.

. . . despite gains in exports of components, EDP

First-half component exports **climbed 30% from last year to $1.26 billion** compared to a 45% rise in imports to $746 million, according to new Commerce Department figures. Computer exports rose 11% to $1.22 billion against $83 million in imports, up 32%. The commercial/industrial/military category posted a 26% rise to $609 million compared to a 53% imports gain to $317 million. A 20% increase in medical electronics exports to $115 million was partially offset by $89 million in imports, up 11%. Telephone- and telegraph-equipment exports of $112 million were up 12%, while imports dropped 2% to $48 million. But test and measuring equipment shipments fell more than 7% to $238 million, while imports rose 14% to $82 million. Calculators again posted a negative trade balance of $54 million, more than double last year's as imports rose 4% to $169 million and exports dropped 16% to $115 million.

Tougher scrutiny of military R&D sought in Congress

With an eye to earlier identification and termination of failing high-risk R&D programs, the new Congress will be asked to give tougher scrutiny to military and space R&D plans next year. That's one major proposal expected to come out of a new 115-page analysis for the Joint Economic Committee's subcommittee on priorities and economies in Government. Nearly $15 billion will be spent in fiscal 1977 on military and space R&D, about 63% of all federal R&D outlays.

Sen. William Proxmire (D., Wis.), subcommittee chairman who won reelection handily last week, said the studies identify **"serious and startling shortcomings"** in the allocation and expenditure of Federal R&D funds. The study challenges congressional funding of large projects without a clear understanding that the potential or actual benefits are worth the costs, the low termination rate of high-risk programs which have an acknowledged success rate of only about 10%, and the failure of the R&D community to "come up with scientific tools for measuring R&D results."

Tunney loss seen easing pressure on surveillance

Most Washington representatives of electronic intelligence and surveillance equipment makers are feeling less defensive about the release by November's end of a 1,000-page Senate subcommittee report. The document is expected to be **highly critical of surveillance technology and its possible threat to individual citizens' liberties.** The reason for their change in mood: Sen. John V. Tunney (D., Calif.), chairman of the Judiciary Committee's constitutional rights subcommittee and champion of the report calling for tighter industry regulation, was defeated in his reelection bid. Nevertheless, industry officials await the report in order to examine its section of the state of technology dealing with electronic eavesdropping, data processors, sensors, optics and imaging, including night vision.

Retailers urge shared, low-cost EFT terminals . . .

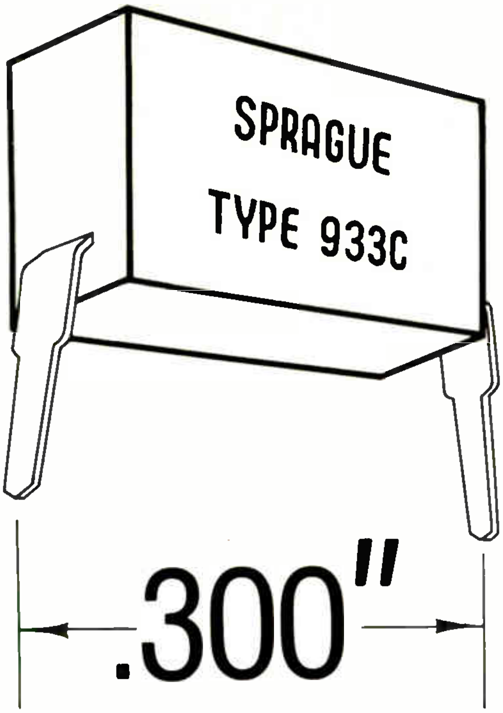
The nation's retailers say they expect bankers to share access to the hardware in their stores and pick up the operating costs if electronic fund-transfer systems are to succeed. The warning was delivered to the National Commission on Electronic Fund Transfers by the American Retail Federation during four days of hearings recently concluded in Washington. **The retailers "oppose the proliferation of hardware in our stores,"** and are convinced that "both the retail industry and consumers will reject EFT if its costs exceed those of existing cash, check, or credit sales."

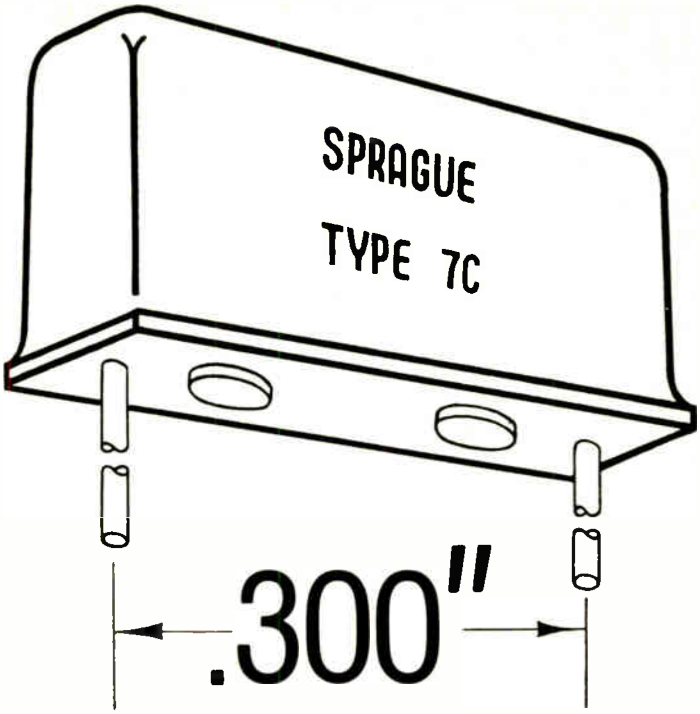
Most bankers agreed EFT technical standards should be permitted to evolve after deployment of terminals in the marketplace, rather than be framed beforehand in anticipation of abuses. That was the view presented by the American Bankers Association to the commission and supported by former U.S. Comptroller of the Currency James E. Smith in a call for more marketplace experience. But it was sharply disputed by several citizens' rights organizations who urged greater protection for privacy of customer data in EFT systems. The commission is pushing to make a preliminary report to Congress by February in order to begin framing EFT legislation, even though it has until October 1977 to complete its final report.

. . . while bankers contest commission on new rules

The National Commission on EFT wants legislation freeing systems from restrictive Federal and state legislation regulating terminals as "branch banks" [*Electronics*, Oct. 14, p. 50]. **But that is opposed by mutual savings banks,** which see an unbeatable competitive threat from "multibillion institutions that might literally flood an area with electronic terminals and be able to shrug off resultant losses if they occur."

While banks dispute the nature and extent of regulation, savings and loan associations are gaining valuable EFT installations and experience. Since S&Ls got initial approval two years ago for EFT systems, the U.S. League of Savings Associations say its 4,500 members have 23 projects under way. Of the 1,368 terminals involved, about half are installed and operating. Twelve projects with 336 terminals are proprietary, while the other 11 involve 1,032 terminals shared in varying degrees by 167 S&Ls and 17 other institutions.





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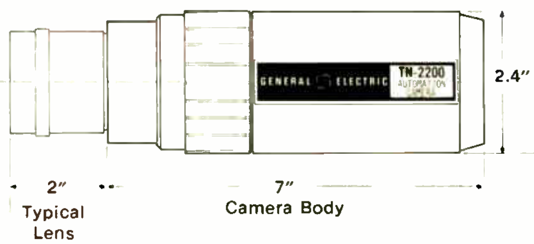

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GENERAL ELECTRIC

I^2L chip, started in Japan, provides phase-locked loop for citizens' radio

Integrated injection logic is used in a phase-locked-loop frequency synthesizer that contains all frequency-determining circuits for single-crystal control of a class-D citizens' band radio, except for the voltage-controlled oscillator and the low-frequency-loop amplifier. Because of the versatility of the XC3390P I^2L chip, initiated by Motorola Semiconductor Products Group applications engineers in Tokyo, many of the peripheral components needed with competitive complementary-MOS devices are eliminated.

Even though the device integrates high-speed and high-density logic on the same chip with linear functions, it is inexpensive because it is processed on the same line as the company's low-cost linear integrated circuits. Use of a 24-pin dual in-line package with same 0.3-inch spacing between lines of pins as packages with a smaller number of pins minimizes the space requirement and maximizes cost-effectiveness.

Operation. The basic design of the new device was developed by Motorola applications engineers in Tokyo, working with their customers. Development of the device, especially for the 40-channel transceivers to be used next year in the U.S., was completed by Motorola engineers in Phoenix, Ariz.

The phase-locked-loop frequency synthesizer operates in double-superheterodyne CB radios with intermediate frequencies of 10.695 megahertz and 455 kilohertz. In the transmit mode, the XC3390P generates the exact channel frequency. In the receive mode, it generates a frequency that is offset from the channel by the first intermediate frequency. A fixed 10.24-MHz frequency converts the first i-f to the second i-f in an off-chip mixer.

Like many other PLL chips, the Motorola device divides the frequency from the reference oscillator down to 5 kHz in a fixed-ratio divider. Also, the frequency of an operating channel, derived from the voltage-controlled oscillator, is divided down to 5 kHz in a programable divider.

Comparing. The two frequencies are then compared in a phase comparator off the chip, which generates a correction voltage to maintain the VCO at the precise frequency of the channel. An internally generated out-of-lock signal is applied to the linear gate, and it effectively turns off the output at the exciter-output pin of the synthesizer chip to prevent out-of-band radiation during the initial look-up time.

The Motorola I^2L chip differs from most competitive devices in that it uses a crystal of 30.72 MHz rather than the usual 10.24 MHz. Two emitter-follower-logic prescalers on the chip separately divide the crystal-oscillator frequency by two to obtain 15.36 MHz and three to produce the 10.24 MHz. The frequencies are divided at a low level on the chip. The 10.24-MHz signal is divided in a binary counter by 2,048 to produce 5 kHz as one input to the phase comparator. □

Around the world

German coupler aligns optical-fiber ends

Researchers at West Germany's AEG-Telefunken have built several experimental connectors that align the ends of optical fibers accurately enough that the plug of one fits into the socket of any other. The connectors hold coupling losses to less than 0.4 decibel for multimode fibers with a core diameter of 45 micrometers and outer diameter of 130 μm. The fiber ends are cemented in V-grooves cut longitudinally to the centers of two steel cylinders that form the plug and socket.

The fibers, flush with the ends of the cylinders, are automatically aligned when the ends of the plug and socket are held in place by an overlapping cylindrical pin, which has one flat side to align the V-grooves of the two parts. The pin is fastened to the cylinder in the plug end, and a spring in the socket end opposite the V-groove forces the cylinder against the pin. The tolerance is controlled by the accuracy of the V-groove angles, rather than other physical dimensions.

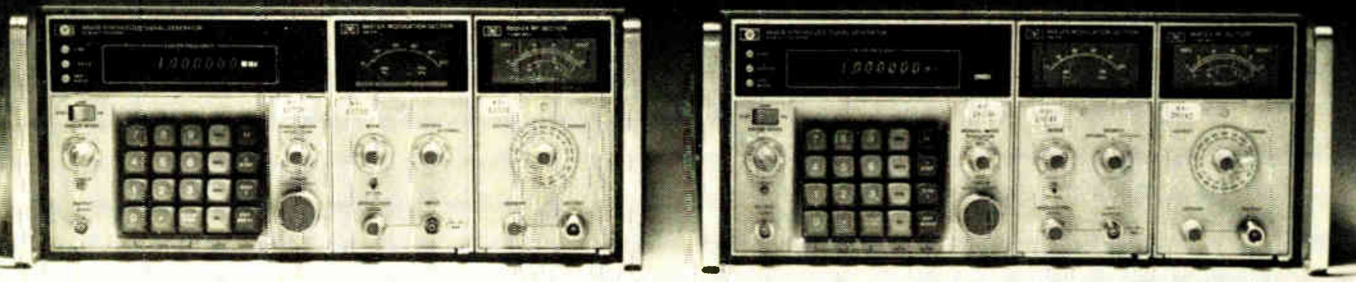
Sony PCM adapter adds hi-fi to video recorder

An experimental pulse-code-modulation adapter can convert a home or industrial video-tape recorder into a stereo tape deck that performs better than the finest professional product. Japan's Sony recently demonstrated the adapter at the International Audio Fair in Tokyo and plans to produce it during the second half of 1977 at roughly the same price as a home VTR—about $800. The attachment should provide outstanding reproduction when connected to the video terminals of any VTR, but Sony will guarantee performance only when it is used with the company's own recorder.

Best results are obtained with commercially recorded tapes, the firm says. However, standardization both of the VTR and the PCM recording technique may be required to build a commercially viable market for prerecorded tapes. The adapter/VTR combination plays back with a dynamic range of 85 decibels for program material it records and 95 dB for commercially recorded tapes. For operation at 0.1% harmonic-distortion level, these values are 40 dB and 50 dB, respectively—better than those that open-reel tapes can achieve. The system can provide harmonic distortion of 0.03%, better than the most expensive professional analog tape recorders.

You can buy this signal generator for a 3-month job, and then let it gather dust.

You can rent this signal generator for a 3-month job, and return it when you're done.



When you buy electronic test equipment for a short-term project, you're stuck with the equipment after the project is completed. Maybe it'll sit around gathering dust and costing you money. Or maybe you could sell it at a loss.

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Circle 54 on reader service card

Quality stressed in Japan's program to bolster defense . . .

Japan is stressing quality rather than quantity in its upcoming national defense program, which begins March 31 at the end of its fourth five-year plan. **One reason for the change is that the government no longer envisions a steady increase in numbers of weapons;** in fact, the number of operational aircraft is expected to decrease from about 490 to 430 because of the withdrawal of F-86 fighters, which are of Korean War vintage.

What's more, the program's provision for a new budget each year minimizes the chances for unreasonable reductions, which in the past have been forced by opposition parties because the entire budget had to be approved in the first year of the plan.

. . . and plan favors U. S. warplanes

U.S. aircraft are expected to be selected to fulfill Japan's latest five-year plan. The new mainstay fighter, probably the F-15 from the U.S., will be selected late this year or early next year. **The fighter is included in the authorizations for 10 squadrons of interceptor units, three squadrons of support fighter units, and one squadron of air-reconnaissance units.** Also authorized is a squadron of early-warning aircraft, which may come from the U.S.

Plessey speeds up ECL line at same power levels

The popular fast emitter-coupled-logic families are about to get even speedier siblings with the same power levels from Britain's Plessey Semiconductors. The first product in the Plessey ECL-3 family is the SP1660F dual four-input gate that is three times faster than standard devices. It has a gate delay of 500 picoseconds with a power dissipation of 200 milliwatts. Targeted applications are instrumentation, nucleonics, and pulse-code-modulation communications links. Still under development is the SP 10131, an ECL 10-kilobit dual-D flip-flop that quadruples the clock rate to 750 megahertz.

Plessey says the higher speed of the device comes from improving its own Process 3 to dope a fully implanted transistor with arsenic that way, it can get well-defined structure edges. Also made by the same process is the SP8619 1.5-gigahertz divide-by-four counter with guaranteed performance from 0°C to 70°C.

Nordmende markets TV games in color from West Germany

A new color television set featuring built-in games and a novel wired-in electronic-photocell rifle is being pushed by West Germany's Nordmende. The 26-inch Nordmende set, called Spectra-Color-Teleplay, provides six different ball games—squash, tennis, soccer, ping pong, hockey, and jai alai—and four shooting-type games—fox hunt, combat shooting, rabbit chase, and pigeon shooting. For the shooting games, the rifle is connected to the set.

The game module, designed around an integrated circuit from General Instrument Corp., is built into the receiver and connected to the video input. **Spectra-Color-Teleplay models cost only $80 more than Nordmende's standard 26-inch color sets.** .

Uncertainty clouds CDC computer sale to mainland China

Although President Ford has approved the sale of two Control Data Corp. Cyber 172 computers to the People's Republic of China, [p. 36], officials of Control Data France remain worried that the new Carter administration might delay or scrap the deal. And the Paris-based International Coordinating Committee for exportation to Eastern Countries still must approve the sale of the computers [*Electronics*, Oct. 14, p. 55].

Control Data France, which is furnishing the computer network in collaboration with France's Compagnie Générale de Géophysique, **hopes that Cocom approval will come by the end of this month and that the first computer will be delivered to Peking by the end of the year.**

Japan urges makers of VTRs to adopt standard products

The Japanese government has applied pressure to the country's manufacturers of consumer video-tape recorders to adopt an industry-wide standard so that a tape made by any of them will play on any recorder. Although the Ministry of Trade and Industry has unofficially urged the companies individually to standardize, this is the first "administrative guidance." MITI **officially called together executives of 13 manufacturers Oct. 28 and urged them to begin work as soon as possible on a new generation of compatible products and stop the proliferation of noncompatible ones.**

The three leaders in the sales race—Sony, Matsushita, and Japan Victor—are expected to intensify their sales effort to grab a dominant market share. If one of these systems is chosen for production and sale by a company not yet in the market, such as Hitachi, the standard could be virtually set. **Still, it may take several years to make agreements on a single design, work out a way to share patents, and formulate a policy with respect to present incompatible equipment and tapes.**

Philips color-TV concept extended to 20-inch tubes

Now that the Philips-developed 20AX self-converging beam system [*Electronics*, Aug. 8, 1974, p. 120] is being used on 18-, 22-, and 26-inch color-television tubes, the Dutch company and its subsidiaries are also gearing up for production of 20-inch versions. **The 20AX tube concept has become the dominant one in Europe since it was introduced about two and a half years ago,** and it is gaining in Asia, Latin America, Australia, New Zealand, and South Africa. The guarantee for color tubes using it has been 134reased to three years in Germany, says Philips subsidiary Valvo GmbH in Hamburg. Philips has nine factories producing color-TV tubes and three making tube-deflection units.

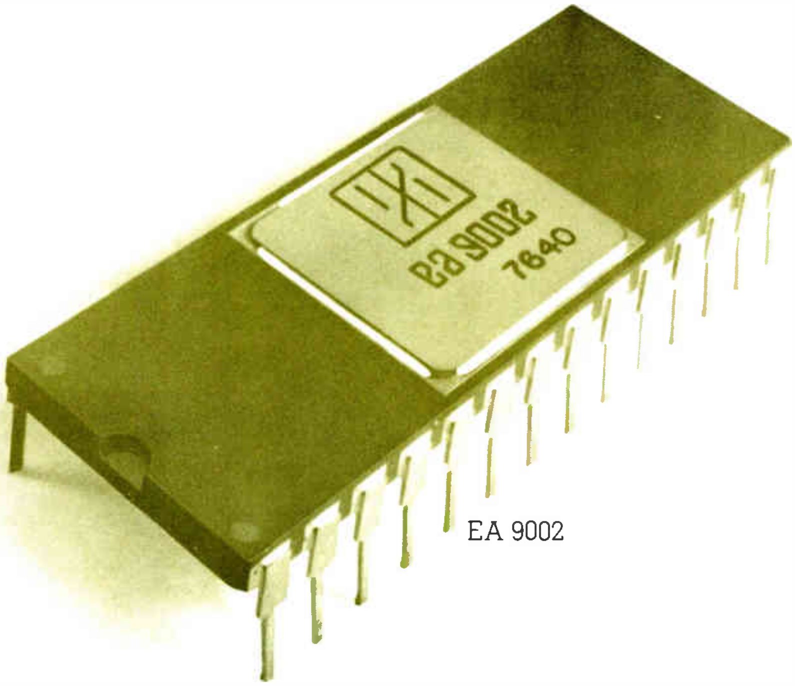
ICL system chosen by European Economic Community

The European Economic Community commission has decided to install a computer system from Britain's International Computers Ltd. at its data center in Luxembourg. The ICL 2980, chosen to meet needs of the center, which are growing about 25% annually, will replace existing equipment from Cie. Internationale pour l'Informatique of France and IBM of the U.S. **The complete system will rent for $225,000 to $245,000 a month.** For several weeks, the commission has leaned toward the ICL system, even though it is fairly new, and despite reports that a similar installation at the European Space Research Organization center at Darmstadt, West Germany, has been having software problems.

At last. A μP built for engineers!

Programmers have had it all their way too long.

The Chip.



EA 9002

electronic arrays

This new engineer-oriented 8-bit microprocessor is both simpler and more economical. The EA 9002 is designed for hundreds of real-time, real-world jobs that engineers used to tackle with hard-wired logic. Systems to do most of these jobs can be built with fewer components and at lower cost than is possible with other μPs.

It's easier to understand.

Easier to program.

Easier to interface because it connects directly to standard ROMs, PROMs, RAMs, I/Os and MSI circuits from most manufacturers. These include the EA 4600, EA 4700 and EA 4900 ROMs, the EA 2708 EPROM, the EA 2111 RAM, et cetera.

We designed the EA 9002 especially for small-to-medium data and process control applications. Like smart instruments. Data collection terminals. Peripheral controllers. POS terminals. Elevator controls. Video games. Machine tool controls. Electronic scales. Bottling machines. Any application that's essentially logic processing and control.

We gave it all these advanced features to make it simple to use:

A 512-bit RAM right on the μP chip. (So you may not need an external RAM at all.)

Binary and BCD arithmetic instructions. (With built-in decimal correction.)

A 28-pin package in place of the usual 40-pin DIP. (That tells you it's got to be simpler—and cuts the cost too.)

A single +5v supply requirement. (Just like TTL.)

Standard TTL inputs and outputs. (So you can interconnect directly from the μP to any standard TTL logic.)

A single-phase clock input (For more simplicity.)

A 2 μsec fetch and execution time. (So the speed is there if you need it.)

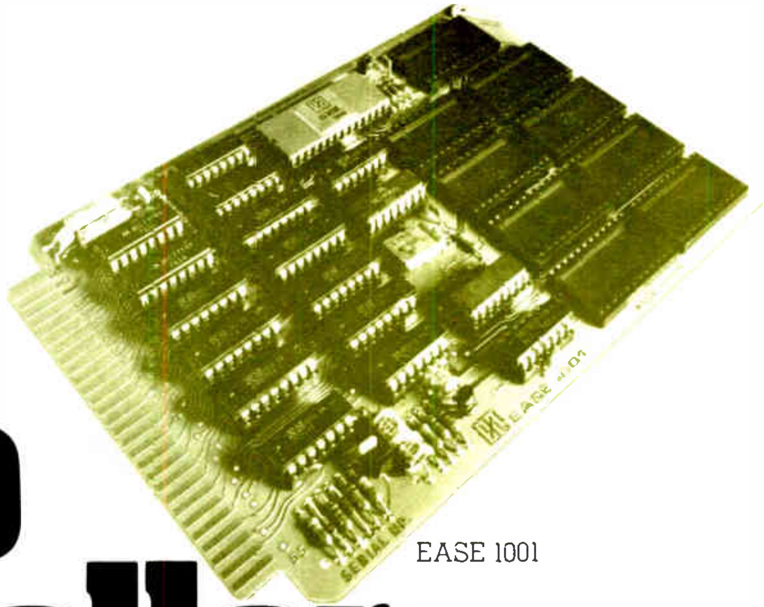
Simple as it is you still need software and firmware support. So we've got that all together for you too. A comprehensive user's manual. A cross assembler available on National CSS and GE time-sharing networks. A micro-controller PC board for prototyping. An emulator for software development, program edit and resident assembly. And a full-blown software development terminal with complete ASCII keyboard, CRT display, and floppy disk memory.

Here's your chance to get out from under unnecessarily complicated μP development—and end up with a less costly system as well.

EASE® μP

Circle 57 on reader service card

The Micro controller.



EASE 1001

Just plug programmed PROMs r one 16K ROM into the EASE 1001 oard to make an operational micro- ontroller. Excellent for prototypes— nd the final product in many cases.

Preconnected on the board are n EA 9002 microprocessor (with an n-chip 512-bit RAM), a clock, I/O cir- uits, and sockets for eight 1702A 2K ROMs plus one EA 4600 16K ROM.

The board interfaces directly o standard TTL circuits. Requires nly +5v and −10v supplies.

Here's a breadboard for your system already complete except for programming. It can save you weeks of development time and expenses.

We built the EASE 1001 primarily for prototyping. The design is so generalized that it works well in a great variety of applications. And many low-volume users find it economical to incorporate this board into their final system.

If you load the board with eight 1702 erasable PROMs, you get 2048 8-bit bytes of program memory. Anytime you're ready, this memory can be replaced with a single economical EA 4600 mask-programmed ROM.

There are two 8-bit TTL input ports (16 terminals) and three 8-bit TTL output ports with latches (24 terminals).

The board has a crystal-controlled oscillator allowing an instruction execution time of either 3.2 or 6.4 μsecs for 1-byte instructions.

The EA 1001 board helps you realize the full potential of the EA 9002 microprocessor. Helps you build complete μP systems, quickly, simply and economically.

and

Circle 57 on reader service card

EASE 2000

The Emulator.

This $995 emulator makes programming easy and inexpensive. Costs only a fraction as much as equipment with comparable capability. And it's the only hardware/software development system that's complete in one stand-alone desk-top machine.

The EASE 2000 is an in-circuit emulator that you can wire right into your system to see how it works. The emulator uses the same components as your final system — except it has RAM where ROM or PROM will be.

You can program with simple hexadecimal object code. Or plug in an optional $250 assembler and program with instruction-set mnemonics through a TTY terminal.

The EASE 2000 has keyboards for both control and data entry. It can also be loaded and dumped via an ASR33 TTY terminal. A built-in hex LED display indicates keyboard entry, a 3-digit address, and 2 digits for data bus contents.

The emulator operates in two basic modes: either EXECUTE or EDIT. In the EXECUTE mode, the program may be run at normal clock speed, stopped automatically at preset breakpoints, or stepped through one instruction at a time while displaying the current address and data status.

In the EDIT mode you may read, modify or write into program memory and microprocessor memory locations as defined within the editor software. All EDIT operations appear in the LED display.

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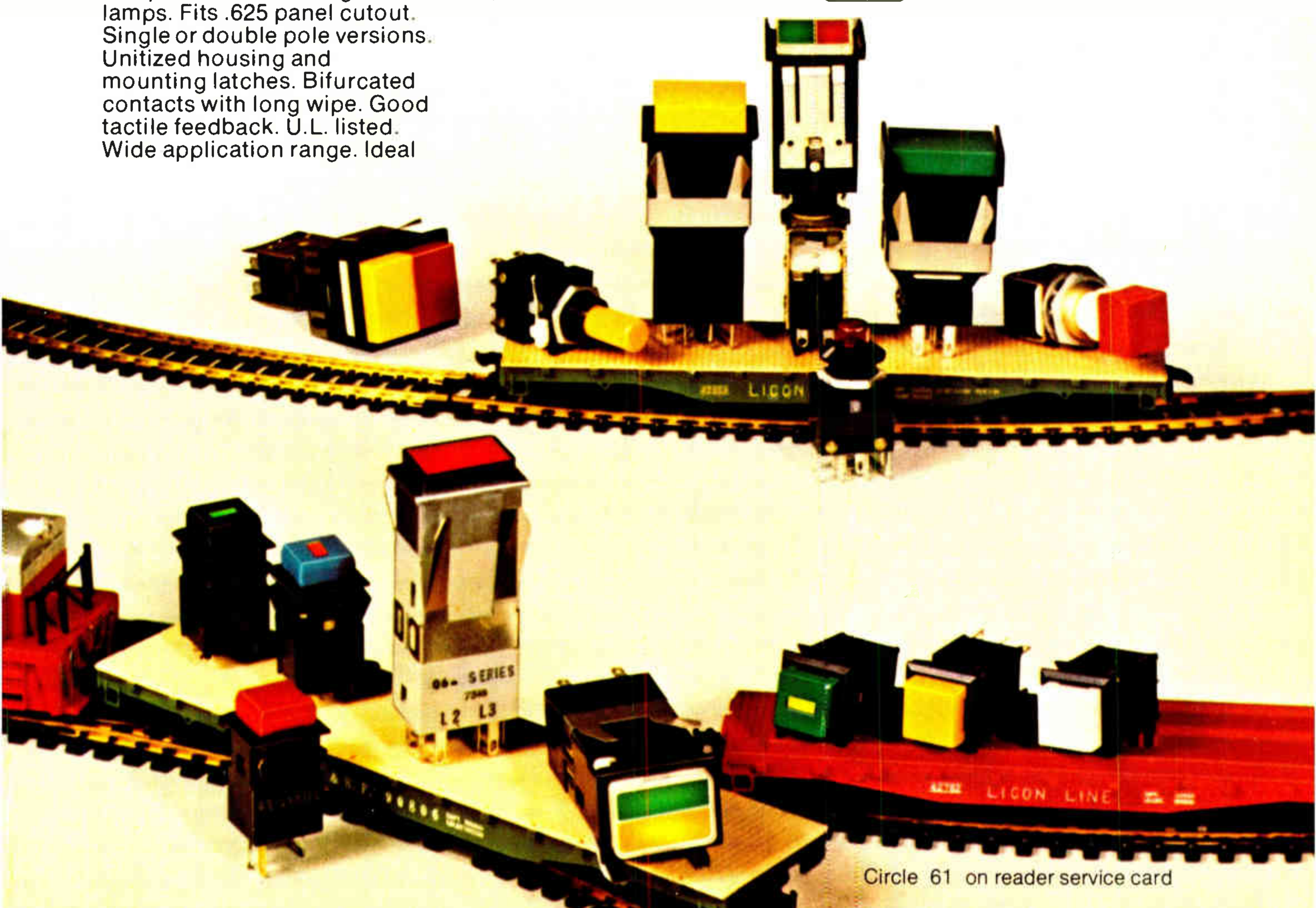

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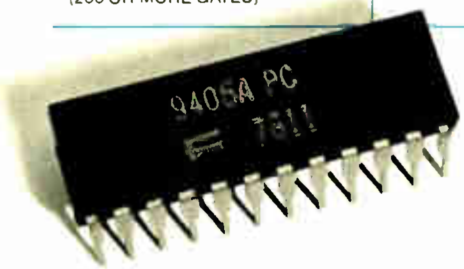

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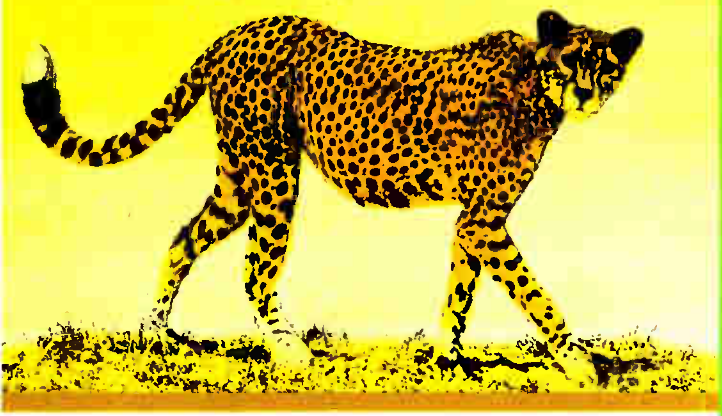

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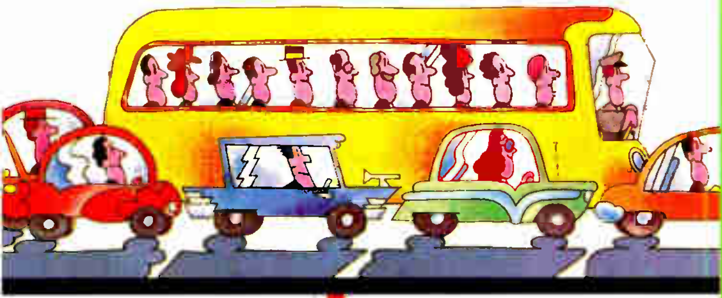

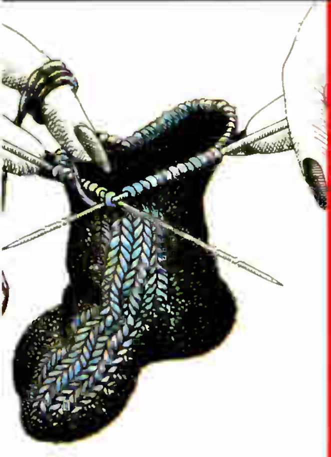

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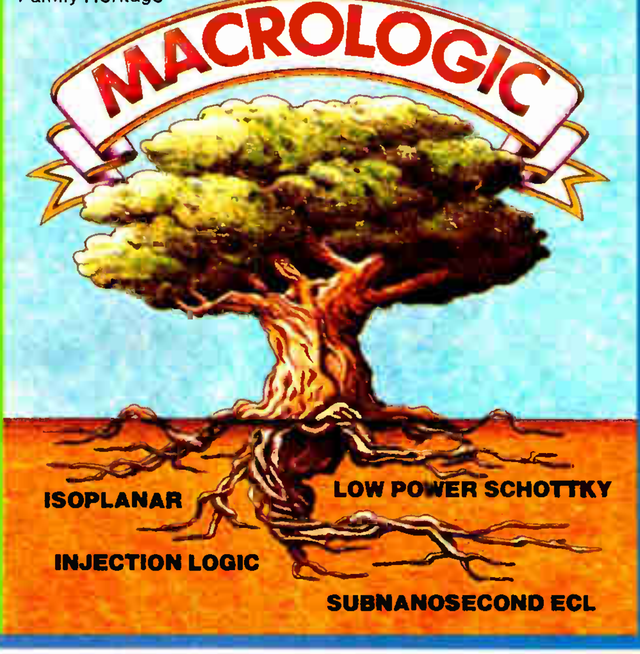

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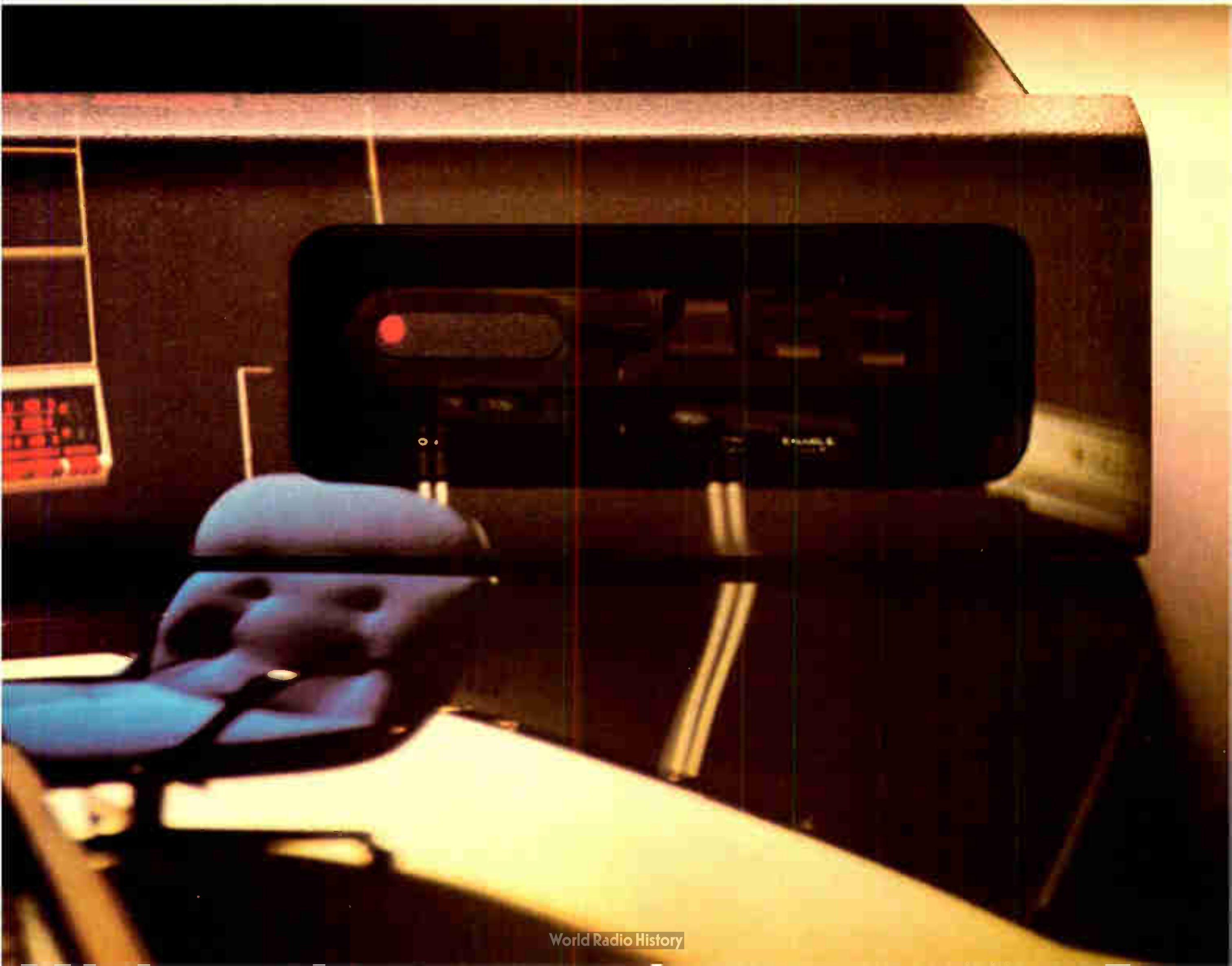

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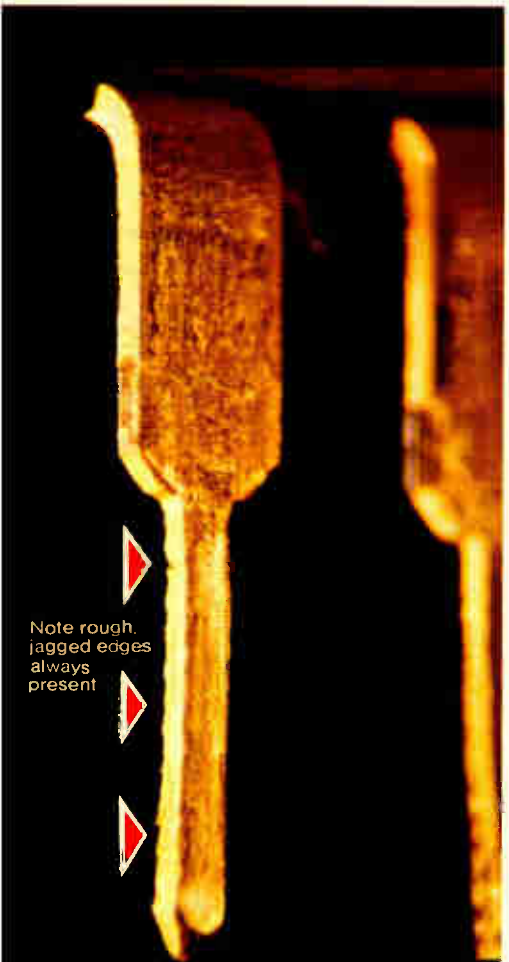


Your IC lead frames look like this at 30X enlargement (unretouched). Because they are punched out of metal, the edges are rough, jagged and irregular. In contrast, the flat sides of the lead frame are smooth, even and perfectly plated.

Arrows indicate scars and abrasions made by rough edge of lead frame.

22X magnification, unretouched.

THEIRS

An ordinary edge-bearing socket contact after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. Notice how the contact has scars and abrasions from *rough, irregular edge of IC lead frame*. Electrical contact is degraded and resistance is increased. Reliability is obviously reduced.

Lead frame in place in an ordinary edge-bearing contact.

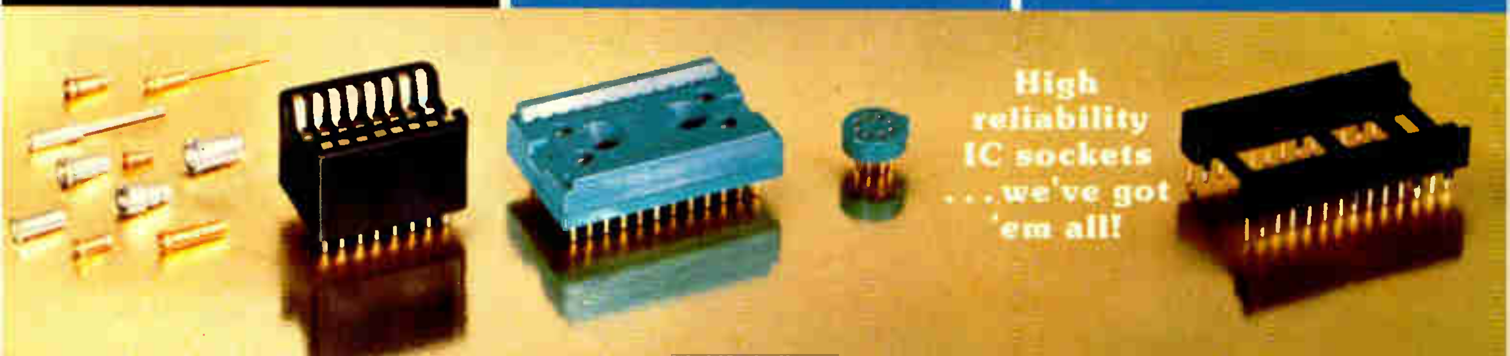
Arrows indicate contact surface still smooth, clean, free from abrasions.

22X magnification, unretouched.

OURS

ROBINSON-NUGENT "side-wipe" socket contact after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. See how the RN contact—because it mates with the *smooth, flat side of the IC lead frame*—retains its surface integrity. This 100% greater lead frame contact results in continued high reliability.

Lead frame in place in RN "side-wipe" contact.



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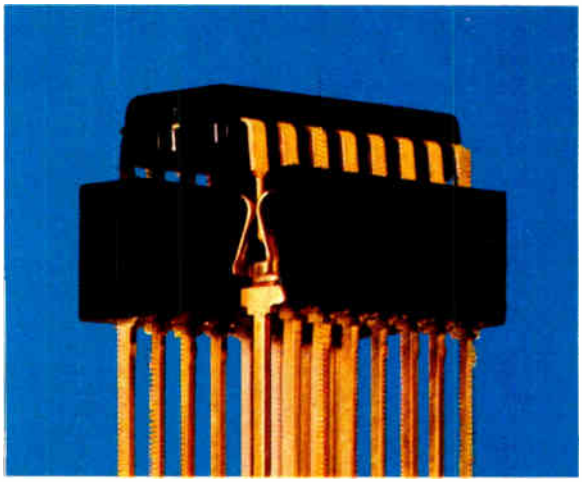

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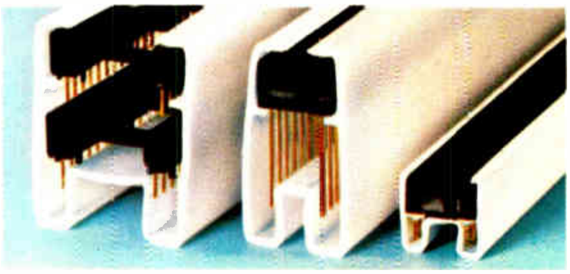

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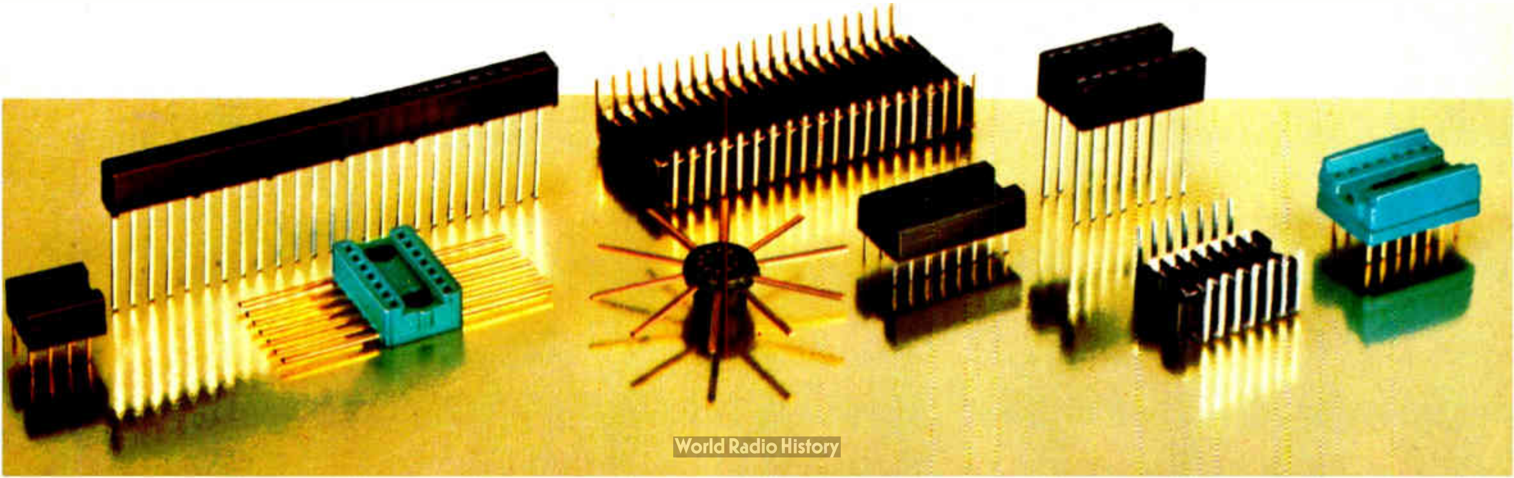
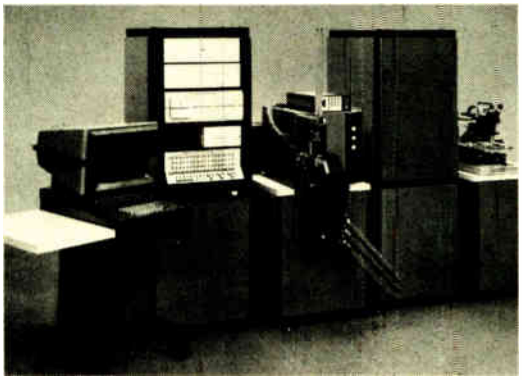


THE J387: WHEN PRODUCTIVITY COUNTS.



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For people with memory problems cut this out and save.

Manpower forecasts need surgery

Experts agree that engineer demand studies are useless, but that fresher and better data could improve them

by Bruce LeBoss, New York bureau manager

Are existing forecasts of engineering manpower needs accurate and scientific? The answer from experts is no—but, they add, while such studies will never be perfect, improved data and methodology could make them better and more useful.

Authorities in the field agree that the forecasts share major faults. Among them:

- They're based on information that is outdated.
- They fail to consider market forces.
- They don't allow for short-term economic changes.
- They ignore regional and international factors.
- They are inaccurate when based on hiring plans, because employers tend to be secretive.

The result is that persons, particularly in engineering schools, using demand studies may be misleading students about career opportunities. That has been a major complaint about data furnished by the Engineering Manpower Commission in New York [*Electronics*, Sept. 16, p. 75], a research arm of the Engineers Joint Council that is supported by 36 professional societies. But other professional groups, industry associations, and government agencies share the guilt, and several of them are beginning to move toward remedies. The IEEE, for one, has a task force that will begin writing a report this month on what data it must have (see "The IEEE steps in," p. 70).

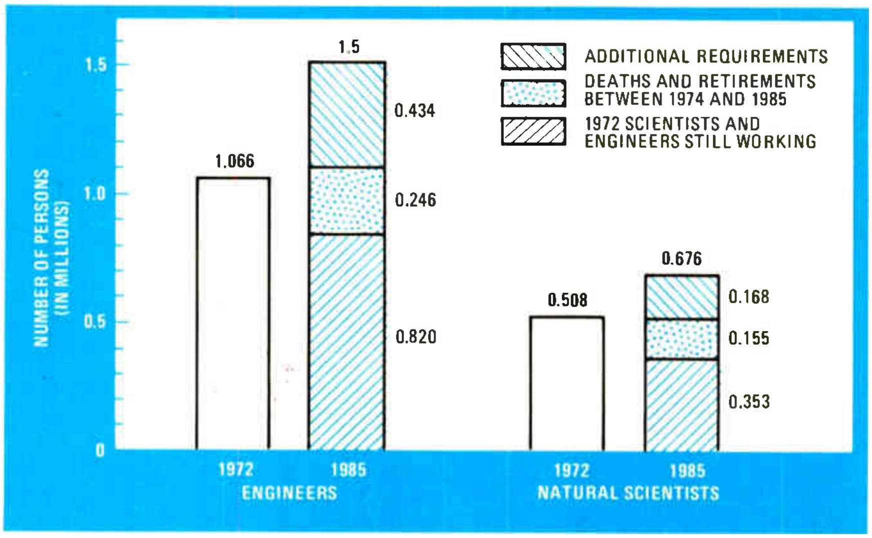
Until reforms are made, statisticians and economists will remain dissatisfied with demand surveys. Perhaps summing up the views of his colleagues is Eli Ginsberg, professor of economics at Columbia University's Graduate School of Business and chairman of the National Commission on Manpower Policies.

"My general view of all demand studies is that they're not worthwhile. I'm unenamored by all of the high-powered model analyses. They're a lot of garbage," he asserts. Nonetheless, "this doesn't mean that they shouldn't be done, but that they should be both done and used with caution and restraint."

A good system of forecasting, according to Herbert Bienstock, New York regional commissioner of the Bureau of Labor Statistics, has to be revised frequently. "These kinds of regression forecasts have a Maginot Line aspect to them, as we are projecting on a number of givens and assumptions that are subject to change," he says. While certain assumptions tend to remain static, others are subject to change given a different set of energy, ecology, and occupational safety and health policies, or a change in technology, administration, or regional movements, he notes.

In the engineering field, Bienstock adds, "we have been through a number of forecasting disasters. Today's job openings are not tomorrow's job opportunities, and tomorrow's job opportunities don't relate to growth alone but substantially to replacement needs." Generally, short-term forecasts (one to three years) tend to miss the mark more than long-term forecasts for obvious reasons, he says. "The economic level for the short term is unpredictable and subject to change. The level of economic activity is not well projected, and it's the most significant factor in any short-term forecast."

Bienstock feels short-term forecasts are just a springboard off the



Slowdown. Typical demand chart, based on Bureau of Labor Statistics data, indicates slower growth in demand after 1980 than in the period leading up to that year.

The IEEE steps in

For the IEEE, what's needed in projecting demand is breadth. John Kinn, the institute's program manager, says that the only way to do a good job of forecasting would be to first get a census, rather than just a sampling of industry and government inputs.

Not many of the companies sampled in the manpower-demand studies by the Engineering Manpower Commission were employers of electrical and electronic engineers, he notes. "We would get a much clearer picture of what's happening in our industry if there was a broader sample by disciplines. It's also important that someone look back to see how the forecasts compared with the actual demand. Otherwise, the demand study might just be an exercise in futility."

Meanwhile, the IEEE has formed a task force that is studying the manpower situation and will begin writing a report this month on what manpower data it thinks the institute should have. Ross Stander, project manager of the task force and manager of microprocessor product planning at RCA Corp.'s Solid State division in Somerville, N.J., says, "We should start giving more realistic projections to the schools so we could control the supply." He believes the IEEE should first establish a strong data base. "Present IEEE data is very limited. It's restricted only to members and not all of them at that."

Stander's task force will recommend that the IEEE make good use of its annual dues mailings. The first mailing, he says, could be broader and include a list of questions to be filled out that would provide data on the specific fields in which engineers are working. "This would establish a more extensive ground zero for future forecasting studies."

basic data one has. "Projections will be no better than the basic data they jump off from. Therefore, there is a need for an improvement in the basic data." Included in such data, he says, should be better information on employment, productivity, production demand in relation to sales, as well as better updating of information of the supply side.

One of the needs for improving the basic data "is geographic disaggregation—in other words, not only data on the labor market, but data on where people live and work; a regional breakout by disciplines," adds Jesse Benjamin, chief of BLS program research. What also might help the demand picture, he notes, "is to do studies of the proportion of engineering graduates taking jobs in their major. We could then determine the number of those generally underemployed and use this as an indicator to be applied to the number of engineers coming out on the supply side."

Bad base. The National Science Foundation, whose *ad hoc* committee on manpower concluded "the data base upon which calculations are made is considered to be inadequate" and that for a number of reasons "manpower projections are tentative at best," is seeking a quantitive understanding of demand on supply and vice versa, "so that the effect of feedback can be better estimated in future projections," says Joel Barries, director of the manpower-utilization-studies group.

His organization also wants information on occupational-specific attrition rates. "We don't have good data on death and retirement rates for scientists and engineers," he says, noting that NSF's data is based on that supplied by the Bureau of Labor Statistics. "BLS has been applying the death and retirement rates for all people to its demand projections, but we believe it to be different for scientists and engineers. If so, this would have a significant impact on the supply and demand picture."

Barries sees a need for a better understanding of the market forces, as does Columbia University's Ginsberg. This could include an improvement in estimates of both demand and supply on a regional basis and how they have changed through time. "There is a tremendous elasticity in the American economy," Ginsberg says. "If we're short on engineers, we have all kinds of technicians and other people that can fill engineering jobs. And if we're long on engineers, we have ways of keeping them around in technician-type jobs. If we could get a better handle on how companies tackle their utilization problems, then we might be able to do a better job of projecting demand."

Another important consideration is national versus international engineering demands. "A multinational company surveyed may have a demand for engineers, but it may be at some facility in South America where the company has to produce its equipment to be competitive in the world market," notes Martin Hamburger, professor of education at New York University's Graduate School of Education.

"We also need to understand regional needs, such as what would occur in the New York and Los Angeles areas if there is a change in policies affecting the aerospace industry. And there needs to be a breakdown by disciplines. It can't be done by groups because that would be meaningless in a real-world situation." Of prime importance too, is that "we need a method of forecasting demand that doesn't take up the lead time to produce the people."

Change coming. Moves are coming on several fronts to change things. The Bureau of Labor Statistics has begun a Federal/state program, in which 32 states are participating, to determine how many people are employed in the various occupations. The bureau provides the states with definitions of job categories, based on the Standard Industrial Classification Code. The states then develop samples that include members of the various industry groups, mail the surveys, and expand the returns to estimate the various occupational levels.

The bureau has a request before the National Science Foundation for funds to survey those states not in the program. Its proposal is being evaluated, and observers expect it to be funded, as it would maintain NSF's data on a yearly basis.

"BLS's long-range goal is to collect data annually," Barries notes. □

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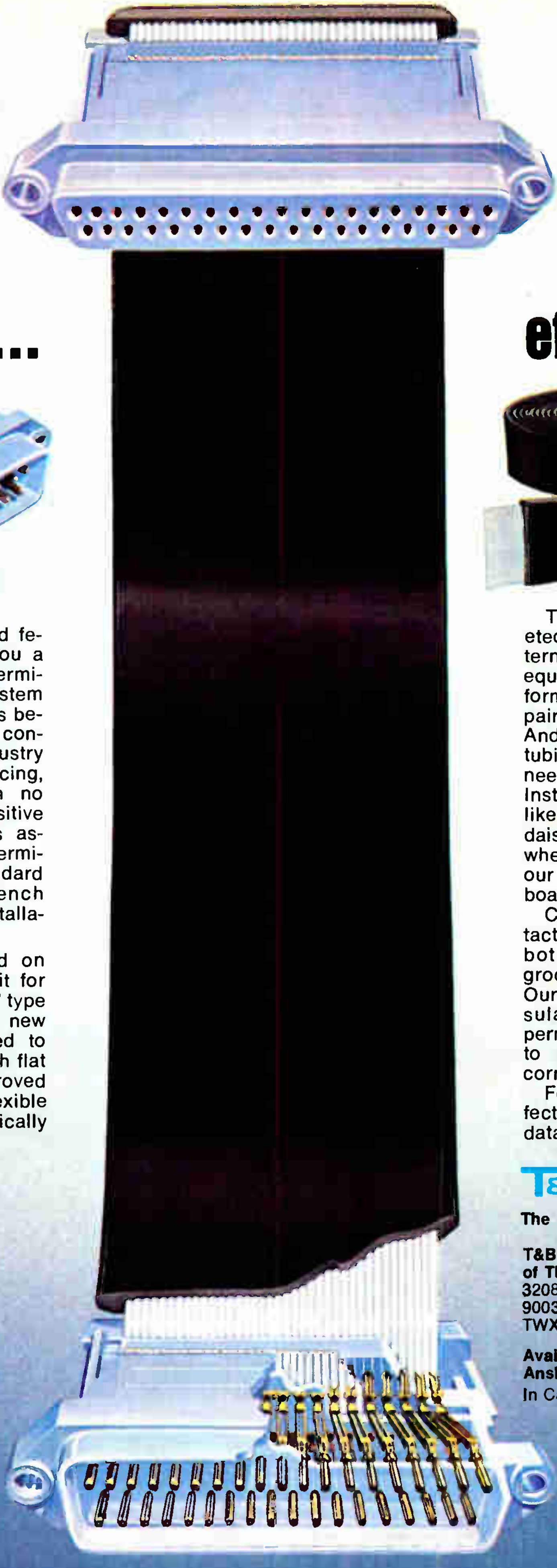

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Electronics abroad

Apprehension pervades Munich show

Manufacturers gathering at biennial Electronica agree that recovery falls short of expectations

by Arthur Erikson, Managing Editor, International, and John Gosch, Frankfurt bureau manager

In the vast beer halls of downtown Munich, the mood of heavy heartiness whipped up by the annual Oktoberfest lingers on. But at the fairgrounds, the late-November atmosphere will be charged with apprehension as Western Europe's electronics community converges there for the biennial Electronica show, Nov. 25 through Dec. 1.

To be sure, the components suppliers who dominate the show won't be as jittery this year as they were at the 1974 edition. Then, market watchers were predicting—rightly—a downturn for the year ahead.

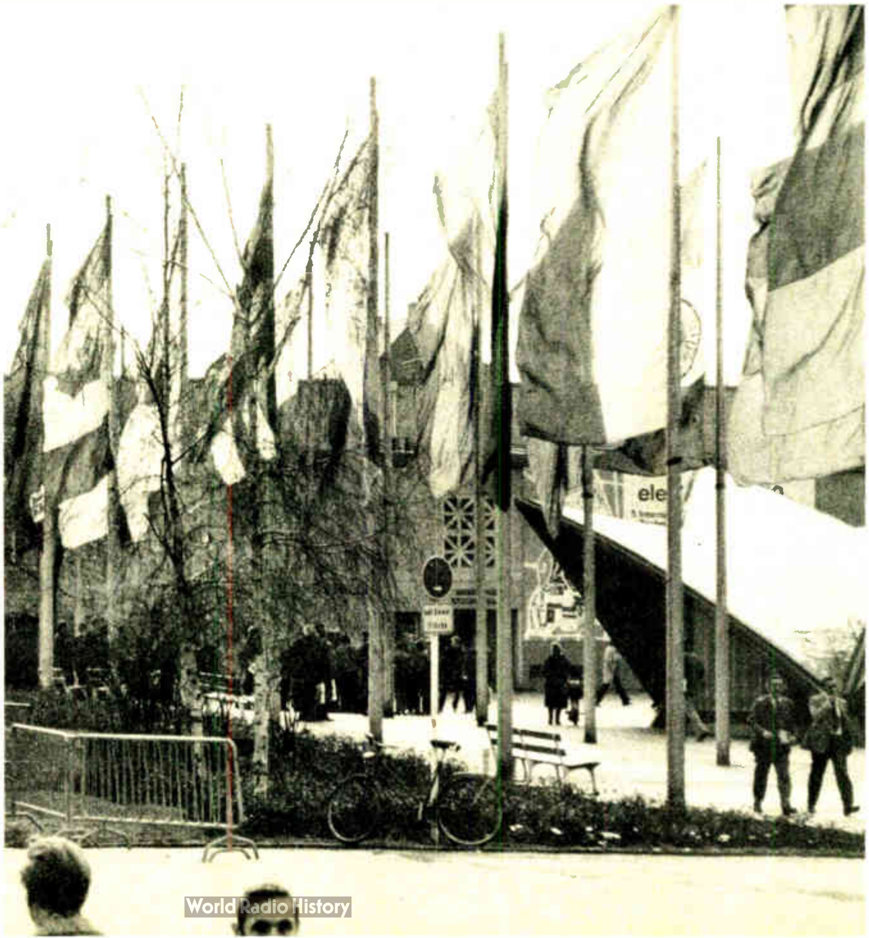
There's been some recovery from the 1975 slump, of course. But 1976 hasn't brought the boom most components makers had hoped for. "This year's expansion won't even push the components business back up to the 1974 level," points out Alfred Prommer, vice president in charge of sales at Siemens' Components division.

Against that benchmark, this year's recovery for components sales turns out to be not as solid as the figures make it look at first sight. Price rises, too, bloat the totals. Industry officials, for example, peg 1976 components consumption in West Germany at $1.63 billion, up 13% over 1975. (All dollar amounts are figured at exchange rates in effect at the end of October.) In France, the industry trade association GIEL (for Groupement des Industries Electroniques) sees a $1.17 billion market this year, up 18%. In Great Britain, the Department of Trade and Industry figures that this year's components business will run $853 million, a gain of 10%. Partial returns from *Electronics'* annual market survey indicate a rise to a $350 million market in Italy this year.

By and large, components-markets watchers figure the sales curves will continue heading upward next year as the recovery—albeit slowed—struggles on. However, Britain and Italy are beset by very shaky economies that could turn erratic. But color-TV set production this year in both countries turned out to be surprisingly high—1.45 million sets in Britain and better than 500,000 in Italy.

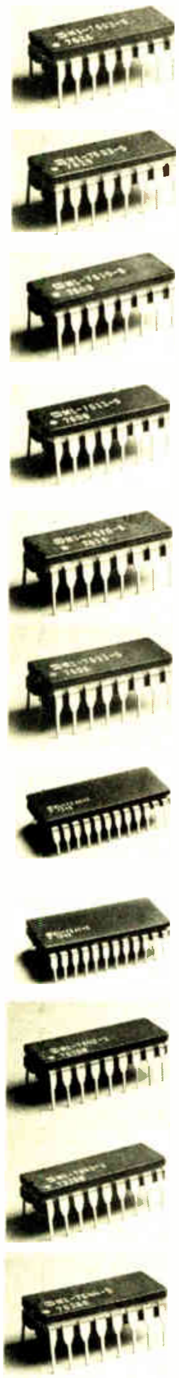
Despite less business than expected, then, in sectors like telecommunications, computers, and industrial equipment, components suppliers in both countries did reasonably well this year. So far, components marketing men are looking toward further rises next year—to something like $1.01 billion in Britain and $400 million in Italy. But either of these markets could turn sour fast.

Better gains. One thing seems sure: semiconductor makers should score above-average gains. "We see overall increases of about 22% with almost no price rise," says Piero Martinotti, marketing director for Motorola Semiconductor in Europe. In West Germany, the market



Munich in November. Scene at fairgrounds will be repeated at end of month as 1976 edition of Electronica opens.

Why Do More Top Designers Insist On Working With Harris Generic PROMs?



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✓ Harris is the only JAN-38510 QPL-1 approved PROM supplier.

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✓ HM-7642/43 (18 pin, 2 enables) extends high density packaging to large memory configurations.

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Device #	No. of Bits	Organization	No. of Pins	Max. Access Time*	
				Com.	Mil.
HM-7602 (open coll)	256	32x8	16	40ns	50ns
HM-7603 (three state)	256	32x8	16	40ns	50ns
HM-7610 (open coll)	1024	256x4	16	60ns	75ns
HM-7611 (three state)	1024	256x4	16	60ns	75ns
HM-7620 (open coll)	2048	512x4	16	70ns	85ns
HM-7621 (three state)	2048	512x4	16	70ns	85ns
HM-7640 (open coll)	4096	512x8	24	70ns	85ns
HM-7641 (three state)	4096	512x8	24	70ns	85ns
HM-7642 (open coll)	4096	1024x4	18	70ns	85ns
HM-7643 (three state)	4096	1024x4	18	70ns	85ns
HM-7644 (active pullup)	4096	1024x4	16	70ns	85ns

*Access time guaranteed over full temperature and voltage range.
Industrial (T_A = 0°C to 70°C, V_{CC} ±5%)
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Proven PROM Capability

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Visit with us at Electronica 76 Booth 16232, U.S. Pavilion should do even better. Gerhard Liebscher, director of marketing services at Intermetall GmbH, part of the ITT Semiconductor Group, puts next year's rise at 25%, which would carry the market to a level well above $550 million.

This assessment fazes almost no one. At a preshow curtain raiser, Electronica's organizers predicted that by 1980, semiconductor and electromechanical sales would match sales of passive components. Last year passives outsold semis almost two to one in West Germany.

The push, of course, will come from the consumer sector, which will gobble up more than half the semiconductors in West Germany next year. Although automobile, washing-machine, and camera makers are becoming increasingly good customers, it's the TV-set producers who buy most. And they're putting more and more semiconductor content into their hardware.

A remote-control system, Liebscher figures, accounts for roughly 18% of the semiconductors in a color-TV set. Fully 65% of the 2.8 million sets have them. Electronic content is continuing to rise as set makers add to their receivers features such as on-screen channel and time displays, digital tuning, and the like.

MOS out front. Although they still rank well below the mainstays like signal transistors and transistor-transistor logic, metal-oxide-semiconductor devices will lead the growth list next year, predicts Helmuth Schuett, a Siemens market researcher. He predicts the West German market for MOS and complementary-MOS circuits next year will be triple the 1975 level, which reached $22 million.

An even steeper rise—a quadrupling from 1975 to 1977—is in store for microprocessors. That would put the level in Germany at more than $14 million. For all of Western Europe, the figure totals some $50 million.

So it's little wonder that all the U.S. and West European heavyweights in semiconductors will be scrambling hard at Electronica to woo customers and win shares of the fast-growing market. □

The American way. Teradyne booth at 1974 show is typical of the stands of U.S. manufacturers. American firms are placed in a single area.

Semiconductors

Keeping an eye out for counterfeiters

Makers, distributors, and buyers agree that major safeguards are to know your vendor and tighten test procedures

by Larry Waller, Los Angeles bureau manager

For semiconductor manufacturers, the sale of counterfeit semiconductors ranks as the industry's most nefarious practice. Almost everyone involved gets hurt when cheap or reject parts are mislabeled or repackaged: the manufacturer whose reputation suffers; the distributor who gets blamed for handling them (often unknowingly); the buyer and the end user whose equipment might fail; and, sometimes, the counterfeiter who now and then gets caught.

With the most recent storm over counterfeiting still boiling—bogus parts were uncovered in assemblies for the Space Shuttle, and paraphernalia allegedly used to alter package markings were turned up in Los Angeles—a major question is: what can potential victims do to protect themselves? A survey of manufacturers, distributors, and users elicits some basic procedures that, when rigorously applied, are effective. In fact, several sources say that letting down their guard caused some users to get burned.

The bedrock recommendation, proclaimed by big semiconductor users to be more important even than testing and inspection, is "know from whom you're buying." While such advice might sound simplistic, ignoring it is perilous, officials agree. Roger Borovoy, vice president and general counsel at Intel Corp. of Santa Clara, Calif., observes that some customers try to bypass the traditional distributor "to save money or for faster delivery. That is where they get into trouble."

Even the big military-systems firms, where large inspection and testing staffs labor to insure quality, stress this principle. John J. Tamsen, who manages reliability and maintainability assurance for the aerospace groups of Hughes Aircraft Co., Culver City, Calif., calls distributor relationships the real key to a company getting what it pays for. Hughes goes as far as running quality audits on distributors, which include actually watching how parts are broken out of large batches and handled internally.

Another military-space contractor, TRW Systems Group of Redondo Beach, Calif., performs quality surveys of distributors that lean heavily on how well the distributors' traceability codes document a part's path from manufacturer to user. "The best protection is to buy from a major vendor and keep up your surveillance," a TRW procurement official advises.

It works. One major distributor, Cramer Electronics Inc. of Newton, Mass. confirms that this technique works, and that large-volume customers keep a vigilant eye on its internal operations. Inspectors come in periodically, "concerned about semiconductors more than anything," a spokesman says.

Also, Cramer buys only from manufacturers and will not sell any product that doesn't originate from the manufacturer. The result is a record unblemished by phony components, the spokesman claims. Another distributor, Hamilton-Avnet of Avnet Inc., New York, N.Y., says it has protective procedures but won't describe them.

Right behind knowing your vendor is testing, the thoroughness of which is largely governed by expense. At the upper end of the semiconductor cost spectrum—microprocessors and custom integrated circuits—buyers are willing to pay for reliability. Beckman Instruments Inc., Fullerton, Calif., for one, screens and tests each IC, and has since 1971. The firm even has an independent testing laboratory do 96-hour burn-ins of all parts. "It adds to the cost," notes Robert Appel, reliability specialist, "but it's worth it." Part failure rate in assembly is down to one-tenth of the 4% prevailing before outside testing was started.

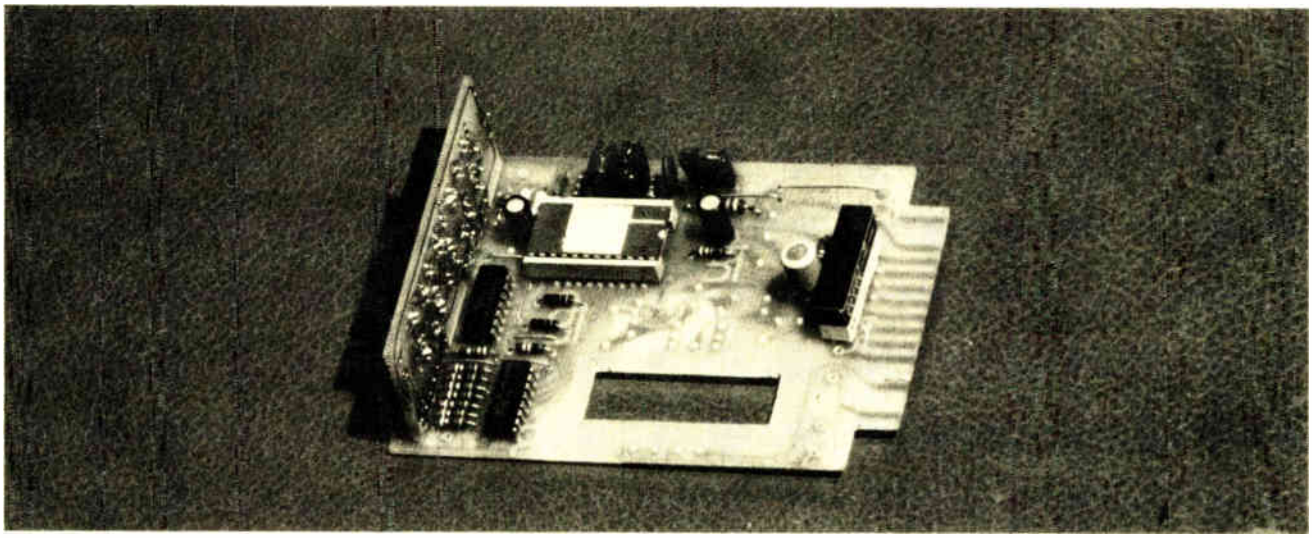
For cheaper, commodity-type devices, such as transistors, resistors, and capacitors, even the large systems houses mostly stick to a sampling approach. Rockwell International Corp.'s Autonetics Group in Anaheim, Calif., which found some faked transistors aboard the Space Shuttle [*Electronics*, Oct. 28, p. 59] has tightened its procedures considerably. For the most part, it sticks to buying from franchised distributors, but, when going to an alternate source, the firm demands certification of source and testing. Then random destructive testing is done on "an appropriate sampling plan based on normal statistical practices," according to a spokesman.

While large-volume consumer product manufacturers would seem to be prime counterfeiting targets, this does not seem to be happening. "We have seen no examples of counterfeit parts," says James R. Smith, director of quality and reliability for RCA Corp.'s Consumer Electronics division in Indianapolis. "On occasion, when we try to buy something through a jobber, he'll send one manufacturer's part when we've ordered another's. But nothing has been misrepresented."

This record is largely due to rigorous incoming inspection procedures instituted by RCA and other television manufacturers. "We 'fingerprint' a part before we qualify it," Smith says, "and our incoming inspection, based on samples, is almost an ongoing qualification. In addition, we dissect almost 100% of failed devices and also track parts through production by, not only the date codes, but also the batch numbers." This routine analysis is good enough to uncover changes in die placements or in process techniques.

Dumping hurts. An industry practice that contributes to counterfeiting is dumping by the manufacturer of surplus or rejected parts, which become stock for the fly-by-night dealer. This is most widespread during business recessions. Some semiconductor firms are recognizing the short-sightedness of that custom, and many will not sell surplus parts because "the counterfeiters would take them and brand them," as Intel's Borovoy says.

Among the majors, both Intel and Fairchild Semiconductor, Mountain View, Calif., say they are developing internal techniques to prevent counterfeiting, but decline to describe them. But they and other Bay-Area semiconductor firms are said to be looking at some exotic countermeasures. One is introduction of tracer elements inside the package, to quickly identify a suspicious batch of parts. Others are marking them with a multitude of codes top and bottom or stamping on the lead frame to make remarking by anyone much more difficult. □



Low-priced DPMs to take two roads

Digital meters are expected to replace some analog units as prices drop and to find way into new applications

by Andy Santoni, Instrumentation Editor

The digital panel meter, heralded as the long-awaited digital replacement for analog instruments or as the wedge into new markets for the meter makers, may turn out to be both. The latest DPMs are still too expensive to replace analog devices—but price-competitive instruments may not be far off as semiconductor makers bring out new, lower-cost DPM chips.

Meanwhile, the DPM field is becoming segmented as the analog market did several years ago, says William Weir, marketing vice president at Weston Instruments Inc. in Newark, N.J. "Right now, we have two strong DPM segments: the classical high-priced, high-performance unit [selling for about $70], and the new, much lower-priced [about $40] and lower-performing DPM. I don't believe the lower segment is going to have any measurable effect on the higher-priced area, nor do I see the $40 DPM having a measurable effect either on the $10 or the $40 analog-panel-meter segments."

Agreeing that the new low-priced DPMs won't replace analog instruments, Fred Katzmann goes a step further. Katzmann, president of Ballantine Laboratories Inc. in Boonton, N.J., says, "it appears there might be a new market developing for them." Although he, like his opposite numbers in the highly competitive instrument business, is reluctant to specify these new analog applications, they probably include microprocessor-based instrumentation. That's because the digital output of the more expensive DPMs analog-to-digital converter is not needed in such uses.

At Simpson Electric Co., Elgin, Ill., the thinking is perhaps typical of meter manufacturers. While marketing director Irving Linker says, "We haven't seen any real impact on our analog business from DPMs"—which Simpson also makes—he agrees that, as prices continue to drop, digital units will replace analogs in some places. "But there are some large markets that will never go digital," Linker maintains, naming trend measurement as one. "It will be a long while before they're used in battery-powered portable testers," he adds.

More coming. But Simpson will expand its digital family. By the end of this month, the firm will begin shipping a $46, 3½-digit panel meter (shown above). It is accurate to within ±1%, has automatic polarity indication, and has 0.43-inch light-emitting-diode readouts. The unit is built around a one-chip a-d converter from Motorola Semiconductor Products Inc. Next year, Simpson will add 3- and 4½-digit units.

Another DPM supplier with a low-priced instrument is Analog Devices Inc. of Norwood, Mass. Its 3-digit AD2026, selling for $39 in hundred-piece quantities, uses a custom integrated-injection-logic chip from RCA [*Electronics*, Oct. 14, p. 34].

Charles Hasley, national sales manager at Newport Laboratories Inc. in Santa Ana, Calif., sees DPMs heading two ways: toward $20 models for the analog replacement market and toward higher-priced instruments incorporating such functions as scaling, digital outputs, and systems interfacing. But price isn't the only consideration, he notes. DPMs aren't the same size as analog meters, so panels have to be replaced; they have printed-circuit connector contacts instead of threaded terminals, and they need a source of power.

One major question still unanswered is just how far the semiconductor firms now making DPM chips and modules will go toward building and selling complete meters. At RCA Solid State, Somerville, N.J. Robert Rauth, manager of industrial linear IC market planning, says his firm won't make either modules, which include conversion circuitry and display, or complete packaged instruments.

Texas Instruments plans to start delivering samples of two chips providing most of the circuitry needed to build a 4½-digit DPM. The set, to sell for $15, consists of the TL 500, a bi-MOS analog chip, and the TL 502, an I²L logic control device.

All the way. But Fairchild Camera and Instrument Corp., Mountain View, Calif., takes a different approach. Its Semiconductor division makes light-emitting diodes, transistors, and ICs for DPMs, and its Instrumentation and Systems group assembles these and other parts into complete meters. The company has a 3½-digit panel meter that uses discrete transistors and sells for $60 to $70. It plans to introduce a $30–$40 unit next year. Later, a completely complementary-MOS, one-chip meter will be phased in.

National Semiconductor Corp.'s Jerry Zis, product marketing manager, says, "We plan to supply 3½- and 4½-digit modules by the middle of next year." The module would have to cost $10 to $15 so that a finished meter could sell for $30 to $40. Zis says the Santa Clara, Calif., company doesn't plan to get into the finished meter business. And Siliconix Inc., which makes two DPM components, plans to remain a component supplier. "The display is a major part of the cost of a DPM," says Art Fury, marketing vice president, "and we don't make them." □

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Companies

Cybernet expects to stay on top

Haruki Tomonoh, president of the leading supplier of CB radios, pins hopes on automated production and wide distribution

Well before the post-oil-crisis boom in citizens' band transceivers in the United States, Cybernet Electronics Corp. of Kawasaki, Japan, set out to establish itself as a leading supplier. In a year's time, a combination of good luck and good timing have made the company number one with 40% of the CB market (according to Japan's Electronic Industries Association), despite the previous position of well-known firms, the overnight entry of some 200 newcomers and the fact that not a single set that it manufactures bears the Cybernet name.

But since the Federal Communications Commission has announced the expansion of CB frequencies from 23 to 40 channels in January and the simultaneous imposition of stricter compliance regulations, the transceiver market has been in a turmoil.

An interview in Japan with company president Haruki Tomonoh provides some insights into how Cybernet gained its position and how the firm hopes to stay on top.

Q. How would you describe the state of the citizens' band transciever market?

A. There has been much confusion because we have to wait until January to sell the new models. I don't think the FCC fully understood the impact its decision would have on the market. Sales to dealers of 23-channel models have almost stopped.

Nevertheless, we estimate there will be a total of 20 million units sold in 1976. After that, demand should reach a level of about 10 million units a year. The change to 40 channels will change the makeup of the competition. By mid-1977 the number of companies making trans-

ceivers will probably drop to half the present number.

Q. Is the United States the only CB market; can't you look elsewhere around the world to expand your sales?

A. There are three factors that make a CB market: a large land space, a large population with buying power, and freedom of communications. Only the U.S. has all three.

Q. What effect will auto companies installing transceivers as original equipment have on Cybernet's business?

A. We see in-dash CB as two possible products: First as a unified CB and a-m/fm combination produced for the auto companies and second as a separate CB kit or part supplied to the regular auto-radio makers to put into their combination radios. Both products need high volume—perhaps 500,000 units a month—to bring down the cost of the ICs used to make in-dash units as small as possible.

Q. How do you account for the rapid growth of Cybernet?

A. Most people believe that the oil crisis brought about the boom in CB radios, but it was only the trigger. Before the boom, we made a survey to find out why CB was not growing faster in America. We found that people wanted to use this personal form of communication but believed that the transceivers were too complicated. On the technical side, we found that failure rates were high and prices were also high.

Why did these conditions exist? We found that, even though production quantities were limited, there were many different models offered by each manufacturer.

Starting with this survey, Cybernet made important changes. First, we decided to design a transceiver that would be easy to use. Then we designed all our models around the same circuit to simplify production and provide room to cut costs through volume. Finally, we set up automated production lines to provide flexibility to expand capacity at short notice.

Our first automated factory has a capacity of 300,000 units a month and employs 800 workers. Our second automated facility has a capacity of 250,000 units a month, but has only 450 employees. We have two other semi-automated facilities making the combined capacity 900,000 units a month.

Cybernet's sales channels in the United States consist of automobile companies, consumer-product companies, CB specialists, importers, and after-market auto-supply companies. You have to have all five; otherwise you miss a share of the market. However, Cybernet will remain an OEM supplier. With this marketing arrangement, we couldn't have our own brand-name products. □

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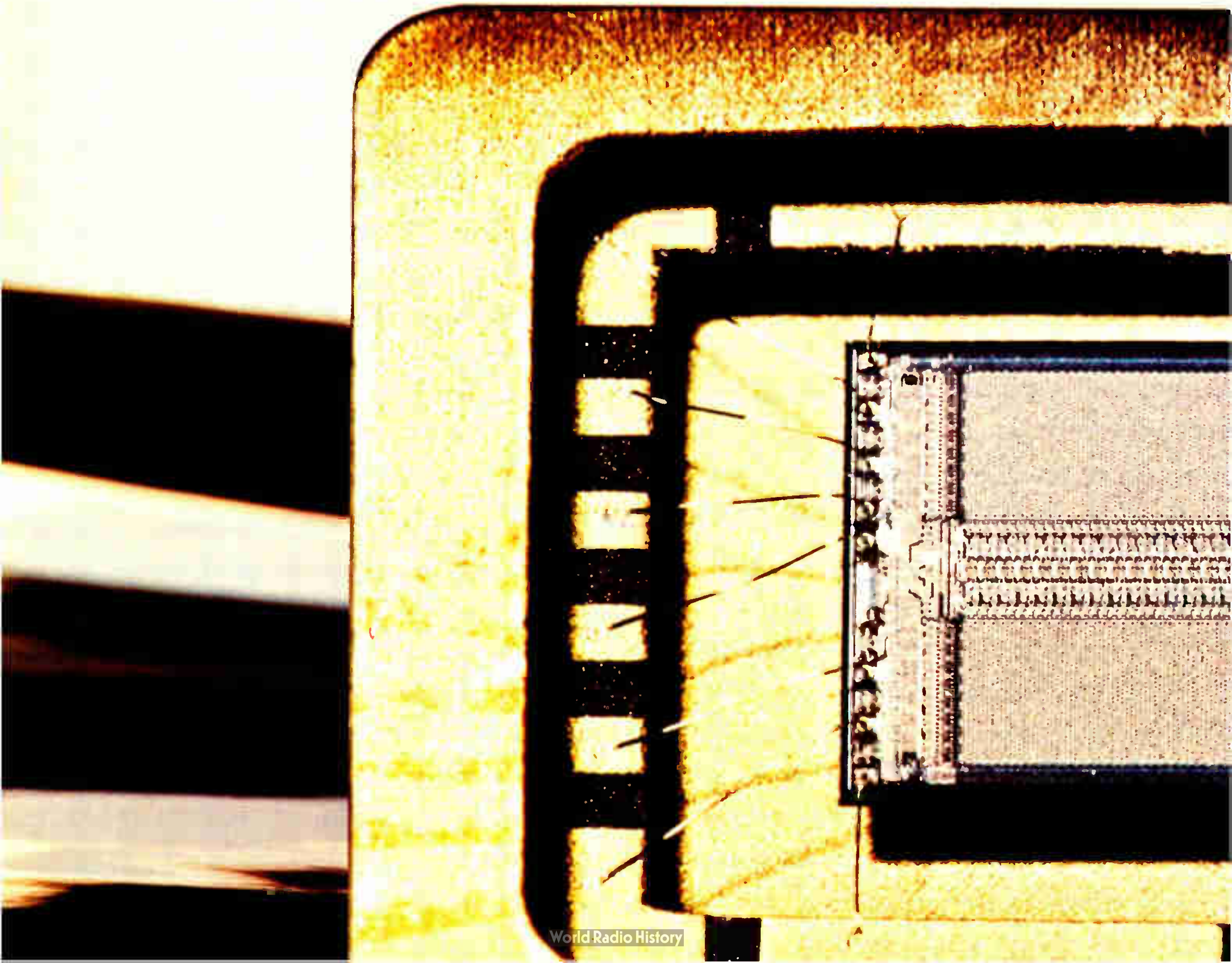

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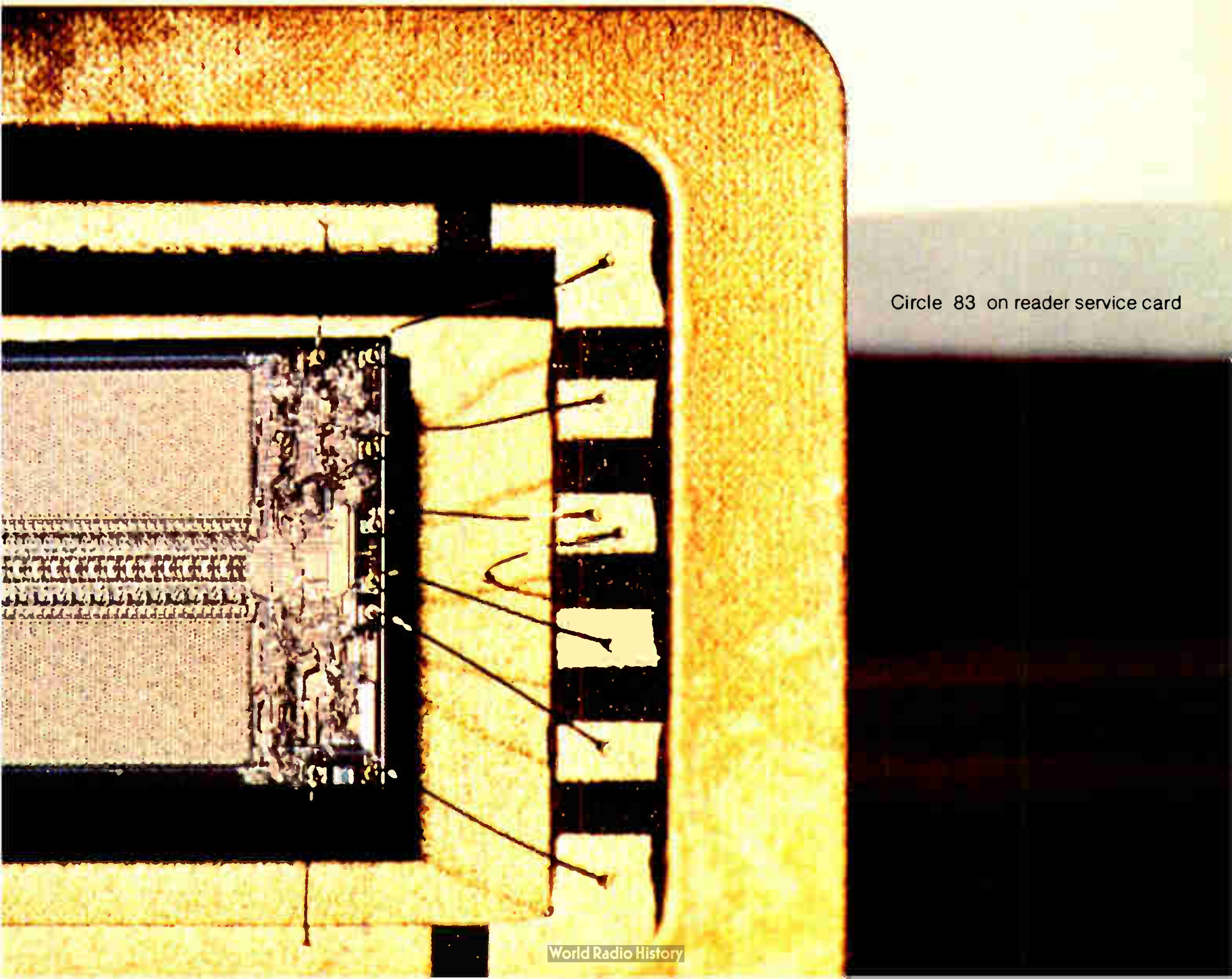

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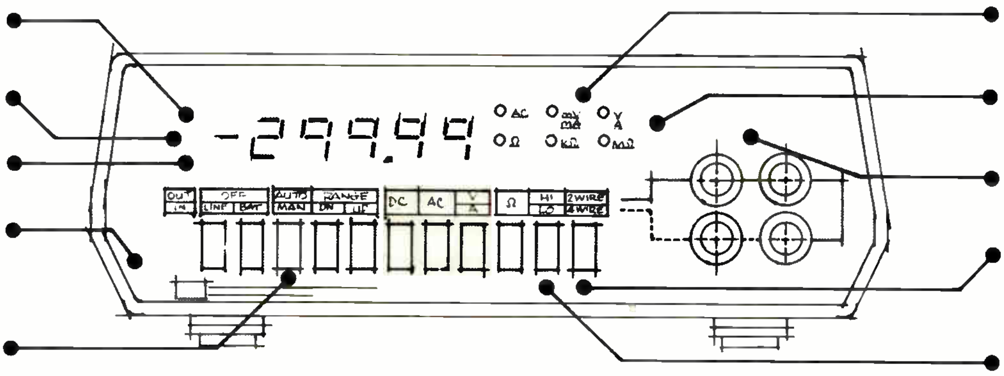

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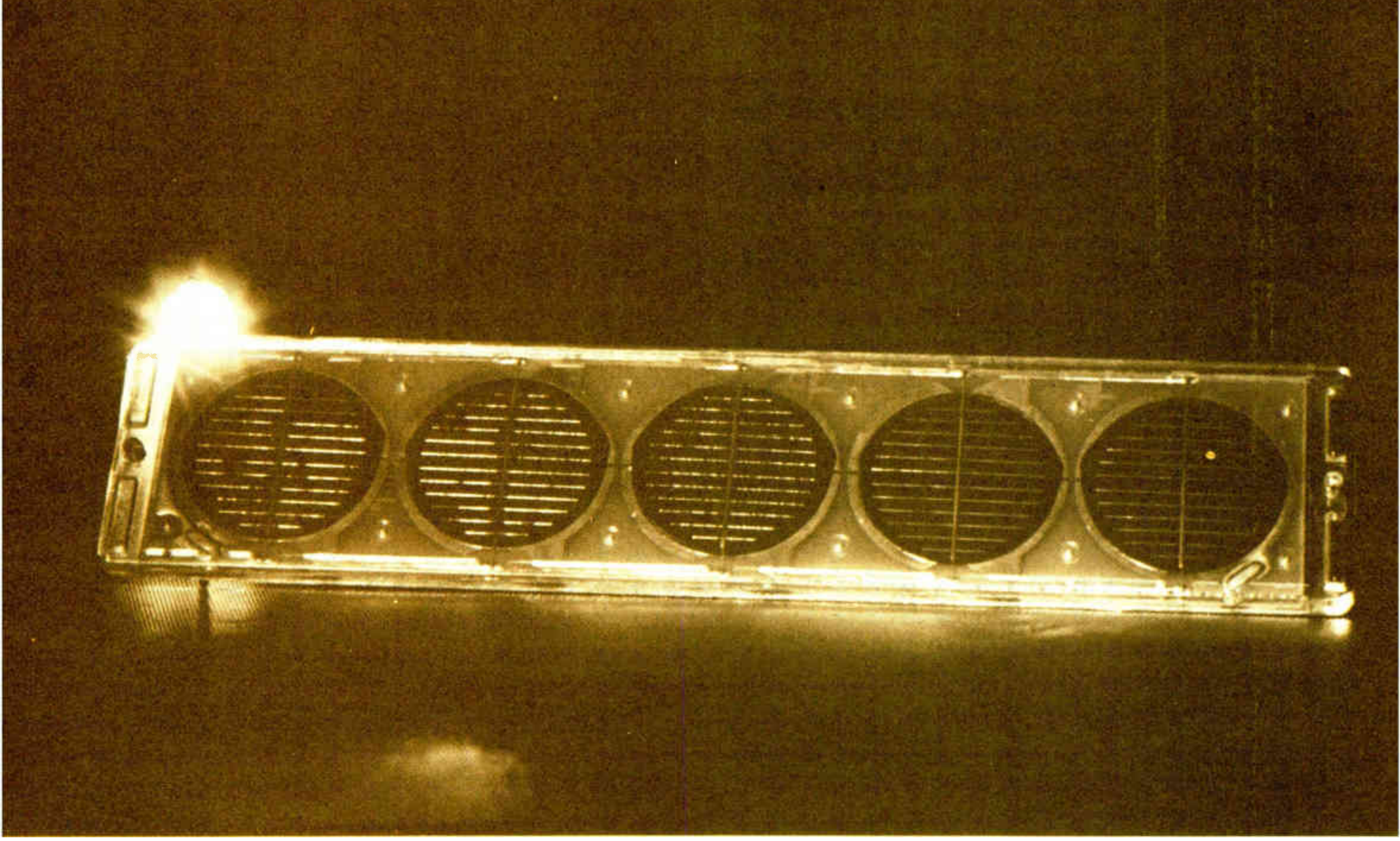


From photons to kilowatts: can solar technology deliver?

Lower-cost, more efficient solar cells are crucial, says Part 1 of this two-part report on photovoltaics today

by Joel duBow, *Colorado State University, Fort Collins, Colo.*

☐ The direct conversion of sunlight into electrical power promises to provide energy that is both abundant and inexpensive. Although it's not a viable worldwide business yet, photovoltaics for terrestrial use is developing fast as a technology. And because of all the recent encouraging progress in the U.S., Japan, and Europe (see p. 92), it's quite possible that multimegawatt power plants based on solar light energy will be operational by the turn of the century.

Solar cells are the key

The success of photovoltaic power systems depends on the availability of solar cells that are sufficiently economical and efficient. Since solar cells represent the first stage in converting sunlight to usable electrical power, overall systems costs are especially sensitive to the price and performance of the cells themselves and their associated hardware. In fact, even small changes in cell efficiency or cost can have important implications for system efficiency and cost.

Outlook is bright

Significant advances are being reported. The cost of conventional solar cells has been cut in half, and many new and promising types of cells are being developed. In the concerted effort to obtain economical power from them, even research bordering on technologies formerly considered esoteric is being brought to the forefront.

However, the present cost—approximately $15 per peak watt—of photovoltaic arrays is still 30 to 50 times too high to compete with fossil fuels. An order-of-magnitude reduction in individual-cell and array costs by 1986 is the present goal of the U.S. Energy Research and Development Administration, and some recent projections indicate that this goal could well be achieved.

Reviewing solar-cell basics

A solar cell is actually a semiconductor photodiode that is optimized to convert sunlight into electrical power efficiently. Although a diode is the oldest form of semiconductor device, much is still unknown concerning its performance limitations—particularly when it is used as a photoconverter.

Every solar cell has seven basic elements, as the structure of a typical device shown in Fig. 1a makes clear. It consists of a base material that forms one side of the junction, a diffused or deposited region that forms the other side of the junction, an anti-reflection coating to boost efficiency, front and back contact grids to reduce series resistance, and a transparent adhesive and cover glass to improve the environmental stability of the cell.

Figure 1b illustrates the electrical characteristics of a typical cell. In the absence of light, the device behaves as a conventional junction diode. But when illuminated, it exhibits a reverse current (I_{SC}) without the application of an external voltage and generates a voltage (V_{OC}) even with no current flowing. That fraction of the maximum output power ($V_{OC} \times I_{SC}$) available for delivery to a load is called the fill factor.

The traditional base materials for solar cells are silicon (Si) and cadmium sulfide (CdS). But a number of other possible semiconducting materials are being explored, including gallium arsenide (GaAs) and thin films of indium phosphide (InP), amorphous Si, or cadmium telluride (CdTe), as well as various combinations of these materials.

Silicon cells are the most promising

Since Si is the most highly developed semiconductor technology, it is the most promising material for solar cells. However, even for optimized versions of present-day technologies, Si solar cells cannot achieve the required ERDA cost goals. At this time, the cost of single-crystal Si starting material is higher than the maximum permissible cost of completed cells under current ERDA targets. The main research efforts going into reducing the cost of current Si cell designs include lowering materials costs, automation of device processing, and development of low-cost materials like polycrystalline and metallurgical Si.

The most efficient Si cell is the nonreflecting structure (Fig. 2a), which can yield efficiencies as high as 18%. It has a textured upper surface that collects a large percentage of reflected light and minimizes the distance photogenerated carriers must diffuse before collection. However, this cell's voltage output is lower than desirable, and its response to short wavelengths is limited.

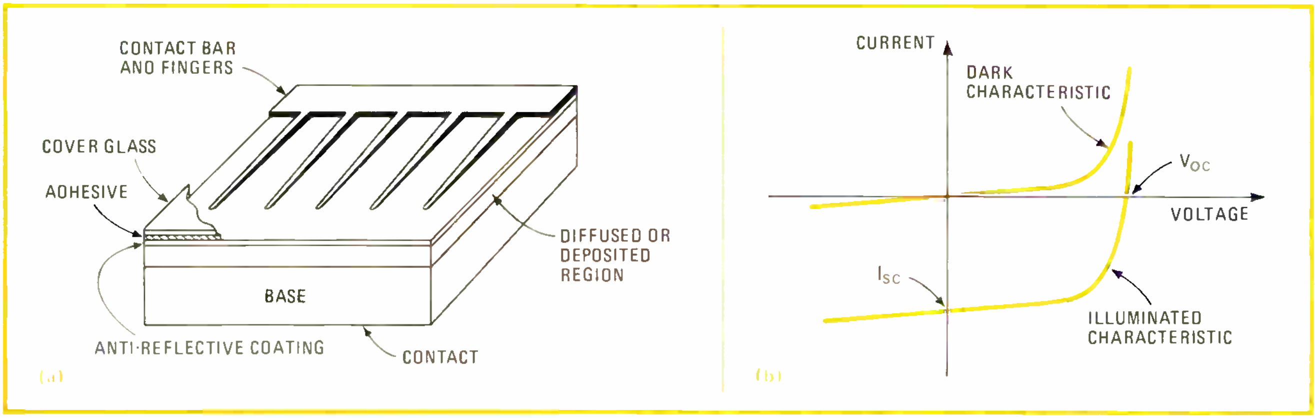
Two other Si solar-cell structures look very promising because of their potential for low cost and relatively high performance. One is the heterojunction structure (Fig. 2b), in which a thin layer of a semiconductor other than Si is deposited on a Si base, forming a diode between the two dissimilar materials. The other is the Schottky-barrier structure (Fig. 2c) that is made by depositing a thin metallic layer on the Si to create a diode.

Heterojunction Si solar cells are made from tin oxide (SnO_2), indium oxide (In_2O_3), CdS, or gallium phosphide (GaP) deposited on n- or p-type Si. Efficiencies of up to 10% may be achieved with SnO_2 on n-type Si, close to 6% with CdS on p-type silicon, and as high as 12% with indium-tin oxide on p-type Si.

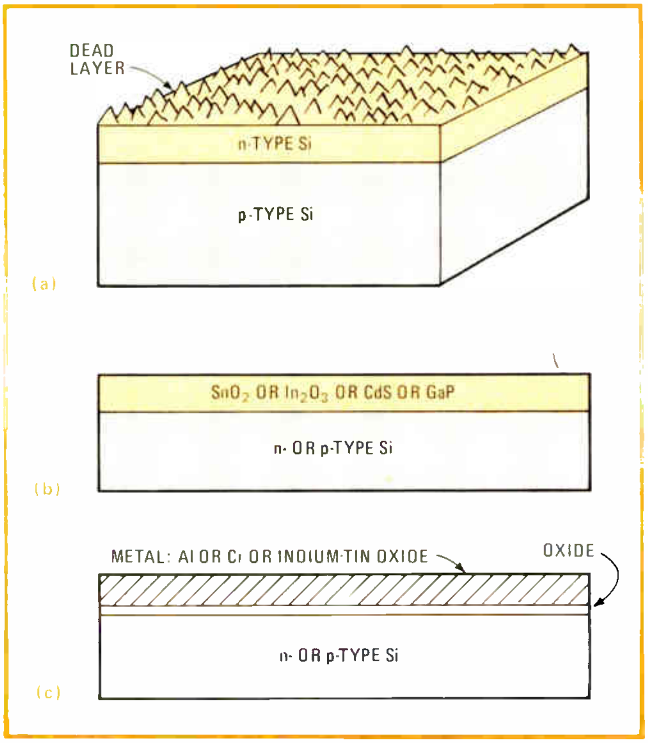
Process simpler for heterojunction cells

Unlike the nonreflecting configuration, the heterojunction Si solar cell has no surface dead layer caused by low-lifetime, highly doped, diffused regions. So, its short-wavelength response is better, and its processing is simpler, as well as amenable to continuous-flow manufacturing. However, the junction interface itself must be carefully controlled because it critically affects device performance.

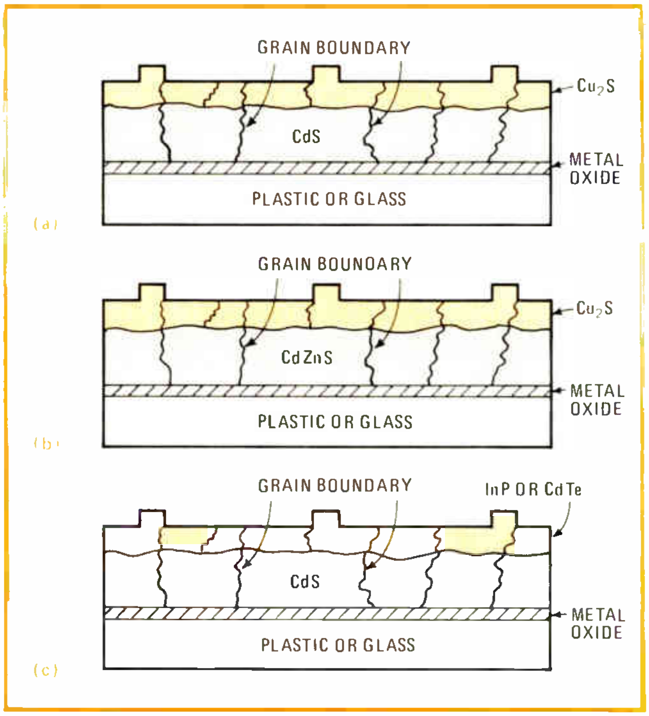
The Schottky-barrier Si cell also features good short-wavelength response. In addition, it does not require processing at elevated temperatures. Efficiencies of up to 8% have been obtained with aluminum (Al) as the



1. Typical solar cell. Essentially, a solar cell is a semiconductor photodiode. It is made up of seven structural elements (a), starting with a base contact and topped by a cover glass. Electrically (b), it behaves like a conventional junction diode when not illuminated. But when illuminated, it develops a small electrical signal, even though no external bias voltage or current is applied.



2. Good efficiency with silicon. Solar cells based on Si provide reasonable efficiencies—on the order of 15%—at reasonable cost. Several variations look quite promising—among them nonreflecting (a), heterojunction (b), and Schottky-barrier (c) structures.



3. Cadmium sulfide for low cost. Although they deliver efficiencies of around only 6%, CdS solar cells are cheapest. They can be built on inexpensive substrates, like plastic or glass, with a cuprous-sulfide coating over either CdS (a) or cadmium zinc sulfide (b), or with either indium phosphide or cadmium telluride over CdS (c).

barrier metal, increasing slightly to 8.6% when chromium (Cr) is the barrier metal.

Heterojunction Si cells are particularly attractive because they require only very small amounts of fairly scarce materials. Since the top layer of a heterojunction cell is typically about 1 micrometer thick, only a small volume of a rare metal, like indium, is needed for a comparatively large surface area.

Tandem cells boost efficiency

Additionally, heterojunction devices permit the construction of tandem cells, which consist of two pn junctions placed back to back. When a metal Schottky barrier or another type of semiconductor junction is deposited on the top layer of a heterojunction cell, creating a tandem cell, photovoltaic conversion occurs in both the top and bottom junctions.

If both junctions are suitably connected, the conversion efficiency of each junction adds, so that efficiencies as high as 40% are possible. Although no commercial tandem structures are currently available, development devices based on either Si or GaAs having conversion efficiencies in excess of 25% are being investigated.

Variations look worthwhile

Both heterojunction and Schottky-barrier Si cells look especially promising for implementation with low-cost Si materials because both are deposited, rather than diffused, structures. Diffusion is not possible with inexpensive ribbon or polycrystalline Si because the high concentration of grain boundaries and defects in these materials leads to uneven diffusion profiles, as well as junction short-circuiting. In general, heterojunction and Schottky-barrier technologies require further development before commercial devices become available.

Another variation in Si cells—oxide semiconductors on Si—is starting to receive a lot of attention. These devices combine the advantages of heterojunction and Schottky-barrier structures. With indium-tin oxide, which is highly transparent and also highly conductive, efficiencies of up to 12% have been achieved with an oxide-semiconductor-on-Si structure.

And interest in metal-insulator-semiconductor solar cells is increasing. In these structures, a thin insulating layer, only 10 to 20 angstroms thick, separates a metallic layer and a semiconductor layer, which is usually Si. The insulator must be thin enough to reduce the short-circuit current only slightly, while yielding an increased open-circuit voltage. Efficiency is somewhat higher than that of Schottky-barrier cells. Both oxide-semiconductor and Schottky-barrier devices are being built as metal-insulator-semiconductor configurations.

Costs lowest for cadmium sulfide

Silicon solar cells combine reasonable efficiency—on the order of 15%—with reasonable cost. However, recent systems studies indicate that if solar cells were free, conversion efficiency need be merely about 6% to produce energy economically. If this hypothesis proves to be true, then CdS cells may well fit the bill—they are the least expensive of all solar cells, but have the lowest conversion efficiencies, only around 6% to 8%.

Figure 3a depicts a typical CdS cell, consisting of polycrystalline CdS deposited on an inexpensive glass or plastic base. The CdS is then covered by a coating of cuprous sulfide (Cu_2S). Although they are the least-expensive solar cells on a per-unit-area basis, CdS devices are plagued by low efficiencies and by stability problems that reduce their effective lifetime.

At present, the efficiency of these cells is too low for them to be viable options for terrestrial applications. However, their low fabrication cost and the large body of expertise developed about them over many years are bringing about a number of other potentially viable structures based on CdS.

Principally, three other configurations of CdS cells are now being investigated—cadmium-zinc-sulfide (CdZnS) devices (Fig. 3b) and cells (Fig. 3c) fabricated on single-crystal CdS where the top layer is either InP or CdTe, replacing the Cu_2S coating of conventional CdS devices. Efficiencies of up to 15% have been obtained from CdZnS structures, close to 13% from cells coated with InP, and up to 7% from those coated with CdTe.

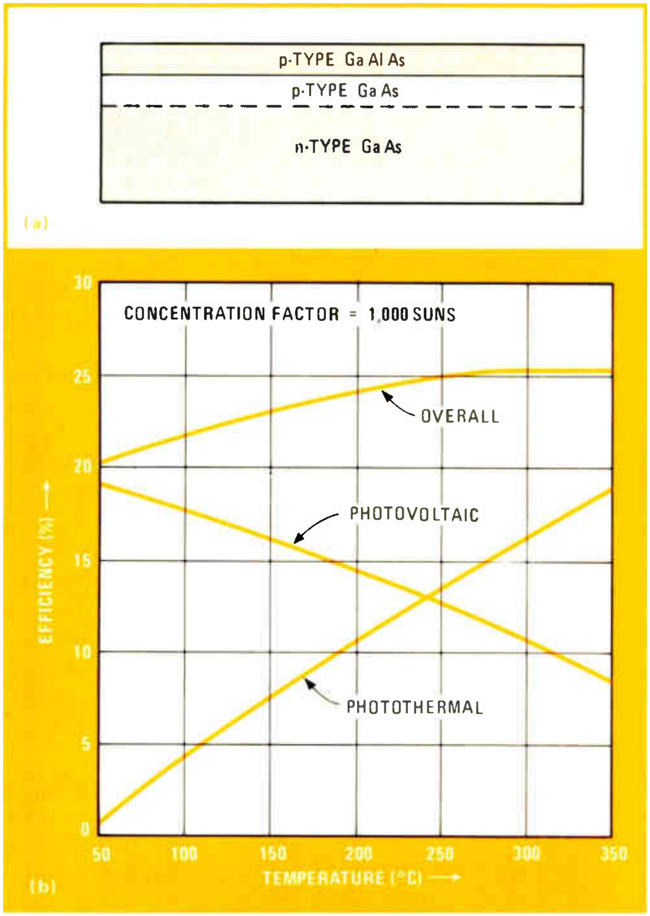
Concentrating sunlight on gallium arsenide

One technique for minimizing the effect of solar-cell fabrication costs on overall systems cost is to intensify the sunlight that shines on a cell. For example, GaAs cells are at least 100 times more expensive than Si devices. However, if sunlight were concentrated by a factor, say, of 1,000, then the combined costs of their fabrication and the associated systems hardware could be less than the cost of making 1,000 cells that operate from unconcentrated sunlight. Moreover, concentrated sunlight causes the cell to operate at an elevated temperature, enabling it to convert both solar light energy and solar thermal energy into electrical power for higher overall systems efficiency.

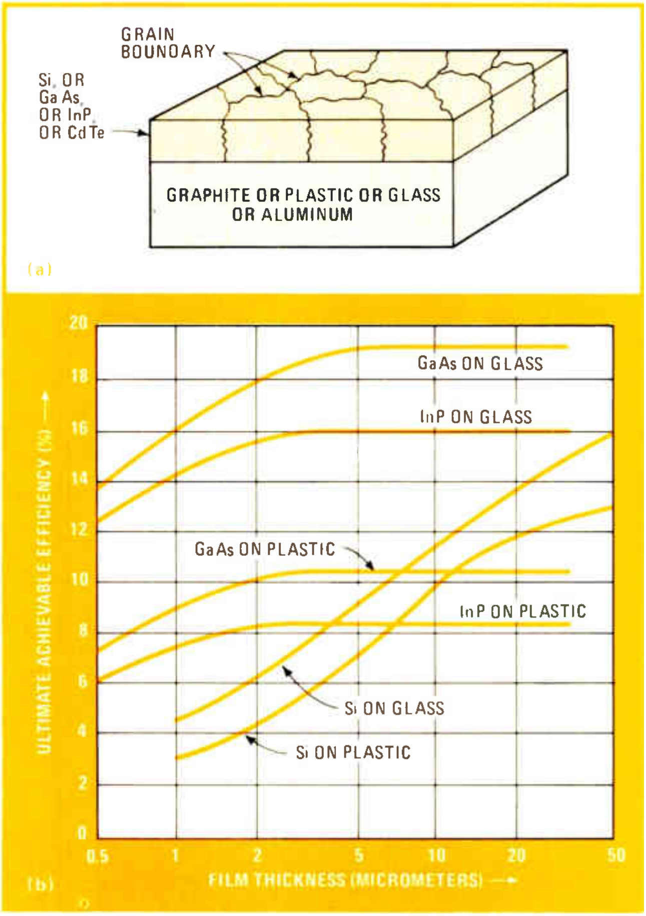
Benefiting from solar thermal energy

On the whole, GaAs cells (Fig. 4a) are expensive small-area devices that are useful primarily at high concentration factors and elevated temperatures, which can be up in the range of 250°C to 300°C. As shown by the efficiency plot of Fig. 4b, for a concentration factor of 1,000 suns, combined photovoltaic and photothermal conversion efficiencies can be as high as 25%.

Although such overall efficiency numbers are impressive, a number of feasibilty factors must be evaluated for these GaAs concentrator cells, including their susceptibility to environmental contamination, their performance in diffused sunlight, and the costs of maintenance



4. For concentrated sunlight. The high cost of fabricating gallium-arsenide cells (a) can be offset to a large extent by intensifying the sunlight that shines on them. What's more, concentrating sunlight raises cell operating temperature, so that both solar light energy and solar thermal energy can be converted into electrical power. The result, as shown in (b), is high overall efficiency.



5. Low cost but not yet practical. Solar cells (a) made with thin films of polycrystalline semiconductors on inexpensive substrates hold the promise of reasonable efficiencies at low fabrication costs. The curves (b) show the theoretical efficiencies achievable for various combinations of substrates and semiconductor films, as a function of the thickness of the semiconductor film.

PERFORMANCE SUMMARY OF PRESENT SOLAR CELLS						
Family	Structure	Efficiency (%)	Open-circuit voltage (V)	Short-circuit current density (mA/cm²)	Fill factor (%)	Comments
Silicon	conventional	12 – 16	0.55	35	73 – 76	cost now $15 W, commercially available
	nonreflecting	18	0.6	36	75	highest efficiency conventional cell
	heterojunction	6 – 10	0.5	15 – 25	0.5 – 0.7	still in research stage
	Schottky barrier	8 – 10	0.55	24	0.67	–
	indium tin oxide on Si	12	0.5	32	0.7	oxide semiconductor on Si structure
	tin oxide on Si	10	0.54	28	0.63	has stability problems
Cadmium sulfide	conventional	5 – 8	0.5	25	65 – 75	lowest cost
	Cd Zn S	15	0.68	28	67	single crystal structure
	InP on CdS	12.5	0.65	20	0.67	single crystal structure
	CdTe on CdS	7	0.5	17.2	0.6	single crystal structure
	cuprous indium selenide on CdS	5.7	0.4	27	0.5	
Gallium arsenide	heterojunction	23	0.9	35	0.8	mainly for concentrator applications
	Schottky barrier	15	0.9	16	0.7	metal insulator semiconductor structure
Thin film	Si on graphite	5	0.5	17	0.6	polycrystalline Si structure
	amorphous Si on glass	5.5	0.8	10	0.58	
	CdS on plastic	5.2	0.4	20	0.5	
	indium tin oxide on CdTe	7.4	0.6	16	0.6	

and hardware. In general, these cells are being considered principally for use in central power stations, as opposed to homes.

Conventional Si solar cells can also operate at concentrated sunlight levels, but the factors must be fairly low—on the order of 10 to 25—or else special cooling becomes necessary. However, it's quite possible that conventional Si cells, operating at low concentration ratios with inexpensive hardware, may be the most economical near-term photovoltaic technology for terrestrial use.

What's more, modifying the Si cell to a vertical multijunction structure enables it to operate at concentration factors as high as several hundred suns. Such a structure consists of a string of vertically oriented junctions formed by alternating adjacent regions of n- and p-type Si. But the fabrication cost of these devices is rather high, so—like GaAs concentrator cells—they are limited to power-station applications.

Cost projections promising for thin films

Solar cells can also be formed with thin films of polycrystalline semiconductors on inexpensive substrates. If reasonable efficiencies are achieved, thin-film cells could offer the low cost required for large-scale terrestrial photovoltaic applications.

For a typical thin-film structure (Fig. 5a), the key material parameters are grain size, grain orientation, and device thickness. Since material grain boundaries act as current sinks for photogenerated carriers, large grain sizes are needed to ensure reasonable carrier collection efficiency. Moreover, a fibrous orientation, with grains extending vertically throughout the thickness of the film, is preferable to a more random orientation of the semiconductor grains.

Figure 5b shows the ultimate achievable efficiencies for various single-crystal thin-film structures as a function of film thickness. The minimum thickness of the thin polycrystalline film depends on the optical properties of the material itself.

Thin films not practical yet

Many of the thin-film cells represented in this graph are still theoretical devices. In practice, efficiencies of up to 4% have been achieved with a 10-μm film of CdTe on glass, nearly 5% with a 15-μm film of GaAs on Al, over 5% with an 8-μm film of CdS on plastic, and up to 5% with a 10-μm film of polycrystalline Si on a substrate made of graphite.

The table summarizes the performance of practically realizable solar cells. However, most of the structures listed here are still in the laboratory stage of development. Only conventional Si cells are commercially available at this time, although conventional CdS cells may soon also become available commercially. □

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Companies look for ways to raise solar-cell output

A specialized market exists, but only volume production will make energy from sunlight competitive with fossil fuels, says Part 2 of this special report on photovoltaics

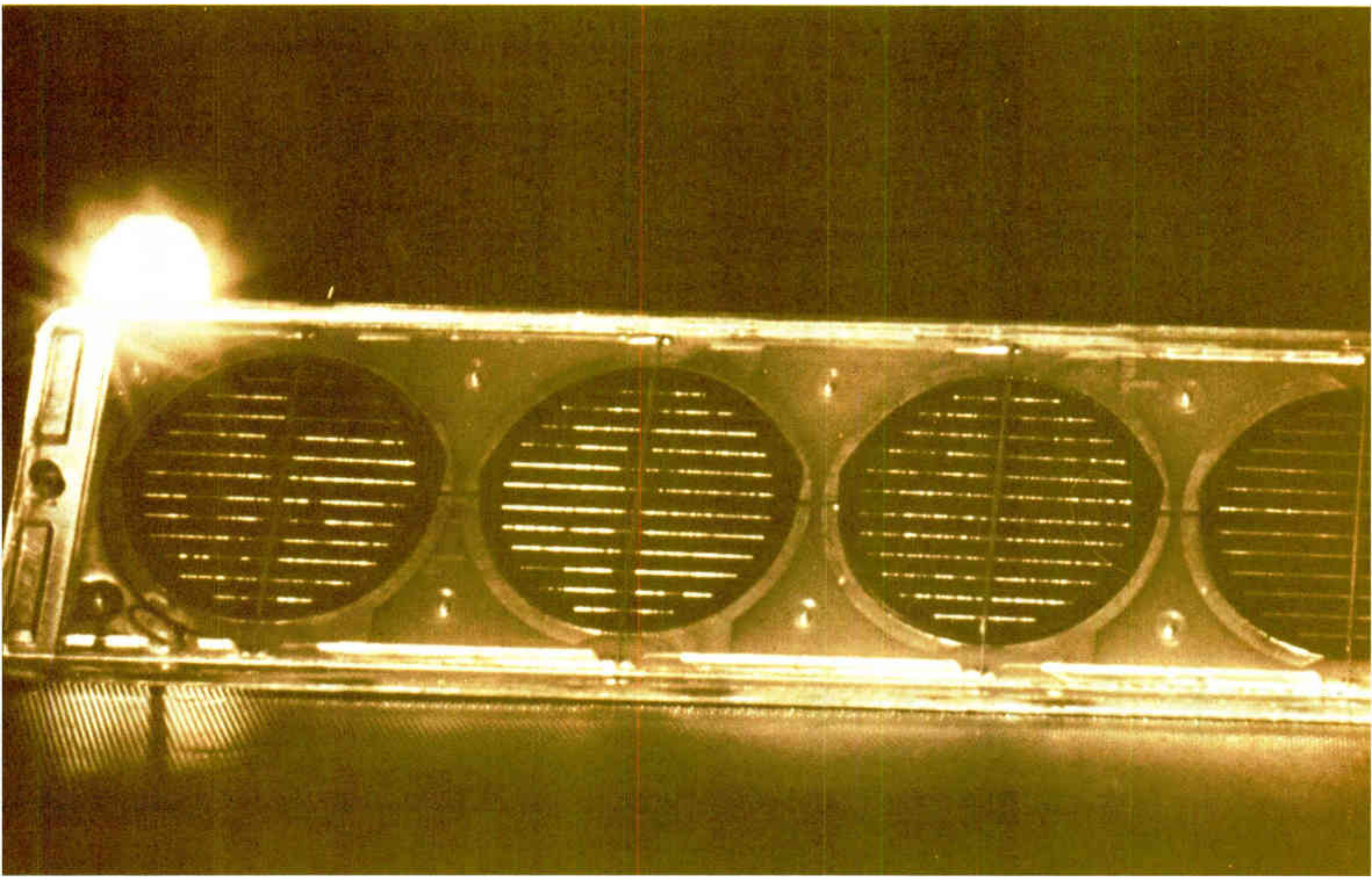
by Lawrence Curran, *Senior Editor*

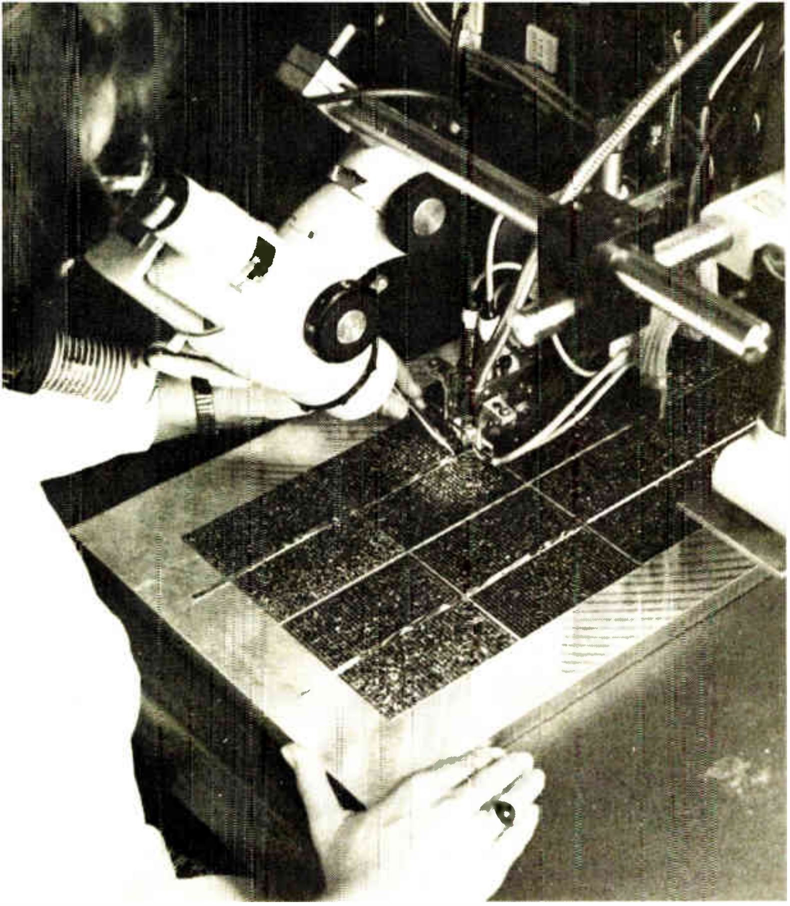
☐ Companies and governments the world over are busying themselves with photovoltaic cells. Already arrays of these cells are sitting on mountaintops, in deserts, or on oil-rigs out at sea, turning sunlight into electrical power at sites that cannot economically link up with the conventional ac grid. But the goal is more ambitious: photovoltaic energy that is cost-competitive for routine power-generation applications.

The main obstacle to commercial success seems to be not technology but the inability to produce efficient enough cells in enough volume. On that both cell makers and the U.S. Energy Research and Development Administration agree. But as to how soon that will change, opinions differ.

The problem is being attacked from many angles. Single-crystal silicon solar cells are still getting most of the attention in the U.S. and abroad. Cadmium sulfide and gallium arsenide are considered to be in the second generation of materials that will emerge between 1980 and 1985, as are polycrystalline and thin-film silicon. The conversion efficiency of silicon cells in production quantities with good yields has inched upward from 10% to 12% in the past two years. The use of sunlight concentrators to boost array power output is fast becoming attractive. And the price of a peak watt of electricity generated by photovoltaic cells has been cut in half—down to about $15—in less than two years.

ERDA is justifiably proud of that $15 figure (see





1. Quantity counts. A new polycrystalline material from Wacker-Chemitronic has enabled AEG-Telefunken to build experimental 10-by-10 centimeter cells with 10% efficiency. Here eight are being electrically welded into one module of a photovoltaic generator.

"ERDA's position on photovoltaics," p. 94). It beats the agency's original goal for this year of $20 per peak watt and is the average ERDA is paying five companies for silicon cells that will generate 130 kilowatts of power. The price for a peak watt just two years ago was $30 and had dropped to $21 in an earlier ERDA buy of 46 kW worth of cells. Both procurements were part of the agency's low-cost silicon solar array project, which is administered by NASA's Jet Propulsion Laboratory, Pasadena, Calif. And both procurements were won by the same companies: Spectrolab Inc., Sylvar, Calif.; Sensor Technology Inc., Chatsworth, Calif.; Solar Power Corp., Billerica, Mass.; M7 International, Arlington Heights, Ill., and Solarex Corp., Rockville, Md.

Nevertheless, in announcing the 130-kW buy, Henry H. Marvin, director of ERDA's division of solar energy, candidly pointed out that "we have a long way to go to meet our 1986 goal of 50 cents a peak watt." That price, ERDA believes, will put photovoltaic energy in direct competition with other energy sources. But that timetable seems optimistic to some. To keep to it, says Joseph Lindmayer, Solarex president, volume would have to more than triple each year. "Volume is more than doubling," he notes, "but it still will not be a factor of three unless there is some change we haven't foreseen."

A growing industry

The 130-kW procurement attracted 17 bidders, and while Mobil Tyco Solar Energy Corp., Waltham, Mass., was not one of them, A. I. Mlavsky, its executive president, says that the number of bidders is a notable achievement in itself, reflecting a considerable expansion of the photovoltaics "industry." Two years ago, such a request for proposals probably would have drawn just about five bids, says Mlavsky, whose company pioneered the silicon ribbon-growing process now being used worldwide by at least five other firms. And expansion of the industry is precisely ERDA's aim.

Another significant achievement, this one unaided by ERDA, will take place early next year if Solar Energy Systems Inc., which is 80% owned by Shell Oil Co., brings it off. The company plans to open a plant in Newark, Del., for the production of arrays of cadmium-sulfide cells capable of delivering more than 500 kW per year of electricity at full capacity. That's about two and a half times the total power today's terrestrial cells can generate—and from a material that has not topped a conversion efficiency of 8% even in the laboratory. It will also represent the first time cadmium-sulfide cells will reach the production stage, an accomplishment that's further in the future for gallium arsenide.

Is there a market for that much photovoltaic energy? SES officials apparently think so, mainly in remote, unattended applications. Like ERDA, president Steven DiZio sees his ultimate goal—a production volume great enough to support the generation of electricity at well below $1 per watt—as 7 to 10 years away.

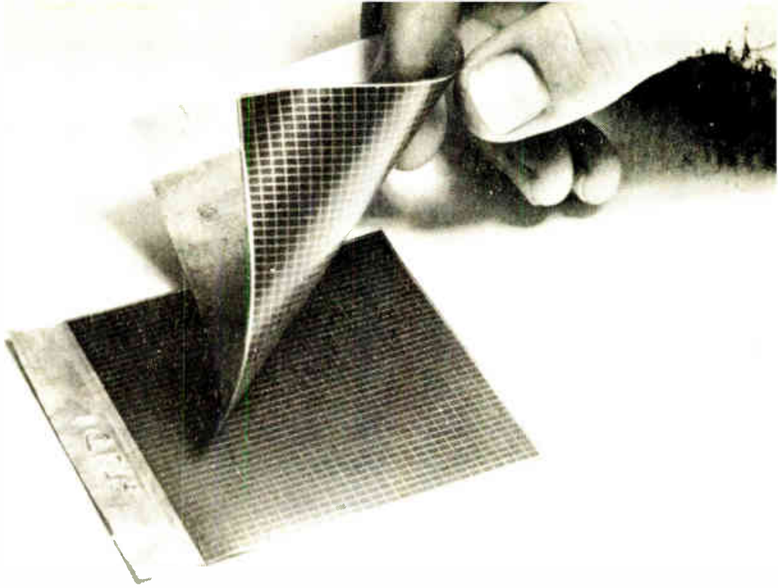
In Japan and Europe

Meanwhile, Japan Solar Energy Co., a joint venture, is fabricating silicon ribbons under license to Mobil Tyco. The goal is to produce ribbons suitable for evaluation by cell makers this year, says technical director Kenjiro Kimura. Capitalization of the firm is divided among Kyoto Ceramic Co. (51%), Sharp Electric Co. (24%), Matsushita Electric Industrial Co. (10%), and Mobil Oil Corp. and Tyco Laboratories (7.5% each).

The 2% improvement in solar-cell conversion efficiency in the U.S. and its 50% price reduction of the past two years has been paralleled in West Germany by AEG-Telefunken. Horst Fischer, who heads the company's solar-cell efforts, says his group is using low-grade polycrystalline silicon. With it, the efficiency of volume-produced cells at air mass zero has been boosted from 10.5% to 12.5%. That increase is the equivalent of approximately 7.5% to 9% efficiencies at air mass one—the standard atmosphere at sea level between the earth and the sun. Fischer says the improvements have been realized by obtaining higher yields from the production process and by enlarging the cell area from 2 by 2 centimeters to 2 by 6 cm. (Laboratory results at AEG-Telefunken are even more impressive: 15% efficiency measured at an atmosphere of air mass zero, while with an air-mass-one material the experimental cells shown in Fig. 1 are delivering 10% efficiency.)

The French leader in silicon photovoltaic technology is La Radiotechnique Compélec, the French components-producing subsidiary of Philips Gloeilampenfabrieken, which has an annual output of silicon cells for terrestrial applications of 30 kW. That makes RTC one of the largest producers in the free world.

To date, the preponderance of work in photovoltaics for terrestrial use at both RTC and its confreres worldwide has drawn on experience gained in producing silicon cells for space applications. That means single-crystal semiconductor-grade material, which is becoming more expensive all the time. According to Paul Caruso, engineering vice president at Solar Power Corp., single-crystal cell efficiency in production devices will rise to 15% in the next two years, as a result of reducing the amount of light reflected off the cell, matching the spectral response of silicon with junction depth, and minimizing photon recombination on the cell's back and front. But in all probability, either cheaper material or the use of concentrators—lens-like devices that intensify the sunlight focused on arrays to boost the power output and cut the amount of material required—will be needed before photovoltaic energy costs can be brought down.



2. Next generation. Least expensive of photovoltaic materials, cadmium sulfide has a theoretical 20% conversion efficiency. These thin-film CdS cells, developed at the University of Delaware's Institute of Energy Conversion, have attained 7.8%, the highest yet.

Toward lower-cost materials

Cadmium sulfide is by far the cheapest photovoltaic material on a per-unit-area basis, and Solar Energy Systems' commitment to it is echoed by physicist Karl Böer at the University of Delaware, also in Newark, Del. He cites some important recent advances in the knowledge of this material. Two years ago, not enough was known about it to predict its theoretical efficiency; Böer now says it is expected to be about 20%, although the highest repeatable conversion efficiency achieved in the lab has been 7.8% (Fig. 2). "We expect significant breakthroughs in efficiency in the next few years," Böer says. The work at the University of Delaware is sponsored by the National Science Foundation under the Research Applied to National Needs program.

Indeed, it is in the laboratory that most of the important recent steps have been taken with all photovoltaic materials. Silicon-ribbon pioneer Mobil-Tyco has an ERDA contract to refine what it now calls its edge-defined film-fed growth (EFG) technique. In the past year, reports executive vice president Mlavsky, the company has progressed from making vertically drawn 1-by-2-centimeter ribbon cells with a 10% efficiency to producing 1-by-4-inch ribbon cells that are 8% to 9% efficient. He is quick to point out, though, that the company is two to three years away from a commercial ribbon product—last year merely gave his firm a better understanding of the EFG process and the material.

Mlavsky probably sums it up best when he says that the company's EFG technique "doesn't produce pristine single-crystal silicon. It's not as good as Czochralski material, but we can make solar cells with efficiencies of 10% plus with it, and that's the bottom line."

The list of companies with a parallel aim includes major chemical firms like Dow and Union Carbide, as well as Westinghouse, Texas Instruments, Honeywell, and Crystal Systems Inc. in the U.S.; Ferranti in England; Laboratoires d'Electronique et de la Physique Appliquée (LEP); the Philips group research facility in Eindhoven, the Netherlands, plus Matsushita in Japan, among others (see "What other governments are doing for photovoltaics," p. 96). Also active in this field are Monsanto, the top U.S. silicon producer, and IBM, which is working on a ribbon process.

Westinghouse, for one, is bullish about being able to cut the cost of high-grade silicon from $60 per kilogram to $10 using electric arc heaters to reduce a silicon intermediate to pure elemental silicon. The company has an ERDA contract via JPL with that cost reduction as its goal. But Westinghouse is still a long way from any kind of demonstration. The initial award is for a nine-month design and feasibility study, which would be followed by an experimental demonstration and, ultimately, construction of a full-scale demonstration plant that would produce large-area silicon sheets suitable for solar arrays. The study is a joint effort between the Westinghouse Research Laboratories, Pittsburgh, Pa., and the company's Power Circuit Breaker division.

Dow Corning Corp. has an ERDA contract with the same goal as Westinghouse—production of solar-grade silicon to sell for $10/kg. It, too, homed in on the electric arc furnace after studying some 200 reactions for converting sand or quartz into single-crystal silicon. Texas Instruments Inc. is investigating a direct reduction of silicon, working with a plasma technology that is not as far advanced as the arc furnace. And Union Carbide Corp., along with Battelle Columbus Laboratories, is investigating still other processes for producing solar-grade silicon (Fig. 3, bottom right).

Larger ingots

Another approach is under development at Crystal Systems Inc., Salem, Mass., where the objective is to produce much larger silicon ingots than has been possible before. This effort, too, is funded by ERDA as part of the low-cost silicon solar array project [*Electronics*, June 24, p. 34], but is also in the early stages. President Frederick Schmid says his company will draw on extensive experience in growing large-area single-crystal sapphire ingots to do the same with silicon. Schmid believes his company's heat-exchanger technique will eventually yield single-crystal silicon ingots from which wafers 6 inches in diameter can be cut. He calls the process "directional solidification" and points out that it differs from Czrochalski growth in that there is no

ERDA's position on photovoltaics

For fiscal 1977, the U.S. Energy Research and Development Administration has budgeted about $65 million for work on photovoltaic energy. That's more than double fiscal 1976's appropriation but still less than half the almost $160 million allotted to all fiscal 1977 solar-energy programs—the rest cover solar thermal energy, the solar heating and cooling of buildings, and similar efforts.

There are also much larger Federal technology programs devoted to research and development into fission power, fossil fuels, fusion power, and the nuclear-fuel cycle. Only energy conservation, environmental control, and geothermal energy rank behind solar energy in funding among the eight major energy technology programs in the Federal energy R&D budget.

With its $65 million, however, ERDA is sustaining a broad program of research and development in photovoltaics, its aim being to reduce the cost of collector arrays from today's $15 per peak watt of electricity produced. The chief elements of that program concern:

- Production of low-cost photovoltaic materials.
- Large-area crystal growth.
- Materials and techniques for array encapsulation.
- Improved cell and array designs.
- High-volume, cost-effective automated assembly techniques of production.

The initial emphasis is on single-crystal silicon because of its abundance and the widespread use of proven techniques for producing large single crystals. But gallium arsenide and cadmium sulfide are also being developed.

ERDA's timetable for achieving these objectives is, in outline:

- Establishment by 1983 of pilot plants capable of producing more than 5 million square meters of silicon sheets per year at a value-added cost of less than $18 per square meter.
- Establishment by 1984 of plants capable of producing approximately 2,000 metric tons of silicon material at a market price of less than $10 per kilogram.
- Establishment by 1985 of plants capable of producing more than 500 peak kilowatts of encapsulated solar-array modules at a market price of less than $500/kW.

Along the way, ERDA will establish a Solar Energy Research Institute to support the national solar-energy program. The goal is to have the institute site selected by next January and to have whatever construction it requires completed by fiscal 1980.

To date, ERDA's investment in photovoltaic energy development, though not large as Government funding goes, far outweighs that of the private sector. Yet the agency's policy in its national plan for energy research, development, and demonstration clearly states that "the private sector has primary responsibility for the development and commercialization of new energy technologies." Federal programs are intended to assist industry "in accelerating the market penetration of energy technologies with near-term potential." However, until the cost of photovoltaic-derived electricity comes down drastically, the market for it will not take off in a big way, and for that reason there has been no big outpouring of private funds, except from some oil companies.

The problem, as ERDA says, is that today's materials and processing costs for photovoltaic arrays, are 30 to 50 times too high to be competitive with conventional systems for almost all but remote-site applications. The agency's timetable fixes 1986 as the year in which it hopes photovoltaic energy will become cost-competitive with fossil fuels. But even so, unless priorities change or there is a huge influx of private funding, it seems unlikely that solar-derived electricity will account for more than 1% to 2% of this nation's needs when the year 2000 dawns.

pulling of the crystal as it grows upward and outward from the bottom of a crucible.

At least one foreign producer of solar cells would like to see efforts such as those at Westinghouse and Dow Corning cut the price of U.S. silicon. Ferranti Ltd., Britain's only maker of photovoltaic cells, is working on a screening process to lower cell costs, but regards itself as at the mercy of U.S. silicon makers. Peter Lilley, product marketing executive at the Electronic Components division, Gem Mill, Chadderton, Oldham, Lancs., notes that cheaper silicon would do a lot to lower the price of cells. Nevertheless, the division is working on silk-screen printing to cut the cost of cell making by 30%, Lilley says. It's a way to get around such expensive processes in semiconductor fabrication as photolithography and evaporation, "replacing five processes with one," says Lilley, who won't divulge more details.

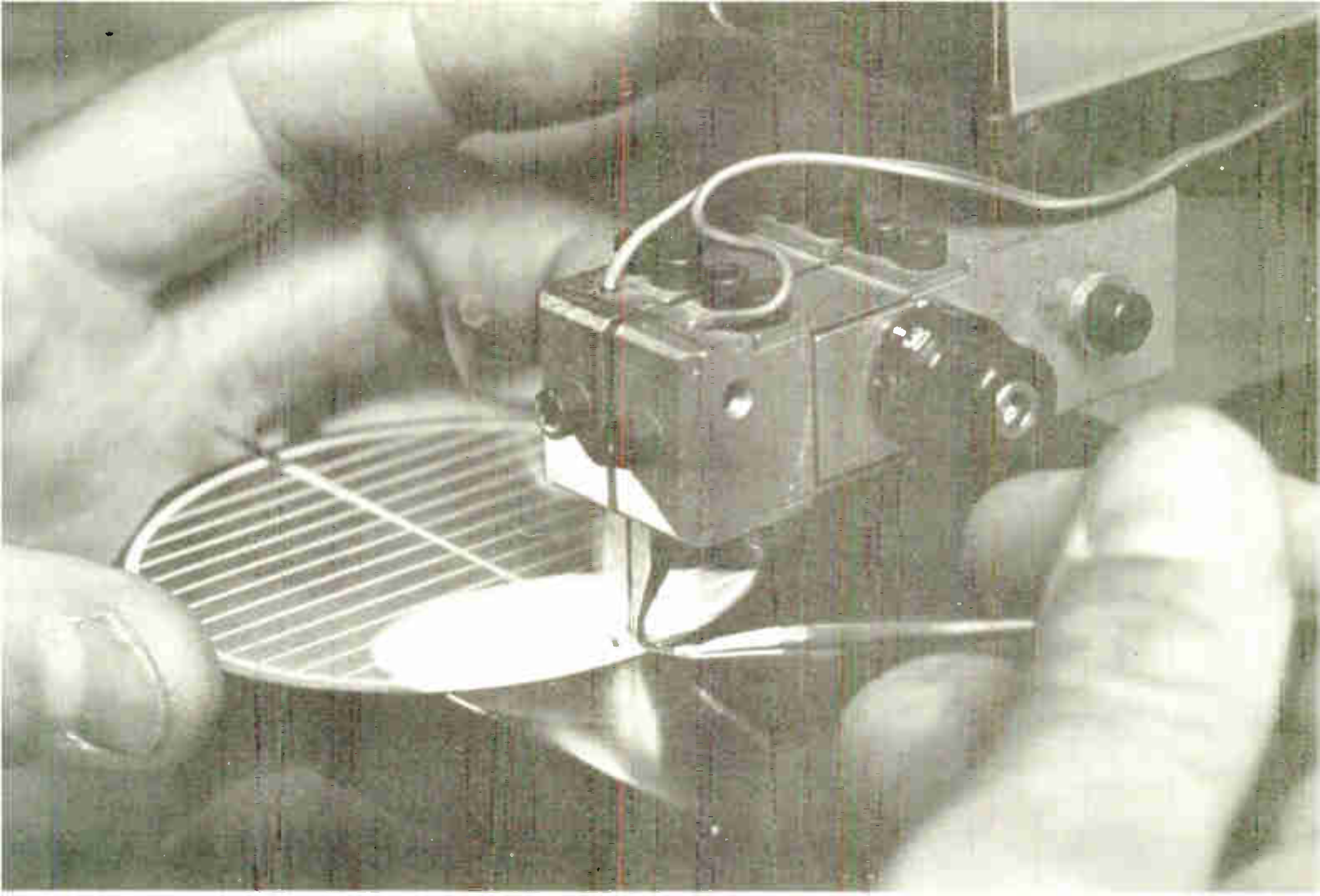
Screening is also getting some attention at Matsushita, along with chemical vapor deposition and vacuum (evaporation) deposition. Indications are that screening is the most economical.

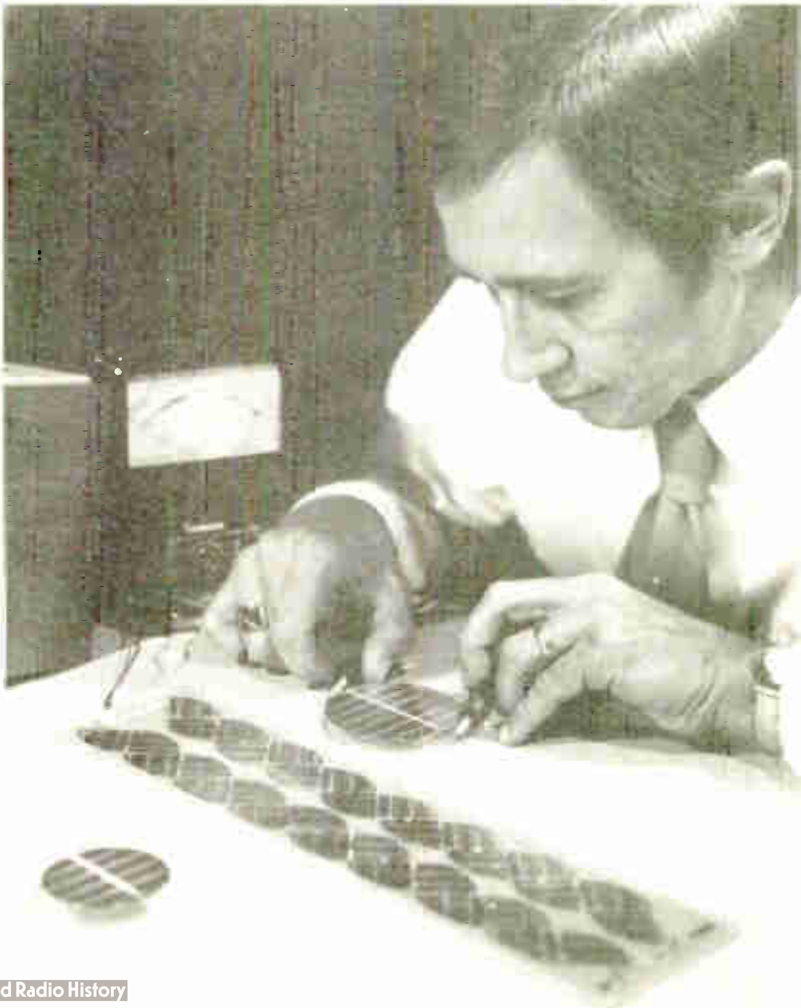
Solar Technology International, Chatsworth, Calif., agrees and since January has actually been shipping products using thick-film conductors on silicon cells 3 inches in diameter (Fig. 3, top). President William Yerkes says he chose screening on the grounds that it is the cheapest way to put conductors on solar cells—they embody a direct labor cost of only 15 cents per wafer.

One of the more novel processes for reducing cell costs is being studied at LEP in France. A research team there is trying to refine a method of dragging a ribbon of graphite across the surface of a molten silicon bath so that a layer of silicon carbide forms and the silicon layer is chemically bonded to the ribbon. Depending on the ribbon's withdrawal angle, temperature of the melt and pulling speed, the technique yields polycrystalline layers ranging from 70 to 150 micrometers thick, with the grains oriented almost parallel to the direction of pulling, explains Jean Jacques Brissot, a member of the team.

LEP is also at work on what it calls a "black cell" that would boost silicon cell conversion efficiencies to near 20% [*Electronics*, March 18, p. 48]. A textured front surface cuts light reflection to about 10% without any reflective coating, and a thin p^+ layer on the back sets up an electric field that inhibits recombination of photocarriers on the back contact, cutting losses there. The black cell is promising enough for RTC-La Radiotechnique Compélec, to have undertaken a one-year program to evaluate its commercial producibility.

LEP is not alone in its dip-coating approach. Honey-





3. From the lab to the real world. Anticlockwise from right, researcher at Battelle Columbus Laboratories is checking silicon cells as part of a program aimed at reducing material and manufacturing costs of photovoltaic devices. In production at Solar Technology International is a 3-inch-diameter silicon cell that uses thick-film conductors, shown here having lug welded to it. Prototype 1-kW photovoltaic generator under construction at Sandia Laboratories will have 135 Fresnel lenses to concentrate sunlight on 135 silicon cells. The unit also produces 5 – 6 kW of solar thermal energy.

What other governments are doing for photovoltaics

The governments of Japan, France, and West Germany have recognized the potential of photovoltaic-derived energy, and they are backing its development. In fact, Japan had established a high-priority "sunshine project" even before the U.S. Energy Research and Development Administration was set up [*Electronics*, April 4, 1974, p. 104].

By the turn of the century, the Japanese expect to have spent between $3.6 billion and $7 billion on the project, which they compare to the U.S. Apollo lunar landing program in national significance. Like ERDA's national program, it includes solar, geothermal, and hydrogen energy development, as well as the liquefaction and gasification of coal.

The Sunshine Project is under the aegis of the Agency of Industrial Science and Technology, which is attached to the Ministry of International Trade and Industry (MITI). This year's budget for solar-cell R&D is about $1 million. There's also an effort in electrical-power generation from solar batteries. Its first phase covers basic research and will extend through fiscal 1980, and it will be followed by a second phase that will be aimed at preparing companies for production.

Many leading companies are involved in the solar-cell portion of the project. Tokyo Shibaura Electric Co. is concerned with the fabrication of single-crystal silicon ribbons by vertical pulling, and Toyo Silicon Co. is doing the same but by horizontal pulling. Nippon Electric Co. and Hitachi Ltd. are working on a single-crystal equivalent to silicon ribbon, the former using ion plating on alumina substrates, and the latter using deposition on alumina substrates. Matsushita Electric Industrial Co. is studying compound cells using cadmium sulfide and similar substances, while Sharp Corp. is focusing on complete silicon solar cells.

The leading French agency in solar energy development is Direction Générale de la Recherche Scientifique et Technique, which has about $1 million a year earmarked for photovoltaics. West Germany's Ministry for Research and Technology has allocated to photovoltaics some $2.2 million out of a total of $40 million to be spent on solar-energy work from 1976 to 1980.

well's Advanced Development Laboratories is working on a proprietary process for dip-coating a ceramic substrate with silicon. Paul Chapman, sensor section head, reports that if ceramic is carbonized and then dipped, a thin layer of silicon carbide forms to provide an interface on which the silicon will grow; it won't grow directly on ceramic. "Our layers look similar to ribbon," he says. "We have large grains—centimeters long and millimeters wide—rather than the micrometer-sized grains found in polycrystalline material."

The other approach to reducing the cost of photovoltaic material is to use less of it. This is possible if more of the sun's rays are concentrated onto a smaller area.

ERDA is pursuing concentrator R&D through Sandia Laboratories, Albuquerque, N. M. [*Electronics*, July 22, p. 41]. Sandia's work in photovoltaics is considered to be parallel to, and not competing with, the silicon efforts handled by JPL, but Sandia researchers feel their efforts should be funded by ERDA more in line with JPL's. Sandia has about a quarter of the $12 million JPL got in fiscal 1976 out of ERDA's then total photovoltaic budget of some $22 million.

Concentrators yield multi-sun intensity

The Sandia team, headed by Jerry G. Fossum and Edward L. Burgess, expects to use plastic Fresnel lenses in conjunction with silicon cells with conversion efficiencies of 15%. Using 135 lenses and 135 silicon cells to produce an intensity equal to that of 50 suns, they are putting together a prototype array that will generate 1 kW of electrical power from sunlight (Fig. 3, bottom left). Next year, Sandia will seek bids on a 10-kW concentrator system with a view to operating a 100-kW unit in 1978 at a price per watt of $1 to $1.50.

There are certain drawbacks to the concentrator systems, however. Most of them must track the sun, they must be cooled, and they depend on bright sunlight. Tracking and cooling add to their cost, although the Sandia team foresees beating JPL to the ERDA goal of 50 cents per peak watt in 1986. They think this can be done with existing concentrator technology, while they believe the low-cost silicon solar array project will have to come up with breakthroughs in materials and in fabrication and automated assembly techniques to get there.

To progress toward that goal, Sandia has awarded a $275,000 contract to RCA Laboratories, Princeton, N.J., to develop concentrator systems using silicon cells. The contract calls for RCA to: deliver six 100-W demonstration units for use by Sandia and the U.S. Army; try to improve the efficiency of silicon cells under high concentrations, and produce systems designs that can be manufactured in quantity at relatively low cost. The first two demonstration units, to be delivered this month, use vinyl plexiglass lenses rather than Fresnel lenses. For the lens size and focal point RCA is using, the only suitable Fresnel lenses have the grooved side facing the sun, and the dust they would collect would block out some light, explains Fred Sterzer, director of RCA's microwave technology center. He adds that later systems may use Fresnel lenses with the smooth side facing the sun.

In the 100-W concentrator systems for Sandia, RCA uses 4-by-4-inch lenses in a 6-by-6-array for each of a system's three modules. Up to seven modules, each providing upwards of 30 W, could be included in a system generating about 250 W. Eventually Sterzer hopes to get the cost of such a system down to about $2 per watt. Further, he envisions producing the lenses in much the same way as phonograph records—by making a master and pressing copies from it. "We could get the cost per lens down to cents, but that's after we would first have to spend $200,000 to $300,000 to have a mold made," Sterzer points out.

Varian Associates, Palo Alto, Calif., is also developing concentrator arrays but is using gallium-arsenide cells with 20–22% efficiencies. John Heldack, marketing director in charge of the concentrator project, says the company's two-axis tracking array of 120 cells will be completed next month. It will use a conical concentrator with a mirror surface and will generate 1 kW. Heldack says the concentrator will represent 80% of the system cost, and because of that, Varian is carefully evaluating slump glass and aluminum as concentrator materials. The glass looks more economical, but the final choice will be determined by the optical design limitations of each material "and by what kind of accuracy we can get," Heldack notes. Funding for the work came initially from the company but has since been supplemented by three ERDA contracts.

ERDA is also funding concentrator development at the Argonne National Laboratory, Argonne, Ill. A compound parabolic concentrator made of acrylic holds out hope for eliminating the need for daily sun tracking—depending on how much concentration of sunlight is desired, it might have to be moved only seasonally. Its basic element is a vertical bar of solid acrylic. The bar presents a flat rectangular surface to the sun, then curves downward in a parabolic taper to a much narrower and slightly shorter rectangle, which matches the shape of an underlying silicon photovoltaic strip. With the bar, six times as much sunlight is funneled onto the strip as would reach it without the bar.

A 36-by-60 array of these bars has been built into a panel having a 100-W output. Researchers at Argonne are currently studying various plastics to cut its cost and weight, and the laboratory hopes to have commercial panels available within two years.

In Japan, Sony Corp. researchers report development of a multiple-junction silicon cell with a multilayer structure that uses a 1,000× concentration. They say cooling it is not a major problem because thermal loading is less than in microwave power transistors. But they still lack an efficient way to track the sun.

Photovoltaic products on the market

Clearly, there's an abundance of R&D into reducing the cost of photovoltaic materials and finished cells, but even the efforts that succeed won't bear fruit for months or years. In the meantime, the market for photovoltaic-derived energy is still limited mainly to applications where a more conventional power source would be difficult or prohibitively expensive to provide. Even so, there are standard products on the market—mostly arrays of silicon cells—that are doing useful work in those applications. Solar Power Corp., a wholly owned subsidiary of Exxon Enterprises Inc., has been selling arrays for terrestrial applications since 1971. The Spectrolab division of Hughes Aircraft Co. has had arrays on the market for about three years, and its 1975 spinoff, Solar Technology International, has been shipping arrays since January—profitably since July, according to president Yerkes—while Sensor Technology, Solarex, Ferranti, RTC, and Nippon Electric also produce commercial arrays. These arrays turn up at railroad crossings, where they power the lights and warning bells, on offshore drilling platforms, at desert water-pumping stations, at remote television stations, and on microwave repeaters (Figs. 4–6).

Solar Power Corp. has two basic types of arrays. The earlier has become a "commodity product," according to president Robert Willis. This module includes only five silicon cell wafers, but many of them can be connected to form a complete working array that sells for $34 a watt now. A newer array with larger wafers develops 25 peak watts at $14 per watt and was built under a JPL contract to provide 15 kW. (The company also holds a second ERDA contract for another 15 kW.)

Actual uses

Two Solar Power arrays are supplying photovoltaic energy to a microwave repeater. The repeater, built by GTE Lenkurt Inc., San Carlos, Calif., is undergoing field trials in a common carrier link between Kayenta, Ariz., and Mexican Hat, Utah. The arrays charge lead-calcium batteries that power the repeater. A GTE Lenkurt spokesperson says the entire installation—arrays, batteries, the 2-gigahertz repeater—cost about $15,000 vs an estimated $100,000 for the traditional "billboard" type of passive repeater that would have been required.

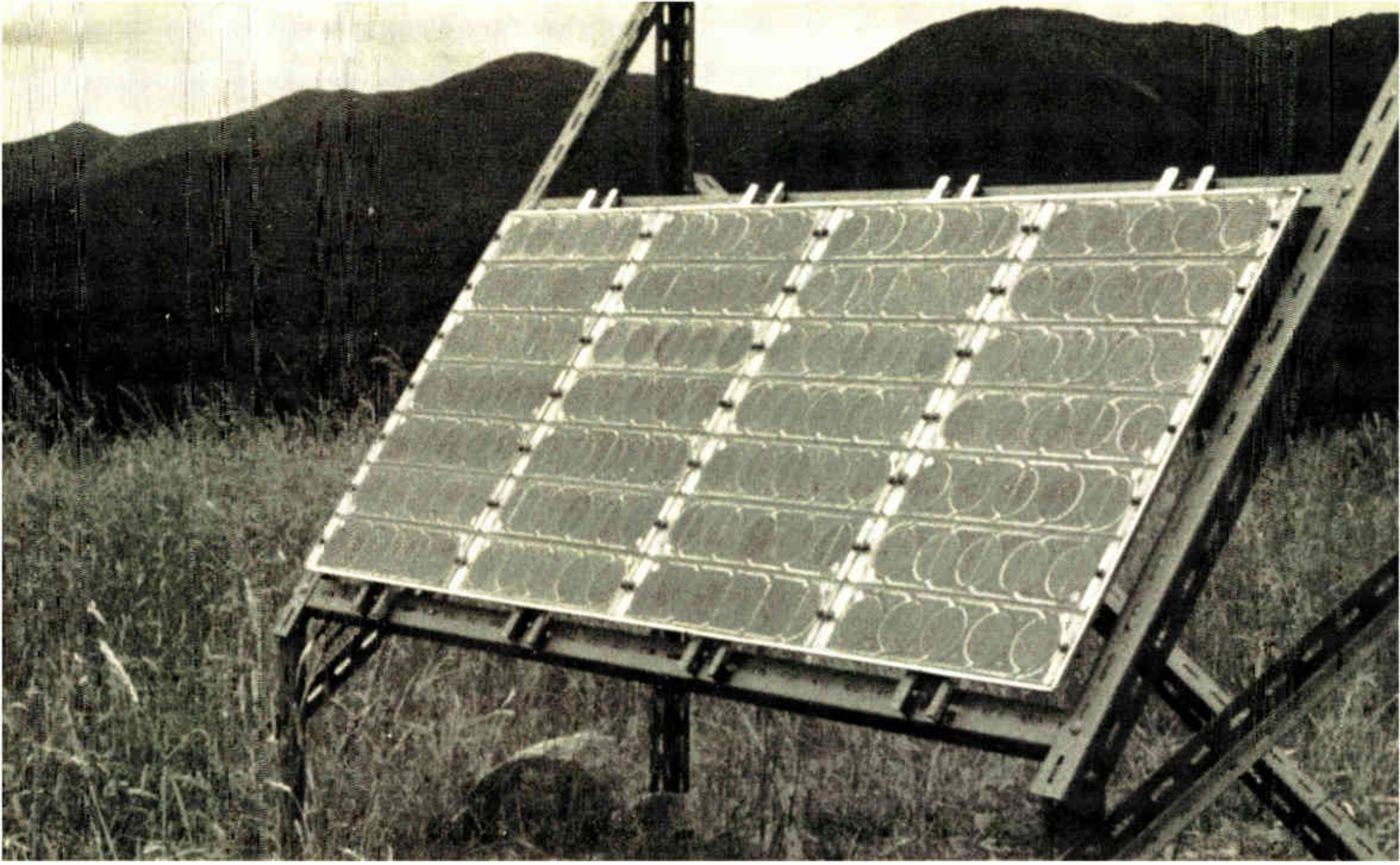
A 6-V array from Sensor Technology Inc., Chatsworth, Calif., supplies power to nickel-cadmium batteries in a domestic water meter marketed by Zurn Industries Inc., Erie, Pa. The batteries power the indoor meter's outdoor display. Solar Technology, also in Chatsworth, makes an array of 33 to 39 cells. Designed to charge a 12-V battery, it puts out 16 V at 1.2 amperes and sells for about $15 per peak watt.

Soon to be introduced is a solar-powered hydrogen-sulfide detector from Dictaphone Corp., Mountain View, Calif. The unit will protect oil field and petrochemical operating personnel from exposure to fatal concentrations of hydrogen sulfide. Four of the detectors will be monitored from a control box that will trigger a shutdown of the well if hydrogen sulfide is sensed. "Solar-powered alarms are cheaper than running a power line 50 to 75 miles," says Greg Horn, engineering manager of Dictaphone's Gas Detection Products division.

Ferranti arrays, besides being used in the more conventional applications, have also recharged batteries in a transatlantic boat race. The basic Ferranti module consists of 32 circular cells and sells for about $170 in small quantities. Cables and Wireless Ltd. is testing three 24-W Ferranti arrays powering an operational repeater station in the Middle East "to see if they stand the test of time," says a Ferranti executive. The customer, however, is also trying out gas-, diesel- and wind-powered generators and may settle on a mix.

RTC's standard array puts out 11 W at 25°C at a cost of roughly $40 per watt. Six panels powered the automatic pilot aboard Eric Taberly's one-man Pen Duick VI in his winning effort in this summer's solo transatlantic yacht race. But another RTC application is probably more indicative of the niche that photovoltaic-derived energy now fills. RTC has orders for "thousands" of panels from the builder of a water-pump system for desert regions, Société Briau. The system is powered by 400 W of silicon cells in parallel with a buffer battery, both controlled by an electronic circuit. The pump, with a capacity of 2,700 liters per hour at a draw of 20 meters, is driven by a ⅓-hp motor.

The system takes 4–6 hours a day for 10–15 cubic



meters of water and is popular because it does not drain the water table too quickly. A high-power thermal pumping unit drains the well after a few minutes in the desert regions near Algeria and Tunisia, where the water table is 20 – 30 meters deep. The photovoltaic-powered pump provides a slower, steadier flow, has low maintenance, and costs about the same.

There have been some consumer products using photovoltaic-derived energy, too, but until recently they have chiefly been novelties, such as solar cells used to charge the batteries of electronic watches. Now M7 International, Arlington Heights, Ill., has introduced a silicon-cell array that can be used to directly power small appliances, requiring low current and up to 12 volts, such as calculators, two-way radios, and portable radios, or can be used as a battery charger [*Electronics*, Oct. 14, p. 30]. M7 is one of five winners in both the ERDA/JPL procurements and got its start as a producer of custom photovoltaic sensors for card and tape readers.

How is ERDA handling its tasks?

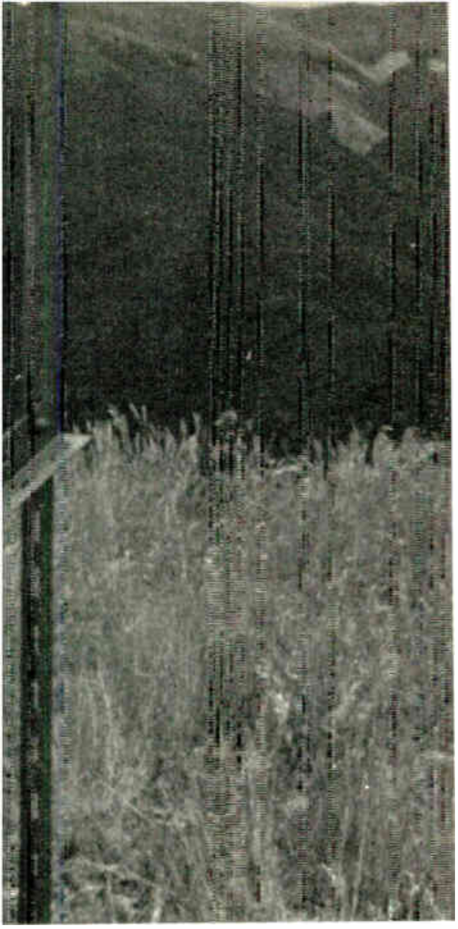
In the U.S., most of the incentive for developing photovoltaic energy clearly comes from ERDA. Most cell makers have contracts with ERDA and are understandably reluctant to bite one of the hands feeding them. There is some restiveness about policy, but no major quarrel with the agency's objectives and progress. Solar Power Corp.'s Willis, for example, says ERDA is doing a "reasonable job" of administering photovoltaic R&D, and that JPL was a good choice to handle the contracts. "They're willing to listen, and they're reasonable people," he adds, "and they have us convinced that they're interested in stimulating this market."

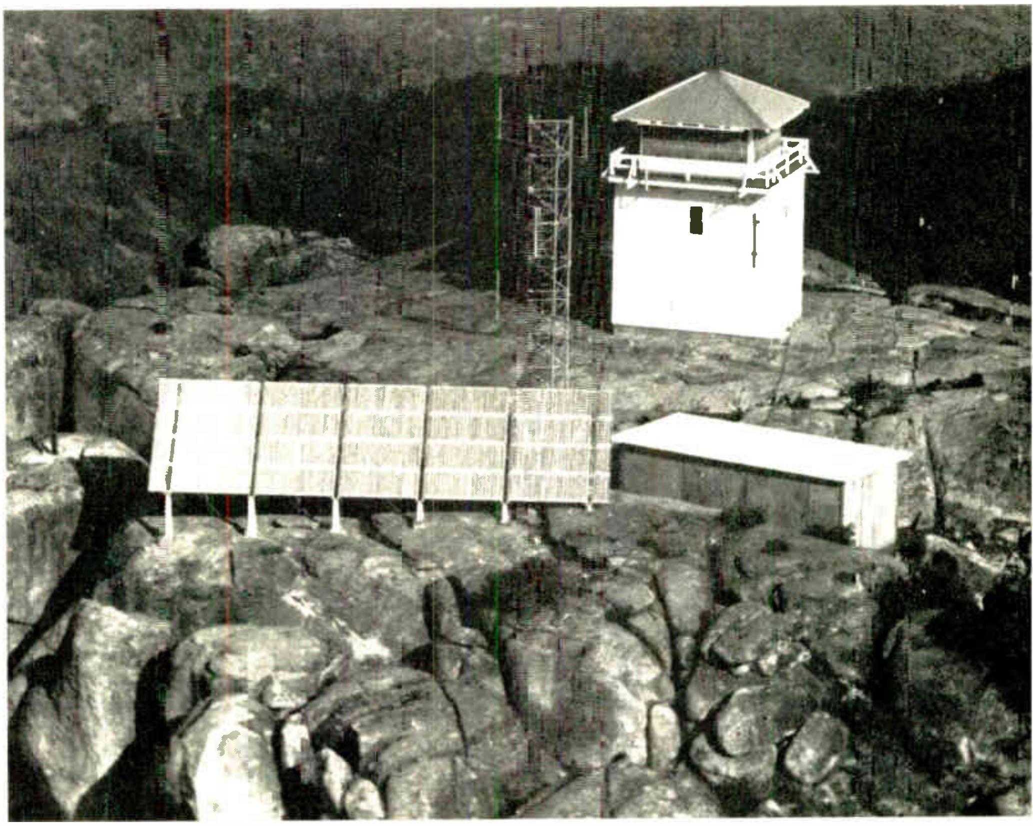
Mobil Tyco's Mlavsky thinks ERDA "is not doing a bad job getting things started." He testified before Congress early this year on the Humphrey-Fannin bill, which helped to more than double ERDA's fiscal 1976 photovoltaics effort to 1977's $65 million. Mlavsky says that scope for the program is appropriate, but believes more than that should be allocated next year, "and a hell of a lot more in fiscal 1979 because of the need to test and demonstrate systems."

ERDA's own Morton Prince, chief of the photovoltaics branch, acknowledges that the early low budgets have attracted some criticism but points out that more money is coming. The early studies, he says, "are intended primarily to give some guidance as to which materials and directions we should pursue. After a year or two, we'll reduce the number of directions and go after those we've selected with a larger program. If I had more money now," he adds, "I would just undertake more parallel approaches and get more performers in."

Getting more performers in is one of the sensitive points with the existing industry. The possibility that some of the non-cell-producing firms now doing R&D on JPL contracts could become competitors concerns Spectrolab, for one. "Let's just say I'm apprehensive about it," says Spectrolab president Gary Wrench. "I hope nothing happens to damage our demonstrated willingness to invest in the field now that we're getting our production capacity cranked up."

Mlavsky shares this concern, but ties it to "background rights" as covered by ERDA policy. These are rights to company-funded developments that are





4. Far from the madding crowd. Array of photovoltaic cells in fields near Nelson, New Zealand, turns sunlight into electrical energy for battery-powered radio repeater.

5. The size of things to come? Powering a communications link on a mountaintop in southern California is a solar-energy conversion array from Spectrolab. Approximately 900 square feet in area, the array produces well over 3 kilowatts of peak power. A big advantage of this kind of power source is that it can be left unattended.

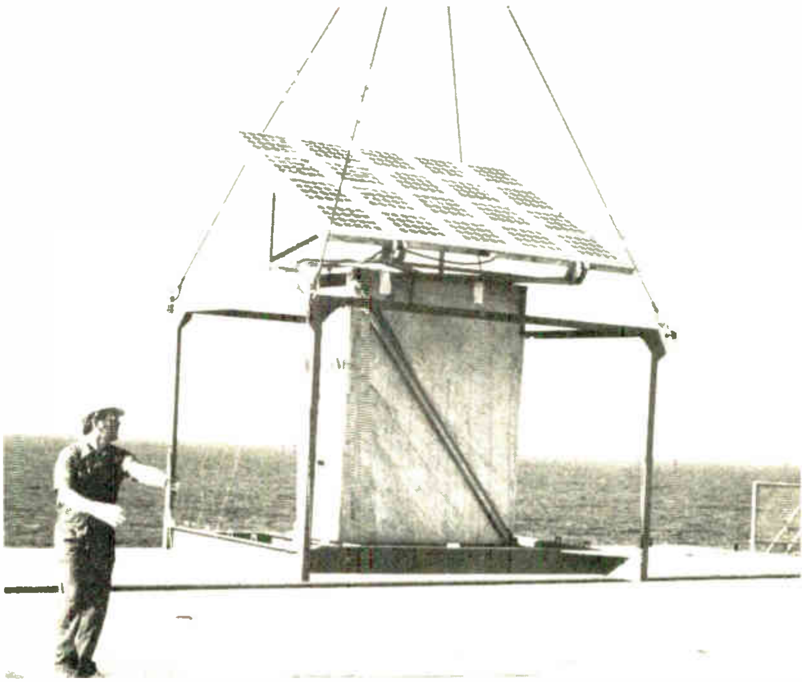
then applied to an ERDA contract effort, which could be compromised by the ERDA patent policy. In other words, ERDA could require its contractor to license a potential competitor before the licensor is in a strong enough position to compete.

ERDA's Morton is not convinced that this is a serious issue. He has worked in several small companies, and "the only way we kept alive was by working and staying ahead," he notes. "I wouldn't even try to patent our things to protect ourselves. It seemed to be a losing proposition because we couldn't afford to fight to maintain the patent. Even if we were successful, a company would be down the tubes with the legal fees."

Perhaps JPL's Robert Forney manager of the low-cost silicon solar array project, best articulates the dilemma when he says that to bring material and solar cell costs down, "we have to enlarge the capacity of the industry. One of our biggest problems is how best to optimize the expansion of that industry." To achieve those goals, JPL believes it's mandatory to bring in those companies that offer vast technological resources and perhaps new approaches to the problems.

Contributions to this special report came from Margaret A. Maas, former Industrial Editor, and field editors Larry Waller, Larry Armstrong, Bruce LeBoss, Judith Curtis, Ray Connolly, John Gosch, William F. Arnold, Arthur Erikson, and Charles Cohen.

6. In operation today. This array of photovoltaic cells is in process of being installed on an offshore oil platform out in the Gulf of Mexico, where its job will be to supply energy to the batteries that power the rig's navigation lights and also its foghorn.



Digital combination lock is virtually crackproof

by Dale Platteter
Naval Weapons Support Center, Crane, Ind.

All the sandpaper in the world wouldn't help a safe-cracker open a 15-digit combination lock with the electronic "tumblers" described here. In fact, it could take more than a million and a half years to generate the correct code, if combinations were tried at the rate of one every 10 seconds.

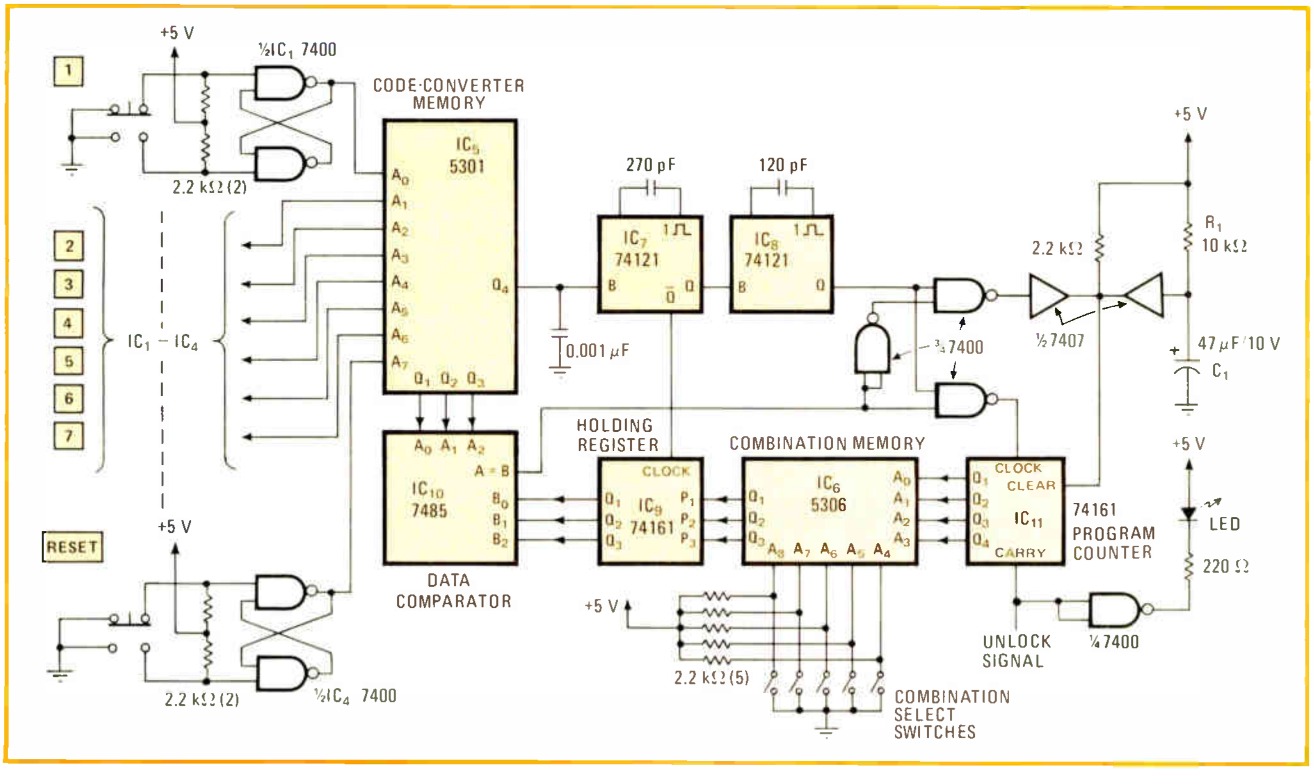
Would-be thieves are further discouraged by the automatic reset of the circuit on entry of any incorrect number—which requires that the entire sequence be reentered and thus disrupts any orderly trial-and-error approach. In addition, the 512-by-4 bit programable read-only memory that stores the correct combination has room for as many as 32 easily selectable combinations, enabling the code to be changed periodically.

The circuit compares the combination entered with one stored in memory, a digit at a time, and latches a transistor-transistor-logic output high after the entire code is correctly entered. The reset button is pushed before the combination is entered to ensure that the lock is ready for entry of the first digit. The operator also presses it to start over after he thinks he may have made a sequence error.

Only eight possible inputs—the reset and seven numbers—may be encoded, because the binary words representing each are 3 bits long. But it's a good idea to use a standard 0–9 push-button array and allow one, two, or all three of the spare buttons (0, 8, and 9 in this example) to serve as reset. This increases security of the lock, since no unauthorized person will know which button to push for reset.

Integrated circuits $IC_1 - IC_4$ in the figure are quad NAND gates connected as R-S flip-flops to debounce the single-pole, double-throw push buttons. The entered numbers are encoded by IC_5, a Monolithic Memories Inc. type 5301 256-by-4-bit PROM programed according to the truth table in Table 1. This chip was selected to simplify programing, because its background is initialized to logic 1 and the reset code of 111 means most of the addresses will be logic 1s. The unlocking codes are programed into the combination memory, IC_6, an MMI type 5306 512-by-4 bit PROM.

Shown in the figure are code-selecting switches that determine the 5 most-significant bits of the address-data inputs (A_4 through A_8) and hence, which of the possible 32 combinations is selected. The five data lines may be programed from a remote location for the temporary exclusion of particular "key holders," or just to change



Maximum security. A total of 13 integrated circuits is used in this digital combination lock, which requires a sequence of 15 digits to open. The design permits easy changing of sequence length and number of possible digits, and the memory stores up to 32 combinations.

PROM PATTERN FOR CODE-CONVERTER MEMORY (IC 5)

Address									Output				Comments
Binary								Decimal					
A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		Q_4	Q_3	Q_2	Q_1	
1	1	1	1	1	1	1	1	255	0	1	1	1	No inputs
1	1	1	1	1	1	1	0	254	1	0	0	1	Enter 1
1	1	1	1	1	1	0	1	253	1	0	1	0	Enter 2
1	1	1	1	1	0	1	1	251	1	0	1	1	Enter 3
1	1	1	1	0	1	1	1	247	1	1	0	0	Enter 4
1	1	1	0	1	1	1	1	239	1	1	0	1	Enter 5
1	1	0	1	1	1	1	1	223	1	1	1	0	Enter 6
1	0	1	1	1	1	1	1	191	1	0	0	0	Enter 7
0	1	1	1	1	1	1	1	127	1	1	1	1	Reset
All remaining addresses									1	1	1	1	Error input reset

PROM PATTERN EXAMPLE FOR COMBINATION MEMORY (IC 6)

Address										Output				Digit
Binary									Decimal					
A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0		Q_4	Q_3	Q_2	Q_1	
1	1	1	1	1	0	0	0	0	496	x	0	0	1	1
1	1	1	1	1	0	0	0	1	497	x	0	0	0	7
1	1	1	1	1	0	0	1	0	498	x	1	0	0	4
1	1	1	1	1	0	0	1	1	499	x	0	1	0	2
1	1	1	1	1	0	1	0	0	500	x	1	1	0	6
1	1	1	1	1	0	1	0	1	501	x	1	0	1	5
1	1	1	1	1	0	1	1	0	502	x	1	0	1	5
1	1	1	1	1	0	1	1	1	503	x	0	1	1	3
1	1	1	1	1	1	0	0	0	504	x	0	0	0	7
1	1	1	1	1	1	0	0	1	505	x	0	0	1	1
1	1	1	1	1	1	0	1	0	506	x	0	0	0	7
1	1	1	1	1	1	0	1	1	507	x	0	1	0	2
1	1	1	1	1	1	1	0	0	508	x	1	0	0	4
1	1	1	1	1	1	1	0	1	509	x	1	0	0	4
1	1	1	1	1	1	1	1	0	510	x	0	1	1	3
1	1	1	1	1	1	1	1	1	511	x	1	1	1	Reset
Remainder of memory is used to store 31 additional combinations x = not used														

the combination in the interest of security.

Timing of the circuit is controlled by two monostable multivibrators. When any button or combination of buttons is pressed, the MSB output (Q_4) of the code-converter memory, IC_5, goes high and triggers the first monostable, IC_7. The rising edge of its Q output latches the binary word at the output of the combination memory, IC_6, into the holding register, IC_9, a 4-bit programable binary counter. After 375 nanoseconds, the rising edge of the $\overline{Q}$ output of IC_7 triggers the second monostable, IC_8.

While the Q output of IC_8 is high, which occurs for 165 ns, a 4-bit magnitude comparator IC_{10}, compares the entered and stored words. If the words of IC_5 and IC_6 are identical, the A = B output of the comparator will go high, incrementing the program counter, IC_{11}, another 4-bit binary counter, through the NAND-gates. If the words differ, the program counter is reset, and the entire combination must be entered again.

Upon entry of the correct combination, the program counter advances 15 counts, and the carry output goes high. This is the unlock signal, indicated by a light-emitting diode. It can drive external TTL circuits, or may be buffered to control a solenoid-operated lock.

The program counter could assume any initial state when power is applied. To prevent opening of the lock when power is periodically interrupted, a power-on reset circuit made up of the R_1-C_1 charging network and a buffer clears the program counter for the first few milliseconds.

If less security is permissible, the circuit may be simplified to keep down the component count and cost. A priority encoder such as the 74147 may be used in place of IC_5, sacrificing the automatic reset effected when two or more buttons are simultaneously pressed. A smaller memory may be used if 32 different combinations are not needed, and the power-on reset circuit may be eliminated.

A 2-bit word length might even be used, greatly reducing circuit complexity. It still could require as much as 4½ years to crack at the rate of one 15-digit combination every 10 seconds—and burying those three possible input numbers in a complete 0–9 push-button array would increase security many times over. The system is completely expandable—word length (hence number of inputs) and sequence length are easily adjusted to suit one's needs.

A PROM sample programing pattern for the combination 174265537172443 is shown in Table 2. Each of the 15-digit combinations is allocated 16 bits of memory, leaving the last bit unused. It is beneficial, as shown, to program 111 into these locations (since the first address is 0, the 16th bits are in every 2^n-1 address, where n is greater than 3—for example, 15, 31, 63, etc.). Reset will then occur automatically when any digit is pressed after the lock has been opened. □

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.

PROM provides linear or logarithmic display

by John Brady
Applied Research Laboratories, University of Texas, Austin, Texas

A read-only memory, programed so that its output words are logarithmically related to the input address words, is useful for displaying a logarithmic response in digital-signal processing. The display has none of the drift and gain error with time that are associated with the use of an analog log amplifier, and, in many cases, is more economical.

In digital-signal processing, the magnitude of a time-varying function or of a frequency-varying function is displayed on an oscilloscope by connecting the digital word to a digital-to-analog converter of the same bit length. The d-a output is the vertical input to the scope, and the sweep is triggered by a suitably repetitive synchronization pulse derived from the signal. If a logarithmic amplitude response is needed, the usual

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The one in front is specifically for use in OEM systems With the Model 1951, you can have controls mounted on the rear panel, or they can be pre-set on an easily accessible PC board And the unit's power supply can be removed and installed elsewhere in your system The 1951 is particularly well suited to medical electronic systems

The scope on the left is our Model 1901C which can be used with our (or anybody's) RF or microwave sweepers The unit has a sensitivity of 1 mV per division which is ideal for low-level detection requirements Features such as Z axis intensity modulation, Y marker adders and a blanking protection circuit contribute to the unit's versatility

Finally, the scope at right is our Model 1910 It's basically the same as the 1901C except that it provides dual trace capability

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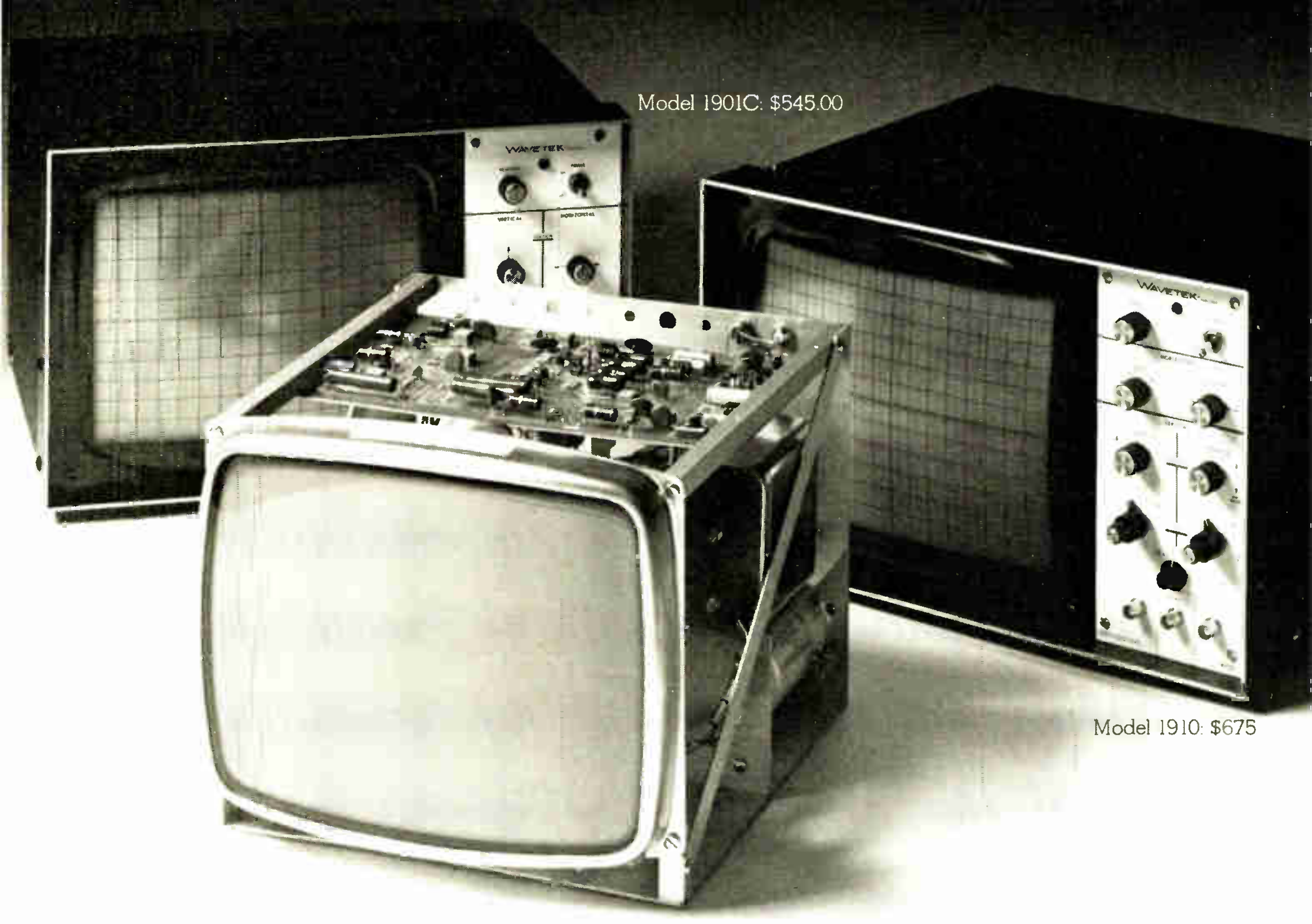
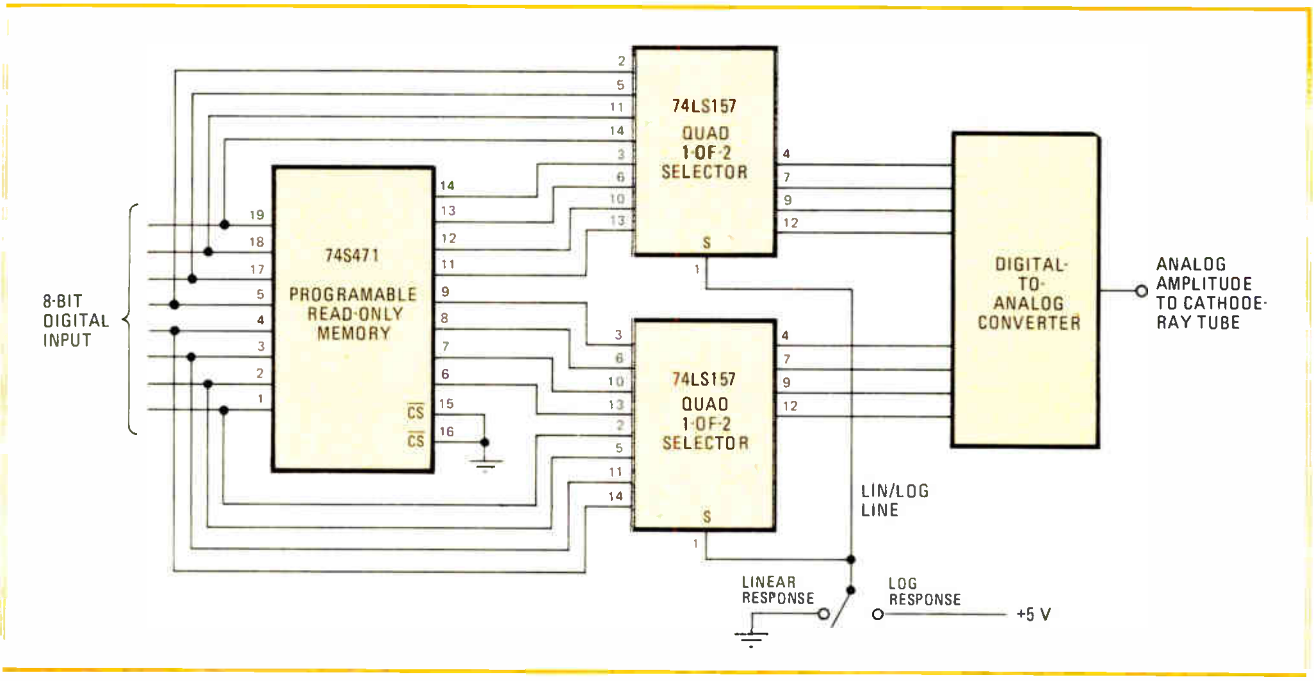
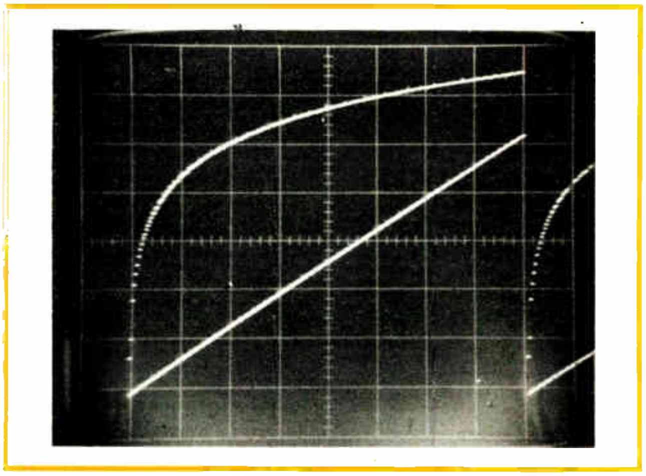


Model 1951 $450 (in small quantities)

Circle 102 on reader service card



1. Three ICs select response. The 74LS157 quad two-line-to-one-line data selectors choose either the linear input code or the logarithmically scaled output from the 74S471 PROM and present it to the d-a converter for display on a scope.



2. Log response. The logarithmic PROM output corresponding to a linear digital ramp input is shown in the top trace after conversion. The ramp input is shown in the lower trace. The scope is triggered by the overflow in the 8-bit counter that generates the ramp signal.

approach is to place an analog log amplifier between the d-a output and the cathode-ray-tube input. However, use of a programable read-only memory makes possible the much simpler solution shown in Fig. 1.

In this circuit the 74S451 transistor-transistor-logic PROM converts the linear 8-bit amplitude into a logarithmically scaled output code. The two 74LS157's (quad two-line-to-one-line data selectors) allow selection of the linear input or the logarithmic response. When the LIN/LOG select line is low, input pins 2, 5, 11, and 14 of the 74LS157 are connected to output pins 4, 7, 9, and 12, respectively, so the response is linear. But if the display-select line is high (+5 volts), pins 3, 6, 10, and 13 of the 74LS157 are connected to pins 4, 7, 9, and 12, so that the response is logarithmic. Both linear and log output responses to a digital input ramp are shown in Fig. 2.

The PROM is used in a basic look-up scheme. The linear input number serves as the address to the PROM. The stored code effectively performs the operation 20 log (input address), with the output code linearly scaled in decibels. For an input signal with n bits, the smallest output step is k decibels, where k is given by:

$$k = (20 \log 2)\, n/(2^n - 1)$$
$$= 6.02\, n/(2^n - 1)$$

The general form of the output is then:

$$y = (20 \log m)/k$$
$$= (2^n - 1)\,(20 \log m)/6.02n$$

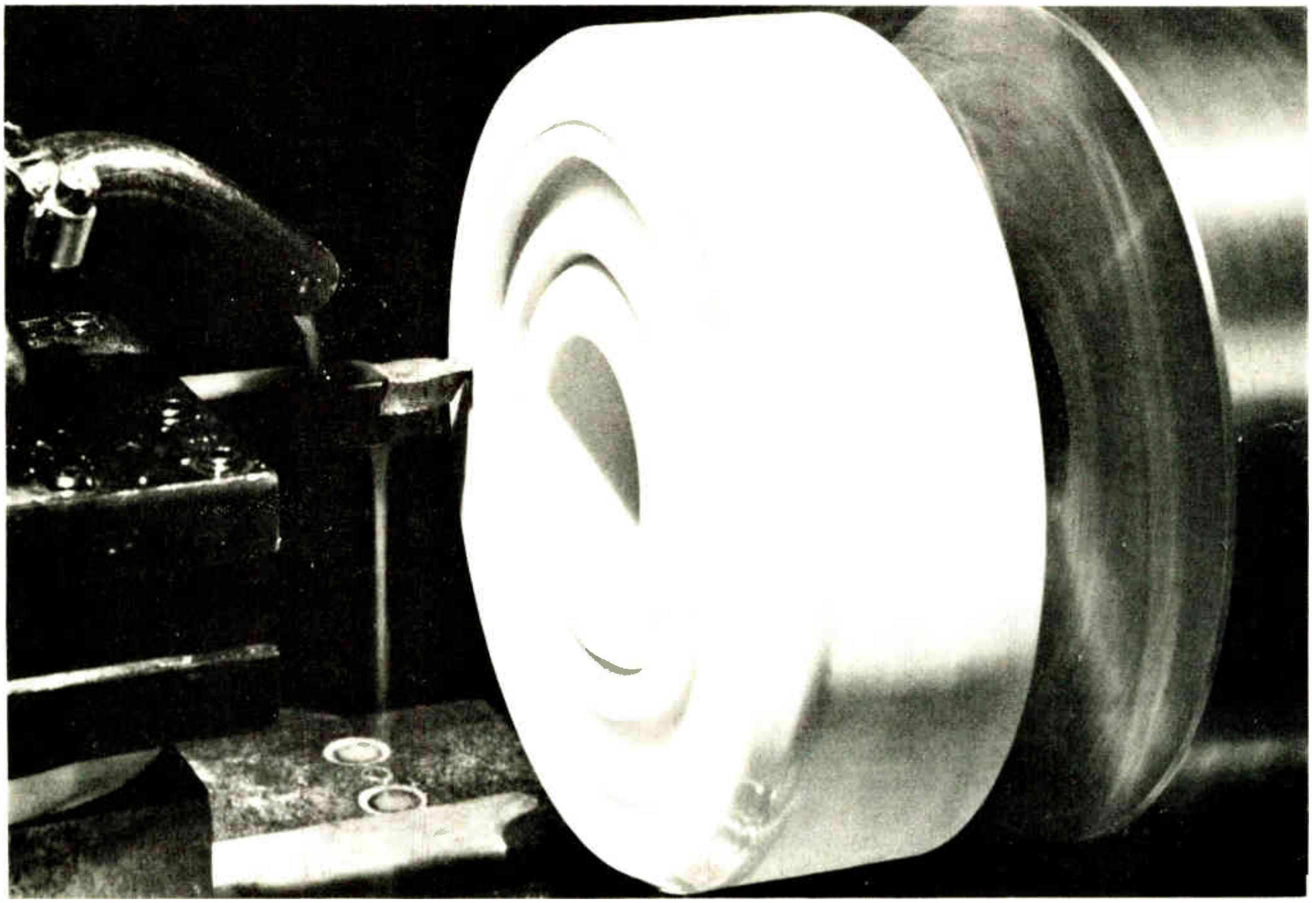
where y is the output code in dB, and m is the linear input code—i.e., the base-10 representation of the binary input number. If the input is a 8-bit binary signal, then:

$$y = 255\,[20 \log (\text{input address})]/48.1$$

In calculating the stored values of the PROM, fractional output codes are rounded to the nearest whole number. Any resulting error is less than 0.1 dB. An input amplitude of zero, which produces an unrepresentable value in decibels, is assigned an output value of zero.

Although the number of PROM output bits does not need to equal the number of input bits, maintaining the equality allows the linear and log displays to have the same base line and full-scale points. ☐

machinable glass? you've got to be kidding!



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CORNING

Satellite processors lighten the burden in computer-run systems

Sharing monitoring and control tasks gives simpler software and faster operation than in centralized setups

by P. David Fisher and Gary S. Krause, *Michigan State University, East Lansing, Mich.*

☐ Super-efficient, omniscient giant computers are the stuff of science fiction, but in real life computer architecture is evolving towards less monolithic systems with greater intelligence at the nerve ends. In fact, distributed monitoring and control using a group of satellite processors linked to a central computer looks like a good bet to displace conventional centralized control and measurement built around one large computer.

The new architectures offer simpler software and—if for no other reason than the reduction in system delays—higher operating speeds. Their success is due to the diminishing costs, greater availability, and improved computing capacities of minicomputers, microprocessors, programable calculators, and intelligent terminals—any of which may serve as the satellite processors in distributed networks.

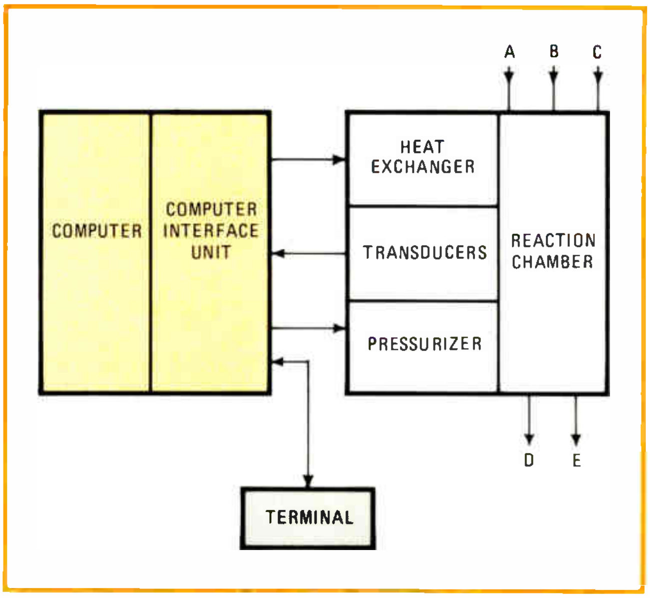
Name that term

Distributed system, distributed monitoring, distributed control, distributed processing, and distributed control system each have their own distinct meaning, even though many of these terms are mistakenly used interchangeably. So, before looking at the architecture of distributed control systems, it is best to define them.

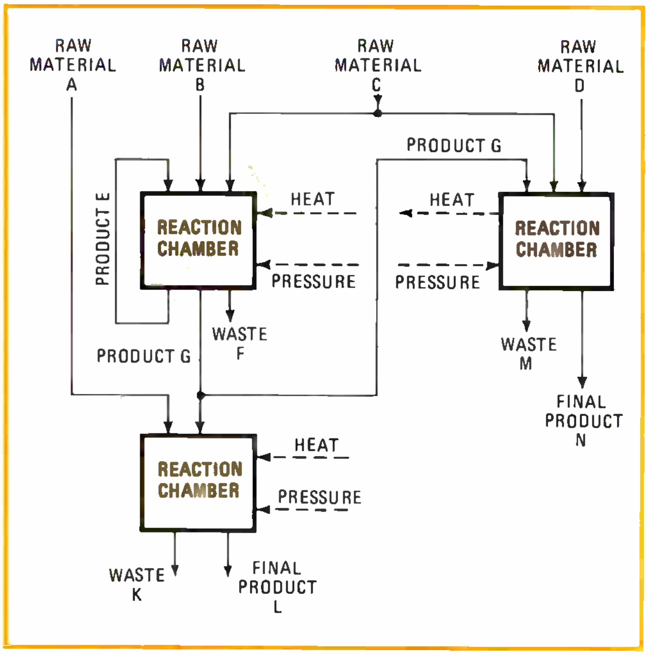
In electronics, "distributed" refers to a characteristic that is spread out over an electrically significant length or area. For example, the capacitance of a coaxial cable is said to be "distributed" as opposed to the "lumped" capacitance of a discrete mica capacitor. The exact point at which a capacitance ceases to be lumped and becomes distributed often depends upon its usage in a circuit. Similarly, the exact point at which a system may be said to be centralized (lumped) is relative. Still, a distributed system may be defined as one spread out over a significant length or area.

Of course, a centralized system may contain distributed components, and vice versa. In a similar fashion, it is entirely possible and, in fact, often desirable for a distributed system to be centrally controlled or for a centralized system to be distributively controlled.

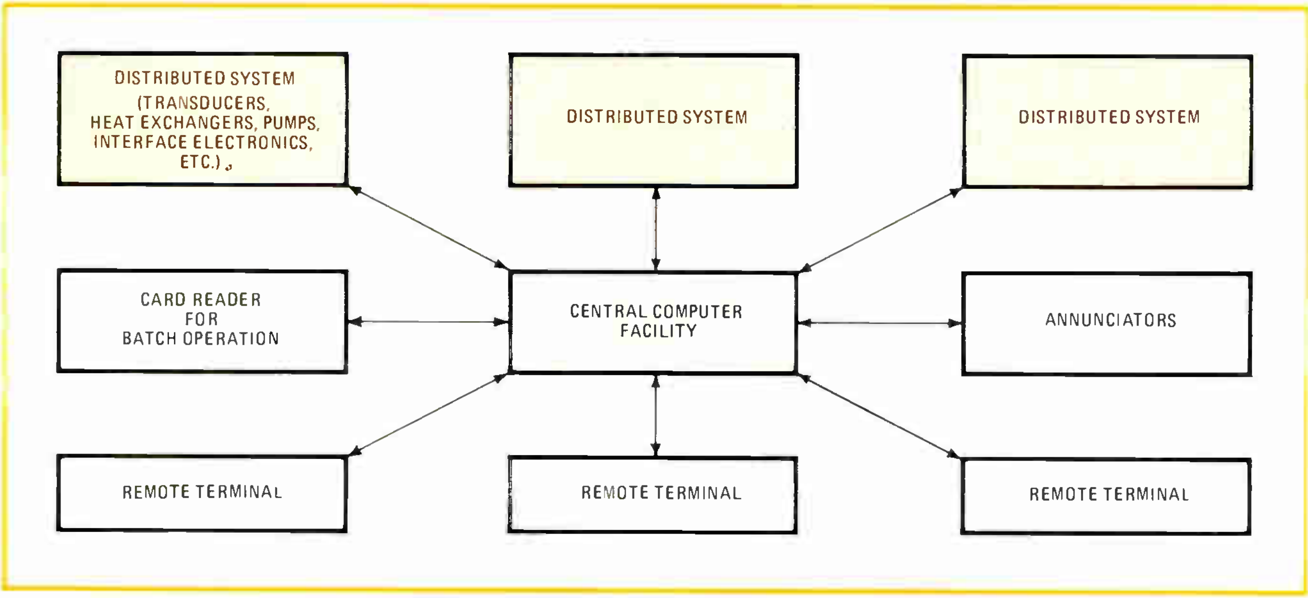
The terms distributed monitoring, distributed control, and distributed processing, on the other hand, do not



1. Centralized control. The data acquisition, processing, and control functions for this computer-controlled reaction chamber are not distributed since they are handled by a single processor.



2. Distributed system. Because all the three chambers used in this process are interdependent and remote from each other, the system can be classified as distributed.



3. Centralized control. Multiple distributed systems can be controlled and monitored by one central computer. However, if a system of this type gets too large, real-time control may no longer be possible because of the resultant large time delays.

necessarily imply spatial distribution. Instead they indicate that particular functions—data acquisition, control, and data processing—are handled simultaneously by more than one piece of hardware. When any of these functions are so handled, then a distributed control system is said to exist, since there always is some control involved.

A simplified model of a completely centralized, computer-controlled reaction chamber is shown in Fig. 1. Materials A, B, and C flow into the chamber at a fixed rate and materials D and E flow out. Temperature and pressure are to be controlled. Since both are assumed to be uniform within the chamber, only one temperature transducer and one pressure transducer are required.

The computer controls

Temperature and pressure are sampled in response to commands issued by the computer to the computer interface unit. With the terminal interfaced to the computer via this unit, an operator may temporarily interrupt an instruction cycle (cycle-steal), ask the current status of the reaction chamber, command the computer to print out a record of a parameter versus time needed to document a reaction, change the control algorithm, or do unrelated computations.

Since all data acquisition is handled by a single data logger, monitoring is not distributed. The control algorithm for maintaining the desired reaction-chamber temperature and pressure is at a single location; therefore, the control function is not distributed. Since all data processing is done by a single processor, processing isn't distributed. Because of the uniform conditions within the reaction chamber, the system being controlled is not distributed.

The system of three simple reaction chambers in Fig. 2 is distributed because each of the chambers is separated from the others by significant distances. Individual chambers can't be viewed as independent systems because the flow of materials from one chamber to another affects the temperature and pressure within the downstream chamber.

The wastes associated with each reaction may be pollutants that go up stacks or solid or liquid wastes that must be removed from the reaction chambers. For the end products to be safely and efficiently produced and have the desired properties, the following parameters must be continuously monitored and controlled:

- The rate of flow of each of the materials in each of the streams.
- The temperature, pressure, and analytic characteristics of each of the materials in the various streams.
- The temperature and pressure within each reaction chamber.
- The stockpile of raw materials, intermediate products, final products, and wastes.

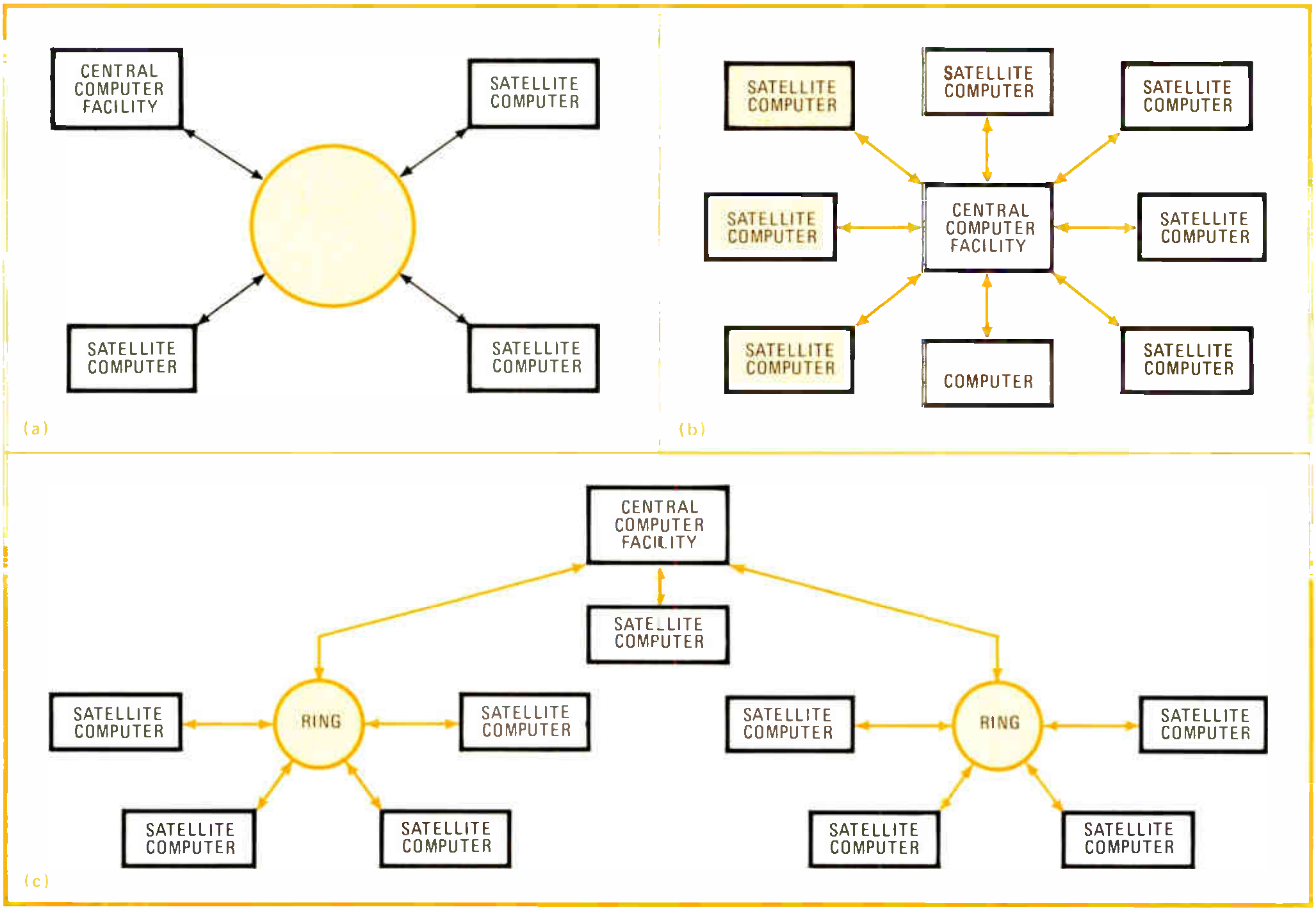
Central computing

A rational decision for selecting the best scheme for monitoring, control, data processing, and operator interaction for such a distributed system is not simple. It depends upon the interrelationships of the process involved, the software, the wiring, the data format, and many other complex factors.

During the 1960s and early 1970s, a systems engineer would most likely have created a system like Fig. 3. The central-computer facility would include a large mainframe central processing unit, with several disk drives and magnetic-tape units, and many input/output ports. Data processing would be centralized, and the software would include a real-time operating system and application programs.

In general, the operating system would have a "foreground/background" architecture. In the foreground mode, it would perform all of the tasks necessary to control the distributed systems in Fig. 2. In the background mode, computer is used for non-real-time tasks such as inventory, billing, or simulation.

Depending upon the layout of the entire plant, analog



4. Distributed-control setup. A distributed-control system can take on three architectures: the ring (a), the star (b), and the hybrid (c). The star is most widely used since it is relatively simple to generate the hardware and software required.

signals or digital data words would be brought back to the control-computer facility. Layout of the plant would determine if bit-serial, byte-serial, or word-serial digital-data-communication interfaces would be employed between the central computer and a given distributed system being monitored or controlled. Annunciators (visual indicators) would be in a control room at the central-computer facility, or they would be strategically positioned at or near the systems being controlled. Remote terminals and card readers would be used for operator interaction or for background data processing. As demand on such a control system grew, main memory, disk drives, magnetic-tape drives, I/O ports, and remote terminals would be added to the existing computer mainframe.

Disadvantages of the centralized approach are manifold. The overall control system becomes very difficult to maintain, and computer downtime becomes intolerable to the point where a backup facility is required to ensure reliable operation. Software, data management, and data-communication formats and procedures (system protocols) become a nightmare. The number of distinct pairs of wires emanating from the computer's I/O ports becomes unwieldy.

However, the ultimate limitation on this architecture is that real-time control is no longer possible if the system gets too big. Significant time delays eventually will occur between the time a given distributed system or portion of a system needs attention and gets it.

Many of these deficiencies can be overcome by distributing monitoring, control, and data processing. This requires intelligence at sites remote from the central computer facility.

Distributed-control system architecture

Three basic distributed architectures are possible: ring, star and hybrid. In the ring configuration of Fig. 4a, each remote-site (satellite) computer can directly communicate with every other computer in the system. This architecture has several important advantages and one key disadvantage.

On the plus side, routine data acquisition and control are distributed; therefore, the amount of information communicated to and from the central computer or any of the satellite computers is minimal. Furthermore, all routine data-processing tasks required for controlling the functions at any remote site are handled there.

In addition, the central computer or one of the satellite computers can make use of the data-processing capabilities of other computers in the system if they indicate that they are idle. Also, if the control strategies implemented at one remote site have an immediate consequence at another, then the satellite computers can communicate directly.

The big disadvantage of the ring approach is the software necessary. The required protocols, particularly with ever-changing control-system requirements, can get quite involved. Each computer must know its monitoring, data processing, and control functions, but it must also be able to communicate intelligently with every other computer on the ring. So the software for every computer must be reconfigured if the ring is expanded. This means that, for many applications, the ring architecture is impractical.

The second distributed architecture is the star approach of Fig. 4b. This architecture has all of the advantages of the ring except that no satellite computer can communicate directly with another. All communications must go through the central computer, which views each satellite computer as just another remote terminal with each satellite oblivious to the others. This greatly simplifies the protocols and, consequently, the software requirements for all computers. As a bonus, expanding the system requires software changes only at the central computer. However, communication between any two or more satellite computers is slower than for the ring.

The third basic architecture combines the best features of star and ring networks to form the hybrid distributed system of Fig. 4c. For portions of the system that require rapid response, the ring setup is employed. For less critical data paths, the star approach is used.

For large, complex applications, this approach is the wave of the future. It eliminates the software headaches of the ring, so it is amenable to system expansion. However, it has more interconnections than the other two architectures, so it has greater protocol problems.

Implementing the star setup

The star architecture is the most widely used of the three distributed configurations, so it rates an in-depth look. The coordinator and supervisor of this type of distributed control system is the central computer. Typically located at some key managerial location, its duties include coordination of all remote-site activities, user interaction, and execution of various managerial programs such as summaries, reports, and projections. The hardware and software configurations are those that are used in any multiuser, multitask, real-time operating system. The only special feature is the central-site-to-remote-station communications interface. This will vary according to the turn-around time required between the central site and a remote site, as well as the volume of data to be communicated between them.

Each remote station functions primarily as a local data-acquisition system, data processor, and controller. It must have sufficient intelligence to control and manage the local processes. All of the attendant characteristics of a controller must be provided, such as changeability, expandability, ease of operation, and manual override capabilities. In these respects, a remote station doesn't differ from any standard autonomous controller.

In light of the importance of the network communication links, careful consideration must be paid to their implementation. Interfaces such as the bit-serial RS-232C or the byte-serial IEEE 488-1975 would always be preferred, because they are industry standards and would significantly increase overall system flexibility while minimizing cost of the data-communication network.

Careful attention must also be paid to the data-communication media; e.g., 20-milliampere twisted-pair current loops, dedicated frequency-shift-keying circuits implemented with any one of a dozen different classes of modems, switched-telephone common-carrier networks, dedicated fiber-optic data paths, and so on. The medium used must be well suited to desired speed and data rates of the system.

Fast independent processing

Although a star network does not have as fast a response time as the ring approach, it is significantly faster than the centralized system of Fig. 3 because of its parallel-processing capability. Each computer in the star system can process data independently. Therefore many tasks that had to be done sequentially or on a cycle-steal basis with a single computer can be accomplished simultaneously.

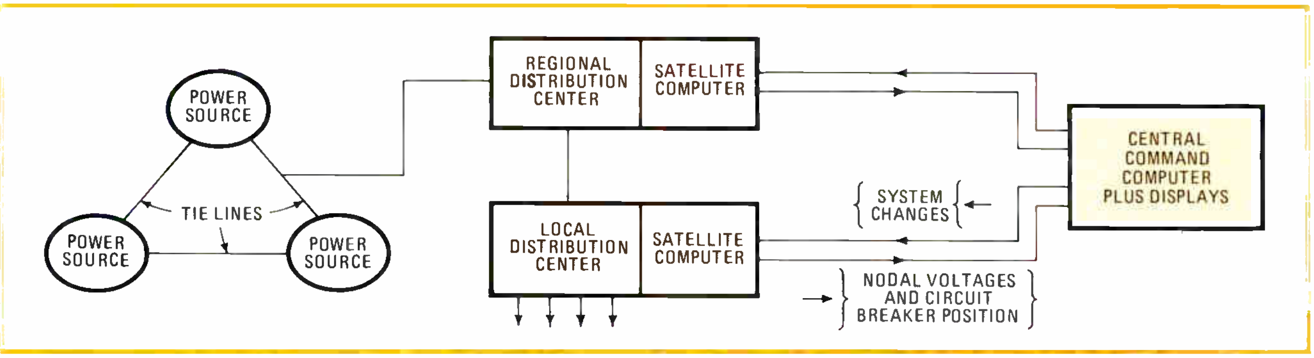
The parallel processing capability means that operator interaction can be handled more easily than with centralized control. In particular, it is much easier for an operator at a satellite station to interact with the computer for seeking system status or for altering the control system.

Information interchange between a satellite station and the central-computer facility would be limited to record-keeping summaries indicating remote-site performance. The only other type of data transfer would be when a satellite computer can't keep its portion of the distributed system under proper control and needs central-site intervention. The central computer would only initiate information interchange when the control strategy must be changed or when it or its operator wants to check system status. In short, a well-designed distributed-control system with a star architecture has minimal data-communication requirements and simple data-management schemes.

The simpler software or hardware updates make for a flexible system. For example, a satellite computer could be used to evaluate the proposed changes. The upgraded portion of the system could then be "cut in" with minimum down time.

This upgrading is feasible because the hardware of each satellite could be identical, costing only a fraction of the central computer necessary to perform the functions distributed to the satellites. Maintenance of the satellite computers would be relatively easy because of the low cost of one or two standbys. These could be used in place of down units or in system development.

Distributed-control systems will replace centralized controllers in many instances. However, their principal impact will be in applications not particularly amenable to centralized control. Prototype systems exist for such applications in the fields of electric-power generation, distribution, and consumption; credit-authorization systems; health-care delivery in hospitals and medical centers; climate control, security, waste disposal, and fire protection in large buildings; urban and intercity mass transportation; manufacturing; agricultural production, processing, distribution, and marketing, and energy and



5. Power generation. Monitoring, managing, and control of a power grid is best done by a distributed network. A typical system will have a number of regional centers and associated local centers, all with processors tied into the central computer.

other natural-resource exploration and use. Distributed architecture is proving its ability in these fields, as the following examples of prototype systems illustrate.

The power utilities are one of the first to apply distributed architectures on a large scale in order to monitor and control the generation and distribution of electricity. A typical company has three components: power generation, transmission, and distribution.

Typical power sources, interconnected in a grid with each other and regional distribution centers (Fig. 5), are monitored for line overloads, faults, and interruptions. Since the lines are not of equal capacity, an added on-line load means power must be routed to avoid line overloads. So there are monitoring and management functions to perform here.

Power from the sources, having reached a regional distribution point, is transformed to a lower voltage and switched onto lines for distribution to local switching centers, where it again is transformed and switched to the customer. The status of the various circuit breakers, transformers, and lines must be known and controlled for the efficient management of the power.

By superimposing a star system on the power network, effective control is achieved. At each switching and distribution center, nodal voltages and circuit-breaker positions are noted and relayed to a central command facility, which houses a mainframe computer.

The mainframe, which is responsible for system management and security, provides the various displays for the decisions. When the need for changing the system occurs, the operator enters the appropriate command, which is forwarded to the local and regional distribution centers for action. The high-speed digital computer can act upon network data, decide what needs to be done, and execute it all within a matter of seconds so that a customer is hardly aware of the action.

Computerizing credit

With more than 275 million credit cards in the hands of American consumers engineering efforts have accelerated rapidly to develop technologies and systems that will make commercial transactions faster, safer, less susceptible to human error, and more economical. Distributed architectures fit right in.

An example is the replacement of an "off-line" credit-authorization system with an "on-line" system (Fig. 6). Even though the computer facility at the bank may itself be a highly sophisticated on-line data-processing system, the credit-authorization system at the top of the figure is an off-line system with respect to the point of sale. It has several serious limitations.

First, credit authorization is slow, principally because of the shortcomings of the telephone communications system. Second, it is difficult to maintain a current hot list at every POS terminal. Third, there is an unnecessary time lag between the updating of the authorization file in the bank and the customer's current credit position. Finally, the credit authorization doesn't relieve the manual data-entry load.

These deficiencies can be overcome with the on-line credit-authorization system at the bottom of the figure. At the heart of this system is an intelligent POS terminal. The retail clerk can enter essential information related to the pending sale using a keyboard. The magnetic-stripe credit card read by the terminal contains the customer's name, address, and account number, and important credit-authorization information.

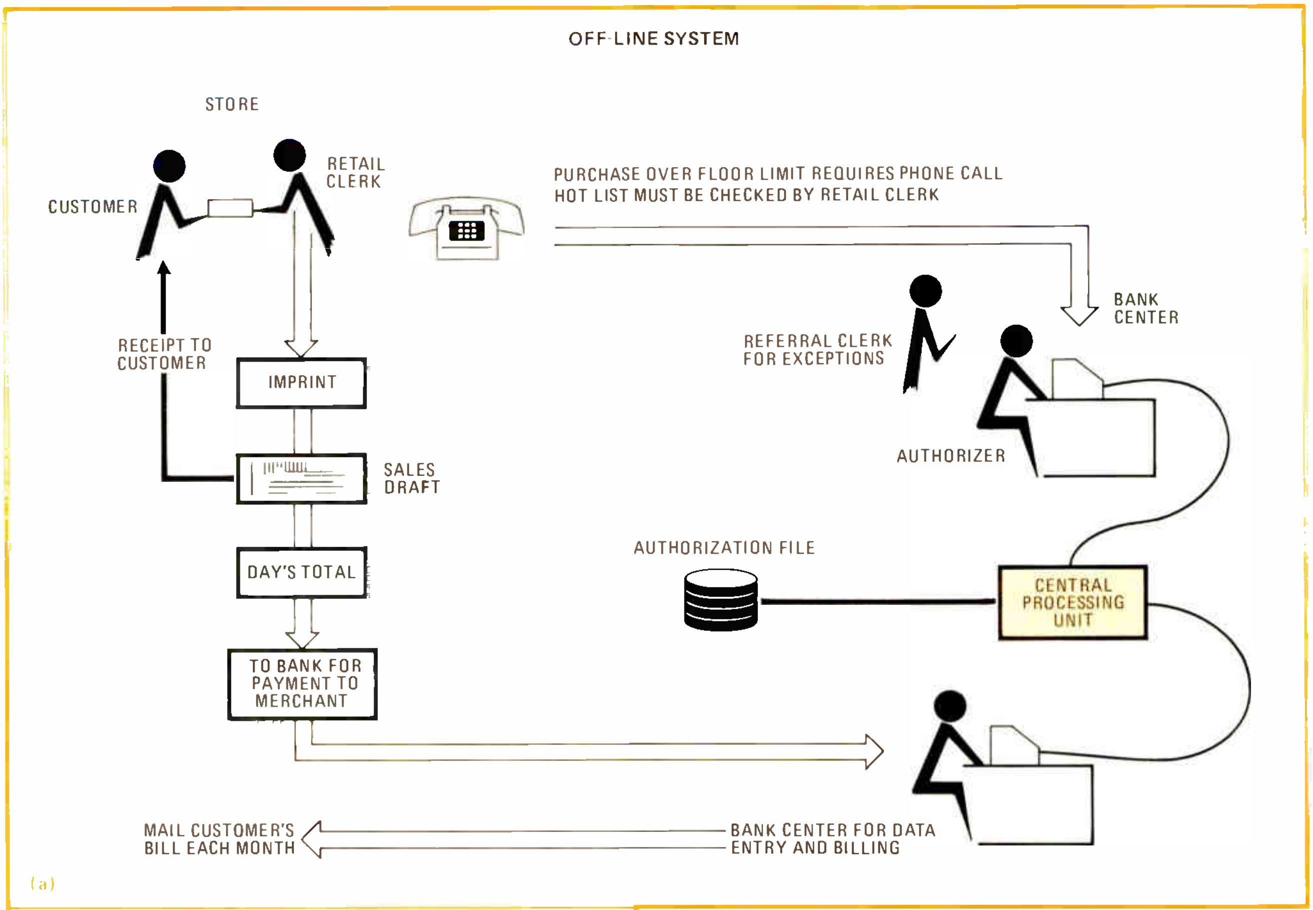
The POS terminal automatically communicates all pertinent information on a real-time basis to the bank's central computer. If the central computer approves the sale, then the satellite computer generates the appropriate copies of the sales draft and updates the customer's authorization file at the central computer, as well as the file on the credit card.

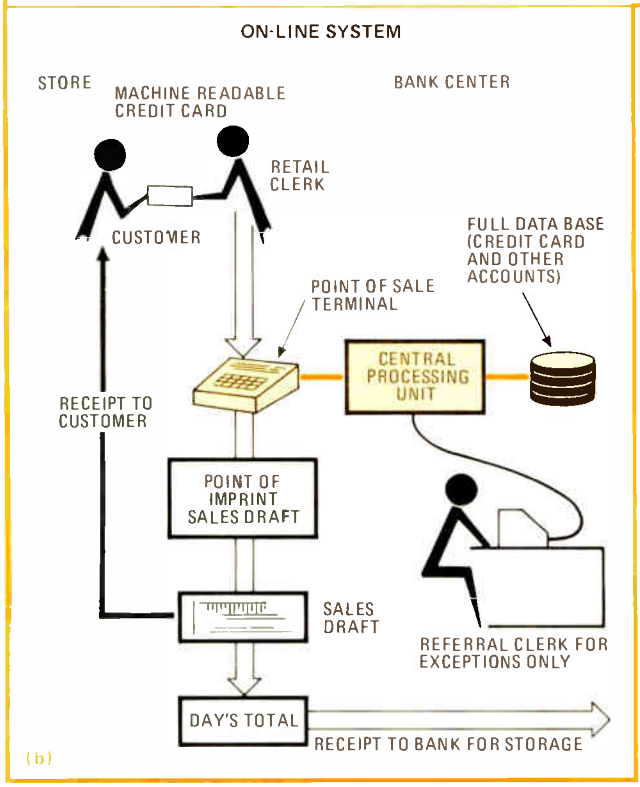
Controlling intensive care

Distributed-monitoring-and-control techniques may also be used advantageously in a hospital's intensive-care unit. Here critical metabolic parameters must be watched closely 24 hours a day. Typically, one nurse monitors four patients from a central display console. By letting each bed represent a remote station and the nurse's station a central station, the four-patient networks of an intensive-care unit fall naturally into a star configuration.

By adding intelligent bedside terminals and a central computer at the nurse's station, it's easy to develop a distributed architecture. With intelligence at each bedside monitor, all required metabolic parameters can be extracted from the analog signals and checked against norms. Summaries of required data would be displayed at the bedside and sent to a central computer at regular intervals or upon detection of an abnormality.

Because of this minimum data flow, one supervisory





6. Electronic credit. Credit-card transactions can be made by the off-line method, top, or the on-line method. On-line authorization uses an intelligent point-of-sale terminal as the remote processor of an overall distributed-control system.

nurse at the central station could handle the entire intensive-care unit, not just four patients. Information on each patient's medical history, progress, treatment, and response to treatment may be maintained more completely and precisely, as well as in a more accessible format. Access to this data base may be from either the bedside terminal or the central station. Finally, the computer reduces the possibility of human error.

Future control

As the potential for the distributed-control field is better understood, a new wave of electronic subsystems will surely appear. One can envision the appearance of inexpensive, modular, microprocessor-based controllers that will be used for distributed data acquisition, data processing, on-line control, data communications, and operator interaction at satellite stations. It is conceivable that one or more of these controllers would be used for each of these functions.

A cost-efficient approach may well dictate the need for standard universal controllers based on microprocessors and reprogramable read-only memories in order to quickly add, alter, interface, or repair remote-site functions. Finally, fiber-optic data links may find their first real test in a distributed-processing-control problem. Many tradeoffs are made today in data communications between remote sites and central sites because of data-channel capacity limitations and radio-frequency radiation problems. Fiber-optic links might solve these problems in many cases. □

How to build high-quality filters out of low-quality parts

If the operational amplifier is wired as a voltage follower, an active filter can use loose-tolerance resistors and capacitors—and still perform well

by Philip R. Geffe, *Lynch Communication Systems Inc., Reno, Nev.*

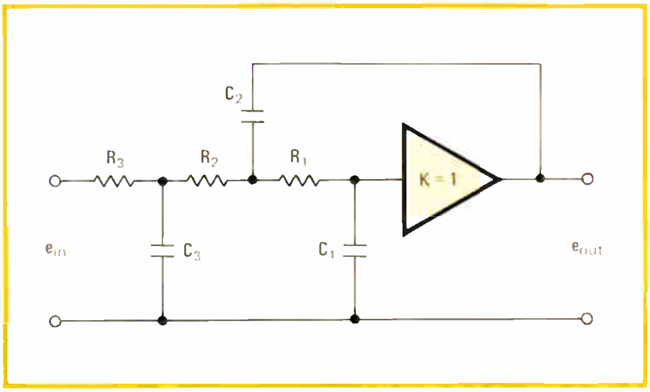
☐ An active filter's sensitivity to component values is an important factor in determining its cost. If the circuit is designed for minimum sensitivity to these values, then inexpensive low-tolerance components can be used without harm to its performance.

In the three-pole filter of Fig. 1, the amplifier closed-loop gain, K, is the parameter that governs sensitivity. This results from the presence of the factor $(1 - K)$ in terms of the transfer-function denominator. If K is greater than unity, the denominator will contain negative terms that lead to high sensitivity. For this reason, the amplification is provided by an operational amplifier connected as a voltage follower. In addition to providing $K = 1$, use of a voltage follower also saves two gain-fixing resistors in the op-amp connection.

Low-pass design

If the amplifier in Fig. 1 is a voltage follower and the resistor values are all 1 ohm, a normalized Butterworth or Chebyshev filter response is obtained by choosing capacitance values from Table 1. The zero-ripple design is the normalized Butterworth filter. It has an attenuation of 3 decibels at a frequency of 1 radian per second, and its asymptotic slope in the stopband is 18 dB per octave. The exact attenuation at any frequency ω is given by the formula:

$$e_{out}/e_{in} = 1/(1+\omega^6)^{1/2}$$



1. Uses loose-tolerance components. The performance of this three-pole low-pass active filter is insensitive to values of resistors and capacitors if the amplifier gain, K, is unity. Therefore inexpensive components with relatively loose tolerances can be used.

TABLE 1: ELEMENT VALUES FOR NORMALIZED THREE-POLE ACTIVE FILTERS

Ripple (dB)	C_1	C_2	C_3
0	0.20245	3.5468	1.3926
0.01	0.091294	2.5031	0.84044
0.03	0.097357	3.3128	1.0325
0.10	0.096911	4.7921	1.3145
0.30	0.085819	7.4077	1.6827
1.00	0.05872	14.784	2.3444

TABLE 2: ATTENUATION CONSTANTS FOR CHEBYSHEV FILTERS

Ripple (dB)	Ripple factor (ϵ^2)
0.01	0.00230524
0.03	0.00693167
0.1	0.023293
0.3	0.0715193
1.0	0.258925

TABLE 3: BAND-EDGE FREQUENCY, ω_C, AS A FUNCTION OF RIPPLE AND BAND-EDGE ATTENUATION α

Ripple (dB)	Band-edge frequency ω_C (rad/s)		
	α = 1 dB	α = 2 dB	α = 3 dB
0	0.798355	0.914491	1.00000
0.01	1.56352	1.74229	1.87718
0.03	1.36673	1.50770	1.61524
0.10	1.20154	1.30707	1.38899
0.30	1.08934	1.16726	1.22906
1.00	1.00000	1.05219	1.09487

The capacitance values corresponding to the nonzero values of ripple in Table 1 yield Chebyshev filters. These filters have equiripple passbands, with the edge of the ripple band at 1 rad/s. The attenuation for the Chebyshev filter designs can be calculated from the voltage-ratio formula:

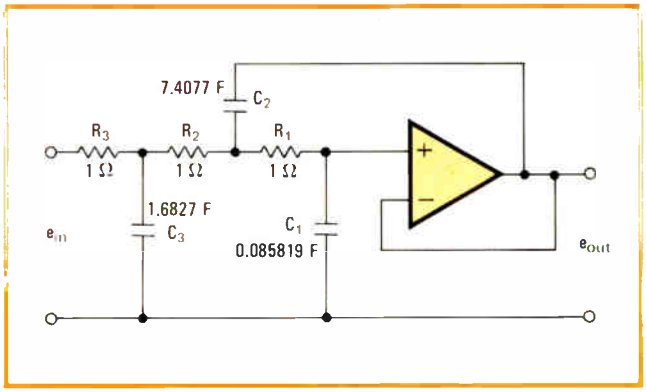
$$e_{out}/e_{in} = 1/[1 + \epsilon^2(4\omega^3 - 3\omega)^2]^{1/2}$$

where ϵ^2 is the ripple factor obtained from Table 2. The user can be expected to define the attenuation at the edge of the passband, but the choice of ripple value is usually left to the designer. As an aid to meeting the passband edge requirement, Table 3 gives the frequencies for attenuations of 1, 2, and 3 dB for all ripple values.

As an example, consider the design of a low-pass Chebyshev filter with 0.3-dB ripple and the calculation of its attenuation at twice the 3-dB frequency.

Frequency scaling

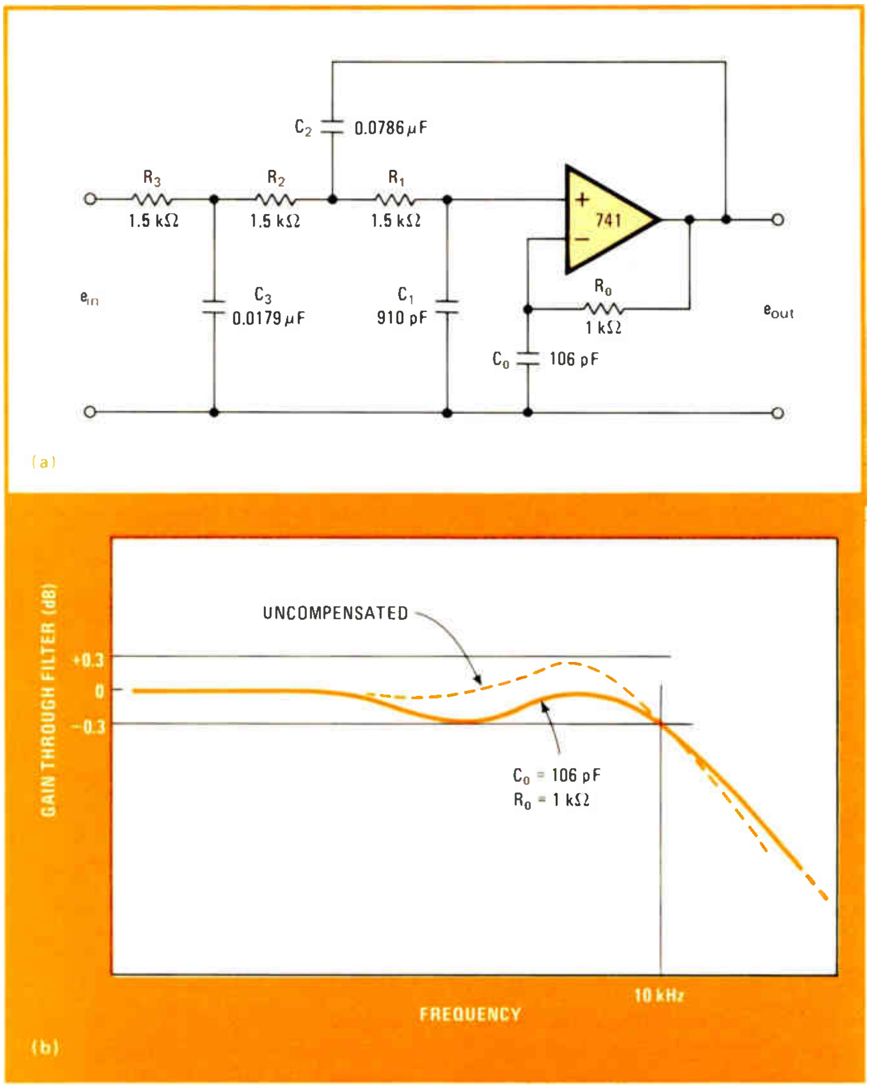
The normalized circuit is shown in Fig. 2, with capacitance values taken from Table 1. Table 2 shows that a 0.3-dB ripple corresponds to ϵ^2 of 0.0715193. The 3-dB frequency of this filter is given by Table 3 as 1.22906 rad/s; at twice this frequency, i.e., ω = 2.45812 rad/s, the attenuation is calculated to be 0.0716734. Expressed in decibels, this attenuation is 20 log (0.0716734), or −22.89 dB.

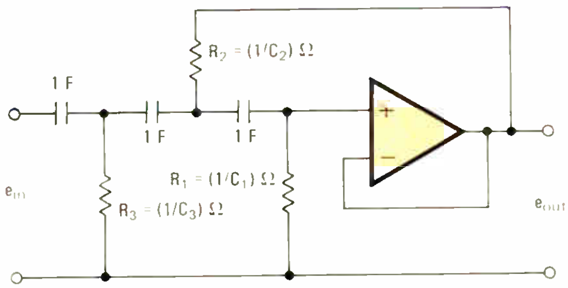


2. Normalized low-pass filter. Design of low-pass Chebyshev filter with 0.3-dB ripple starts with R values of 1 ohm and C values from Table 1, plus a voltage-follower op amp to make K = 1.

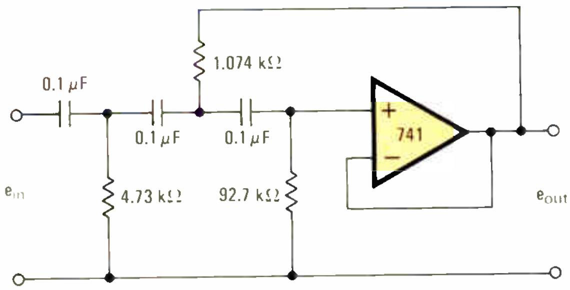
To scale the design so that the edge of the ripple band (that is, the highest 0.3-dB frequency) occurs at 10 kilohertz, divide all capacitance values by $2\pi(10{,}000)$.

3. Practical 10-kHz low-pass filter. The example in the text shows how the component values in Fig. 2 are scaled to provide the edge of the ripple band (the highest frequency at which attenuation is equal to or less than 0.3 dB) at 10 kHz. Boctor compensation is added to voltage follower that uses a type 741 operational amplifier.





4. High-pass filter. In the normalized high-pass three-pole active filter, the series capacitors are all 1 F, and the resistor values (in ohms) are found by reciprocating the numbers in Table 1.



5. Practical 200-Hz high-pass filter. The example in the text gives details of the design of this filter, which has 0.3-decibel ripple above 200 hertz and 31.35-dB attenuation at 60 Hz.

This gives:

$C_1 = 1.36585\ \mu F$
$C_2 = 117.897\ \mu F$
$C_3 = 26.7888\ \mu F$

These values are correct but impractical. A practical design can be obtained by multiplying all impedances by a suitable scale factor, say 1,500. This gives:

$R_1 = R_2 = R_3 = 1{,}500\ \Omega$
$C_1 = 910.6$ pF
$C_2 = 0.0786\ \mu F$
$C_3 = 0.0179\ \mu F$

The frequency response of this filter is the same as that of the normalized design, except that all attenuations are referred to the band-edge frequency, f_c, of 10 kHz, instead of to 1 rad/s. Consequently, the attenuation formulas serve for the denormalized filters if ω is replaced by f/f_c.

Gain compensation

These filters require rather precise values of closed-loop gain, which is why an operational amplifier is used instead of some simpler unity-gain amplifier. But even an op amp may require compensation if its open-loop gain drops to less than 60 dB at the band edge of the filter.

A voltage divider consisting of resistor R_o and capacitor C_o provides the Boctor compensation, as it is called, by shunting off part of the feedback at high frequencies. R_o and C_o are given by:

$$R_oC_o = 1/(2.6 \times 2\pi f_o)$$

where f_o is the 0-dB frequency of the amplifier open-loop gain curve.

For a 741 op amp, the open-loop gain is less than 40 dB at 10 kHz, and the measured value of f_o is 581 kHz. Therefore, R_o and C_o are 1 kilohm and 106 picofarads, respectively. The complete circuit for the 10-kHz filter in the example, including Boctor compensation, is shown in Fig. 3.

High-pass design

The element values given in Table 1 are the reciprocals of the resistances in a normalized high-pass filter, as shown in Fig. 4. The normalized capacitance values for the high-pass filter are all 1 farad. In the attenuation formula used for frequency-response calculations, ω must be replaced by f_c/f, where f_c is the band-edge frequency; this applies to both normalized and denormalized highpass filters.

As an example, consider the design of a high-pass filter that must pass signals above 200 hertz and must suppress 60-Hz signals by at least 30 dB. Here f_c/f is 200/60; the voltage-ratio expression shows that a Chebyshev filter with 0.3-dB ripple will give an attenuation of 31.35 dB. Therefore, the resistors in the normalized circuit (Fig. 4) have values found from Table 1 as follows:

$R_1 = 1/C_1 = 1/0.085819 = 11.6524\ \Omega$
$R_2 = 1/C_2 = 1/7.4077 = 0.1350\ \Omega$
$R_3 = 1/C_3 = 1/1.6827 = 0.59428\ \Omega$

Frequency-scaling this design to $\omega_c = 2\pi(200$ Hz) gives 1256.6 for ω_c, and dividing the 1-F capacitances by this number gives the value $C_1 = C_2 = C_3 = 795.8\ \mu F$ for the capacitors.

Finally, to get practical component values, all the impedances are multiplied by the factor 7,958 to make the capacitors 0.1 μF. The resistors then turn out to be as shown in Fig. 5. □

How to design three-pole filters

The following equations will yield component values for three-pole active filters not covered by Table 1. Given:

$$e_{out}/e_{in} = 1/(a_3s^3 + a_2s^2 + a_1s + 1)$$

with known numerical coefficients a_3, a_2, a_1, component values for the circuit in Fig. 1 are obtained by finding a positive real root of:

$$18x^3 - 12a_1x^2 + (2a_1^2 + 3a_2)x + (2a_3 - a_1a_2) = 0$$

If x_0 is such a root, then:

$$y = -a_3/(3x_0^2 - a_1x_0)$$
$$z = a_1 - 3x_0$$

Then the element values for Fig. 1 are K = 1, $R_1 = R_2 = R_3 = 1$, $C_1 = x_0$, $C_2 = y$, and $C_3 = z$, where resistances are in ohms and capacitances are in farads.

Color-TV set calibrates standard oscillators

by Carl F. Buhrer
GTE Laboratories Inc., Waltham, Mass.

A 3,375-kilohertz crystal oscillator is a good laboratory frequency standard because it is easily calibrated with great precision against a commercial TV network color signal, and because its frequency can be divided to provide many useful substandards. Several other frequencies also possess these characteristics to greater or lesser extent, and therefore are also discussed here.

Use of the television color subcarrier for adjusting local frequency standards to high accuracy has been recommended by the National Bureau of Standards [*Electronics*, May 10, 1971, p. 96, and March 20, 1975, p. 107]. The frequencies suggested here don't need phase-locked-loop synthesis and display-generating circuitry in the frequency comparison. The calibration can be made with just a color-TV receiver.

The method is based on the formation of steady color-stripe patterns on the TV screen when certain frequencies are substituted for the set's chroma signal. A succession of these stripes, each having a red, green, and blue component, will intersect vertically m times and horizontally n times per full video frame for an input frequency f_k given by:

$$f_k = f_c + nf_h + mf_v$$

Here n and m are positive or negative integers, and f_c, f_h, and f_v are the color-subcarrier, horizontal-scan, and vertical-scan frequencies, respectively. All three are nonintegral, but they are related as follows:

$$f_c = 5 \text{ MHz} \times 63/88 = 3.5795454\ldots \text{ MHz}$$
$$f_h = f_c \times 2/455 = 15.734265\ldots \text{ kHz}$$
$$f_v = f_h \times 2/525 = 59.940057\ldots \text{ Hz}$$

However, their combination, f_k, can be an integer. If n and m are chosen in relation to an integral index k such that:

$$n = -13 + 21\,k$$

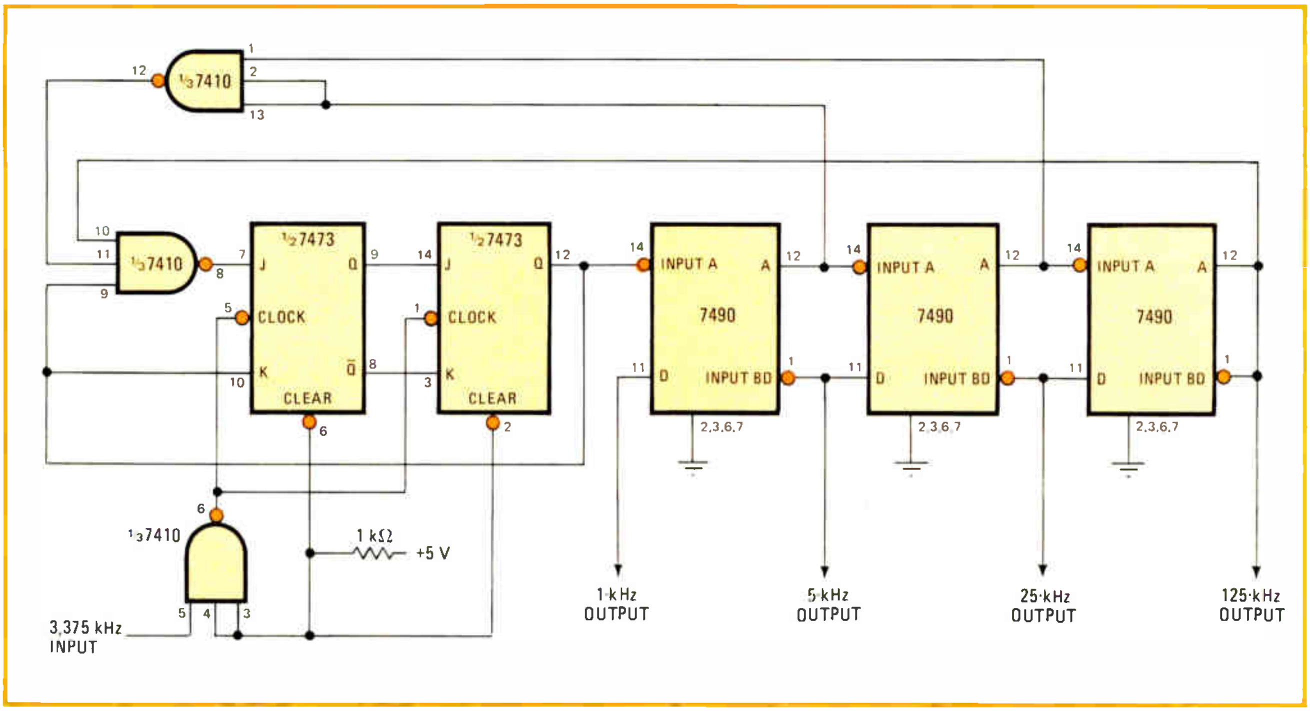
and:

$$m = -7\,k$$

then f_k becomes an integral multiple of 15 kHz, given by:

$$f_k = (225 + 22\,k) \times 15 \text{ kHz}$$

The table shows suggested standard frequencies that correspond to k of −1, 0, 1, and 2. For the non-0 values of k, m is not 0, and the result is diagonal stripe patterns on the TV screen. Therefore 3,375 kHz is the most useful as a standard frequency; since m = 0, that frequency



Frequency divider. This circuit uses a dual flip-flop and three divide-by-2 stages with feedback to divide the input frequency by 27. Three divide-by-5 stages then give further reductions. The input frequency of 3,375 kHz is convenient for use as a laboratory standard oscillator frequency because it has many useful submultiples and, besides, can be calibrated with great precision simply with a color-TV set.

gives a vertical stripe pattern easily distinguished from the associated m = ±1 frequencies, which are 59.94 hertz away. Moreover, all of its prime factors are small; 3,375 kHz = $2^3 \times 3^3 \times 5^6$ Hz, so a variety of lower frequencies such as 50, 60, 500 Hz, 1, 3, 5, 15, 25 . . . kHz can be obtained directly by division.

Calibration of the oscillator against the TV networks' rubidium standard for color video transmission requires selection of a broadcast originating live in New York or Los Angeles, where the standards are located. A sample of the 3,375-kHz frequency is injected into the chroma input of the demodulator circuit after the program color is turned off with the color-level control. About 1 to 2 volts fed into a 15-picofarad capacitor connected to the chroma input pin of the color-demodulator integrated circuit is sufficient to give vivid color stripes. (Since most TV chassis are not grounded, care is necessary to avoid electrical shock in this operation.)

When the crystal oscillator is tuned about 60 Hz higher than 3,375 kHz, the pattern with n = −13, m = +1 appears, with stripes tilting to the left. As the oscillator frequency is lowered, this tilted pattern drifts faster and faster to the left until the drift is too fast to be observed. As 3,375 kHz is approached, the desired vertical stripe pattern appears drifting to the right. As the frequency is further reduced through 3,375 kHz the vertical stripe pattern stops and then starts drifting to the left. At about 60 Hz below 3,375 kHz, the m = −1 stripe pattern, tilted to the right, appears to stop.

Because of an offset of approximately -300×10^{-10} in the network frequency relative to the National Bureau of Standards value, the crystal oscillator should be tuned to a frequency slightly higher than the network signal. This is done by adjusting the oscillator such that the vertical stripe pattern drifts to the right one stripe width in about 9.31 seconds. Exact offsets of the network standards are published regularly by NBS.

When 3,705 kHz is used as the standard frequency, the directions of tilt and drift are reversed, because n is positive. This frequency is a desirable standard if its prime factors 13 or 19 are needed.

As an example of use of the 3,375-kHz standard to produce precision submultiples, a simple divider chain useful as a counter time base or frequency synthesizer reference is shown in the figure. It consists of a 7473 dual flip-flop predivider followed by three binary stages with feedback to give a divide-by-27 output of 125 kHz and then three divide-by-5 stages with outputs at 25 kHz, 5 kHz, and 1 kHz. Harmonics of 125 kHz also permit comparison of this standard with all of the high-frequency transmissions of WWV. □

USEFUL STANDARD FREQUENCIES

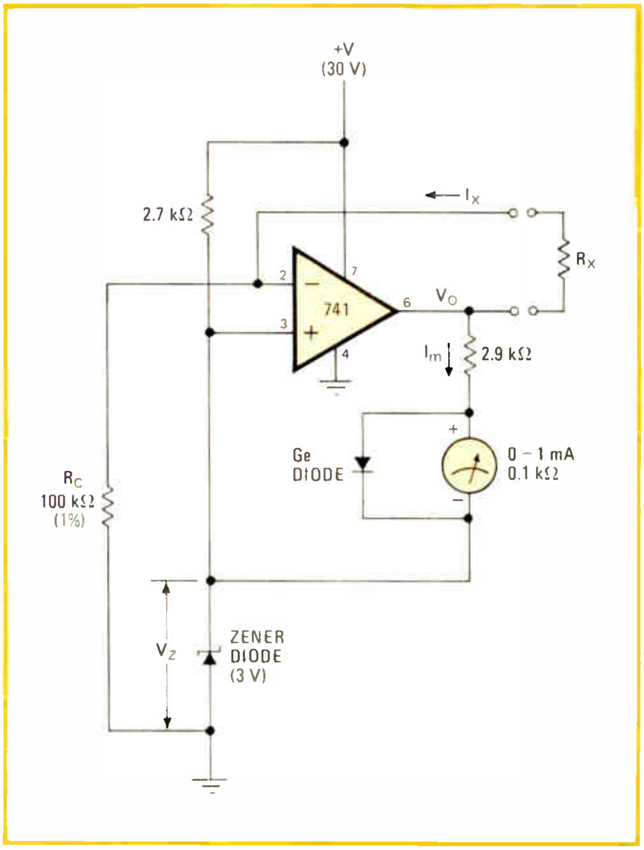
k	n	m	f_k	Factors
−1	−34	+7	3,045 kHz	7 x 29 x 15 kHz
0	−13	0	3,375 kHz	3^2 x 5^2 x 15 kHz
+1	+8	−7	3,705 kHz	13 x 19 x 15 kHz
+2	+29	−14	4,035 kHz	269 x 15 kHz

Direct-reading ohmmeter needs no calibration

by V. Ramprakash
Electronic Systems Research, Madurai, India

A direct-reading ohmmeter with a linear scale can be made by connecting an operational amplifier, a milliammeter, a zener diode, and some resistors as shown in the circuit diagram. This ohmmeter does not require calibration, is self-zeroing, and is insensitive to the supply voltage.

The value of an unknown resistor is measured by connecting it as R_x. The reading on the milliammeter, I_m, is then R_x/R_c, where R_c is the resistance of a known standard resistor in the circuit. The current through the meter equals $(V_o - V_z)/R_m$, where V_o is the voltage at the output of the op amp, V_z is the drop across the zener diode (3 V), and R_m is the resistance in the meter circuit; here R_m is (2.9 + 0.1) kilohms. Since the voltages at the



Milliamperes indicate resistance. The meter reading in mA is the value of the ratio R_x/R_c, so full-scale meter deflection indicates an R_x of 100 kilohms. An open circuit pins the meter, but does no damage because the germanium diode clamps the meter voltage. Since a short circuit produces no deflection, the circuit is self-zeroing.

inverting and noninverting input terminals of the op amp must be equal, $V_oR_c/(R_c+R_x)$ must equal V_z. Therefore: $V_o = V_z(R_c+R_x)/R_c$, or $I_m = (V_z/R_m)(R_x/R_c)$ The values of V_z and R_m shown yield:

$$R_x = (R_c)(I_m)$$

if I_m is the meter reading in milliamperes.

For an R_c of 100 kilohms, the 1-mA meter deflects full scale when R_x is 100 kilohms. Similarly, full scale can be made to indicate 10 kilohms or 1 kilohm by selecting these values for R_c. A range switch can be included in the circuit to set these values.

The current through the unknown resistor, I_x, is independent of the value of R_x. The equality of the op-amp input voltages makes V_z equal to I_xR_c, so $I_x = V_z/R_c$.

The meter has automatic zeroing because, if the measuring leads are short-circuited, V_o rises to exactly 3 V, sending no current into the meter. No calibration is necessary because the meter deflection has direct correspondence to the value of resistance being measured.

The germanium diode limits the voltage across the meter, and thus protects it from over-current when the measuring leads are left open. □

Calculator notes

HP-25 calculator serves as clock

by Jack L. Aker
San Jose, Calif.

The HP-25 calculator can be programed to serve as a clock, displaying the time of day as HH.MMSS. One or more digits show the hour, followed by a decimal point, and then two digits indicate minutes, and two digits the seconds.

As shown by the accompanying program steps, the last displayed value of time is kept in register 1 in decimal-hours format. The execution time of the program sequence (3.2975146 × 10^{-4} hours, or about 1.2 seconds) is then added to that value. If the incremented value is less than 13, it is converted to the hr/min/sec representation and displayed for about ¾ second (the pause period).

If the incremented decimal-hours time is greater than 13, only the decimal portion is retained, and a 1 is added to it (so that the hour after 12 is 1, not 13). The incremented value in register 1 is then converted to the HH.MMSS format and displayed for ¾ second.

In either case, the program then recycles after the pause.

To operate the HP-25 as a clock, first enter the program. Then, in the run mode, initialize registers 4 and 7 by the following entries:

3.2975146
EEX
CHS
4
STO 4

and:

13.00
STO 7

To run the clock program, enter the initial value of time in HH.MMSS format, and press:

f FIX 4
g →H
STO 1
f PRGM
R/S

HP-25 CLOCK PROGRAM

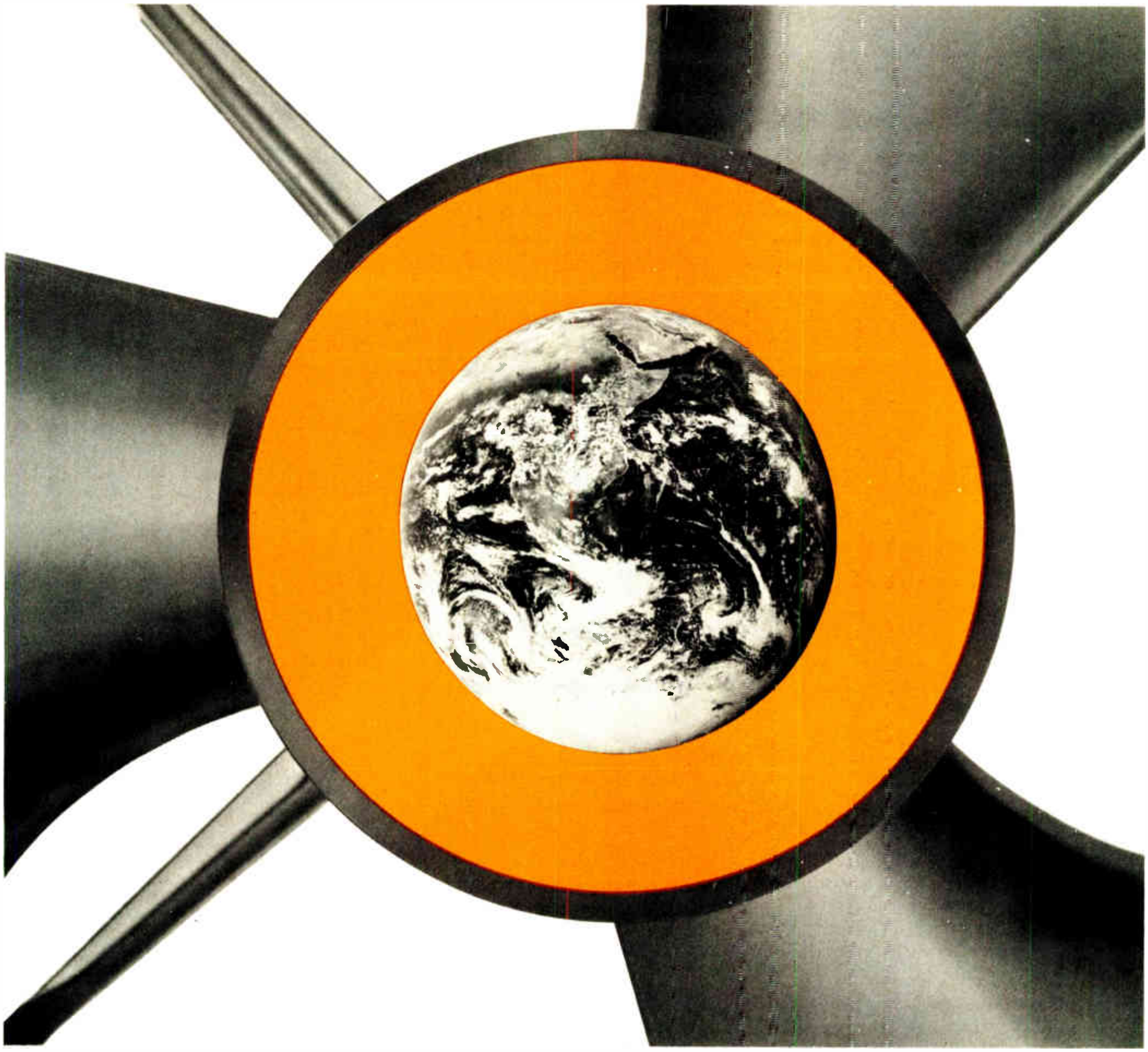
LOCATION	CODE	KEY ENTRY
01	24 01	RCL 1
02	24 04	RCL 4
03	51	+
04	23 01	STO 1
05	24 07	RCL 7
06	21	x ⇄ y
07	14 41	f x < y
08	13 13	GTO 13
09	15 01	g FRAC
10	01	1
11	51	+
12	23 01	STO 1
13	14 00	f →H.MS
14	14 74	f PAUSE
15	13 01	GTO 01

REGISTER	CONTENTS
1	decimal time
4	3.2975146 x 10^{-4}
7	13.00

If 24-hour timekeeping is preferred, 24.00 is stored in register 7 instead of 13.00, and a 0 is entered at location 10 in the program instead of a 1.

The accuracy of the HP-25 as a clock depends on its internal clock oscillator for the correctness of the value for program execution time that is stored in register 4. This number can be changed, if necessary, to give accuracy within a few seconds during several hours. To adjust the timing, compare the timing accuracy with an electric clock over several hours. Divide the difference in seconds by the number of seconds of running time, and multiply this quotient by the value in register 4 to find the fractional correction that must be added to or subtracted from the value in register 4. □

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.



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What makes Josephson junctions interesting to IBM

Why is IBM so enthusiastic about the superconducting Josephson junction, which allows electrons to tunnel through an insulator in a controlled manner? Well, **Josephson-junction circuits dissipate about 0.1% the power of present silicon circuits, and this might mean they're the only way to get a large-scale computer with subnanosecond delays.** Propagation times like those won't permit any point in the circuitry to be more than 7 inches away from any other point, so the whole processor would have to fit inside a 7-inch sphere—about the size of a soccer ball. However, if the machine had the complexity and used the same circuitry as, say, an IBM 370/168, it would have to dissipate an impossible 10 kilowatts, say scientists at IBM's Thomas J. Watson Research Center, Yorktown Heights, N.Y.

The IBM group has built both logic and memory elements using Josephson technology—most recently a 4-bit multiplier on a substrate about 250 mils square. One of the major problems still remaining is the precise deposition of the insulating films between metal layers.

FETs and front ends

Those mixed-process operational amplifiers, which use a mixture of bipolar and field-effect transistors on the same monolithic chip, give you a choice between junction FETs or MOSFETs at the front end. Here's a gross distinction that can be made between the two types: **the JFET front end generally gives slightly better performance in some respects—like lower noise and lower offset-voltage drift.** But don't overlook the fact that the MOSFET front end should be the choice if you're really interested in broad common-mode-voltage operating range—in fact, it can go from rail to rail of the supply voltage. This means that you can even operate the op amp from a single-polarity supply without jacking up your input signal.

DMMs supply constant current

Need a constant-current source quickly for, say, low-voltage bias applications? Most digital multimeters use a precise current to measure resistance. **Just set the DMM to one of the ohms ranges and measure the current it puts out.** A 3½-digit (2,000-count) DMM, for example, typically puts out 1 milliampere on the 0-to-200 ohm range and goes down to 10 or 100 microamperes for the higher resistance ranges. Of course, unless the meter is well protected, be careful when working with active circuits.

Figure it out for yourself

You can't beat the price of this new infrared-radiation slide-rule calculator from Sensors Inc., P.O. Box 1383, Ann Arbor, Mich. 48106. A letter to marketing and sales director W. T. Baker gets you one for free. The calculator has 20 marked scales for such parameters as temperature, emissivity, power density, wavelength, and range. . . . And, for $9.25, you can get a copy of a Government publication, "A User's Manual for Optical Waveguide Communications." Written by R. L. Gallawa of the Institute for Telecommunication Sciences in Boulder, Colo., **the 293-page report adopts an intuitive nonmathematical approach to subjects like optical sources and detectors,** fiber waveguides, modulation, and multiplexing. Order No. PB-252 901/WZ from the National Technical Information Service of the Department of Commerce, 5285 Port Royal Rd., Springfield, Va. 22151.

Stephen E. Scrupski

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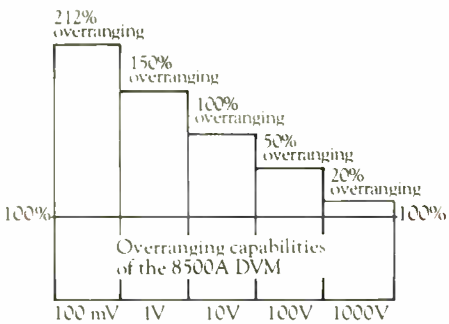

Most other DVM's offer only 20%-60% overranging.

The 8500A is a high-speed 5½-digit DVM capable of 500 readings per second at full resolution and accuracy. Fluke's patented Recirculating Remainder (R^2) A/D Conversion technique is used for high, long-term accuracy and linearity. There's a calibration memory that allows for automatic correction of calibration error. And it's the only systems DVM that measures ac and dc current.

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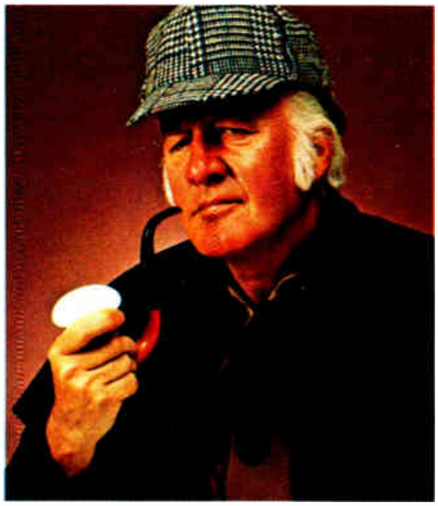


"It's not difficult to understand why it's called the finest. After all, it is a Fluke DVM, isn't it?"

312.5 mV is possible with a resolution of 1 μV. Displays on the lower ranges are in volts, followed by an exponent display of −3.

Two types of ac measurement options are available for the 8500A. While only one can be installed in the instrument at a time, removing one option and installing the other requires a minimum of time and/or operator training. At power up or after reset, the front panel displays whether the averaging converter, true rms converter or neither is installed in the instrument.

The Averaging Converter (Option -01) measures up to 1000V ac on four ranges with a bandwidth from 30 Hz to 100 kHz and accuracies up to ±0.05% + 5 digits. The True RMS Converter (Option -09) measures up to 1000V ac on four ranges with a bandwidth from 10 Hz to 300 kHz and accuracies up to ±0.1% + 15 digits.

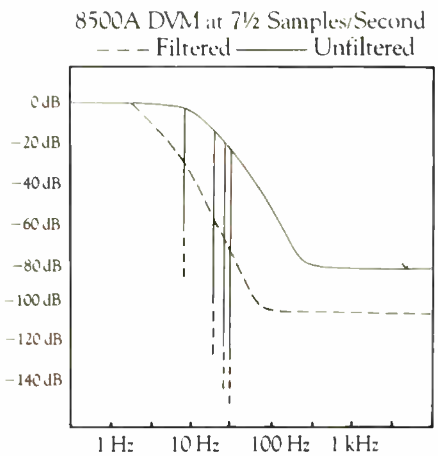
Resistance measurements can be made on eight ranges from 10Ω full scale to 100 MΩ full scale with the Ohms Converter (Option -02). Basic accuracy from 100Ω to 1 MΩ is ±0.003% + 1 digit, with resolutions up to 100 μΩ obtainable.

Both ac and dc current can be measured with the Current Module (Option -03) provided one of the ac options is installed in addition to the basic dc. Current measurements to 1A can be made with sensitivity to 1 nA. Accuracies to ±0.03% + 10 digits, for dc readings and to ±0.06% + 8 digits for ac readings. Bandwidth of the 100 μA through Amp ranges is 30 Hz to 10 kHz. For the 1A range only, the bandwidth is 30 Hz to 3 kHz.

Guaranteed accuracies for the 8500A measurement options are based on 90 days, 18°C to 23°C.

Three Remote Interface options are available with the system. Only one of the three may be installed at a time; however, one can be easily exchanged for another when the top cover is removed. This allows the instrument to be used with more than one interface system, requiring only that additional modules for the desired interfaces be obtained.

The IEEE Standard 488-1975 Bus Module (Option -05) provides an eight-bit (one byte) parallel interface. The Bit Serial Asychronous Interface Module



Fantastic noise rejection without sacrificing speed.

(Option -06) interfaces the 8500A to systems using either RS232B, RS232C, or Current Loop interface. Selection of type and Baud rate is made with bit switches accessible through an entry

Automatic correction for zero, offset, calibration and drift with microprocessor controlled memory storage.

Extra digit of resolution.

As an extra bonus, the range digit can be converted to a 6th measurement digit—for 6½ digits of resolution.

port on the rear panel. And the Parallel Interface Module (Option -07) provides a 16-bit duplex register interface compatible with mini-computer and microprocessor systems.

A non-volatile calibration memory module stores correction factors desired from a standard input during CAL mode operations. It can also be used to compensate for long-term drift, eliminating the need for manual adjustments or trips to the calibration laboratory. This allows the operator to remove power from the instrument or the system to suffer a power failure without loss of automatic calibration factors. The battery permanently installed on the module will keep power on the memory to retain the stored data in excess of 90 days after removal of power.

Service capability is one of the strong points in the 8500A program. Of course, extensive overload protection has been designed into the instrument. But should problems develop, most of them can be handled in the field by using the available service aids. An extender card, a bus monitor, a test module, and a static controller, together with diagnostic programs and the microprocessor control should handle 60%-80% of most troubleshooting problems.

If you've read this far, you know why the 8500A is called the world's finest DVM. Microprocessor control, modular design, complete measurement and systems interface capability and ease of service are all combined in one instrument. And the best thing about it is that it's made by Fluke. So you know you can count on quality and service throughout the world.

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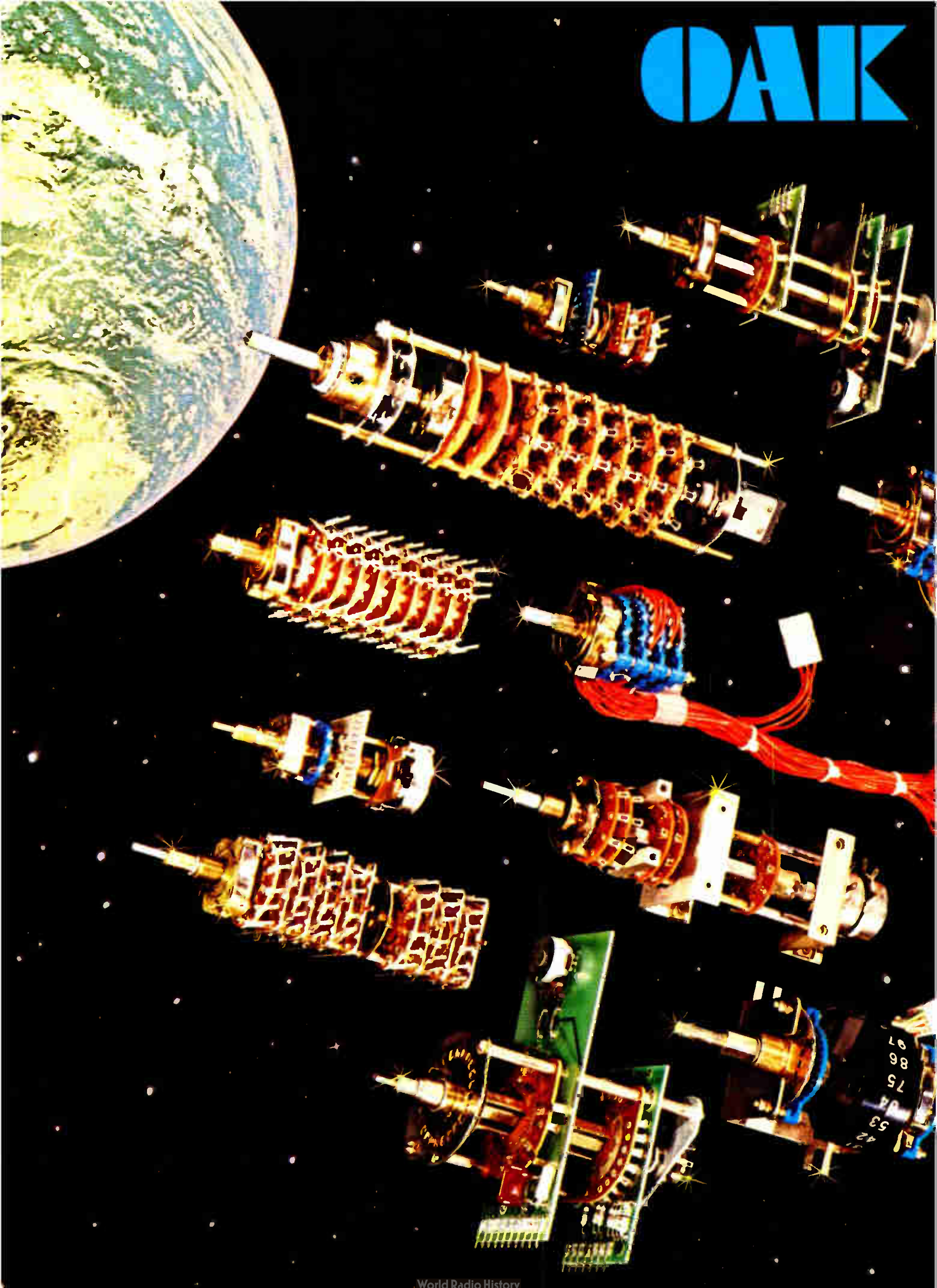
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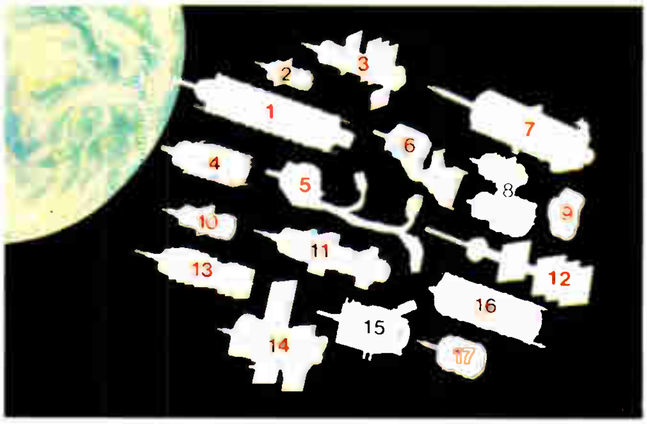

1. Combination push-button/rotary switch. Rotation can occur only after shaft is pushed in to activate push-button. Special hardware designed and built by Oak.

2. PC Board assembly with Unidex detent concentric shaft and PC switch section, with two variable resistors controlled from center shaft.

3. Test equipment assembly, combining phenolic switch sections, resistors and capacitors attached to PC boards, with concentric shafts, brackets and potentiometer.

4. Nine section Unidex switch with PC terminals at opposite sides for attachment to parallel PC boards.

5. Connector and harness assembly attached to four section, 24 position Multidex switch.

6. Five section Multidex switch wired and terminated with customer supplied connectors.

7. Triple concentric shaft with dual detent, with potentiometer on inner shaft, rear bank of 3 sections on center shaft and 4 front sections on outer shaft.

8. Switch assembly for electronic test equipment assembled by Oak. Includes six switch sections, gear system, potentiometer and special brackets.

9. Compact assembly controlling four 7.5A, 32V snap switches

10. For PC board insertion, this Unidex dual concentric switch combines a PC board switch section, standard switch section and shielded variable resistor.

11. Stamped and machined mounting brackets and shielding hardware on multi-section switch with variable resistors controlled by center shaft.

12. Glass epoxy PC board switch sections with added components, solder terminals, special brackets and shielding for hi-fi equipment.

13. Seven section dual concentric Unidex switch with PC board terminals and shielding between sections.

14. Printed circuit section switch with additional wiring and components; for attachment to PC mother board.

15. Dual concentric switch with bracket and special counting dials, wired sections and attached connector.

16. Dual-concentric, 7 section switch, with shielding and special locking mechanism for use in test equipment.

17. Three 18-position sections, dual concentric switch with counting gear mechanism used for airborne equipment. Special brackets and gears assembled at Oak to customer's specifications.

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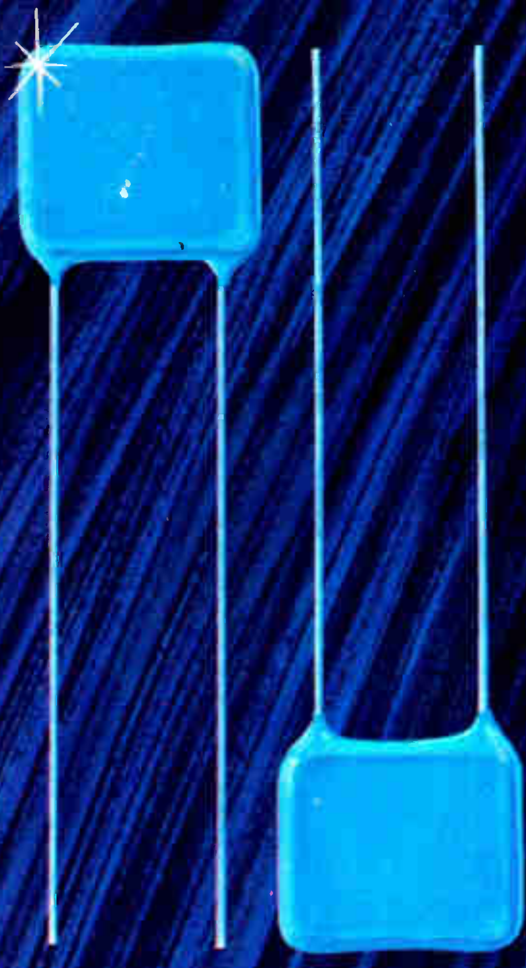

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First-in first-out unit is fast, dense

Bipolar FIFO memory uses ion implantation to reduce resistor areas and allow 64 4-bit words of storage with 20-MHz input and output rates

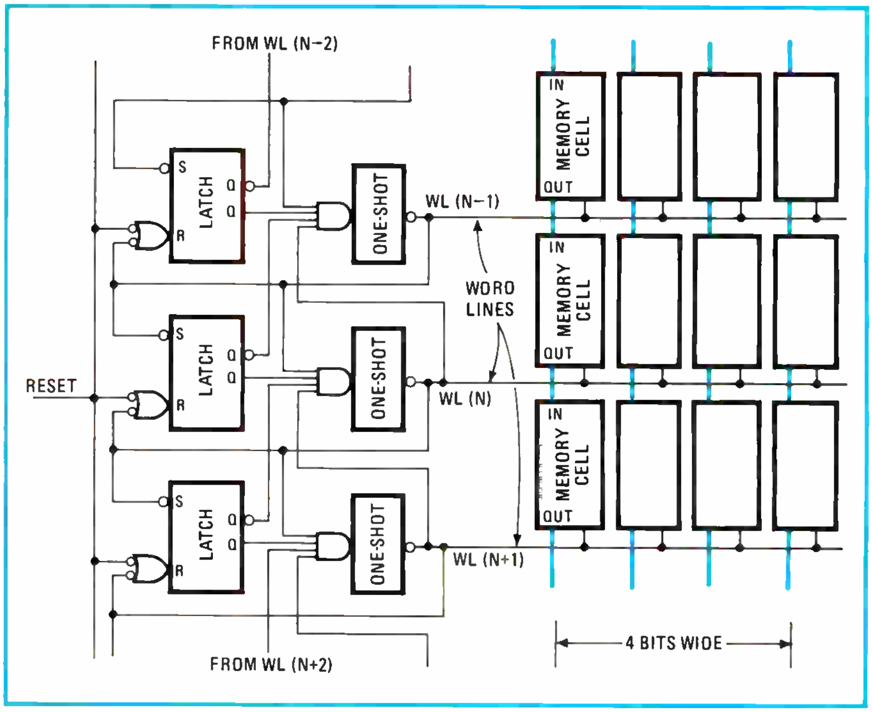
by Stephen E. Scrupski, Computers Editor

By combining bipolar Schottky-TTL technology with ion implantation, Monolithic Memories Inc., Sunnyvale, Calif., has developed a first-in first-out (FIFO) memory that it says combines the speed of bipolar with the bit density of MOS shift-register circuits. The memory, type 67401, is in a 16-pin package that is pin-compatible with an earlier metal-oxide-semiconductor FIFO, the 3341.

However, the new memory runs at a typical speed of 20 megahertz and at a minimum of 12 MHz, both at the input and output, while the MOS device runs at 1 MHz minimum, according to Ed Barnett, marketing manager. An earlier bipolar part operates at about 12 MHz but holds only one fourth as much data, he adds.

The new memory is organized as 64 by 4—it takes in 4-bit-wide words and can hold 64 such words. It is essentially a pipeline—when a 4-bit word enters, it ripples down the register chain and queues up behind any other data that's in the pipeline. If no data is ahead of it, the word appears at the output at most 4 microseconds and typically 1.8 μs later (the MOS device has about a 16-μs maximum fall-through time). One of the key features of such devices is that they can be loaded and read out at the same time, and at different speed rates.

The higher density is required in this type of circuit because the shift-register circuits, comprising normal bistable flip-flops with load resistors, should have high-value load resistors in order to reduce the power dissipation. However, if diffused resistors were used, the achievable resistivities, typically about 200 ohms/square, would mean that the resistors would take up a lot of chip area. With ion implantation, resistivities of about 1,200 ohms/square are achievable, so the resistors can be made much smaller. The result is that the gates typically dissipate about 0.7 milliwatt and delays range between 10 and 20 nanoseconds.



Shift down. Control circuitry for the 67401, comprising latch, AND gate, and one-shot, monitors cell contents and allows data to propagate from top to bottom. Data does not shift from word-line N − 1 into N unless the line is empty, having sent its contents to N + 1.

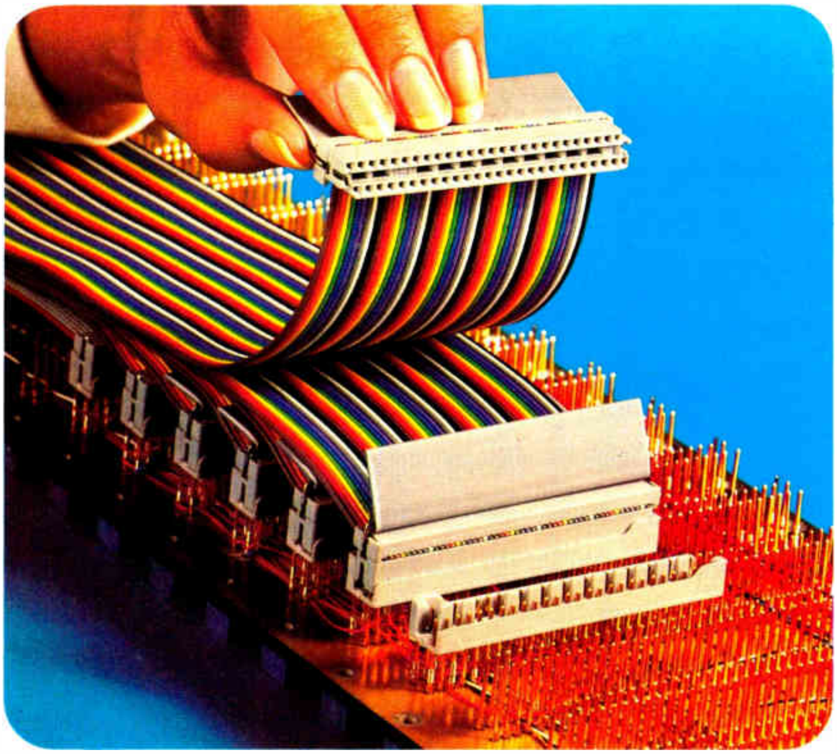
One application of the FIFO is as a buffer between a head-per-track disk and a memory. Data comes off the disk skewed, and then extra sense amplifiers, delay lines, and reshaping networks are used to adjust the data back to synchronization. The FIFO, however, can act as a variable-length memory that removes the skew and as the place where the data can be taken out in parallel.

The 15 pins (one is unconnected) are used as follows: input, four; output, four; input ready—the device is ready to receive data; output ready—ready to be read out; write in; read out; master reset for control circuitry (to reset the cells themselves, a series of 0s must be sent in); power supply, and ground.

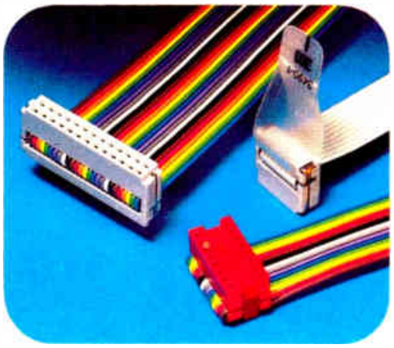
The 67401 is specified at 0° to 75°C. A military version will be announced by the end of the year. Price for the 67401 is $25 each for quantities of 100 and up.

Monolithic Memories Inc., 1165 East Arques Ave., Sunnyvale, Calif. 94086 [338]

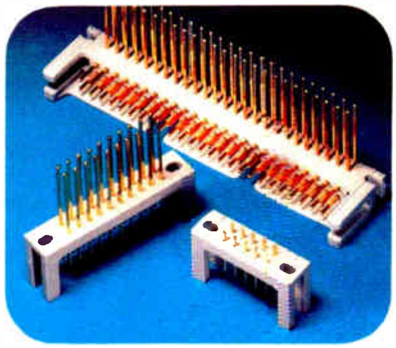
Want simpler backplane connections? Come to the source.



Now, a unique Scotchflex brand Socket Connector and Keying Header system lets you interface directly with backplane wire wrap pins and provides for easy, positive polarization and keying. The header design allows for thousands of unduplicated polarizing combinations without loss of backplane pins. The 50-position connector mates with .025″ square pins on .100″ x .200″ grid spacing. Header allows space for and protects two layers of wrap below it. System also provides polarizing keys and strain relief handles.



Need some other ways to simplify wiring and increase circuit density? 3M's Scotchflex line offers you a broad choice of mass terminating socket connectors, plus wire wrap or solder tail headers to suit your specific design problem. Keying capability is also provided.



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See our catalog in EEM, page 1056

Miniature relay handles 15 A

Low-cost solid-state ac device occupies less than 0.5 cubic inch; family is aimed at appliances and other consumer applications

by Lawrence Curran, Boston bureau manager

The bulky type of solid-state ac relay package will become obsolete, if Edward T. Rodriguez has his way. He's chairman and technical director of Theta-J Relays Inc., which is introducing its J-Tab series of 5-, 10-, and 15-ampere ac units that aren't much larger than a TO-220 plastic triac package and cost $7-$8 less than their bigger forerunners, he says.

The size has been cut substantially by using a highly simplified package that has the relay's output-switching triac acting as the mounting tab and heat-sink interface [*Electronics*, July 22, p. 35]. The units occupy less than half a cubic inch, which Rodriguez says is a sixth to an eighth of the volume of comparably rated larger relays. The package measures merely 0.875 by 0.6 by 0.7 in.

There are no printed-circuit boards or thick-film substrates inside the package. The circuit is assembled using semiautomatic techniques more common to mechanical assemblies. The J-Tab series includes the output triac, Theta-J's photocell optical coupler, and a light-emitting diode for optical isolation—a simple setup that reduces costs and improves reliability, according to Rodriguez. "All the user really wants is an isolated triac," he notes, "and he often has to pay $10 for that isolation in the plate-mounted relays. With ours, he mounts it just like he would a TO-220 triac, and that's all there is to it. The other two components ride piggyback on the triac."

Rodriguez expects the 10-A entry to be the workhorse of the series, with applications including photocopiers, large appliances such as washers and dryers, as well as microwave ovens which are being designed with triac controls. The relay will be offered in 120-volt (JT-12) and 240-V (JT-24) versions, with the JT-12 breaking the $3 price barrier—it has a price tag of $2.50 in quantities of 10,000. For 100-unit lots, the JT-12 sells for $5 each, and for $7.50 each singly.

The 5-A and 15-A members of the family will also be available in 120-V and 240-V ratings, with the prices of the former about 10% below the JT-12 levels, and the latter approximately 8% above.

"Our objective is to make the cheapest and best ac relay up to 15 amperes," Rodriguez says. "We took these to the raw bones so that the customer doesn't spend two cents more than necessary." Theta-J has made the relays programable with an external input series resistor "so that we can tell the user which half-watt resistor to use to operate on 3 to 100 V ac or dc, whatever he wants," he points out.

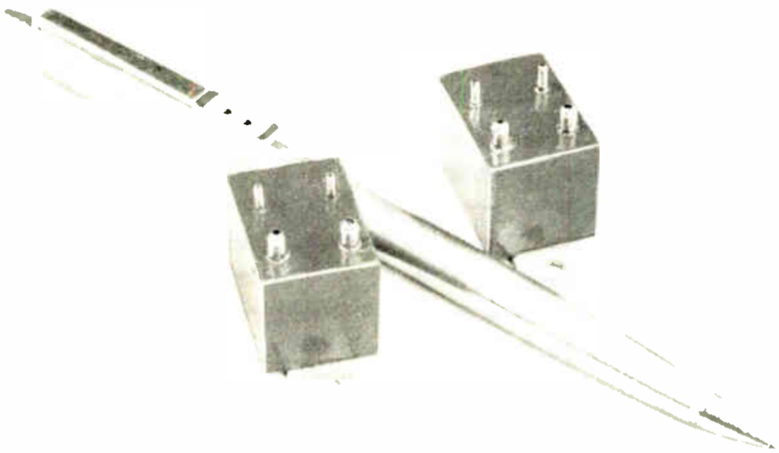
Rodriguez is optimistic about the sales potential for the J-Tab, linking it to the microprocessor boom in consumer electronics. "The low-cost solid-state relay is going hand in hand with consumer-oriented CPUs," he asserts. "We let the microprocessor do the thinking, and the interface device will do the work."

With an eye toward putting the J-Tab in intelligent home electronics devices, from self-defrosting refrigerators to remote-controlled equipment to entertainment sets, Rodriguez has already talked with major manufacturers of remotely operated televisions, garage-door openers, photocopiers, and pinball machines.

Load voltage for the 10-A JT-12 is 90-140 V ac; for the JT-24, it is 180-280 V ac. Off-state leakage current for the 10-A units is 1 milliampere, and the contact voltage drop is 1.5 V maximum. Response time is typically 16 milliseconds, and input-output isolation is 1,500 V ac.

Delivery time of all three current ratings is 90 days.

Theta-J Relays Inc., 2 Linden St., Reading, Mass. 01867 Phone (617) 942-0390 [339]



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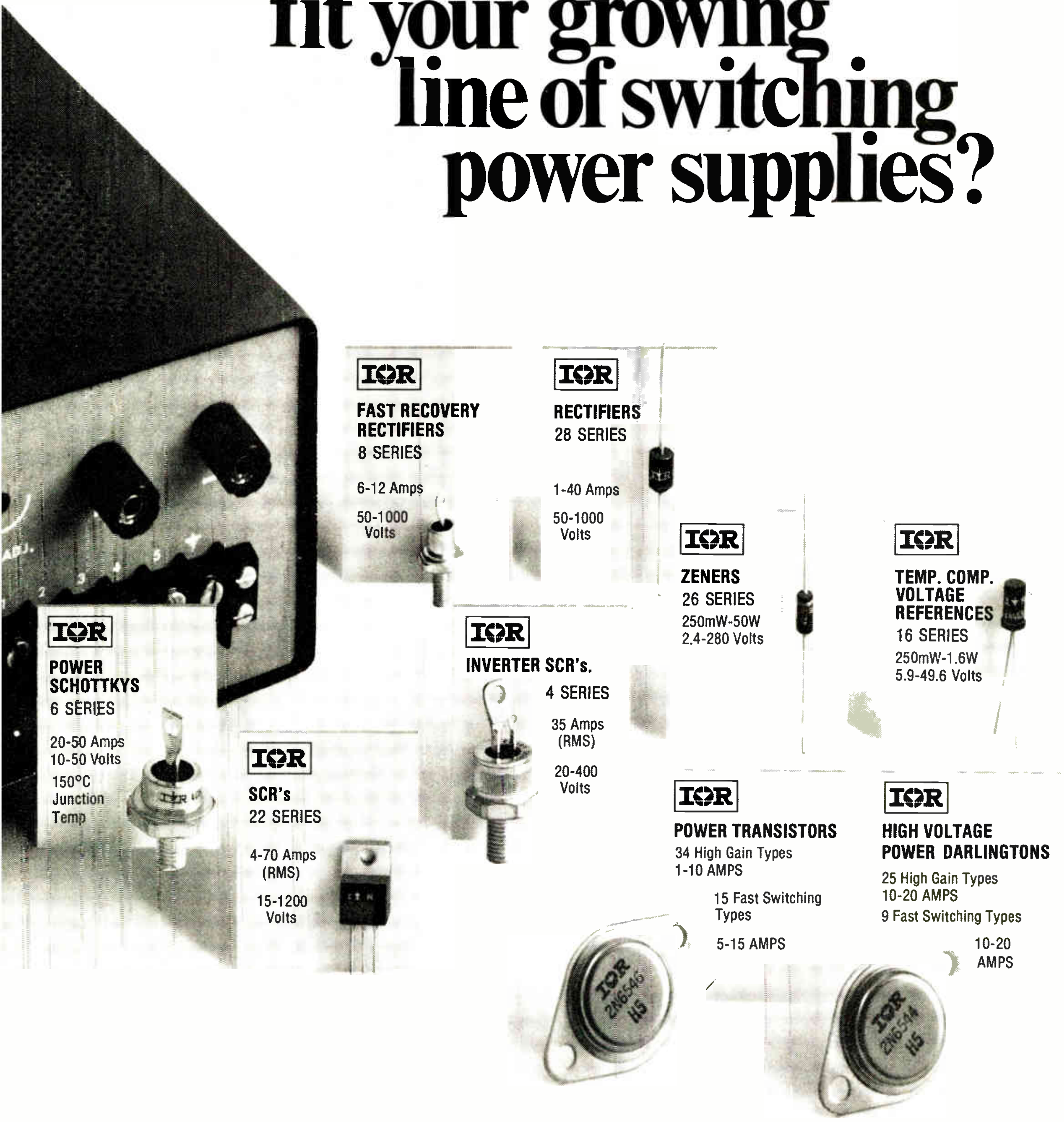

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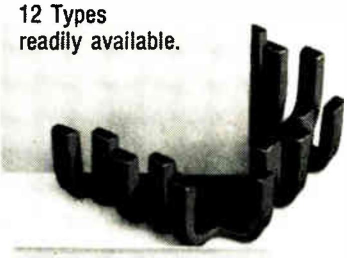

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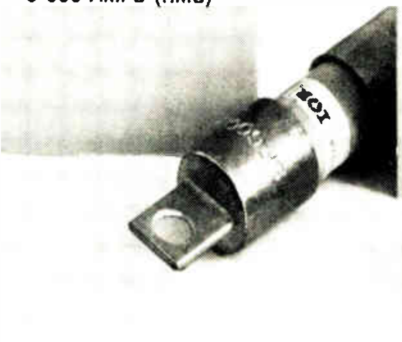

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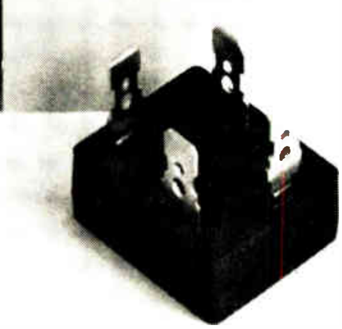

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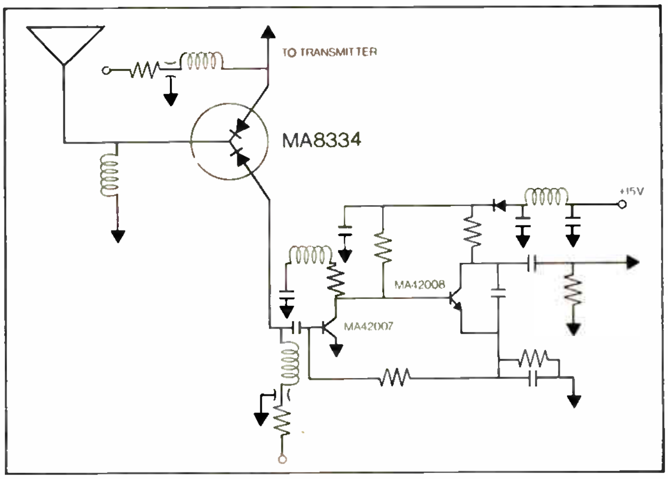

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Components

Solid-state relays are priced low

North American Philips breaks into market with three series

The new low prices for solid-state relays look like they're here to stay. Another established relay manufacturer, North American Philips Controls Corp., is entering the market with a miniature low-cost no-frills series without zero-crossover switching. The company is also introducing two series of larger zero-switching units.

Occupying less than 0.75 cubic inch, the series 501 non-zero-switching devices measure only 1.1 by 0.9 by 0.6 in. They are compatible with transistor-transistor, diode-transistor, and complementary-MOS logic circuits. Typically, control voltage is 5 volts dc at 7 milliamperes, and load voltage is 115 V ac at 60 hertz.

These printed-circuit-board units require no heat sink, yet they can switch load currents of 2 amperes maximum. Their turn-on time is typically 8 milliseconds, while turn-off time is 32 ms typical. They are optically isolated, with a light-emitting diode and a photocell providing an isolation voltage of 1,500 V ac root-mean-square.

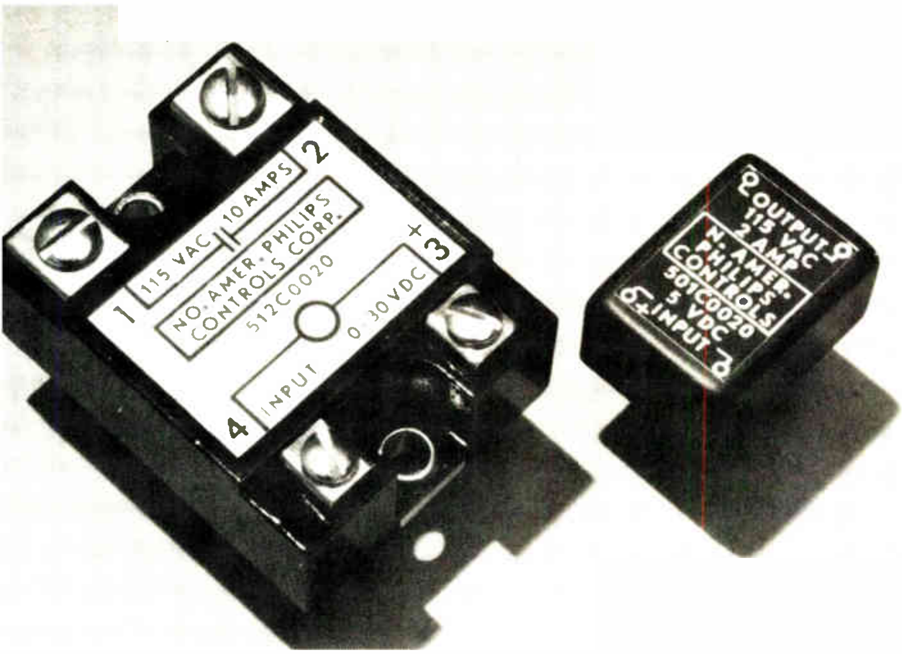
Applications for the new 501 series include business machines, computer peripherals, process controls, computers, and traffic controls. In quantities of 1,000, they are priced at $5.85 each. Delivery time is six to eight weeks.

The zero-switching 512 and 513 series of relays are capable of handling load currents of 10 A maximum at 115 V ac and 60 Hz. They are designed to operate over a control voltage range of 3 to 30 V dc at a typical control current of 10 mA.

Between input and output, these units provide an isolation voltage of 1,500 V ac rms, which is obtained with a LED and a silicon photodetector. Because of the zero-switching feature, turn-on and turn-off times are each a half-cycle.

Series 512 units come with screw terminals, while series 513 devices have quick-connect terminals. Both sell for $13.75 each in production quantities. Delivery takes six to eight weeks.

North American Philips Controls Corp., Frederick, Md. 21701. Circle [341] for series 501; [342] for series 512 and 513.



Sub-C nickel-cadmium cell has capacity of 1.4 Ah

Sub-C rechargeable nickel-cadmium cells, which previously were available only in capacities of 1 and 1.2 ampere-hours, are now being offered with a capacity of 1.4 Ah. Used in many OEM applications, including portable power and garden tools, scientific instruments, and photo equipment, sub-C cells measure 0.906 inch in diameter by 1.646 in. high. The published price of the 1.4 ampere-hour cell is $1.47 in quantity, compared to $1.25 for the 1.2-Ah unit and $1.15 for the 1.0-Ah cell.

General Electric Co., Battery Business Dept., P.O. Box 861, Gainesville, Fla. 32602 [343]

Thermistor assembly includes heating element

The model K365 dual-circuited indirectly heated thermistor consists of a thermistor bead and a heating element enclosed in a common glass bulb. Since the input (heater) and output (thermistor) are separated, the K365 is easy to design into automatic-gain-control circuits such as those found in telephone repeaters, audio oscillators, signal generators, and harmonic distortion analyzers.

Sensitivity of the indirectly heated thermistor is quite high. With approximately 40 milliwatts of power applied to the heater, the thermistor temperature increases 1°C. For a typical thermistor, this changes the resistance from about 50,000 ohms to about 15,000 ohms.

Fenwal Electronics, 63 Fountain St., Framingham, Mass. 01701. Phone (617) 872-8841 [345]

Solid-state relay occupies only 1.27 square inches

Requiring only 1.27 square inches of space on a printed-circuit board, a miniature solid-state relay can

New products

switch up to 3 amperes at 120 or 240 volts ac. Versions are available with input-voltage ranges of 3 to 8, 8 to 18, and 18 to 32 V dc. Capable of being driven directly by TTL levels, the relays offer zero-crossover switching and optical isolation between input and output. The price is $5 each for 1,000 of the 1.5-ampere 120-volt version, and $5.79 for the 3-A 120-V unit. Delivery time is six to eight weeks.

Elec-Trol Inc., 26477 N. Golden Valley Rd., Saugus, Calif. 91350. Phone (213) 788-7292 [346]

Relay packs three Form C contacts into a 14-pin DIP

A high-density, multipole reed relay that fits into a standard 14-pin dual in-line package is available with as many as six Form A, four Form B, or three Form C contacts. The Form A and B contacts are rated at 0.5 ampere, 100 volts dc, and 10 watts; the Form C contacts have ratings of 0.2A, 100 V, and 6 W. Available coil voltages are 5, 6, 12, and 24 V dc. Electrostatic shielding and clamping diodes can be supplied, if necessary. Delivery is from stock.

Computer Components Inc., 88-06 Van Wyck Expwy., Jamaica, N.Y. 11418. Phone (212) 291-3500 [348]

Zener transient suppressor can handle 1,500 watts

The TVP1500 series of zener transient suppressors can handle peak-power pulses as high as 1,500 watts to protect circuits, systems, and

HIGH VOLTAGE CERAMIC CAPACITORS

SEMTECH NEWS

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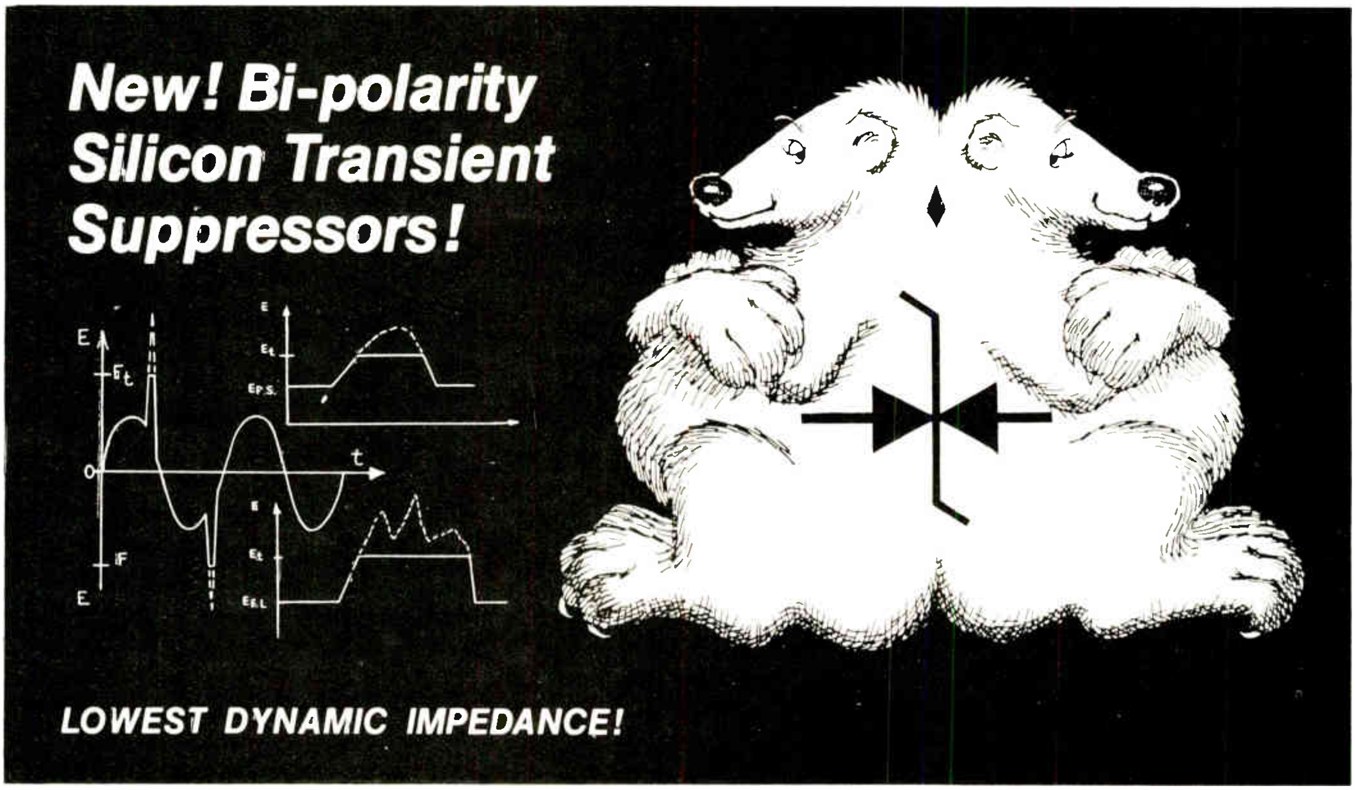

Can be supplied as JAN, JANTX or JANTXV to MIL-S-19500/516 (EL)

This new series of silicon bi-polarity transient suppressors is unique in that a single device will provide voltage transient protection symmetrically (i.e., provide protection for A.C. signals in addition to D.C.). This new series of devices has peak pulse power ratings of 500 to 1500 watts for 1 millisecond and its response time is effectively instantaneous (less than 1×10^{-12} sec.). Therefore, these versatile devices have many protection applications where large voltage transients can permanently damage voltage-sensitive components. The devices are encased in Semtech's Metoxilite, fused directly to the high temperature metallurgically bonded assembly. For use in commercial, industrial, military and space programs.

500 Watt

Peak Pulse Power

Types IN6102 through IN6137
Break down Voltage V(BR):
From 6.8 to 200Vdc ± 10%
Peak Surge Voltage (Vsm): 11.0 to 286.0V
Peak Surge Current (Ism): 45 4 to 1.7A
Temperature Coefficient of (VBR): 05 to .11%/°C
Case Size (Max.): .140" D x .165" L

1500 Watt

Peak Pulse Power

Types: 1N6138 through 1N6173
Breakdown Voltage V(BR):
From 6 8 to 200 Vdc ± 10%
Peak Surge Voltage (Vsm): 11 0 to 286 0V
Peak Surge Current (Ism): 136 4 to 5 2A
Temperature Coefficient of V(BR): 05 to .11%/°C
Case Size (Max.): 180" D x 165" L

☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆ ☆

4-LAYER DIODE IN METOXILITE!

Reduce circuit costs and increase reliability!

Semtech's 4 Layer Diode (PNPN) is a silicon switch that is controlled by the amount of voltage applied. The application of this diode to a circuit often reduces the number of associated components which in turn, leads to cost reduction and increased reliability. Now available in Semtech's proven Metoxilite construction as two terminal, fast-switching devices specifically designed for low voltage applications such as logic circuits, pulse generators, memory and relay drivers, relay replacements, alarm circuits, multivibrators, ring counters, and telephone switching circuits.

Types: 1N5779 thru 93, 1N5158 thru 60
Switching Voltage: 10 to 15V
Switching Speeds: t(on) = 75ns, t(off) = 250ns
Junction Capacitance: 150pF
Case Size (Max.): .070" D x .165" L

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equipment from voltage surges. The devices, which are offered with breakdown voltages from 8.2 through 200 volts, have a clamping time of only 1 picosecond. All devices in the family can withstand temperatures to 400°C, and can be operated from −65°C to 175°C. In quantities of 100, they are priced at $1.35 each and have a delivery time of six to eight weeks.

TRW Capacitors, 301 West O St., Ogallala, Neb. 69153. Phone John Gamet at (308) 284-3611 [347]

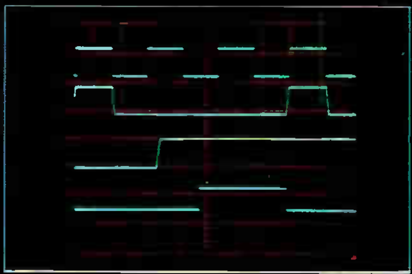
TOPICS

Components

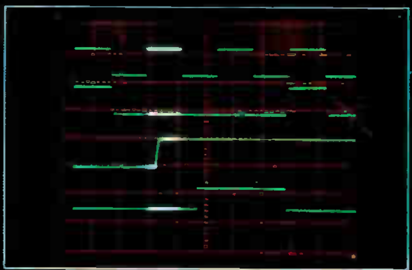
The Micro Switch division of Honeywell, in Freeport, Ill., has added reflector-backed light-emitting diodes to its line of AML lighted push-button switches. The new design is said to improve both the brightness and viewing angle of the push buttons. . . . **Cherry Electrical Products Corp.,** has added a seven-segment, 0.7-inch, four-digit clock display to its line of Plasma-Lux gas-discharge displays. The W04-0001 sells for $12.45 each in small quantities, dropping to $6.10 each for 2,000 pieces. . . . **C & K Components Inc., Watertown, Mass.,** has introduced its model 1101CQ subminiature slide switch—a spst device with a contact rating of 6 amperes. A free engineering sample of the switch is available on request. . . . **Sierra Electric, Gardena, Calif.,** introduced a line of 15- or 20-ampere toggle or key-lock switches that are totally enclosed and constructed with all exterior surfaces nonconducting and non-corroding. The dead-front, dead-sides, and dead-back switches meet all NEC, UL, NEMA, and Federal specification tests and design requirements.

Four 50 MHz channels. Unique triggering facilities. Ideal for parallel data analysis.

Zero in on



As illustrated on the front panel detail, triggering is fully independent and multi-sourced. This gives a number of unique triggering possibilities and is just as useful for more conventional dual-trace measurements.



Here the main and delayed timebases are triggered from different channels, one example of the PM 3244's unique triggering facilities. Signals can therefore be shown even when they are not related to the main timebase.

Differential measurements can be made on the PM 3244 in the conventional manner or by using the composite triggering mode.

Four traces give you the logic story: show the relationships at a glance. But only the PM 3244 gives you four traces and fully independent triggering of main and delayed timebases. Thus the main timebase can be triggered on any of the four channels plus composite, external and line. The delayed timebase can be triggered on any of the four channels plus composite: independently! This gives a number of unique triggering possibilities, for example showing relationships that are not directly related to the main timebase, like the information in a data line when the main timebase is triggered on an address line.

Doubles for dual-trace with *extra* performance.

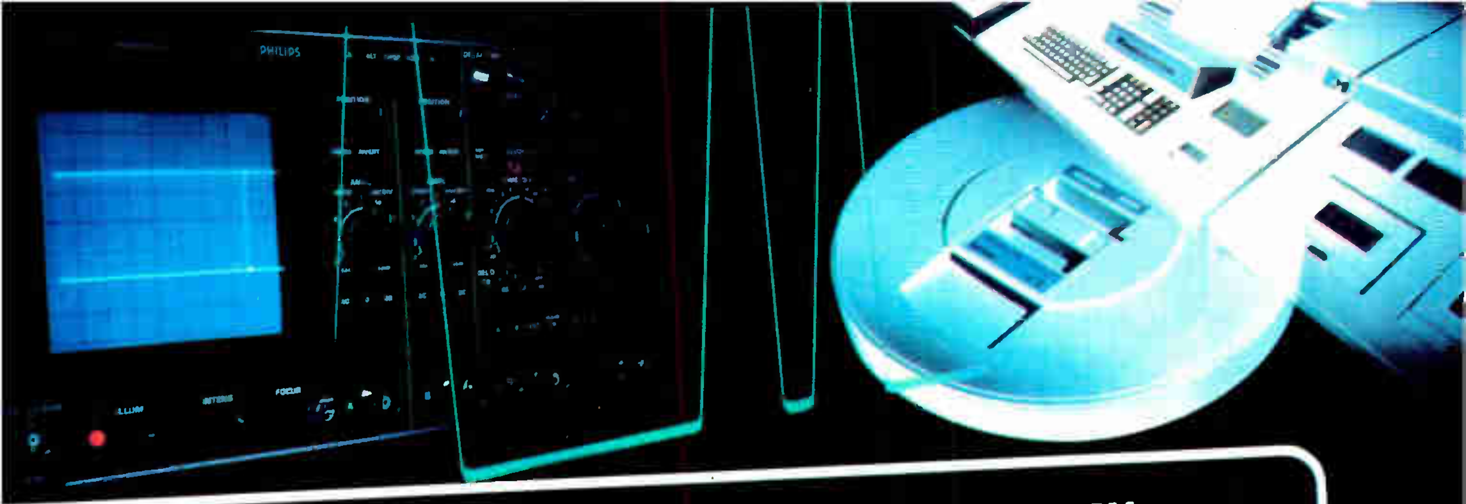
PM 3244 is the world's first four-channel compact and all channels have full display facilities i.e. sensitivity, attenuation, invert, etc. It can therefore be used to make isolated or differential measurements and when you need conventional dual-trace displays, this scope also gives them, with two traces in reserve plus unmatched triggering facilities.

All displays are on a large 8 x 10 cm screen and the compact construction weighs in at a mere 9.6 kg (21 lb). The price is rather compact too!

Write for more details. Read opposite about another data break-through.

PHILIPS

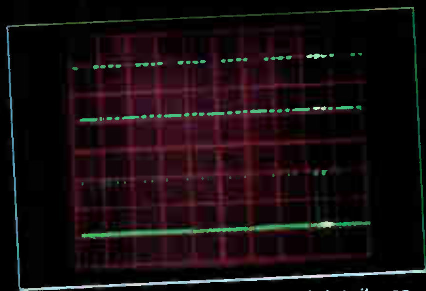
Test & Measuring Instruments



120 MHz with digitally delayed triggering to over 200 MHz. Ideal for serial data.

ones and zeros

The PM 3261 is another world first. In addition to conventional triggering facilities, the instrument features a digitally delayed timebase that can be set to trigger on a particular pulse in a data stream, the position being displayed on the built-in, five-digit LED. This facility allows individual events to be located quickly and accurately in data streams of up to 100,000 bits and then be 'trapped' for detailed display.

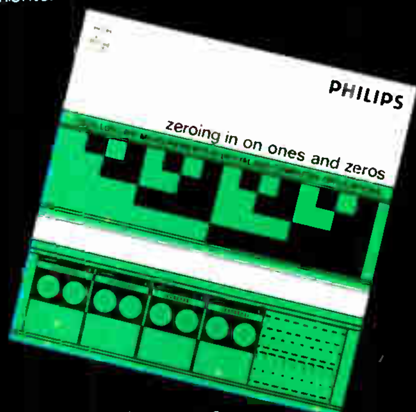


As illustrated on the front panel detail, one push button and one control knob are all that's needed to operate the digital delay. The required event in the data stream 'lights up,' as shown, and can then be displayed using the normal delayed timebase in order to make accurate time interval measurements.

The event is located using the illustrated delay counter, which can be set to count up or down at an adjustable speed as low as one step every two seconds. Specific sections can thus be examined and the counting stopped and stepped back to pick up and locate any irregularities.

The digitally delayed counter also overcomes problems of jitter, such as occur in mechanical systems like disk memories, tape drives, etc. In such cases, if the jitter is longer than one period, a conventional delayed timebase cannot be effectively employed. Once that display has been trapped, accurate time interval measurements can be made using the normal delayed timebase controls.

In addition, the main timebase has a TTL triggering facility to eliminate triggering problems on preshoot, overshoot, ringing, etc.



Zero in on ones and zeros with the aid of this useful 64-page booklet. For further information simply circle the reader service number.

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And so is your design range.

The introduction of AMP Coaxial Ribbon Cable assemblies represented a major breakthrough in interconnection technology. Lower costs with no compromise in performance. Now, AMP has broadened the line to give you an extremely wide range of high speed, low noise interconnections.

AMP ribbon coax is available in 50-, 75- and 93-ohm ratings, 6 to 26 positions, on .100-inch centers. Or in a 95-ohm rating on .125-inch centers.

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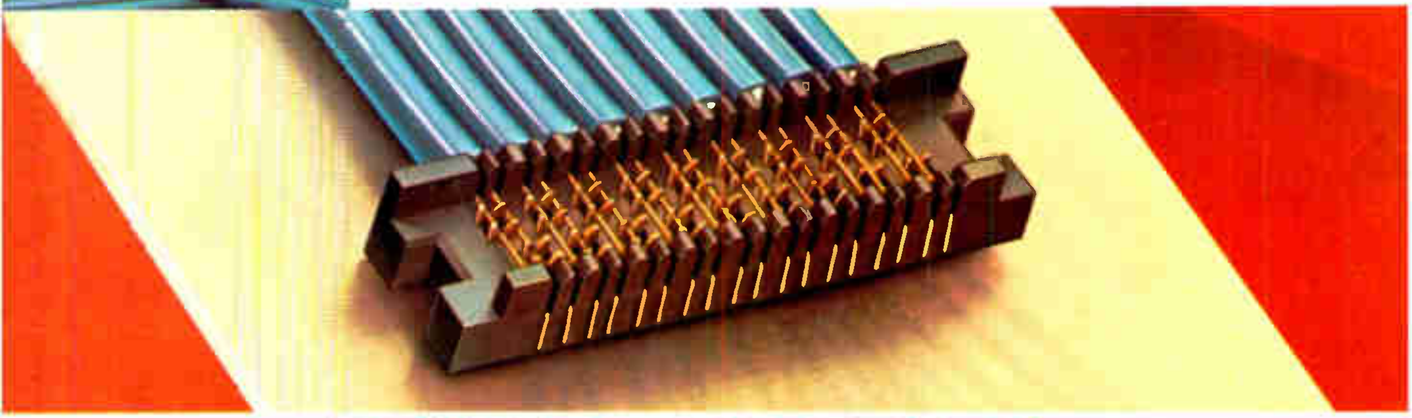

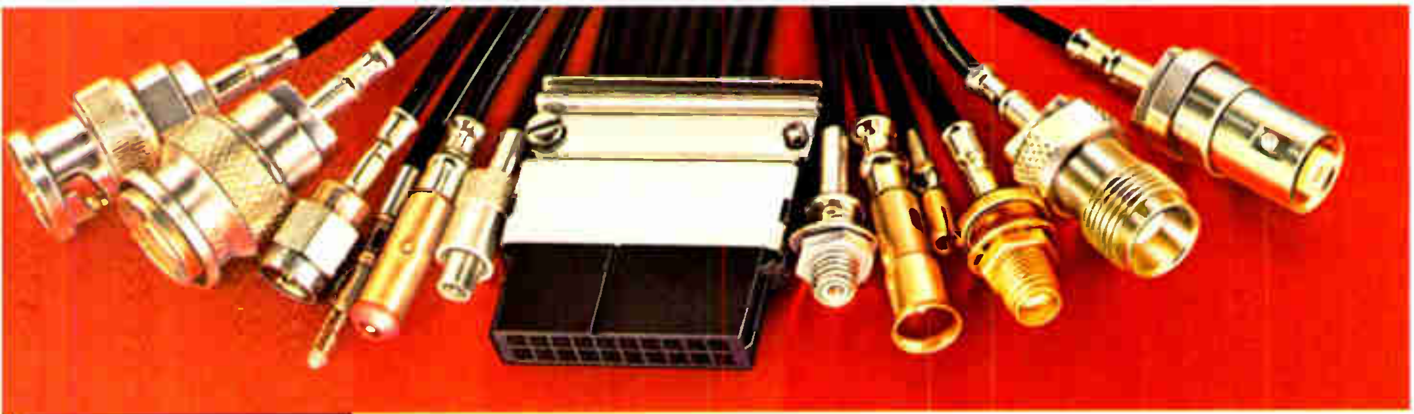

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Circle 141 on reader service card

Semiconductors

IC converter resolves 10 bits

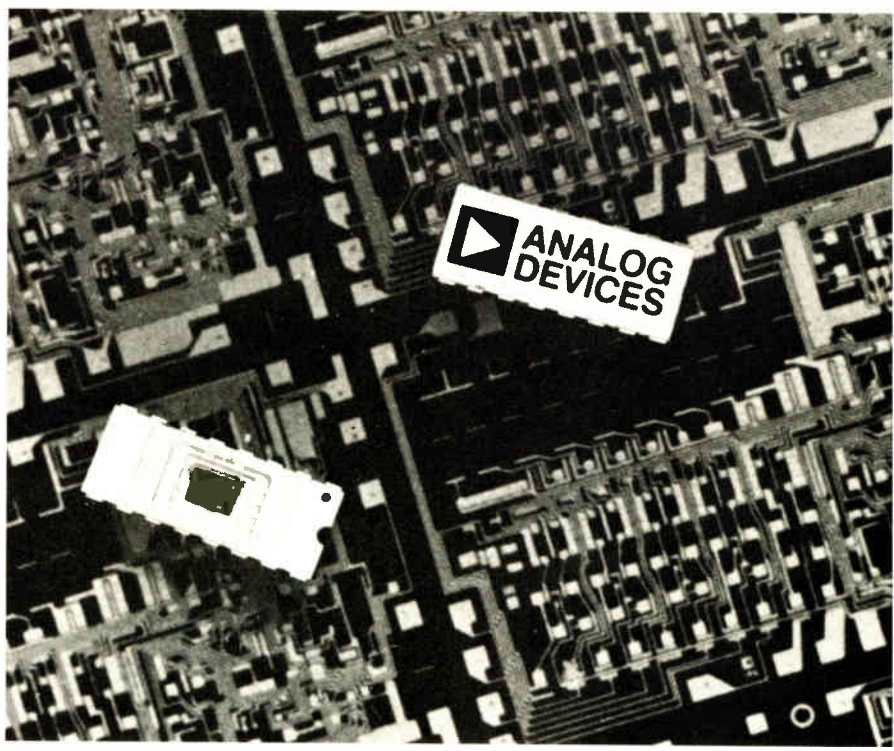
Buried zener reference diode enhances stability; resistors are laser-trimmed

Semiconductor manufacturers usually peg integrated-circuit digital-to-analog converters at the highest resolution being sought, such as 10 bits. The best of the lot gets that rating, while the remainder are binned for sale at a less demanding 8 bits. That procedure is not followed with a new 10-bit d-a converter from Analog Devices Semiconductor division. The AD561 will be sold only as a 10-bit unit because its developers are confident that it will be an accurate and stable 10-bit monolithic converter.

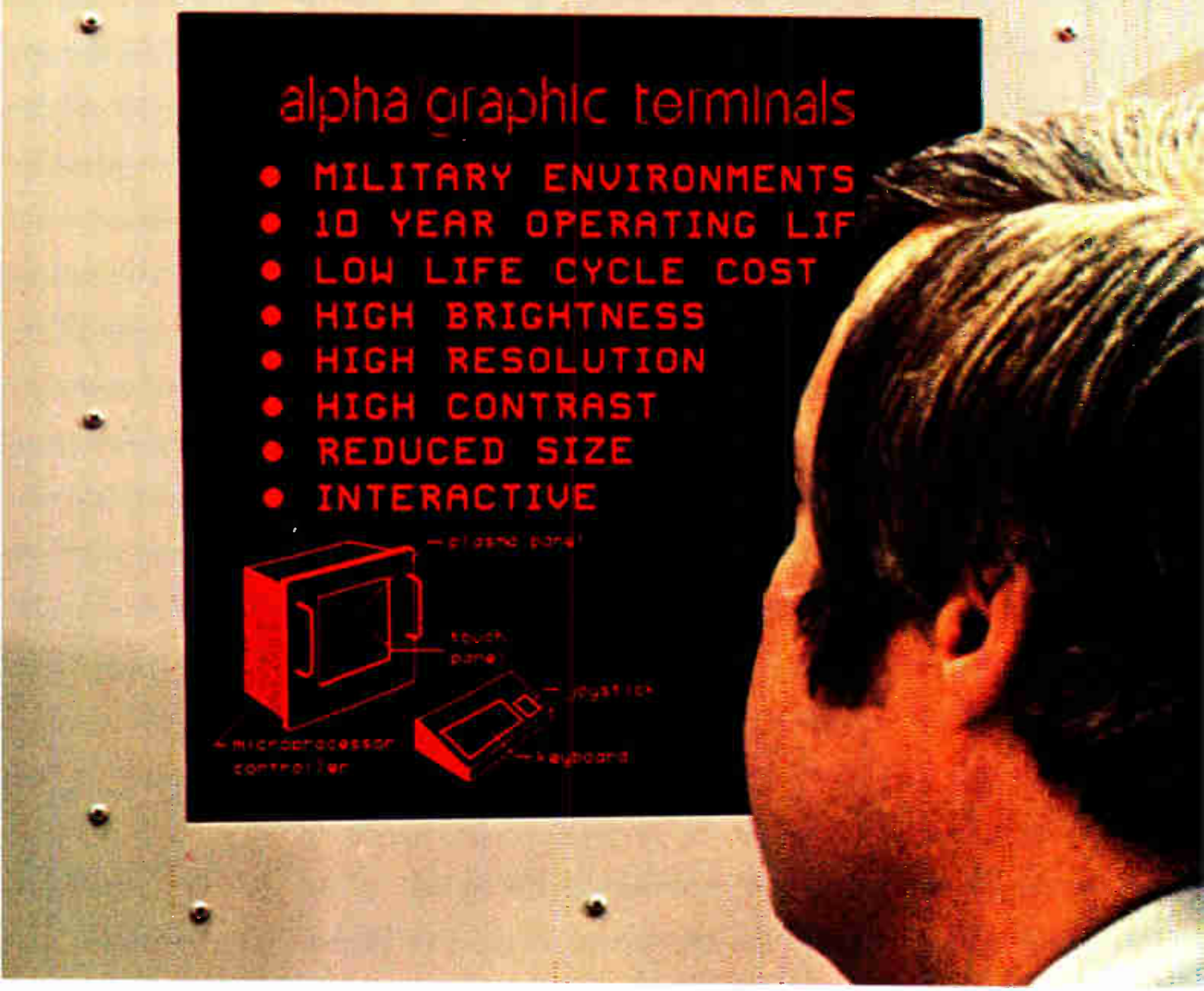
Laser trimming of the thin-film resistors at the wafer level is the big contributor to accuracy, explains Rich Frantz, product-marketing specialist. And David Kress, also a marketing specialist, points out that the device is trimmed to about 14 bits true resolution on the wafer. Two versions, the AD561K and AD561T, have a maximum relative accuracy to within ¼ least significant bit; and J and S versions deliver accuracy to within ½ LSB.

Stability of 100 parts per million/°C is achieved primarily through the integration of a buried zener reference diode, says Kress [*Electronics*, Sept. 16, p. 111]. He says surface references can't deliver the kind of long-term stability that the buried zener does—it is diffused deeper into the device than are the surface zeners. The laser-trimmed thin-film resistors, buried zener and an R-2R ladder network with a low temperature coefficient all combine to produce the tight accuracy, stability, and monotonicity over the full operating temperature of each version of the converter.

The AD561J, which sells for $9.95 in quantities of 100, is specified for operation from 0°C to 70°C, the same range as the K version, priced at $15 in hundreds. The S and T versions, designed for the full military temperature range of −55°C to +125°C, are priced at $18 and $32,



Look at the latest in plasma display.



Now look at the source.

Interstate Electronics—veteran supplier of military computer-based electronic equipment.

For over 20 years, we've designed and delivered hardware for a range of environments, from laboratory to full Mil-Spec conditions. Today, we're among the leading 100 defense contractors in America.

Now we're producing plasma display terminals under multiple military contracts. Our products range from standard off-the-shelf models to special configurations, with display features like joystick interactive editing and microprocessor control. All have the inherent advantages of plasma display—plus Mil-Spec capability.

Your new military display source—Interstate Electronics—a dynamic part of the Electronics Group of A-T-O Inc.

Give us an opportunity to discuss your operational environment and performance requirements. Write Sid Wing, Military Products Manager, Interstate Electronics Corp., Marketing Department, 707 E. Vermont Ave., Anaheim, CA 92802. Better yet, call him at (714) 772-2811.

INTERSTATE ELECTRONICS CORPORATION

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Circle 143 on reader service card

respectively. In addition, there are MIL-STD-883 versions of the AD561S and T.

All grades are housed in 16-pin hermetic ceramic DIPs, and all have the same fast typical settling time of 250 nanoseconds to ½ LSB. Kress points out that the current-steering switches are designed to settle in less than 250 ns for the worst-case digital-code transition, which allows a successive-approximation 10-bit conversion in 5 microseconds.

All versions of the AD561 are available from stock.

Analog Devices Inc., Route 1 Industrial Park, P.O. Box 280, Norwood Mass. 02062. Phone (617) 329-4700 [411]

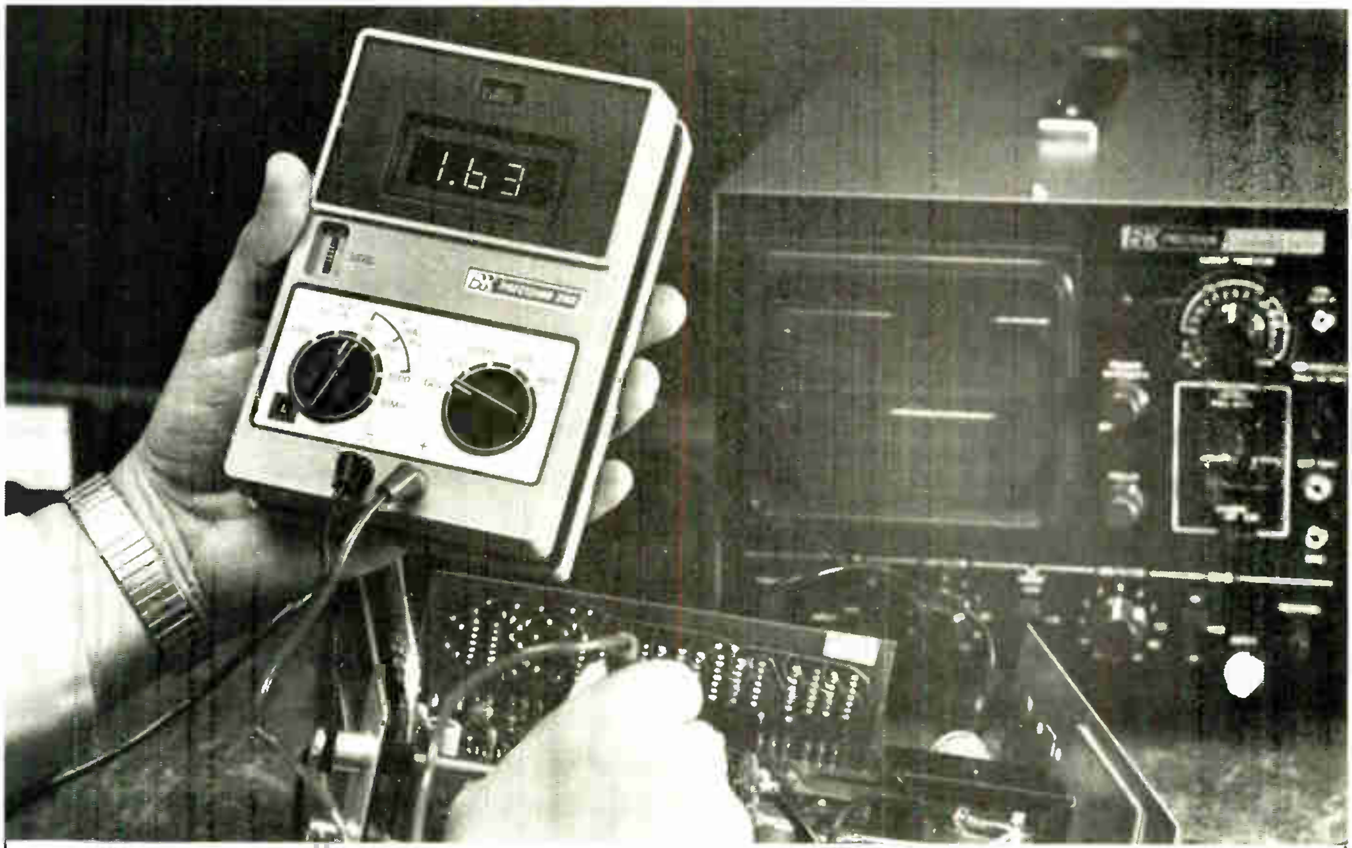
Power MOSFET family takes aim on bipolar transistors

Six MOS field-effect transistors—three with a power rating of 4 watts and three that are rated at 25 W—are intended to replace assemblies built around bipolar power transistors. Because they have a negative temperature coefficient, the enhancement-mode MOSFETS do not suffer from current-hogging problems when two or more of them are connected in parallel for applications beyond the capability of either.

Noteworthy for their capability to be driven by lower-power C-MOS circuits such as those in microprocessors, the transistors have a typical

switching time of 4 nanoseconds at a drain current of 1 ampere. Other key specifications include a maximum continuous drain current of 2 amperes (for the 25-W VMP 1 series), and a typical input leakage current of less than 1 nanoampere.

The 25-W devices, housed in TO-3



Why is the 280 at $99.95 our fastest selling multimeter ever?

The reasons are easy to understand. The 280 is a battery-operated portable, full-feature digital multimeter at less than the price of a precision analog meter. The 280 features a large three-digit LED readout, automatic polarity indication, automatic decimal point placement and out-of-range indication. The 280 is fully overload protected for reliability and has an industry-standard input impedance of 10 megohms for all voltage ranges.

It has High/Low power ohms ranges for accurate in-circuit measurements. And digital accuracy ± 0.5% DCV thru lowest ranges; ± 1% 1000 V range. ± 1% ACV thru lowest ranges; ± 2% 1000V range. ± 1% typical ohms and digital resolution (1mV, 1μA, 0.1 ohm).

No compromises on range either—DC and AC voltage ranges to 1000 V, DC and AC current ranges to 1000 mA and ohms ranges to 10 megs. There are actually 22 operating ranges controlled by the smooth rotary range and function switches.

B&K-PRECISION also has a full complement of optional accessories for the 280:

- LC-28 carrying case ($6.00) protects your 280 and provides test lead storage.
- MS-28 wire tilt stand ($3.00) allows positioning the 280 on two convenient viewing angles.
- BC-28 AC adapter/charger ($8.00) offers AC operation and battery recharging.
- PR-28 high-voltage probe extends the 280's capability to 40,000 volts.
- PR-21 direct/isolation probe ($10.00) prevents capacitive loading when measuring DC in an RF circuit.

Our fastest seller ever? We're not surprised.
IN STOCK AT YOUR DISTRIBUTOR.

B+K PRECISION

PRODUCTS OF DYNASCAN

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In Canada: Atlas Electronics, Toronto

packages, are priced from $5.50 to $8.10 each in hundreds, depending upon breakdown voltage. The 4-W transistors, which sell for $3.60 to $5.30 each in hundreds, are supplied in TO-39 packages. Available breakdown-voltage ratings are 35, 60, and 90 volts.

Delivery of the units is from stock.

Siliconix, 2201 Laurelwood Rd., Santa Clara, Calif. 95054 [413]

High-current diode chips have low recovery times

A line of diode chips for use in hybrid circuits includes units with forward-current ratings from 1 ampere to 100 A and reverse recovery times from 9 to 90 nanoseconds. The ion-implanted devices are offered with peak reverse voltage ratings from 20 volts to 660 V. Leakage currents range from 50 microamperes for the 1-A units to 500 μA for the 100-A diodes. Maximum surge currents are 10 times rated current in the 100-A devices and 50 times rated current in the 1-A units. Chip prices range from 25 cents to $5 each in lots of 100 pieces. Delivery is from stock.

Solid State Devices Inc., 14830 Valley View Ave., La Mirada, Calif. 90638. Phone (213) 921-9660 [415]

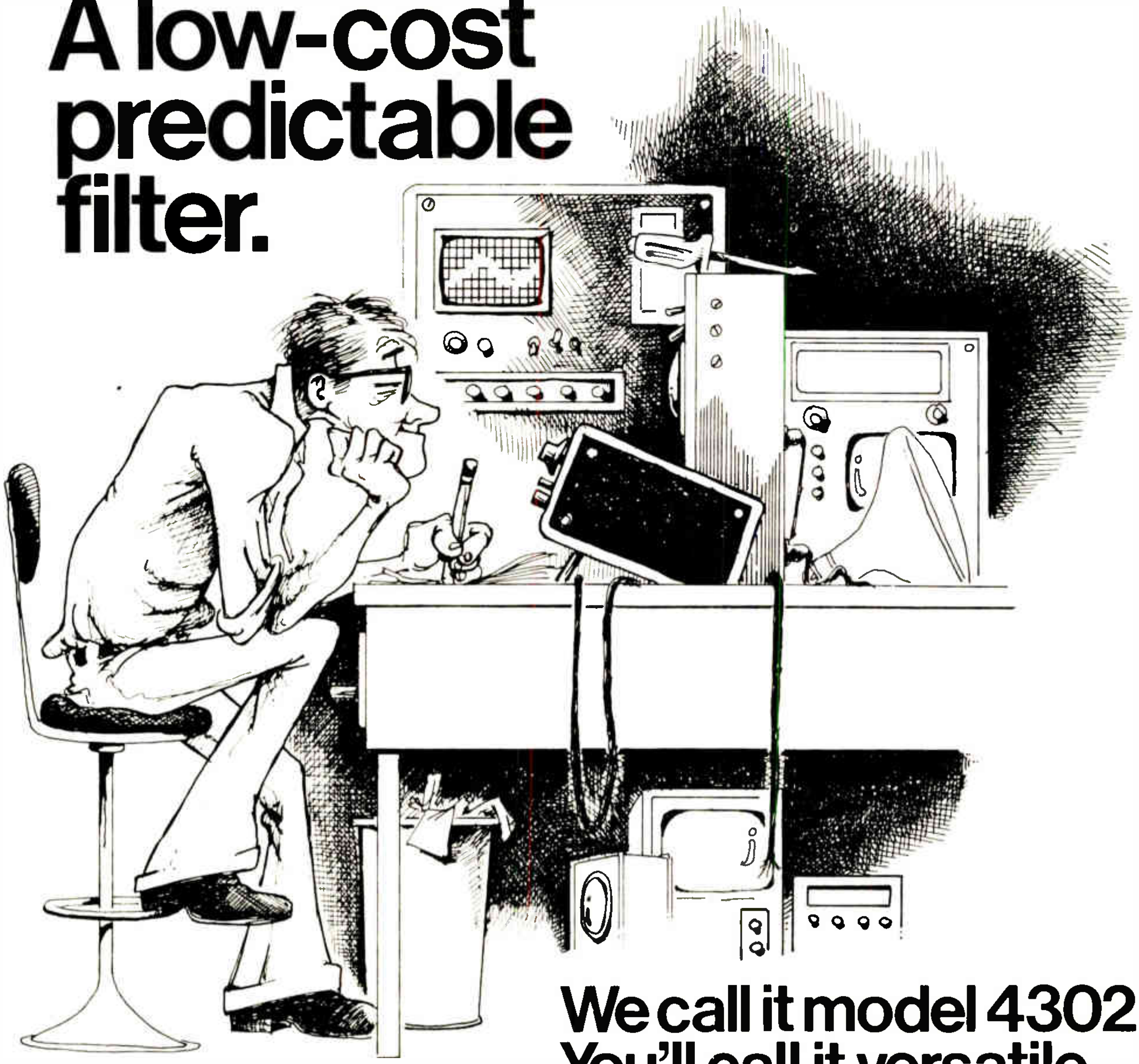
Analog multiplexers are protected against faults

A series of 4-, 8-, and 16-channel analog multiplexers, manufactured with a dielectrically isolated complementary-MOS process, has a high degree of immunity to input and power faults. No damage results even when an MX-series multiplexer

 Circle 146 on reader service card

Circle 211 on reader service card

Finally. A low-cost predictable filter.



We call it model 4302. You'll call it versatile.

You probably have equipment in your lab or data acquisition system that you don't really trust, or that you have to calibrate whenever you use it. So we thought you'd appreciate a high performance, low-priced dual filter that's predictable.

It takes unusual performance to make a predictable filter.

Like .005% distortion at 20 volts peak to peak output. 25 μvolts self noise. 100dB outband rejection. And 100dB crosstalk attenuation. All better than any competitive filter, even higher priced ones. And switch selectable frequency settings (10 Hz to 1MHz), let you repeat settings over and over again. With predictable results.

Versatility is written all over its face.

Each 24dB/octave filter can be used as high pass or low pass with selectable gain of 1 or 10. Or connect them in series for bandpass, 48dB/octave high pass, or 48dB/octave low pass, with selectable gain of 1, 10, or 100. Select normal (Butterworth) and pulse (Bessel) by the push of a button. All of this is standard.

Send for our data sheet.

It'll tell you all you need to know about our newest filter. And when you need a filter that does just what you expect, you'll know where to find it. The predictable filter.™ $655. Ithaco. Box 818, Ithaca, New York 14850. Call (607) 272-7640.

ITHACO

is subjected to an input overvoltage of up to ±20 volts, a logic input overvoltage of up to ±4 v, or a loss of power with control and signal inputs applied. Break-before-make switching ensures that no two channels are ever shorted together, and an inhibit input makes it easy to connect several of the devices together to expand their channel-handling capability.

Unit price is either $14 or $34, depending upon the number of channels and whether the inputs are single-ended or differential. The 16-channel multiplexer is offered only with single-ended inputs, while the 4-channel device is only available with differential inputs. All units are available from stock.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. Phone Eugene Zuch at (617) 828-8000 [414]

Unit multiplies two 8-bit words in 130 nanoseconds

The MPY-8 multiplier circuit is an 8-bit monolithic device that can perform a complete 8-by-8-bit parallel multiplication in 130 nanoseconds, typically. Inputs and outputs are TTL-compatible, and the outputs are of the three-state type.

The multiplier, organized as a four-port device, is housed in a 40-pin dual in-line package. It uses emitter-follower logic for high speed and lower power consumption. Only one 5-volt power supply is required.

The MPY-8 sells for $100 each in small quantities. Delivery time for samples is 30 days.

TRW Defense and Space Systems, E2/9085, One Space Park, Redondo Beach, Calif. 90258. Phone Bill Groves at (213) 536-1977 [416]

3-digit voltmeter chip is accurate within 0.1%

Intended to provide competition for high-accuracy analog panel meters, the LD130 digital voltmeter is a monolithic device that includes most of the circuitry needed for a three-digit voltmeter. The circuit, which is accurate within 0.1% ±1 count, needs only one external reference voltage, three capacitors, and a field-effect transistor to form a BCD-output voltmeter. To provide a display requires the addition of three LED seven-segment readouts, three digit-driving transistors, a BCD-to-seven-segment decoder/driver, and seven current-limiting resistors.

Automatic polarity and range-switching are included on the chip, so these features need add no cost to the meter. Priced at $8.75 each in quantities from 100 to 999, the LD130 reduces the cost of building a meter into a new product to approximately $15 to $20, depending upon the number of measurement modes and the display elements.

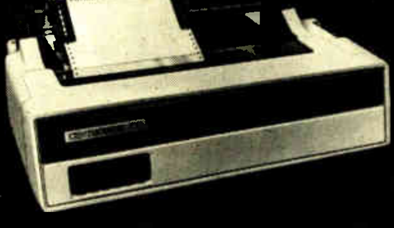
Siliconix, 2201 Laurelwood Rd., Santa Clara, Calif. 95054 [417]

Semiconductors

Intersil Inc., Cupertino, Calif., is now second-sourcing the AMI 1424A five-function LCD watch circuit. The ICM1424A is a silicon-gate C-MOS circuit designed to drive a 3½-digit field-effect liquid-crystal display. . . . **Advanced Micro Devices Inc., Sunnyvale, Calif.,** has introduced three serial-in/parallel-out universal shift registers that have typical shift frequencies of 50 megahertz. The 8-bit registers are called the Am54/74LS299, the Am25LS23, and Am25LS299. . . . **The Linear Integrated Circuits division of Fairchild Camera and Instrument Corp., Mountain View, Calif.,** has extended its line of monolithic interface circuits with two dual memory drivers. The 55/75326 and 55/75327 are priced from $2.62 to $3.14, depending upon packaging. . . . **Signetics Corp., Sunnyvale, Calif.** has added two military versions of its field-programable logic arrays to its product line. The Schottky-TTL devices operate over the temperature range from −55°C to 125°C.

"We'll sell you the best, lowest priced 132-column printer available anywhere."

Bob Howard, President, Centronics



But the low initial price for the Centronics 700 Series 132-column printer isn't the whole story.

It's the lower cost of ownership based on the 700's inherent reliability and simplified construction.

The 700's unique modular construction using four different modules — printing, electronics, forms handling and keyboard — and less moving parts mean easier maintenance, lower cost and a smaller spares inventory.

Write for the full details of this tremendous offer . . . and information on the rest of the printers and teleprinters in the new Centronics 700 Series.

Centronics means more than low price.

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Circle 151 on reader service card

Packaging & production

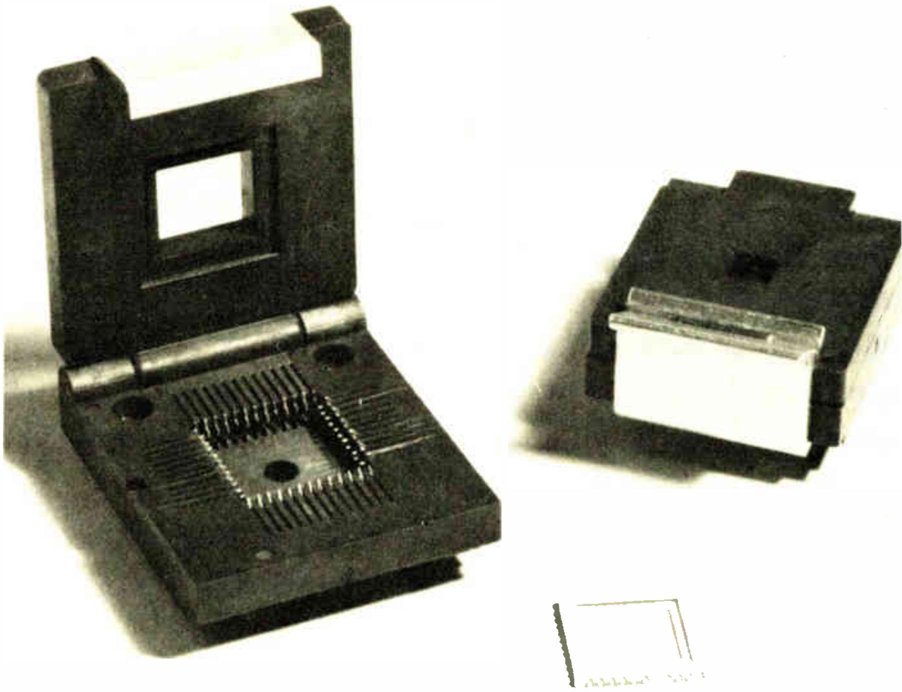
IC socket takes chip carriers

Zero-insertion-force receptacle burns in LSI devices up to 220°C

Both parametric testing and accelerated burn-in procedures are musts for expensive LSI chips like microprocessors or large-scale semiconductor memories. Today, a great many of these LSI-chip types are being packaged in small square ceramic chip carriers [*Electronics*, July 22, 1976, p. 98], which make neat space-saving, reflow-solderable, hermetically sealed packages for high-density hybrid applications. But until recently there was no commercially available solderless socket for testing chips mounted on a ceramic carrier. Most users soldered the ceramic substrates, which have gold bumps on their bottom faces, to a motherboard and functionally tested the entire board.

In response to queries from several large companies for a test or burn-in socket for the square carriers, Robinson Nugent has developed a whole family of sockets that can do this dual job. The photo illustrates the general construction of the new devices. The square ceramic substrate of the carrier is placed in the square cavity of the socket. Then the top lid is snapped shut with the metal piece locking the assembly tight. The substrate is held down tightly on wiping contact springs that mate with the conductive pattern on the carrier. This arrangement makes a zero-insertion-force connection between carrier and socket. Contacts of the cavity are internally connected to solid pins coming out of the bottom of the unit. The pins interface with the outside world.

Body of the new socket is a brown polyphenylene-sulfide glass material. Normal temperature range of the new unit is −65 to +150°C. An optional socket configuration is available for use up to +220°C. According to Don Fleming, vice president of marketing for Robinson Nugent, "More and more users of LSI chips are going in for accelerated high-temperature burn-in of chips on ceramic carriers at up to 220°C. This



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Some of the other features offered by these low-cost solid state units include: zero crossover switching, photo isolation between input and output. total epoxy encapsulation. long life. and immunity to shock and vibration.

With their convenient pin mounting and small footprint. these new solid-state units can be squeezed into tiny spaces on your printed circuit boards for such applications as business machines. air conditioning or traffic controllers. computer peripherals. medical electronics, process control units, automatic test equipment. and automated machine tools.

For more information. use the reader service card. For immediate action. contact your local distributor, representative or the factory direct:

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ELEC-TROL

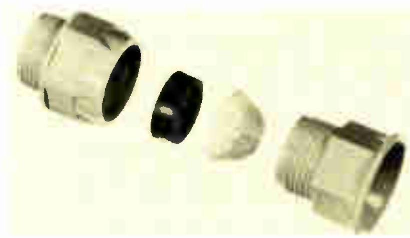
testing weeds out the infant-mortality type of failure."

Standard socket contacts are beryllium copper while beryllium-nickel contacts are used in the high-temperature version. Sockets with 18 to 64 contacts are available in this series. A typical socket, the 18-pin low-temperature version, costs $6.12 each in 100-piece lots. The high-temperature versions of this socket cost $8.40 in the same quantities. Delivery is from stock to 4 weeks depending on type.

Robinson Nugent Inc., 800 East Eighth St., New Albany, Ind. 47150. Phone (812) 945-0211 [391]

Nonmetallic grip fitting provides strain relief

A completely nonmetallic grip fitting, in which a nylon gripper and a neoprene seal are enclosed in a hex-head housing, provides positive-grip strain relief for cables and tubes. Made of high-impact Lexan, the fittings totally isolate the cable from contact with metal. They are oil- and water-tight, and meet the requirements of NEMA 4X. Eight sizes are available, to accommodate cable



diameters from 0.23 inch to 0.70 in.

Rose-Stahlin Enclosures Inc., Belding, Mich. 48809. Phone John Lawther at (616) 794-0700 [394]

Guided-clip/probe system tests logic circuit boards

The Magiclip system is an optional hardware and software package that provides users of the Mirco 6500 test/programing station with a tool that can be used by relatively

VACTEC Photodetectors

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Vactec serves manufacturers of a wide range of modern electronic products. Pictured are a few examples. All these devices are both made and sold by Vactec, including complete lines of LDR's (photoconductive cells, CdS and CdSe); silicon solar cells, as well as silicon high speed and blue enhanced cells; NPN phototransistors and darlingtons; opto-couplers (LED/LDR, lamp/LDR and neon/LDR); selenium photovoltaic cells; silicon photodiodes, blue enhanced and PIN; and custom C-MOS and bi-polar IC's. Write for technical bulletins on the types that suit your requirements. Or send your application, and Vactec will recommend the right cell for the job.

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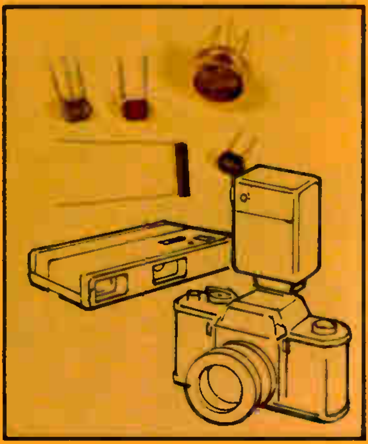
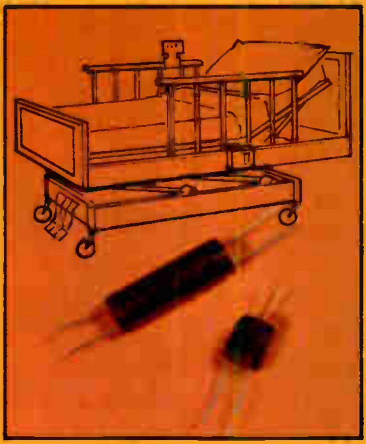


Cameras and Projectors

CdS or blue enhanced silicon photodiodes for automatic shutter timing; aperture servo systems for automatic projector focus, and slave flash controls.

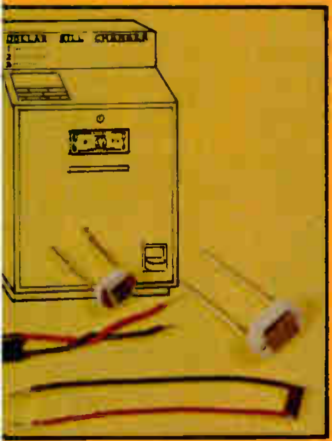


Triac Motor Controls

A special Vactrol gates a triac for forward and reverse motor operation as in hospital beds.

LED Watches

Photoconductive or phototransistor chip controls LED brightness.



Dollar Bill Changers

ilicon photovoltaic cells analyze
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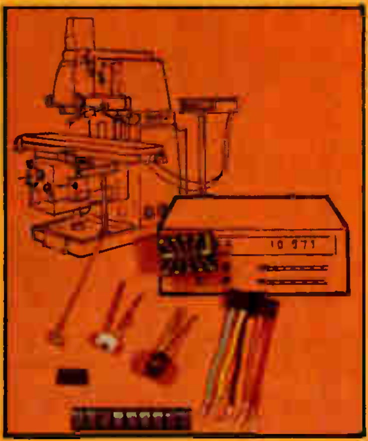
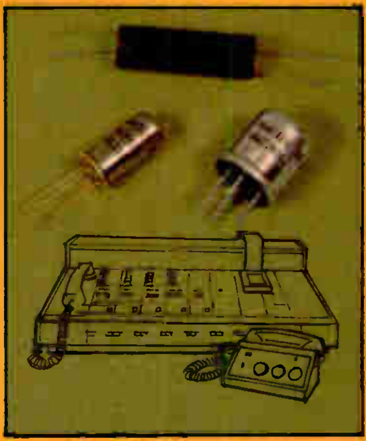


Machine Tool Controls

High-speed photovoltaic cells or transistor arrays help computer control repetitive operations, non-contact sensing, and counting and weighing.



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Scientific Instruments

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Circle 155 on reader service card

New products

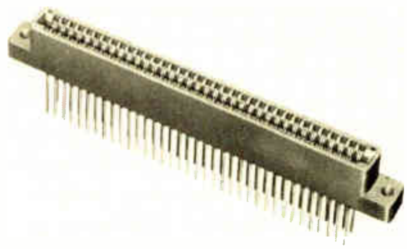
unskilled operators to isolate circuit-board faults. System hardware includes a 16-pin IC clip and a single-tip probe. Connected by cable to the 6500 test head, the clip and probe are positioned by the operator in accordance with instructions displayed on a CRT terminal. Both clip and probe are protected against overvoltages to ±30 volts.

Depending upon other options, a 6500 system with Magiclip sells for from $40,000 to $60,000. Delivery time is two to four weeks.

Mirco Inc., Systems Division, 10888 North 19th Ave., Phoenix, Ariz. 85029. Phone (602) 997-5931 [393]

Card-edge connectors are for automated assembly

Designed for automated assembly, series CH card-edge connectors are high-reliability devices designed to be dimensionally and functionally interchangeable with those covered by MIL-C-21097. The connectors have contact tails for printed-circuit-board mounting or wire soldering and are available with 6, 10, 15, 18, 22, 36, or 43 dual positions. Series CH contacts are spaced on 0.156-



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For complete information or a demonstration, contact your local Data Precision representative or Data Precision Corporation, Audubon Road, Wakefield, MA. 01880, (617) 246-1600. TELEX (0650) 949341.

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For Demonstration circle 157
For Additional Information circle 214

inch centers on the circuit card.

Series CM connectors are similar to series CH units except they are spaced on 0.100-inch centers and are supplied with bifurcated simple cantilever terminations. Series CM devices are offered with 15, 22, 36, 43, or 50 dual positions.

Eby Co., 4701 Germantown Ave., Philadelphia, Pa. 19144. Phone (215) 842-3000 [396]

PROM programer is low in price

A combination programer and duplicator for programable read-only memories, the series 92, consists of a master control unit and a plug-in PROM personality module. The M920 master control unit sells for only $995, and personality modules range in price from $350 to $550.

By itself, the device is only a PROM duplicator. A 20-milliampere current-loop interface is provided for

connecting the programer with a teletypewriter or similar terminal through which it can be commanded to program, list, duplicate, and verify PROMS.

The unit comes in an attaché case and weighs less than 15 pounds with the personality module. Options include an RS-232 interface.

Pro-Log Corp., 2411 Garden Rd., Monterey, Calif. 93940 [397]

Flat-cable system has from 10 to 60 contacts

A line of insulation-displacement systems, including socket connectors, a variety of flat cable, plugs, and

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Because our Mediterranean-like climate makes good things really grow.

And speaking of good growing things—San Jose is the hub of the 31st largest metropolitan area in the country—over 1.2 million people, with an effective buying income of $16,804—7th highest in the nation. A climate people like for living—in fact, our area was recently rated the 4th best place in the United States to make your home.

But what if you're looking for a new home for your electronics firm?

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Our area hosts the largest concentration of high-technology companies in the world, according to Fortune magazine.

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There's more than just an "open for business" city attitude.

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There's a highly skilled pool of labor, with thousands more coming into the market every year from our area's superb educational facilities.

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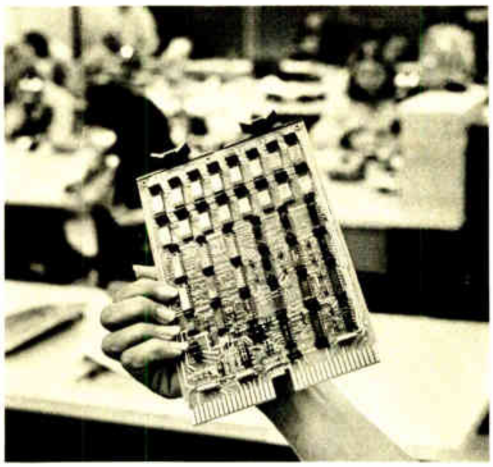
San Jose. A great place for growing things, like families, grapes, prunes, and electronics firms.

Look into it today.



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arbor presses, allows speedy fabrication of cable assemblies with no need for prestripping the cable insulation. Using the arbor press, the connectors are mass-connected to the cable by means of insulation-piercing tines that wrap around each conductor wire. Available connectors have 10, 14, 16, 20, 26, 34, 40, 50, and 60 contacts. The cables, all of which are spaced on 0.050-inch centers, are offered in twisted-pair, flat-ribbon, and combination types. The cable types are all listed by Underwriters' Laboratories under their component-recognition program.

Circuit Assembly Corp., 3169 Red Hill Ave., Costa Mesa, Calif. 92626. Phone (714) 540-5490 [398]

Universal fixture terminates most flat ribbon cables

A universal fixture for the mass termination of round-conductor ribbon cables can handle plugs with from 10 to 60 contacts. Unlike proprietary units, which handle only certain plugs, the Vector P187 fixture accommodates all female insulation-displacement connectors made by AMP, Alpha, Ansley, Berg, CW, JAE, 3M, SAE, and Vector.

The fixture consists of two aluminum blocks with milled slots to position the plug and a cable guide to align the cable. Spacing washers and stepped surfaces in both the pressure bar and the base accommodate the different vertical dimensions.

The fixture is used in conjunction with an arbor press, which supplies the force needed to seat the cover of the plug body and which Vector supplies in a low-cost version, the P186-1, for $59.50. But, regardless of what arbor press is used, the fixture always exhibits positive bottoming to eliminate the need for delicate operator feel; one merely pushes on the press handle until it can't be moved any further. Available from stock, the P187 sells for $29.50.

Vector Electronic Co. Inc., 12460 Gladstone Ave., Sylmar, Calif. 91342. Phone (213) 365-9661 [399]

If memories hold no future for you, come to where the action is.

RAMs and ROMs and P-ROMs are a huge market, and there's the rub. People get lost in the shuffle. Tied to too small an aspect of the job. Technology becomes technique, and soon it's boredom, boredom, boredom. We've all been there in the big semiconductor houses, watching the excitement of the early sixties become the mechanical men of a mature market. Yecch.

We can help. With a scientific based product line that requires a sure technological grasp at every phase of its design, manufacture and marketing. From device design through circuit design, from packaging through test and quality control, from wafer fabrication and applications engineering, in every aspect of our operations, you'll put your hard-won knowledge to work and watch it grow. As you grow. In a company which is big enough to support your ideas and small enough to encourage them. You won't be tied down to a single, repetitive responsibility, either. Our people track their responsibilities through manufacturing, applications, R&D and marketing. Customer contact extends to all members of our teams. We're the leader in a super market, substantial and growing. And one of the few remaining where technology reigns supreme.

You can help. If you've got the goods in any area of semiconductor technology—manufacture, process engineering, applications and circuit design, device design, packaging or marketing—we've got an excellent spot for you. With elbow room. Where your help will count. And be recognized. And rewarded.

For some people, it's too much work. For our kind of technological people, it's the opportunity to work. And see the results. For us, and for themselves. If you're that kind of person, call me or send me your resume. It's time we got together. Communications Transistor Corporation, a wholly owned subsidiary of Varian Associates, 301 Industrial Way, San Carlos, California 94070, (415) 592 9390.

Thomas E. Ciochetti, President

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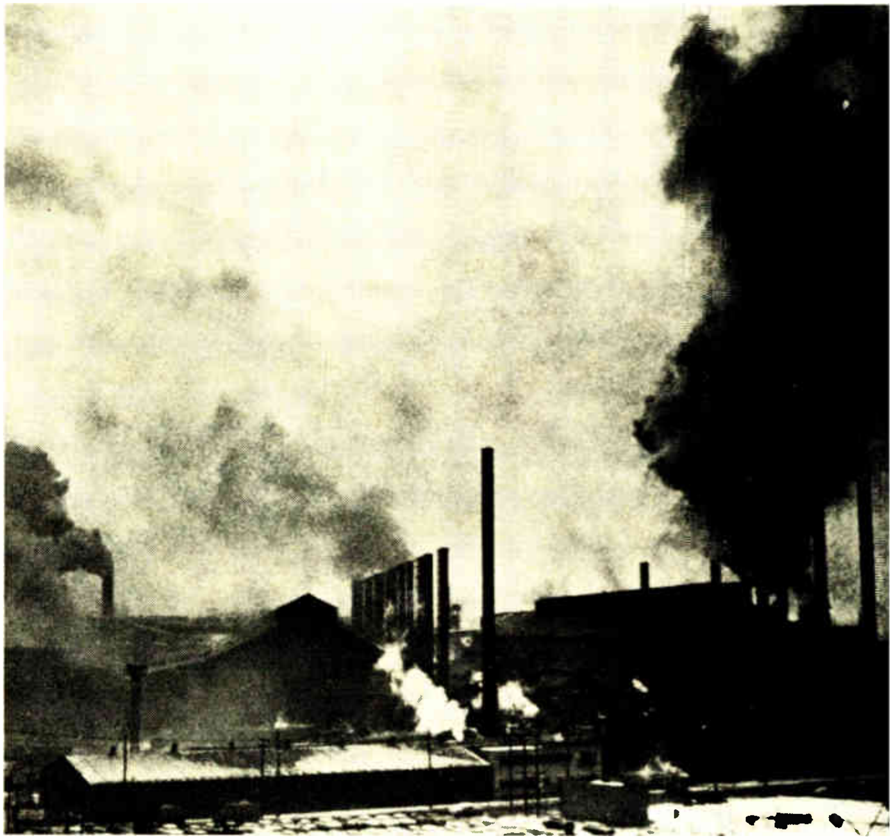

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Microprocessors

Prototyping system offered

Prompt 80 from Intel is self-contained development service

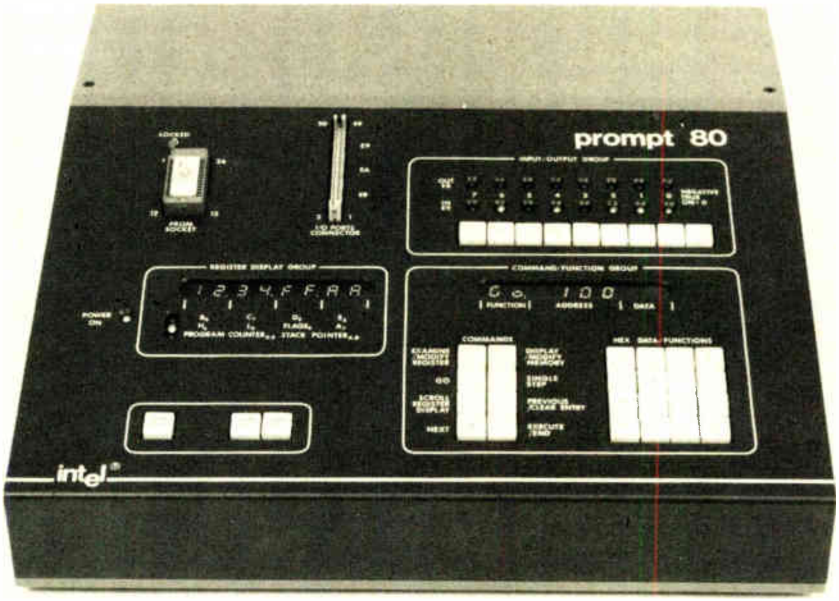
Microcomputer-system designers can now enter, develop, and save machine-language programs with calculator-like ease on an intelligent programer for erasable electrically programable read-only memories (Eproms). The Intel Corp. Microcomputer Systems division says its Intellec Prompt 80 personal programing tool is the industry's first self-contained development service. John Doerr, product manager, says it is a complete self-programing microcomputer based on Intel's widely used SBC 80/10 single-board computer.

The programer, which supports the design of any 8080 system, allows a user to enter, execute, debug, and save programs easily, much like a programable desk calculator. Like a programable calculator, Prompt 80 can be highly personalized by using self-programing to develop new operating routines. These programs can be stored in Eproms provided by Intel and plugged into resident memory.

In addition, Prompt 80 can be used as a microcomputer-system prototyper, a satellite or peripheral of the larger Intellec microcomputer-development system, a production-line Eprom programer, a programer/communications terminal for field engineering, or a personal engineering computer, says Doerr.

The designer operates the Prompt 80 by keying in sentence-like command function and data sequences, similar to calculator keying sequences. However, the display panel is large and organized for easy interpretation and modification of instruction flows. As programs are entered or single-stepped, the designer can also check logic operations of the SBC 80/10's 8080A CPU, memory addresses and contents, and programable input/output ports, Doerr points out.

This technique, which is easier and faster than using a display terminal or teletypewriter, says Doerr, eliminates the need to buy those peripherals or other auxiliary equipment. Programs are entered through a hexadecimal keyboard that also doubles as a hex calculator to speed data conversion. Hex entry allows typical 8080 operations to be



specified with only two keystrokes.

"To facilitate debugging, programs can be developed and executed in increments from 16 bytes to 2 kilobytes," he says. Large programs can be developed as modules up to 2 kilobytes, or continuously by expanding resident memory. Intel supplies two 8708 1-kilobyte Eproms that plug into the system, along with ROMS containing system-monitor programs. Also, the company supplies a comprehensive library of tutorial and 8080 system-design material for users who are just beginning to design software.

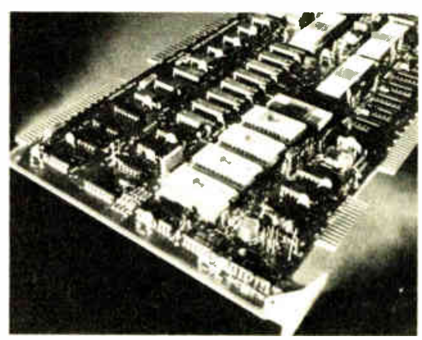
Doerr expects a high percentage of Prompt-80 users to be designers with little or no experience in microcomputing because surveys indicated that nearly half of all designers now planning to use the SBC 80, system 80, and other 8080 products lack that type of experience.

The Intellec Prompt 80 personal programing tool is available from stock at $1,495. The price includes complete assembly and testing, two 8708 Eproms, three 8308 ROMS containing system monitor programs, and the design library.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [401]

Software development tools work on microcomputer

An inexpensive package of software-development tools is designed to ease the generation of programs for the Intel SBC 80/10 microcomputer. The package, called RDP2, includes an editor, an assembler, and a monitor. All are contained on four 2708 programable read-only memories



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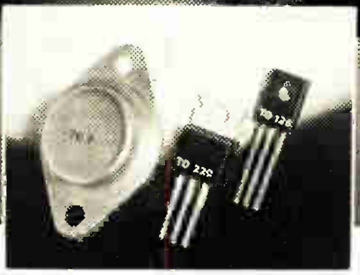

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Circle 165 on reader service card

that plug directly into the SBC 80/10 board.

The editor aids in the preparation of input tapes. The one-pass assembler translates the assembly-language input tapes into machine code and stores them in the SBC 80/10 memory. The monitor contains functions for software debugging, including tape dumping and loading, storage and register modifications, and selective program execution.

The RDP2 price of $995 includes the four PROMs, documentation, periodic software updates, and a warranty. Delivery is from stock.

Extensys Corp., 592 Weddell Dr., Suite 3, Sunnyvale, Calif. 94086. Phone (408) 734-1525 [363]

Floppy-disk system operates with SBC 80/10 computer

Designed to operate with Intel's SBC 80/10 single-board computer, the iCOM model FF36-1 floppy-disk system includes a disk drive with daisy-chain capability, an IBM-compatible controller, and all necessary cables and connectors. Also provided is the model 360-56 interface card, including a PROM with interfacing software that plugs into a slot in the Intel SBC card cage. The software includes a macroassembler and a string-oriented text editor. Priced at $1,495, the disk system has a delivery time of three weeks.

iCOM Inc., 6741 Variel Ave., Canoga Park, Calif. 91303. Phone Terry Zimmerman at (213) 348-1391 [364]

Instrument analyzes any 6800-based microcomputer

The model MPA AO 6800 microprocessor analyzer is a development and debugging instrument that can be connected to any 6800-based microprocessor system without placing any constraints on hardware or software. Among its standard functions are the setting and examining of registers (A and B accumulators, index, stack pointer, condition codes,

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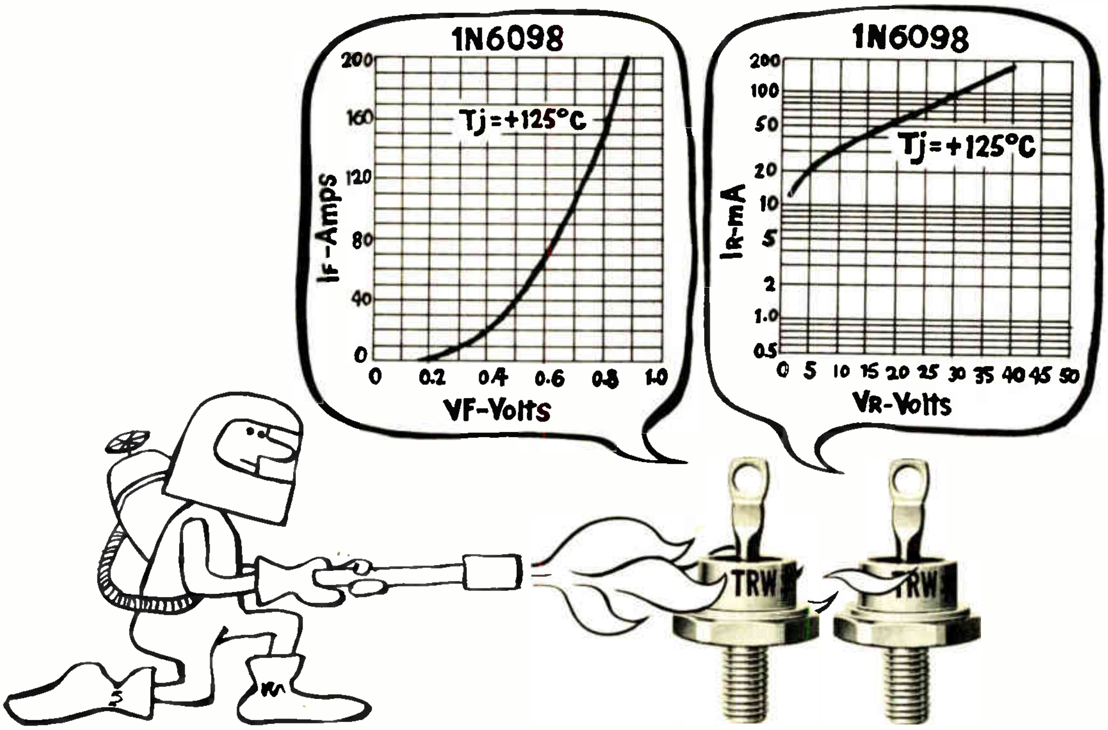
OK, you Power Schottkys, the heat's on. Talk!



These new TRW Power Schottkys have quite a story to tell and it starts with the fact that they're JEDEC registered. Then they'll tell you that they let you maintain 50 Amps—typically 0.55 Volt forward drop at a T_j of 125° C. The highest operating junction temperatures, lowest reverse leakage typically less than 200mA @ 40V, 125° C, and highest voltages on the market today. (Yet, for all that, they're competitively priced.)

Yes, TRW's Schottky Diodes are now 1N registered. And they're about to be JAN and JANTX qualified.

Let these new Power Schottkys take your heat, try one in your present circuit or in the circuit you're working on, you'll find out they're not just talk.

1N6095	25 AMP	30V	DO-4
1N6096	25 AMP	40V	DO-4
1N6097	50 AMP	30V	DO-5
1N6098	50 AMP	40V	DO-5

If you'd like to hear more about how TRW's Power Schottkys can help you in the design of low-voltage, high-current power supplies, call John Power at (213) 679-4561. Or use the coupon. (These components are available from stock from our distributors.)

TRW Power Semiconductors
An Electronic Components Division of TRW, Inc.,
14520 Aviation Boulevard, Lawndale, California 90260

☐ **Please send me data sheets on TRW's Power Schottky Diodes**
☐ **Have a salesman get in touch with me**

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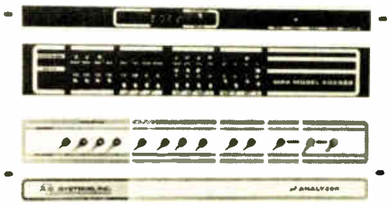
TRW POWER SEMICONDUCTORS

ANOTHER PRODUCT OF A COMPANY CALLED TRW



and program counter), examining and depositing data in memory, run/halt control, and single-step control. Readouts are provided to display system status, analyzer status, and the contents of the address bus and the data bus.

A special control function allows the analyzer to simulate the effect of a memory that is slower than the one in the system. An execute control allows the insertion of instructions independent of normal program flow.

The model MPA AO 6800 sells for $695. It has a delivery time of four weeks.

A O Systems Inc., 1736 Front St., Yorktown Heights, New York 10598. Phone (914) 962-4264 [365]

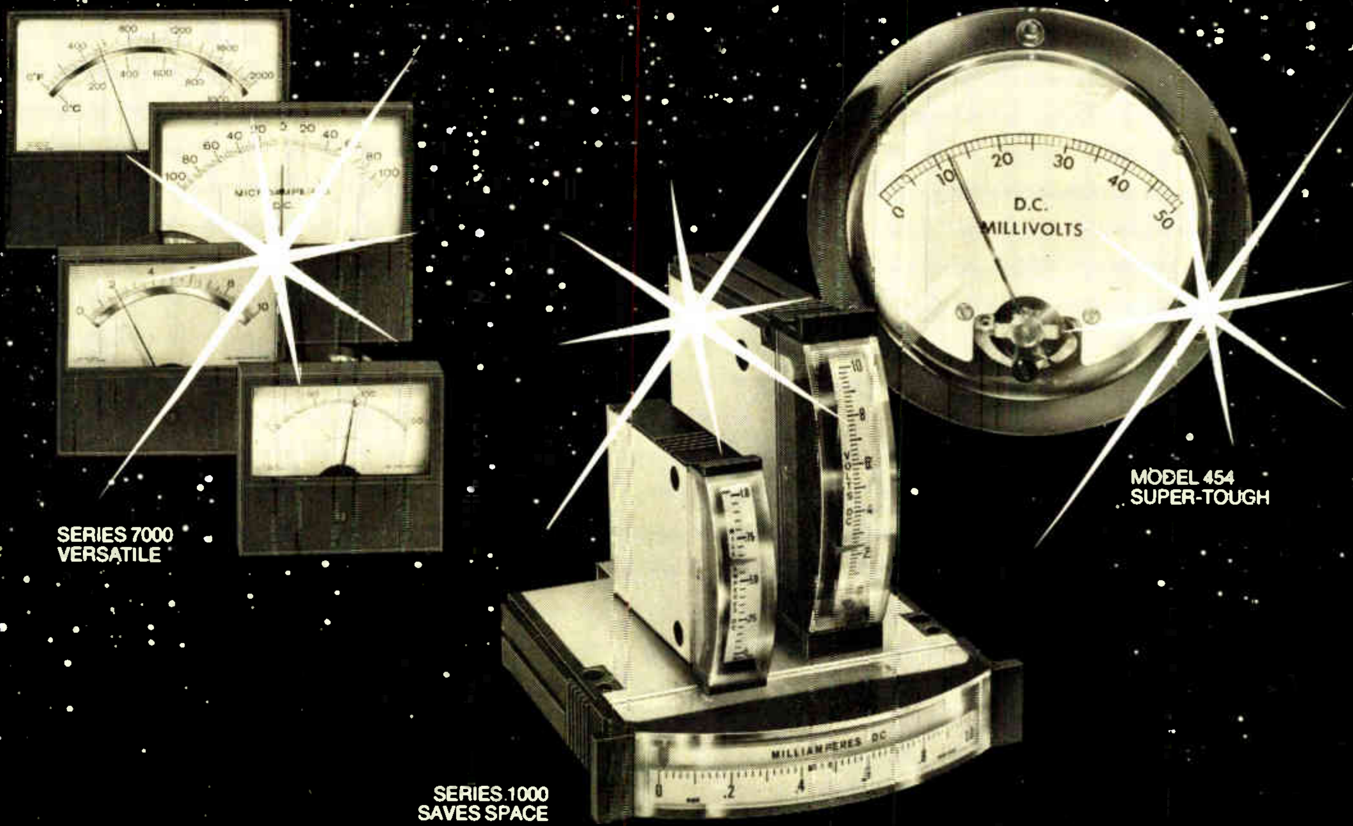
Interface module generates three-dimensional displays

Designed to interface with standard 8-bit microprocessors, the model 6711 provides a means for storing 256 three-dimensional points in a high-speed recirculating memory. The display-interface module provides three analog output data streams representing each of the three mutually perpendicular deflection axes of a 3-d display.

To the microprocessor, the 6711 appears as a memory location. It connects to the 8-bit data bus or an 8-bit data output port. It requires two address lines plus a strobe or read/write command line. In addition, it sends back an execution bit when it is ready to receive another byte of data. Programs can be furnished for the F-8, 8080A, 6800, 2650, 1802, and SC/MP microprocessors.

The 6711 sells for $322 in small quantities, dropping to $261 for 10

STAR PERFORMERS



api Panel Meters

Get the performance you need – with API panel instruments. Need economy? Small package? Tough case? ½% accuracy? LFE has them all.

VERSATILE: Series 7000 can be panel, lens, or bezel mounted. Slide-out scales facilitate modification.

SAVES SPACE: Series 1000 in 1½", 2½" and 3½" sizes feature rugged polycarbonate case, quick stackable mounting, and famous API quality and styling. Surprisingly economical too.

SUPER-TOUGH: Our new 4½" round Model 454 is an ideal replacement for glass-window instruments in portable, industrial, and plant uses. Its wrap-around polycarbonate case tosses off blows that would destroy lesser meters. Large clear dial for great visibility.

Circle 169 on reader service card

ACCURATE: Nobody makes more precise panel instruments. We start at a standard 2% rating, with 1% tracking for taut-band ranges. We stop at ½% accuracy. You can have anything in between.

There's a LFE distributor or authorized modification center near you to provide quick service on standard or special ranges. Call him. Or call us. We perform. LFE Corporation, Process Control Division, 1601 Trapelo Road, Waltham, Mass., 02154, (617) 890-2000

LFE CORPORATION

Process Control Division

New products

to 29. Delivery is from stock.

Optical Electronics Inc., P.O. Box 11140, Tucson, Ariz. 85734. Phone (602) 624-1283 [367]

External power supplies cut computer-design problems

By keeping high voltage, heat, and potential interface outside of the product enclosure, an external power supply can reduce some of the more annoying problems associated with designing a microcomputer. Two UL-listed supplies—a desktop unit and one that plugs flat against the wall—convert 120 V ac into regulated dc. Most useful for microprocessor applications is a triple-output version that provides 5 V at 500 milliamperes and ±12 V at ±150 mA. Line regulation is to within 3%, load regulation to within 2%. Ripple and noise are 3.5 millivolts rms.

Dynamic Instrument Corp., 933 L.I. Motor Parkway, Hauppauge, N.Y. 11787. Phone (516) 234-2900 [366]

TOPICS

Microprocessors

National Semiconductor Corp., Santa Clara, Calif., is selling its SC/MP kit microcomputer boards in assembled, fully tested form. Priced at $125 for small quantities, this factory-assembled version of the kit will be known as the SC-8 board (pronounced skateboard)... .**General Instrument Microelectronics, Hicksville, N.Y.,** has cut the price of its 16-bit CP1600 microprocessor from $99 to $49 for small quantities. Prices were dropped at higher-volume levels, too; for 100 to 499 pieces, for example, the price is down from $65 to a selling price of $38.50... .**Mostek Corp., Carrollton, Texas,** has announced a three-week turn-around time on its MK 34000 16-kilobyte read-only memory. In thousands, the plastic-packaged version sells for $13.85, and the ceramic version is priced at $14.85.

All aerosols are not alike.

The constant progression of sophistication in electronics has demanded a parallel progression in standards of purity. Industrial cleaning is one very vital link in maintaining component and system purity and reliability.

Let's look at eight important criteria and compare Miller-Stephenson products to the general aerosol industrial cleaner industry.

SOLVENTS:

Miller-Stephenson — Most of our aerosols contain 80% Active Ingredient, 20% Propellant.
Other Aerosol Cleaners — Active Ingredient averages 70-75%.
Miller-Stephenson — Uses only Certified Virgin Solvent.
Other Aerosol Cleaners — Some utilize reclaimed solvents. Though lower in cost, reclaimed solvents usually contain foreign substances.

PROPELLANTS:

Miller-Stephenson — Uses only the highest purity, safest propellants. They are nonflammable - TWA 1000 ppm.
Other Aerosol Cleaners — Many use cheap, sometimes flammable, sometimes higher order of toxicity propellants.

FILTERING:

Miller-Stephenson — We double filter "Freon" solvent and propellant — first with a 0.5 micron filter, then with a Millipore 0.2 absolute filter.
Other Aerosol Cleaners — Some use no filters; others only a 0.5 micron filter.

LOADING LINES:

Miller-Stephenson — All loading lines are dedicated to the individual ingredients used.
Other Aerosol Cleaners — Loading lines are often used for multiple products and if not thoroughly flushed, contamination will occur.

LOADING ENVIRONMENT:

Miller-Stephenson — Class 100 Clean Room conditions.
Other Aerosol Cleaners — Normally uncontrolled — environmental contamination can occur.

VOLUME PRODUCTION:

Miller-Stephenson — Our principal raw materials come direct from Du Pont tankers into our 5500 gallon storage tanks through a closed system direct to container.
Other Aerosol Cleaners — Low volume suppliers often load from open 55-gallon drums thereby introducing possibility of contamination.

CONTAINER:

Miller-Stephenson — Our new seamless cans further reduce the possibility of contamination.
Other Aerosol Cleaners — Cans with soldered seams may introduce residual contaminants.

SAFETY IN SHIPPING:

Miller-Stephenson — Most of our "Freon" aerosol solvents are non-regulated items, exempt from all Federal Regulations "Restricted Articles". May be Shipped Air Transport.
Other Aerosol Cleaners — Do not meet Air Transport Regulations.

MS aerosol solvents have the lowest residual contamination in the industry — some approaching 5-7 ppm. The general range for the industry is 50-130 ppm.

"Freon" is Du Pont's registered trademark for its fluorocarbon compounds.

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Scrubbing action dislodges hard-to-remove residue. Fits all Miller-Stephenson aerosol solvents and cleaners.

Subassemblies

Hybrid pair resolves 14 bits

Complete converter for synchro inputs fits in two 36-pin DIPs

Only about two years have gone by since synchro-to-digital converters were first reduced from large boards to compact modules. Yet already they have shrunk from modules to hybrid versions, supplied in dual in-line packages that are compatible with integrated circuits.

The latest entry to hit the marketplace is a pair of thick-film hybrids from ILC Data Device Corp. Together they form a complete 14-bit tracking synchro-to-digital converter that even includes its own solid-state input transformer. One package serves as the control transformer, while the other package is the data processor.

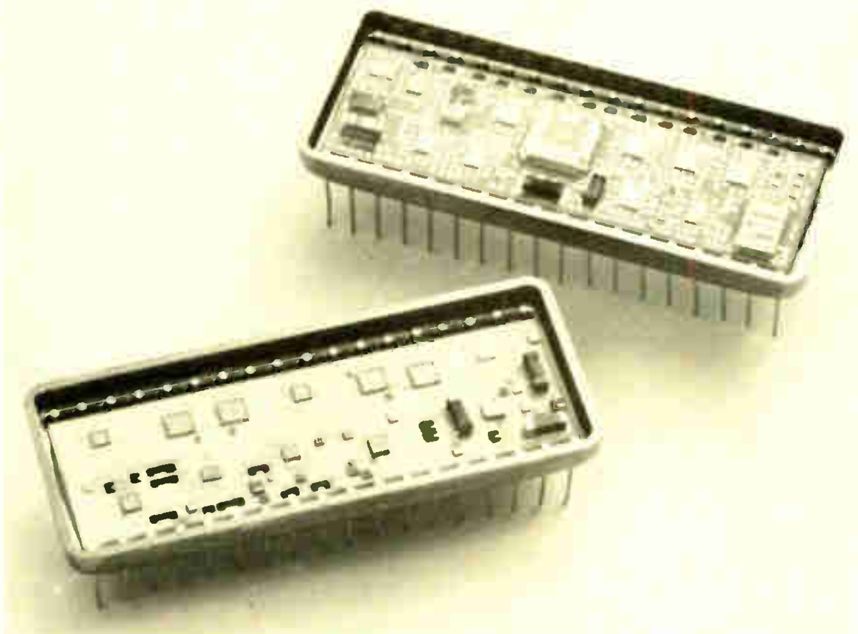
Because it is built with complementary-MOS logic, the model HSDC-14 converter set holds power consumption to a minimum—only 750 milliwatts for either package. Accuracy, including quantizing error, is maintained within ±4 minutes under all static and dynamic conditions, as well as over the full operating temperature range and for speeds of up to ±10 revolutions per second at 400 hertz.

The HSDC-14 accepts broadband inputs of 360 to 1,000 Hz or 47 to 1,000 Hz. The output angle, which is coded as natural-binary parallel positive logic, is compatible with both C-MOS and transistor-transistor-logic circuitry. Also, the unit can be easily synchronized to a computer system via its output BUSY line and its input INHIBIT line.

Standard input options include all the normal three-wire synchro and four-wire resolver formats. What's more, says a company spokesman, separate input-isolation transformers are seldom required because the unit's solid-state signal and reference inputs are truly differential, with high common-mode rejection.

Supplied in two 36-pin DIPs, the converter set is processed to level C of MIL-STD-883, with level-B processing available on special order. All models are completely calibrated at the factory, so field adjustments are not necessary. Operating temperature range can be −55°C to +125°C or 0°C to 70°C.

The complete two-DIP set sells for



$495 to $795, depending on the configuration, temperature range, and processing selected. Delivery time is within 60 days after receipt of order.

ILC Data Device Corp., Subsidiary of ILC Industries Inc., Airport International Plaza, Bohemia, N.Y. 11716. Phone (516) 228-7324 [381]

Dual-output dc-dc converters are housed in 24-pin DIPs

A series of dual-output dc-to-dc converters, designed to power operational amplifiers, microprocessors, and devices with similar requirements, comes housed in a 24-pin dual in-line package. The four devices in the series accept either a 5-volt input or a 12-v input and put out either ±12 v or +12 v and −5 v. Output ripple is only 30 millivolts peak to peak over the band

from 20 hertz to 20 megahertz. Line and load regulation are to within 0.3%, and efficiency is typically 65%.

The converters, which have a maximum power rating of 1 watt, sell for $38.20 each in small quantities. Small lots are available from stock.

Reliability Inc., 5325 Glenmont, Houston, Texas 77036. Phone (713) 666-3261 [383]

Hybrid voltage regulator delivers 5 A at 5 V

Housed in a standard TO-3 package, a hybrid voltage regulator with built-in short-circuit protection delivers up to 5 amperes at 5 volts dc. The model 78H05KC regulator subsystem also has automatic thermal

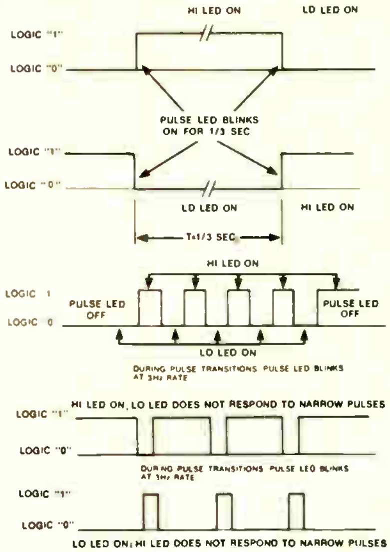
Logic Probe 1 is a compact, enormously versatile design, test and troubleshooting tool for all types of digital applications. By simply connecting the clip leads to the circuit's power supply, setting a switch to the proper logic family and touching the probe tip to the node under test, you get an instant picture of circuit conditions.

LP-1's unique circuitry—which combines the functions of level detector, pulse detector, pulse stretcher and memory—makes one-shot, low-rep-rate, narrow pulses—nearly impossible to see, even with a fast scope—easily detectable and visible. HI LED indicates logic "1", LO LED, logic "0", and all pulse transitions—positive *and* negative as narrow as 50 nanoseconds—are stretched to ⅓ second and displayed on the PULSE LED.

By setting the PULSE/MEMORY switch to MEMORY, single-shot events as well as low- rep-rate events can be stored indefinitely.

While high-frequency (5-10MHz) signals cause the "pulse" LED to blink at a 3Hz rate, there is an additional indication with unsymmetrical pulses: with duty cycles of less than 30%, the LO LED will light, while duty cycles over 70% will light the HI LED.

In all modes, high input impedance (100K) virtually eliminates loading problems, and impedance is constant for all states. LP-1 also features over-voltage and reverse-polarity protection. Housed in a rugged, high-impact plastic case with strain-relieved power cables, it's built to provide reliable day-in, day-out service for years to come.



CSC'S MULTI-FAMILY LOGIC PROBE 1. AT $44.95, IT DIGS UP A LOT OF INFORMATION WITHOUT BURYING YOUR BUDGET.

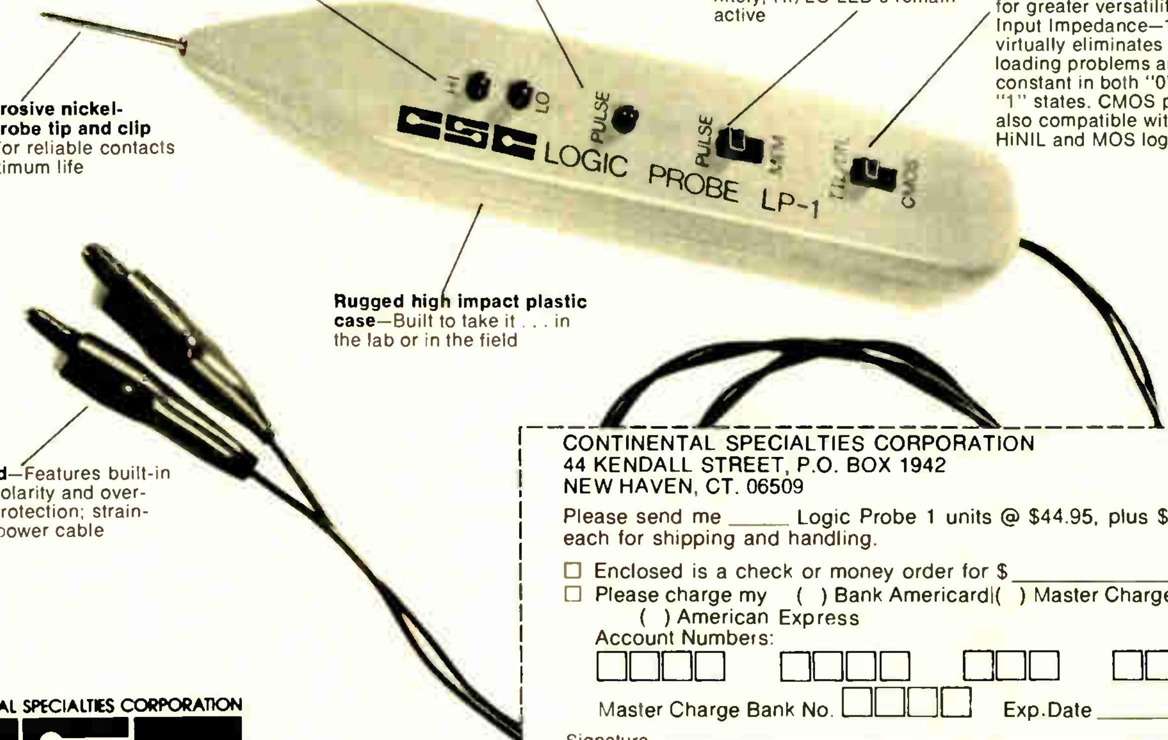
PULSE LED—Lets you know what's going on—and off. Indicates positive *and* negative pulse and level transitions. LP-1 stretches pulses as narrow as 50 nanoseconds to full ⅓ sec. (3Hz pulse rate)

PULSE/MEMORY Switch—PULSE position detects and stretches pulses as narrow as 50 nanoseconds to ⅓ sec. Switch to MEMORY and it stores single shot and low-rep-rate events indefinitely; HI/LO LED's remain active

HI/LO LED's—Display level (HI-logic "1", LO-logic "0") of signal activity at node under test

Logic Family Switch—TTL/DTL or CMOS matches Logic "1" and "0" levels, for greater versatility. High Input Impedance—100K virtually eliminates circuit loading problems and is constant in both "0" and "1" states. CMOS position also compatible with HTL, HiNIL and MOS logic

Non-corrosive nickel-plated probe tip and clip leads—For reliable contacts and maximum life



Rugged high impact plastic case—Built to take it . . . in the lab or in the field

Protected—Features built-in reverse polarity and over-voltage protection; strain-relieved power cable

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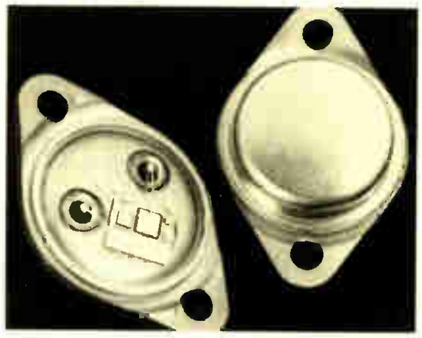


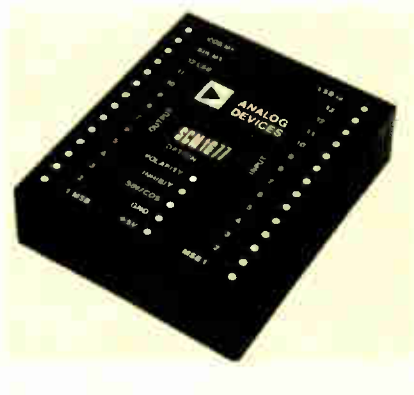
overload protection. If the junction of the power output transistor gets too hot, the regulator simply shuts down before it damages itself or any other system components. The 78H05KC is available from stock.

Automotive-Hybrid Products, Analog Products Division, Fairchild Camera and Instrument Corp., 464 Ellis St., Mountain View, Calif. 94042. Phone Bill Callahan at (415) 962-3816 [384]

Sine/cosine converter has 14-bit resolution

The SCM1677 sine/cosine converter is a completely digital module that accepts digital inputs representing angles from 0° to 360° and produces digital outputs representing either the sine or the cosine of the input angle. The input information is a 14-bit binary number while the output is a 12-bit binary number plus a polarity bit. The outputs may be switched from sine to cosine by changing the state of a programing pin.

Although designed for radar display systems, the converter is also useful in computer hardware for applications in which its speed



The world's smallest complete Isolation Amplifier has

the world's smallest price.

We knew what you needed in isolation amplifiers. Smaller size, lower cost, better performance. So, we did it. We designed the Model 284J Isolation Amplifier to give you the kind of performance and versatility you need for a broad range of applications.

The 284J costs only $41 in 100s, yet delivers all the key parameters in a small (1.5″ x 1.5″ x 0.62″), self-contained module. It even includes isolated power supply outputs for input pre-amplifiers or calibration signals. And because it requires no external DC/DC converter, the 284J is the smallest and least expensive isolation amplifier available today.

The 284J's total noise referred to input is a mere 8μV p-p in a 100 Hz bandwidth. Add an adjustable gain of 1 to 10V/V, a CMV of 5000V pulse or 2500V continuous and a minimum CMR of 110dB. And you've got all you need for a myriad of applications where optimum measurement accuracy and safety are concerned.

We didn't stop there with the product line. Consider our higher performance, Model 277 Instrument Grade Isolation Amplifer. Its uncommitted op amp front end gives you extreme versatility. Its CMR of 160dB and its gain nonlinearity of less than 0.025% for a full 20V swing plus a drift of less than 1μV/°C give you exceptional performance. The 277's versatility and performance at a pice of $114 (1-9) make it an excellent alternative in your most demanding instrumentation applications.

Then there's our Model 275 Industrial Grade Isolation Amplifier, $79 (1-9), that is gain programmable over a range of 1 to 100 by a single resistor with nonlinearity to less than 0.05%. And our Model 285 is like the 275 but features a low impedance op amp output. And our Models 279, 282 and 283 for multichannel applications.

We could go on and on about this line. But our free Analog Devices Isolation Amplifier Handbook says it all. Ask for a copy along with the data sheets on our new Isolation Amplifiers. Write Analog Devices, the real company in isolation amplifiers.

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Analog Devices, Inc., Norwood, Massachusetts 02062
East Coast: (617) 329-4700, Midwest: (312) 894-3300, West Coast: (213) 595-1783, Texas: (214) 231-5094. Belgium: 03 38 27 07, Denmark: 97 95 99, England: 01/94 10 46 6, France: 686-77 60, Germany: 089/53 03 19, Japan: 03/26 36 82 6, Netherlands: 076-122555 and representatives around the world.

New products

(2 microseconds) makes it a much better choice than a cordic or similar algorithm. Housed in a module that measures 3.125 by 2.625 by 0.8 inches, the converter requires only a single 5-volt supply that can deliver 600 milliamperes. A version that works from 0°C to 70°C sells for $350 in small quantities. Also available is a unit that works from −55°C to 105°C.

Analog Devices Inc., P.O. Box 280, Norwood, Mass. 02062. Phone Lowell Wickersham at (617) 329-4700 [385]

Voltage-frequency converter is linear to within 0.025%

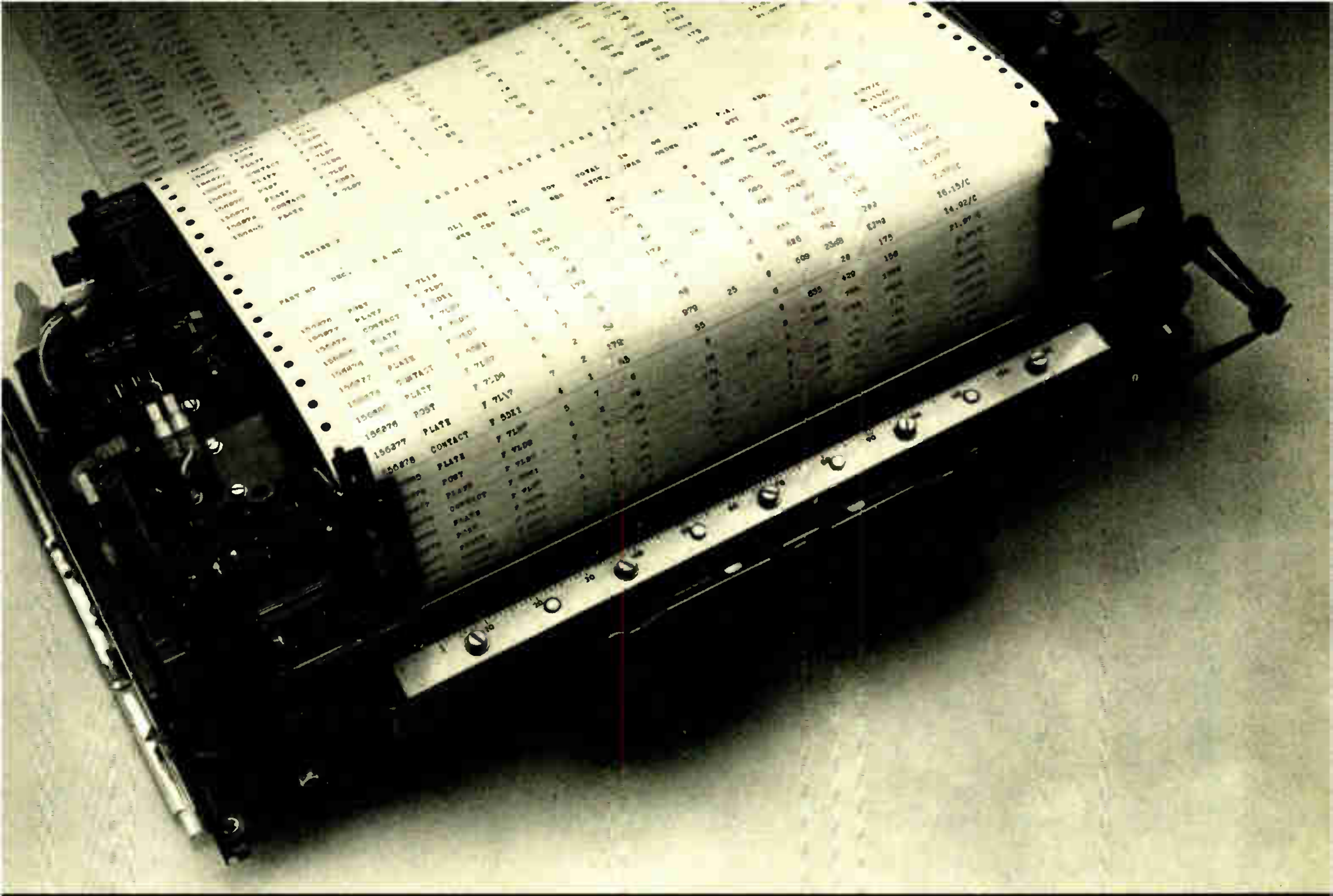
Able to operate from a single 15-volt supply, a line of general-purpose voltage-to-frequency converters features 13-bit resolution, a maximum offset temperature coefficient of 20 microvolts/°C, and a linearity to within 0.025% of full scale. Three full-scale ranges are offered: 10, 20, and 100 kilohertz. The full-scale frequencies of the 10- and 20-kilohertz models are trimmed to within 0.2%, while the 100-kHz models are trimmed to within 0.4%. Prices for the 8001 family start below $30; evaluation quantities of all 12 models are available from stock.

Dynamic Measurements Corp., 6 Lowell Ave., Winchester, Mass. 01890. Phone toll-free at (800) 225-1151 [386]

Buffered multiplexer is completely self-contained

The model 4550 16-channel analog multiplexer is a buffered unit that contains digital input buffers, an output buffer amplifier, decoder logic, and analog switches in a single compact package. The multiplexer, which has a transfer accuracy of within 0.01% up to 20 kilohertz, accepts input voltages from −10 V to +10 V. It is overvoltage-protected up to ±35 V. And the protection is maintained even when the collector supply voltage is removed.

Typical small-signal bandwidth



The Teletype® model 40 OEM printer. When you look at it from price and performance, you'll find it difficult to look at anything else.

The fact of the matter is simply this:
We don't think any other printer can even come close to the model 40.

And that's no idle boast. Not when you consider the facts.

Consider: Where else can you get a 132-column, heavy-duty impact printer that delivers over 300 lines per minute for less than $2000, or an 80-column printer for under $1400?

The big reason behind the model 40's price/performance advantage is our unique design. Even though it operates at speeds of more than 300 lpm, wear and tear is less than you'd find in a conventional printer operating at considerably slower speed. Fewer moving parts and solid-state components add up to greater reliability and reduced maintenance.

Here's something else to consider: Where else can you get a printer that delivers the kind of flexibility and reliability the model 40 offers?

For complete information, please contact our Sales Headquarters at: 5555 Touhy Ave., Skokie, Ill. 60076. Or call Terminal Central at: (312) 982-2000.

TELETYPE

The Teletype model 40 OEM printer. Nothing even comes close.

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New products

of the unit is 2.5 megahertz. The 4550 sells for $125 in small quantities; delivery of the multiplexer is from stock.

Teledyne Philbrick, Allied Dr. at Route 128, Dedham, Mass. 02026. Phone Robert W. Jacobs at (617) 329-1600 [387]

Quadrature hybrid sells for $35

Priced at only $35 for small quantities, the Q-116 quadrature hybrid is an extremely compact device that operates over a bandwidth of 10% centered at 30 megahertz. Other center frequencies up to 300 MHz are also available by special order.

The device, which can be used to split a signal into two isolated, quadrature-phased outputs or to combine two quadrature-phased inputs into a single output, is housed in a four-pin TO-5 header that measures only 0.3 inch high and 0.375 in. in diameter. The hybrid weighs only 2.5 grams.

Key operating specifications for the model Q-116 include nominal coupling of 3 decibels, minimum isolation of 25 dB, maximum insertion loss of 0.25 dB, quadrature angle of 90° ±3°, amplitude matching within 0.8 dB, impedance of 50 ohms, maximum VSWR of 1.3, and average power of 1 watt.

Merrimac Industries Inc., 41 Fairfield Pl., West Caldwell, N.J. 07006. Phone Alan Egger at (201) 228-3890 [388]

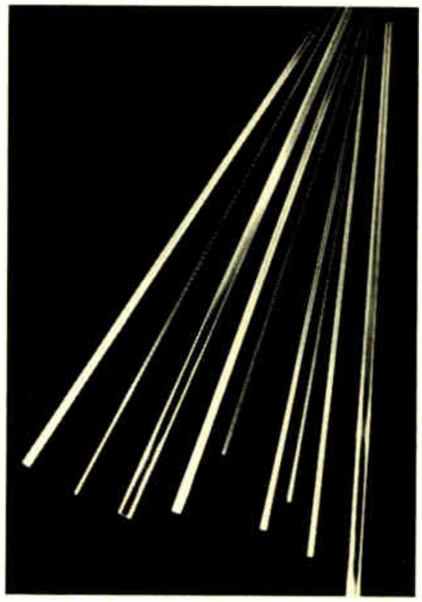
Hybrid amplifier spans 30 to 300 megahertz

The model CA2840 rf/i-f amplifier is a thin-film hybrid device that covers the frequency range from 30 to 300 megahertz. Intended for communications applications, the amplifier has a gain of 22 dB ±1.0 dB at 30 MHz and a noise figure of 6 dB, maximum. Its third-order intercept point is at 65 dBm. The amplifier sells for $50.

TRW RF Semiconductors, 14520 Aviation Blvd., Lawndale, Calif. [389]

New products/materials

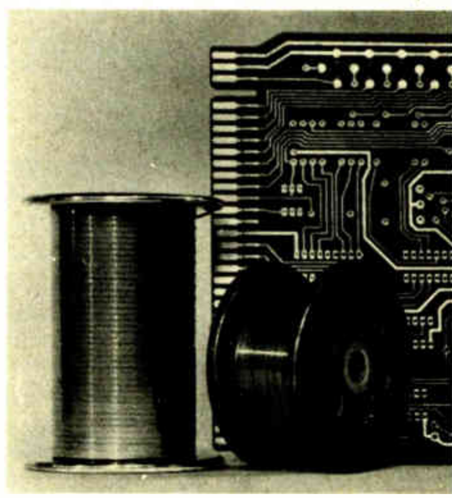
Single-crystal sapphire rod has tensile strength in excess of 25,000 kilograms per square centimeter, making it a superior material for wear guides, nonmagnetic supports, elec-

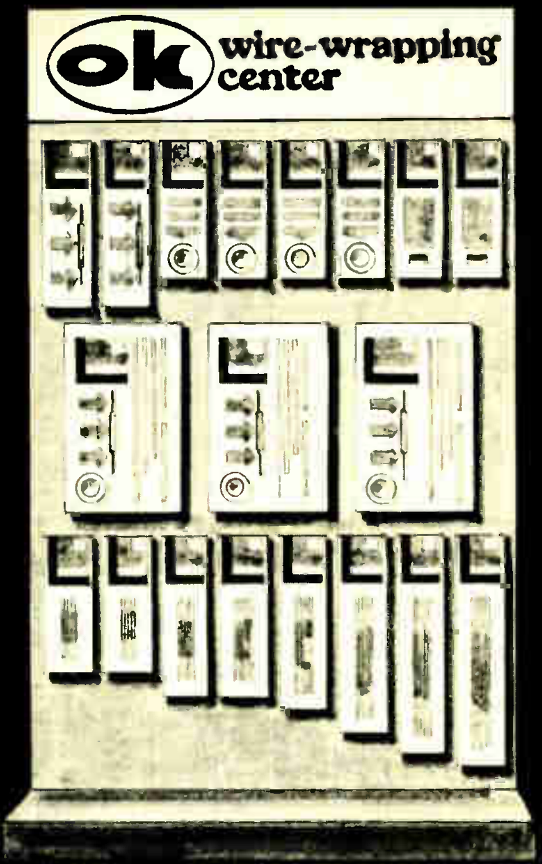


trical insulators, and similar applications that do not require optical transmission. It is offered in a variety of shapes—round, square, rectangular, elliptical, and triangular—in diameters from 0.01 to 0.2 inch. Available lengths vary from one inch to several hundred feet, depending upon diameter.

Tyco Saphikon Division, 16 Hickory Dr., Waltham, Mass. 02154 [476]

Metal ribbon for repairing or manufacturing circuit boards is available in a variety of sizes. Typically, widths are between 10 and 50 mils,





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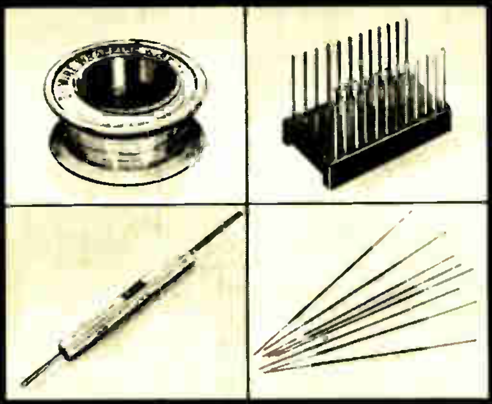

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and thicknesses are between 4 and 6 mils. Both gold-plated Kovar and gold-plated copper ribbons are recommended for repair work, while pure gold ribbon is available for the manufacture of microwave integrated circuits. In the latter, loops of ribbon are sometimes arched to produce lumped-circuit effects.

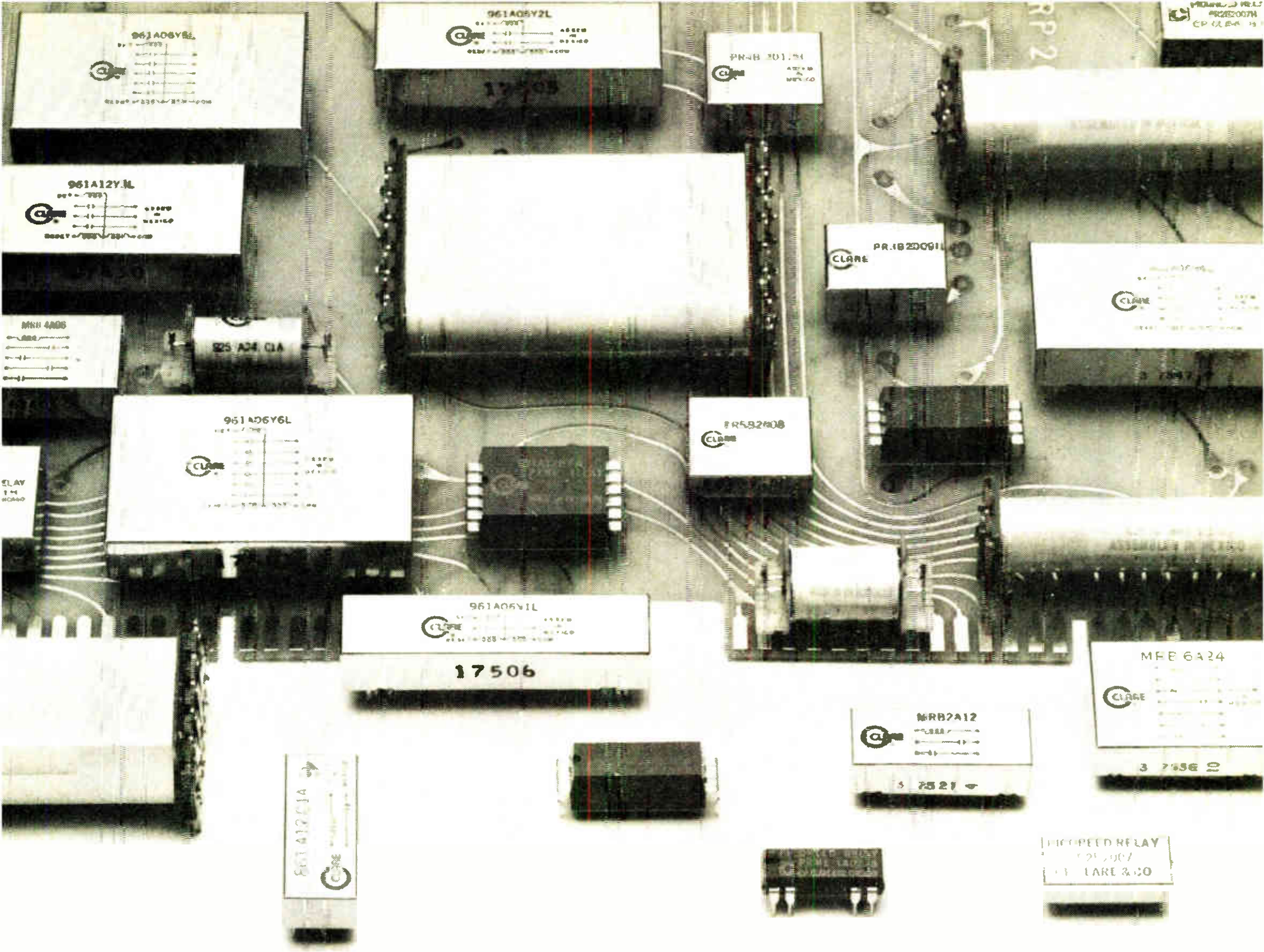
Consolidated Refining Co. Inc., 115 Hoyt Ave., Mamaroneck, N.Y. [477]

Three cleaning formulations, a polyurethane lacquer, and a mold-release material are offered for use in the manufacture and assembly of electronic equipment. Circuitkleen removes solder flux and other residue from printed-circuit boards, Polykleen is a fast-drying degreaser, and Electrical Contact Cleaner is just that. Polykote is a polyurethane lacquer for touching up and repairing printed-circuit boards and damaged insulation. And No-Sil-Kote is a silicone-free, paintable, mold-release agent, which is nonflammable, nonoxidizing, and greaseless. All five materials are packaged in aerosol cans and bulk containers.

Polycal Research Corp., P.O. Box 4624, Irvine, Calif. 92716 [478]

Solder-cleaning agent SnPb 2000 is a one-part solution for cleaning and activating solder prior to reflow fusing. It eliminates residual oxides and other contaminants and can also be used to clean, activate, and brighten tarnished and aged fused boards. SnPb 2000, which is available in 1-, 5-, 15-, and 55-gallon containers, has an unlimited shelf life.

Coppertech Inc., Ninth and Greenleaf streets, Allentown, Pa. 18102 [479]



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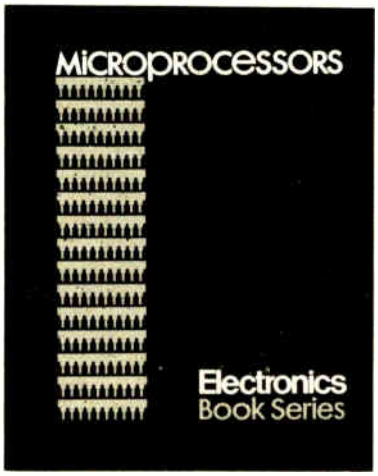

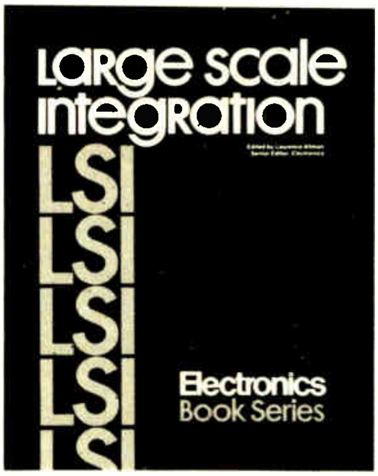

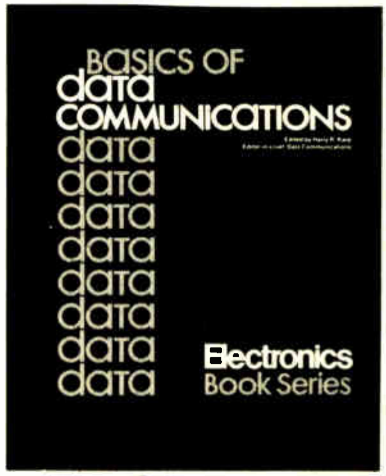

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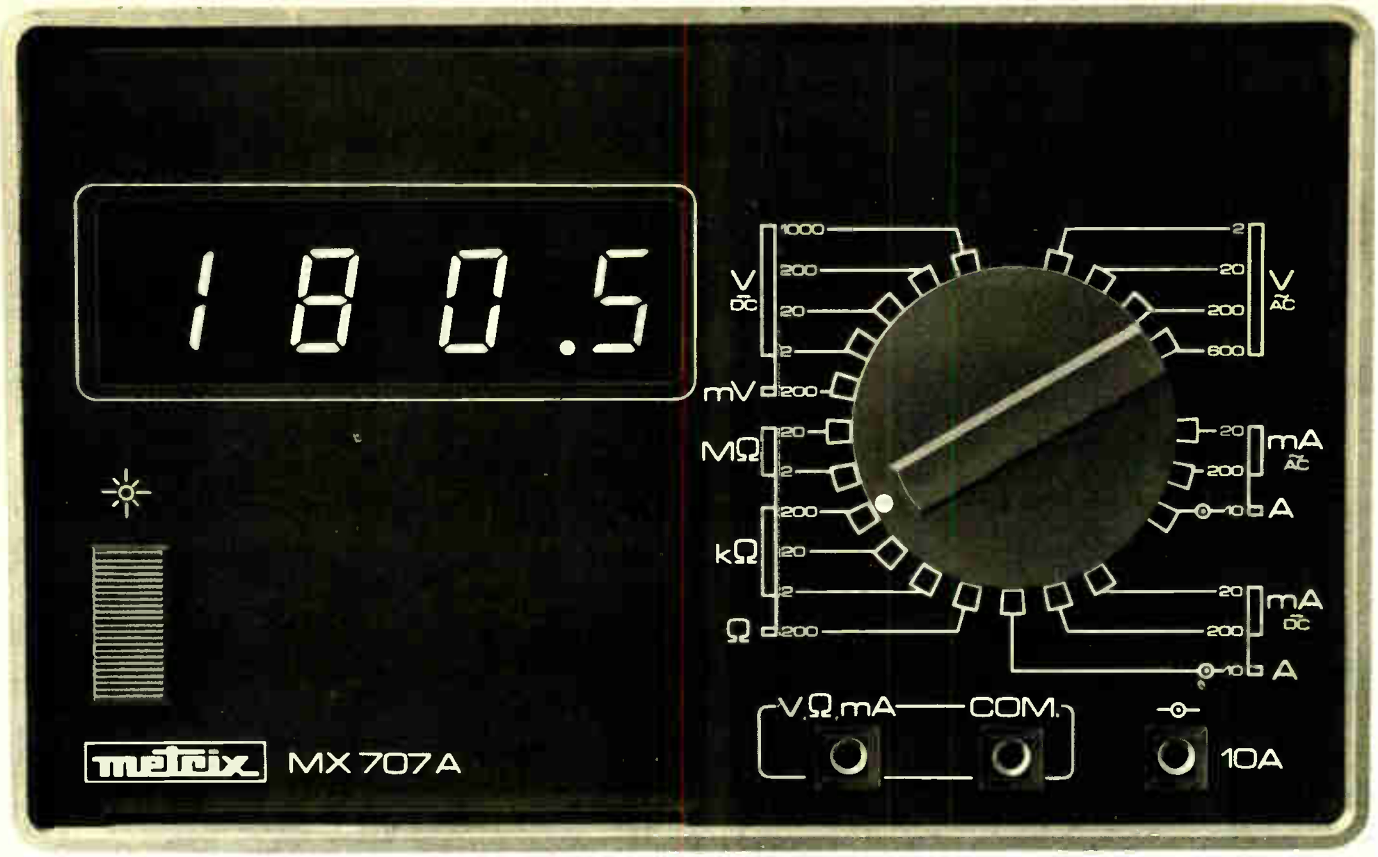

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New literature

Analyzing microprocessor systems. Eight application notes, each describing the use of logic-state troubleshooting instruments to analyze a commonly used microprocessor system, are offered by the Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. The format is identical for all eight notes. Operation of the particular microprocessor is described in detail with the aid of charts and schematics. Separate sections discuss pin assignments, probe and pin connections, analyzer control settings, interpretation of the display, mapping, and viewing address and data. Circle the indicated reader service number for the microprocessor of interest.

Fairchild F8	421
Intel 4004	422
Intel 4040	423
Intel 8008	424
Intel 8080	425
Motorola 6800	426
National IMP	427
National SC/MP	428

Specifying modules. The manufacturers and users of operational amplifiers, logarithmic amplifiers, and dc-to-dc converters often have different notions about the meaning of some of the specifications of these devices. To help reduce confusion in this area, Teledyne Philbrick has published three application notes that make clear exactly what that company means by the various terms that appear on its data sheets. AN-23 covers op amps, AN-26 deals with dc supplies, and AN-27 with log amps. Copies of all three notes are offered by Teledyne Philbrick, Allied Drive at Route 128, Dedham, Mass. 02026 [429]

Measuring microwave pulses. An eight-page application note, "The Automatic Microwave Pulse Counter—A New Approach to Frequency Measurement in the Time Domain," contrasts the operation of wavemeters, manual transfer oscillators, and the EIP model 451 microwave pulse frequency counter. The note, which includes a detailed description and block diagram of the 451, is avail-

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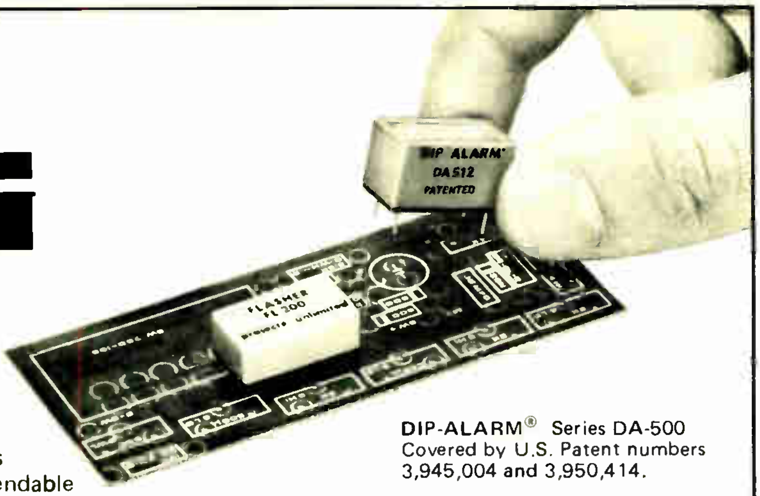

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available from EIP Inc., 3230 Scott Blvd., Santa Clara, Calif. [430]

Strain-gage specifications. The Instrument Society of America has published a standard on strain-gage specifications and tests. Designated S37.8-1975, the 16-page document outlines uniform general specifications, acceptance and qualification methods, and methods for data presentation. It also includes terminology. Copies may be obtained for $5 each ($3 to Instrument Society members) from the Publications Dept., Instrument Society of America, 400 Stanwix St., Pittsburgh, Pa. 15222

Computer privacy. The National Bureau of Standards has published a report entitled "A Methodology for Evaluating Alternative Technical and Information Management Approaches to Privacy Requirements." The report deals with the costs of achieving the privacy requirements of the Privacy Act of 1974 (PL 93-579). Copies of the report may be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Orders must include payment ($1.35 in the U.S.; $1.70 elsewhere), and they must mention SD Cat. No. C13.46:906.

Image analysis. The Magicscan image-analysis system, a programmable, digital system for the analysis of TV images, is described in a 12-page brochure put out by Joyce-Lobel, Ltd., Princeway, Team Valley, Gateshead NE11 0UJ, England. Useful wherever quantitative assessment of visual objects is required—in particle-size analyses, in the making of measurements on aerial photographs, in the classification of biological cells, etc.—Magicscan has sufficient built-in intelligence to extract the structural boundaries of features even when the boundaries are not well defined. [437]

Ultrasonic transducers. A line of ultrasonic transducers for use in nondestructive flaw-detecting equipment is described in an eight-page catalog put out by the Transducer

Sales Dept., Piezo Products Division, Gulton Industries Inc., 300 S. State College Blvd., Fullerton, Calif. 92631 [434]

Power transistors. Lansdale Transistor and Electronics Inc., which recently purchased the germanium-manufacturing facilities of Motorola, has published a 16-page catalog that covers its line of germanium power transistors. Catalog No. 101 can be obtained from Lansdale Transistor and Electronics Inc., 600 W. 24th St., Tempe, Ariz. 85282 [433]

Iberian electronics. Names, addresses, and products of the significant electronics companies in the country are listed in the 1976 edition of "Electronics in Spain." The 118-page English-French-Spanish catalog covers both components and equipment. It is available free, upon letterhead request, from Secartys, Avda. Jose Antonio 456, Barcelona 15, Spain

Components. A short-form catalog covering all of its components is offered by RCL Electronics division, AMF Inc., 700 South 21st St., Irvington, N.J. 07111. The 36-page guide supplies engineering information on precision and power wirewound resistors, miniature rotary switches, DIP switches, ladder networks, delay lines, knobs and accessories. [436]

Terminal boards. A 12-section catalog from Kulka Electric Corp., 520 South Fulton Ave., Mount Vernon, N.Y. 10551, gives data on the company's lines of terminal boards, blocks, and strips. The manual, which provides information on design, applications, and materials, covers standard boards, stud-and-turret units, wrapped-wire boards, military devices, Quick Connect Kliptites, marker strips, surface and bottom termination hardware. Also included are details on the company's new series of thermoplastic components for printed-circuit boards. [438]

Filtering for signal processing. "The Application of Filters to Analog and Digital Signal Processing" is a 24-page book designed to provide all the information necessary for the effective employment of filters in signal-processing systems. The book uses Fourier-transform concepts to explain how proper filtering can improve signal-to-noise ratios and prevent aliasing in sampled-data systems. Available for $3 from Rockland Systems Corp., 230 West Nyack Rd., West Nyack, N.Y. 10994, the book can be obtained free of charge, until Dec. 31, by circling reader service number [439]

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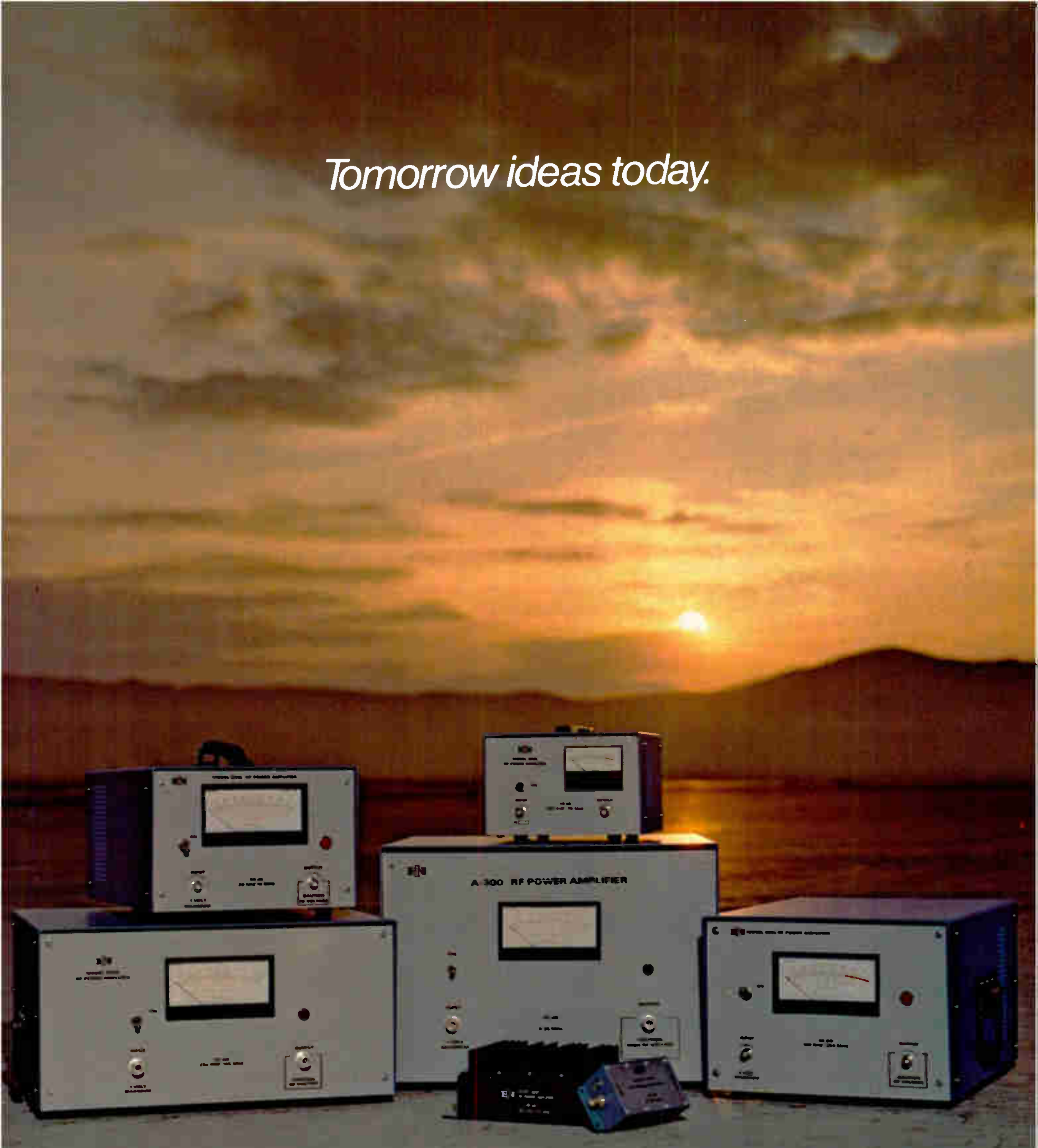

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